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Revision 0

Engineering Evaluation Report for Single-Shell Tank Waste Management Area T Groundwater Monitoring

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Richland, Washington 99352

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APPROVED
By Julia Raymer at 2:56 pm, Jul 24, 2018

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Statement of certification:

I am a licensed Professional Engineer in the State of Washington, No. 41198, with a degree in Environmental Engineering. I have over 26 years of professional experience, including 15 years with groundwater systems. I reviewed the attached engineering study referenced as "Engineering Evaluation Report for Single-Shell Tank Waste Management Area T Groundwater Monitoring, SGW-60575, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington" and I certify that it demonstrates completeness in compliance with WAC 173-303-806(4)(a).

May 14, 2018

Leonard D. Habel, P.E.
Sr. Principal Engineer
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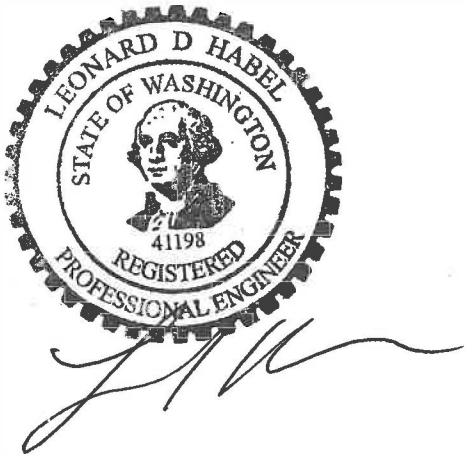
Date



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Terms

AEA	*Atomic Energy Act of 1954*
CAS	Chemical Abstracts Service
CCU	Cold Creek unit
CCUc	Cold Creek paleosol sequence
CCUz	Cold Creek Unit calcic paleosols
CPGWM	Central Plateau Groundwater Model
cpm	count per minute
DOE	U.S. Department of Energy
DWMU	dangerous waste management unit
DWS	drinking water standard
ECF	environmental calculation file
ECN	Engineering Change Notice
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
H1	Hanford 1
H2	Hanford 2
H3	Hanford 3
HEIS	Hanford Environmental Information System
K_d	distribution coefficient
LLBG	Low-Level Burial Ground
MT3DMS	Modular Three-Dimensional Multi-Species Transport Model
OU	operable unit
P&T	pump and treat
PFP	Plutonium Finishing Plant
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI/CMS	RCRA Facility Investigation/Corrective Measures Study
SST	single-shell tank
REDOX	reduction-oxidation

RLM	Ringold lower mud
TCE	trichloroethylene
TDS	total dissolved solids
TOC	total organic carbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
TSD	treatment, storage, and disposal
UPR	unplanned release
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System
WMA	waste management area

1 Introduction

This engineering evaluation report provides information to support the proposed final status groundwater monitoring for Waste Management Area (WMA) T based on evaluation of contaminants associated with WMA T, the expected migration behavior of contaminants in the WMA, and historical observations and measurements of groundwater contamination at WMA T. This evaluation includes results of groundwater transport simulations conducted using the Central Plateau Groundwater Model (CP-47631, *Model Package Report: Central Plateau Groundwater Model Version 8.3.4*). WMA T is an inactive single-shell tank (SST) farm that will be incorporated into Revision 9 of WA7890008967, *Hanford Facility Dangerous Waste Permit (Site-Wide Permit)* (hereinafter referred to as the Hanford Facility Dangerous Waste Permit) as Closure Unit Group 4. WMA T will be closed under WAC 173-303-665(6), "Dangerous Waste Regulations," "Landfills," "Closure and post-closure care," which is allowed by WAC 173-303-640(8)(b), "Tank systems," "Closure and post-closure care." This report provides supporting documentation regarding the protection of groundwater required by the *Resource Conservation and Recovery Act of 1976* (RCRA) permitting process for final status facilities.

WMA T is located in the 200 West Area of the Hanford Site in Washington State and overlies the 200-ZP-1 Groundwater Operable Unit (OU) (Figure 1-1). WMA T includes 16 SSTs and ancillary equipment of the 241-T Tank Farm that were used for interim storage of dangerous waste from chemical processing of reactor fuel for plutonium production.

This report addresses the additional information for groundwater monitoring requested in Washington State Department of Ecology (Ecology) Letter 16-NWP-090, "Groundwater Monitoring Requirements for 200 West Area Single-Shell Tank (SST) Farms Final Status Groundwater Monitoring Plan." The letter requests that the U.S. Department of Energy (DOE) develop engineering reports in advance of the complete permit application for the SST WMAs, with an associated groundwater monitoring plan developed for the final status permit application. The enclosure to the letter requires submittal of an engineering report with the following information included:

1. Information necessary to support the design of the groundwater monitoring well network, such that it is capable of yielding representative samples of groundwater potentially impacted by releases from the dangerous waste management units (DWMUs) resulting from changes in groundwater flow direction, declining water tables, and/or degrading wells that may be causing sample or groundwater contamination.

2. Information supporting design of the groundwater monitoring program that is capable of detecting significant statistical increases in groundwater contamination at the earliest practicable time.

3. Uncertainty in groundwater flow direction so that the appropriate number of wells can be located and drilled. This includes 1 year of background monitoring for WAC 173-303-110(3)(c) and (7), "Sampling, Testing, Methods and Analytes," unless previously performed to Ecology's satisfaction. Given the 3-year schedule for drilling and installing new wells, there should be at least 2 years minimum of planning, scheduling, and construction for any new wells or revised groundwater monitoring networks that are approved by Ecology.

4. Descriptions of the approach, input data, any additional information needs, and analysis proposed to evaluate and respond to changes listed in 1. Submit a full report of the complete analysis supporting the proposed approaches, including the methodology and results of validation of any modeling. Modifications of the groundwater monitoring network(s) may be needed to ensure they will continue to yield representative samples of groundwater potentially impacted by releases from DWMUs.

The analysis documented in this report complies with WAC 173-303-806, “Final Facility Permits,” which outlines the contents of the Part B permit application pertinent to the protection of groundwater. WAC 173-303-806(4)(a)(xx)(E) and (G)(V) require the preparation of detailed plans and an engineering report describing the proposed monitoring program to meet the requirements of WAC 173-303-645(8), “Releases from Regulated Units,” “General Groundwater Monitoring Requirements,” WAC 173-303-645(8) requires a groundwater monitoring system consisting of a sufficient number of wells installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer. These samples are intended to represent the quality of background groundwater that has not been affected by the leakage from a regulated unit, represent the quality of groundwater passing the point of compliance, and allow for the detection of contamination when dangerous waste constituents have migrated from the WMA to the uppermost aquifer.

WAC 173-303-806(4)(a)(xx)(E) and (G)(V) specify that a detailed plan describing the proposed groundwater monitoring program be included in the Part B application with this engineering evaluation report. This engineering evaluation report provides the technical basis for the groundwater monitoring that will be described in that plan. As groundwater monitoring under the compliance monitoring program (WAC 173-303-645(10)) will be performed along with the general monitoring requirements (WAC 173-303-645(8)), this engineering evaluation report also provides the supporting information for the compliance monitoring requirements. When the groundwater monitoring plan associated with this network is incorporated into the Hanford Facility Dangerous Waste Permit, it will replace any other groundwater monitoring plans associated specifically with WMA T under interim status.

In addition, this report provides information required by WAC 173-303-806(4)(a)(xx)(C) (topographic map), WAC 173-303-806(4)(a)(xx)(A) (summary of interim status groundwater monitoring data), WAC 173-303-806(4)(a)(xx)(B) (hydrogeological information), and WAC 173-303-806(4)(a)(xx)(D) (plume maps).

Applicable groundwater monitoring requirements of WAC 173-303-645 and WAC 173-303-806(4)(a)(xx) are detailed in Table 1-1.

Documented releases to the environment have occurred at WMA T. Details of the operational, regulatory, and groundwater monitoring history can be found in Chapter 2.

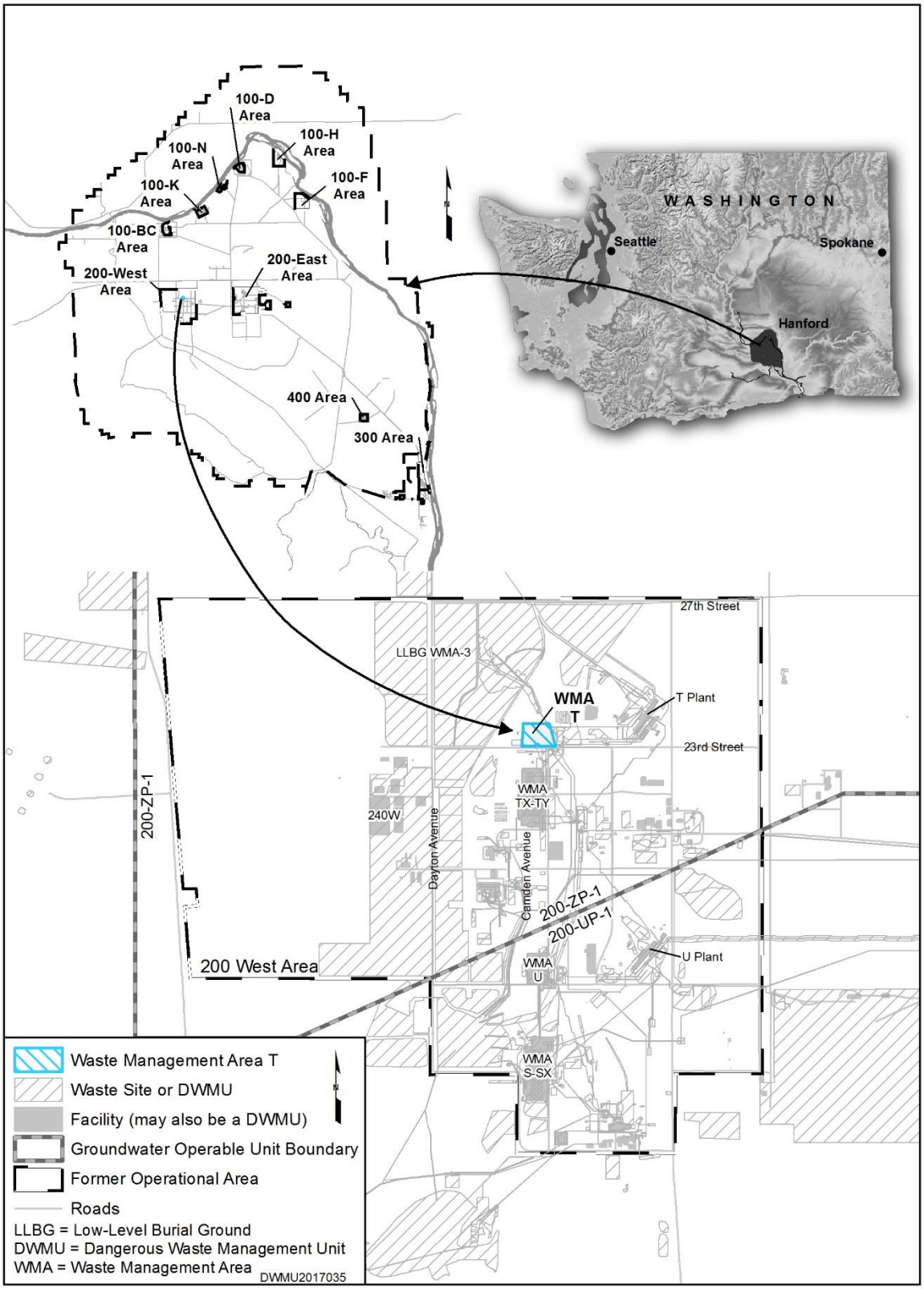


Figure 1-1. Location Map for WMA T

This report is organized as follows:

- Chapter 2 includes historical information to support the final status groundwater monitoring program determination.
- Chapter 3 describes the geology and hydrogeology of WMA T.
- Chapter 4 describes the contaminant migration conceptual model.
- Chapter 5 describes groundwater flow simulations for the 200 West Area.
- Chapter 6 describes calculations performed to evaluate wells for the proposed WMA T monitoring well network.
- Chapter 7 presents conclusions from the calculations performed in Chapters 5 and 6.
- Chapter 8 identifies the groundwater monitoring constituents of interest.
- Chapter 9 describes the proposed final status groundwater monitoring program.
- Chapter 10 describes how the monitoring well network will be maintained.
- Chapter 11 lists the references cited in this report.
- Appendix A contains the interim status groundwater monitoring data summary.
- Appendix B contains the identification of site-specific monitoring constituents evaluation environmental calculation file (ECF) (ECF-200ZP1-17-0203, *Identification of Site-Specific Monitoring Constituents for Waste Management Area T*).
- Appendix C contains the topographic map.
- Appendix D contains regional plume maps in the vicinity of WMA T.
- Appendix E contains well as-built diagrams and proposed well design information.
- Appendix F contains the 200 West Area modeling ECF (ECF-200W-17-0070, *Groundwater Flow and Migration Calculations to Support Assessment of the Hanford Central Plateau 200 West Area Facilities Monitoring Network*).
- Appendix G contains the WMA T modeling ECF (ECF-200W-17-0075, *Groundwater Flow and Migration Calculations to Support Assessment of the WMA T Monitoring Network*).
- Appendix H contains the process for defining the groundwater monitoring statistical method.

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
WAC 173-303-806(4)(a)(xx)(A) A summary of the groundwater monitoring data obtained during the interim status period under 40 C.F.R. 265.90 through 265.94, where applicable	Appendix A
WAC 173-303-806(4)(a)(xx)(B) Identification of the uppermost aquifer and aquifers hydraulically interconnected beneath the facility property, including groundwater flow direction and rate, and the basis for such identification (that is, the information obtained from hydrogeologic investigations of the facility area)	Section 3.2 Section 3.3
WAC 173-303-806(4)(a)(xx)(C) On the topographic map required under (a)(xviii) of this subsection, a delineation of the waste management area, the property boundary, the proposed "point of compliance" as defined under WAC 173-303-645(6), the proposed location of groundwater monitoring wells as required under WAC 173-303-645(8), and, to the extent possible, the information required in (a)(xx)(B) of this subsection	Appendix C
WAC 173-303-806(4)(a)(xx)(D) A description of any plume of contamination that has entered the groundwater from a regulated unit at the time that the application was submitted that: (I) Delineates the extent of the plume on the topographic map required under (a)(xviii) of this subsection; (II) Identifies the concentration of each constituent throughout the plume or identifies the maximum concentrations of each constituent in the plume.	Appendix D
WAC 173-303-806(4)(a)(xx)(E) Detailed plans and an engineering report describing the proposed groundwater monitoring program to be implemented to meet the requirements of WAC 173-303-645(8)	Chapter 9
WAC 173-303-806(4)(a)(xx)(G) If the presence of dangerous constituents has been detected in the groundwater at the point of compliance at the time of permit application, the owner or operator must submit sufficient information, supporting data, and analyses to establish a compliance monitoring program which meets the requirements of WAC 173-303-645(10)... To demonstrate compliance with WAC 173-303-645(10), the owner or operator must address the following items: (I) A description of the wastes previously handled at the facility; (II) A characterization of the contaminated groundwater, including concentrations of dangerous constituents and parameters; (III) A list of constituents and parameters for which compliance monitoring will be undertaken in accordance with WAC 173-303-645(8) and (10); (IV) Proposed concentration limits for each dangerous constituent and parameter, based on the criteria set forth in WAC 173-303-645(5)(a), including a justification for establishing any alternate concentration limits…	Section 2.3 Chapter 8 Chapter 9 Appendix A Appendix B

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
WAC 173-303-645(2)(a) Owners and operators subject to this section must conduct a monitoring and response program as follows: (i) Whenever dangerous constituents under subsection (4) of this section, from a regulated unit are detected at the compliance point under subsection (6) of this section, the owner or operator must institute a compliance monitoring program under subsection (10) of this section. Detected is defined as statistically significant evidence of contamination as described in subsection (9)(f) of this section;…	Chapter 9
WAC 173-303-645(3) The owner or operator must comply with conditions specified in the facility permit that are designed to ensure that dangerous constituents under subsection (4) of this section, detected in the groundwater from a regulated unit, do not exceed the concentration limits under subsection (5) of this section, in the uppermost aquifer underlying the waste management area beyond the point of compliance under subsection (6) of this section, during the compliance period under subsection (7) of this section…	Chapter 9
WAC 173-303-645(4)(a) The department will specify in the facility permit the dangerous constituents to which the groundwater protection standard of subsection (3) of this section, applies…	Section 9.4
WAC 173-303-645(5) (a) The department will specify in the facility permit concentration limits in the groundwater for dangerous constituents established under subsection (4) of this section... (b) The department will establish an alternate concentration limit for a dangerous constituent if it finds that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded...	Section 9.5
WAC 173-303-645(6)(a) The department will specify in the facility permit the point of compliance...at which monitoring must be conducted. The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.	Section 9.2
WAC 173-303-645(7) The department will specify in the facility permit the compliance period during which the groundwater protection standard of subsection (3) of this section applies…	Section 9.6

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
WAC 173-303-645(8)(a) The groundwater monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that: (i) Represent the quality of background groundwater that has not been affected by leakage from a regulated unit; (ii) Represent the quality of groundwater passing the point of compliance. (iii) Allow for the detection of contamination when dangerous waste or dangerous constituents have migrated from the waste management area to the uppermost aquifer.	Section 9.3
WAC 173-303-645(8)(c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole. This casing must allow collection of representative groundwater samples. Wells must be constructed in such a manner as to prevent contamination of the samples, the sampled strata, and between aquifers and water bearing strata. Wells must meet the requirements applicable to resource protection wells, which are set forth in chapter WAC 173-160, "Minimum standards for construction and maintenance of wells."	Section 9.3 Appendix E
WAC 173-303-645(8)(h) The owner or operator will specify one of the following statistical methods to be used in evaluating groundwater monitoring data for each hazardous constituent which, upon approval by the department, will be specified in the unit permit. The statistical test chosen must be conducted separately for each dangerous constituent in each well. Where practical quantification limits (pqls) are used in any of the following statistical procedures to comply with (i)(v) of this subsection, the pql must be proposed by the owner or operator and approved by the department. Use of any of the following statistical methods must be protective of human health and the environment and must comply with the performance standards outlined in (i) of this subsection.	Appendix H
WAC 173-303-645(8)(i) Any statistical method chosen under (h) of this subsection for specification in the unit permit must comply with [standards provided in WAC 173-303-645(8)(i)(i), (ii), (iii), (iv), (v), and (vi)] as appropriate.	Appendix H

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
WAC 173-303-645(10)(a) The owner or operator must monitor the groundwater to determine whether regulated units are in compliance with the groundwater protection standard under subsection (3) of this section. The department will specify the groundwater protection standard in the facility permit, including: (i) A list of the dangerous constituents and parameters identified under subsection (4) of this section; (ii) Concentration limits under subsection (5) of this section for each of those dangerous constituents and parameters; (iii) The compliance point under subsection (6) of this section; and (iv) The compliance period under subsection (7) of this section.	Chapter 9
WAC 173-303-645(10)(b)* The owner or operator must install a groundwater monitoring system at the compliance point as specified under subsection (6) of this section. The groundwater monitoring system must comply with subsection (8)(a)((ii), (b)*, and (c) of this section.	Chapter 9

* WAC 173-303-645(8)(b) is not applicable because WMA T is one regulated unit. It is not being monitored as part of a group of regulated units.

2 Supporting Historical Information

2.1 Background

This chapter describes WMA T and its operations, regulatory basis, waste characteristics, and interim status groundwater monitoring history.

2.1.1 Facility Description

WMA T, which includes the 241-T Tank Farm, is located in the northern portion of the 200 West Area (Figure 2-1) and was used for interim storage of radioactive waste from chemical processing of reactor fuel for plutonium production. WMA T contains 16 underground SSTs that were constructed in 1943 and 1944. Tanks 241-T-101 through 241-T-112 have capacities of 2,000,000 L (528,000 gal), and tanks 241-T-201 through 241-T-204 have capacities of 208,000 L (55,000 gal). In addition to the tanks, diversion boxes and ancillary pumps, valves, and pipes are included in WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8c (hereinafter referred to as the Hanford Facility RCRA Permit) Part A Application for the SST System.

Drywells surround the tanks in a clockwise pattern with a few drywells located within the tank farm fence boundary. These are open-bottom, 15 cm (6 in.) or 20 cm (8 in.) steel casings placed vertically around the tank perimeters and extend between 23 m (75 ft) and 61 m (200 ft) below grade. Historically, the drywells were monitored with gross gamma and other radiation logging tools as part of a secondary leak monitoring system. Figure 2-2 depicts SST schematics from the Hanford Facility RCRA Permit Part A Application for the SST System.

2.1.2 Operational History

The tanks in WMA T began receiving waste in 1944 and were in continual use until 1980, at which time they were removed from service. From 1944 to 1980, the WMA received metal and first-cycle waste from chemical processing, including the bismuth phosphate, tributyl phosphate, and reduction-oxidation (REDOX) processes. The SSTs also received predominantly 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 tanks at WMA T.

Waste management operations created a complex intermingling of tank wastes. Nonradioactive chemicals were added to the tanks and varying amounts of waste and heat-producing radionuclides were removed. In addition, natural processes caused settling, stratification, and segregation of waste components. As a result, the composition of the waste remaining in the tanks is difficult to estimate through operational records. Pumpable liquid has been removed from the WMA T SSTs, and the tanks have been interim stabilized. Each tank contains less than 189,270 L (50,000 gal) of drainable interstitial liquid and less than 45,424 L (12,000 gal) of supernatant liquid (Table 4-1 in HNF-EP-0182, *Waste Tank Summary Report for Month Ending May 31, 2017*).

Berms were constructed around the 241-T Tank Farm in 2001 to stop run-on of natural precipitation, and known water lines have been tested or cut off. In 2008, a felt with polyuria coating interim surface barrier was constructed over the 241-T Tank Farm in order to prevent the meteoric water from entering soil and consequently reduce the rate of downward movement of flow and dissolving contaminants (Section 1.3 in PNNL-19772, *T-TY Tank Farm Interim Surface Barrier Demonstration – Vadose Zone Monitoring Plan*).

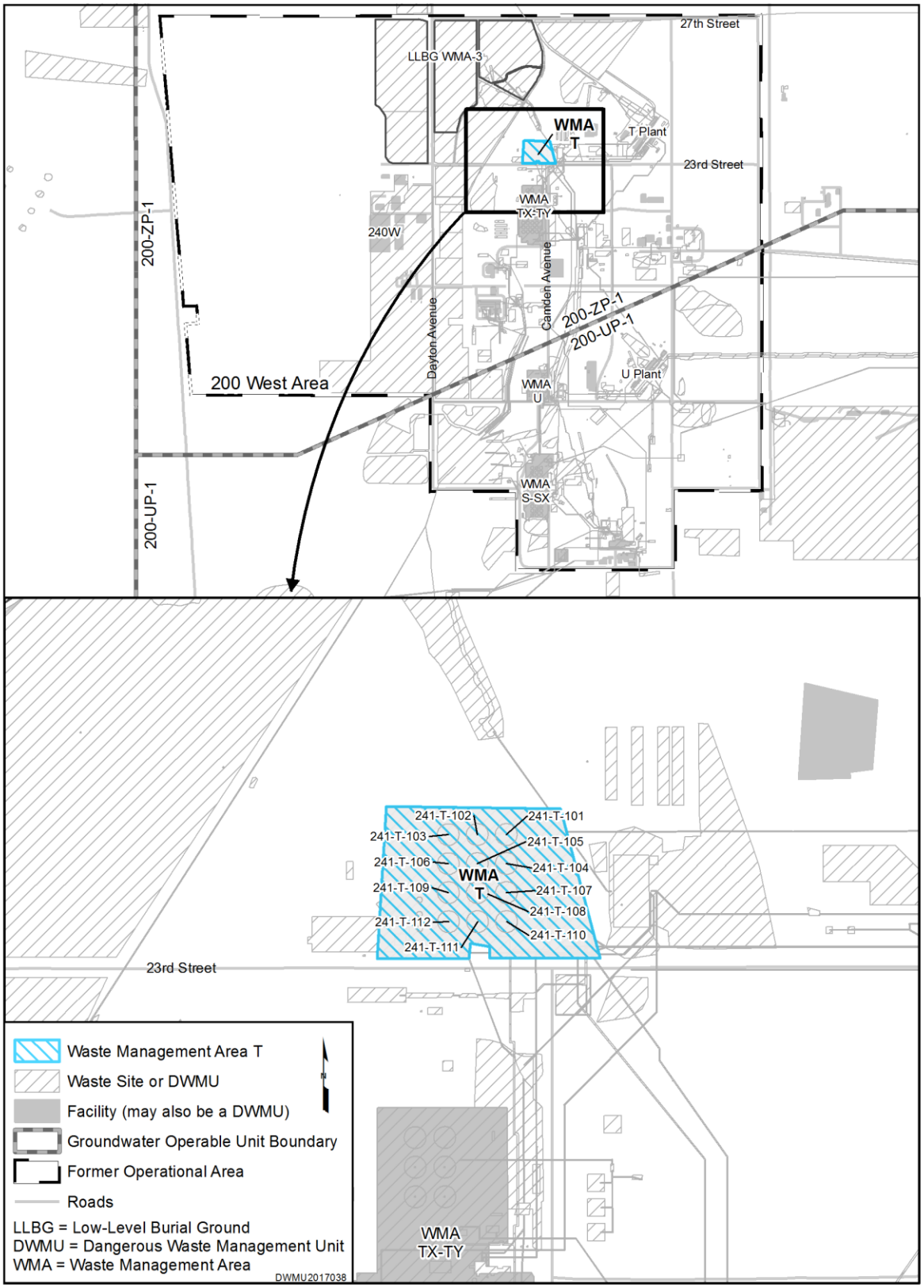
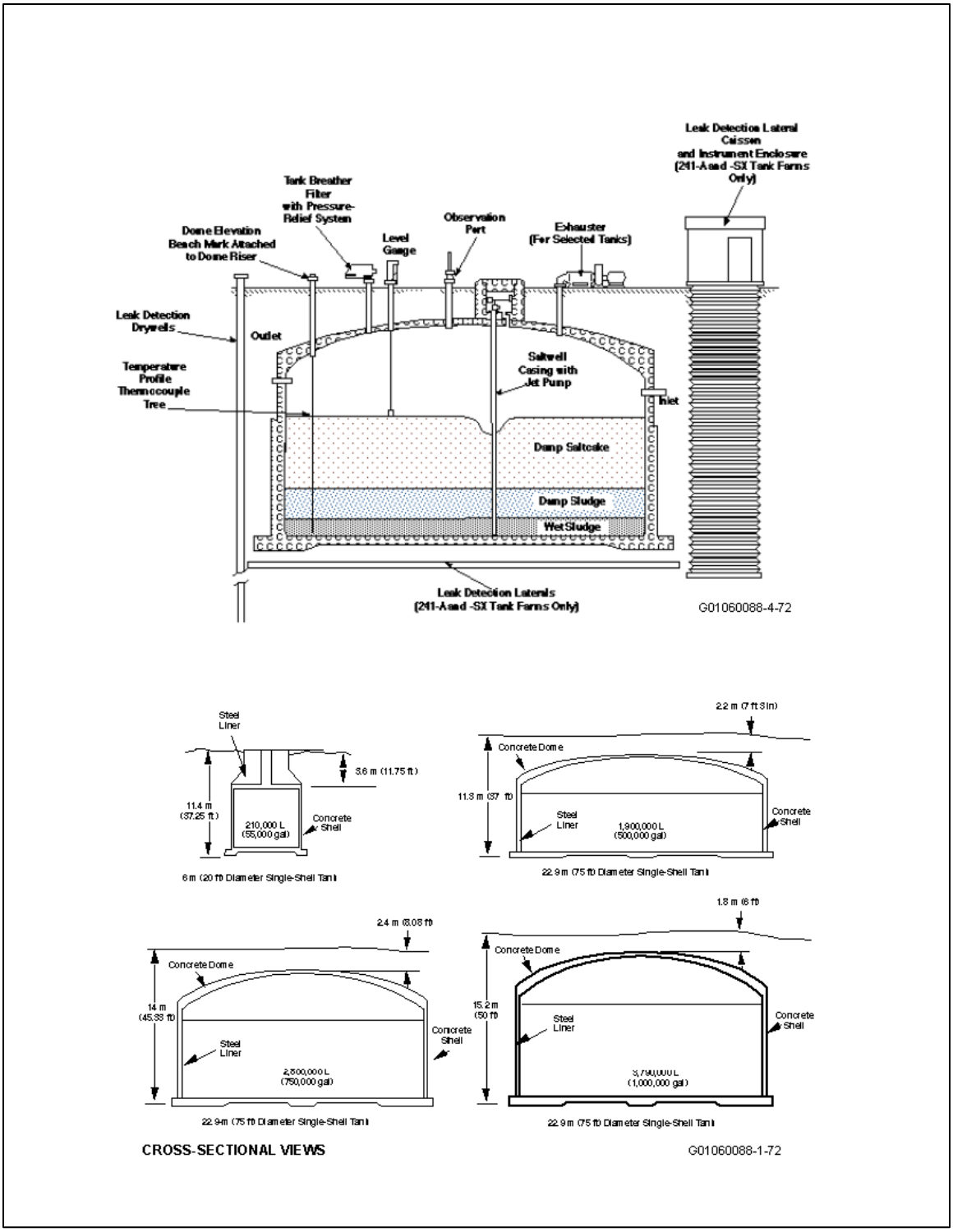


Figure 2-1. Location of WMA T within the 200 West Area



Source: p. 10 in 11-NWP-054, "Approval of the Single-Shell Tank System Dangerous Waste Permit Application Part A Form, Revision 13."

Figure 2-2. SST Schematics from the Hanford Facility RCRA Permit Part A Application

2.1.3 Single-Shell Tanks and Liquid Handling Structures within WMA T

Tank 241-T-101 was categorized as an assumed leaker in 1991 and has a total leak volume of 28,400 L (7,500 gal) (Section 4.0 in HNF-EP-0182). The tank was overfilled in the 1960s and is reported to have lost an unknown quantity of REDOX cladding waste through a defective spare inlet port in 1969 (Section 10.2.1 in GJO-99-101-TAR, *Hanford Tank Farms Vadose Zone T Tank Farm Report*). The nonradiological waste profile for the tank during the timeframe of the leak can be found in Table 2-1. Additional information on tank leak inventories can be found in RPP-RPT-55084, *Hanford 241-T Farm Leak Inventory Assessment Report*. The declaration of 241-T-101 as an assumed leaker appears to have been based on liquid level losses; however, gross gamma logging data failed to detect evidence of the leak and estimated leak volumes have been disregarded (Section 2.2.1 in RPP-7218, *Preliminary Inventory Estimates for Single-Shell Tank Leaks in T, TX, and TY Tank Farms*). Water intrusion into tank 241-T-101 was visually confirmed in 2014 with an estimated water intrusion rate of 136 to 227 L/yr (30 to 50 gal/yr) (Section 4.0 in RPP-RPT-50799, *Suspect Water Intrusion in Hanford Single-Shell Tanks*).

Table 2-1. Nonradiological Waste Profile for WMA T SSTs During Leaks

Analyte	241-T-101 during 1969 Leak (kg)	241-T-103 during 1973 Leak (kg)	241-T-106 during 1973 Leak (kg)
Aluminum	8.87 E+02	1.39 E+02	5.53 E+03
Bismuth	5.45 E-03	1.56 E-01	8.55 E+00
Butanol	9.11 E-02	8.09 E+00	3.39 E+02
Calcium	1.20 E+01	3.53 E+00	1.59 E+02
Carbonate	1.91 E+01	1.13 E+02	4.80 E+03
Chlorine	3.24 E+01	2.66 E+01	1.11 E+03
Chromium	2.38 E+01	2.32 E+01	9.66 E+02
Dibutyl phthalate	2.59 E-01	2.29 E+01	9.62 E+02
Fluoride	2.55 E-02	6.28 E-01	4.48 E+01
Iron	3.72 E+00	2.27 E+00	9.81 E+01
Lanthanum	8.92 E-09	1.23 E-06	5.16 E-05
Lead	1.01 E+01	5.72 E-01	2.17 E+01
Manganese	1.04 E-02	1.28 E+00	5.41 E+01
Mercury	6.13 E-02	3.72 E-03	1.51 E-01
Nickel	3.07 E+00	1.02 E+00	4.60 E+01
Nitrate	2.18 E+03	8.00 E+02	3.37 E+04
Nitrite	1.62 E+03	4.14 E+02	1.67 E+04
Normal paraffin hydrocarbon	0.00 E+00	0.00 E+00	0.00 E+00
Phosphate	1.60 E-01	9.73 E+00	4.49 E+02

Table 2-1. Nonradiological Waste Profile for WMA T SSTs During Leaks

Analyte	241-T-101 during 1969 Leak (kg)	241-T-103 during 1973 Leak (kg)	241-T-106 during 1973 Leak (kg)
Potassium	8.23 E+00	7.77 E+00	3.43 E+02
Silicon	1.69 E+01	8.48 E+00	3.58 E+02
Sodium	2.66 E+03	1.05 E+03	4.34 E+04
Strontium	0.00 E+00	0.00 E+00	0.00 E+00
Sulfate	5.20 E+01	8.74 E+01	3.71 E+03
Tributyl phosphate	0.00 E+00	0.00 E+00	0.00 E+00
Uranium	3.16 E+01	7.54 E+00	3.12 E+02
Zirconium	2.37 E-04	9.01 E-03	1.14 E+00

Source: Adapted from Tables 1 through 3 of RPP-7218, *Preliminary Inventory Estimates for Single-Shell Tank Leaks in T, TX, and TY Tank Farms*.

Tank 241-T-103 was categorized as an assumed leaker in 1974 and has a total leak volume of <4,546 L (<1,000 gal) (Section 4.0 in HNF-EP-0182). The leak has been suggested to have originated from a waste loss through a grout seal surrounding a spare fill line when the tank was overfilled in 1973 (Section 10.2.3 in GJO-99-101-TAR). Radionuclide profiles suggest that the lost tank waste may have originated from B Plant (Section 2.2.2 in RFP-7218). The nonradiological waste profile for the tank during the timeframe of the leak can be found in Table 2-1. The solids inventory for tank 241-T-103 is 104,560 L (23,000 gal) of sludge (Section 4.0 in HNF-EP-0182).

Tank 241-T-106 was categorized as an assumed leaker in 1973 and has a total leak volume of 522,800 L (115,000 gal) (Section 4.0 in HNF-EP-0182). The leak occurred in 1973 and comprised B Plant isotope recovery waste (Section 2.1 in DOE/RL-2009-66, I*nterim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*, Rev. 1). The nonradiological waste profile for the tank during the timeframe of the leak can be found in Table 2-1.

Tank 241-T-107 was categorized as an assumed leaker in 1984; however, it does not have an estimated leak volume (Section 4.0 in HNF-EP-0182). Neither spectral gamma logging data nor waste transfer records show evidence of a leak from 241-T-107 and no inventory estimates exist (Section 2.2.4 in RFP-7218). Water intrusion into tank 241-T-107 was visually confirmed in 2016 (Section 4.2 in HNF-EP-0182)

Tank 241-T-108 was categorized as an assumed leaker in 1974 and has an estimated leak volume of <4,546 L (<1,000 gal) (Section 4.0 in HNF-EP-0182). Neither spectral gamma logging data nor waste transfer records show evidence of a leak from 241-T-108, and no inventory estimates exist (Section 2.2.5 in RFP-7218).

Tank 241-T-109 was categorized as an assumed leaker in 1974 and has an estimated leak volume of <4,546 L (<1,000 gal) (Section 4.0 in HNF-EP-0182). Neither spectral gamma logging data nor waste transfer records show evidence of a leak from 241-T-109, and no inventory estimates exist (Section 2.2.6 in RFP-7218).

Tank 241-T-111 was categorized as an assumed leaker in 1974 and again in 1994 and has an estimated leak volume of <4,546 L (<1,000 gal) (Section 4.0 in HNF-EP-0182). Neither spectral gamma logging data nor waste transfer records show evidence of a leak from tank 241-T-111, and no inventory estimates exist (Section 2.2.7 in RFP-7218). The leak in tank 241-T-111 was first noted in 1974, and the tank liquid levels were periodically pumped down to the extent practical until 1978. An intrusion was evident in the tank beginning at that time and continued until at least 1993 when it was apparent that the tank was leaking again. The tank was saltwell jet pumped to the extent practical in 1994, after which an intrusion was again apparent. The rate at which the level was increasing appeared constant for several years; the rate of increase then began to slow down, and eventually the level stabilized about 2006. The level began to drop by 2007 and continued dropping at an accelerating rate. It was apparent that the tank was leaking again. It is impossible to determine exactly when the leak started, but an analysis of the data and level change rates suggests that the tank may have begun leaking again as early as 2002 or even before. (Section 2.0 in RPP-RPT-50799). Water intrusion into tank 241-T-101 was visually confirmed in 2014 (Section B.2.22.6 in RPP-RPT-50799).

Other liquid handling structures within WMA T, including diversion boxes, valve pits, and process pipelines, were used to transport or contain liquid waste associated with the tank farms. Information for these structures, which are included for WMA T in the SST System Hanford Facility RCRA Permit Part A Application, is provided below:

- There are four diversion box waste sites in WMA T. Diversion boxes are concrete structures containing transfer piping and were designed to contain leaks from transfers and drainage of effluent from operations within the unit. The diversion boxes drained to catch tanks or double-shell tanks.
- There are 22 valve pits in WMA T. Valve pits are underground concrete structures designed to contain leaks from transfers and drainage operations and then drain to catch tanks. Valve pits were equipped with a leak detection system that was designed to shut down operations if a leak in the pit was detected.
- There is one catch tank in WMA T. Catch tanks are underground structures designed to receive valve pit or diversion box leaks during transfers and drainage operations. Catch tanks are constructed of concrete and, in some cases, were lined with stainless steel.
- There is one settling tank in WMA T.

Pipeline structures in WMA T transferred effluent or condensate waste from the tank farm to surface liquid waste facilities. The pipelines were constructed of either carbon steel, stainless steel, vitrified clay, or fiberglass-reinforced epoxy. Pipelines were either buried or encased in concrete. The pipelines delivered process fluids or condensate and were either gravity or pressurized lines.

2.1.4 Unplanned Releases

The following information about unplanned releases (UPRs) within WMA T is from Table 2.6 in DOE/RL-91-61, *T Plant Source Aggregate Area Management Study Report*, and the Waste Information Data System (WIDS). The locations of UPRs are shown in Figure 2-3. In addition to the previously discussed documented leaks from SSTs, eight UPR waste sites are associated with WMA T:

- UPR-200-W-7 occurred in 1950 at the 241-T-151 and 241-T-152 diversion boxes. The material and amount released are not documented. Contaminated soil was partly removed and the remainder of contaminated soil was covered with approximately 0.3 m (1 ft) of clean soil.

- UPR-200-W-14 occurred in October 1952 along the waste line connecting the 242-T Building and the 207-T retention basin. The release was detected when contaminated water rose to the ground surface above the waste line. The waste line was repaired and the contaminated soil was covered with approximately 0.3 m (1 ft) of soil. The specific contaminant and the amount of contaminant released are not documented in DOE/RL-91-61 or WIDS.

- UPR-200-W-29 occurred in November 1954 at a cave-in located approximately 23 m (75 ft) east of Camden Avenue and 23 m (75 ft) south of 23rd Street, between the 241-T-152 and 241-TX-153 diversion boxes. The UPR resulted from failure of an uncased line connecting the diversion boxes. First-cycle supernatant waste from SST 241-T-105 (Figure 2-1) was released with dose rates of 11.5 rem/hr at 5 cm (2 in.). The area was hosed down with water and backfilled. A second spill occurred at the same location in May 1966 due to reuse of the same line. The amount of material released is not documented in DOE/RL-91-61 or WIDS.

- UPR-200-W-63 occurred in September 1966 along 23rd Street at diversion box 241-TX-153. Approximately 1 Ci of strontium-90 was released from a used diversion box jumper that was in transit in a truck along the road. Contamination was removed from the road and the area covered with 15 cm (6 in.) of soil.

- UPR-200-W-64 occurred in February 1969 along Camden Avenue and 23rd Street. Six hundred counts per minute (cpm) of cesium-137 was discovered in mud samples in an area cordoned off as a radiation zone. The cause may have been snow melt runoff from nearby radiation zones.

- UPR-200-W-97 occurred in May 1966 at the southeast corner of 23rd Street and Camden Avenue south to near 22nd Street. Second-cycle liquid waste was released from a broken underground line during transfer of bismuth phosphate waste from tank 241-T-107 (Figure 2-1) to the 242-T Evaporator feed, surfaced, and crossed Camden Avenue but did not run down the side of the road. Surface contamination at 600 cpm was detected. Surface contamination was removed to a depth of 0.9 m (3 ft). UPR-200-W-62 is a duplicate WIDS entry of UPR-200-W-97, and the information has been consolidated in this summary for UPR-200-W-97.

- UPR-200-W-147 occurred in 1973 at the southeast side of SST 241-T-103. Contamination was encountered while monitoring wells were being drilled to track a tank leak. The leak may have resulted from a failed grout seal in a spare entry line to the tank. The spill was approximately 5 m^3 (177 ft^3).

- UPR-200-W-148 occurred in April 1973 and is located adjacent to tank 241-T-106. The UPR comprises contaminated soil due to leaking of the tank. The UPR is suspected to have occurred during a routine filling operation of tank 241-T-106. As a result of this UPR, tank 241-T-106 was labeled a confirmed leaker and was removed from service in 1973.

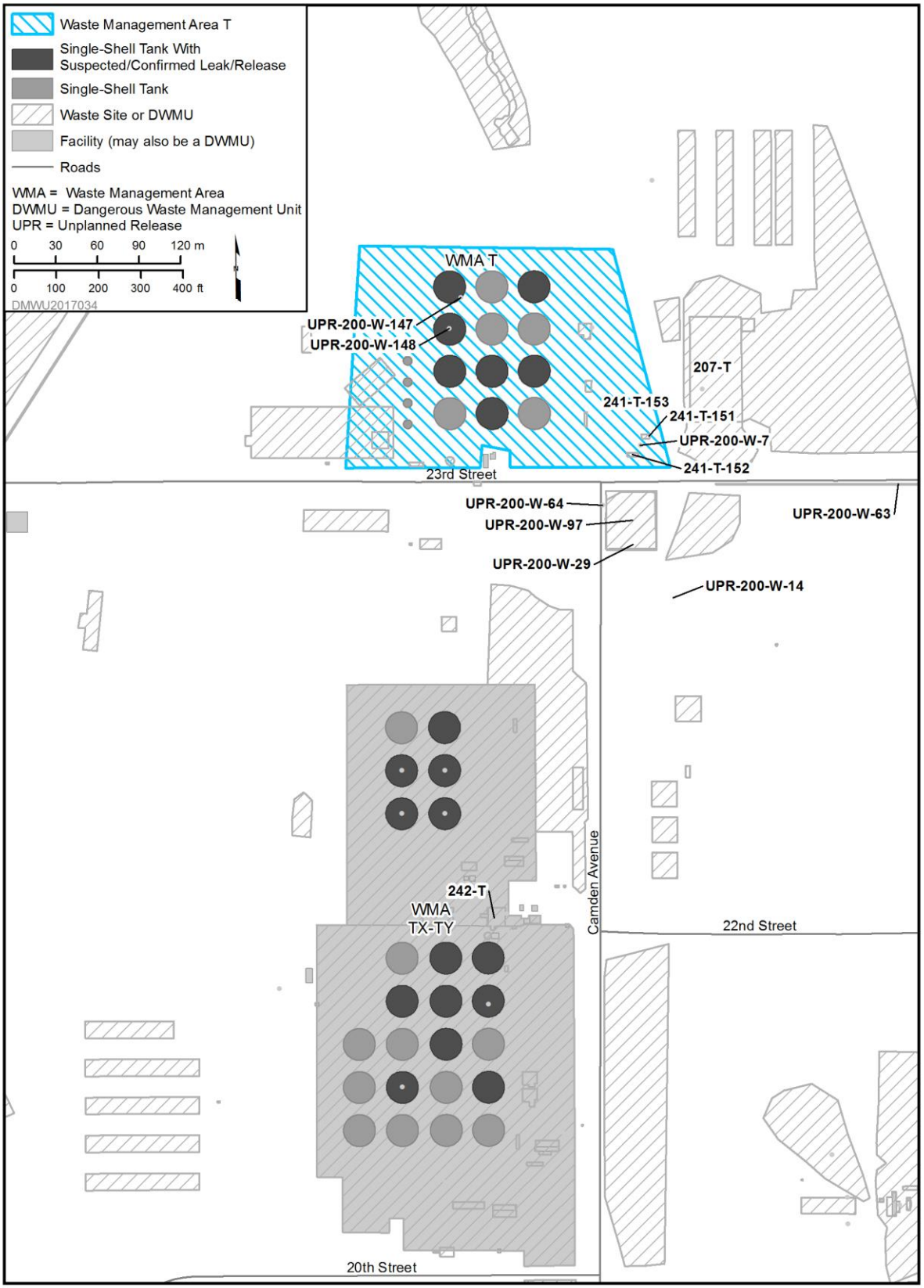


Figure 2-3. WMA T and Unplanned Releases

2.2 Regulatory Basis

In May 1987, DOE issued a final rule (10 CFR 962, "Byproduct Material") stating that the hazardous waste components of mixed waste are subject to RCRA regulations. Ecology gained regulatory authority over the hazardous waste components of mixed waste on August 19, 1987.

In May 1989, DOE, the U.S. Environmental Protection Agency (EPA), and Ecology signed Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes WMA T. Under interim status, groundwater monitoring at WMA T has been conducted in accordance with WAC 173-303-400(3), "Dangerous Waste Regulations," "Interim Status Facility Standards" (and, by reference, 40 CFR 265, Subpart F, "Ground-Water Monitoring"), which requires monitoring to determine whether dangerous waste constituents from the DWMU have entered the groundwater in the uppermost aquifer underlying the unit.

Dangerous waste is regulated under RCW 70.105, "Hazardous Waste Management," and its Washington State implementing regulations (WAC 173-303). Radionuclides in mixed waste may include "source, special nuclear, and byproduct materials" as defined in the *Atomic Energy Act of 1954* (AEA). The AEA states that these radionuclide materials are regulated at DOE facilities, exclusively by DOE, acting pursuant to its AEA authority. Radionuclide materials are not hazardous/dangerous wastes and, therefore, are not subject to regulation by the State of Washington under RCRA or RCW 70.105.

An interim status indicator parameter groundwater monitoring program (WHC-SD-EN-AP-012, Rev. 0, *Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks*) was initiated in 1989 at WMA T in accordance with 40 CFR 265, Subpart F (as referenced by WAC 173-303-400(3)). The indicator parameter monitoring program continued until 1993 when WMA T was placed into a groundwater quality assessment program in accordance with 40 CFR 265.93(d). The groundwater quality assessment was required because specific conductance results in downgradient well 299-W10-15 had exceeded the upgradient critical mean in November 1992 (Section 4.2 in WHC-SD-EN-AP-132, *Interim-Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Areas T and TX-TY*). Specific conductance results in 299-W10-15 subsequently dropped below the critical mean in 1994; however, specific conductance in downgradient well 299-W11-27 began to increase in 1995 and exceeded the critical mean in 1996 (Section 5.9.2.1 in PNNL-11793, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*).

In 1998, a phase I assessment report for WMA T and TX-TY was issued (PNNL-11809, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas T and TX-TY at the Hanford Site).* For WMA T, the report attributed elevated specific conductance and nitrate in well 299-W10-15 to past-practice waste disposal activities and not from a current source in WMA T (Section 4.1.1 in PNNL-11809). However, WMA T was identified as the most likely source for contamination, which included chromium and nitrate above the drinking water standard (DWS), in well 299-W11-27 (Section 5.0 in PNNL-11809).

Because the phase I assessment did not attribute the contaminants in well 299-W11-27 to another source, the assessment was to move into a phase II, in which the extent, concentration, and rate of contaminant migration would be determined (Section 5.1.3 in PNNL-11803, *Hanford Site Environmental Surveillance Master Sampling Schedule*). However, a phase II report was not issued for WMA T.

In 2001, a revised assessment plan (PNNL-12057, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T at the Hanford Site*) was issued that addressed monitoring for WMA T only

(WMA TX-TY continued in assessment under a separate plan). Based on the findings from the phase I assessment report for WMA T and TX-TY (PNNL-11809), a RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) was to be initiated at WMA T and WMA TX-TY. The primary focus of the RFI/CMS was characterizing the nature and extent of vadose zone contamination and assess the data to identify initial activities to minimize intrusion and contaminant migration to groundwater (Section 1.1 in PNNL-12072). Results from the revised assessment plan were to also be used for the RFI/CMS to be conducted at WMA T under Tri-Party Agreement Change Request M-45-98-03, *Agreement Commitments Regarding Initial Single-Shell Tank Waste Management Area (WMA) Corrective Actions, Vadose Zone and Groundwater Characterization, Assessment, and the Integration of Vadose Zone and Groundwater Activities at Specified Associated Sites*. Ecology, EPA, and DOE agreed that the groundwater quality assessment and RFI/CMS would be conducted for WMA T and WMA TX-TY under separate but coordinated plans (Section 1.1 in PNNL-12072).

The presence of chromium, a dangerous waste constituent, in groundwater required continued groundwater assessment. In 2001, separate updated assessment monitoring plans were issued for WMA T and WMA TX-TY and monitoring of these facilities has since been performed individually. As a result of the continued elevated levels of chromium, groundwater monitoring at WMA T continued under a groundwater quality assessment program through the interim status period. Revisions to the assessment plan were issued during this period, with the last interim status monitoring plan revision occurring in 2012 (DOE/RL-2009-66, Rev. 1).

In 2008, an interim corrective measure that consisted of surface barrier emplacement over a portion of WMA T, designed and constructed to reduce infiltration and the subsequent migration of contaminants through the vadose zone to groundwater, was completed (Section 3.4.3 in DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*). The barrier was placed over the location of tank 241-T-106, which had leaked approximately 435,000 L (115,000 gal) of waste in 1973. The barrier covered 6,575 m^2 (70,773 ft^2).

Under Revision 9 of the Hanford Facility Dangerous Waste Permit, the SST System treatment, storage and disposal (TSD) unit, which includes WMA T, will become a final status closure unit. Part II, Condition II.F of the Hanford Facility RCRA Permit specifies that final status groundwater monitoring program requirements will comply with WAC 173-303-645. This engineering evaluation report is prepared in accordance with WAC 173-303-806(4)(a)(xx)(E) and (G)(V) to implement the requirements of WAC 173-303-645.

This engineering evaluation report also provides supporting information for Part B application general requirements of WAC 173-303-806(4)(a)(xx)(C) (topographic map), WAC 173-303-806(4)(a)(xx)(A) (summary of interim status groundwater monitoring data), WAC 173-303-806(4)(a)(xx)(B) (hydrogeological information), and WAC 173-303-806(4)(a)(xx)(D) (plume maps).

2.3 Waste Characteristics

Three basic chemical processing operations were the source of most of the hazardous waste transferred to WMA T, including the bismuth phosphate process, tributyl phosphate process, and REDOX process (Section 2.3 in DOE/RL-2009-66, Rev. 1). The bismuth phosphate and REDOX processes were chemical separation programs for recovering plutonium from irradiated reactor fuels. The tributyl phosphate process recovered uranium metal in waste generated by the bismuth phosphate process. Waste from the three processes was made alkaline for storage in the tanks (Section 2.3 in DOE/RL-2009-66, Rev. 1).

The dangerous wastes identified on the SST System Part A Application are presented in Table 2-2. The nonradiological waste profile for tank 241-T-101 during its 1969 leak and the waste profiles for tanks 241-T-103 and 241-T-106 at the time of their 1973 leaks are presented in Table 2-1.

Table 2-2. Dangerous Wastes in the SST System Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
D001	Ignitable waste	D034	Hexachloroethane
D002	Corrosive waste	D035	Methyl ethyl ketone
D003	Reactive waste	D036	Nitrobenzene
D004	Arsenic	D038	Pyridine
D005	Barium	D039	Tetrachloroethylene
D006	Cadmium	D040	Trichloroethylene
D007	Chromium	D041	2,4,5-Trichlorophenol
D008	Lead	D043	Vinyl chloride
D009	Mercury	F001	Spent halogenated solvents
D010	Selenium	F002	Spent halogenated solvents
D011	Silver	F003	Spent nonhalogenated solvents
D018	Benzene	F004	Spent nonhalogenated solvents
D019	Carbon tetrachloride	F005	Spent nonhalogenated solvents
D022	Chloroform	WP01	Extremely hazardous waste/persistent dangerous waste
D028	1,2-Dichloroethane	WP02	Dangerous waste/persistent dangerous waste
D029	1,1-Dichloroethylene	WT01	Extremely hazardous waste/toxic dangerous waste
D030	2,4-Dinitrotoluene	WT02	Dangerous waste/toxic dangerous waste
D033	Hexachlorobutadiene	--	--

Source: WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*.

* Dangerous waste code contaminant descriptions are from WAC 173-303-090, "Dangerous Waste Regulations," "Dangerous Waste Characteristics;" WAC 173-303-104, "State-Specific Dangerous Waste Numbers;" and WAC 173-303-9904, "Dangerous Waste Sources List."

2.4 Interim Status Monitoring Network and Sampling History

Table 2-3 identifies the interim status groundwater monitoring plans implemented at WMA T. Figure 2-4 provides the locations of wells discussed in this section. Appendix A contains the interim status data collected at WMA T network wells and meets the requirement of WAC 173-303-806(4)(a)(xx)(A). The status of the monitoring wells through the plans indicated in Table 2-3 is provided in Appendix A.

Table 2-3. Interim Status Monitoring Plans

Document	Date Issued	Monitoring Program[a]
WHC-SD-EN-AP-012, Rev. 0, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks*	1989	Indicator Evaluation Program
ECN-150201[b]	1991	
WHC-SD-EN-AP-012, Rev. 1, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks*	1991	Indicator Evaluation Program
ECN-150144, *Engineering Change Notice to the WHC-SD-EN-AP-012*	1992	
ECN-172204, *Engineering Change Notice to the WHC-SD-EN-AP-012*	1993	
ECN-618171, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 1, Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*	1994	
WHC-SD-EN-AP-132, *Interim-Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Areas T and TX-TY*	1993	Groundwater Quality Assessment Program
PNNL-12057, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T at the Hanford Site*	2001	Groundwater Quality Assessment Program
ICN-PNNL-12057.1, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T at the Hanford Site, Interim Change Notice*	2002	Groundwater Quality Assessment Program
PNNL-15301, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T*	2006	Groundwater Quality Assessment Program
DOE/RL-2009-66, Rev. 0, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*	2011	Groundwater Quality Assessment Program
DOE/RL-2009-66, Rev. 1, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*	2012	Groundwater Quality Assessment Program

a. The Indicator Evaluation Program satisfies the requirements of 40 CFR 265.92(b)(2), (b)(3), (d)(1), (d)(2), and (e), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis." The groundwater quality assessment program's first determination satisfies the requirements of 40 CFR 265.93(d)(4) and (d)(6), "Preparation, Evaluation, and Response."

b. ECN-150201, *Engineering Change Notice to WHC SD EN AP 012 Rev 0, Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*, is associated with WHC-SD-EN-AP-012, Rev. 0 and identifies changes that were incorporated in the Rev. 1 plan. Although it references the Rev. 0 plan, ECN-150201 is also incorporated as part of the Rev. 1 plan.

ECN = engineering change notice

ICN = interim change notice

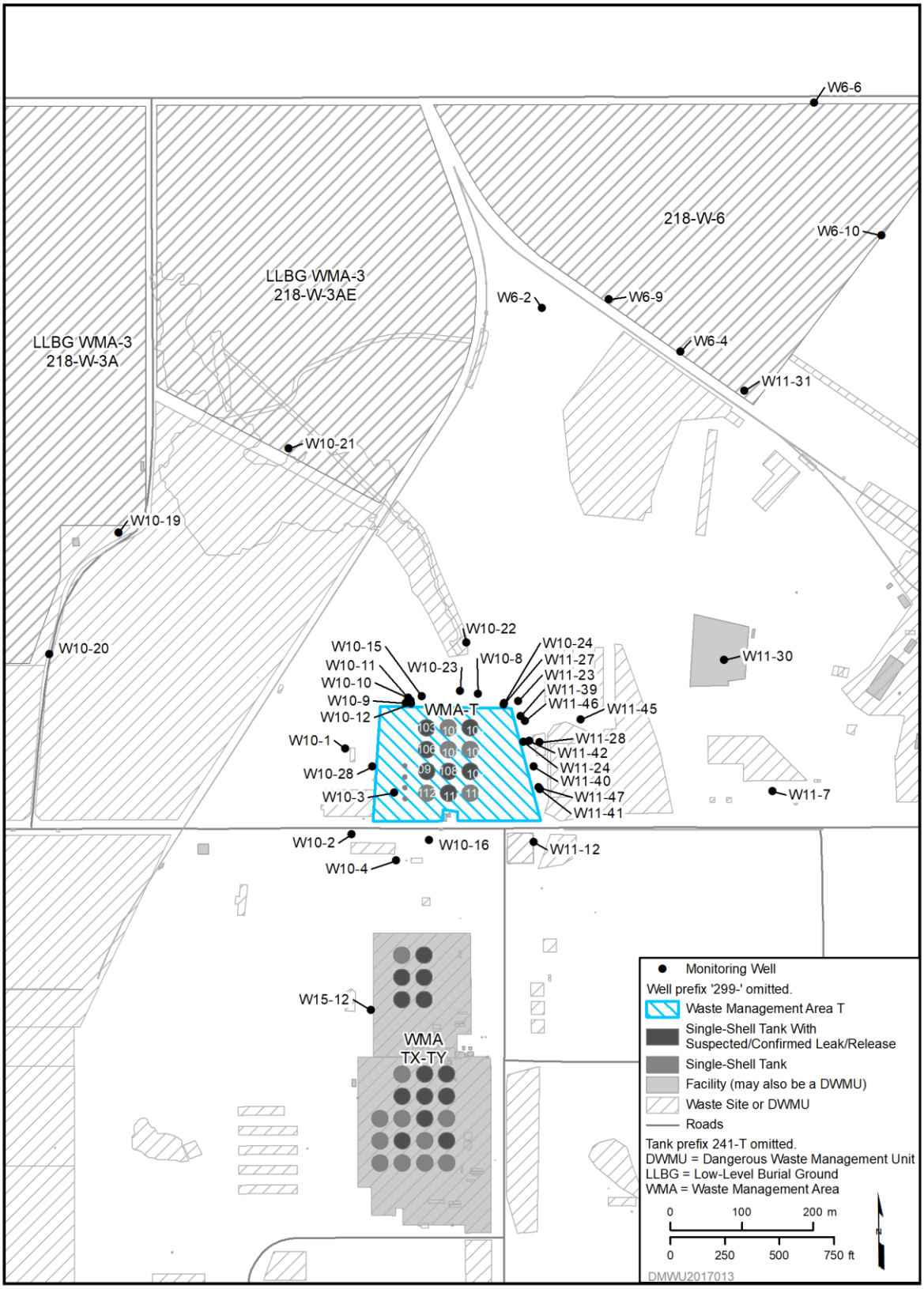


Figure 2-4. Wells Used During Interim Status Monitoring of WMA T

In 1989, DOE-RL initiated an interim status groundwater monitoring program at WMA T as described in WHC-SD-EN-AP-012, Rev. 0, based on the interim status indicator evaluation program requirements of 40 CFR 265, Subpart F, and WAC 173-303-400. The 1989 plan addressed interim status monitoring for each of the SST WMAs. For WMA T, the plan identified one planned upgradient well (299-W10-16) and nine existing downgradient wells (299-W10-3, 299-W10-8, 299-W10-9, 299-W10-10, 299-W10-11, 299-W10-12, 299-W10-15, 299-W11-23, and 299-W11-24) (Table 3.7 in WHC-SD-EN-AP-012, Rev. 0). While existing wells were identified for the network, the construction dates varied with the oldest well, constructed in 1947 (well 299-W10-1). Therefore, the existing wells were to be evaluated for their ultimate use in the network (e.g., sample collection or water-level measurements only) (p. 110 in WHC-SD-EN-AP-012, Rev. 0). Well 299-W10-1, crossgradient of WMA T, was included for water-level information only (Table 3.7 and Chapter 3.0, p. 123 in WHC-SD-EN-AP-012, Rev. 0). Monitoring constituents included the contamination indicator parameters, groundwater quality parameters, and drinking water parameters required by 40 CFR 265.92(b). In addition, each well was to be sampled one time during the first year of monitoring for an expansive list of metals, anions, pesticides, herbicides, volatile organic compounds (VOCs), semivolatile organic compounds, polychlorinated biphenyls, cyanide, phenol, total dissolved solids (TDS), hydrazine, ammonium ion, dioxins, tritium, uranium, and gamma scan (p. 110, Table 3.1, and Appendix C in WHC-SD-EN-AP-012, Rev. 0). The monitoring wells for WMA T are shown in Figure 2-4.

In 1990, additional existing upgradient wells (299-W10-2, 299-W10-4, and 299-W11-12) were included as part of the WMA T network (Table 15-1 in DOE/RL-91-03, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1990*). In 1991, WHC-SD-EN-AP-012, Rev. 0 was revised (Rev. 1 and Engineering Change Notice [ECN]-150201, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 0, Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*) to modify the well network and constituent list and report information obtained from recently installed wells. The compliance sampling network comprised one upgradient well (299-W10-16) and one downgradient well (299-W10-15) (Table 3-6 in WHC-SD-EN-AP-012, Rev. 1). Upgradient well (299-W10-4) and downgradient wells (299-W10-3, 299-W10-8, 299-W10-9, 299-W10-10, 299-W11-23, and 299-W11-24) were included for water-level measurements and either radionuclide sampling or limited nonradionuclide constituents (Table 3-7 in WHC-SD-EN-AP-012, Rev. 1). Crossgradient well 299-W10-1 was included for water-level measurement only and wells 299-W10-11 and 299-W10-12 were identified for abandonment (Table 3-7 in WHC-SD-EN-AP-012, Rev. 1). Two new wells (299-W11-27 and 299-W11-28) were planned for WMA T (Table 3-2 in WHC-SD-EN-AP-012, Rev. 1). Well 299-W10-2 was not included in the network due to a sidetracked bailer and a cracked casing (Section 3.3.4.9.1 in WHC-SD-EN-AP-012, Rev. 1). The constituent list was revised to add site-specific parameters (cesium-137, strontium-90, total uranium, total plutonium, gamma scan, and tritium) (Section 3.4.1.12 and Table 3-11 in WHC-SD-EN-AP-012, Rev. 1).

In 1990, quarterly sampling to obtain background data began at WMA T (Section 15.2.2 in DOE/RL-91-03) but groundwater sampling was temporarily discontinued in June 1990 due to cancelation of the laboratory contract. The sampling program resumed in June 1991 (Introduction in DOE/RL-92-03, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*) and quarterly sampling continued until July 1992 when WMA T completed background monitoring (Section 4.3 in WHC-SD-EN-AP-132).

For 1991, Table 16-1 in DOE/RL-92-03 included downgradient wells 299-W10-9, 299-W10-15, 299-W11-27, and 299-W11-28 and upgradient well 299-W10-16. Several older carbon steel wells (299-W10-4, 299-W10-3, 299-W10-8, 299-W10-11, 299-W10-12, 299-W11-23, 299-W11-24, and 299-W10-10) were identified for water-level measurements only (Table 16-1 in DOE/RL-92-03).

Three ECNs to WHC-SD-EN-AP-012, Rev. 1, were issued in 1992, 1993, and 1994. In 1992, the groundwater monitoring plan was revised to add downgradient wells 299-W11-27 and 299-W11-28 to the WMA T monitoring network (Section 12 in ECN-150144, *Engineering Change Notice to the WHC-SD-EN-AP-012*). The 1993 ECN-172204, *Engineering Change Notice to the WHC-SD-EN-AP-012*, and 1994 ECN-618171, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 1, Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*, did not affect WMA T.

In November 1992, downgradient well 299-W10-15 exceeded the critical mean for specific conductance (Section 4.4.3 in WHC-SD-EN-AP-132). A similar exceedance was measured at two downgradient WMA TX-TY wells (Section 4.13.1.2 in DOE/RL-93-88, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*).

In July 1993, WMA T entered a groundwater quality assessment in accordance with 40 CFR 265.93(d), and a groundwater quality assessment plan (WHC-SD-EN-AP-132) was issued. The assessment monitoring plan included both WMA T and WMA TX-TY because wells at both WMAs exceeded the specific conductance critical mean in 1992. Furthermore, the two WMAs are located close together and were situated above an aerially widespread plume of high-conductivity groundwater in the northern part of the 200 West Area (Section 4.13.1.2 in DOE/RL-93-88).

The groundwater quality assessment plan included sampling for the contamination indicator parameters, groundwater quality parameters, drinking water parameters required by 40 CFR 265.92(b), anions (nitrate, sulfate, phosphate, chloride, and fluoride), metals (aluminum, sodium, calcium, copper, magnesium, manganese, and nickel), and radionuclides to identify specific source facilities (iodine-129, cobalt-60, cesium-137, strontium-90, americium-241, europium-152, europium-154, gross plutonium, and uranium) (Sections 5.2 and 5.4 in WHC-SD-EN-AP-132). The well network remained the same as that in WHC-SD-EN-AP-012, Rev. 1 (as modified by ECNs). However, the network was to expand beyond WMA T and TX-TY and include other suitably located existing compliance wells, such as the wells at Low-Level Burial Grounds (LLBGs) (Section 5.2 in WHC-SD-EN-AP-132). Older carbon steel wells were also to be evaluated for use in the compliance network (Section 5.2 in WHC-SD-EN-AP-132).

In 1993, the network consisted of one upgradient well (299-W10-16) and three downgradient wells (299-W-10-15, 299-W11-27, and 299-W11-28) with wells 299-W10-4, 299-W10-3, 299-W10-8, 299-W10-9, 299-W10-11, 299-W10-12, 299-W11-23, 299-W11-24, and 299-W10-10 identified for water-level measurements only (Table 4.13-1 in DOE/RL-93-88). In 1993, downgradient well 299-W11-28 was remediated to address ongoing issues with high turbidity levels (Section 4.11.1.2 in DOE/RL-94-136, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1994*). Issues with elevated turbidity continued in 1994, and the well was considered for abandonment and replacement (Section 4.11.3.2 in DOE/RL-94-136).

In 1994, wells from LLBG WMA-3 and LLBG WMA-5 (now the 218-W-6 Burial Ground) (Figure 2-4) that were in the vicinity of WMA T were evaluated for incorporation into an expanded monitoring network (Section 4.11.1.2 in DOE/RL-94-136). The expanded network included downgradient wells 299-W10-15, 299-W11-27, and 299-W11-28; upgradient well 299-W10-16; and wells 299-W10-8, 299-W10-9, 299-W10-11, 299-W10-12, 299-W11-23, and 299-W11-24 included for water-level measurements only (Table 4.11-1 in DOE/RL-96-01, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1995*). Beginning in 1996, results from the expanded network were reported for WMA T (Table 6.1-12 in PNNL-11470, *Groundwater Monitoring for Fiscal Year 1996*).

Specific conductance in well 299-W10-15 subsequently dropped below the critical mean in 1994; however, specific conductance in downgradient well 299-W11-27 began to increase in 1995 and exceeded the critical mean in August 1996 (Section 5.9.2.1 in PNNL-11793). The increase in specific conductance

was accompanied by increases in technetium-99 and other co-contaminants (Section 5.9.3.1 in PNNL-11793). Assessment findings indicated that contaminants in well 299-W10-15 were a result of sources external to WMA T (Section 5.9.2.1 in PNNL-11793). However, contaminants in well 299-W11-27 were attributed to sources within WMA T. Therefore, a phase II assessment was deemed necessary. Based on the declining water levels, it was anticipated that each of the network wells would be dry by the end of 1998 (Section 5.9.2.1 in PNNL-11793). Two new wells were planned for WMA T.

In 1998, a phase 1 assessment report for WMA T and TX-TY was issued (PNNL-11809). The report found that elevated specific conductance in well 299-W10-15 had declined slowly since 1993; however sodium and nitrate remained high, with nitrate levels above the DWS (Section 3.2.3.1 in PNNL-11809). Levels of sodium, nitrate, fluoride, and chromium in well 299-W10-15 were greater than those in upgradient well 299-W10-16. Elevated specific conductance, nitrate, and tritium at well 299-W10-15 were attributed to past-practice waste disposal activities and not from a current source in WMA T (Section 4.1.1 in PNNL-11809).

PNNL-11809 reported that concentrations of several constituents (technetium-99, tritium, nitrate, chromium, calcium, magnesium, sulfate, and total organic carbon [TOC]) began to increase rapidly at well 299-W11-27 in 1995, with calcium, magnesium, sulfate, and nitrate as the principal contributors to the elevated specific conductance (Section 3.2.3.1 in PNNL-11809). Chromium, gross beta, nitrate, technetium-99, and tritium exceeded DWSs in this well. No upgradient sources for the contaminants was identified and a source within WMA T was indicated (Section 4.1.2 in PNNL-11809).

By 1998, wells in the WMA T network were observed to be going dry at a faster rate than anticipated due to the cessation of effluent discharges to the local groundwater in 1995 (Section 5.9.2.1 in PNNL-12086, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*). Well 299-W6-6 was no longer included in the network and well 299-W10-12 was used as a substitute for dry well 299-W10-15. Wells 299-W10-8, 299-W11-23, and 299-W11-24 were also sampled as WMA T downgradient wells (Section 4.2.3.4 and Table A-19a in PNNL-12086). The well network reported for 1998 included upgradient well 299-W10-16 and downgradient wells (including wells in the expanded network) 299-W6-2, 299-W6-4, 299-W6-6, 299-W10-8, 299-W10-12, 299-W10-16, 299-W10-19, 299-W10-20, 299-W10-21, 299-W11-23, 299-W11-24, 299-W11-27, 299-W11-28, and 299-W11-31 (Table A-19a in PNNL-12086). Wells 299-W10-9 and 299-W10-11 were included for water level only. Also in 1998, well 299-W10-23 was drilled north of WMA T and well 299-W10-24 was drilled adjacent to well 299-W11-27 (Section 5.9.2.1 in PNNL-12086). One additional well was planned east of WMA T.

The monitoring well network underwent additional changes in 1999 as the groundwater flow direction underneath WMA T continued to change. Initially, flow direction was primarily to the north due to the groundwater mound beneath U Pond, shifting to the north-northeast after decommissioning of U Pond in 1985, and then to the east in 1998 (Section 3.6.3.2 in PNNL-12086). Existing wells 299-W10-1, 299-W10-2, and 299-W10-4 were included in the network (Table A.11 in PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*). Upgradient coverage was identified as inadequate due to changing groundwater flow direction (Section A.7.2 in PNNL-13116), as the previously upgradient well 299-10-16 had gone dry and no wells were identified as upgradient (Table A.11 in PNNL-13116). The 1999 network consisted of downgradient wells (including wells in the expanded network) 299-W6-2, 299-W6-4, 299-W6-9, 299-W6-10, 299-W10-1, 299-W10-2, 299-W10-4, 299-W10-8, 299-W10-12, 299-W10-19, 299-W10-20, 299-W10-21, 299-W10-22, 299-W10-23, 299-W10-24, 299-W11-7, 299-W11-12, 299-W11-23, 299-W11-24, 299-W11-27, 299-W11-28, 299-W11-30, 299-W11-31, and 299-W15-12 (Table A.11 in PNNL-13116).

In 2000, wells 299-W10-2, 299-W11-27, and 299-W15-12 were not reported within the network while well 299-W10-3 was included again (Table A.10 in PNNL-13404, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*). In 2001, a revised assessment plan (PNNL-12057) was issued that addressed monitoring for WMA T only (WMA TX-TY continued in assessment under a separate plan). The WMA T and WMA TX-TY plans were divided as a result of Tri-Party Agreement Change Request M-45-98-03, in which it was determined that ongoing RCRA groundwater quality assessment at the WMAs would be conducted under separate but coordinated plans (Section 1.1 in PNNL-12057). The plan updated the well network to align with changes since the previous plan and included 11 wells, none of which were upgradient (299-W10-1, 299-W10-4, 299-W10-8, 299-W10-12, 299-W10-23, 299-W10-24, 299-W11-7, 299-W11-12, 299-W11-23, 299-W11-24, and 299-W11-28), and proposed 4 new wells for 2000 and 5 new wells for 2001 (pending funding availability), 1 of which would be upgradient (Section 3.1 and Tables 3.1a and 3.1b in PNNL-12057). The constituents included temperature, specific conductance, pH, inductively coupled plasma metals, anions, alkalinity, TDS, gross alpha, gross beta, technetium-99, and tritium, with TOC and radionuclides at selected wells (Tables 3.1a, 3.1b, and 3.2 in PNNL-12057).

The four new wells installed in 2000 included downgradient wells 299-W11-39, 299-W11-40, 299-W11-41, and 299-W11-42. Only one of the five proposed wells for 2001 was drilled: upgradient well 299-W10-28. In 2001, well 299-W10-22 was included in the WMA T network and well 299-W10-1 was utilized as an upgradient well (Table A.38 in PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*).

In 2002, ICN-PNNL-12057.1, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T at the Hanford Site, Interim Change Notice*, was issued to capture monitoring network changes due to changes in flow direction and declining water level and revise the monitoring constituents. Well 299-W10-12 had been decommissioned in August 2000 and was removed from the network (Summary in ICN-PNNL-12057.1). The network comprised 14 wells with 12 downgradient wells (299-W10-4, 299-W10-8, 299-W10-22, 299-W10-23, 299-W10-24, 299-W11-7, 299-W11-12, 299-W11-30, 299-W11-39, 299-W11-40, 299-W11-41, and 299-W11-42) and two upgradient wells (299-W10-1 and 299-W10-28) (Table R1.3.1a in ICN-PNNL-12057-1). The monitoring constituents were revised to remove TDS (which was determined not to be as good of an indicator parameter as turbidity, specific conductance, and alkalinity) and TOC (due to the potential for the carbon tetrachloride plume from the Plutonium Finishing Plant (PFP) underlying WMA T to mask any organic releases from WMA T) (Table R1.3.1a and Table R.1.3.2 in ICN-PNNL-12057.1). The update changed the monitoring frequency for radionuclide sampling from quarterly to either semiannual or annual (Table R1.3.1a and Table R.1.3.2 in ICN-PNNL-12057.1). In 2002, the designation of well 299-W10-4 was changed from downgradient to upgradient (Table A.36 in PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*).

In 2006, PNNL-15301, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T*, was issued to address changes to the monitoring network and to determine the vertical and horizontal waste profiles in the vadose zone, rate of contaminant migration, likely sources for groundwater contamination at WMA T, and the groundwater flow rate and direction (Section 1.2 in PNNL-15301). The plan presented data that predicted when the declining water table would cause the wells within the existing WMA T network to go dry, with dates ranging from 2011 for 299-W10-22 to 2033 for 299-W10-1 (Table 2.8 in PNNL-15301). Based on historical groundwater sampling, the continued elevated levels of carbon tetrachloride, trichloroethene, and tritium originated primarily from outside of WMA T (Section 2.6.1 in PNNL-15301). Elevated fluoride, nitrate, chromium, and tritium were at least partially attributed to WMA T (Section 2.6.1 in PNNL-15301).

PNNL-15301 identified chromium and nitrate as the constituents of concern for WMA T and technetium-99, tritium, iodine-129, and fluoride as constituents of interest (Sections 3.4.4.1 and 3.4.4.2 in PNNL-15301). Other constituents included gamma scan, gross beta, gross alpha, metals, anions, alkalinity, pH, specific conductance, turbidity, temperature, dissolved oxygen, oxidation-reduction potential, and iodine-129 at either a quarterly or semiannual basis (radionuclides were sampled semiannually or annually and wells 299-W10-22 [crossgradient to WMA T] and 299-W11-7 [far-field] were sampled semiannually) (Section 3.4.3 and Table A.1 in PNNL-15301). The revised well network included two upgradient wells (299-W10-1 and 299-W10-28); eight existing downgradient wells (299-W10-8, 299-W10-24, 299-W11-12, 299-W11-39, 299-W11-40, 299-W11-41, 299-W11-42, and 299-W11-46); three "assessment" wells (crossgradient to WMA T) (299-W10-4, 299-W10-22, and 299-W10-23); one existing far-field well (299-W11-7); and proposed one new downgradient and one new far-field well. The two new wells (downgradient well 299-W11-46 and far-field well 299-W11-45) were drilled in 2005. By the time PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*, was published, well 299-W10-4 had been redesignated as an upgradient well (Table B.35 in PNNL-15670). In 2006, a third new downgradient well (299-W11-47) was drilled and included in the WMA T network (Table B.35 in PNNL-16346, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*).

The 2005 RPP-23752, *Field Investigation Report for Waste Management Areas T and TX-TY*, presented the most current understanding of the nature and extent of historical releases from SSTs in WMA T and TX-TY by conducting two-dimensional simulations and evaluating impacts of interim corrective action alternatives. Modeling simulations evaluated the migration of technetium-99, uranium-238, nitrate, and chromate considering a no-action alternative, interim surface barriers, waterline leaks, nonuniform spatial distribution inventories in the vadose zone, and differing estimates of meteoric recharge (Chapter 4 in RPP-23752). The simulations determined that historical releases from SSTs in WMA T and WMA TX-TY would cause DWS exceedances at the east boundaries of the WMAs if no further action was taken (Chapter 4 in RPP-23752). The interim measures that had been implemented in the WMAs (capping boreholes, cutting off active water lines, and building surface run-on barriers and diversions) were expected to mitigate future contamination risks (Chapter 6 in RPP-23752). The report concluded that interim surface barriers would provide significant reduction in peak concentration of mobile constituents and that near-surface soil and ancillary equipment removal should also be considered (Chapter 7 in RPP-23752). An interim surface barrier demonstration project over the SST 241-T-106 leak (in WMA T) was recommended.

In 2007, well 299-W10-4 was no longer designated as an upgradient well due to a change in groundwater direction flow to due east (Table B.1 and Table B.35 in DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*). In September 2007, two of the WMA T downgradient monitoring wells (299-W11-45 and 299-W11-46) were converted to pump and treat (P&T) extraction wells as part of the 200-ZP-1 P&T system to remediate the technetium-99 plume, located east (downgradient) of WMA T (Sections 2.8.2.5 and 2.8.3.3 in DOE/RL-2008-66). Conversion of monitoring wells to extraction wells included installation of high-capacity pumps and plumbing of extraction water from the well head to the treatment system. The extraction operation altered the groundwater flow regime and caused a drawdown around WMA T (Section 2.8.3.3 in DOE/RL-2008-66). The converted wells remained in the WMA T network (Table B-35 in DOE/RL-2008-66).

In 2008, an interim corrective measure that consisted of surface barrier emplacement over a portion of WMA T designed and constructed to reduce infiltration and the subsequent migration of contaminants through the vadose zone to groundwater was completed (Section 3.4.3 in DOE/RL-2008-66). The barrier

was placed over the location of tank 241-T-106, which had leaked approximately 435,000 L (115,000 gal) of waste in 1973. The barrier covered 6,575 m^2 (70,773 ft^2).

In 2011, a revised assessment monitoring plan was issued that updated the well network and monitoring constituents (DOE/RL-2009-66, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*, Rev. 0). The plan identified the dangerous constituents found in groundwater at WMA T as chromium, carbon tetrachloride, and trichloroethylene (TCE). The origin of carbon tetrachloride and TCE was attributed to PFP; however, chromium was attributed to WMA T (Section 2.5.1 in DOE/RL-2009-66, Rev. 0). Nitrate and fluoride were also present, with a local, high-concentration nitrate plume beneath WMA T (Section 2.5.1.2 in DOE/RL-2009-66, Rev. 0). More than one source, including WMA T, likely contributed to this plume (Section 7.4.3.2 in DOE/RL-2010-11). The well network in the revised plan included two upgradient (299-W10-1 and 299-W10-28); nine downgradient (299-W10-8, 299-W10-24, 299-W11-12, 299-W11-39, 299-W11-40, 299-W11-41, 299-W11-42, 299-W11-46, and 299-W11-47); two "assessment" (crossgradient to WMA T) (299-W10-4 and 299-W10-23); and one far-field (299-W11-45) (Table 3-2 in DOE/RL-2009-66, Rev. 0). Wells 299-W11-7 and 299-W10-22 were removed from the network because they were no longer downgradient (Section 3.3 in DOE/RL-2009-66, Rev. 0).

The monitoring constituents included dangerous constituents (hexavalent chromium), supporting parameters (nitrate, metals [aluminum chromium, sodium, magnesium, potassium, and calcium], anions [nitrate, chloride, sulfate, and fluoride], and alkalinity), and field-measured parameters (pH, specific conductance, turbidity, temperature, and dissolved oxygen) (Table 3-2 in DOE/RL-2009-66, Rev. 0). Additionally, the primary nonradiological constituents potentially present in SST waste (RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*) that are also identified in Appendix 5 of Ecology Publication Number 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, were included for the first sample event (Table 3-1 in DOE/RL-2009-66, Rev. 0). Any detected constituents that were not attributable to another source or measured above upgradient or background concentrations were to be included for routine sampling.

The sampling frequencies for network wells were revised in Section 3.3 in DOE/RL-2009-66, Rev. 0, with upgradient (west) wells and wells north of WMA T changed to an annual sampling frequency. Downgradient wells either remained on a quarterly frequency or were changed to semiannual or annual, depending on the constituents monitored. Hexavalent chromium was added for quarterly sampling at downgradient wells and annual sampling at upgradient wells. This eliminated filtered metals analyses, so only unfiltered metals would be sampled (Sections 3.1 and 3.3 in DOE/RL-2009-66, Rev. 0).

In 2012, well 299-W11-12 went dry and extraction well 299-W11-46 was taken offline (Table B-39 in Section 3.2.10.1 of DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*). The assessment plan was revised in 2012 to remove these wells from the network (Section 3.3 in DOE/RL-2009-66, Rev. 1). Also in 2012, well 299-W11-45 was taken offline as an extraction well to be converted to a monitoring well (200-ZP RCRA – WMA-T Section in DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*). In 2013, assessment well 299-W10-4 and downgradient well 299-W10-8 became dry due to declining water levels from P&T operations (Section 200-ZP RCRA - WMA T in DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). The remainder of the monitoring network (upgradient wells 299-W10-1 and 299-W10-28; downgradient wells 299-W10-24, 299-W11-39, 299-W11-40, 299-W11-41, 299-W11-42, and 299-W11-47; assessment [crossgradient] well 299-W10-23; and far-field well 299-W11-45 [Table B-74 in DOE/RL-2016-09, *Hanford Site Groundwater Monitoring Report for 2015*]) continued to have concentrations of hexavalent chromium (maximum result of 72.7 µg/L) and nitrate (maximum result of 240 mg/L) above comparison values

(48 µg/L for hexavalent chromium and 45 mg/L for nitrate) (Table B-76 in DOE/RL-2016-09). Due to the 200 West P&T System, groundwater velocity and flow direction changed from east/southeast to southeast in 2015 (Section 2.11.1 in DOE/RL-2016-09).

In 2016, the groundwater elevation increased from 0.1 to 1.9 m (0.3 to 6.3 ft) beneath WMA T due to changes in 200 West P&T extraction and injection (Section 3.5 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*). While in 2016 groundwater flow changed again to the east-southeast, the direction of groundwater flow is not expected to change with continued operation of the 200 West P&T (Section 3.5 in DOE/RL-2016-66). Elevated levels of hexavalent chromium, nitrate, fluoride, carbon tetrachloride, and TCE were observed in 2016 (DOE-RL-2016-66, Section 3.5). While the fluoride, carbon tetrachloride, and TCE contamination are attributed to PFP, WMA T is known to be a source of hexavalent chromium and nitrate due to past leaks from SSTs and waste pipelines (Section 3.5 in DOE/RL-2016-66). Upgradient sources are considered to be larger contributors to nitrate contamination than WMA T.

3 Geology and Hydrogeology

This chapter describes the local geology and hydrology beneath WMA T. The geology of the 200 West Area is discussed in PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200 West Area and Vicinity Hanford Site Washington.* The geology specific to WMA T was first described in ARH-LD-135, *Geology of the 241-T Tank Farm*, and later in WHC-SD-EN-AP-012. Summaries of the geology at WMA T are also provided in HNF-2603, *A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination*; RPP-7123, *Subsurface Conditions Description of the T-TX-TY Waste Management Areas;* and RPP-7578, *Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMAs T and TX-TY,* Rev. 2.

More recently, RPP-23748, *Geology, Hydrogeology, Geochemistry, and Mineralogy Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*; PNNL-15955, *Geology Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*; PNNL-15301; and PNNL-15837, *Data Package for Past and Current Groundwater Flow and Contamination Beneath Single-Shell Tank Waste Management Areas,* provided updated information on the geology and hydrology at WMA T, including hydrogeologic observations made during the installation of new wells in the area.

3.1 Stratigraphy

The generalized stratigraphic column for the Hanford Site is shown in Figure 3-1. The geology beneath WMA T includes a basalt basement overlain by an approximately 150 m (490 ft) thick sedimentary sequence. Geologic cross sections prepared in the vicinity of WMA T are shown in Figures 3-2 through 3-4. The geologic sequence below WMA T from top to bottom includes the following:

- Holocene eolian sediments and/or backfill material – These deposits are limited to wind-blown silt and sand. Eolian sheet sands occur sporadically at the surface and generally are less than 1 to 2 m (3 to 7 ft) thick. Eolian sediments do not occur in the tank farm where they were removed during construction. Backfill material occurs to about 15 m (49 ft) depth in the tank farm (Figure 3-3). The backfill is poorly sorted, gravelly sand to sandy gravel (Section – Backfill Material, p. 10 in ARH-LD-135) from the gravel-dominated sequence of the Hanford formation.

- Hanford formation – Cataclysmic flood deposits equivalent to hydrostratigraphic unit 1. The Hanford formation consists of three facies subunits (silt-dominated, sand-dominated, and gravel-dominated) that grade into one another both vertically and laterally (Figure 3-1). On the Central Plateau (where the 200 West Area is located), the Hanford formation is sometimes further delineated into Hanford 1 (H1), Hanford 2 (H2), and Hanford 3 (H3) lithostratigraphic sequences. The H1 and H3 gravel-dominated sequences are not differentiated in areas where the intervening sandy H2 sequence is absent. Units H1 and H3 consist of coarse-grained, basalt-rich, sandy gravels with varying amounts of silt/clay. These gravel units may also contain interbedded sand and or silt/clay lenses. The H2 sequence is dominated by sand to gravelly sand, with minor sandy gravel or silt/clay interbeds. Both the gravel-dominated H1 and sand-dominated H2 sequences are present underlying the 241-T Tank Farm.

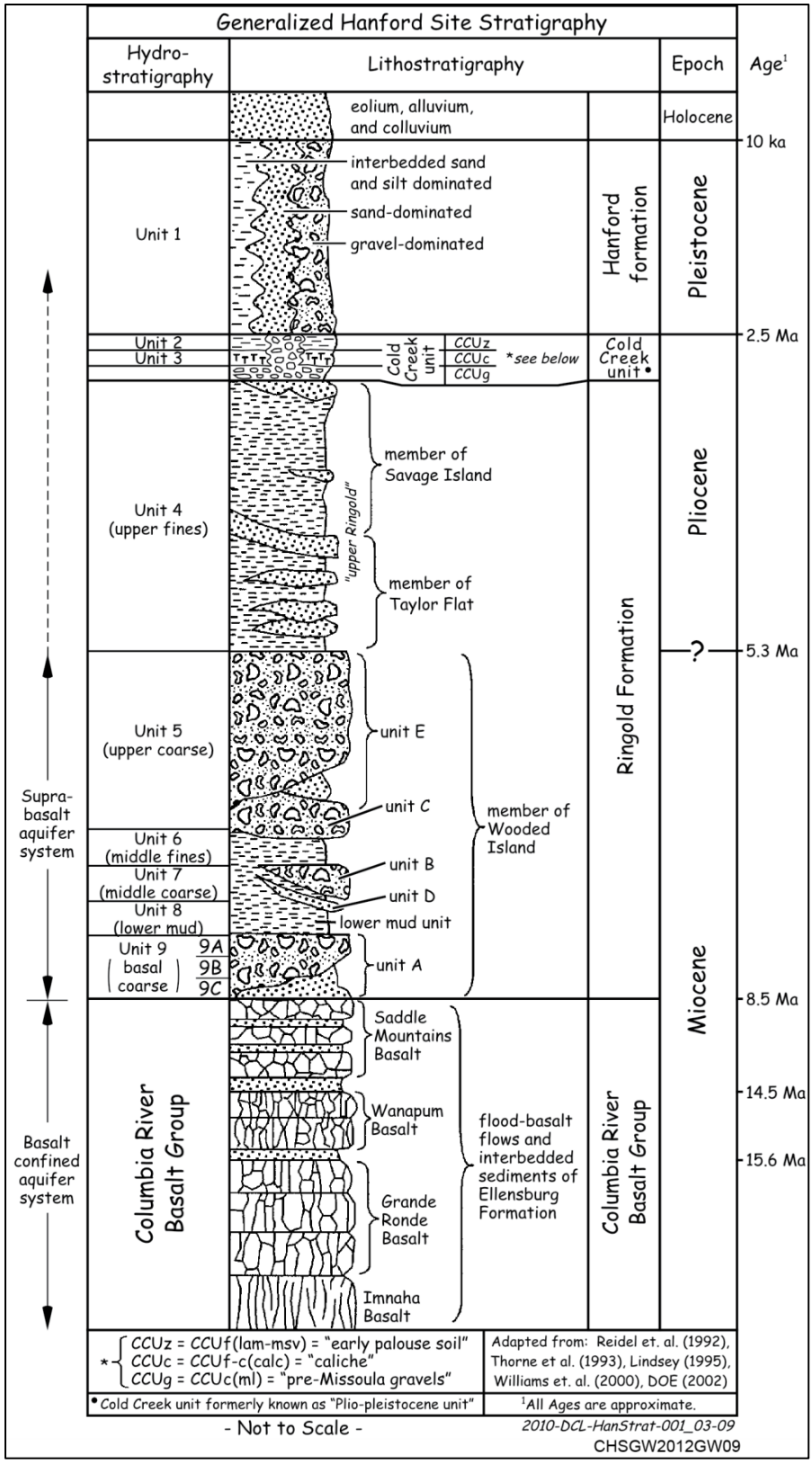


Figure 3 1. General Stratigraphy at the Hanford Site

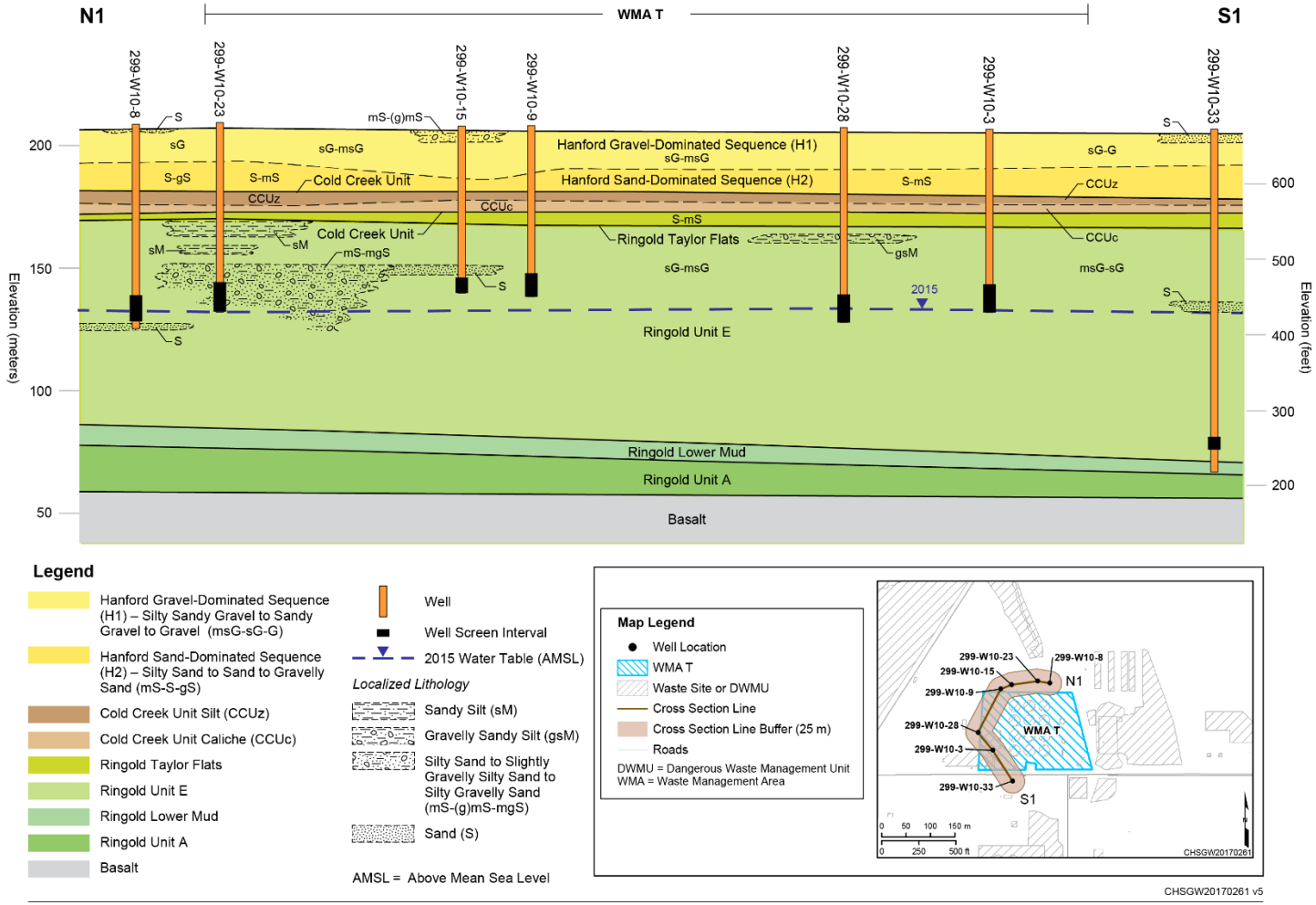


Figure 3-2. North to South Cross Section for the West Side of WMA T

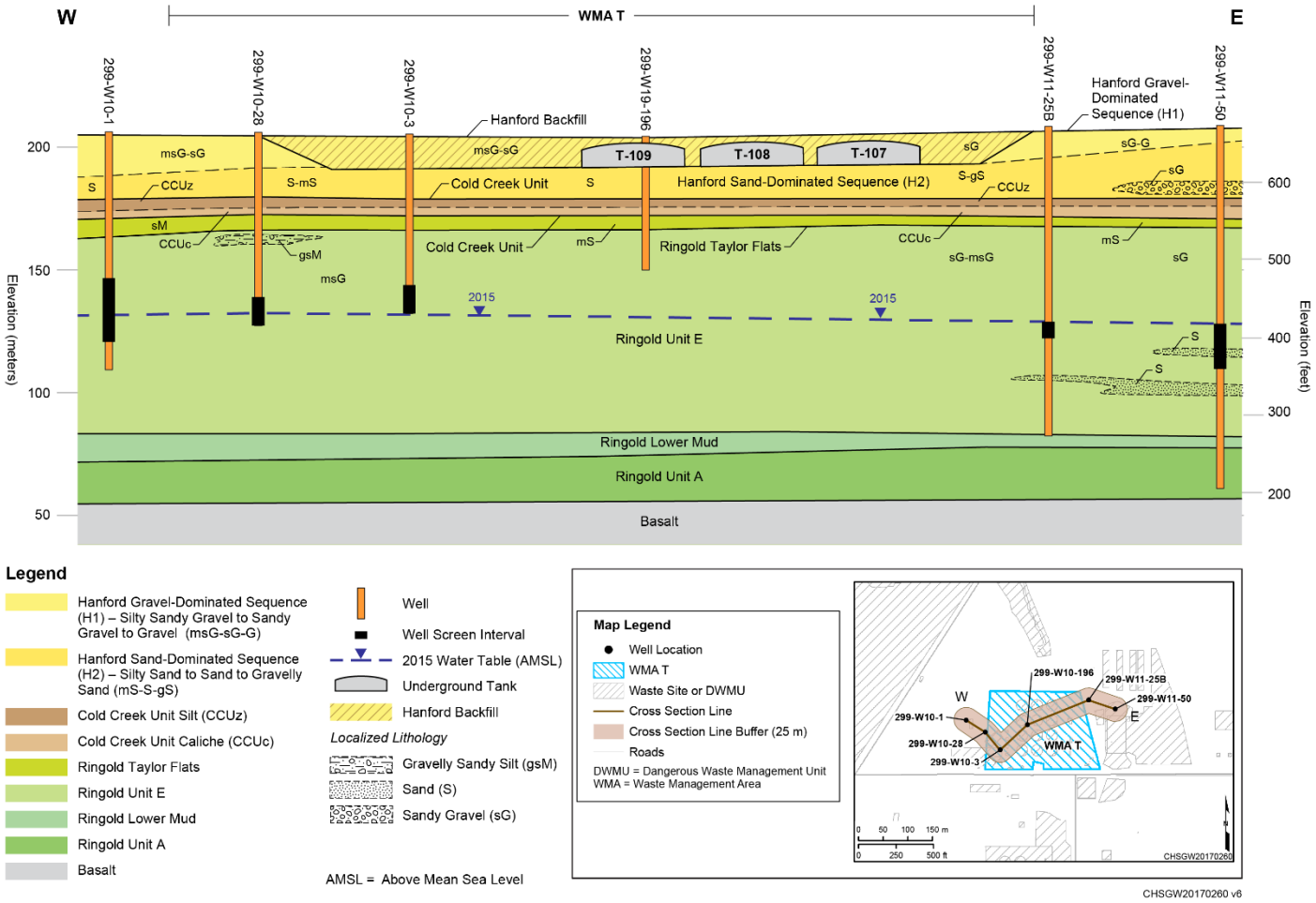


Figure 3-3. East to West Cross Section through WMA T

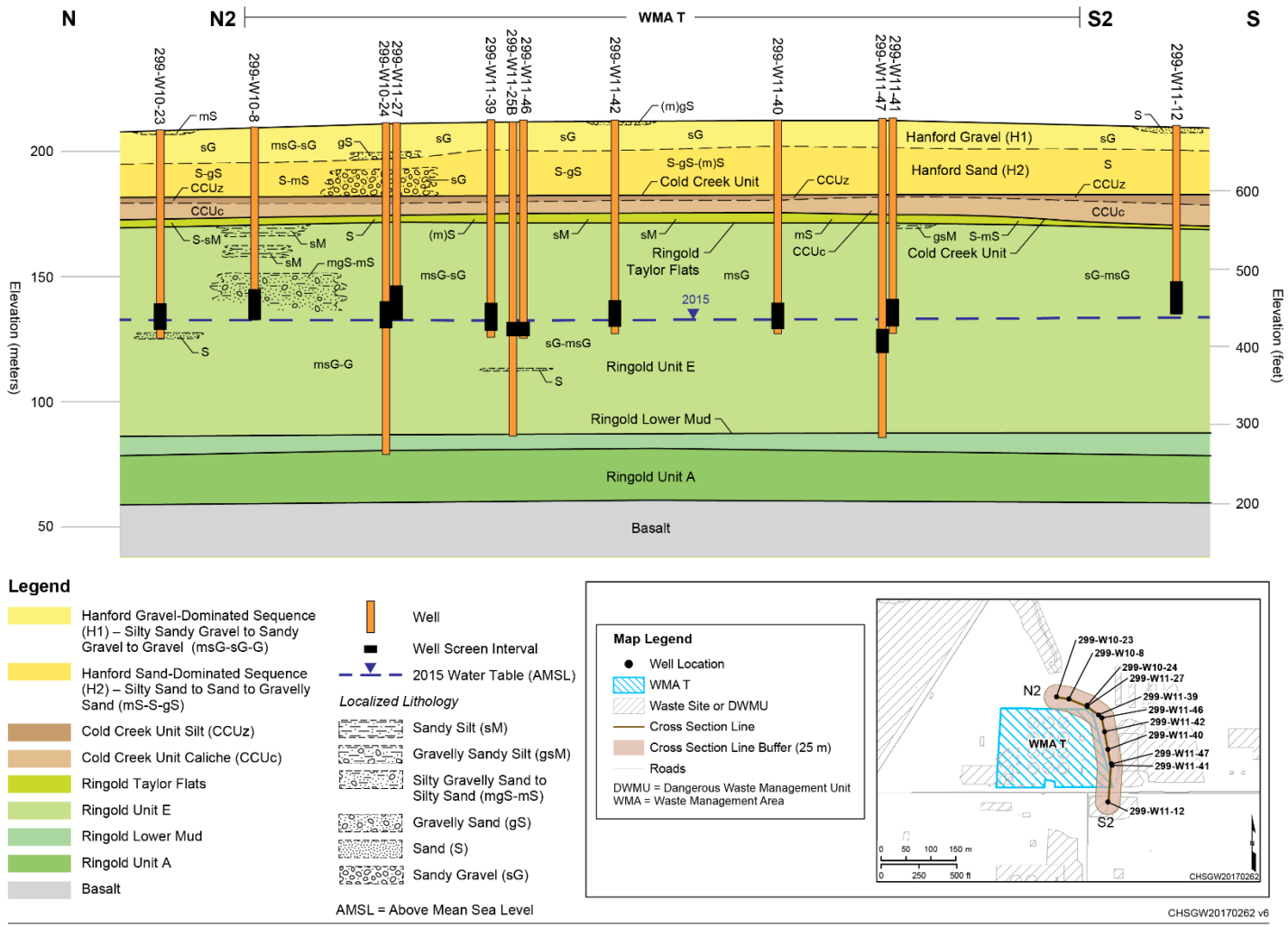


Figure 3-4. North to South Cross Section East Side of WMA T

- Hanford formation gravel-dominated sequence (H1) – The Hanford formation gravel-dominated sequence varies from approximately 9 to 18 m (30 to 59 ft) thick in the WMA T area and averages about 13 m (43 ft) thick. Much, or the entire unit, was removed from most, if not all, of the tank farm during construction and replaced as backfill after construction was complete. The Hanford formation gravel-dominated sequence overlies the sand-dominated sequence.
- Hanford formation sand-dominated sequence (H2) – The Hanford formation sand sequence ranges from about 4 to 20 m (13 to 66 ft) and averages about 14 m (46 ft) in thickness beneath the WMA. The sequence is not cemented but does contain zones with calcium carbonate as small concretions and as coatings on grains. Thin silt lenses cap some individual beds within the Hanford formation sand-dominated sequence. These lenses are generally 15 cm (6 in.) or less in thickness but range up to about 30 cm (12 in.) thick. Generally, the silt lenses cannot be correlated among boreholes. The Hanford formation sand-dominated sequence tends to be thicker beneath the eastern part of the WMA (Figures 3-3 and 3-4). A Hanford formation sand-dominated sequence overlies the Cold Creek fluvial sediments beneath WMA T.

- Cold Creek unit silts and sands (CCUz) and Cold Creek unit calcic paleosols (CCUc) – The Cold Creek unit calcic paleosol sequence (formerly known as the Plio-Pleistocene caliche) overlies the member of Taylor Flats.
  - Cold Creek unit fluvial and/or eolian sediments (CCUz) overlie the calcic paleosol sequence at WMA T. The CCUz sediments are slightly to well consolidated, moderately to well sorted silt and sandy silt. They may contain calcium carbonate but lack the extensive cementation found in the underlying calcic paleosols. The Cold Creek fluvial and/or eolian sequence is between about 1 and 6 m (3 to 20 ft) in thickness and averages about 3 m (10 ft) thick at WMA T.
  - The CCUc consists of calcium carbonate-cemented silt, silty sand, and sandy silt with some gravel in places. The calcium carbonate is generally fairly continuous throughout the unit, but there are caliche-rich and caliche-poor zones. In places, the sediment becomes extremely cemented with calcium carbonate. The Cold Creek unit calcic paleosol sequence occurs in all wells at WMA T. The sequence ranges in thickness from about 1 to 15 m (3 to 49 ft) with an average thickness of about 6 m (20 ft) in the vicinity the WMA.

- Ringold Formation, member of Taylor Flats – Bedded sandy silt, sand, and silty sand. These sediments are unconsolidated to consolidated and poorly to well sorted. Local pebbly areas occur. In places, calcium carbonate occurs as stingers and nodules; in other places no calcium carbonate exists. The member of Taylor Flats ranges in thickness from about 2 to 8 m (6 to 26 ft) at WMA T but is generally thicker than 3 m (10 ft) and averages about 5 m (16 ft).

- Ringold Formation, member of Wooded Island Unit E – Pebble to cobble gravel with a fine- to coarse-grained sand matrix. Gravel content is usually greater than 60% to 70%. Occasionally, what are interpreted as large boulders are encountered during drilling. The sediments are variably consolidated, usually poorly sorted and show variable amounts of calcium carbonate. Iron oxide staining is common. Unit E ranges in thickness at WMA T from approximately 82 to 85 m (269 to 279 ft). The water table occurs within Ringold Unit E (Figures 3-2, 3-3, and 3-4).

- Ringold Formation, member of Wooded Island lower mud – The lower mud unit is equivalent to hydrogeologic unit 8 (Section 3.1.2.2 in PNNL-13858). The unit is composed of a sequence of fluvial overbank, paleosol, and lacustrine silts and clay with minor sand and gravel. Hydrogeologic unit 8 is described as separating the suprabasalt aquifer into an upper unconfined aquifer in the sediments above the lower mud unit and a lower, confined aquifer in the Ringold Formation Unit A. Groundwater in the unconfined aquifer and the confined Ringold Formation Unit A aquifer does not flow vertically through hydrogeologic unit 8 (Section 3.1.2.2 in PNNL-13858). Where the Ringold lower mud (RLM) unit is not present on the Central Plateau, the suprabasalt aquifer is a single system. Available data from the WMA T area indicates that the lower mud unit extends laterally beneath the entire WMA. Regional mapping shows the unit thins and pinches out north and northeast of the 200 West Area (Figure 3-5).
- Ringold Formation, member of Wooded Island Unit A – Pebble to cobble gravel with up to 15% sand and very little silt. Some interstratified sand horizons exist within the gravel and there are some highly cemented zones. Regional mapping of the top of Unit A shows a dip to the southwest (Figure 3-6).
- The Elephant Mountain Member of the Saddle Mountains Basalt – This unit is the base of the suprabasalt aquifers in the area. The Elephant Mountain Member is not penetrated by any boreholes completed in the WMA T area. Regional mapping of the Saddle Mountain Basalt surface indicates a dip to the southwest into the Cold Creek syncline (Figure 3-7).

ARH-LD-135 (Section – Clastic Dikes, p. 10 in ARH-LD-135) states that clastic dikes were detected in the 241-T Tank Farm during construction, although they could not be mapped. Clastic dikes have not been recognized during drilling of wells at WMA T, although they have been identified in recent wells drilled at WMA TX-TY and WMA S-SX.

3.2 Hydrogeology

Groundwater beneath WMA T occurs as an unconfined aquifer and deeper confined aquifers. The water table occurs in the Ringold Formation Member of Wooded Island Unit E. Depth to water ranges from 74.7 m (245.2 ft) to 78.5 m (257.6 ft). The RLM serves as a confining or semiconfining layer separating the unconfined aquifer from a confined, or partly confined, aquifer in the underlying Ringold Formation Unit A (Figures 3-2, 3-3, and 3-4). The unconfined aquifer increases in thickness towards the southwest and is estimated to range in thickness from approximately 44 to 56 m (144 to 183 ft) based on water levels and the depth of the RLM unit. The uppermost confined aquifer occurs in Ringold Unit A and is confined above by the lower mud unit and below by basalt (Figures 3-2, 3-3, and 3-4). Deeper confined aquifers occur between the basalt flows.

Additional descriptions of the hydrogeology of WMA T are provided in RPP-7123 (Section 2.4) and RPP-23748 (Section 8.2.1). Section 3.1 in PNNL-13858 describes the hydrogeology of the entire 200 West Area and vicinity.

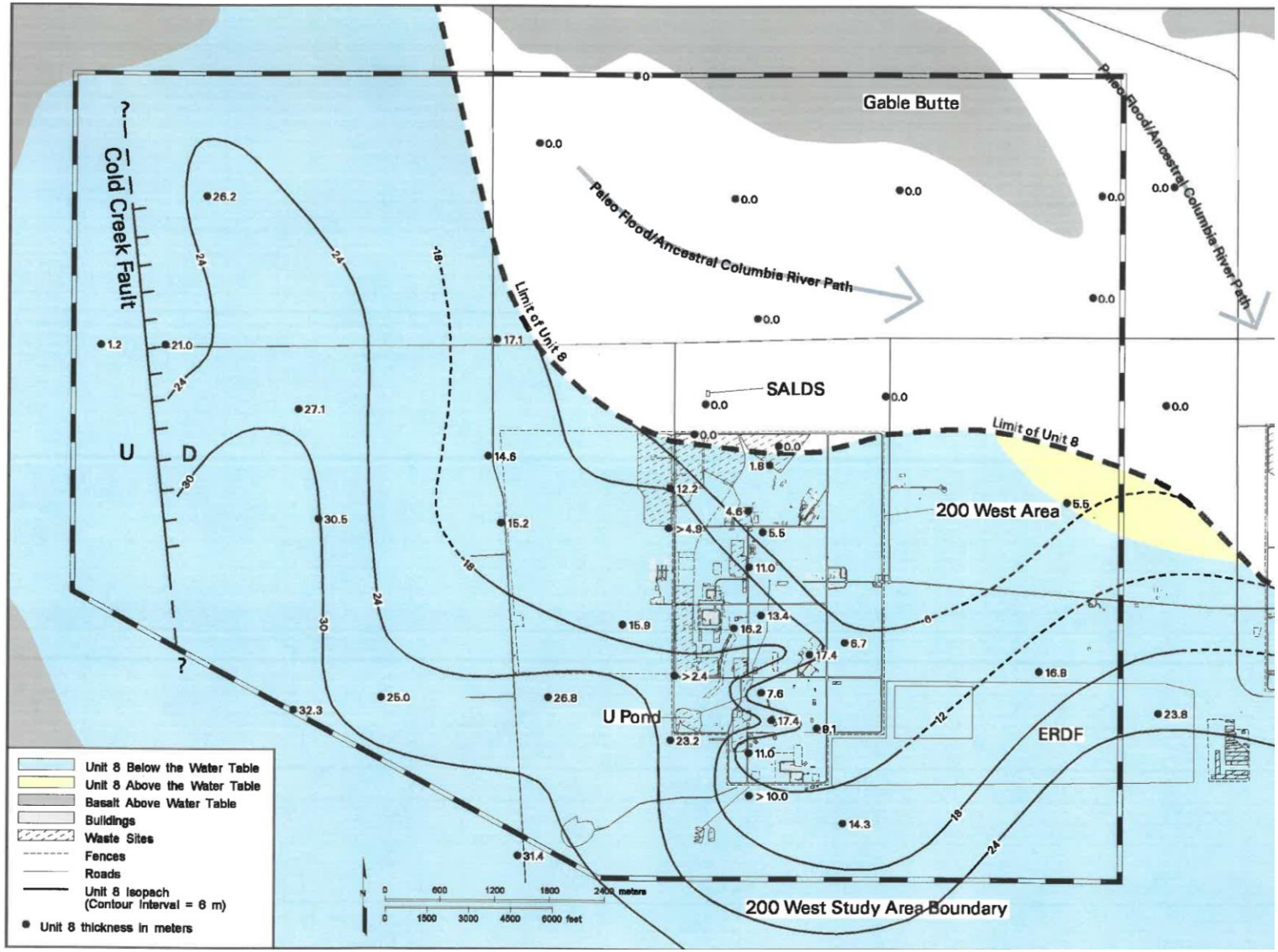


Figure 3-5. Isopach Map Showing Extent of the Ringold Lower Mud (Unit 8) in the Vicinity of the 200 West Area and Underlying WMA T (from PNNL-13858)

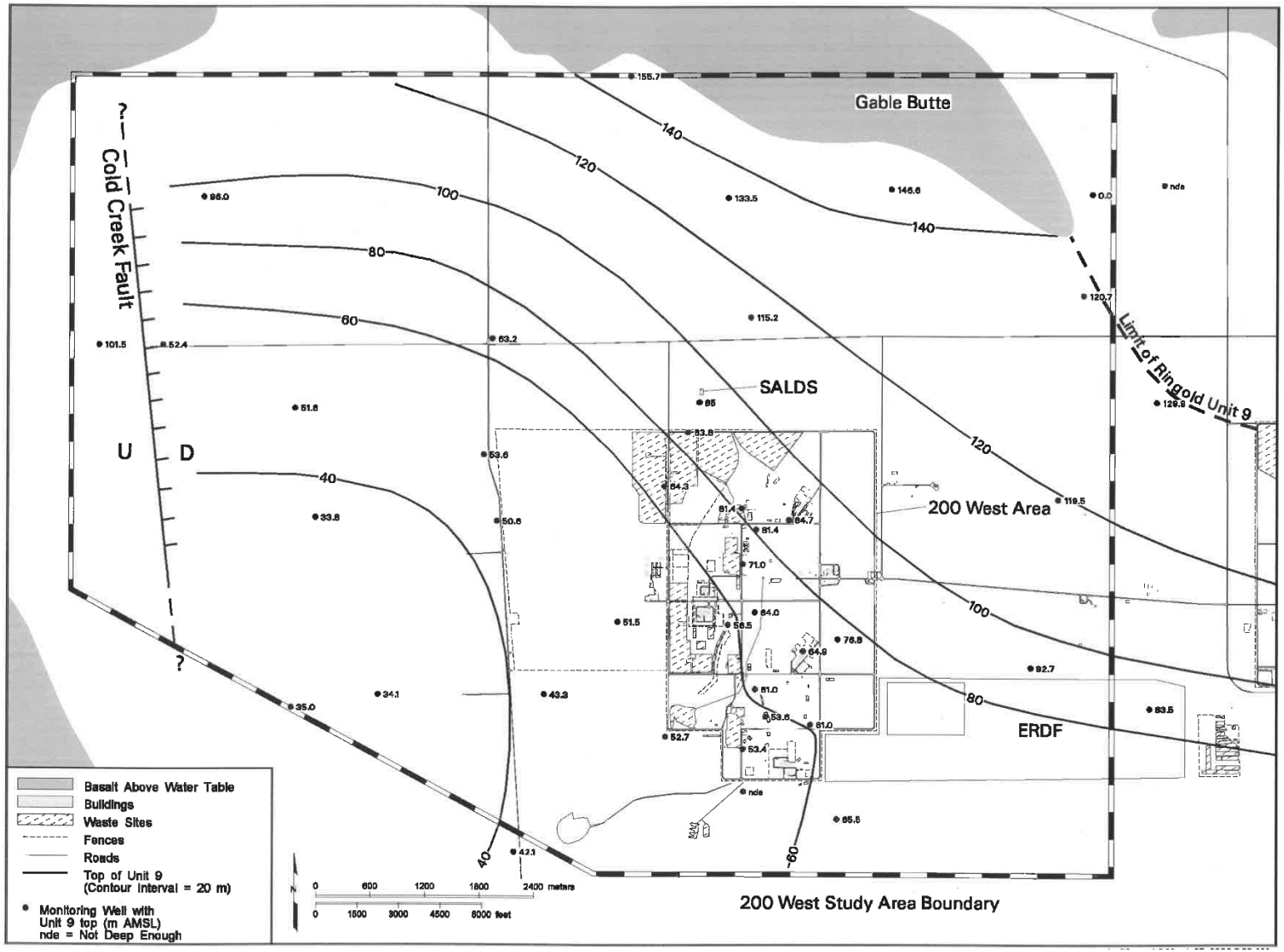


Figure 3-6. Structure Contour Map Showing Dip Direction for the Top of the Ringold Unit A in the Vicinity of the 200 West Area and Underlying WMA T (from PNNL-13858)

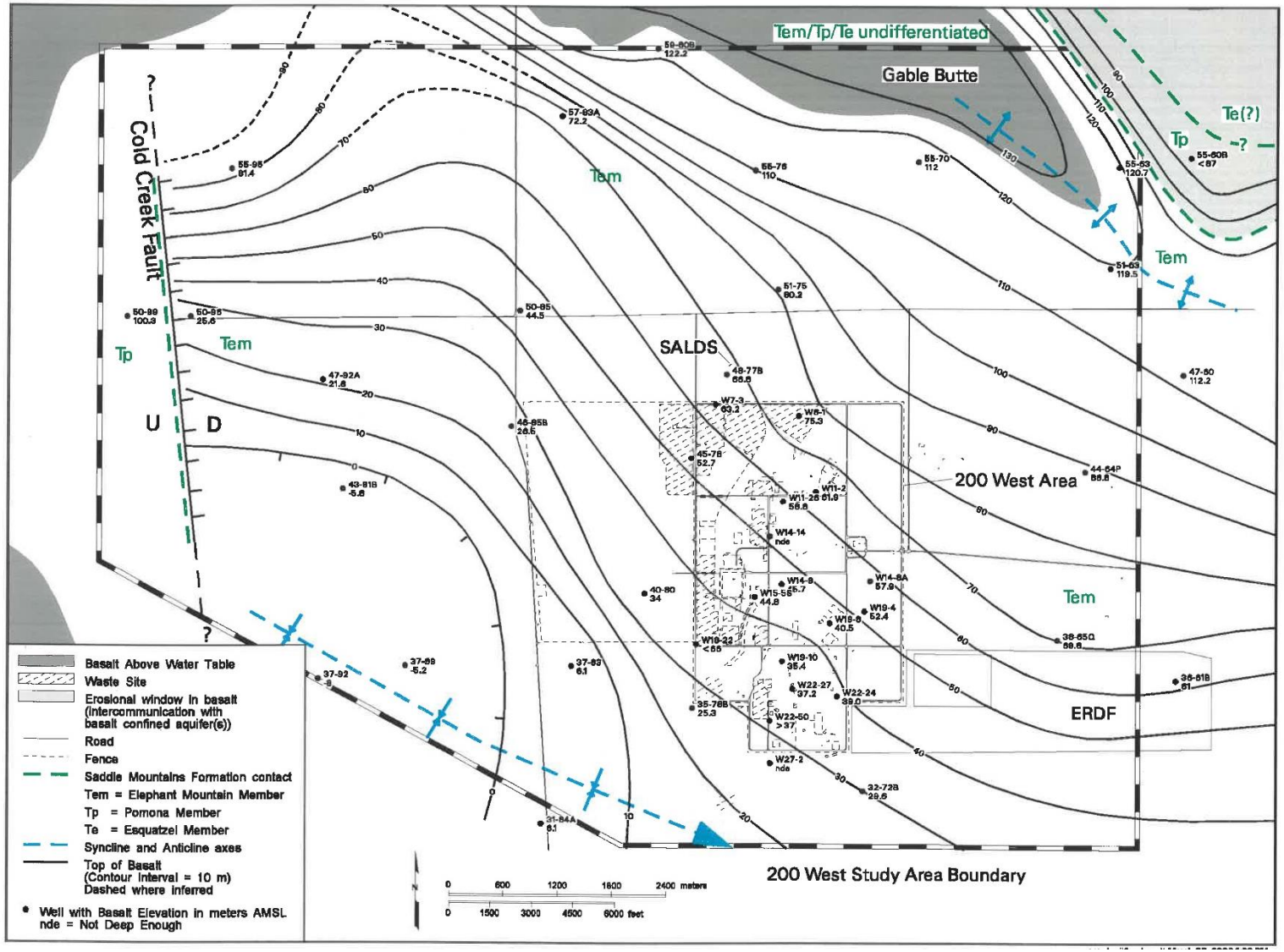


Figure 3-7. Structure Contour Map Showing Dip Direction of the Saddle Mountain Basalt Surface in the Vicinity of the 200 West Area and Underlying WMA T (from PNNL-13858)

Since 1999, several aquifer tests have been performed at the new wells at WMA T. Details of the tests, data analyses, and test results are provided in the following documents:

- PNNL-13378, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 1999*
- PNNL-14113, *Results of Detailed Hydrologic Characterization Tests—FY 2001*
- PNNL-14186, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2002*
- PNNL-17348, *Results of Detailed Hydrologic Characterization Tests – Fiscal and Calendar Year 2005*
- PNNL-17732, *Analysis of the Hydrologic Response Associated with Shutdown and Restart of the 200-ZP-1 WMA T Tank Farm Pump-and-Treat System*

The salient results of the aquifer tests include the following:

- The vertical in-well flow rates range from 0.001 to 0.017 m/m (downward), determined during testing in two wells in the WMA well network.
- Vertical heterogeneities in hydraulic conductivity were recognized among wells and within individual well screens.

The saturated hydraulic conductivity underlying WMA T is 5 m/d (16.4 ft/d) (Table 4-9 in CP-47631). Table 5-1 in PNNL-17732, Analysis of the Hydrologic Response Associated with the Shutdown and Restart of the 200-ZP-1 WMA T Tank Farm Pump and Treat System gives saturated hydraulic conductivities ranging from between approximately 6.11 to 9.69 m/d (20.1 to 31.8 ft/d) based on field measurements. Soil properties of the Cold Creek unit (CCU) indicate that this horizon will likely slow the rate of downward movement and promote lateral spreading in the vadose zone. The RLM and basalt are considered aquitards relative to other sediments beneath WMA T because of the units' very low hydraulic conductivities (Section 5.0 in PNNL-13858).

A major stratigraphic change occurs at the top of the CCU. This unit, located between 22 m (72.2 ft) and 30 m (98.4 ft) below ground surface, would slow the downward movement of water and divert it to the southwest, the direction the top of the unit is dipping beneath the WMA. Historically, perched water was present on the Cold Creek unit within the vicinity of 216-T Pond (216-T-4 Pond) located northwest of WMA T and was projected to pinch out between the 241-T second-cycle tile field (216-T-7 Crib and Tile Field) located immediately west of WMA T and WMA TX-TY (Section 200-West Area on p. 62 in HW-17088, The Underground Disposal of Liquid Wastes at the Hanford Works, Washington). Currently, perched water is not present in the vicinity of WMA T as discharges to the 216-T Pond (216-T-4 Pond) have ceased. Water from a waste release may reach the water table at a time, location, and concentration depending on its volume, depth of release, and diversion from downward movement at a stratigraphic change; however, PNNL-11809 (Section 5.0) concluded that contamination in immediate downgradient well 299-W11-27 was sourced from WMA T. Over time, wastewater released to the sediment column near ground surface will evaporate or be driven downward to the water table by new inputs of water to the sediment column from above. It is this downward movement of water in the vadose zone that carries waste contaminants to the water table. Water movement in the unsaturated zone is relatively slow compared to groundwater flow below the water table, delaying the observed impact of a near-surface waste release on groundwater quality.

3.3 Groundwater Flow System

Groundwater flow conditions in the 200 West Area, and more specifically in the region surrounding WMA T, have varied greatly over the past several decades due to changing wastewater disposal practices and, more recently, P&T operations. The following sections discuss changes in the hydrologic condition the occurred proceeding and subsequent to operation of the 200 West P&T System in 2012.

3.3.1 Hydrologic Conditions Prior to 200 West P&T Operations

Water levels in the unconfined aquifer increased as much as 13.5 m (44.3 ft) above the pre-Hanford natural water table beneath WMA T due to artificial recharge from liquid waste disposal operations between the mid-1940s and 1995 (Figure 3-8). Between 1950 and 1997, the groundwater flow direction beneath the WMA varied between east (pre-Hanford direction), southeast, north, and northeast depending primarily on effluent disposal volumes to the former 216-T-4 Pond to the north of WMA T and the former 216-U-10 Pond to the southwest (Sections 3 and 4 in PNNL-16069, *Development of Historical Water Table Maps of the 200 West Area of the Hanford Site (1950-1970)*; Figures 7 and 8 in PNL-7498, *Evaluation of Hanford Site Water-Table Changes 1980 to 1990*; and Figure 2.9 in PNNL-15301,). A northeast to east-northeast to east flow direction has occurred in the vicinity of WMA T since the late 1990s until initiation and impact of 200 West P&T operations (Figure 2-9 in PNNL-15301; Figures 10 through 13 in SGW-60338, *Historical Changes in Water Table Elevation and Groundwater Flow Direction at Hanford: 1944 to 2014*).

Groundwater levels were evaluated in two dimensions by interpolating water-level data obtained during June 2012, prior to operation of the 200 West P&T remedy (Figure 3-9). At that time, groundwater flow direction was to the east. The hydraulic gradient prior to P&T operations was estimated to be 0.002 m/m, with an average linear velocity of 0.12 to 0.20 m/d (0.39 to 0.66 ft/d) (Table 3-1 in SGW-55438, *Hanford Site Groundwater Monitoring for 2012: Supporting Information*) (Figure 3-10).

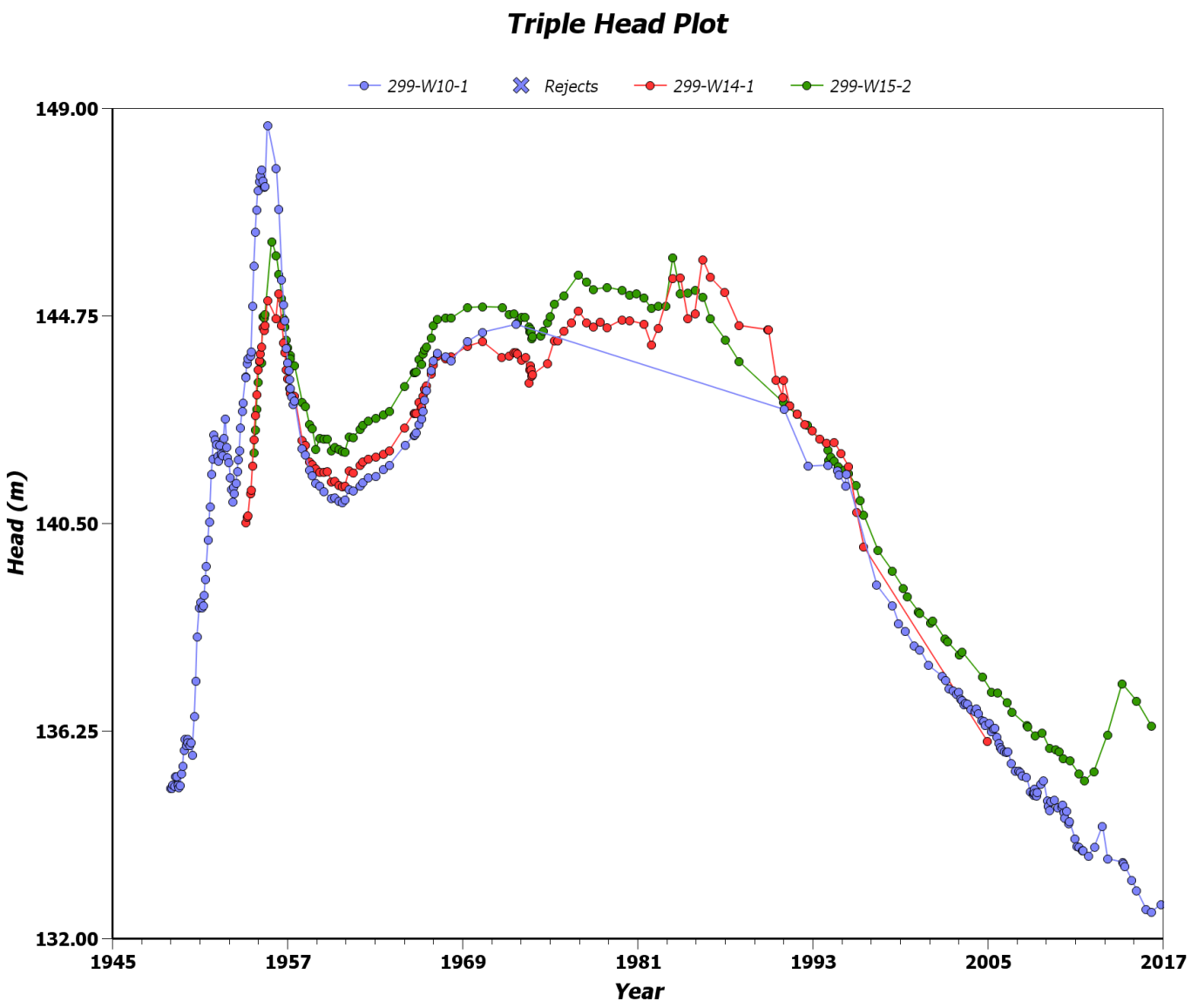


Figure 3-8. Historical Water Table Elevation Changes in the Northern Portion of the 200 West Area in the Vicinity of WMA T

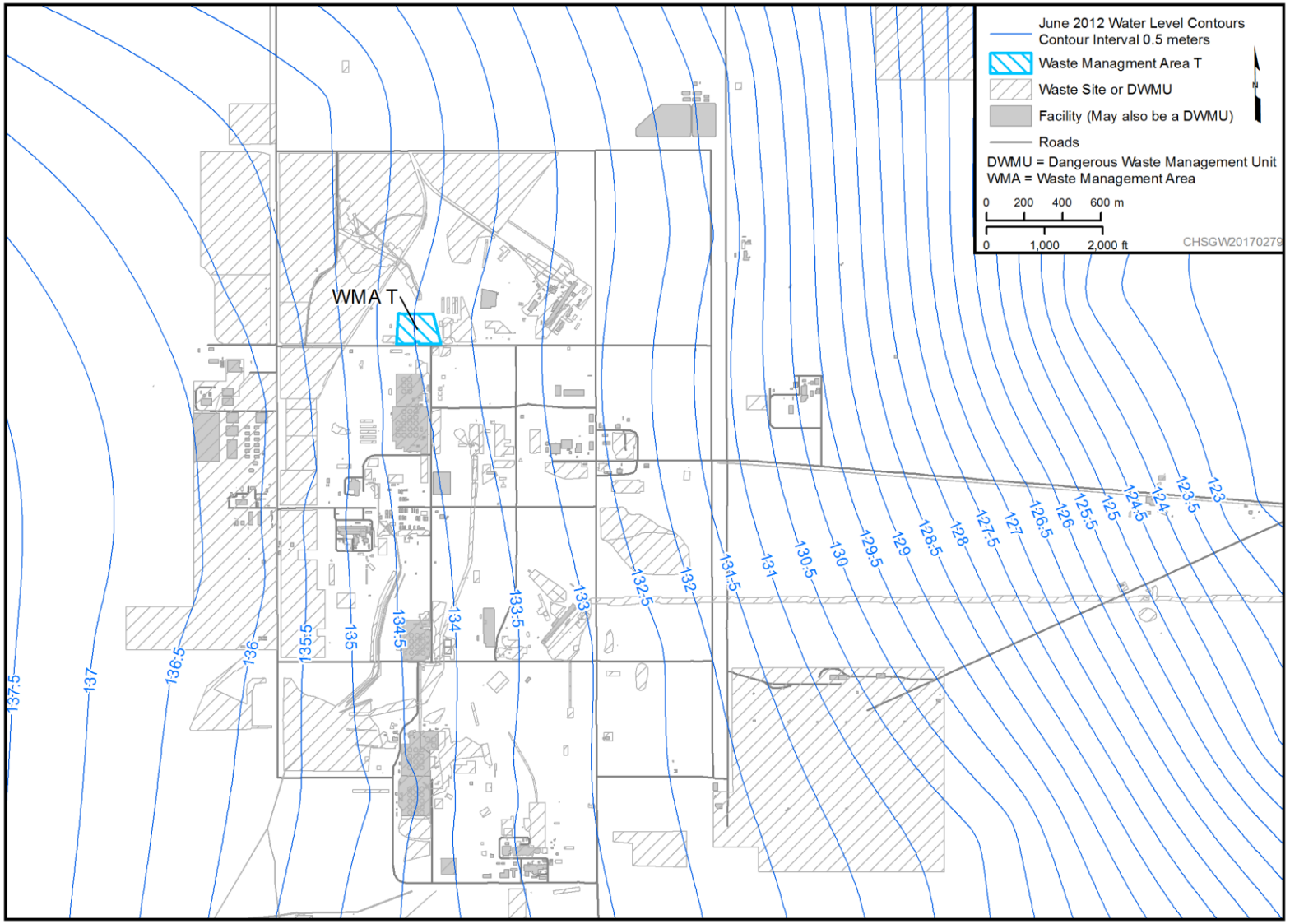


Figure 3-9. Groundwater Elevation Contours Computed Using Water-Level Mapping above the Ringold Lower Mud in June 2012 Prior to 200 West P&T Operations

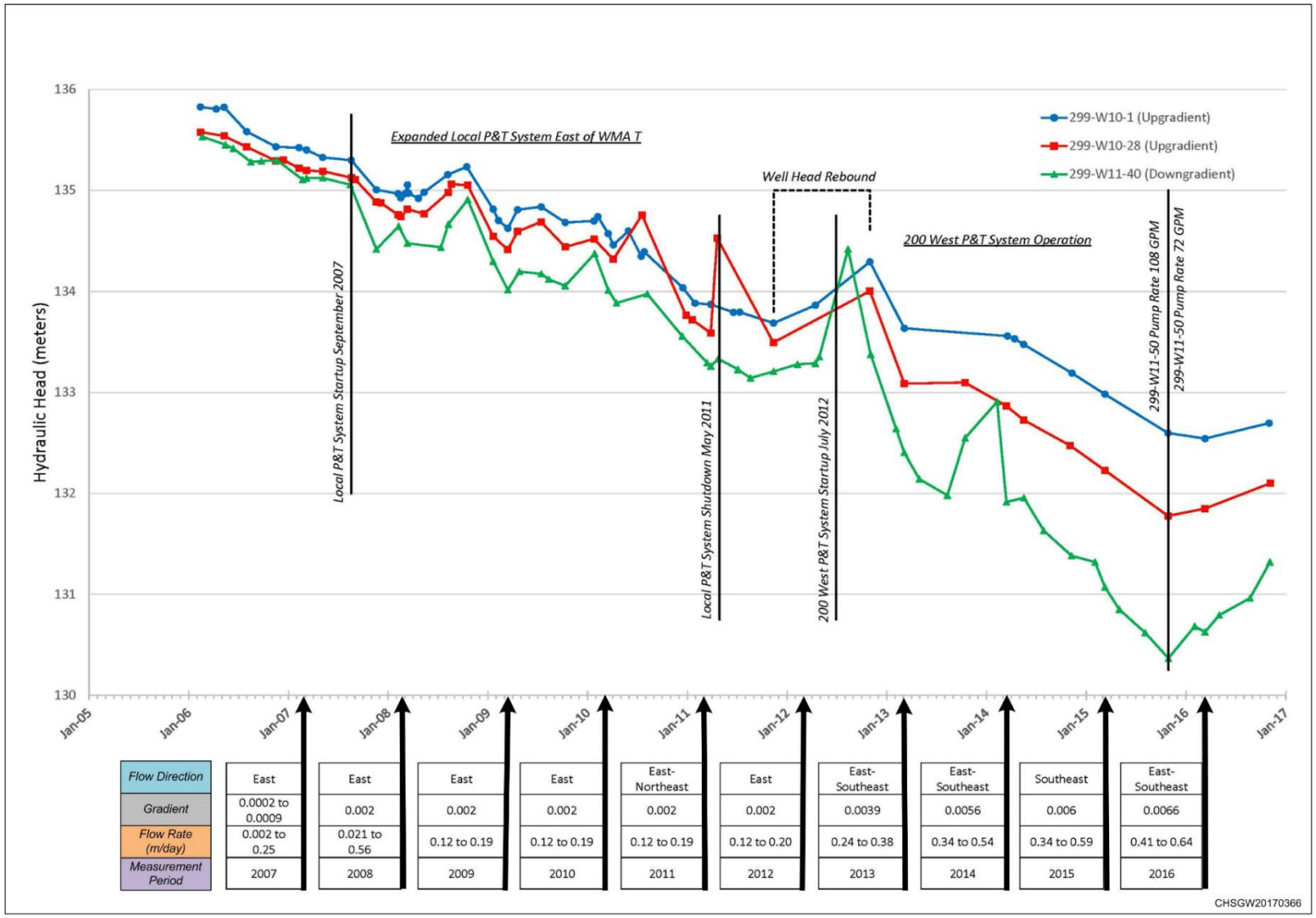


Figure 3-10. Change in Water Table Elevation, Flow Direction, Gradient, and Flow Rate at WMA T from 2007 through 2016

3.3.2 Hydrologic Conditions Due to Operation of the P&T Remedy

Since 2012 the most significant influence to the groundwater flow direction in the vicinity of WMA T is operation of the 200 West P&T. Operation of the 200 West P&T began in July 2012, initially treating contaminated water from the 200-ZP-1 OU and from WMA S-SX in the 200-UP-1 OU (Section 1.0 in DOE/RL-2016-20, *Calendar Year 2015 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump and Treat Operations*). The system is designed to capture and treat contaminated water and reduce the mass of contaminants of concern throughout the 200-ZP-1 OU. The 200 West P&T extraction and injection well network is designed for hydraulic containment and recovery of groundwater contaminants within the 200-ZP-1, 200-UP-1, and 200-BP-5 OUs (Figure 3-11). Some of the treated water is injected to the northeast and east of the 200-ZP-1 OU extraction wells to reduce and locally reverse the natural eastward hydraulic gradient in the aquifer and to minimize the potential for groundwater in the northern portion of the aquifer to flow northward through Gable Gap toward the Columbia River (referred to in the Record of Decision [EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*] and Performance Monitoring Plan [DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*] as flow-path control). Mounding of groundwater in the aquifer from these injection wells slows the natural eastward flow and keeps the majority of the contaminants of concern within the hydraulic capture zone of the extraction wells, enabling natural attenuation to reduce contaminant concentrations. Injection wells installed in 200-ZP-1 to the west (i.e., upgradient of the 200-ZP-1 OU extraction wells) are used to recharge the aquifer and steepen hydraulic gradients to the east to accelerate the flushing of the most highly contaminated portions of the aquifer (Section 3.1.1 in DOE/RL-2016-20).

Figures 3-9 and 3-12 depict groundwater elevation contours computed using water-level mapping. DOE/RL-2013-14, *Calendar Year 2012 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*, and ECF-200-ZP1-13-0006, *Description of Groundwater Modeling Calculations for the Calendar Year 2012 (CY2012) 200 Areas Pump-and-Treat Report*, provide details on the original preparation of these contours. Figure 3-9 depicts the water table during June 2012, when no P&T remedy was operating in the 200 West Area. Figure 3-12 shows the water table during December 2015 with the 200 West P&T and 200-UP-1 remedies operating in the 200 West Area. Figures 3-9 and 3-12 were prepared by interpolating water-level data obtained in wells screened above the RLM unit (i.e., the unconfined aquifer) and incorporating groundwater extraction and injection that occurs above the RLM within one kriging trend (drift) term (Section 3.2.2.1 in DOE/RL-2016-20). Comparison of Figures 3-9 and 3-12 shows areas of groundwater mounding in response to injection at wells screened partially or entirely above the RLM.

Because the majority of groundwater extraction occurs above the RLM, drawdown and mounding are clearly reflected in the measured water-level data and elevation contours. Figures 3-11 and 3-12 show a well-defined area of convergent hydraulic gradients centered on the extraction wells to the east of WMA T.

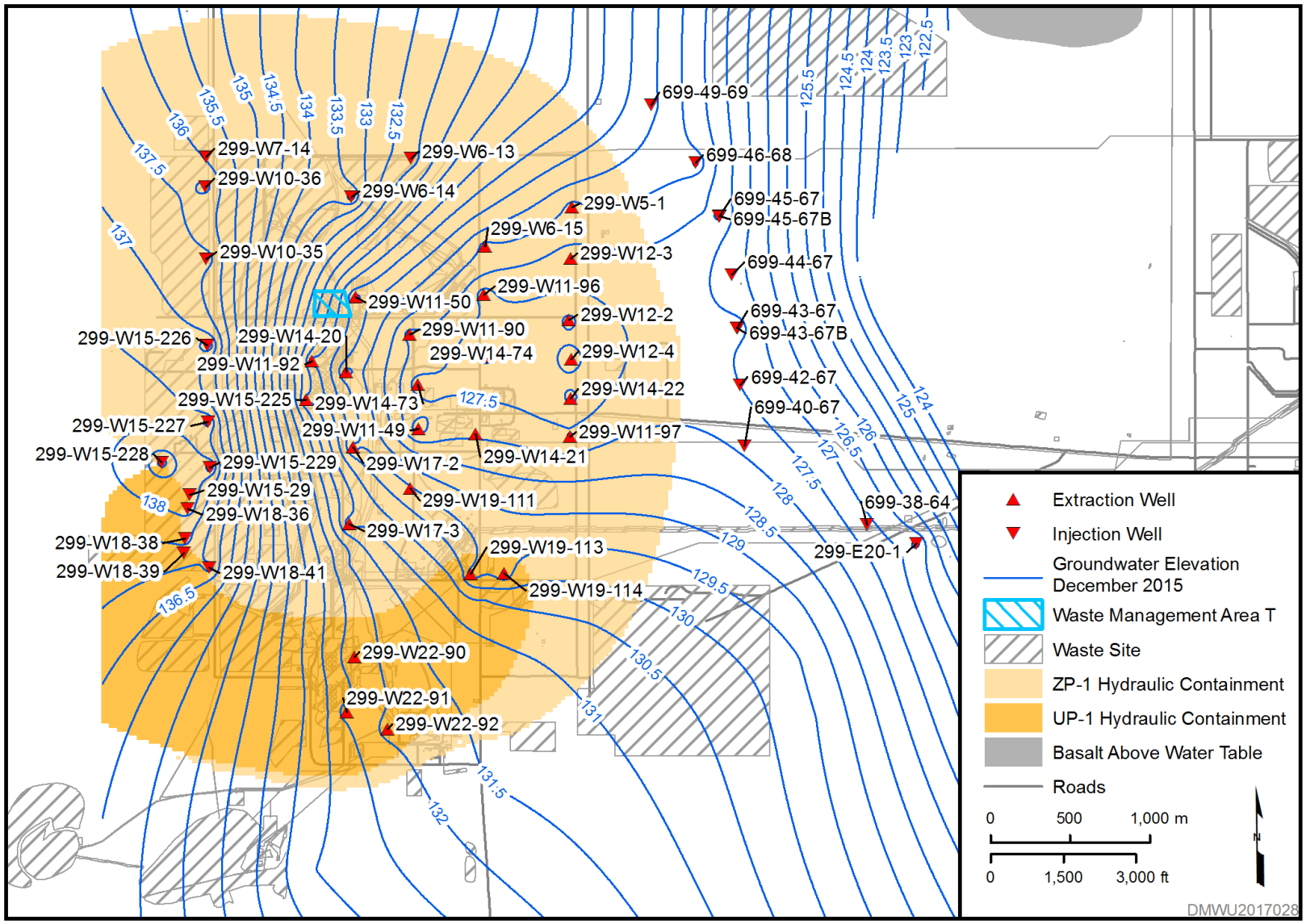


Figure 3-11. 200-ZP-1 and 200-UP-1 P&T Extraction and Injection Wells Showing Extent of Hydraulic Containment Computed for December 2015

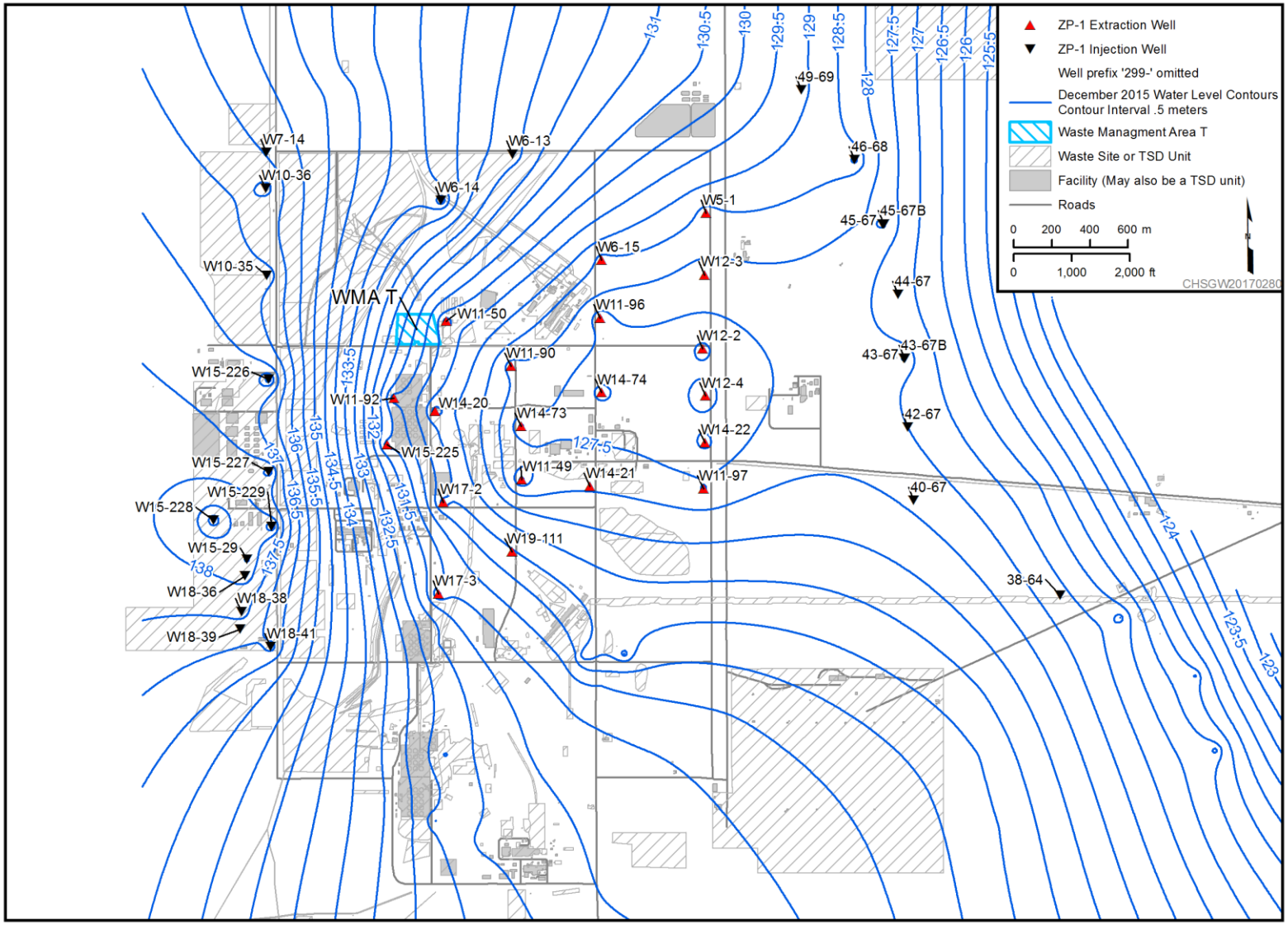


Figure 3-12. Groundwater Elevation Contours Computed Using Water-Level Mapping above Ringold Lower Mud in December 2015 During Active 200 West P&T Operations

The regional groundwater elevation has continued to decline due to cessation of artificial recharge from liquid waste disposal operations in the area. In March 2015 the water table elevation ranged from approximately 132.5 m (434.73 ft) to 130.6 m (428.5 ft) across the WMA T area. In 2016 the water table elevation increased beneath WMA T due to changes in 200 West P&T extraction and injection (Figure 3-10). The increase in water table levels at WMA T wells in 2016 ranged from approximately 0.1 to 1.9 m (0.3 to 6.3 ft) (Figure 3-10). Changes in water table elevation are primarily due to two factors which are simulated with the CPGWM:

1. The substantial reduction of wastewater discharges to the soil column associated with the cessation of discharges in the mid-1990s.
2. Commencement of operation of the 200 West P&T system in 2012. Water-level changes associated with the startup (SGW-50907, *Predicted Impact of Future Water-Level Declines on Groundwater Well Longevity within the 200 West Area, Hanford Site*, and ECF-200ZP1-12-0074, *Presentation & Initial Evaluation of Water-Level & Pumping Data for the Hanford 200-ZP-1 Groundwater Pump-and-Treat Remedy*).

Figure 3-10 shows the changes in water table elevation both upgradient (wells 299-W10-1 and 299-W10-28) and downgradient (well 299-11-40) of WMA T resulting from implementation of the 200 West P&T system that started in 2012. The declining regional water table generally remained on trend during the 2006 through 2015 time period (Figure 3-10). The impact of the 200 West injection and extraction system operations in the WMA T area beginning in 2012 is manifested by the changes in hydraulic head in wells located adjacent to the facility. The increased head differences noted between upgradient and downgradient wells correlates to an increase in hydraulic gradient in the area. The increased gradient is the result of the influence of the P&T system operation in the area (Figure 3-10).

Prior to temporary conversion of wells 299-W11-45 and 299-W11-46 located east of WMA T (Figure 3-13) to 200-ZP-1 P&T extraction wells, the water table gradient beneath WMA T was approximately 0.001 m/m (Table B.1 in PNNL-16346). After conversion of the two wells to extraction in September 2007, the local gradient increased to approximately 0.002 (based on March 2008 water levels [Figure 3-10]). The hydraulic gradient beneath the WMA T was estimated to be 0.006 m/m in March 2015 and increased slightly to 0.0066 m/m for March 2016.

The estimated groundwater and contaminant flow rates beneath WMA T ranged from 0.37 to 0.59 m/d (1.21 to 1.94 ft/d) in 2015 (Table 3-1) and 0.41 to 0.64 m/d (1.35 to 2.1 ft/d) in 2016 (Table 3-2) (Table 3-15 in DOE/RL-2016-66). The 2015 and 2016 Hanford Site water table maps show that the groundwater flow direction varied from southeast to east-southeast beneath WMA T (Figure 3-14). The local groundwater flow direction, hydraulic head, and gradient in the vicinity of WMA T respond to both the 200 West P&T system groundwater extraction wells and the injection wells in the area (Figures 3-11 and 3-12). The direction of groundwater flow is not expected to change beneath WMA T during the next several years with continued operation of the 200 West P&T System. The groundwater flow rate and direction are further described in Section 4.3.

Table 3-1. Groundwater Flow at WMA T in 2015

Flow Direction	Southeast
Flow Rate (m/d)	0.37 to 0.59
Hydraulic Conductivity (m/d) (Source)	6.11 to 9.69
Effective Porosity	0.1
Gradient (m/m)	6.0×10^{-3}
Comments	Gradient and direction were determined by trend surface analysis. Velocity was calculated from the Darcy equation.

Source: Table 3-14 in DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*.

Table 3-2. Groundwater Flow at WMA T in 2016

Flow Direction	East-southeast
Flow Rate (m/d)	0.41 to 0.64
Hydraulic Conductivity (m/d) (Source)	6.11 to 9.69
Effective Porosity	0.1
Gradient (m/m)	6.6×10^{-3}
Comments	Gradient and direction determined by trend surface analysis of data collected in March 2016; velocity calculated from the Darcy equation

Source: Table 3-15 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*.

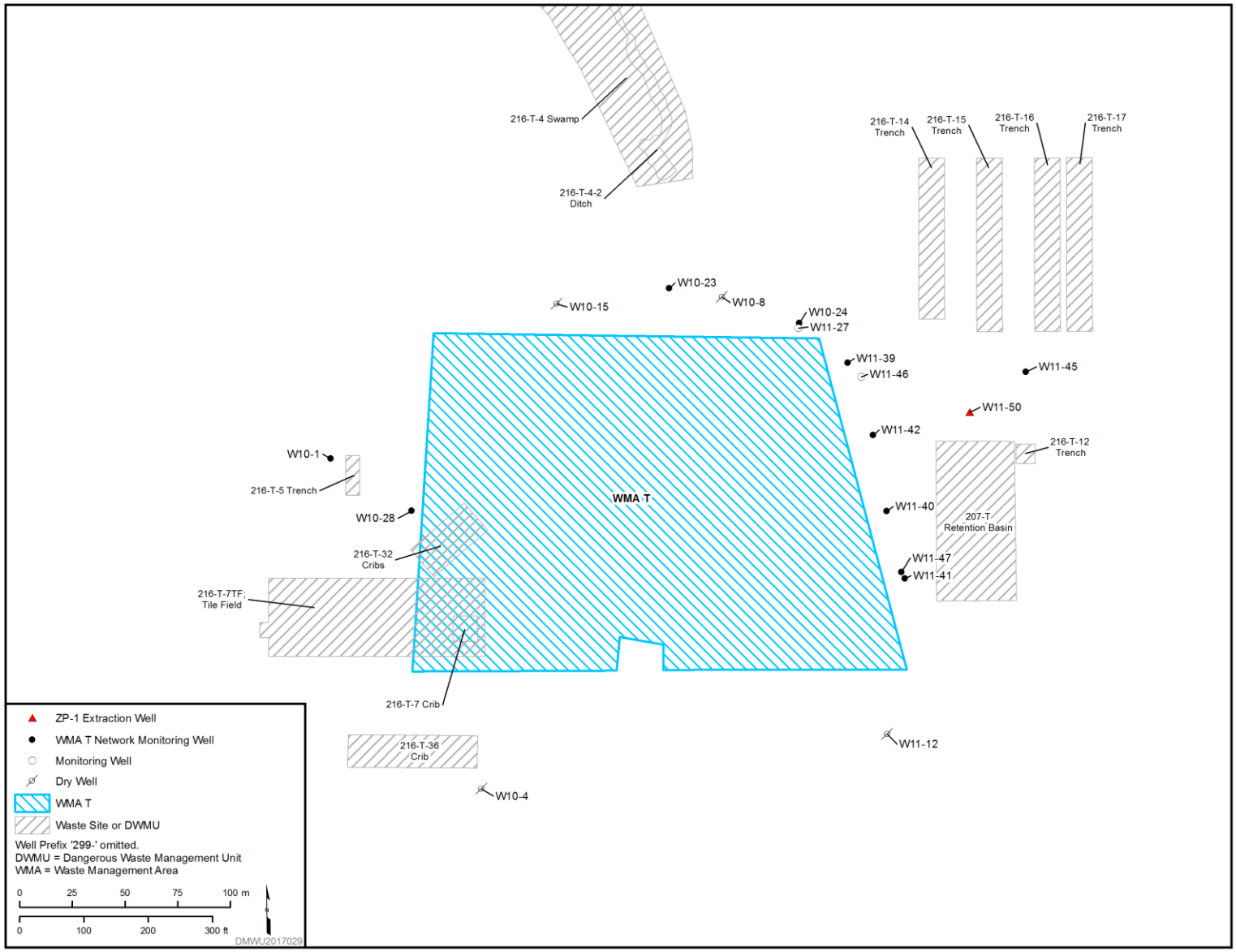


Figure 3-13. 2015 Well and Feature Location Map in the Vicinity of WMA T

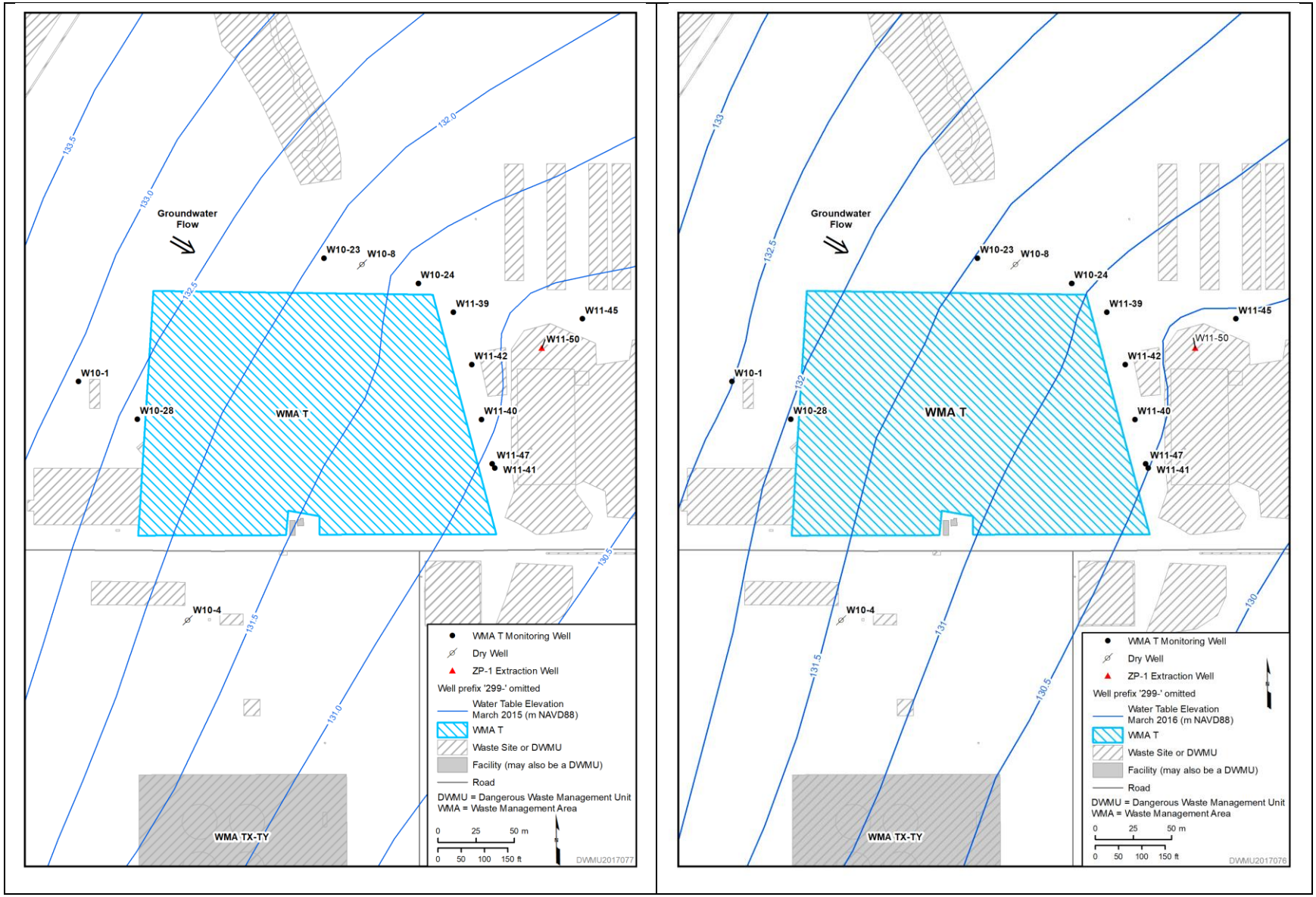


Figure 3-14. Water Table Maps of the WMA T Area in 2015 and 2016

4 Contaminant Migration Conceptual Model

RPP-23752, *Field Investigation Report for Waste Management Areas T and TX-TY*, summarizes a conceptual model for tank leak/release pathways to the groundwater and presents the groundwater pathway conceptual model in detail that includes specific aspects related to the 241-T Tank Farm. Section 2.6 in DOE/RL-2009-66, Rev. 1 describes the vadose zone and groundwater conceptual model for WMA T.

4.1 Vadose Zone

The vadose zone at WMA T is between approximately 72 and 79 m (236 and 259 ft) thick and consists of the Hanford formation, the CCU, the Taylor Flat member of the Ringold Formation, and the upper portion of Unit E of the Wooded Island member of the Ringold Formation (Figures 3-2, 3-3, and 3-4).

The unsaturated sediments above the water table affect how waste solutions move through the soil, how much is retained in the sediment column, and how much waste eventually reaches the water table. The source of contamination for WMA T is liquid waste released to near-surface or subsurface sediments. Small-volume leaks would tend to be retained in the vadose zone near the leak point. Larger leaks would be expected to move deeper in the soil, spreading laterally as the wetting front moves downward. Contaminant migration through the vadose zone is highly dependent on heterogeneities and anisotropy in the soil properties.

The sediment layers with the most influence on moisture migration through the vadose zone beneath WMA T are the CCU and the Taylor Flat member of the Ringold Formation. The relatively low permeability of these units is expected to impede vertical moisture migration. Lower hydraulic conductivity of the CCU is likely to slow downward movement of moisture and contaminants because of the finer textured sediment and caliche cementing that characterize this stratigraphic feature in the vadose zone. The CCU is known to pond water locally in several places in the 200 West Area (Section 2.5.2 in PNNL-15301).

Improperly sealed wells can act as a preferential pathway through the vadose zone. Section 3.1.3.3 of PNNL-15301 indicates that 45 of the 67 drywells in the 241-T Tank Farm (used for secondary leak detection) have been modified to retrofit an annular seal. No documentation is provided in PNL-8800, *Hanford Wells*, the Hanford Well Information System database, or the Pacific Northwest National Laboratory well library indicating that the remaining 22 drywells have an annular seal. Therefore, the potential exists for unsealed wells to promote vertical moisture migration in WMA T (Section 3.1.3.3 in PNNL-15301).

Some evidence suggests that past tank leaks have migrated through the vadose zone to the groundwater (Sections 2.6.1 and 2.6.2 in PNNL-15301; Sections 4.2.5.2 and 4.2.5.3 in PNNL-15837); however, this evidence is not unequivocal. Earth resistivity surveys have shown that vadose zone contamination possibly extends from the base of the 216-T-7 Crib and Tile Field to the water table. Thus, at least some of the nearby past-practice disposal facilities may have impacted groundwater (Section 2.6.2 in PNNL-15301). Pipeline leaks and overfilling of SSTs have been documented at WMA T (Sections 2.1 and 2.2 in RPP-7218). Any remaining contamination in the vadose zone resulting from pipeline leaks or overfill events remains a source for possible future groundwater contamination.

4.2 Soil Moisture Factors

Tank leak/release events began with rapid discharge of some waste fluid volume into the subsurface from a point of entry likely having a small spatial extent (on the order of inches to rarely feet). This discharge

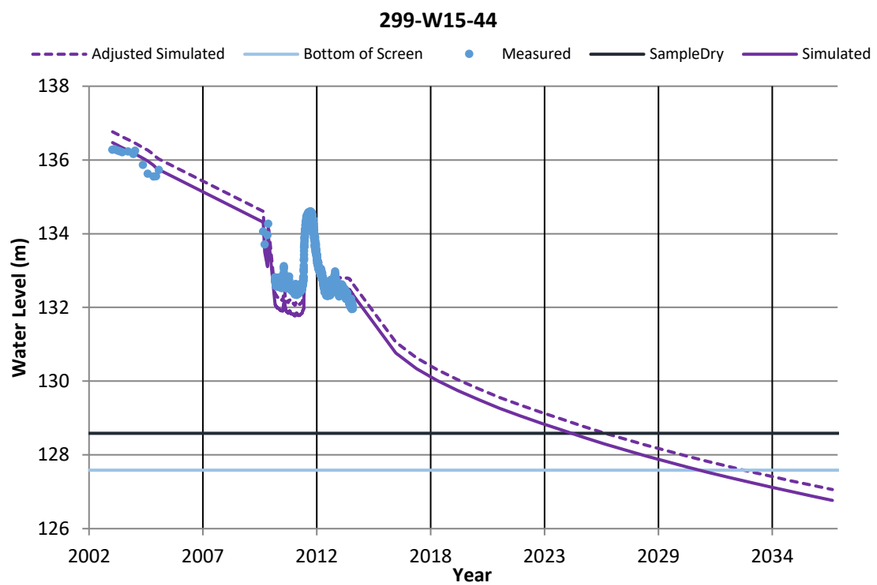
temporarily increased the moisture content of the unsaturated soil, particularly at the point of entry. Points of entry included poorly sealed openings in the tank structure, ruptured areas of steel tank liners near underlying concrete shell fractures, and breaks in waste transfer lines. Natural processes then redistributed the excess moisture within the vadose zone, eventually returning the soil to ambient conditions.
The migration process occurred, for the most part, in partially saturated soils because leak/release volumes were not sufficient to fill the soil pore spaces for an appreciable length of time or very far from the point of entry. This condition is referred to as "unsaturated flow." Infiltration of natural precipitation remains the likely principal driver to mobilize vadose zone contamination. Steps have been taken to reduce infiltration of precipitation at WMA T. Berms have been erected around the tank farm to stop run-on of rain and melting snow, and an interim cap has been placed over the largest tank leak in the WMA (tank 241-T-106) to inhibit remobilization of that leak.

4.3 Hydrogeologic Considerations

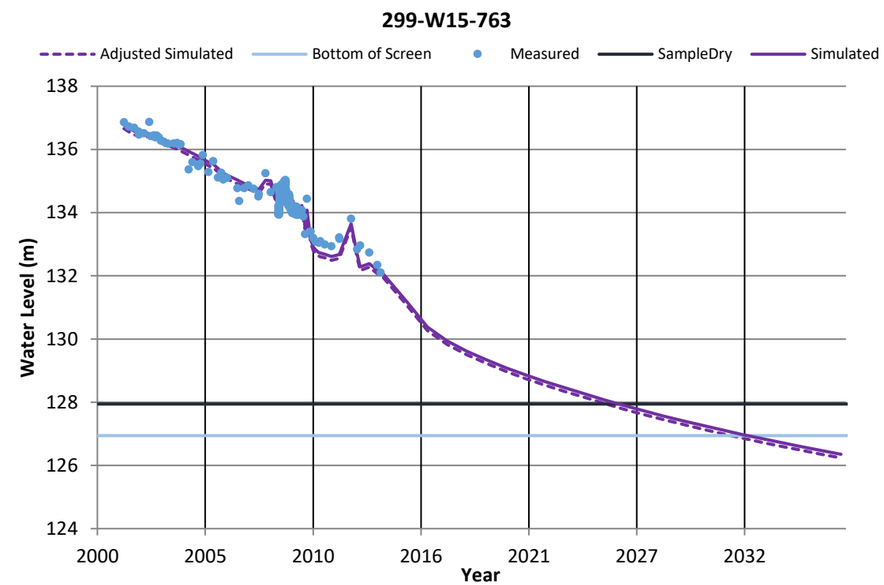
Large changes have occurred in the groundwater flow direction beneath WMA T. Analyses of historic hydraulic gradients suggest that groundwater could have traveled and carried contaminants from WMA T and nearby past-practice disposal facilities. Historic flow directions are discussed in (Section 2.5.2 in PNNL-15301). Pre-Hanford Site (circa 1944) groundwater flow direction was toward the east (Figure 4 in BNWL-B-360, *Selected Water Table Contour Maps and Well Hydrographs for the Hanford Reservation, 1944-1973*). The groundwater flow had changed toward the south in the area by the early 1950s.
This shift resulted from disposal of large volumes of liquid to the 216-T Pond system, located north of WMA T. In 1956, groundwater flow direction changed again towards the northeast due to the increasing influence of the groundwater mound under the 216-U Pond and a decreasing influence of the mound under the 216-T Pond. Discharges to the 216-T Pond ended in 1976, but continued at the 216-U Pond until 1984. As discharges to the 216-U Pond declined in the early 1980s, groundwater flow shifted to a more northward direction as the groundwater mound began to decrease and discharges to the 216-U-14 Ditch continued. The slight westward component to the groundwater flow direction between the early 1980s and mid-1990s is probably a result of the discharges to the 216-U-14 Ditch, located southwest of WMA T, influencing water levels in some of the wells used in the flow direction analysis. Nonpermitted discharges to the ground ceased, and the influence of the 216-U Pond mound on the groundwater beneath the 241-T Tank Farm diminished in 1995. Consequently, the flow direction changed again in about 1996 and began to return toward an east-northeast to eastward direction through 2012. With implementation of the 200 West P&T system in July 2012, groundwater flow direction changed to east-southeast or southeast (Figure 3-10).

The historical variations in the groundwater flow direction could have contributed to relatively widespread contaminant distribution. Water levels have continued to decline in the area since the cessation of liquid waste disposal operations (Figure 3-8). As the large-scale P&T system operating in the 200 West Area expanded, groundwater flow direction, water table gradient, and flow velocities were affected at WMA T. The magnitude of the impact was most pronounced when system operations at the 200 West Facility were initiated in 2012 (Figure 3-10). The future influence that the 200 West P&T system operation is projected to have on the water-level decline for wells adjacent to WMA T is shown in Figure 4-1.

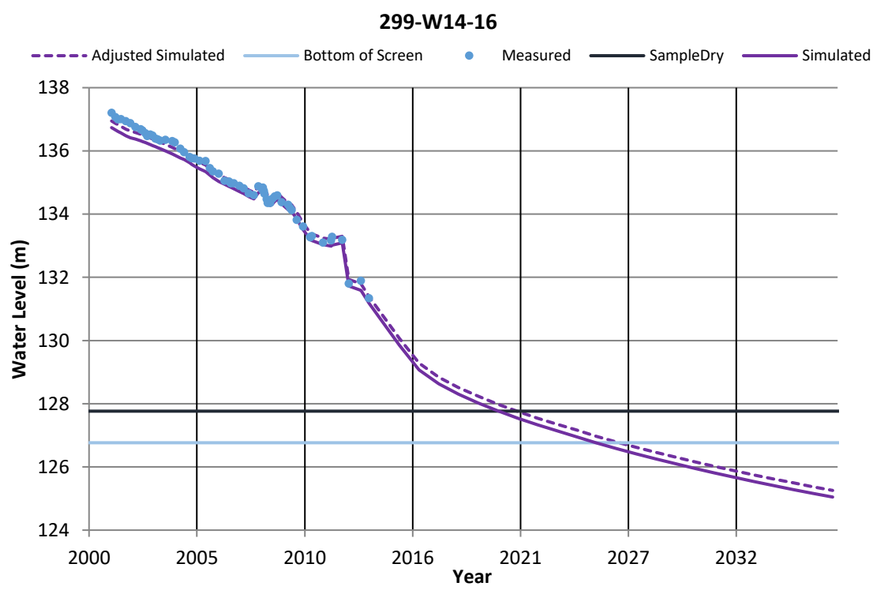
Upgradient Well



Cross-Gradient Well



Downgradient Well



Far-Field Downgradient Well

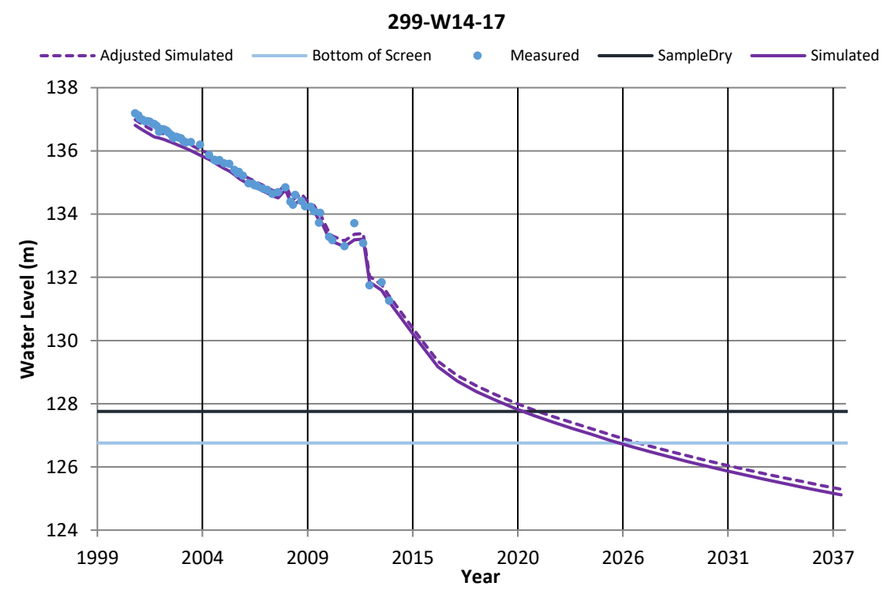


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Figure 4-1. Hydrographs Showing the Projected Impact of P&T Operations on the Rate of Water-Level Decline for Wells Adjacent to WMA T

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P&T operations are expected to continue in this region until 2037. After active groundwater remediation is completed and the 200 West P&T system is shut down, groundwater flow is anticipated to return to pre-200 West P&T startup conditions. The changing groundwater flow directions and gradients will be considered when evaluating the groundwater monitoring network. These factors are assessed in evaluating impact to groundwater beneath WMA T in the simulations described in Chapters 5 through 7 of this report.

4.4 Groundwater Chemistry

Groundwater chemistry in the vicinity of WMA T is dominated by high sodium, high nitrate groundwater containing varying concentrations of chromium, technetium-99, nitrate, fluoride, carbon tetrachloride, and trichloroethene. Contaminants are a result of over 50 years of waste management activities in the 200 West Area (Section 2.6.1 in PNNL-15301). Chromium, carbon tetrachloride, and trichloroethene are the only dangerous waste constituents found in the groundwater beneath WMA T. Elevated chromium in groundwater at WMA T is primarily attributed to hexavalent chromium concentrations. Carbon tetrachloride and trichloroethene are monitored as part of the 200-ZP-1 OU. Nitrate and fluoride are also found in groundwater beneath the facility. In addition to the dangerous waste constituents, technetium-99 and tritium are found in groundwater at WMA T. The current understanding of the lateral distribution of hexavalent chromium (Figure 4-2), carbon tetrachloride (Figures 4-3 and 4-4), nitrate (Figure 4-5), and trichloroethene (Figure 4-6) groundwater contaminants in the vicinity of WMA T is shown in 2016 plume maps (Figures 12-9, 12-5, 12-14, and 12-22 in DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*). Concentration trending during the period 2011 through 2016 associated with hexavalent chromium, trichloroethene, carbon tetrachloride, and nitrate for an upgradient well (299-W10-1) and for downgradient or far-field wells (299-W11-40, 299-W11-42, 299-W11-45, or 299-W11-47) are presented in Figures 4-7, 4-8, 4-9, and 4-10.

Several lines of evidence show that vertical contaminant concentration gradients exist in the area of WMA T. Contaminant concentrations increase with depth in the aquifer in some places (i.e., well 299-W11-46) and decrease with depth in other places (i.e., well 299-W10-24) (Section 2.6 in PNNL-15301).

The portion of the chromium immediately downgradient of WMA T is attributed to release(s) from the facility. Carbon tetrachloride is present in the unconfined aquifer beneath most of the 200 West Area (Figures 4-3 and 4-4). The carbon tetrachloride is believed to be from pre-1973 waste from PFP and not from WMA T. The extensive nitrate plume in the area has multiple sources, but some contribution is associated with release(s) from WMA T. The most likely source for most the nitrate in this area is one or more of the past-practice liquid disposal facilities upgradient of the 241-T Tank Farm (Section 2.6 in PNNL-15301).

The major sources for the trichloroethene plume are disposal sites associated with PFP. A second potential source is disposal near T Plant (PNNL-14187). The WMA is not considered a source for trichloroethene. Trichlorethene in groundwater near the WMA originated from waste sites associated with PFP (Section 2.6 in PNNL-15301).

Between mid-1997 and late 2000, a fluoride plume appears to have passed well 299-W10-4 (Section 2.6 in PNNL-15301). Fluoride concentrations exceeding the DWS of 4,000 µg/L occurred in wells 299-W10-23 and 299-W10-8 north of WMA T between 2007 and 2012. Historically, the highest concentration of fluoride (5,250 µg/L) has been in well 299-W10-4 in 1999 and is likely associated with nearby cribs (Section 2.6.1 in PNNL-15301).

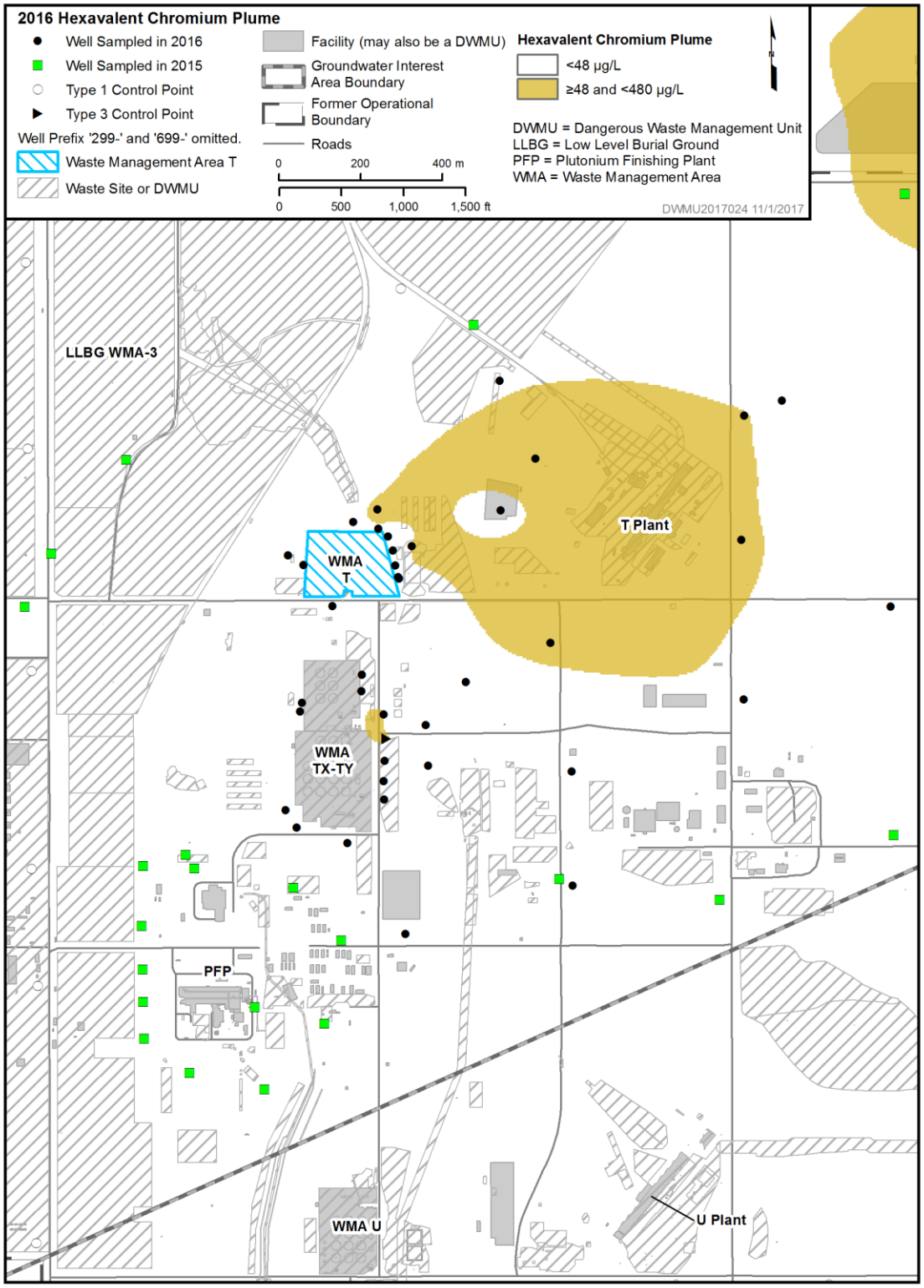
4.5 Summary of Vertical Contaminant Distribution

Eight completed wells in the vicinity of WMA T have been characterized for vertical distribution of contaminants in groundwater during drilling. Identified wells include 299-W10-24, 299-W10-33, 299-W11-25B, 299-W11-42, and 299-W11-47 located near the perimeter of WMA T; and 299-W11-45, 299-W11-48, and 299-W11-50 located distally from WMA T. See Figure 4-11 for general well location in relation to WMA T. These wells were installed between 1998 and 2010 and have varying quantities of measurements, collected samples, and depths of characterization. The temporal separation in observations and measurements introduces substantial uncertainty in interpreting correlation between individual well data and the TSD operation. In addition, a CERCLA P&T remedial action is currently in operation in the vicinity of these wells.

Contaminants associated with irradiated uranium fuel reprocessing and single shell tanks in 200-ZP-1 OU were evaluated and include: carbon tetrachloride, nitrate, hexavalent chromium, and fluoride. Where hexavalent chromium was not analyzed, filtered chromium was included where available. During drilling of the wells, groundwater samples were collected from the boreholes at selected depths and analyzed by field and/or laboratory methods. Laboratory data were selected where both field and laboratory data were available for each of the vertical contaminant distribution plots. See Figures 4-12 to 4-18 for observed vertical distribution of identified contaminants.

A vertical contaminant distribution plot for well 299-W11-42 is not included due to the characterization being limited to the uppermost 12 m (42 ft) of the unconfined aquifer, and of the identified constituents only three samples of carbon tetrachloride were collected. The carbon tetrachloride results in well 299-W11-42 ranged from 900 to 1,271 pCi/L, collected 2.7 to 5.9 m (9 to 19 ft) below the water table. Based on vertical characterization data, contaminants are present throughout the unconfined aquifer; consistent with the presence of multiple sources and extents of regional plumes. However, vertical zones of increased contaminant concentrations are evident to varying degrees within the wells. Well 299-W10-24 located immediately northeast, and well 299-W10-33 located immediately south of WMA T exhibit an increase in contaminant concentrations beginning about 15 m (50 ft) and extending to 33 m (108 ft) below the 2017 water table. However, the remaining wells, in addition to well 299-W10-33, exhibit indications of highest contaminant concentrations within the upper approximately 5 to 17 m (16 to 56 ft) of the unconfined aquifer. Well 299-W10-24 does not include a corresponding increase in concentrations of contaminants at the water table in comparison to the remaining wells; however, evaluation of 299-W10-24 does not include samples collected at the water table during drilling.

In summary, all wells indicate a general decreasing trend in concentrations with depth to the RLM or Ringold A units. Available data for the wells do not indicate the presence zones of concentrations within the deeper portion of the aquifer that are substantially greater than those within the upper most portion of the aquifer.



Note: Control points have been utilized to correct projected plume extents based on known site condition. Control points used for 2016 plume modeling are documented in ECF-HANFORD-16-0138, *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2016 (CY2016) Hanford Site Groundwater Monitoring Report*.

Figure 4-2. Hexavalent Chromium Plume in the Vicinity of WMA T

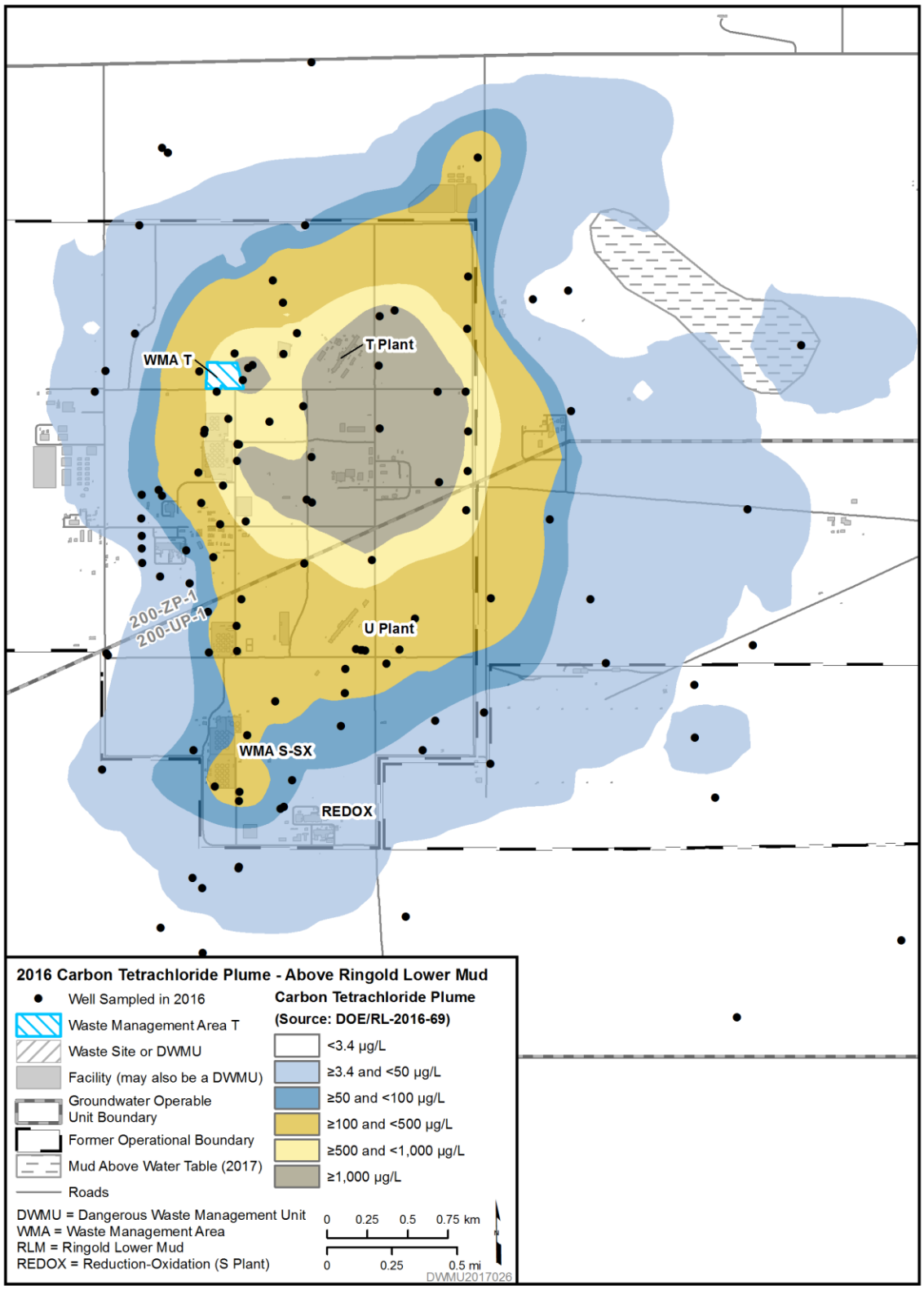


Figure 4-3. Carbon Tetrachloride Plume Above Ringold Lower Mud in the Vicinity of WMA T

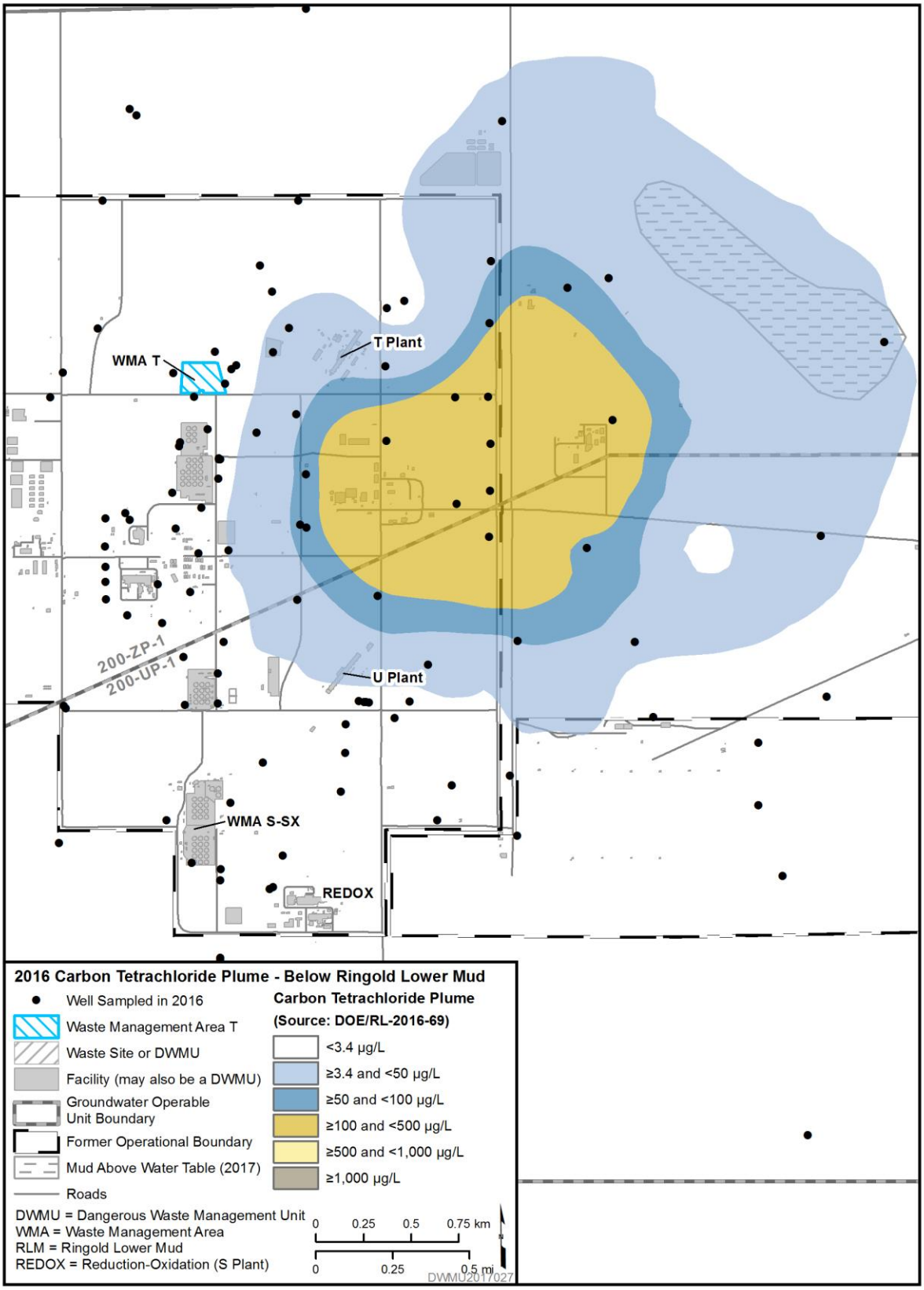
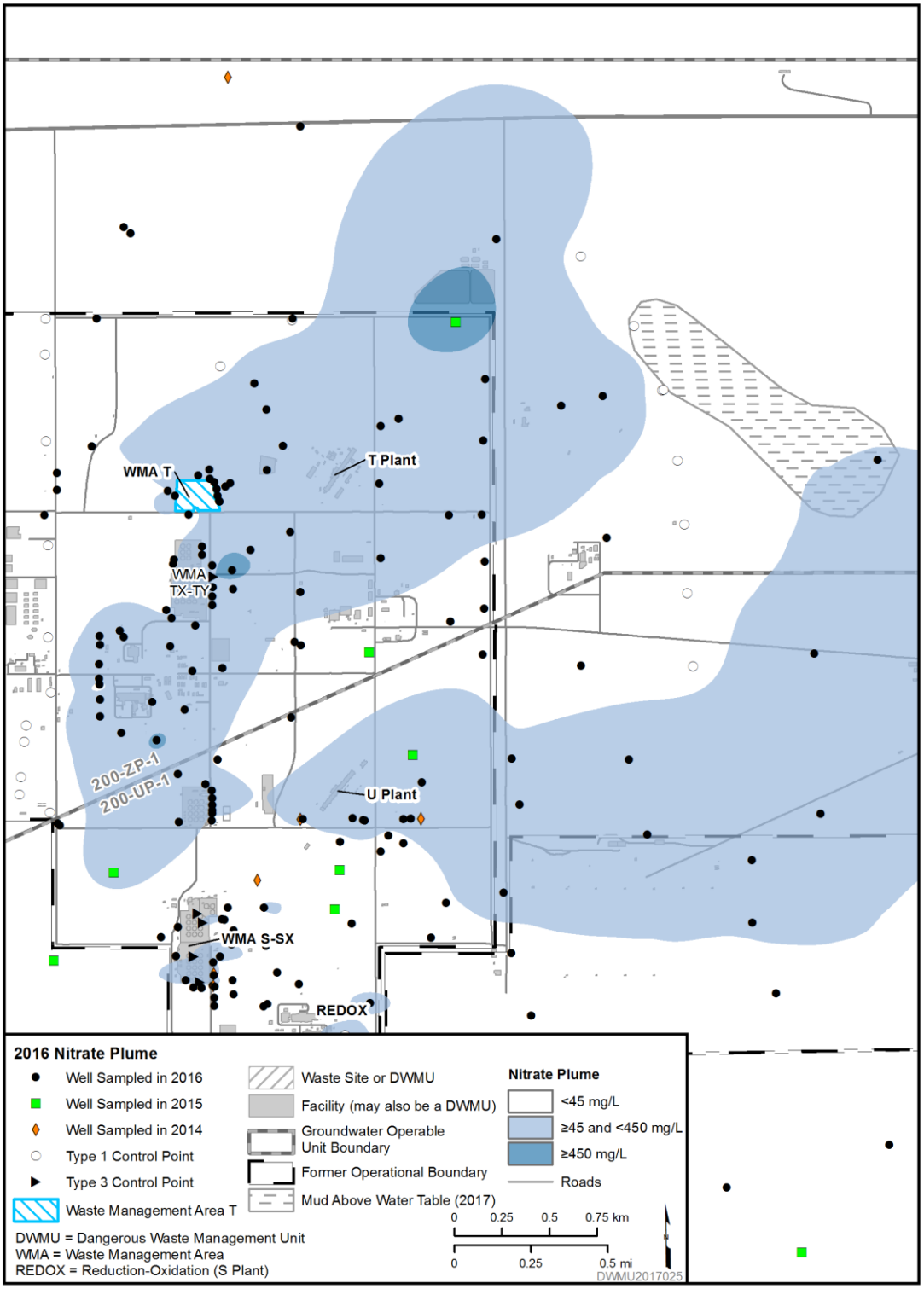
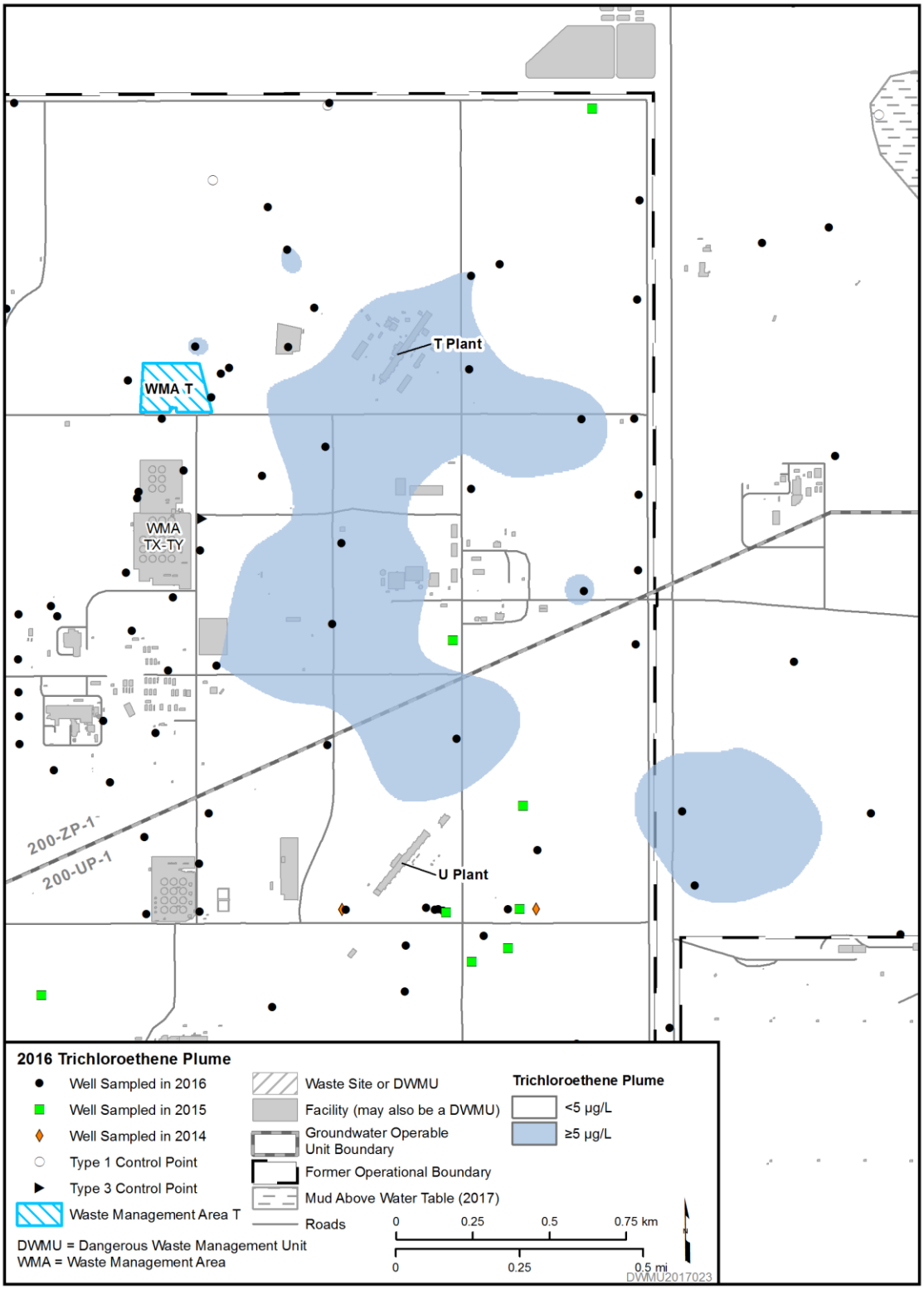


Figure 4-4. Carbon Tetrachloride Plume below Ringold Lower Mud in the Vicinity of WMA T



Note: Control points have been utilized to correct projected plume extents based on known site condition. Control points used for 2016 plume modeling are documented in ECF-HANFORD-16-0138, *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2016 (CY2016) Hanford Site Groundwater Monitoring Report.*

Figure 4-5. Nitrate Plume in the Vicinity of WMA T



Note: Control points have been utilized to correct projected plume extents based on known site condition. Control points used for 2016 plume modeling are documented in ECF-HANFORD-16-0138, *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2016 (CY2016) Hanford Site Groundwater Monitoring Report*.

Figure 4-6. Trichloroethene Plume in the Vicinity of WMA T

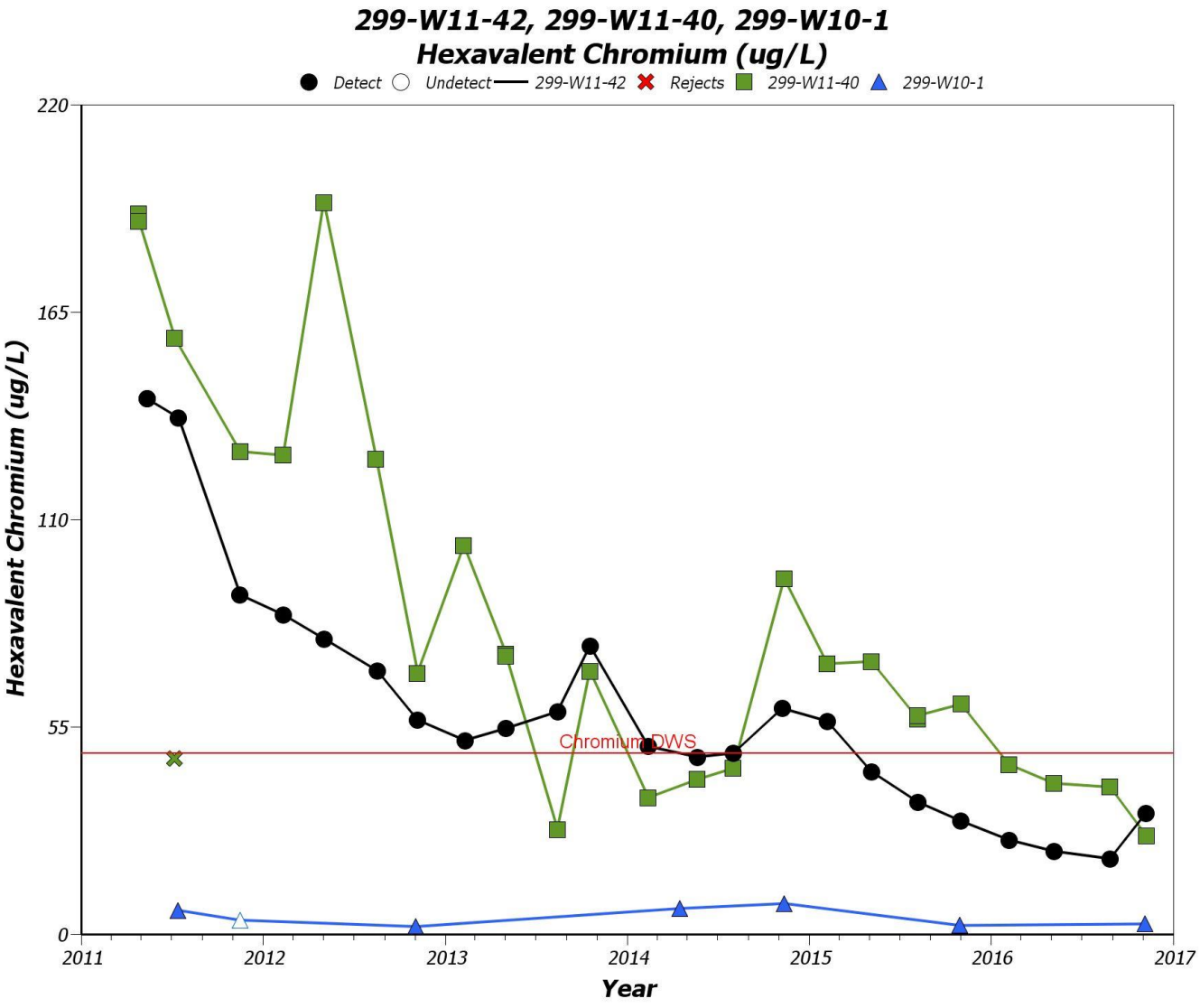


Figure 4-7. Hexavalent Chromium Concentration Trending for Downgradient Wells 299-W11-42 and 299-W11-40 and Upgradient Well 299-W10-1

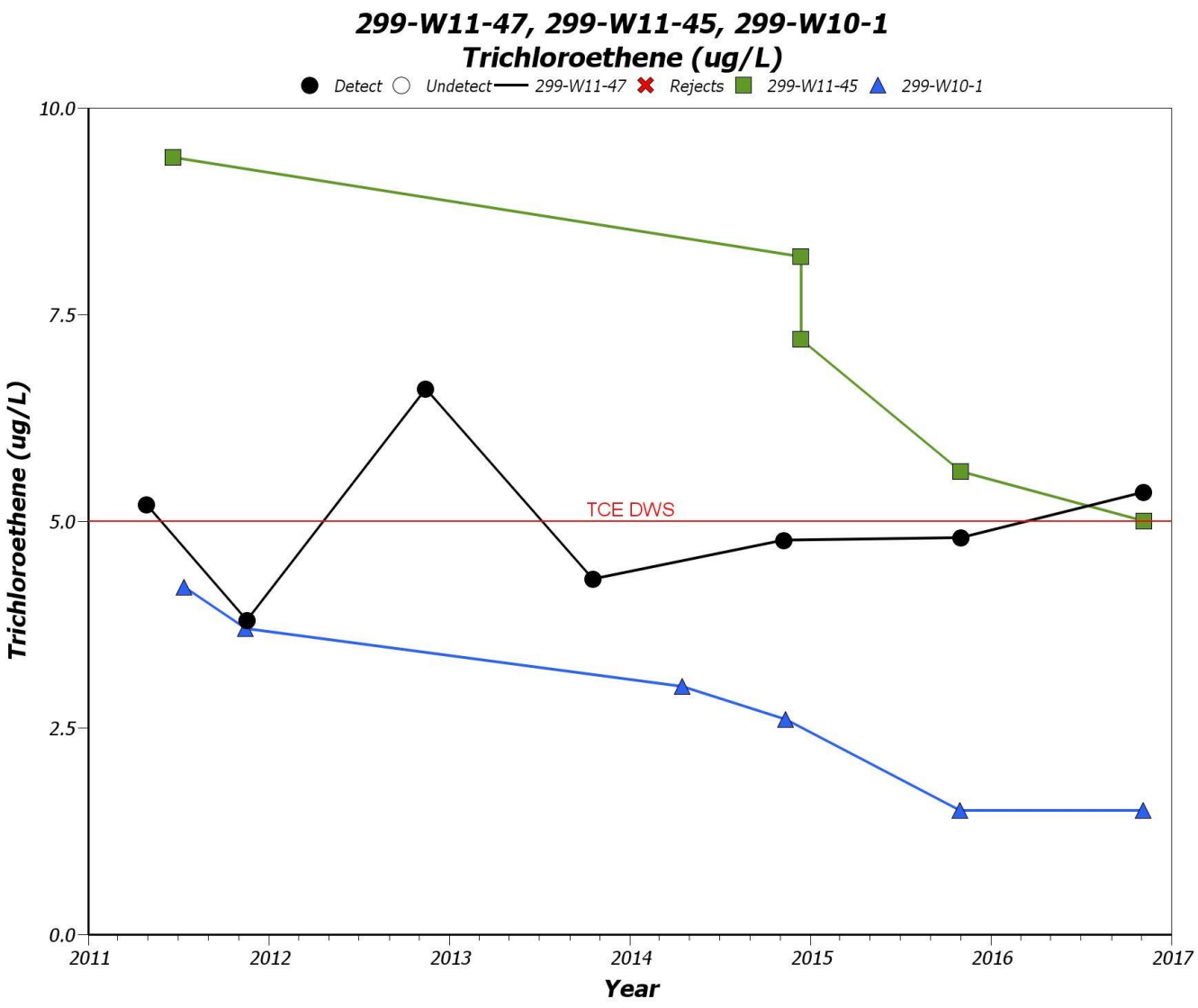


Figure 4-8. Trichloroethene Concentration Trending for Downgradient Well 299-W11-47, Far-Field Well 299-W11-45, and Upgradient Well 299-W10-1

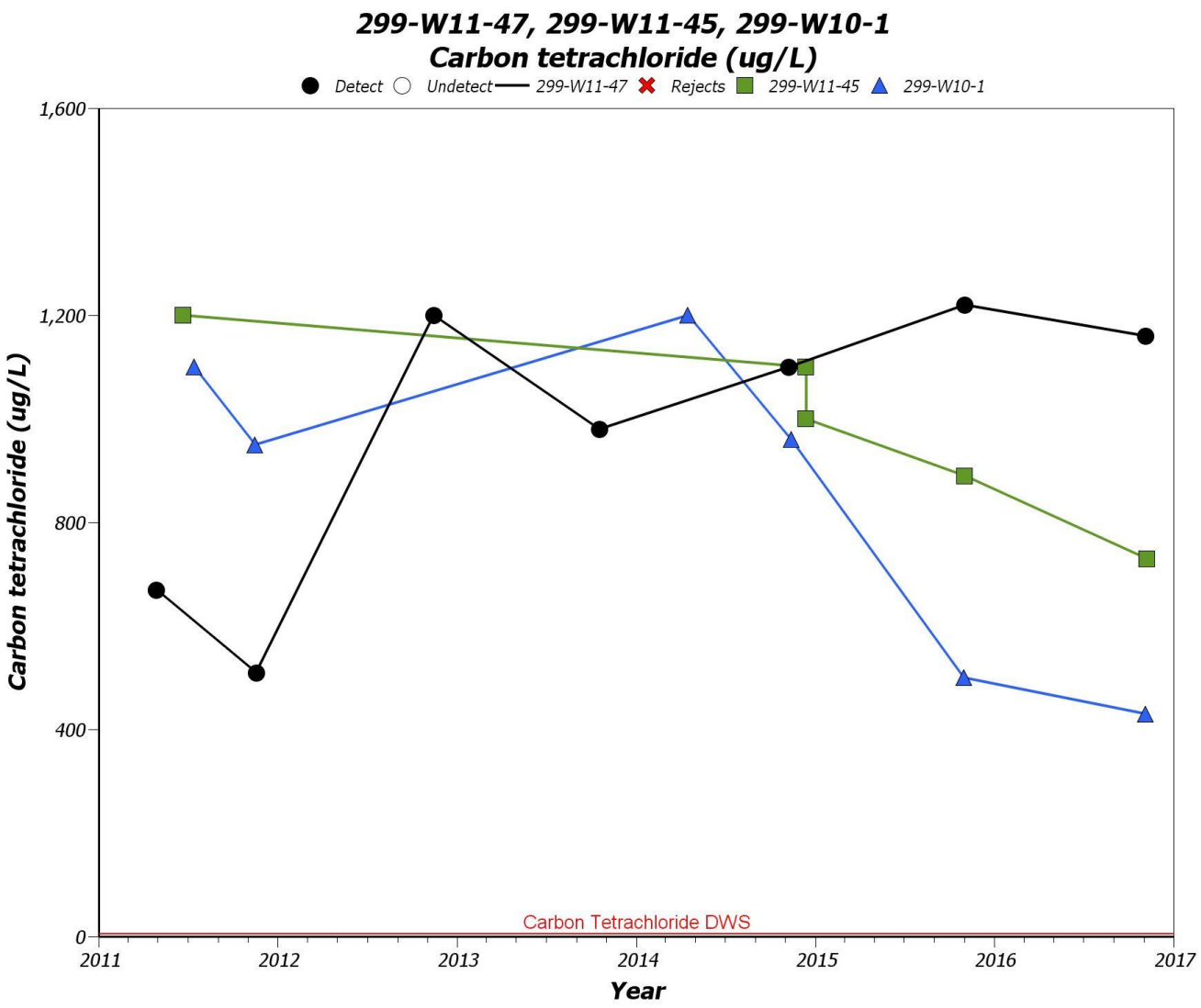


Figure 4-9. Carbon Tetrachloride Concentration Trending for Downgradient Well 299-W11-47, Far-Field Well 299-W11-45, and Upgradient Well 299-W10-1

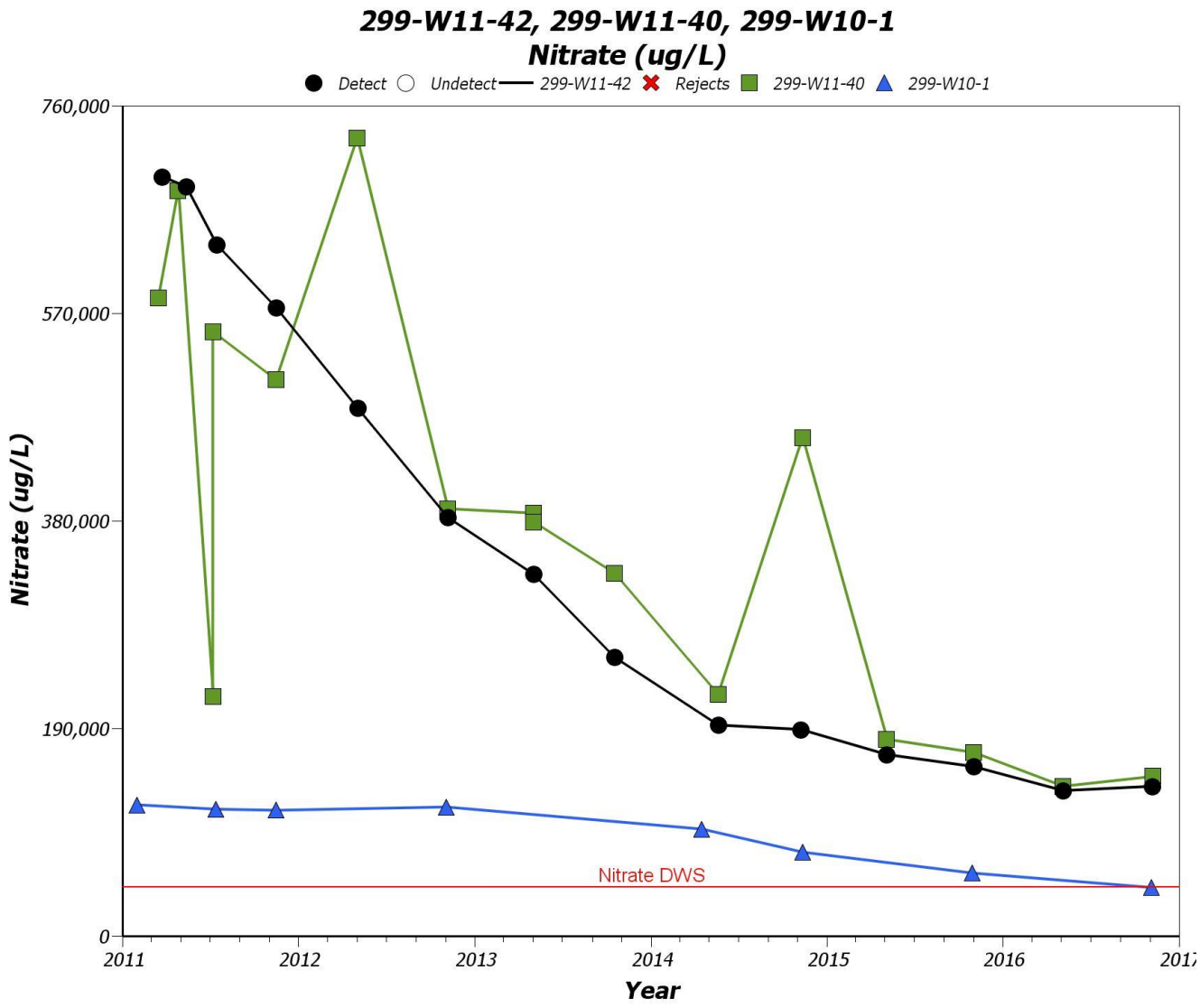


Figure 4-10. Nitrate Concentration Trending for Downgradient Wells 299-W11-42 and 299-W11-40 and Upgradient Well 299-W10-1

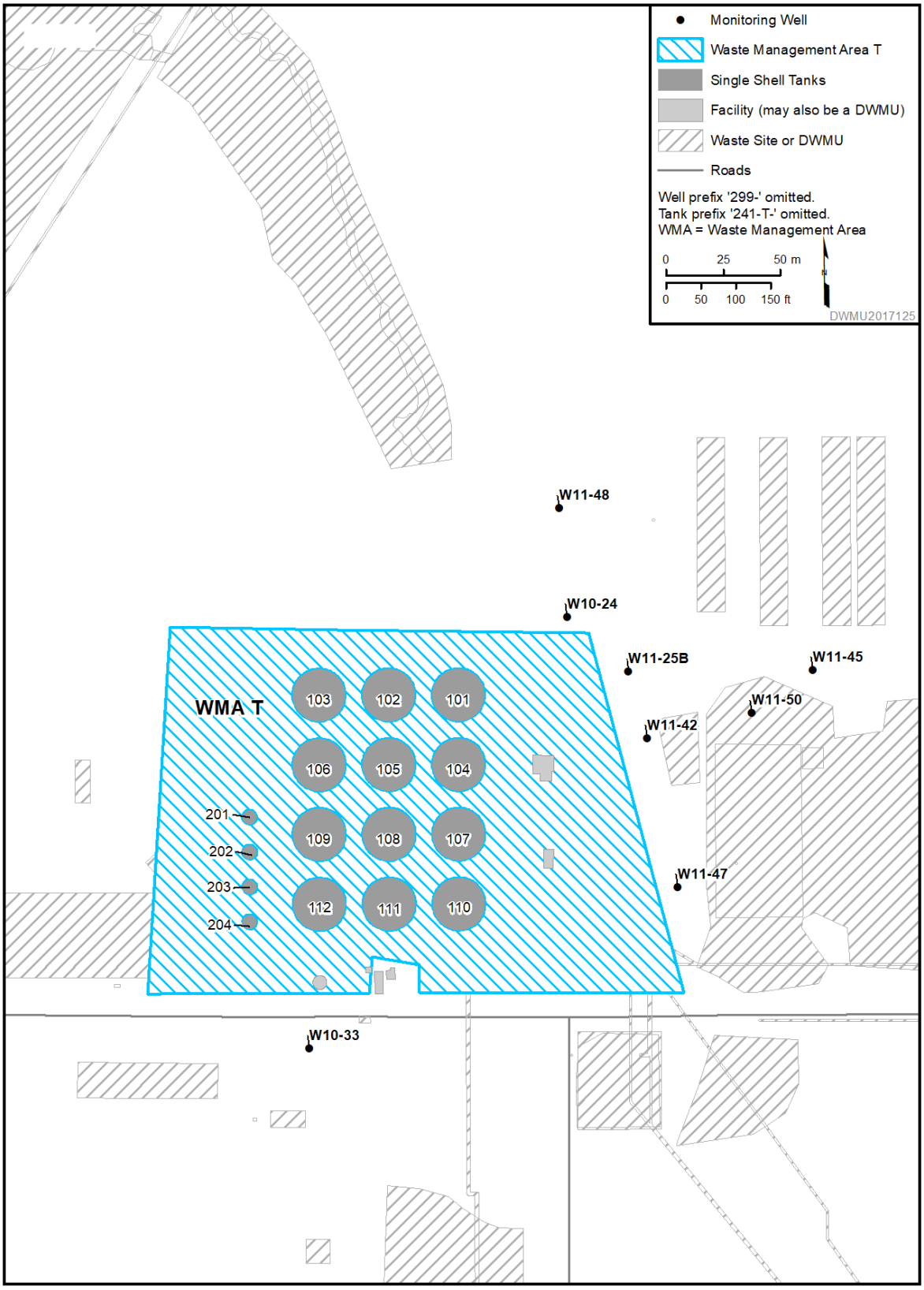


Figure 4-11. Vertical Contaminant Characterization Well Location Map

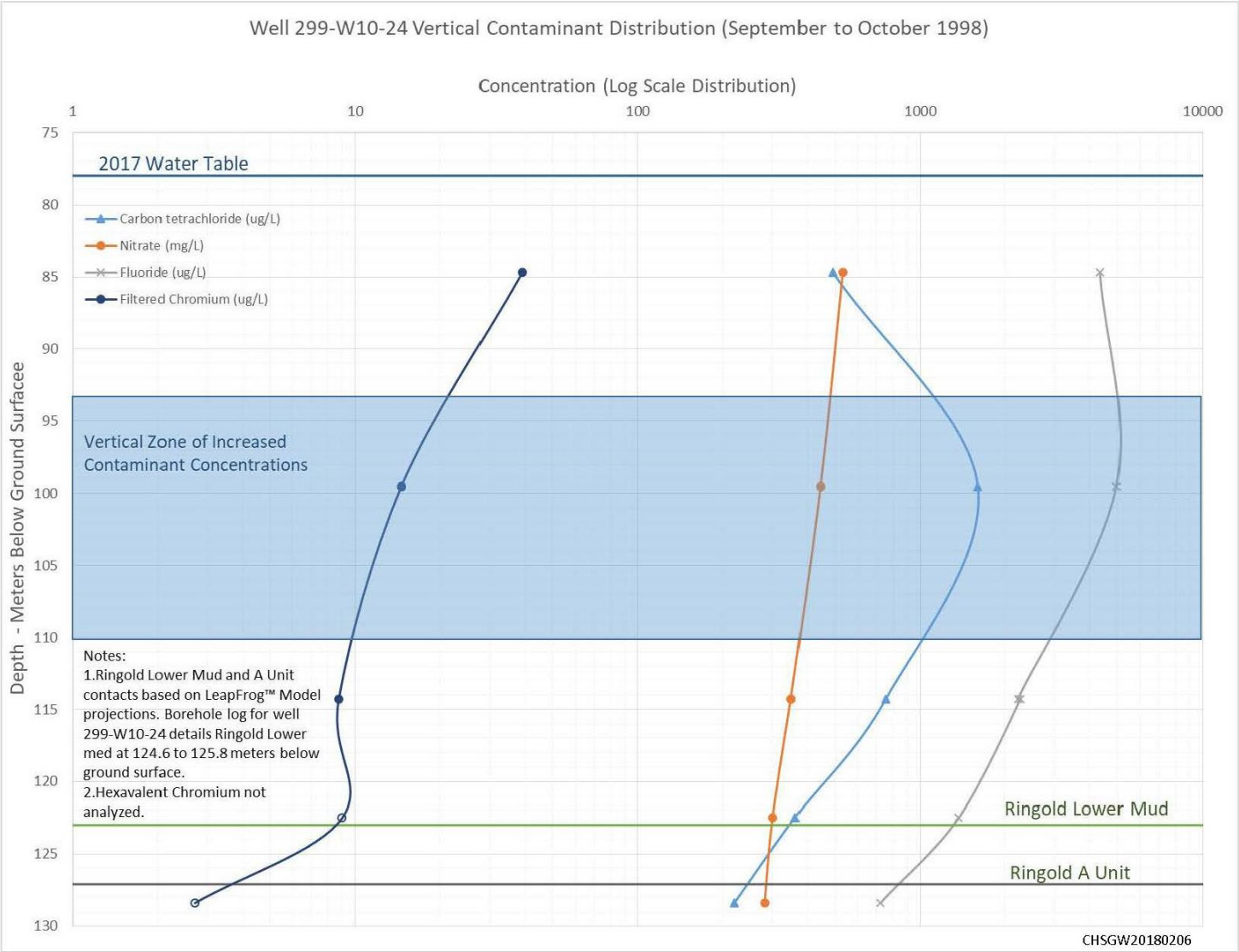


Figure 4-12. Vertical Contaminant Distribution Well 299-W10-24

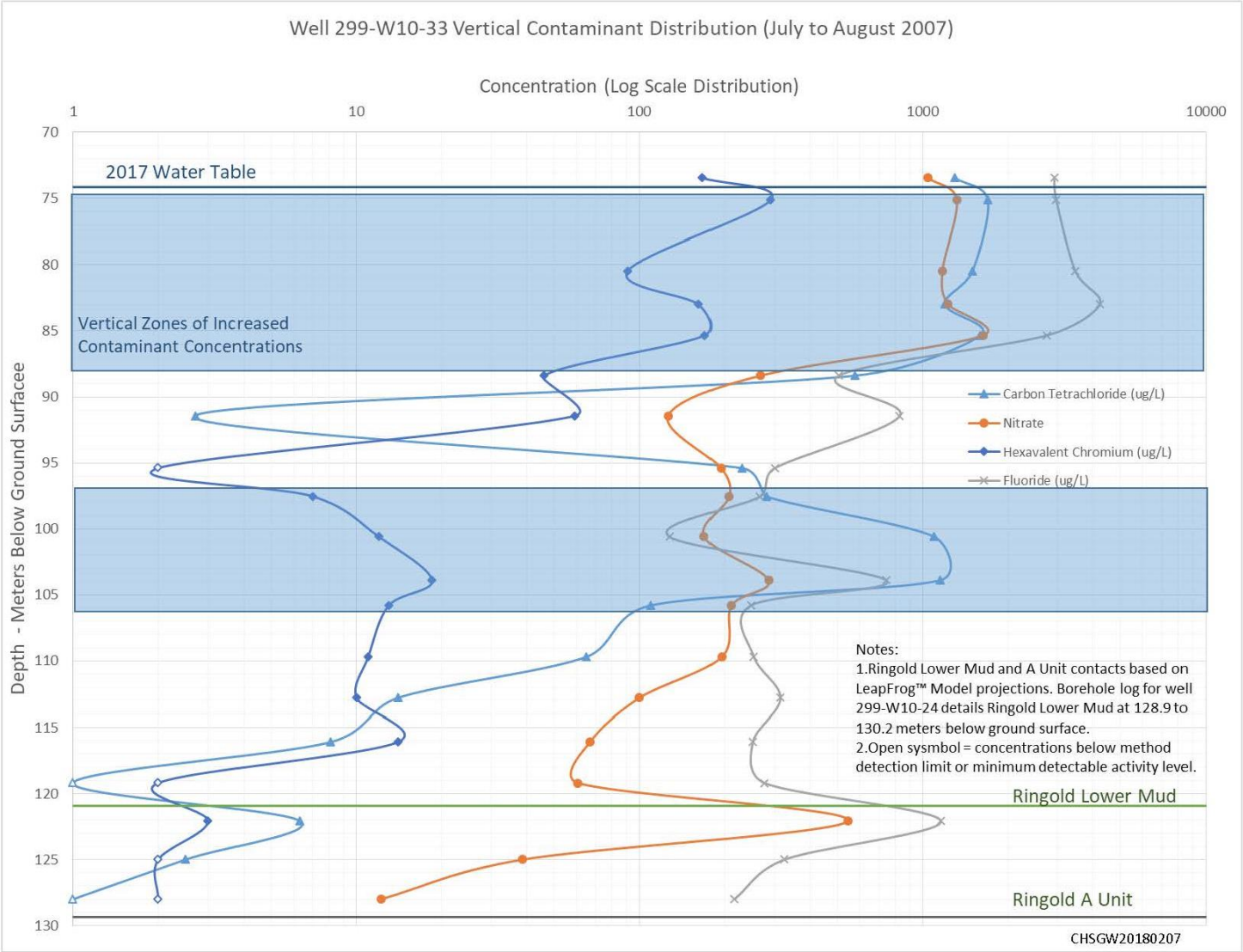


Figure 4-13. Vertical Contaminant Distribution Well 299-W10-33

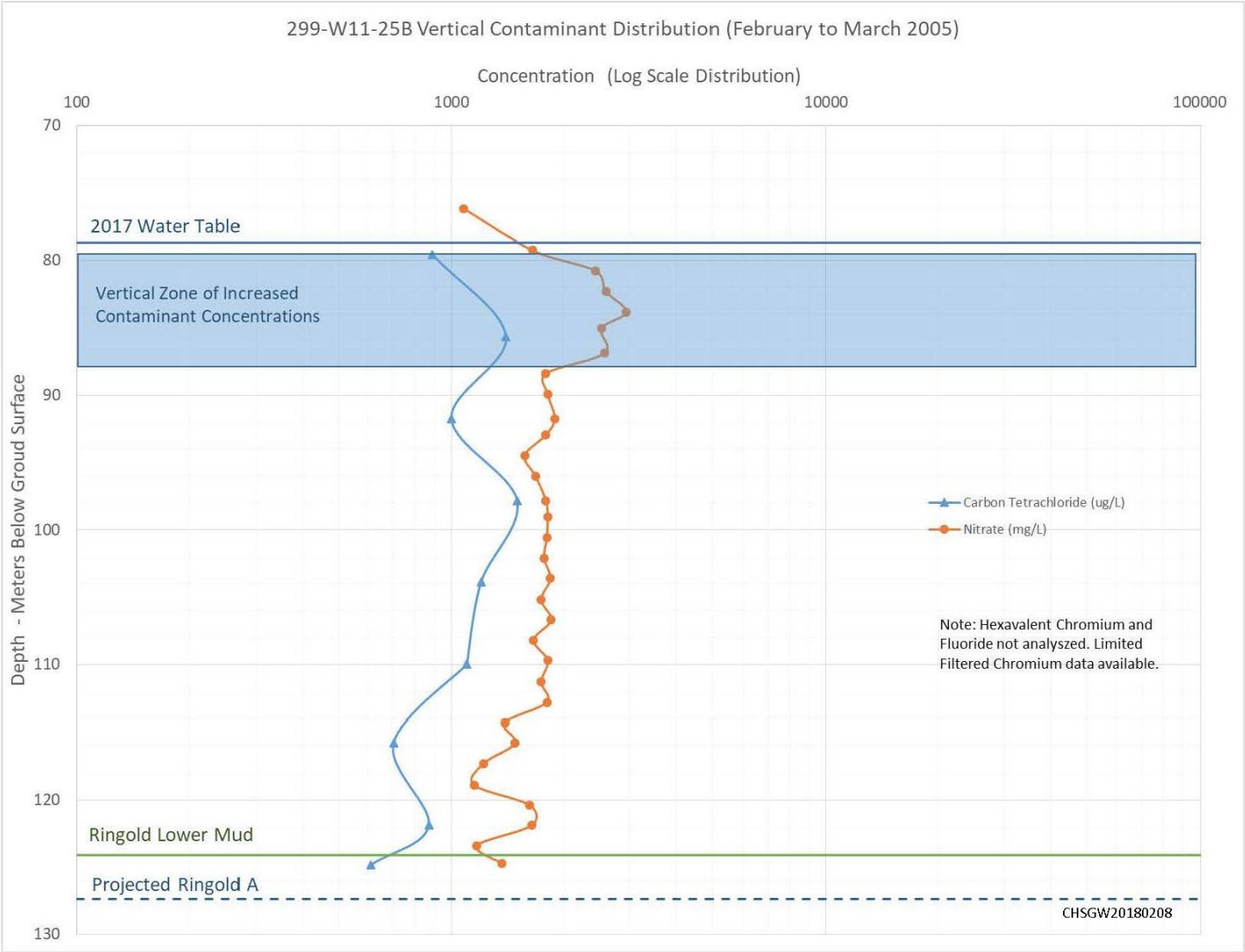


Figure 4-14. Vertical Contaminant Distribution Well 299-W11-25B

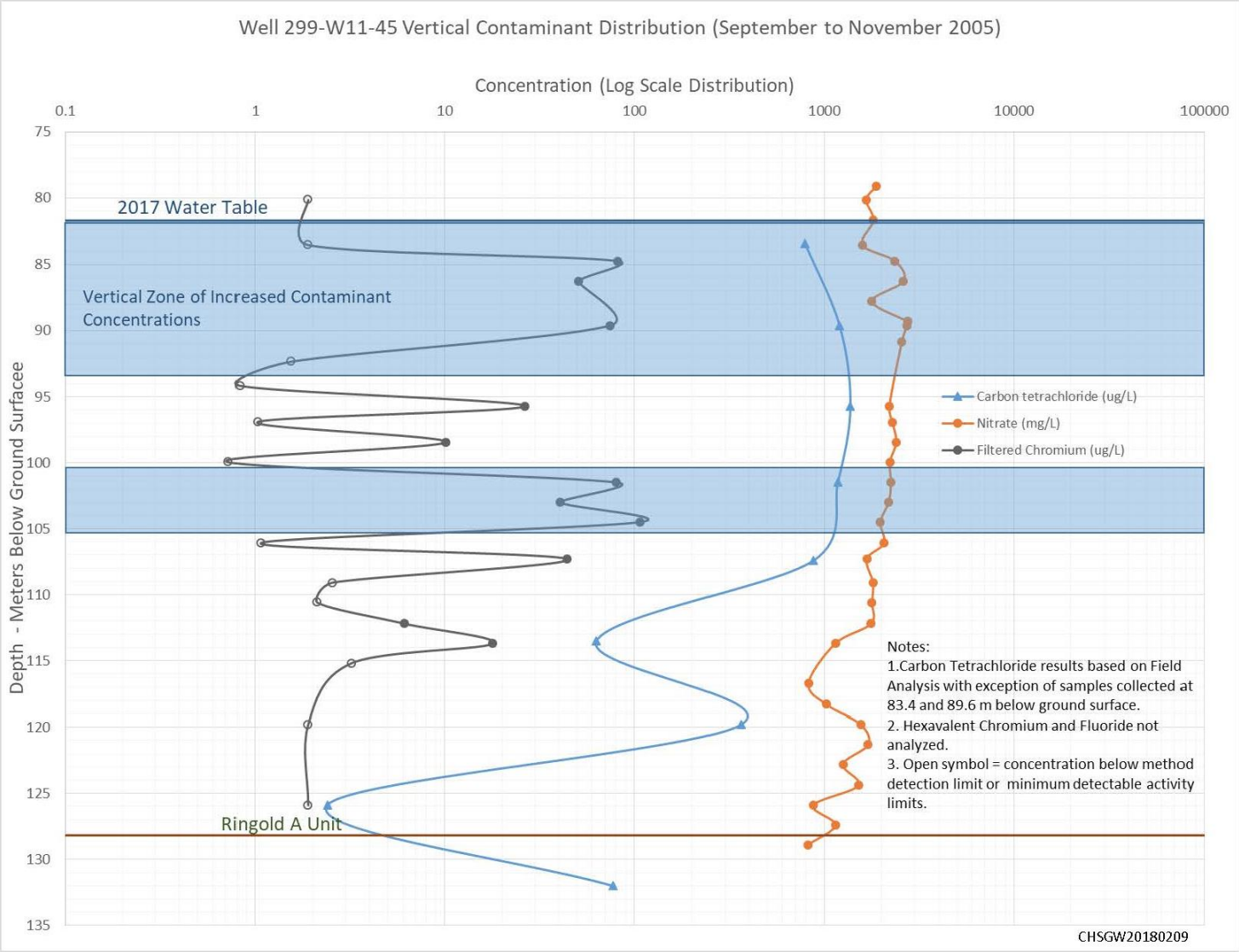


Figure 4-15. Vertical Contaminant Distribution Well 299-W11-45

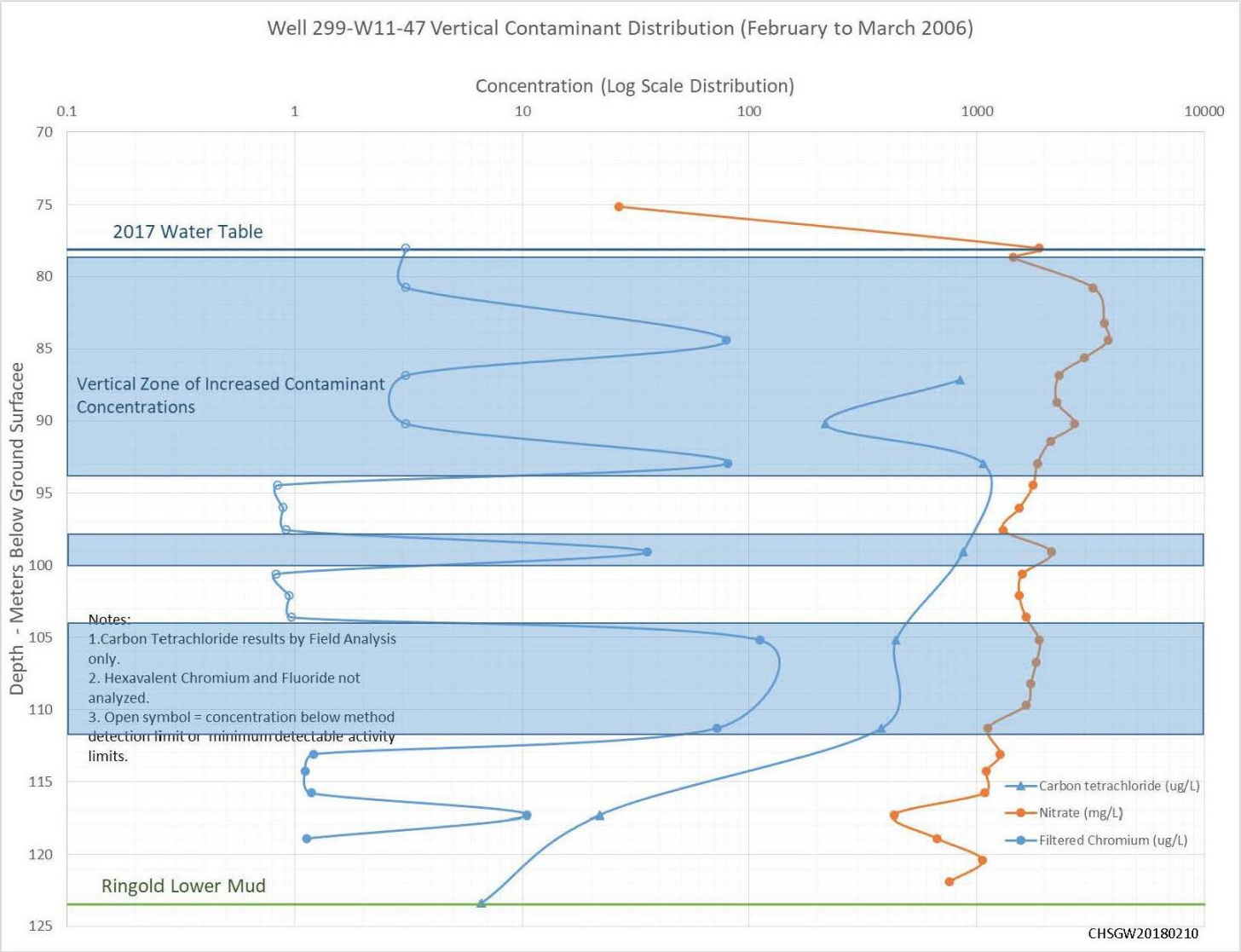


Figure 4-16. Vertical Contaminant Distribution Well 299-W11-47

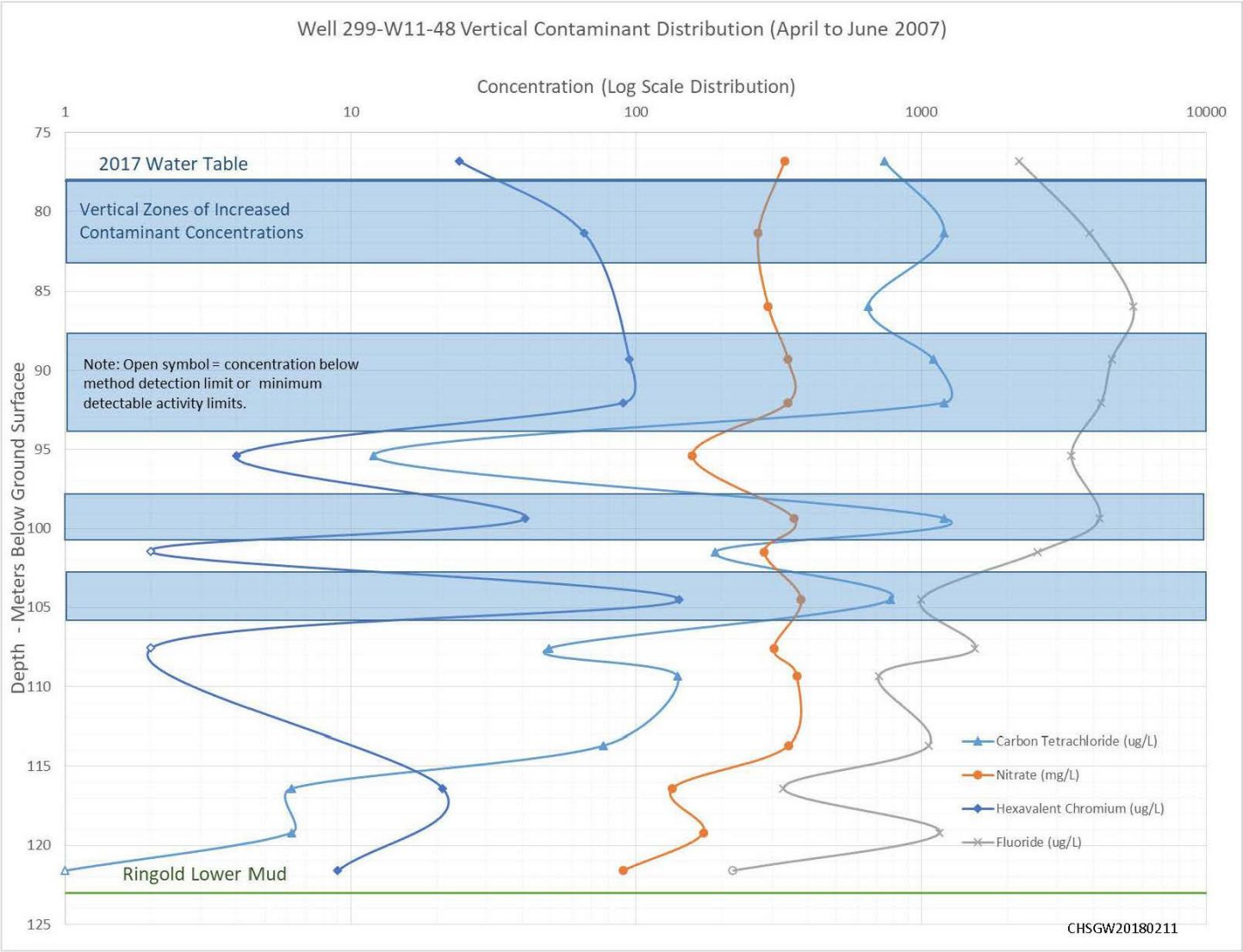


Figure 4-17. Vertical Contaminant Distribution Well 299-W11-48

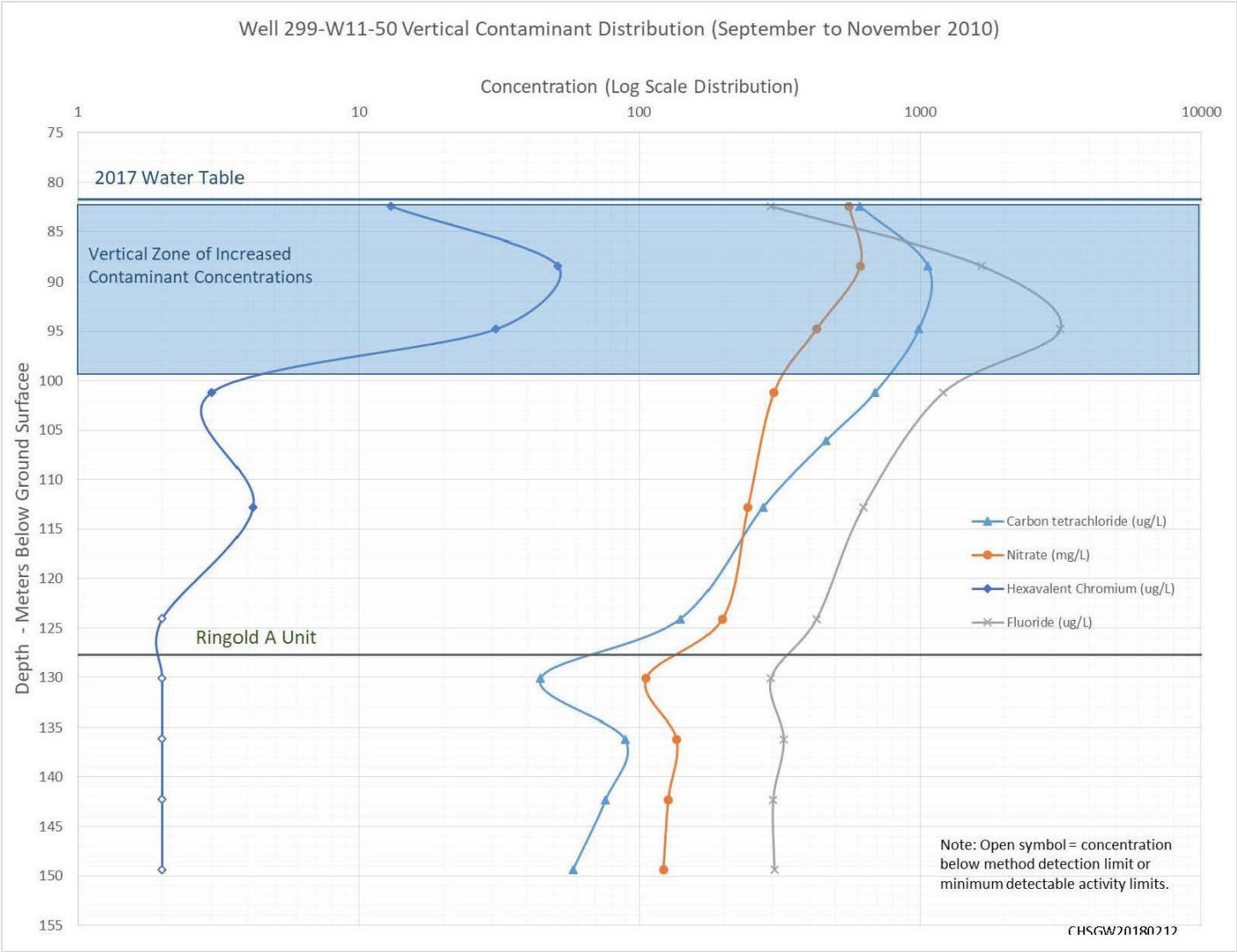


Figure 4-18. Vertical Contaminant Distribution Well 299-W11-50

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5 Groundwater Flow Simulations

Groundwater flow simulations were conducted to evaluate the groundwater monitoring network for WMA T (Figure 5-1) for its ability to detect increases in groundwater contamination due to hypothetical releases from the facility both under the influence of the 200 West P&T system and after cessation of P&T operations. The wells included in the interim status groundwater monitoring network are documented in Table 3-14 in DOE/RL-2016-66 and shown in Figure 5-1. The CPGWM is the principal computational tool used to simulate groundwater flow and evaluate the performance of the 200 West P&T groundwater remedy (CP-47631). The CPGWM and the scenarios that were simulated to evaluate the monitoring network are described briefly in this chapter. The modeling effort was aimed at potential future releases, and is not intended to address the effect of pre-existing contamination. A more detailed summary is included in Appendix F. Two simulation approaches were used: (1) a plume migration (transport modeling) analysis that provides insight into the dilution of groundwater contaminant concentrations at monitoring locations, and (2) a particle-tracking analysis that indicates the potential travel paths for contaminants released under hypothetical conditions. Both approaches are based on the continuous release of a hypothetical unit source at the water table beneath WMA T.

5.1 Central Plateau Groundwater Model

The model package report describing the CPGWM (version 8.3.4) was released in 2016 (CP-47631). The CPGWM simulates groundwater flow using the U.S. Geological Survey modular three-dimensional, finite-difference groundwater flow model, MODFLOW.

Contaminant transport is simulated using the Modular Three-Dimensional Multi-Species Transport Model (MT3DMS) code. MT3DMS was developed specifically for use with MODFLOW to simulate contaminant advection, dispersion, sources and sinks, and chemical reactions in groundwater systems.

Both particle-tracking and transport modeling calculations were performed to evaluate the monitoring well network. For particle tracking, the post-processor ModPath3DU was used to compute pathlines based upon results obtained from the CPGWM flow simulations. Additional information on the model and processing, including a more detailed description of the model, time discretization, calibration, and software, is included in Appendix F.

5.2 Simulation Scenarios

Using the CPGWM, groundwater flow simulations were performed to evaluate a range of possible 200 West P&T system operating conditions, referred to as “scenarios” and “sub-scenarios.” These scenarios reflect the potential range of groundwater flow and contaminant migration directions that could result from varying the adjacent 200 West P&T system extraction rates and injection well operations. Three scenarios were evaluated:

- Scenario 1: 200 West P&T system operating at an expected capacity of 8,725 L/min (2,305 gal/min).
- Scenario 2: 200 West P&T system operating at the planned expanded capacity of 9,464 L/min (2,500 gal/min).
- Scenario 3: 200 West P&T system shut down. These conditions would apply when the remedy is complete.

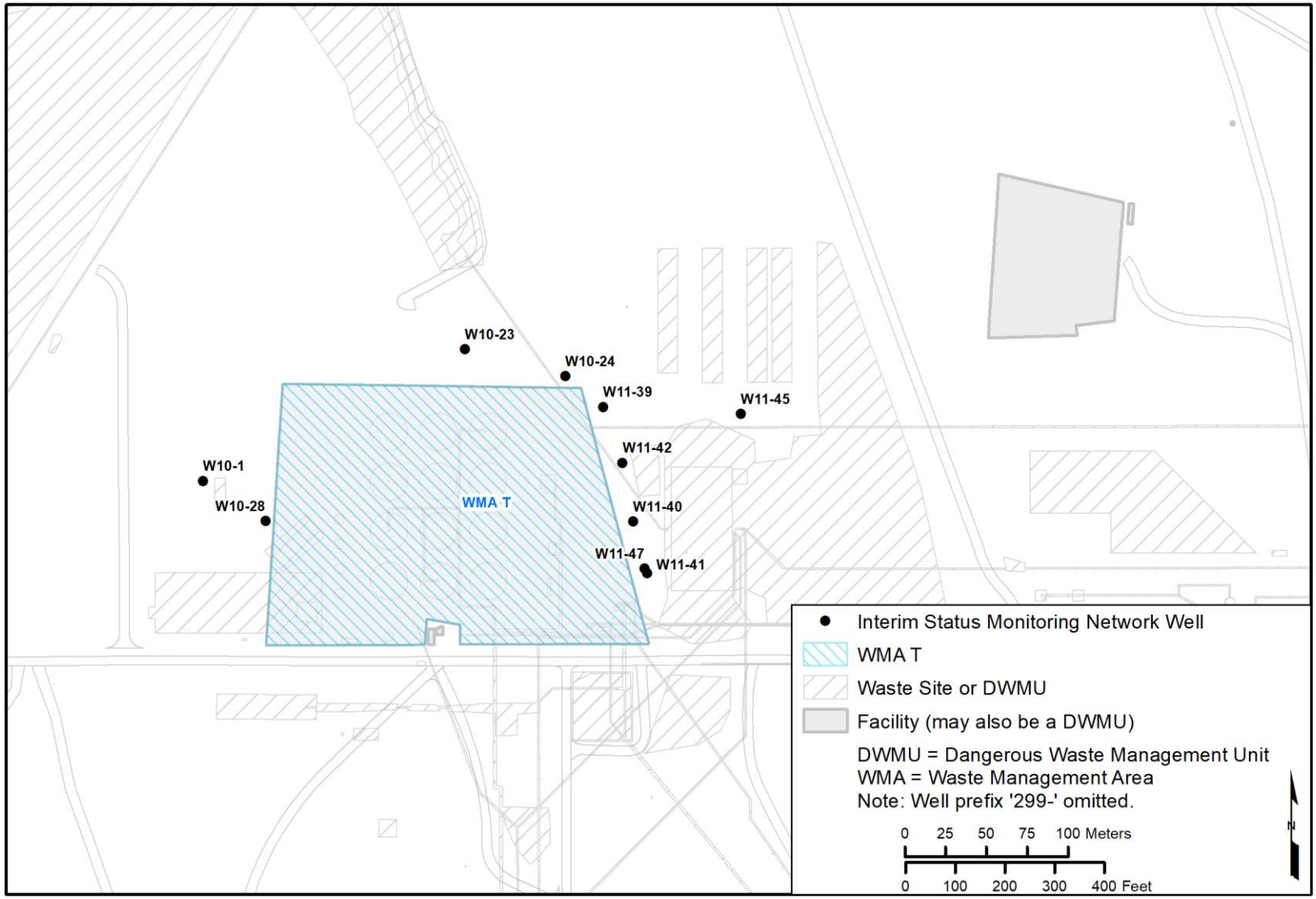

Figure 5-1. Interim Status Groundwater Monitoring Network (Table 3-14 in DOE/RL-2016-66)

Scenarios 1 and 2 both include 18 sub-scenarios (A through R) that evaluate how changes in the operation of injection wells could impact the effectiveness of the monitoring network. Extraction well pumping rates were not varied because the pumping within the plume is expected to continue at rates that maintain hydraulic capture until the P&T system operation is shut down in 30 years. Descriptions of the scenarios and sub-scenarios are provided in Table 5-1. The locations of the 200 West P&T system injection and extraction wells are shown in Figure 5-2. Average pumping rates for December 2016 are shown in parentheses next to the wells.

Table 5-1. Simulation Scenarios

Scenario	P&T System Capacity[a]	Sub-Scenario	Description	Scenario Weight (%)
1	2,305 gal/min (8,725 L/min)	A	Current conditions[b].	55
		B	Injection well 299-W10-35 operating at 50%.	5
		C	Injection well 299-W10-35 not operating.	3
		D	Injection well 299-W15-226 operating at 50%.	3
		E	Injection well 299-W15-226 not operating.	3
		F	Injection wells 299-W10-35 and 299-W15-226 not operating.	1
		G	Injection well 299-W10-36 not operating.	2
		H	Injection wells 299-W10-36, 299-W10-35, and 299-W15-226 not operating.	1
		I	Injection well 299-W6-14 not operating.	3
		J	Injection well 299-W6-16 not operating.	3
		K	Injection wells 299-W6-14 and 299-W6-16 operating at 50%.	3
		L	Injection wells 299-W6-14 and 299-W6-16 not operating.	1
		M	Injection wells 299-W18-41 and 299-W15-229 not operating.	2
		N	Injection wells 299-W15-29, 299-W18-36, 299-W18-38, and 299-W18-39 not operating.	3
		O	Injection wells 299-W15-228, 299-W15-229, 299-W15-29, 299-18-44, 299-W18-36, and 299-W15-29 operating at 50%.	5
		P	Injection wells 299-W18-41, 299-W18-39, 299-W18-38, 299-18-42, and 299-18-43 operating at 50%.	5
		Q	Injection wells 299-W15-229, 299-W15-29, 299-18-44, and 299-W18-36 not operating.	1
		R	Injection wells 299-W18-41, 299-W18-39, 299-W18-38, 299-18-42, and 299-18-43 not operating.	1
2	2,500 gal/min (9,464 L/min)	A	2,500 gal/min, injection rates rebalanced.	55
		B	Injection well 299-W10-35 operating at 50%.	5
		C	Injection well 299-W10-35 not operating.	3
		D	Injection well 299-W15-226 operating at 50%.	3
		E	Injection well 299-W15-226 not operating.	3

Table 5-1. Simulation Scenarios

Scenario	P&T System Capacity[a]	Sub-Scenario	Description	Scenario Weight (%)
2 (cont.)	2,500 gal/min (9,464 L/min)	F	Injection wells 299-W10-35 and 299-W15-226 not operating.	1
		G	Injection well 299-W10-36 not operating.	2
		H	Injection wells 299-W10-36, 299-W10-35, and 299-W15-226 not operating.	1
		I	Injection well 299-W6-14 not operating.	3
		J	Injection well 299-W6-16 not operating.	3
		K	Injection wells 299-W6-14 and 299-W6-16 operating at 50%.	3
		L	Injection wells 299-W6-14 and 299-W6-16 not operating.	1
		M	Injection wells 299-W18-41 and 299-W15-229 not operating.	2
		N	Injection wells 299-W15-29, 299-W18-36, 299-W18-38, and 299-W18-39 not operating.	3
		O	Injection wells 299-W15-228, 299-W15-229, 299-W15-29, 299-18-44, 299-W18-36, and 299-W15-29 operating at 50%.	5
		P	Injection wells 299-W18-41, 299-W18-39, 299-W18-38, 299-18-42, and 299-18-43 operating at 50%.	5
		Q	Injection wells 299-W15-229, 299-W15-29, 299-18-44, and 299-W18-36 not operating.	1
		R	Injection wells 299-W18-41, 299-W18-39, 299-W18-38, 299-18-42, and 299-18-43 not operating.	1
3	0		System shutdown following active P&T.	100

Notes: For injected treated water dilution calculations, unit concentrations released at injection wells correspond with initiation of each injection well (i.e., using actual dates/timing).

For release pathline calculations, unit concentrations released at the facility assumed a late 2017 release date for scenarios 1 and 2 and 2037 for scenario 3.

a. Scenario 1 pumping rate = 2,305 gal/min (composed of 305 gal/min from 200-UP-1 extraction wells and 2,000 gal/min from 200-ZP-1 extraction wells); Scenario 2 pumping rate = 2,500 gal/min (composed of 305 gal/min from 200-UP-1 extraction wells and 2,195 gal/min from 200-ZP-1 extraction wells); In both cases, an extraction rate of 60 gal/min at well 299-E33-268, located in the 200-BP-5 Operable Unit, is included in the extraction total for 200-ZP-1.

b. Current conditions as defined in Appendix G.

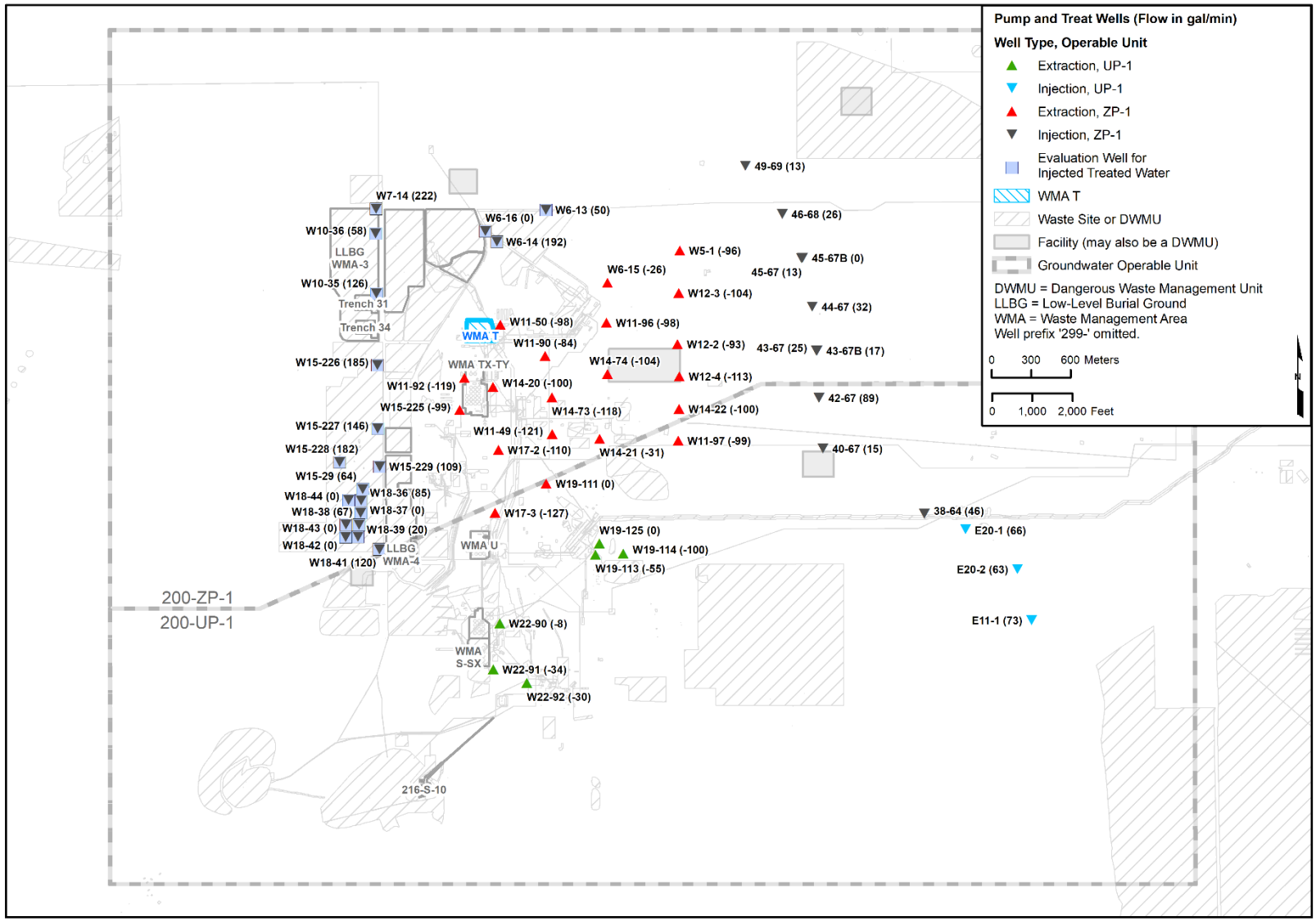

Figure 5-2. Locations and Average Pumping Rates (for December 2016) of 200 West P&T System Wells

The scenarios and sub-scenarios were selected to describe a range of conditions near the facilities evaluated within the 200 West Area. Some sub-scenarios were selected to examine conditions under typical, current, or likely injection well operating conditions, whereas others were selected to represent extreme or unlikely operating conditions. These extreme operating conditions, or bounding scenarios, are included to provide a bounding set of resultant groundwater flow and contaminant migration directions that can be used to evaluate the locations of the interim status monitoring network wells for WMA T and to assist in determining whether adjustment to the monitoring network is needed.

As described in Appendix F, a weight, in terms of a percentage, was assigned to each sub-scenario to reflect the relative probability of each operating condition. Those weights, shown in Table 5-1, are normalized on a scale of 0% to 100%. The highest weight is assigned to the most likely operating conditions, represented by sub-scenario A, while the extreme, or boundary, conditions are given low weights. The weights are used, as described in Section 6.2.2, in calculations that combine the results for all the sub-scenarios to identify areas where a hypothetical release to the water table would be most likely to migrate and be detectable.

Appendix A in Appendix F provides pumping rates for the 200 West P&T system extraction and injection wells for scenarios 1 and 2; scenario 3 evaluates conditions with no active extraction or injection well operations. The CPGWM represents the “as-built” screened intervals (i.e., top and bottom elevations) for extraction and injection wells (Konikow et al., 2009, *Revised Multi-Node Well (MNW2) Package for MODFLOW Ground-Water Flow Model*) and hence the depth below the water table at which injection (or extraction) at each well is focused. The monitoring wells were assumed to be screened across the water table, so that sampling from them focuses on the quality of water at or close to the water table. The P&T operations were assumed to end in year 2037, which is the end date of P&T operations per EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*.

Simulations were run for each scenario to examine dilution from injection of treated water and particle pathlines of hypothetical releases from WMA T. The results of those simulations were used to evaluate the efficacy of the groundwater monitoring network to detect hypothetical releases from WMA T.

6 Calculations

Particle-tracking and transport simulations were performed to evaluate the efficacy of the groundwater monitoring network to detect significant increases in groundwater contamination that might occur from a hypothetical release at WMA T. The simulations also account for the hydraulic influence of the 200 West P&T system extraction and injection wells. The simulations performed and output produced during the evaluation of the monitoring well network are described briefly in this chapter. Additional details about the modeling, including software used, inputs, and assumptions, are described in Appendix F and in Appendix G.

Particle-tracking was performed first on a regional scale and then on a facility-specific scale. The regional-scale particle-tracking simulations presented in Appendix F included an analysis of the pathlines of injected treated water from 200 West P&T system injection wells for each scenario that considered advection only. Particle tracking using both advection and dispersion was then performed on a facility-specific scale to simulate a hypothetical release from the facility.

Similarly, transport modeling was performed on a regional scale to represent the migration, mixing, and dilution of treated water injected at the 200 West P&T system injection wells for each of the scenarios. On a facility-specific scale, transport modeling was performed to evaluate the migration, mixing, and dilution of groundwater impacted by a hypothetical release to the water table beneath the facility.

Particle-tracking and transport modeling calculations and the output produced for WMA T are described in the following sections and discussed in more detail in Appendix G.

6.1 Principal Assumptions and Inputs

The principal inputs to the modeling performed to evaluate the monitoring network for WMA T are the assumed extraction rates and injection well operations for the 200 West P&T system, model boundary conditions, and the assumed transport parameters of a hypothetical conservative contaminant release to groundwater beneath the facility. The parameters of the groundwater flow component of the CPGWM have been formally calibrated to historical data and conditions. As discussed in Appendices F and G, the outputs of the flow model (i.e., heads and flow fields) correspond in general with measured data throughout the area of interest. The parameters of the transport component of the CPGWM have not been formally calibrated to historical data and conditions. The transport parameters, however, have been qualitatively corroborated via simulations conducted as part of the work to simulate tritium concentrations in monitoring wells adjacent to the State-Approved Land Disposal Site. Tritium is a conservative contaminant with respect to migration in groundwater.

Analysis presented in Section 7.4 of Appendix F shows that, based on present conditions, no significant vertical migration is expected in the 200 West Area. The vertical movement that is likely to occur is limited to area near extraction wells. Section 7.4 of Appendix F also concludes that the American Petroleum Institute (API) calculator can be used to verify the appropriateness of the depths of the well screens for monitoring wells. In addition to confirming the use of the API calculator, the results of the analysis of particle vertical distribution agree with the conclusion of Hantush, 1964, “Hydraulics of Wells,” that the flows at locations that are a distance greater than approximately 1.5 to 2 times the saturated thickness from extraction wells are predominately horizontal. The facility-specific results of the API calculator are presented in Section 7.5 of Appendix G. Transport parameters used in the simulations are unchanged from the transport parameters used in modeling performed for annual reports of the 200 West P&T operations (Section 3.5 in DOE/RL-2016-20, *Calendar Year 2015 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump and Treat Operations*). Since these parameters are fundamental to the calculations, they are listed in Table 6-1, and references are provided in

the table footnotes. Additional details on the inputs to and assumptions used in the calculations are included in Appendices F and G.

Table 6-1. Properties Assumed for Transport Calculations Using the CPGWM

Assumed Properties for Purposes of Conservative Dilution Calculations					
Distribution Coefficient (mL/g)	**Half-Life (yr)**	**Half-Life (d)**	**Degradation Rate (one/d)**	**Reference for Distribution Coefficient**	**Reference for Degradation Rate**
0.0	None assumed	None assumed	None assumed	None assumed	None assumed
Aquifer-Dependent Transport Parameter Values for the Central Plateau Model					
Property	**Value**	**Comments**			
Effective porosity	0.15	Approximate central value (Table D-2 of DOE/RL-2007-28)			
Longitudinal dispersivity	3.5 m	Introduced for stability of the transport calculations based on recommendation from the MT3DMS manual (Zheng and Wang, 1999)			
Transverse dispersivity	0.7 m	20% of longitudinal (DOE/RL-2008-56)			
Vertical dispersivity	0.0 m	DOE/RL-2008-56			
Molecular diffusion constant	0.0 m^2/d	Negligible term			

References: DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*.

DOE/RL-2008-56, *200 West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses*.

Zheng and Wang, 1999, *MT3DMS: A Modular Three-Dimensional Multispecies Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide*.

6.2 Particle Tracking

To evaluate the efficacy of the groundwater monitoring network to detect hypothetical increases in concentrations in groundwater due to releases from WMA T, facility-specific particle-tracking calculations were performed for each sub-scenario in scenarios 1 and 2 and for scenario 3. Particles were released to the water table annually and tracked forward, with initial release in 2017 along the perimeter of each of the twelve 2,000,000 L (528,000 gal) SSTs located in WMA T. The particle release locations are shown in Figure 6-1 in Appendix G. These "focused releases" reflect hypothetical tank leaks from the SSTs that reach the water table. This release scenario does not incorporate any aspects of transport through the overlying vadose zone. Once released to the water table, the particle movement is then predominantly horizontal, with minor components of vertical migration in response to very limited infiltration from groundwater recharge and the operation of nearby extraction and injection wells.

In all sub-scenarios for scenarios 1 and 2, particles were released annually and tracked through to the end of fiscal year (FY) 2037, which is when the 200-ZP-1 groundwater P&T remedy component is expected to cease operation in accordance with EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* . For scenario 3, which evaluates conditions after cessation of P&T system operations, the initial release to the water table is the end of FY 2037, after which the particles are released every 5 years thereafter for 100 years.

6.2.1 Particle Pathlines

The particle-tracking post-processor ModPath3DU was executed to track particles using both advection and dispersion. To simulate dispersion with particle tracking, the Random-Walk tracking option within ModPath3DU was used as discussed in Appendix F. The results were post-processed and superimposed upon figures showing injection and monitoring wells. These particle-tracking maps indicate if monitoring locations lie in the migration pathway of any hypothetical releases from the facility.

Particles were tracked for hypothetical releases from WMA T for each of the simulation scenarios identified in Table 5-1. Details on generation of the input files, particle tracking, and post-processing of the output data are provided in Appendices F and G.

6.2.2 Relative Detectability Calculations

For each scenario, a calculation was performed to identify areas of the aquifer where a hypothetical release to the water table from WMA T would be most likely to migrate and be detectable. There is no assumption of a concentration, allowing a comparison between scenarios and also geographically between wells as the relative detectability stays the same. The effects of the spreading and reduction of detectability as the result of injection are not applied as a specific element. In each scenario, the flow rates and directions all explicitly include the effects of injection. Across scenarios modeled, the relative detectability calculation allows for the placement of wells in the most likely locations to detect a potential release. This calculation of “relative detectability” was performed on a finer spatial resolution than provided by the discretization of the CPGWM simulation grids. This refined “calculation subgrid”, shown in Figure 6-1, comprises 20 by 20 m (66 by 66 ft) cells, resulting in 25 calculation cells within each CPGWM simulation cell (100 by 100 m [328 by 328 ft], also shown in Figure 6-1). The relative detectability was calculated as follows:

- As described for particle tracking, particles are released to the water table within the focused release area for the conditions in each sub-scenario. A particle count map is then produced for each sub-scenario by counting the number of particles that pass through each pre-defined calculation subgrid cell, which enables development of a contour map of the particle count for each grid cell.
- For each scenario, the relative detectability was then determined by calculating the weighted sum of all the particles that traversed each refined calculation subgrid cell over all the sub-scenarios within that scenario. The weights given to the sub-scenarios are shown in Table 5-1. The weighted sum of these counts was computed as described in Appendix G. This method produces a relative detectability map for each scenario that gives more weight to the more likely scenarios and less weight to the more extreme and less likely scenarios. The relative detectability map for scenario 3 is equivalent to the particle count map because scenario 3 has no sub-scenarios.

The resulting maps of relative detectability for each scenario show the overall distribution for a release from WMA T considering both advection and dispersion. The release distributions are color coded to reflect the weighted percent distributions of particle counts throughout the release pathline. Where the weighted percent distribution of particle counts is higher, the probability of release detection is also higher.

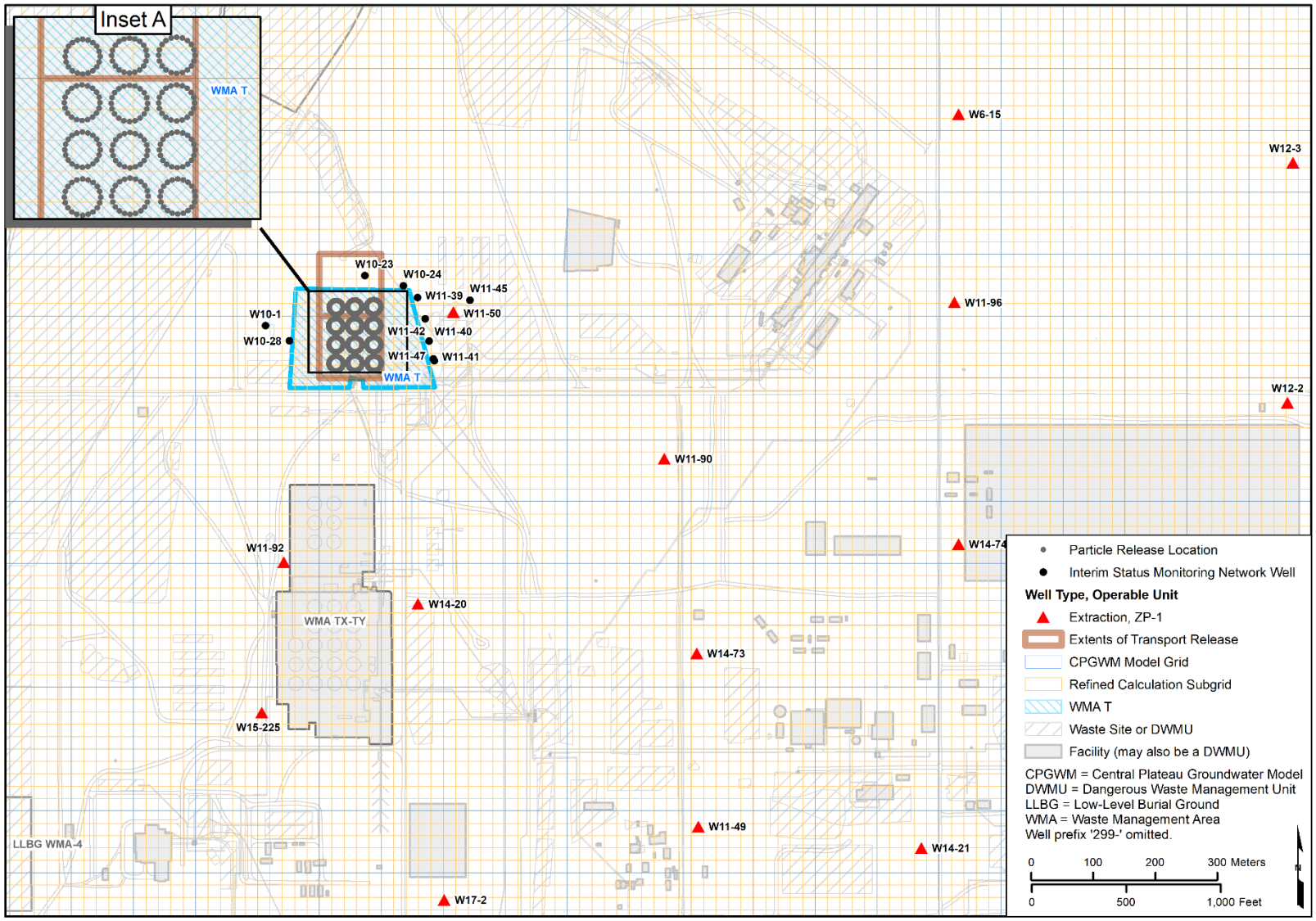

Figure 6-1. Location of Calculation Subgrid in Relation to 200 West Area Facilities Evaluated in Appendix F

6.3 Transport Calculations

Transport calculations were performed to evaluate the impact of the injection of treated water at injection wells as well as the impact of hypothetical releases from the facility to the underlying water table. Treated water injected at the 200 West P&T system injection wells will mix with ambient groundwater, resulting in dilution of the ambient groundwater to varying degrees at different locations and times. A release of contamination from WMA T that ultimately reaches the underlying water table will be diluted as a result of this same mixing process.

The potential effects of dilution were evaluated using a "unit-plume" approach to transport simulation. When using a unit-plume approach, the unit concentration can represent a single contaminant, a combination of contaminants, or treated water. In each case, for purposes of the analysis performed, the unit concentration is referred to as a "unit source." The objective is to use the concept of a unit source to simulate in relative rather than absolute terms the likely fate (i.e., migration and mixing) of the injected treated water or of a particular release of contaminant(s) in the subsurface.

For this analysis, a unit concentration (C = 1.0) is used to represent either the treated water that is injected at the 200 West P&T system injection wells or water that is impacted by a release from a DWMU that mixes continuously with groundwater over an area immediately beneath the facility. Consistent with the unit-plume concept, the ascribed value of 1.0 at the unit source – whether an injection well or the impacted water table beneath the facility – denotes that the water at the location of interest comprises 100% of the quantity of interest (i.e., it has not yet undergone any mixing with other water sources). The effects of mixing and dispersion within the aquifer are simulated as water migrates away from the location of the unit source. As a result, over time and throughout space, the simulated concentration represents that fraction of the original water present that remains out of the water released or injected at the unit source location. For example, a concentration of 0.5 indicates that at that time and location, 50% of the water comprises water that was released at the unit source location, and 50% of the water comprises other water – typically, ambient groundwater with which the water originating from the unit source has mixed and migrated. The simulated concentrations from these calculations can be interpreted in terms of a dilution factor.

- If the unit source represents injection of treated water, then the simulated concentration at any point or time represents the fraction of the water at that location that comprises injected treated water, demonstrating how that fraction has been reduced via the processes of advection and dispersion. This calculation was performed only for scenarios 1 and 2 because scenario 3 assumes cessation of 200 West P&T system operations.
- If the unit source represents a contaminant release or water table impact, then the simulated concentration at any point or time can be interpreted two ways:
  - First, as representing the fraction of the water at that location that comprises the originally impacted groundwater from beneath the facility where the release occurred. That value, 1.0 minus the concentration, thus represents the fraction of other water (typically a combination of ambient groundwater and injected treated water from the P&T system) with which the water originating from the unit source has mixed and migrated.
  - Second, as representing a "dilution factor" or ratio to which the concentration at the source has been reduced via the processes of advection and dispersion.

The following "unit plume" transport calculations were performed to illustrate the potential effects of dilution via mixing.

- To represent the migration, mixing, and dilution of treated, injected water, unit concentrations representing injected water were released to the water table from injection wells to simulate the injected water migration and transport through FY 2037.
- To represent the migration, mixing, and dilution of groundwater impacted by a continuous release from a hypothetical contaminant source at WMA T, unit concentrations representing the hypothetical contaminant release were released at the water table in two model grid cells representing WMA T (shown in Figure 6-1 in Appendix G).The migration and transport of the release in groundwater were simulated through FY 2037 for scenarios 1 and 2. Scenario 3 was simulated from 2037 through 2137.

In each case, two sets of outputs from these dilution calculations were prepared. These comprise time-series plots of concentrations at selected spatial locations and spatial "snapshots" of concentrations at the water table throughout the aquifer at certain times.

- The interpretation and thus the descriptor of the figures that plot the simulated concentrations over time at selected spatial locations differ depending on the type of unit source that was simulated:
  - In the case of treated water injection as the unit source, the time-series plots are referred to as "injected treated water dilution breakthrough curves."
  - In the case of a simulated release to the water table being the unit source, the time-series plots are referred to as "release concentration breakthrough curves."
- The figures that depict the simulated concentrations at the water table throughout the 200 West Area at a selected time are similarly referred to as:
  - "Injected treated water dilution plumes" for the cases where the unit source is the injected water entering the aquifer via the 200 West P&T system injection wells. Those figures indicate the fraction of the water at those locations that comprises treated water injected at the 200 West P&T system injection wells.
  - "Release unit plume maps" for the cases where the unit source is the release to the water table from the facility. Those figures indicate the fraction of the water at those locations that comprises the originally impacted groundwater from beneath the facility where the release occurred.

7 Simulation Results and Conclusions

This chapter presents the simulation results and conclusions regarding the groundwater monitoring network's ability to detect hypothetical releases from WMA T under varying 200 West P&T system operating conditions. The interim status groundwater monitoring network wells that were evaluated are shown in Figure 5-1. The results presented here (conclusions can be found in Section 7.4) are derived from the calculations described in Chapter 6 that were performed for the various scenarios described in Chapter 5. Throughout this chapter, sub-scenario A represents current operating conditions as defined in Appendix G.

Both transport and particle-tracking calculations accounted for advection and dispersion processes, and both types of calculations were considered in the evaluation of the monitoring well network. As described in Chapter 6, the output of transport calculations include the following:

- Injected treated water dilution breakthrough curves – Time-series plots for each monitoring well of simulated treated water concentrations from treated water injected at 200 West P&T system injection wells.
- Release concentration breakthrough curves – Time-series plots for each monitoring well of simulated unit contaminant concentrations from the hypothetical release in the CPGWM model grid cell(s) beneath the WMA T defined release area.
- Injected treated water dilution plumes – Maps that indicate, at a selected point in time, the relative fraction of the groundwater that comprises the treated water injected at 200 West P&T system injection wells.
- Release unit plume maps – Maps that indicate, at a selected point in time, the relative fraction of the groundwater that comprises the hypothetical release to groundwater beneath WMA T.

Outputs of the particle-tracking calculations include the following:

- Particle-tracking maps – Maps that show the particle pathlines of a hypothetical release to groundwater.
- Particle count maps – Maps that show the count of particles that traverse each cell of the refined calculation subgrid over a selected time-frame.
- Relative detectability maps – Maps that show the distribution of a release from the facility. The relative detectability map combines all the particle count maps within each scenario, assigning greater weight to the results for more likely scenarios and less weight to scenarios that are characterized by unlikely or extreme operating conditions.

For existing downgradient well locations, breakthrough curves for injected treated water dilution and release concentrations can be compared to evaluate which well locations are likely to show higher dilutions from injected treated water and which are likely to have more detectable concentrations from releases from WMA T. The breakthrough curves for the existing monitoring wells are discussed in Section 7.1.

Differences between transport modeling and particle-tracking methods can result in variations in outputs. Those variations are apparent when comparing the release unit plume maps created using transport modeling and the particle tracking maps created using particle tracking. Each type of map shows the results or each calculation method for the same selected point in time for the hypothetical release to the groundwater table beneath the facility for each sub-scenario. Selected release unit plume maps and particle-tracking maps are included in Sections 7.1 and 7.2, respectively. The maps represent conditions at the end of operation of the 200 West P&T system in 2037 for scenarios 1 and 2 and in 2137 for scenario 3.

Maps of relative detectability for scenarios 1, 2, and 3 identify where a hypothetical release to the groundwater table beneath WMA T would most likely migrate and be detectable. The relative detectability maps are discussed in Section 7.2. Section 7.3 presents an evaluation of proposed new monitoring wells, and Section 7.4 presents the conclusions to the evaluation of the monitoring well network.

7.1 Breakthrough Curves and Release Unit Plume Maps

Transport modeling was used to create breakthrough curves for unit concentrations of injected treated water and release concentrations for each monitoring well location. It was also used to create spatial snapshots of the release unit concentration plumes, or release unit plume maps.

For monitoring wells 299-W10-1, 299-W10-23, 299-W10-24, 299-W10-28, 299-W11-39, 299-W11-40, 299-W11-41, 299-W11-42, 299-W11-45, and 299-W11-47 (Figure 5-1), injected treated water dilution breakthrough curves and release concentration breakthrough curves were prepared for each sub-scenario under scenarios 1 and 2 and for scenario 3. For both types of breakthrough curves, bold black lines are used to indicate sub-scenario A, which is considered to represent the most likely future operating scenario.

The injected treated water dilution breakthrough curves indicate, for each sub-scenario, the estimated dilution at the monitoring well from the injection of treated water at the 200 West P&T system injection wells and the relative time of arrival of the treated water at the monitoring well. The start of the simulation represents 2012, the year of startup of the 200 West P&T operations. The simulations assume that the 200 West P&T system operating conditions of sub-scenario A continue until October 1, 2017, at which time, the operating conditions for each separate sub-scenario are assumed to start. This assumption is reflected in the breakthrough curves by the single trend line for injection treated water dilution up to October 2017 followed by diverging curves representing adjustments to the injection well operations for each sub-scenario. Figures 7-1 through 7-10 show the injected treated water dilution breakthrough curves for monitoring wells 299-W10-1, 299-W10-23, 299-W10-24, 299-W10-28, 299-W11-39, 299-W11-40, 299-W11-41, 299-W11-42, 299-W11-45, and 299-W11-47, respectively, for scenario 1. Table 7-1 shows the range of the injected treated water dilution breakthrough curves for the monitoring wells for scenarios 1 and 2.

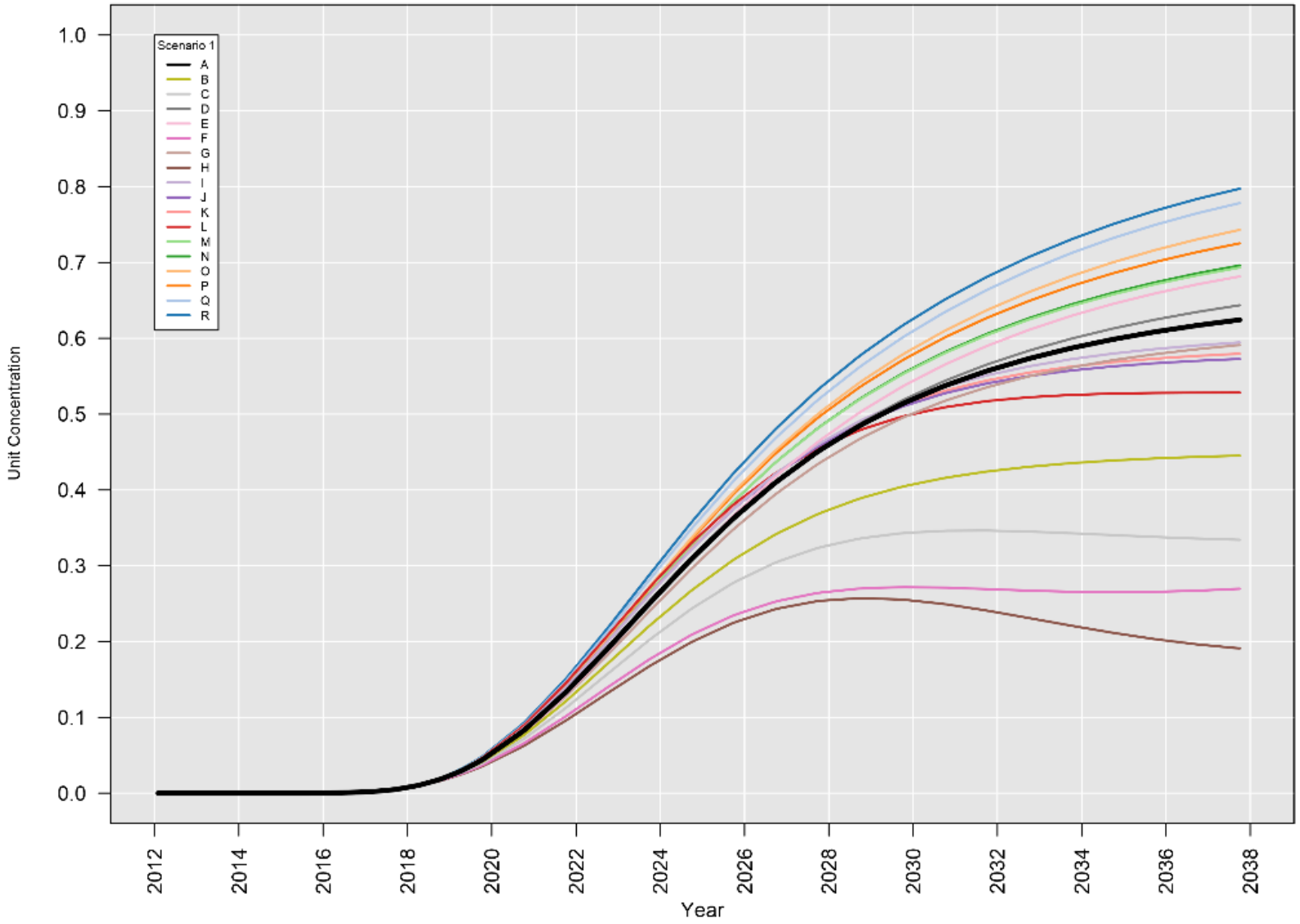

Figure 7-1. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-1

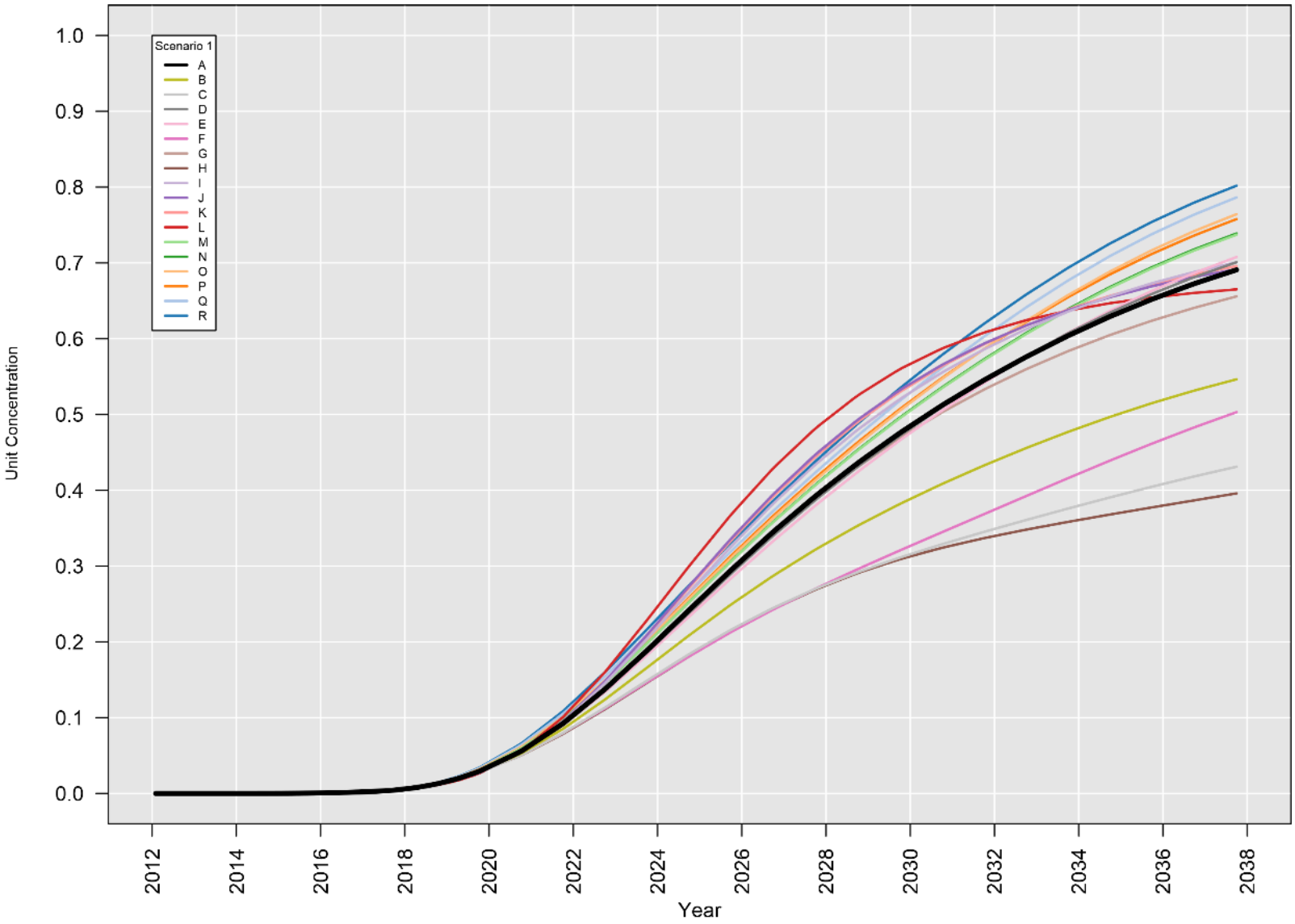

Figure 7-2. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-23

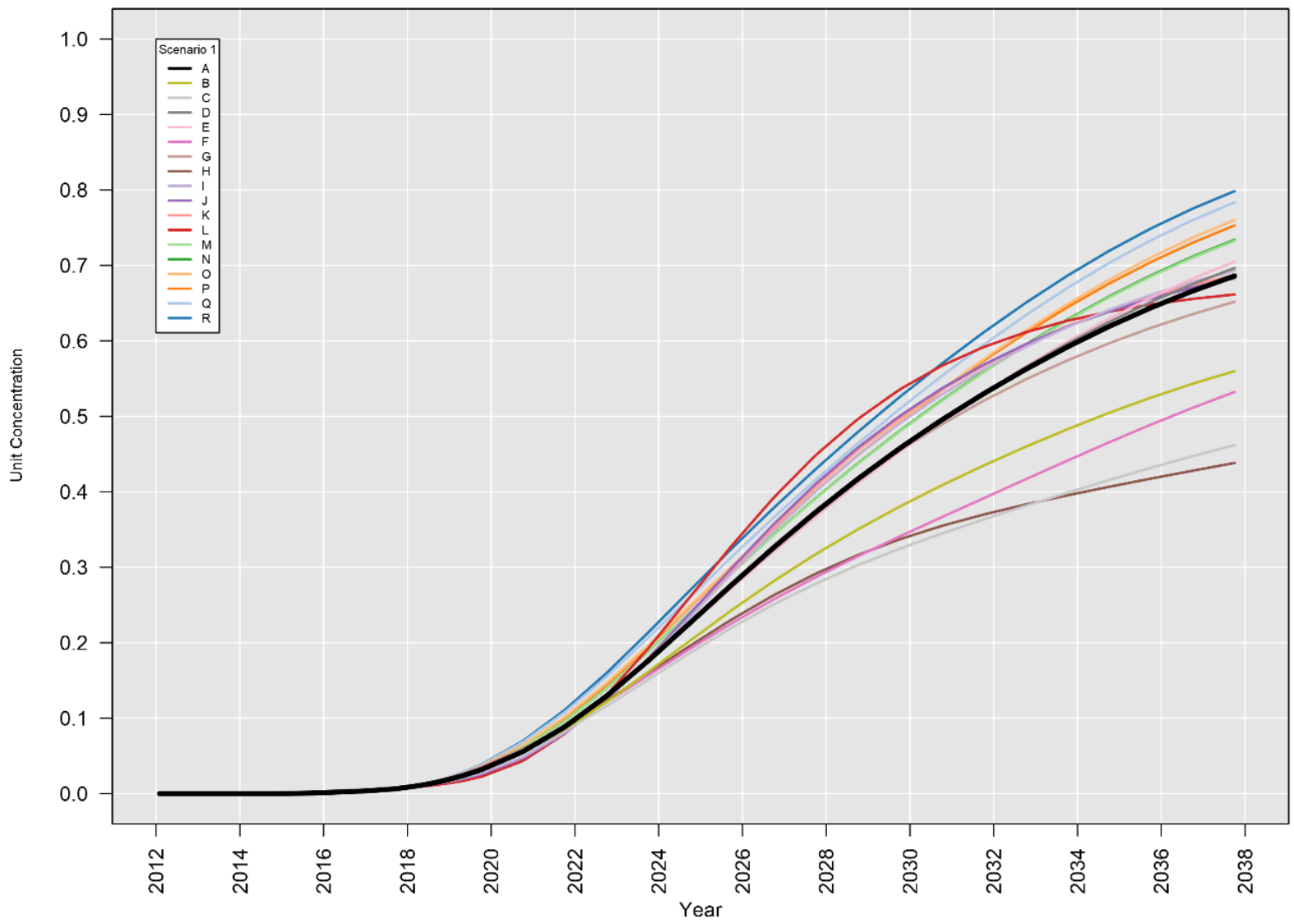

Figure 7-3. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-24

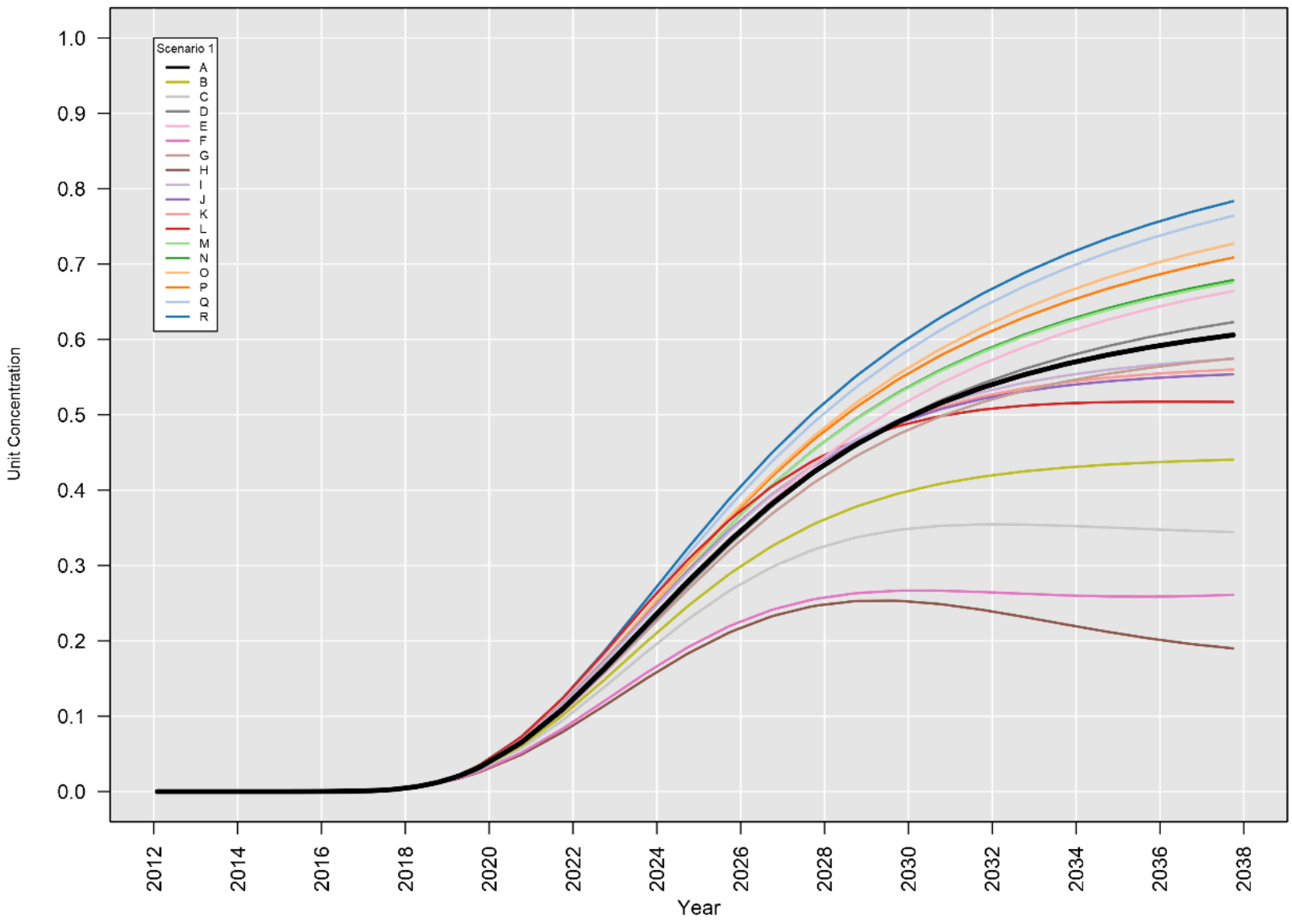

Figure 7-4. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-28

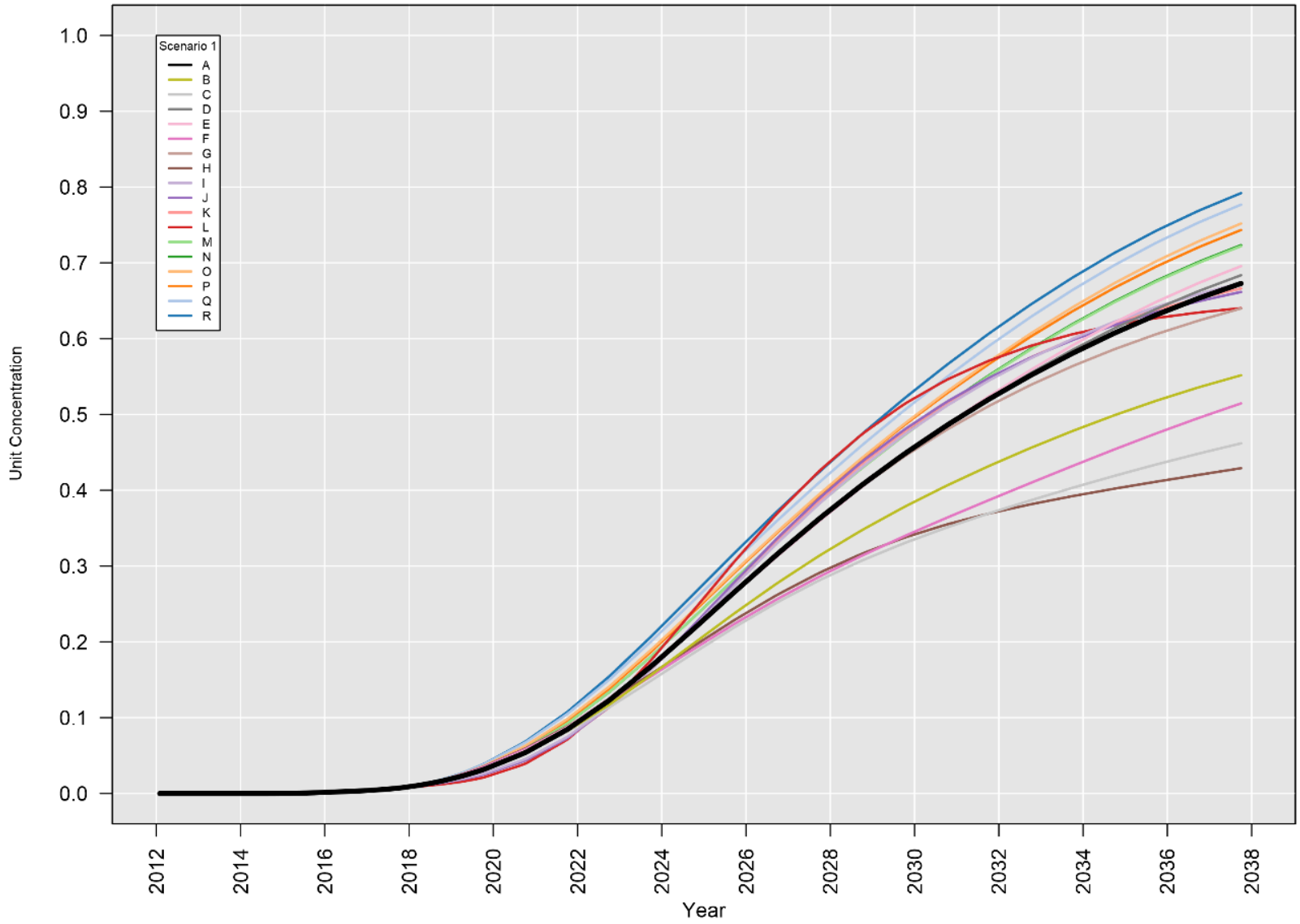

Figure 7-5. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-39

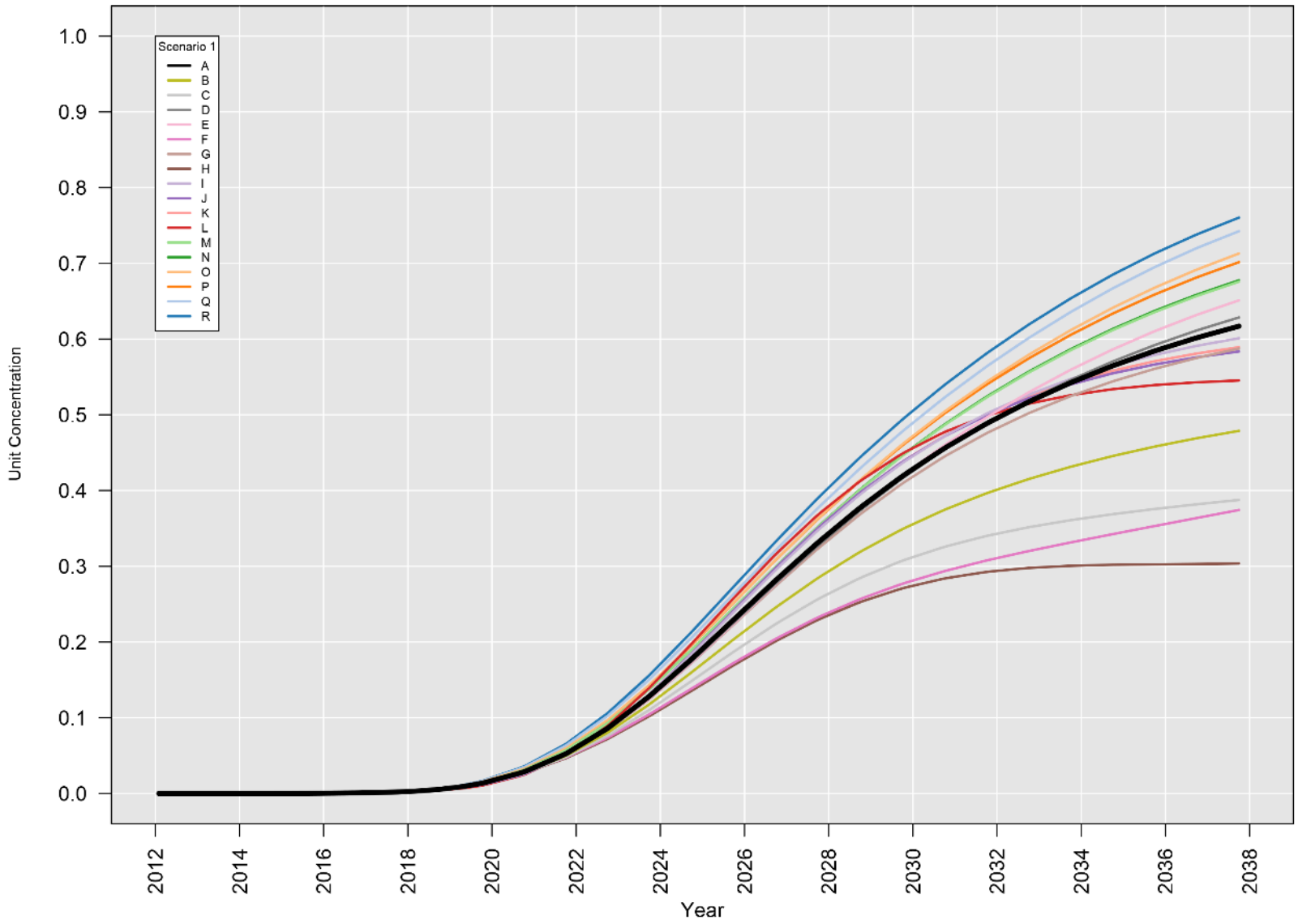

Figure 7-6. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-40

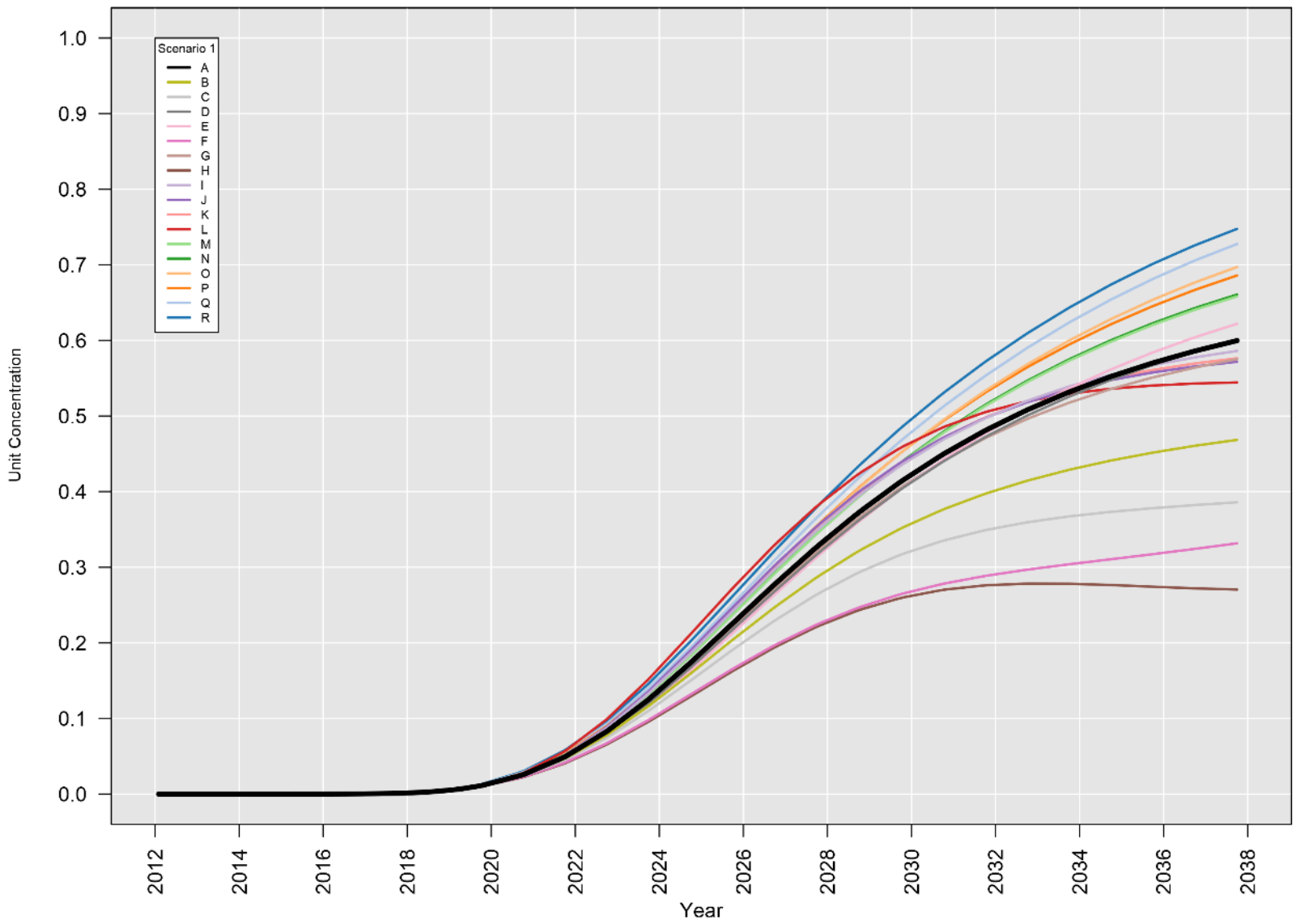

Figure 7-7. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-41

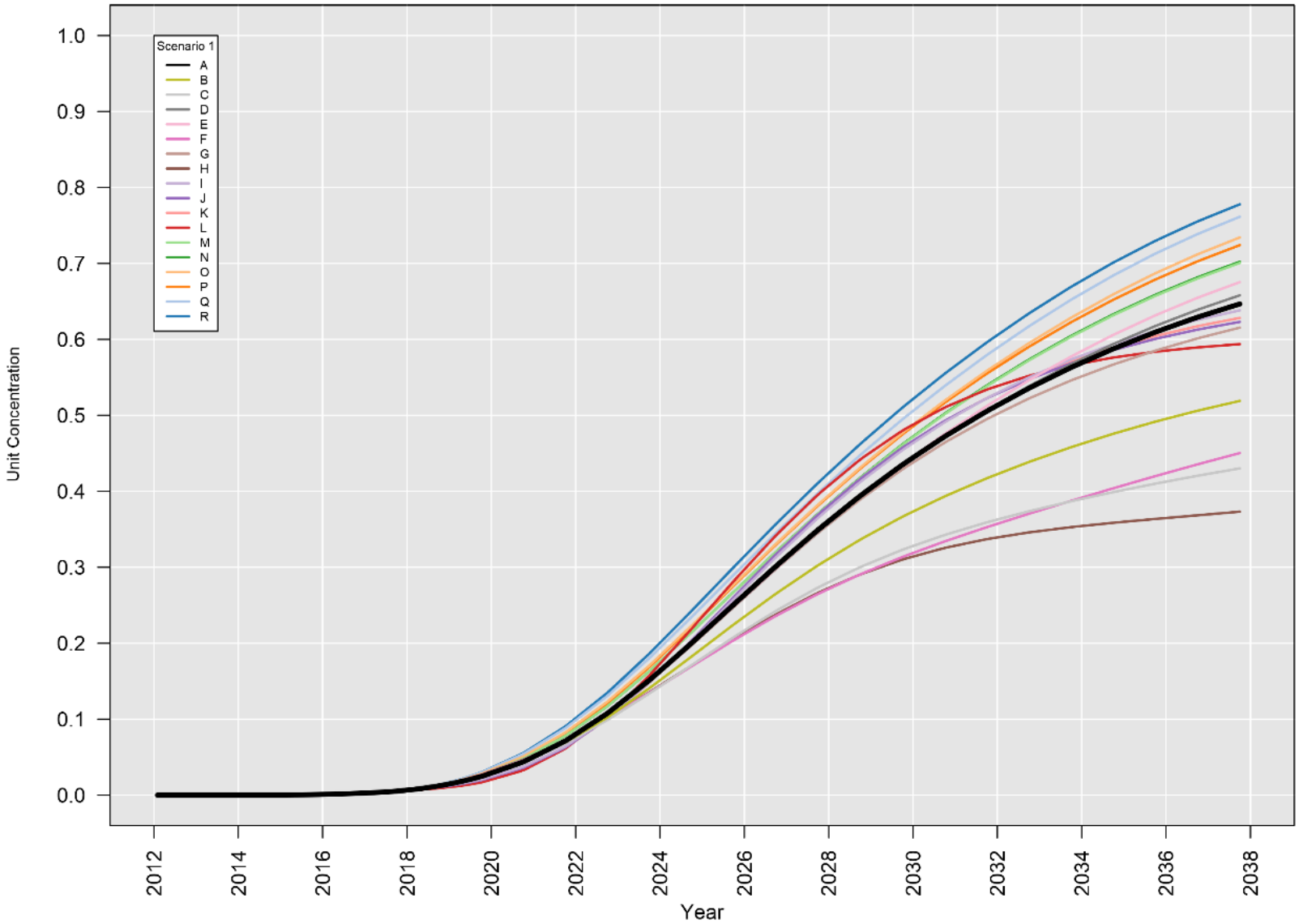

Figure 7-8. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-42

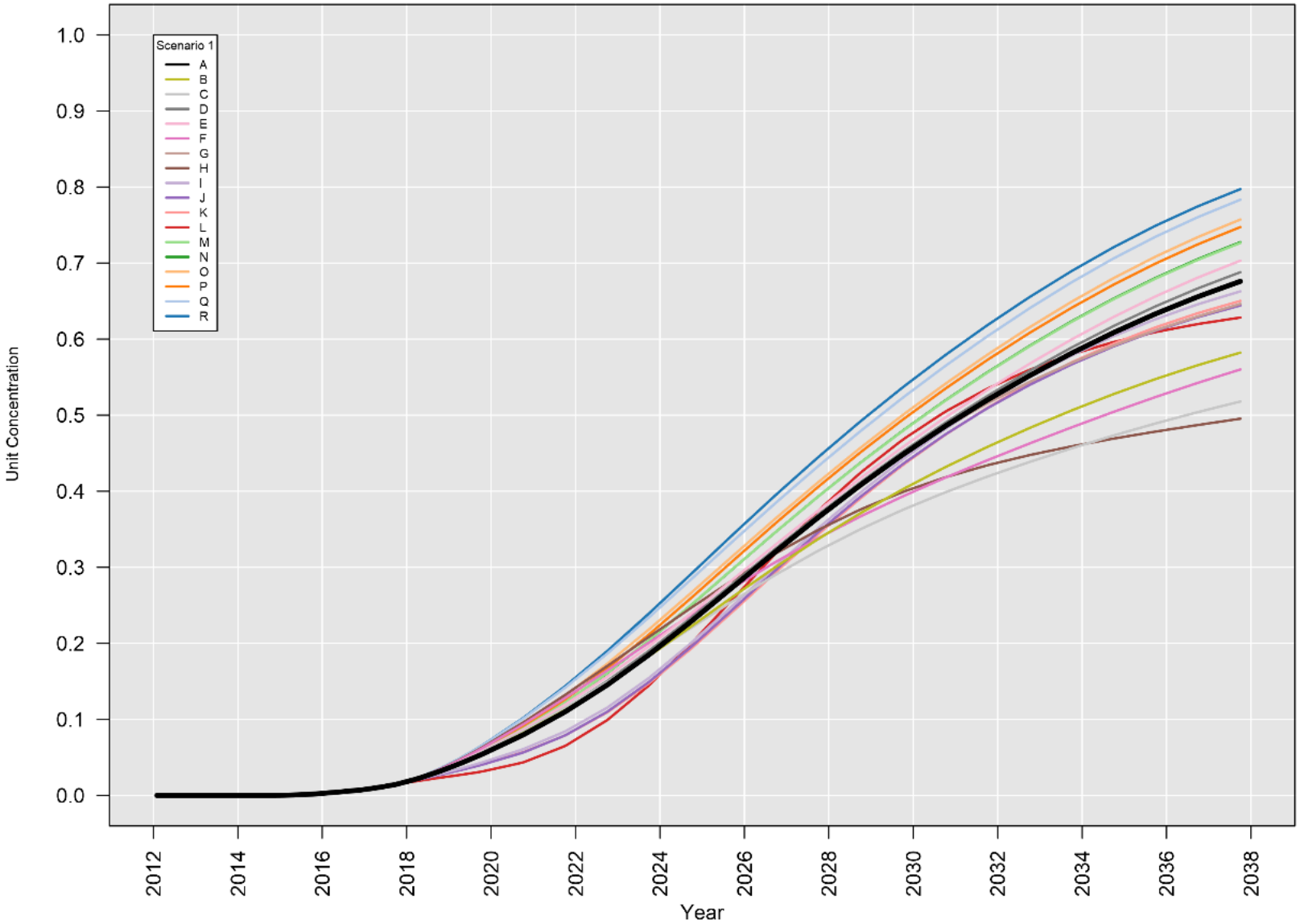

Figure 7-9. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-45

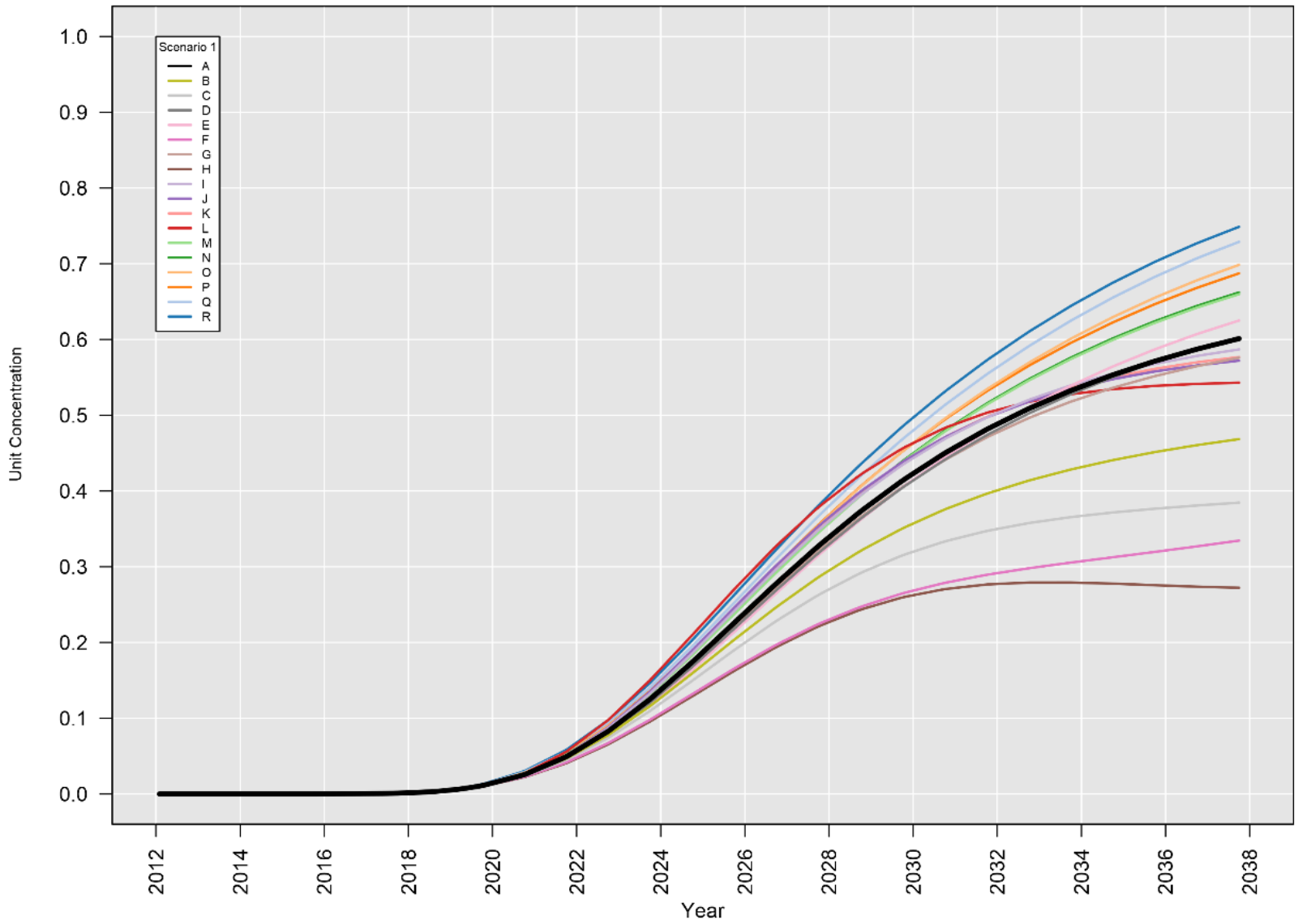

Figure 7-10. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-47

Table 7-1. Range of Unit Concentrations of Injected Treated Water Dilution Breakthrough Curves

Well Name	Scenario	Minimum Unit Concentration	Maximum Unit Concentration	Weighted Average
299-W10-1	1	0.191	0.797	0.613
	2	0.197	0.807	0.641
299-W10-23	1	0.396	0.802	0.683
	2	0.429	0.823	0.722
299-W10-24	1	0.438	0.798	0.681
	2	0.472	0.822	0.722
299-W10-28	1	0.190	0.783	0.597
	2	0.195	0.794	0.625
299-W11-39	1	0.429	0.792	0.668
	2	0.460	0.816	0.709
299-W11-40	1	0.304	0.760	0.610
	2	0.321	0.782	0.648
299-W11-41	1	0.270	0.748	0.593
	2	0.283	0.767	0.630
299-W11-42	1	0.373	0.778	0.641
	2	0.398	0.800	0.681
299-W11-45	1	0.495	0.797	0.674
	2	0.525	0.822	0.716
299-W11-47	1	0.272	0.749	0.595
	2	0.285	0.769	0.631

Each well and each sub-scenario has a unique injected treated water dilution breakthrough curve. The treated water breakthrough curves at each monitoring well for WMA T show variability among the different sub-scenarios. This result suggests that varying injection well operations influences the treated water observed at the WMA T monitoring wells. The variability was greatest (ranging from a unit concentration of approximately 0.2 to 0.8) for the upgradient monitoring wells 299-W10-1 and 299-W10-28. The results for scenario 2 (included in Appendix G) were similar to those for scenario 1.

At WMA T, the zero starting point in 2012 for the injected treated water dilution breakthrough curves in Figures 7-1 through 7-10 incorporates the operation of the interim ZP-1 P&T system, as described in Section 3.3.1 of this report. For the purpose of this analysis, the dilution effect of the interim ZP-1 P&T system was not explicitly considered. The impacts of the interim ZP-1 P&T system are historical with respect to the analysis performed. The analysis is forward looking so the fact that this component was not explicitly considered does not affect the outcome of well selection.

The release concentration breakthrough curves for monitoring wells 299-W10-1, 299-W10-23, 299-W10-24, 299-W10-28, 299-W11-39, 299-W11-40, 299-W11-41, 299-W11-42, 299-W11-45, and 299-W11-47 for all sub-scenarios in scenario 1 are shown in Figures 7-11 through 7-20, respectively. The figures, which depict the simulated breakthrough of a unit-source release to the groundwater table from WMA T, provide for a relative comparison of the monitoring well locations. The plotted

unit-concentrations are the ratios of the simulated concentration that would be observed at a downgradient monitoring well location to the original concentration of the release. A unit concentration of 1 represents the original concentration of the release reaching the monitoring well. The breakthrough curves show the relative time of arrival of the release concentration at the monitoring well in terms of years after release to groundwater beneath the facility. The release time (represented on the figures as arrival time year 0) corresponds to October 1, 2017. The unit concentrations and arrival times consider advection and dispersion but do not include chemical-specific, predictive calculations for more complex, constituent-dependent processes such as sorption and degradation (decay) that would decrease the concentration or delay arrival time at the wells.

In general, release concentration breakthrough curves displaying higher unit concentrations for a larger range of operating conditions (different sub-scenarios) and, in particular, displaying higher unit concentrations for sub-scenario A, indicate well locations that are effective for monitoring releases from the facility. Wells for which breakthrough curves display high variation among different operating scenarios are sensitive to changes in the 200 West P&T system operating conditions. Wells for which breakthrough curves display lower unit concentrations (in particular, for the most likely operating conditions) indicate less optimal well locations.

Figures 7-11 through 7-20 show minimal variation in the breakthrough curves for the 200 West P&T system operating scenarios evaluated, indicating that detection of releases at the well locations is not sensitive to changes in the 200 West P&T system operating conditions. Results for wells 299-W10-1 and 299-W10-28 show an approximate unit concentration of 0 because these wells are located upgradient from a hypothetical release from the facility. The breakthrough curves for well 299-W11-45 indicates relatively more dilution (attributed to its distance from WMA T), and, therefore, the well is less likely to detect releases for all the operating scenarios relative to the other monitoring well locations. Breakthrough curves for 299-W11-40, 299-W11-41, and 299-W11-47 show minimal dilution, indicating the wells are located in areas having high potential for detecting releases from WMA T. The release concentration arrival times for all monitoring wells are similar. The results for scenario 2 (included in Appendix G) are similar to those for scenario 1. Table 7-2 shows the range of the release concentration breakthrough curves for the monitoring wells for scenarios 1, 2, and 3.

The release concentration breakthrough curves for scenario 3 (Figure 7-21) indicate most of the wells have high unit concentrations (near or above 0.8) after the cessation of 200 West P&T system operations. The unit concentrations at the northern wells (299-W10-23, 299-W10-24, 299-W11-39, and 299-W11-45) increased significantly compared to scenarios 1 and 2. The unit concentrations at the two southern wells (299-W11-41 and 299-W11-47) decreased compared to scenarios 1 and 2 and are lower than the other wells in scenario 3. Wells 299-W10-1 and 299-W10-28 have unit concentrations near zero, indicating they remain upgradient of WMA T in scenario 3. The release time for scenario 3 (represented on the figure as arrival time year 0) corresponds to October 1, 2037.

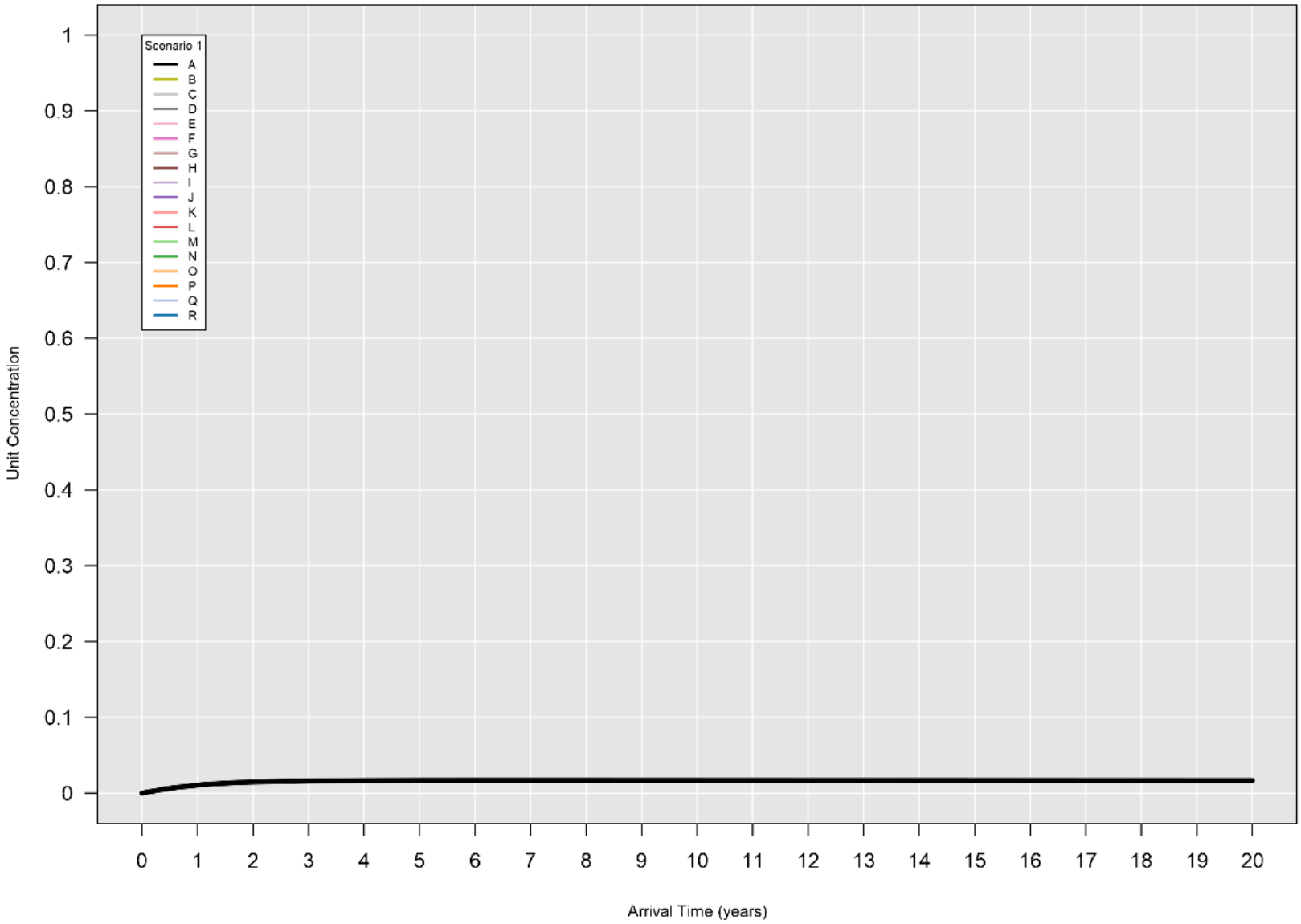

Figure 7-11. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-1

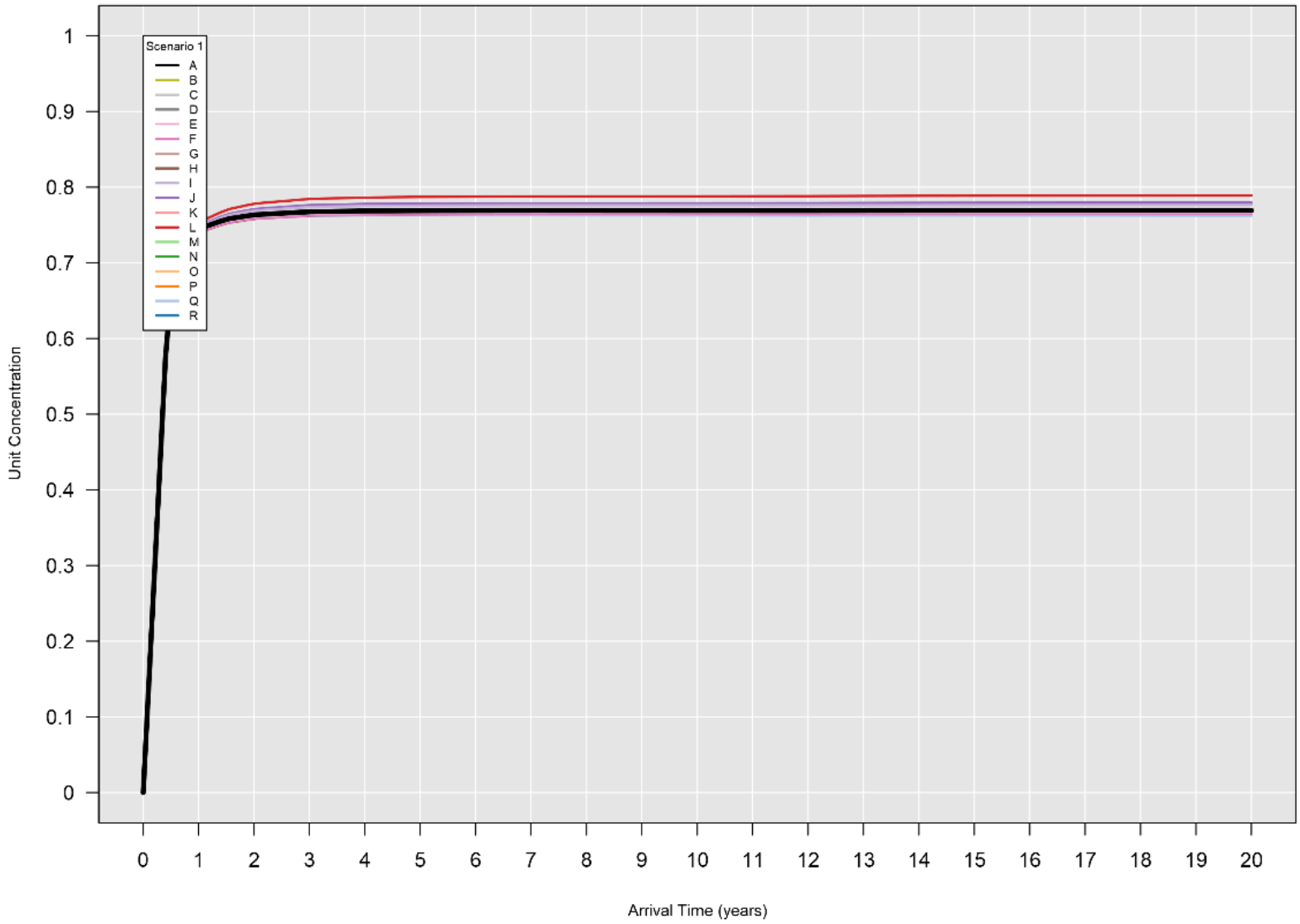

Figure 7-12. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-23

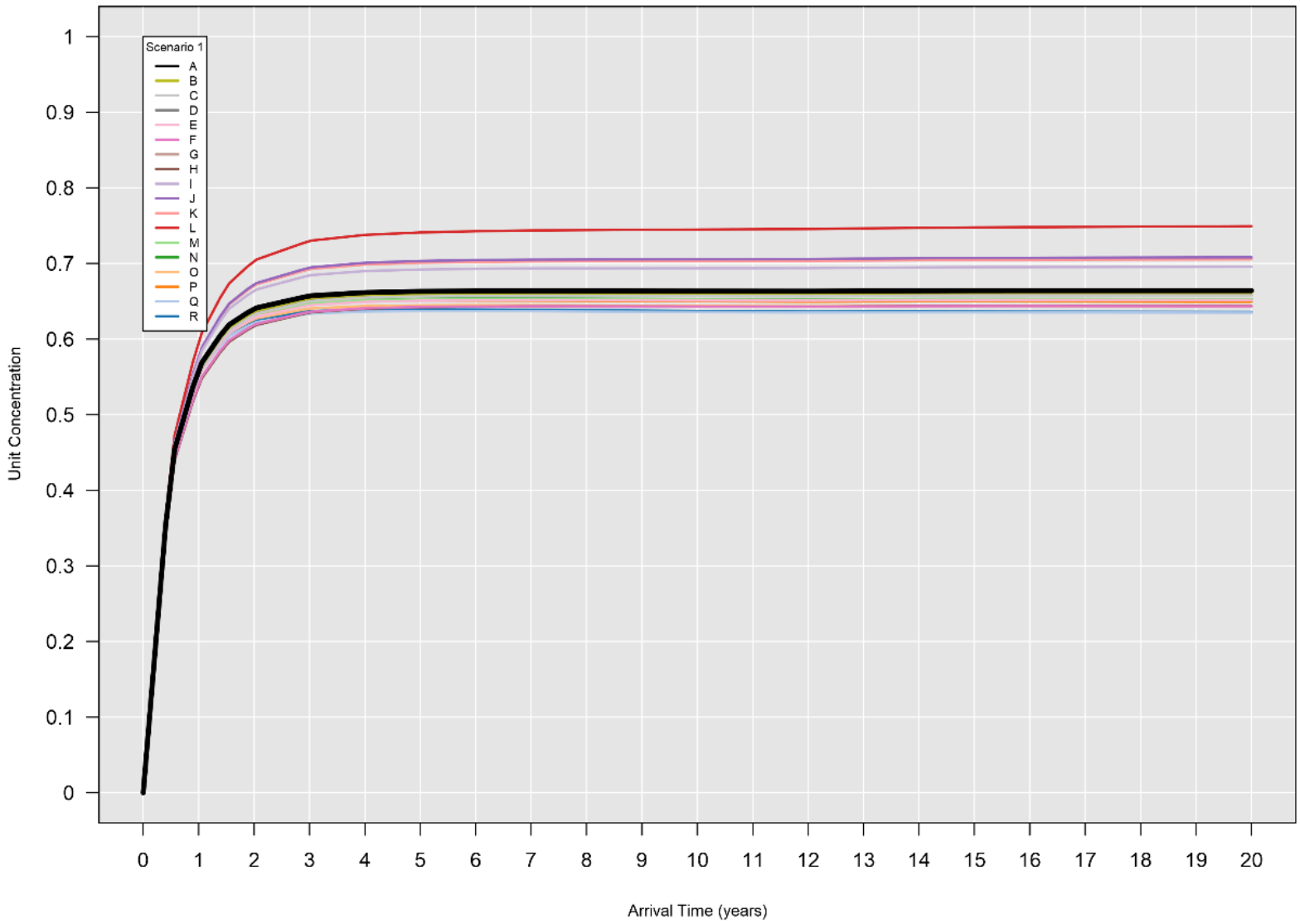

Figure 7-13. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-24

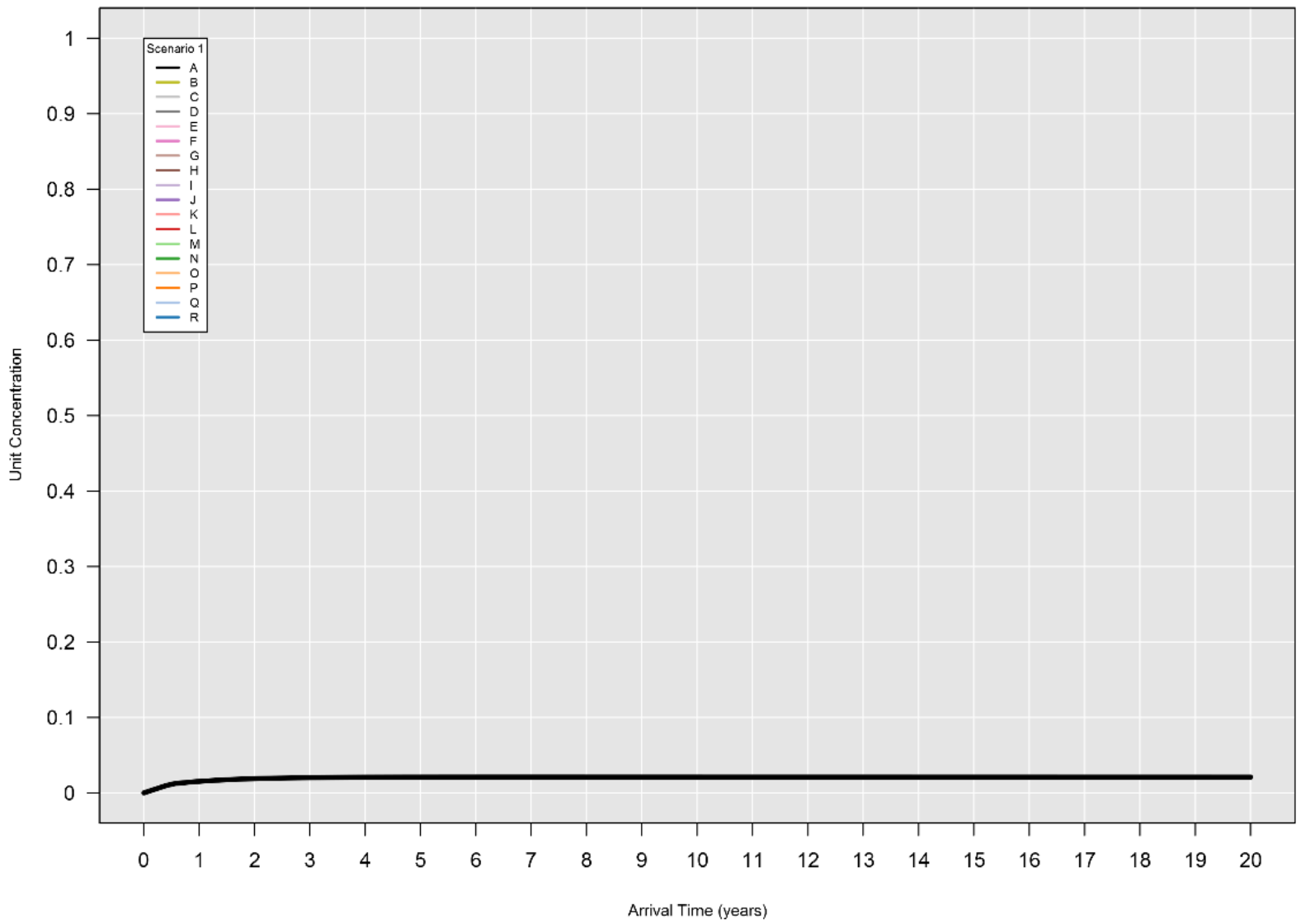

Figure 7-14. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-28

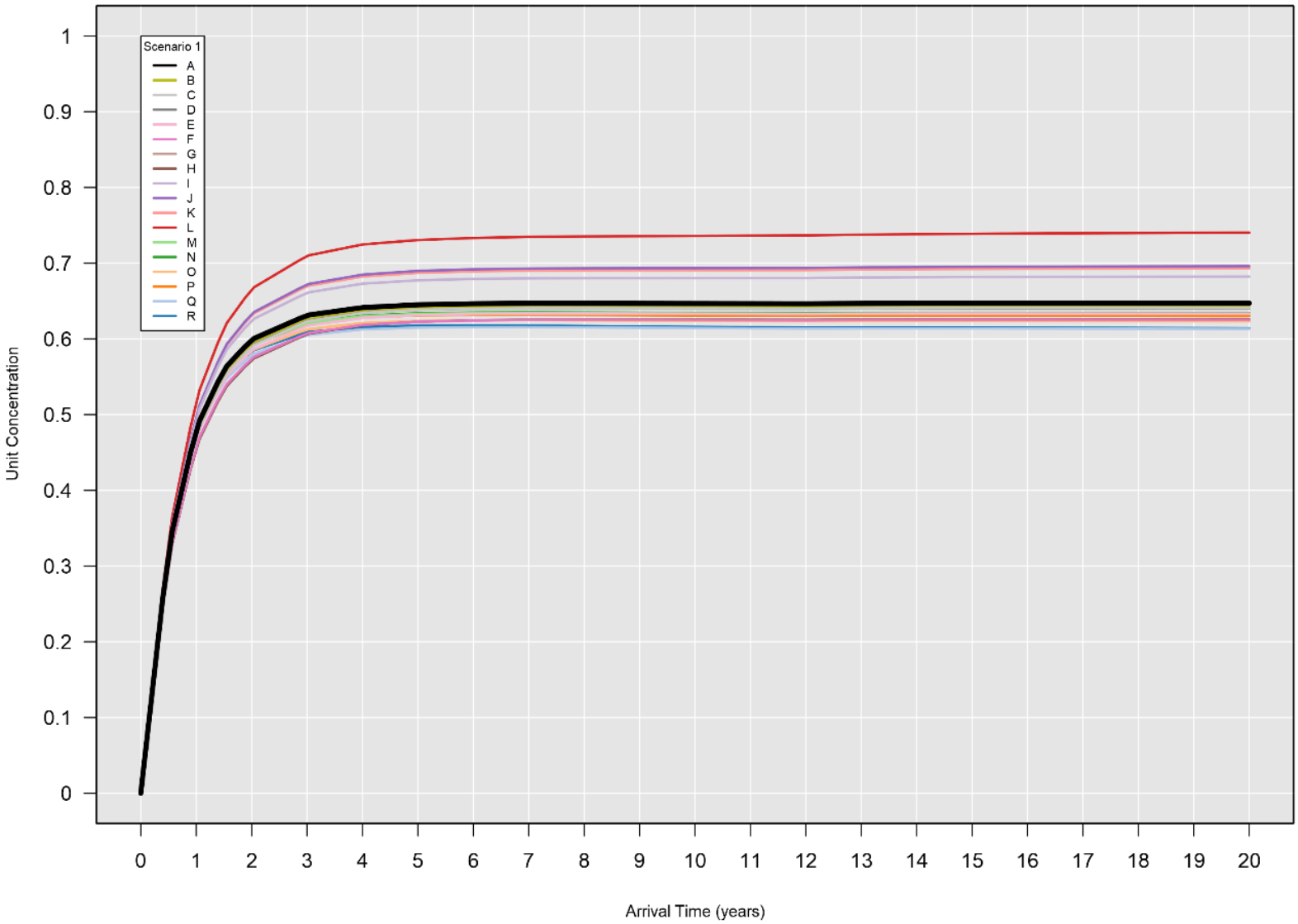

Figure 7-15. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-39

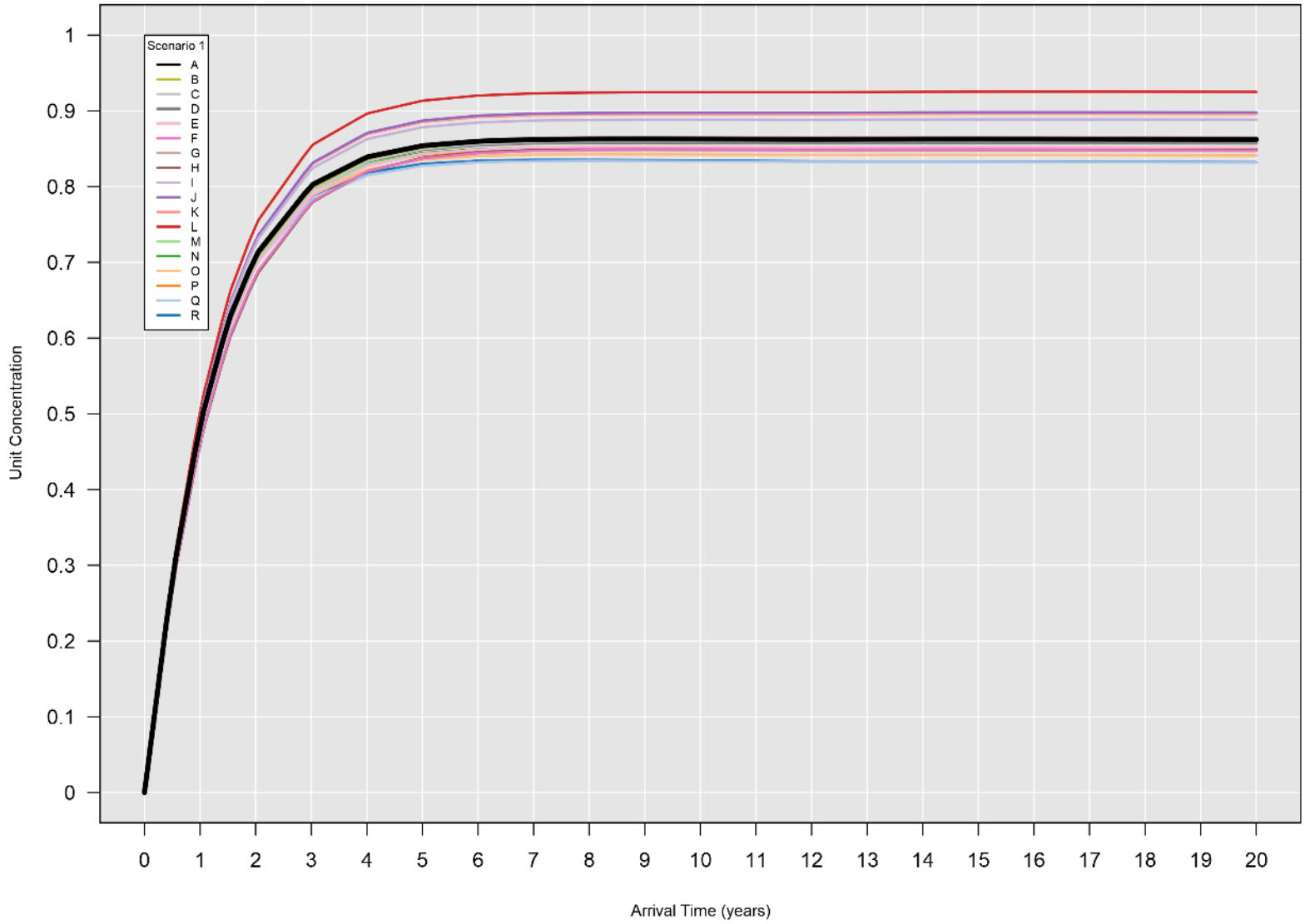

Figure 7-16. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-40

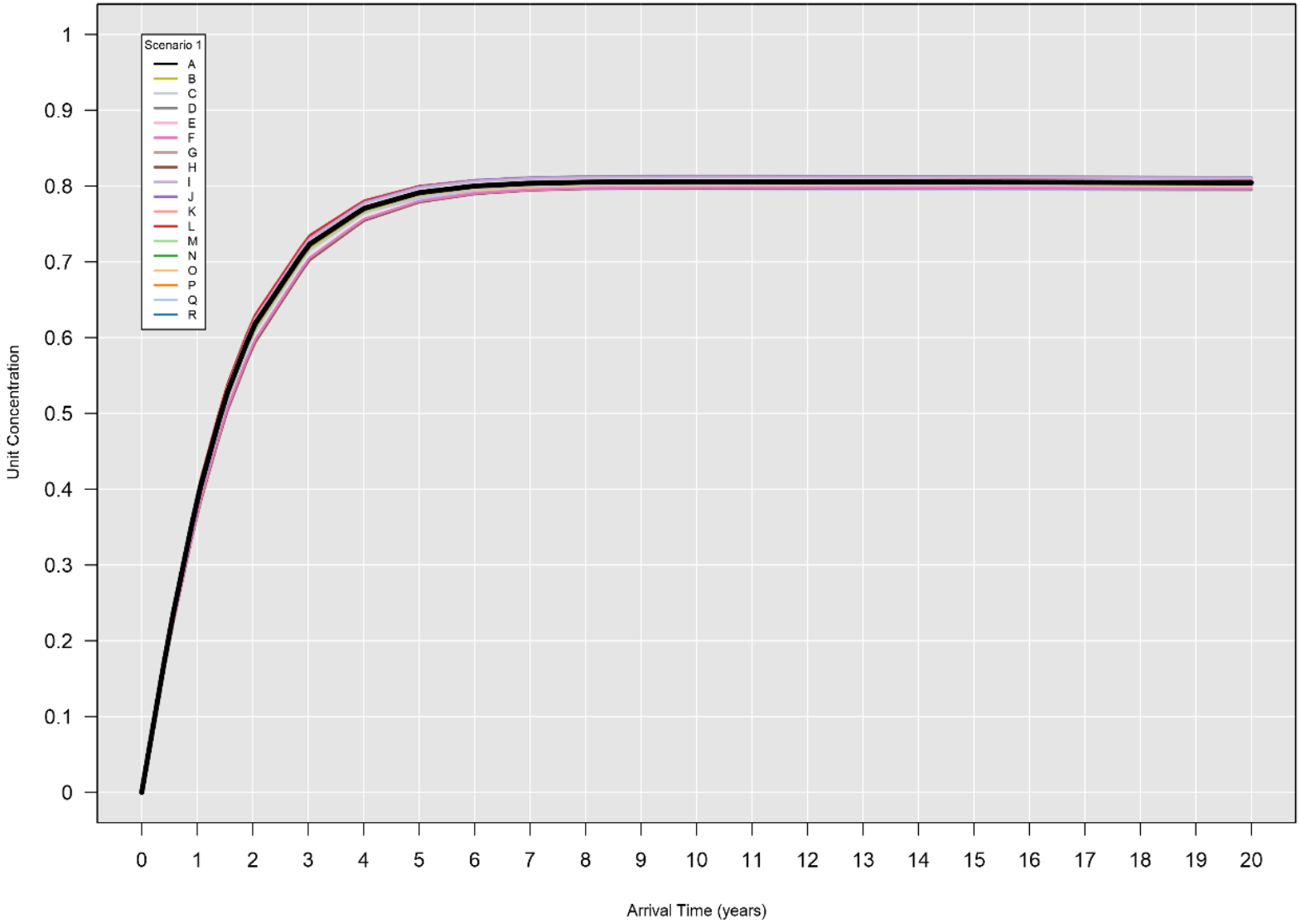

Figure 7-17. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-41

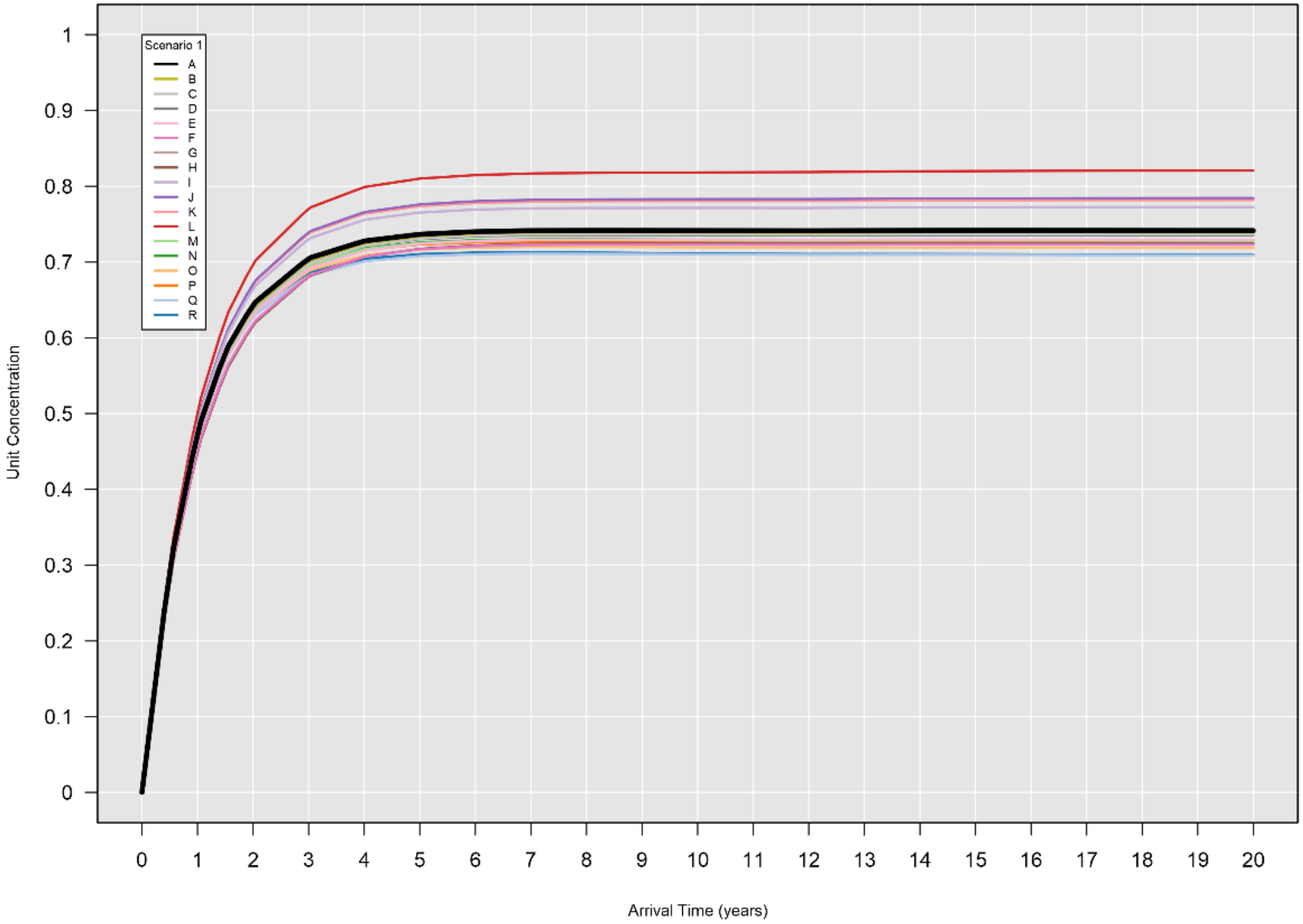

Figure 7-18. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-42

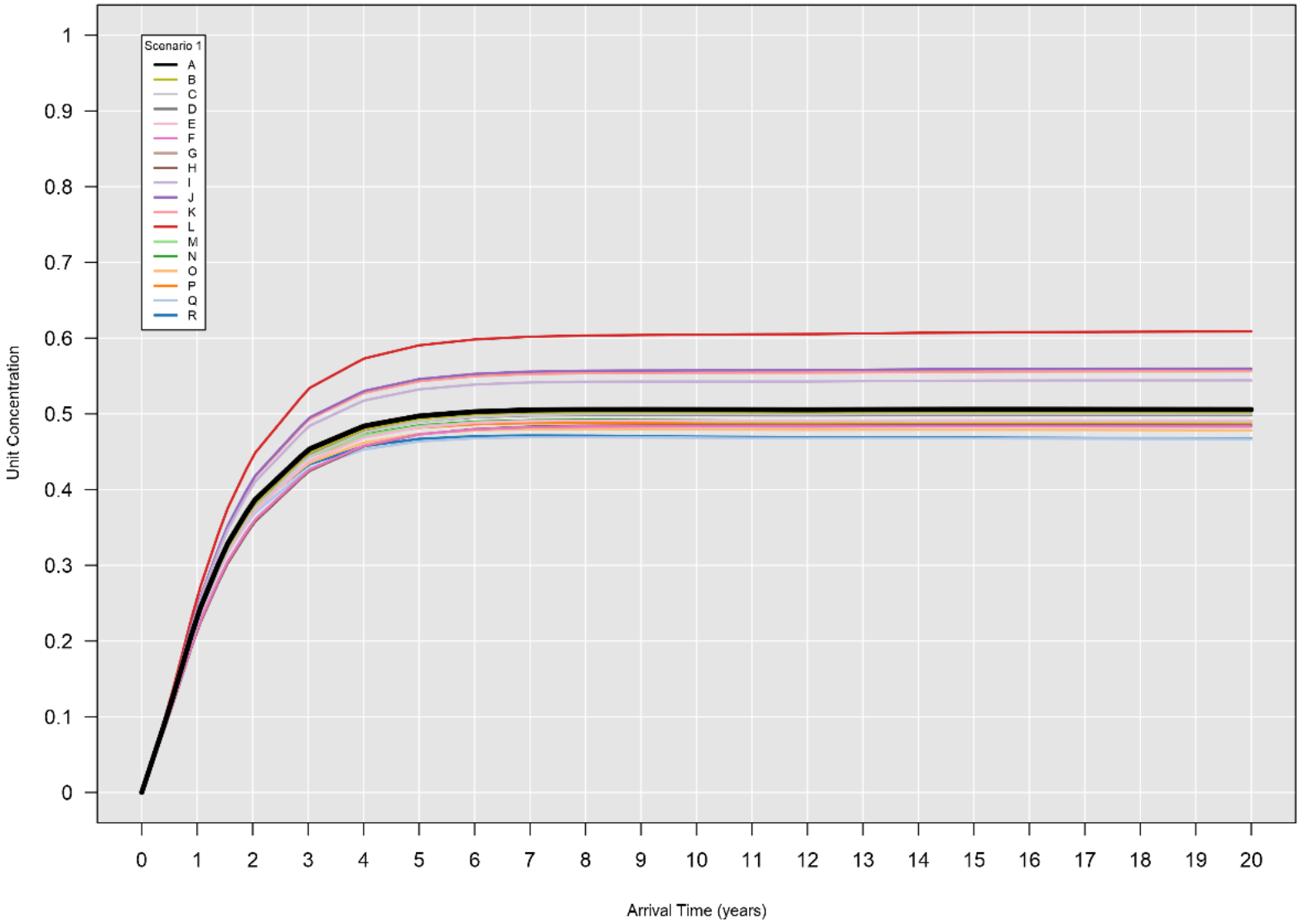

Figure 7-19. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-45

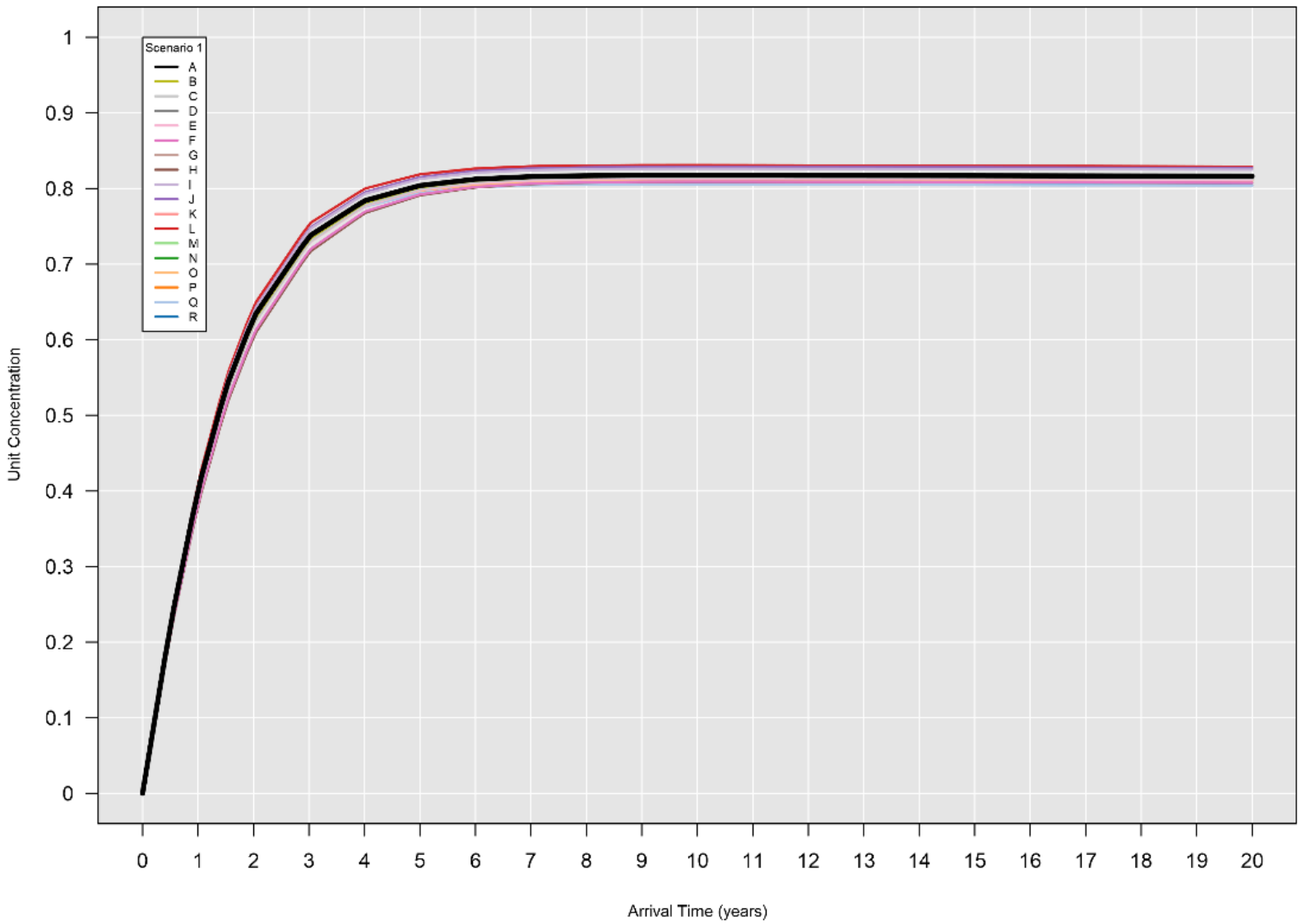

Figure 7-20. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W11-47

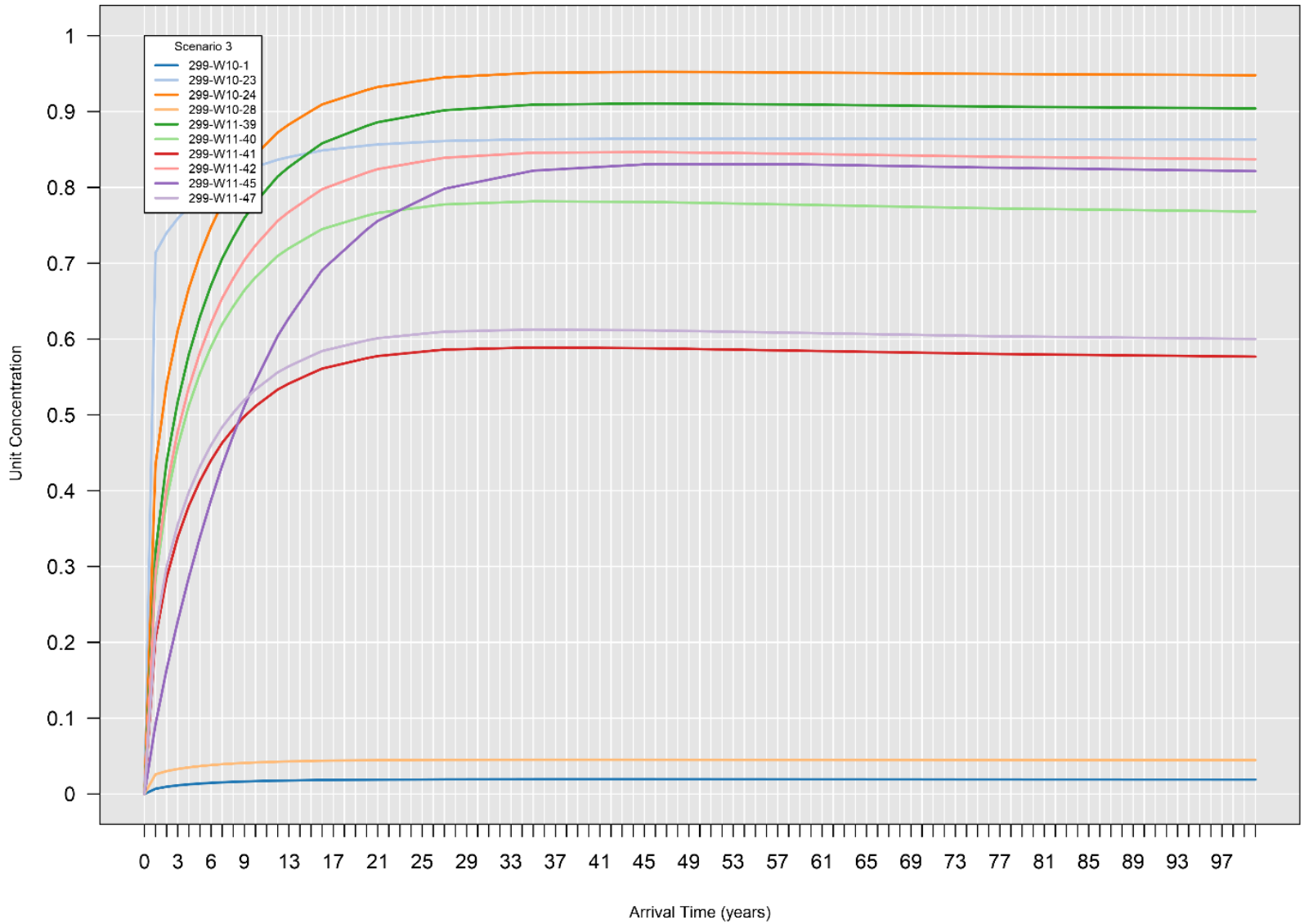

Figure 7-21. Release Concentration Breakthrough Curves at Monitoring Wells, Scenario 3

Table 7-2. Range of Unit Concentrations of Release Concentration Breakthrough Curves

Well Name	Scenario	Minimum Unit Concentration	Maximum Unit Concentration	Weighted Average	Scenario 3
299-W10-1	1	0.016	0.018	0.017	0.019
	2	0.016	0.018	0.017	
299-W10-23	1	0.762	0.789	0.769	0.863
	2	0.762	0.789	0.769	
299-W10-24	1	0.635	0.749	0.664	0.949
	2	0.633	0.750	0.663	
299-W10-28	1	0.040	0.043	0.041	0.045
	2	0.040	0.043	0.041	
299-W11-39	1	0.613	0.740	0.647	0.905
	2	0.611	0.741	0.646	
299-W11-40	1	0.832	0.925	0.862	0.770
	2	0.831	0.925	0.862	
299-W11-41	1	0.795	0.812	0.804	0.578
	2	0.794	0.812	0.804	
299-W11-42	1	0.709	0.821	0.741	0.838
	2	0.707	0.821	0.741	
299-W11-45	1	0.467	0.609	0.506	0.823
	2	0.464	0.609	0.504	
299-W11-47	1	0.804	0.829	0.816	0.602
	2	0.804	0.829	0.816	

Figures 7-22 through 7-24 show plume maps of release unit concentrations based on transport modeling representing conditions at the end of 200 West P&T system operation in 2037 for scenarios 1 and 2 and in 2137 for scenario 3. Figures 7-22 and 7-23 depict sub-scenario A for scenarios 1 and 2, which corresponds to the bold black lines on the breakthrough curves. Release unit plume maps for all sub-scenarios in scenarios 1 and 2 are included in Appendix B in Appendix G. Figures 7-22 through 7-24 show that the wells are generally well located for detecting releases, which is consistent with the conclusions from the breakthrough curves. However, the northern wells (299-W10-23, 299-W10-24, 299-W11-39 and 299-W11-45), are located on the northern edge of the unit plumes for scenarios 1 and 2 and therefore are less likely to detect releases. After cessation of 200 West P&T system operations, the shift in the groundwater flow from a southeasterly to an easterly flow direction results in the southern wells (299-W11-41 and 299-W11-47) being located at the edge of the unit plume extent in scenario 3.

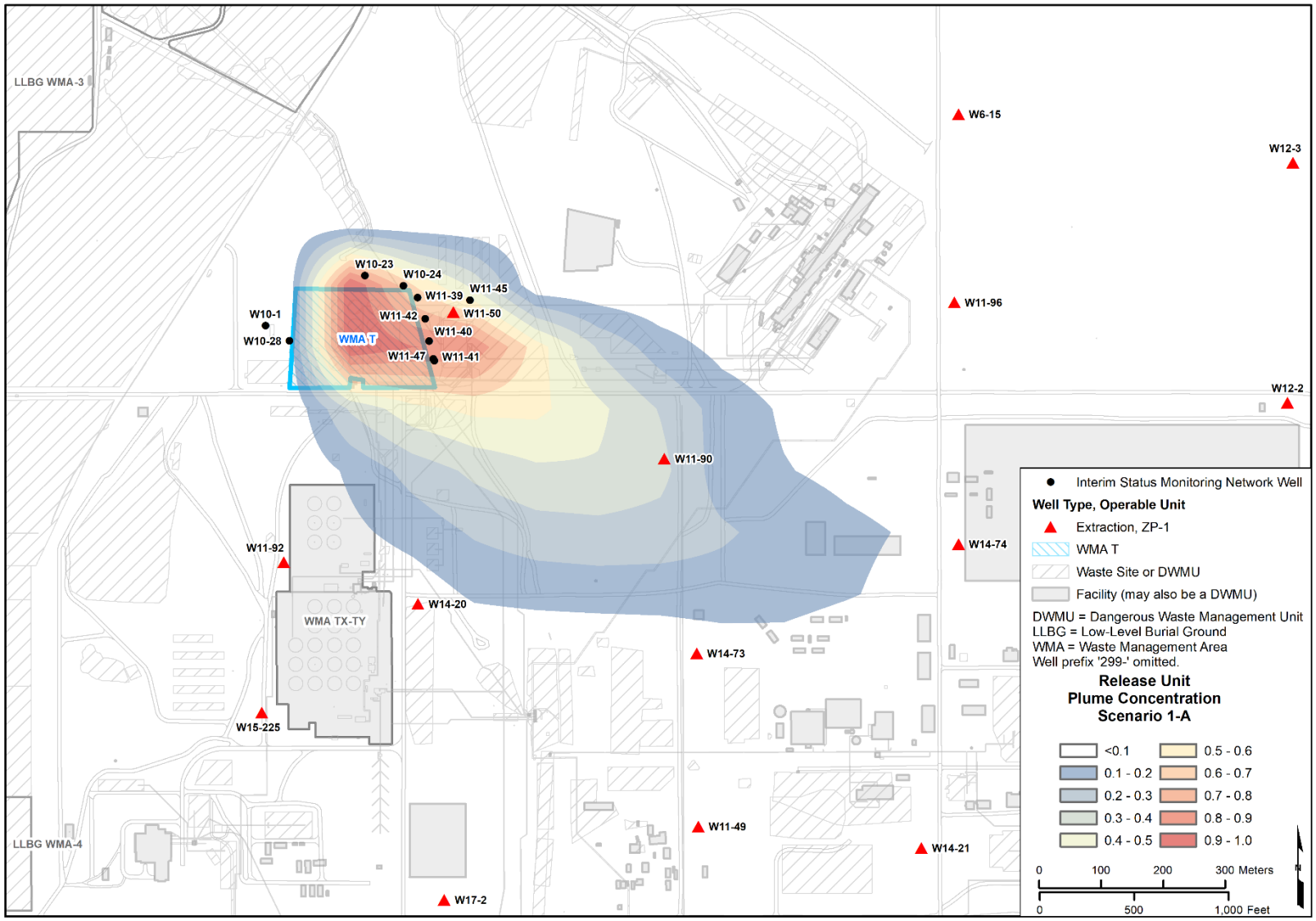

Figure 7-22. Release Unit Plume Map, Scenario 1, Sub-Scenario A

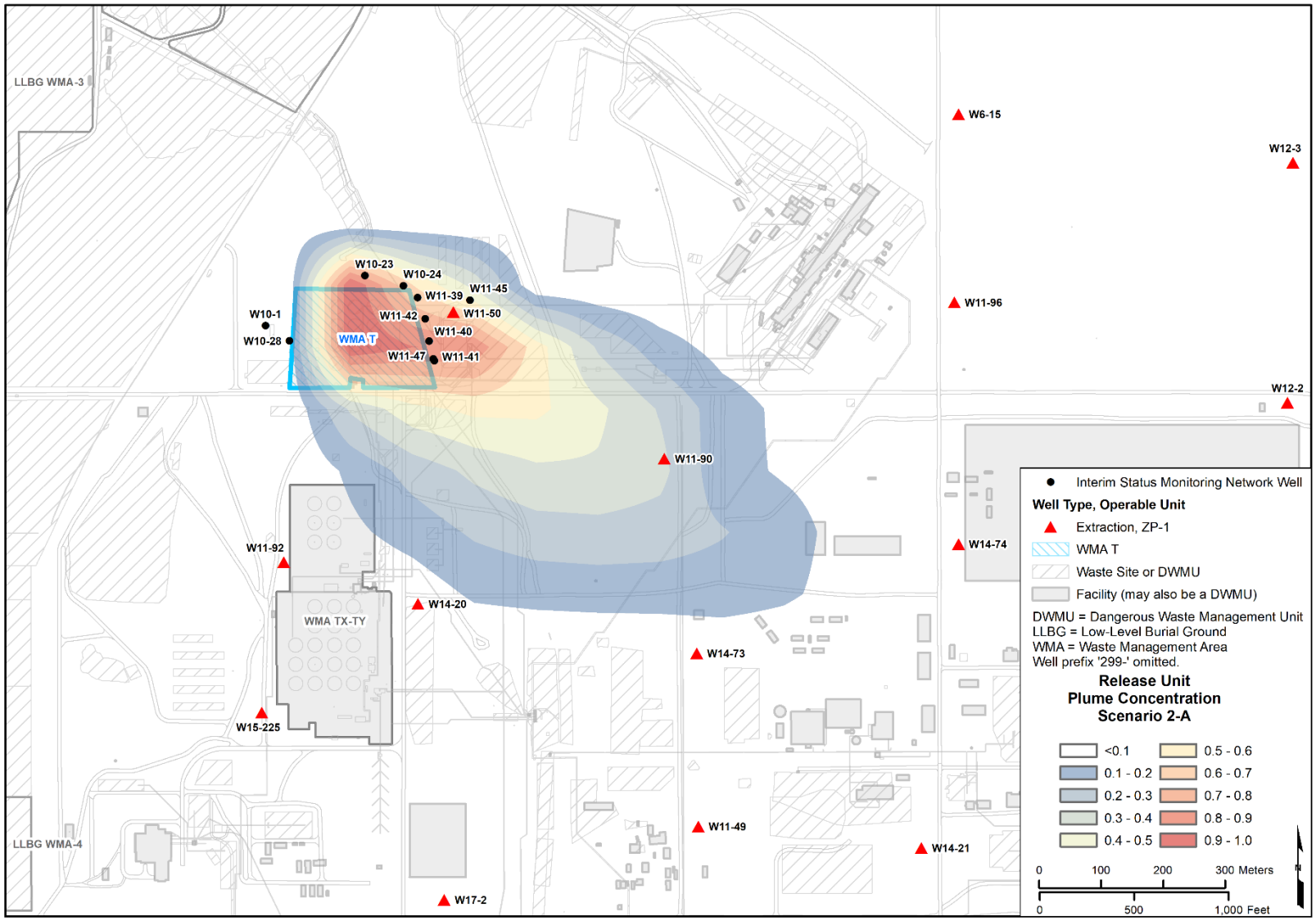

Figure 7-23. Release Unit Plume Map, Scenario 2, Sub-Scenario A

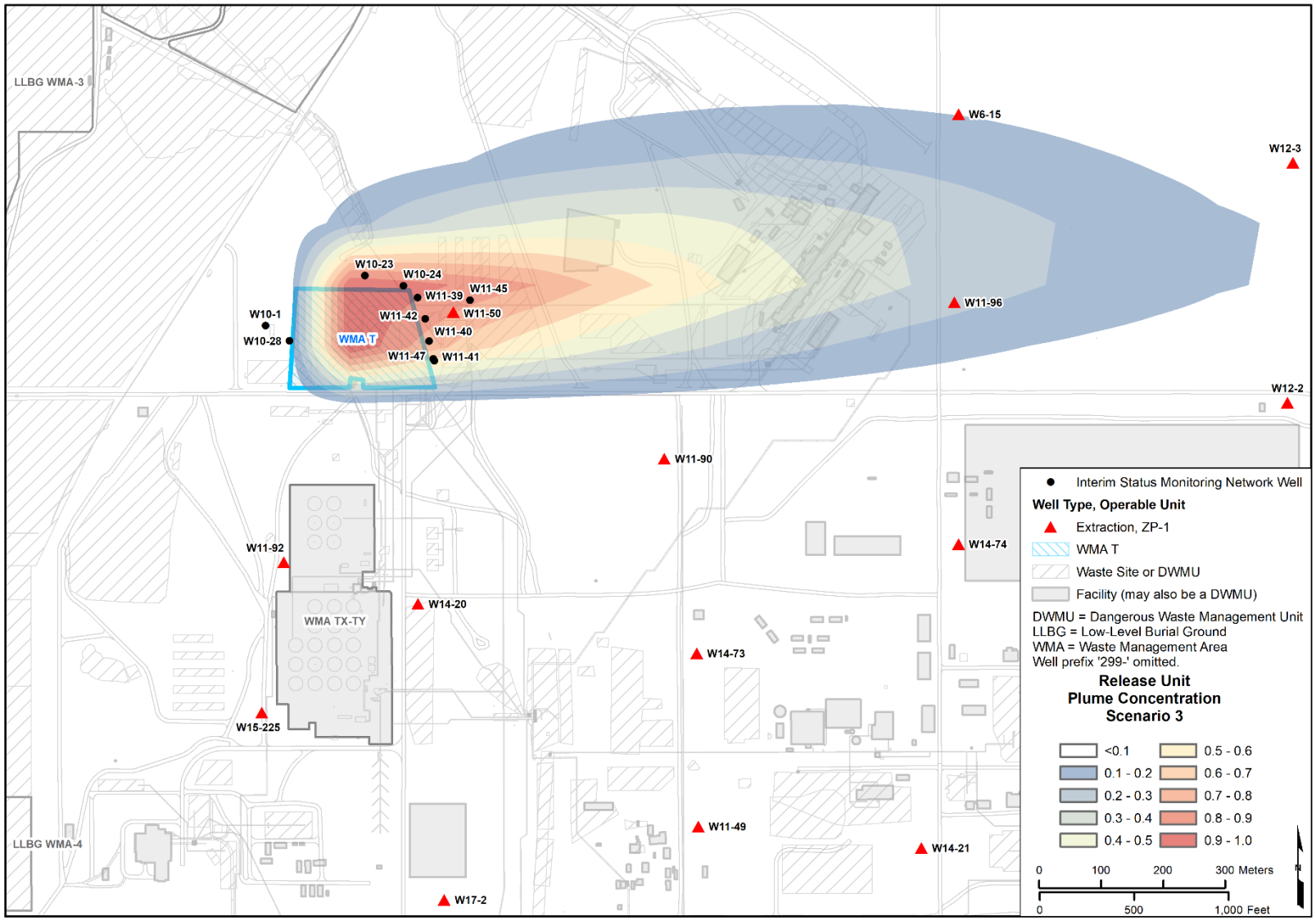

Figure 7-24. Release Unit Plume Map, Scenario 3

The release unit plume maps provide a visual representation of the release dispersion predicted by the transport modeling results. The release plumes are produced using a bilinear interpolation process within ArcGIS™ to smooth the grid block modeling results that are calculated on the 100 by 100 m (328 by 328 ft) CPGWM grid cells. This interpolation process is performed to depict a visually smooth transition between concentrations calculated for the model grid cells; the unit plume maps would have a blocky appearance if they represented only the outputs obtained directly from the model. This interpolation process does, however, result in some spread of the unit plumes, particularly at the margins, and some differences in the visual representation of the transport modeling results when compared to results of particle-tracking calculations. Differences between the results shown in the release concentration breakthrough curves and the release unit plume maps generally are a result of this interpolation.

The release unit plume maps are one of the methods used in evaluating the robustness of the monitoring well network for coverage of the interpolated plume spread. However, because of the size of the model grid used in transport modeling and the plume spread caused by the interpolation between the nodes (centers) of the model cells, particle-tracking results are used in conjunction with the release unit plume maps for proper interpretation of model results.

For WMA T, upgradient well 299-W10-28 is shown on the edge of where the release unit concentration is greater than zero (Figures 7-22 through 7-24). The outer fringe of the release unit plume is a result of the spatial interpolation between the nodes of the grid cell representing the facility (in which the unit concentration of 1 was released) and the upgradient grid cell where well 299-W10-28 is located, which has a simulated unit concentration near zero. This results in a depiction of this well location being within an interpolated area of release unit concentration. The particle-tracking results for releases from WMA T, which are discussed in Section 7.2, indicate well 299-W10-28 remains upgradient of the hypothetical release from WMA T in the scenarios evaluated.

Figures 7-22 through 7-24 show that downgradient wells are generally well located for detecting releases. This conclusion are consistent with the conclusions based on the breakthrough curves.

7.2 Particle-Tracking and Relative Detectability Maps

For each scenario, particle-tracking and relative detectability maps generated using particle-tracking calculations show the overall distribution, given advection and dispersion, of a hypothetical release to the water table below WMA T. For scenarios 1 and 2, the maps represent conditions in 2037; for scenario 3, the maps represent conditions in 2137.

Based on the calculations, particles released to the water table exhibited predominantly horizontal migration, with minor components of vertical migration in response to very limited infiltration from groundwater recharge and the operation of nearby extraction and injection wells.

Figures 7-25 and 7-26 show particle pathlines superimposed upon injected treated water dilution plume maps (created using transport modeling) for sub-scenario A of scenarios 1 and 2 (the most likely operating conditions). The dilution factor represents the simulated relative fraction of injected water from the injection wells. Similar figures for all sub-scenarios in scenarios 1 and 2 are included in Appendix G.

The particle tracking indicates that most of the wells are generally well located for detecting releases from the facility, with the exception of wells 299-W10-23 and 299-W10-24, which are located cross-gradient to the north of the release particle pathlines, and wells 299-W10-1 and 299-W10-28, which are located upgradient.

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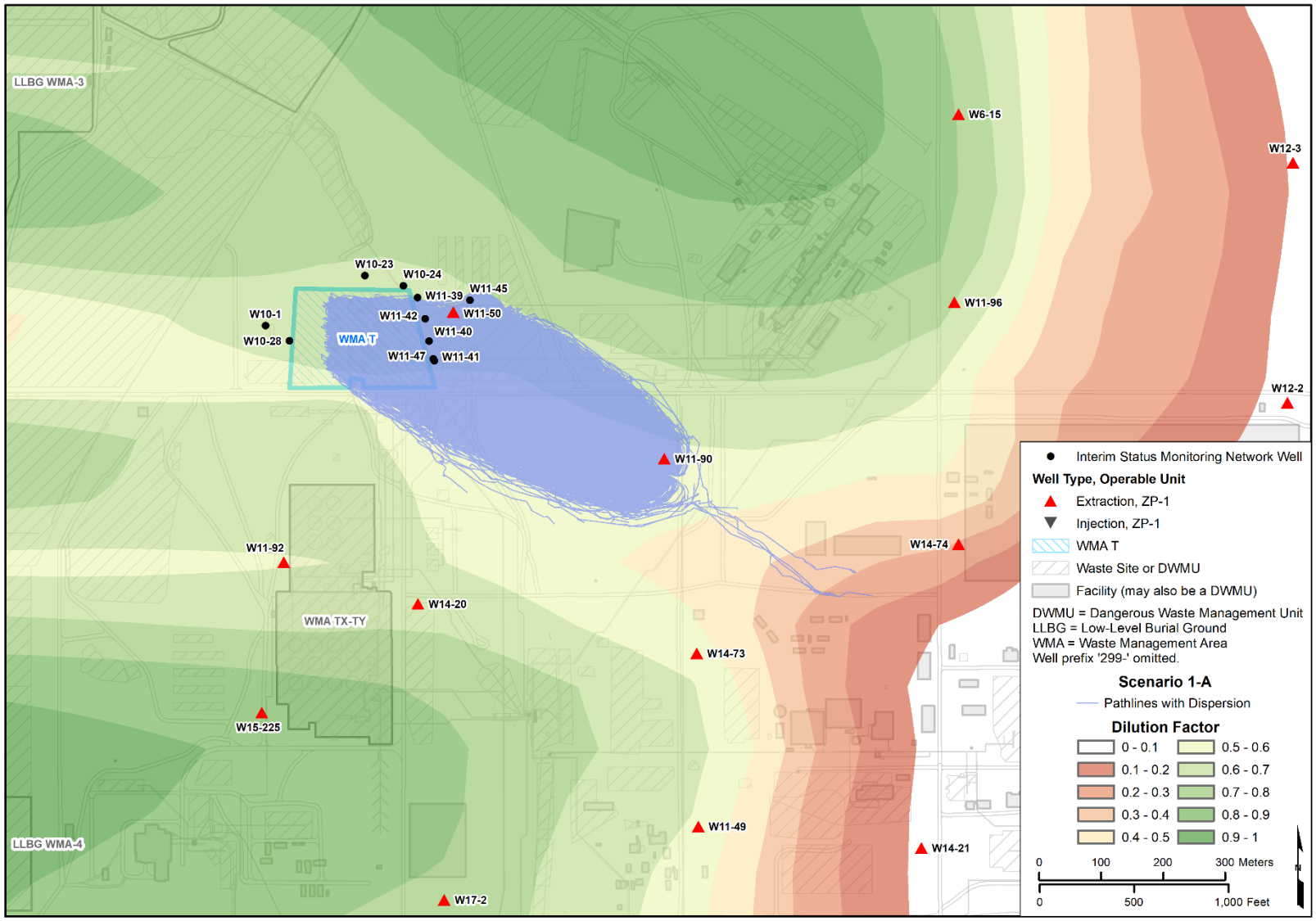

Figure 7-25. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 1, Sub-Scenario A

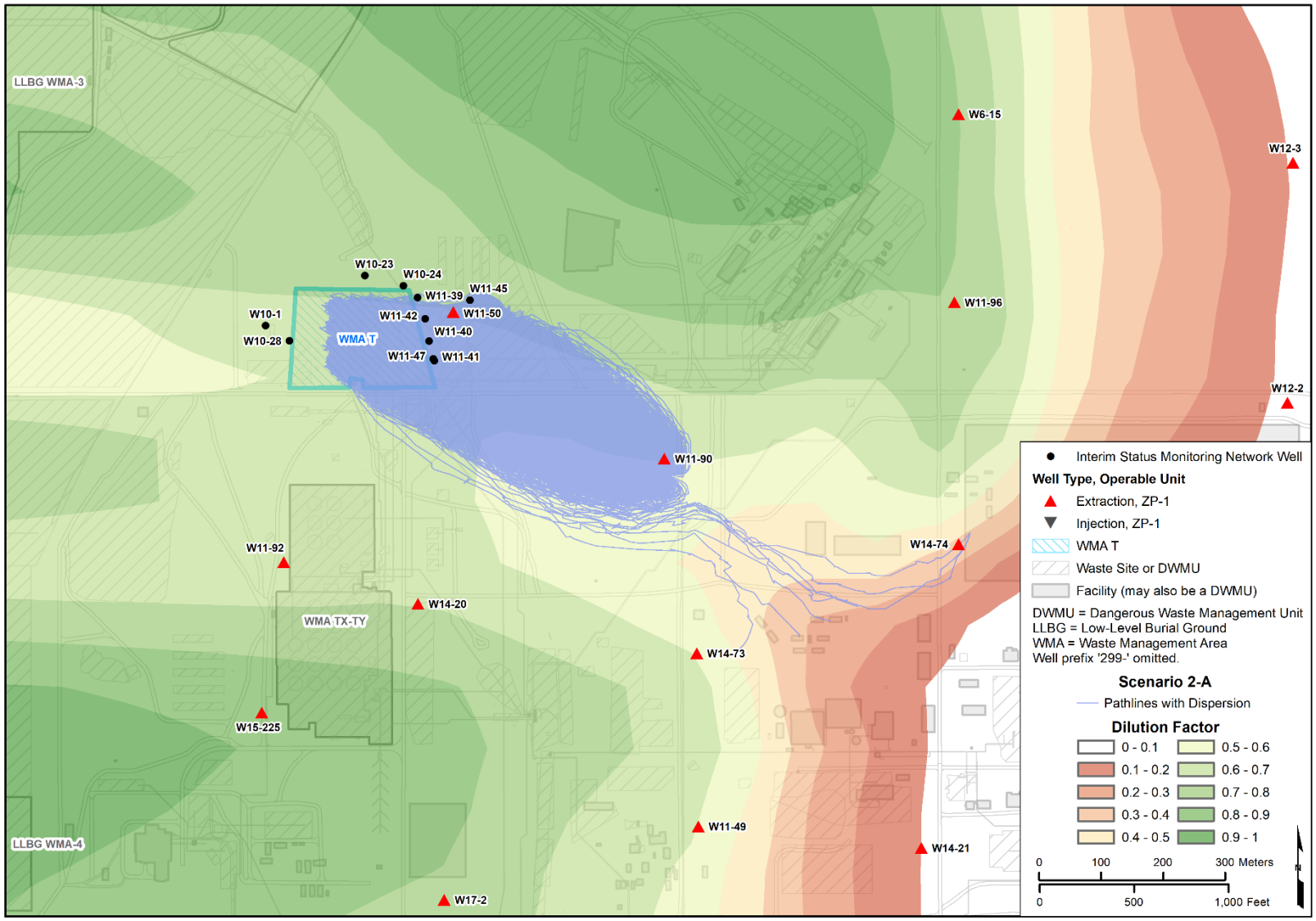

Figure 7-26. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 2, Sub-Scenario A

The particle-tracking map for scenario 3 (Figure 7-27) represents conditions after cessation of the 200 West P&T system operations and therefore does not have an injected treated water component. The results indicate well 299-W10-24 is located on the northern edge of the particle pathlines and well 299-W10-23 is located outside of the simulated particle paths.

Maps of relative detectability identify areas of the aquifer where a hypothetical release that impacts the water table beneath WMA T would be most likely to migrate and be detectable. Whereas particle-tracking maps present the results for each sub-scenario separately, the relative detectability maps evaluate the sub-scenarios together while accounting for the weighting (estimated relative probability) of the various operating scenarios.

Details of the calculations for these simulations are presented in Appendix G. In general, the relative detectability was determined by first calculating, for each sub-scenario, the number of released particles that traversed each calculation subgrid cell. Particle count maps generated for each sub-scenario are included as Appendix A in Appendix G. Using the particle counts, relative detectability for each scenario was determined by computing a weighted sum of the particle counts for each individual cell for all sub-scenarios within each scenario using the weights shown in Table 5-1 to account for the estimated relative probability of each sub-scenario.

Figures 7-28 through 7-30 depict the relative detectability distribution for releases to the water table beneath the facility for scenarios 1, 2, and 3, respectively. The release distribution is color-coded to reflect the results of the weighted percent distribution of particle counts throughout the release pathline. Where the weighted percent distribution of particle counts is higher, the probability of release detection is also higher.

The relative detectability maps for scenarios 1 and 2 show that the downgradient groundwater monitoring wells generally are located in areas of high relative detectability for particle releases from WMA T. Northern monitoring wells 299-W10-23 and 299-W10-24 are located outside of the relative detectability area in scenarios 1 and 2. After the cessation of 200 West P&T system operations, however, the shift in the groundwater flow direction from southeast to east results in these wells being within the relative detectability extents for scenario 3.

Figures 7-28 and 7-29 for scenarios 1 and 2 (as well as release unit plume maps [Figures 7-22 and 7-23] and particle-tracking maps [Figures 7-25 and 7-26]) show detectable areas extending south of WMA T where there are no existing monitoring wells. Three new monitoring wells (wells WMA T_PW1, WMA T_PW2, and WMA T_PW3) are proposed as shown in Figures 7-28 through 7-30.

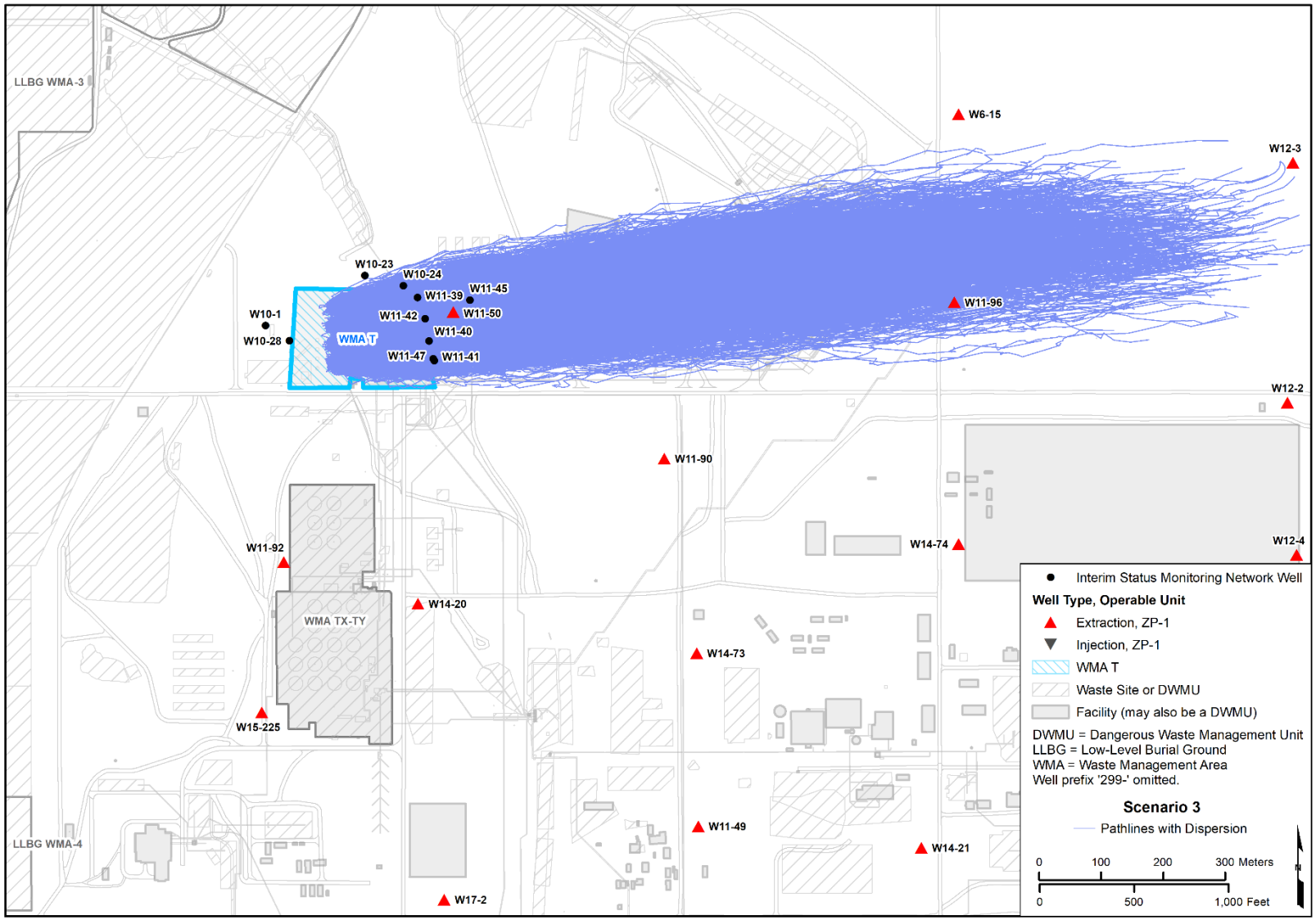

Figure 7-27. Particle Pathlines, Scenario 3

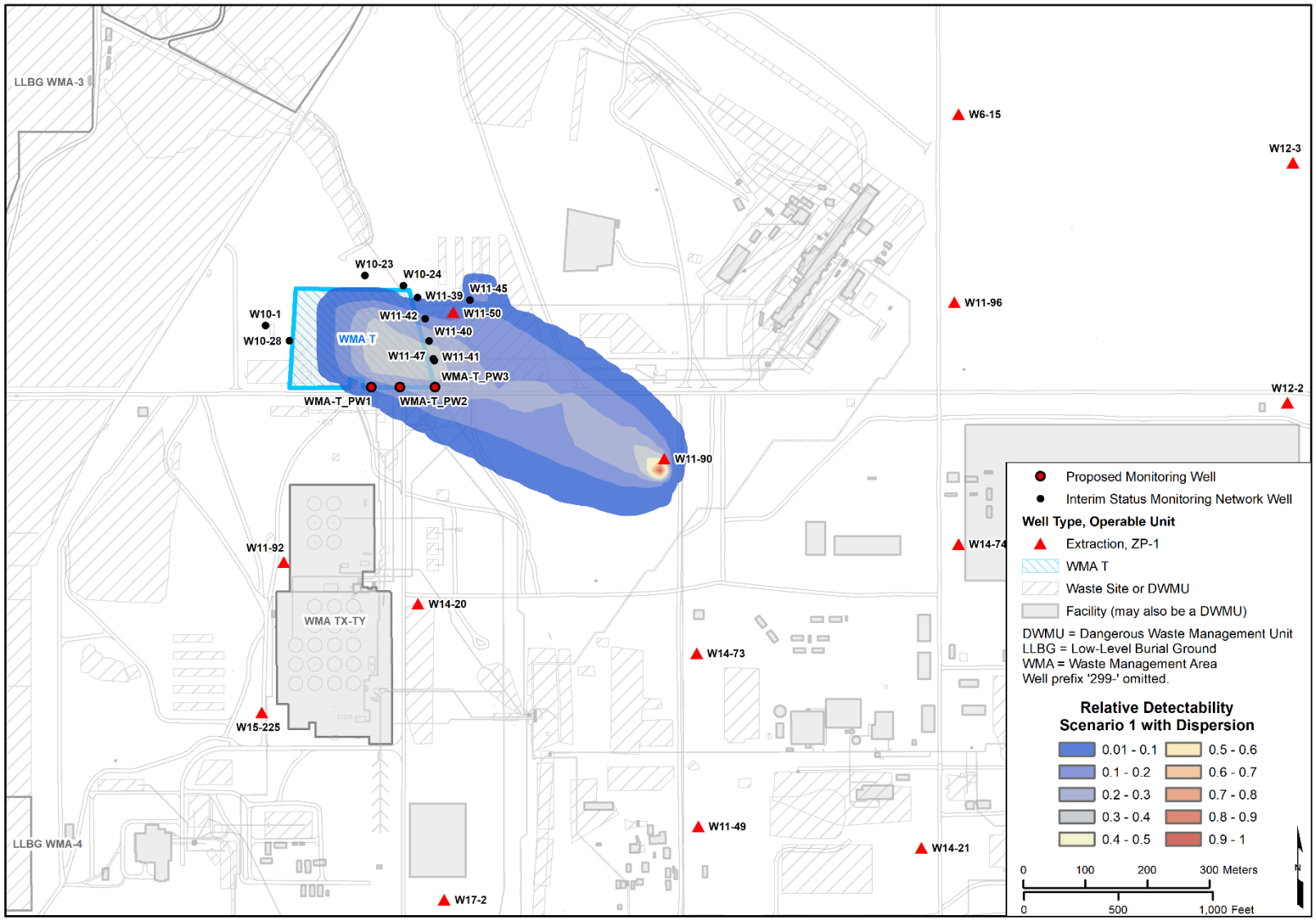

Figure 7-28. Relative Detectability of Release, Scenario 1

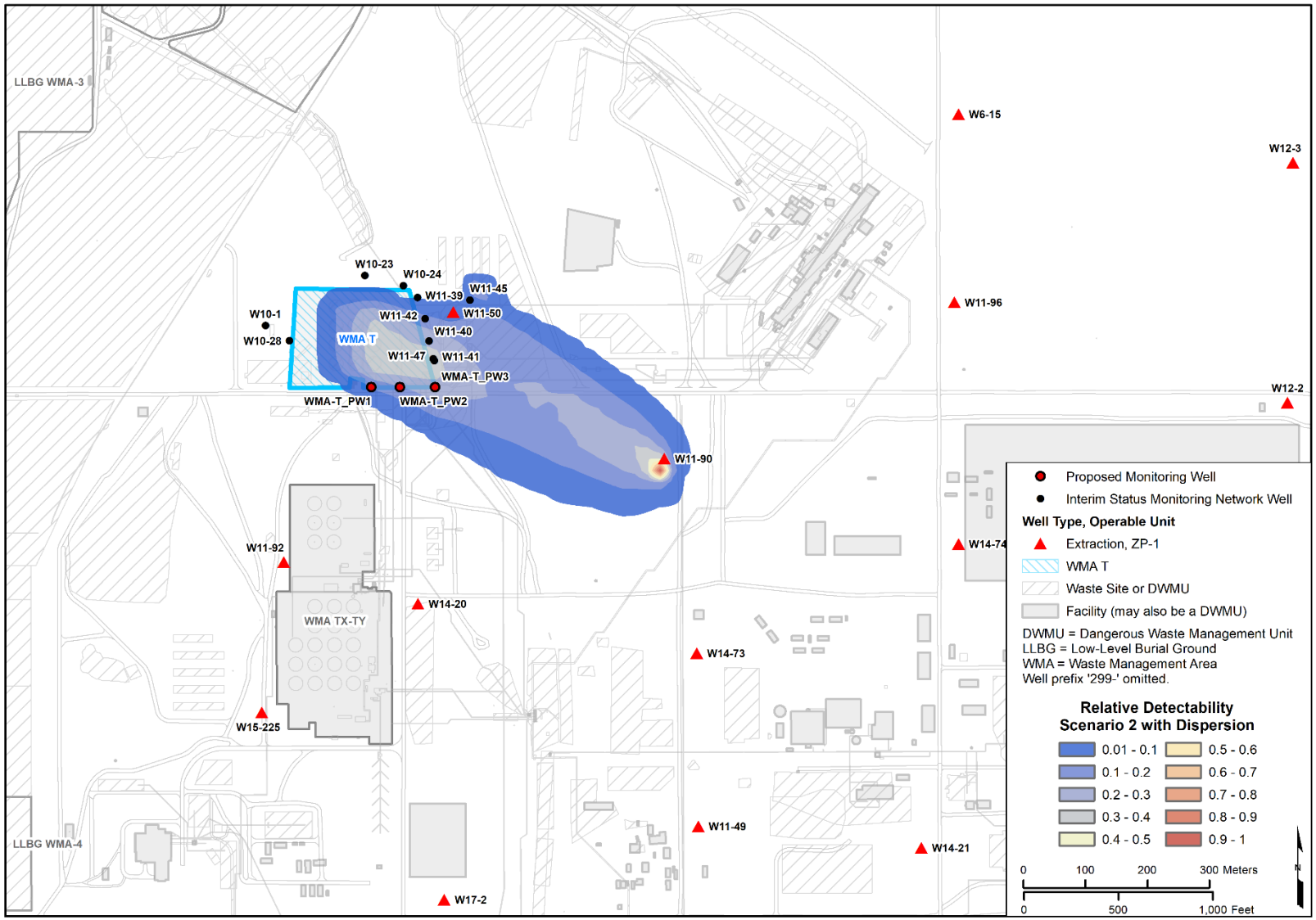

Figure 7-29. Relative Detectability of Release, Scenario 2

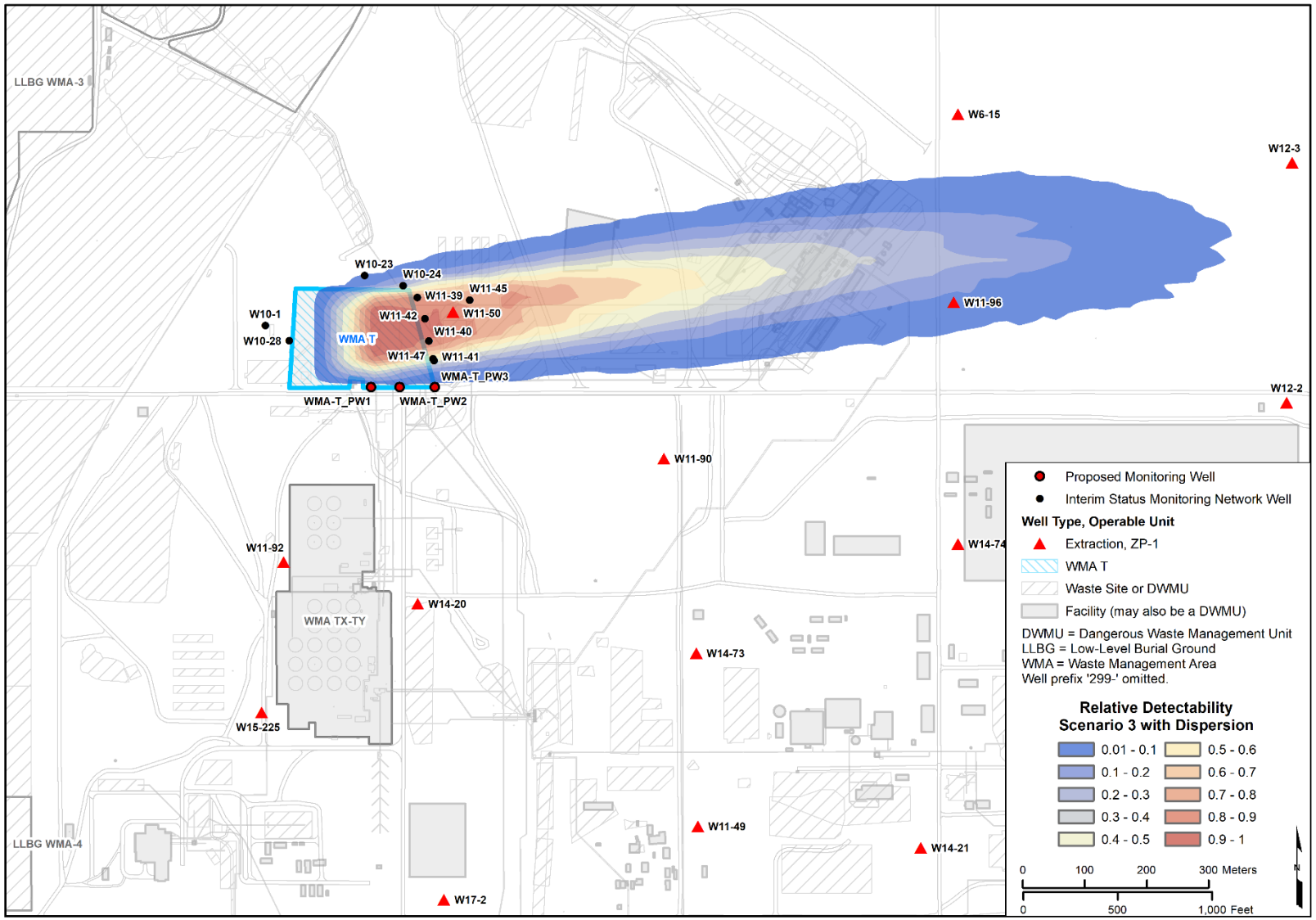

Figure 7-30. Relative Detectability of Release, Scenario 3

7.3 Breakthrough Curves for Proposed Wells

Using transport calculations, injected treated water dilution breakthrough curves and release concentration breakthrough curves were generated for each scenario and sub-scenario to evaluate the proposed wells WMA T_PW1, WMA T_PW2, and WMA T_PW3. Figures 7-31 through 7-33 show injected treated water dilution breakthrough curves for the proposed wells for scenario 1. Figures 7-34 through 7-36 show release concentration breakthrough curves for the proposed wells for scenario 1. The injected treated water dilution breakthrough curves and release concentration breakthrough curves for scenario 2 for the proposed wells are included in Appendix G.

The injected treated water breakthrough curves for these wells indicate sensitivity to variations in 200 West P&T system injection operations. Table 7-3 shows the range of the injected treated water dilution breakthrough curves for the proposed wells for scenarios 1 and 2. Results for scenario 2 were similar to the results for scenario 1. The release concentration breakthrough curves indicate that the suitability for the three new wells are similar, with the potential for detecting releases to the water table from the facility improving as the well locations progress east.

The release concentration breakthrough curves for scenario 3 for the proposed wells are shown in Figure 7-37. These curves indicate that proposed wells will be less likely to detect releases from the facility after cessation of the P&T system operations compared to the curves for these wells during 200 West P&T system operations. Table 7-4 shows the range of the release concentration breakthrough curves for the proposed wells for scenarios 1, 2, and 3.

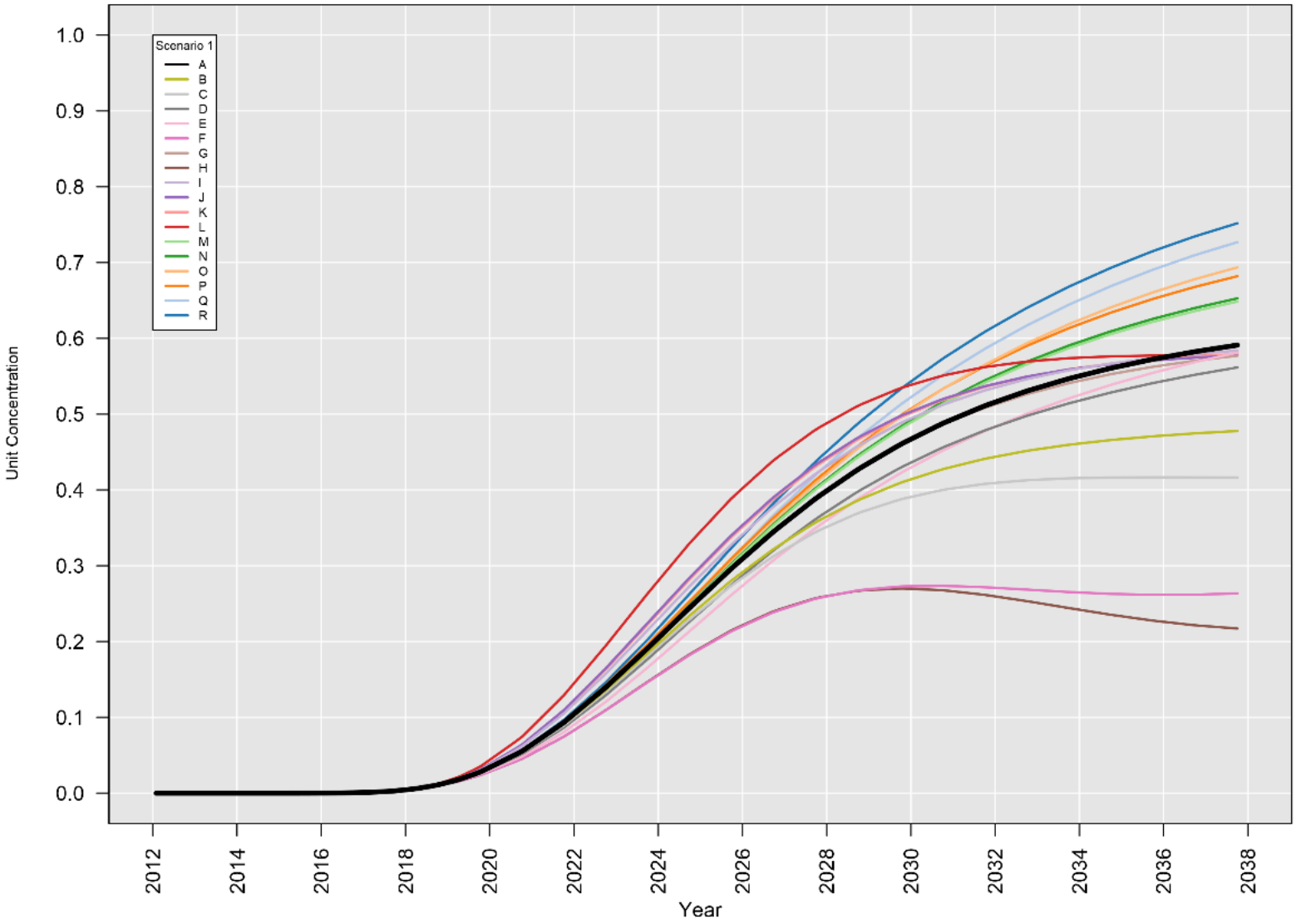

Figure 7-31. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well WMA T_PW1

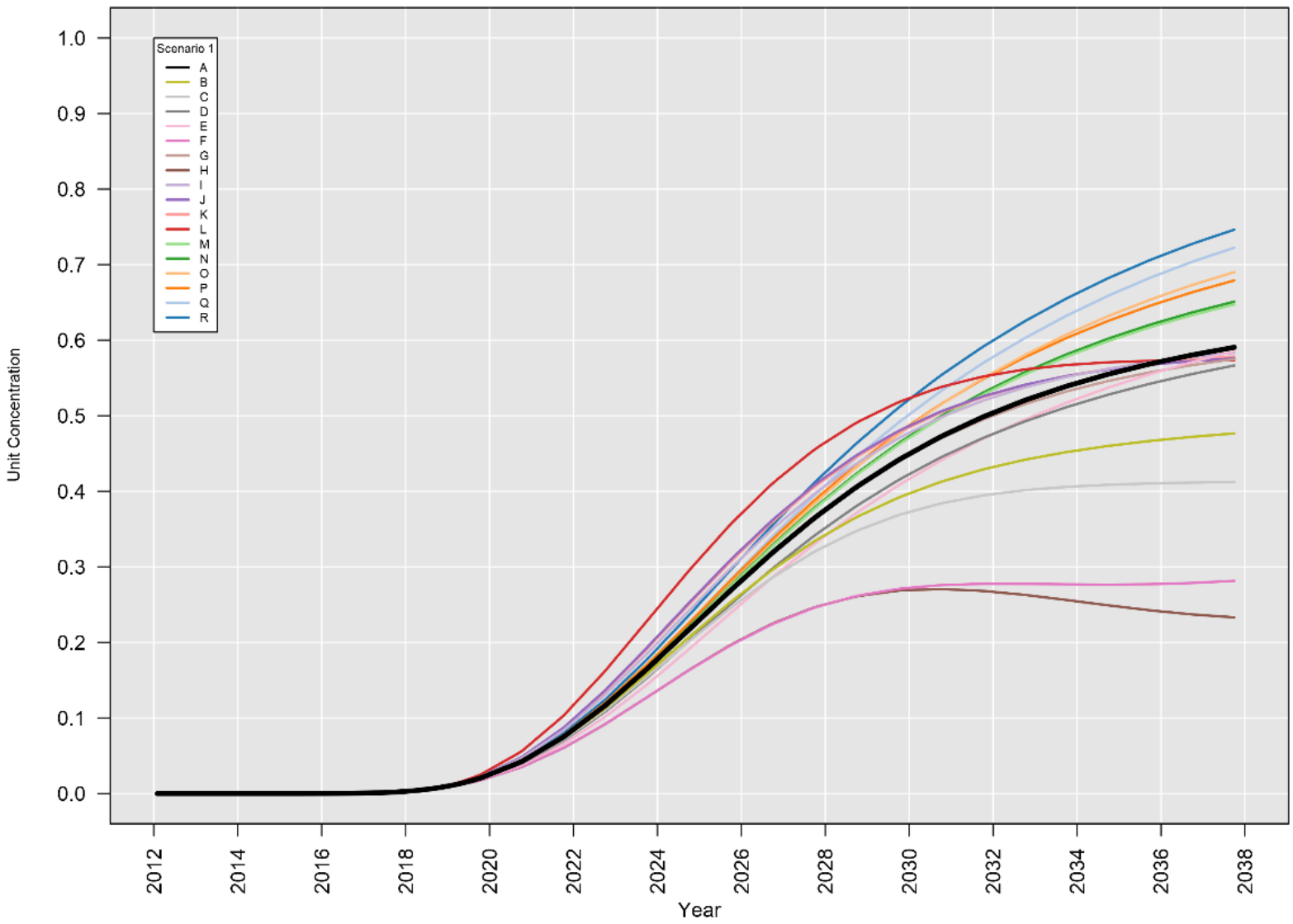

Figure 7-32. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well WMA T_PW2

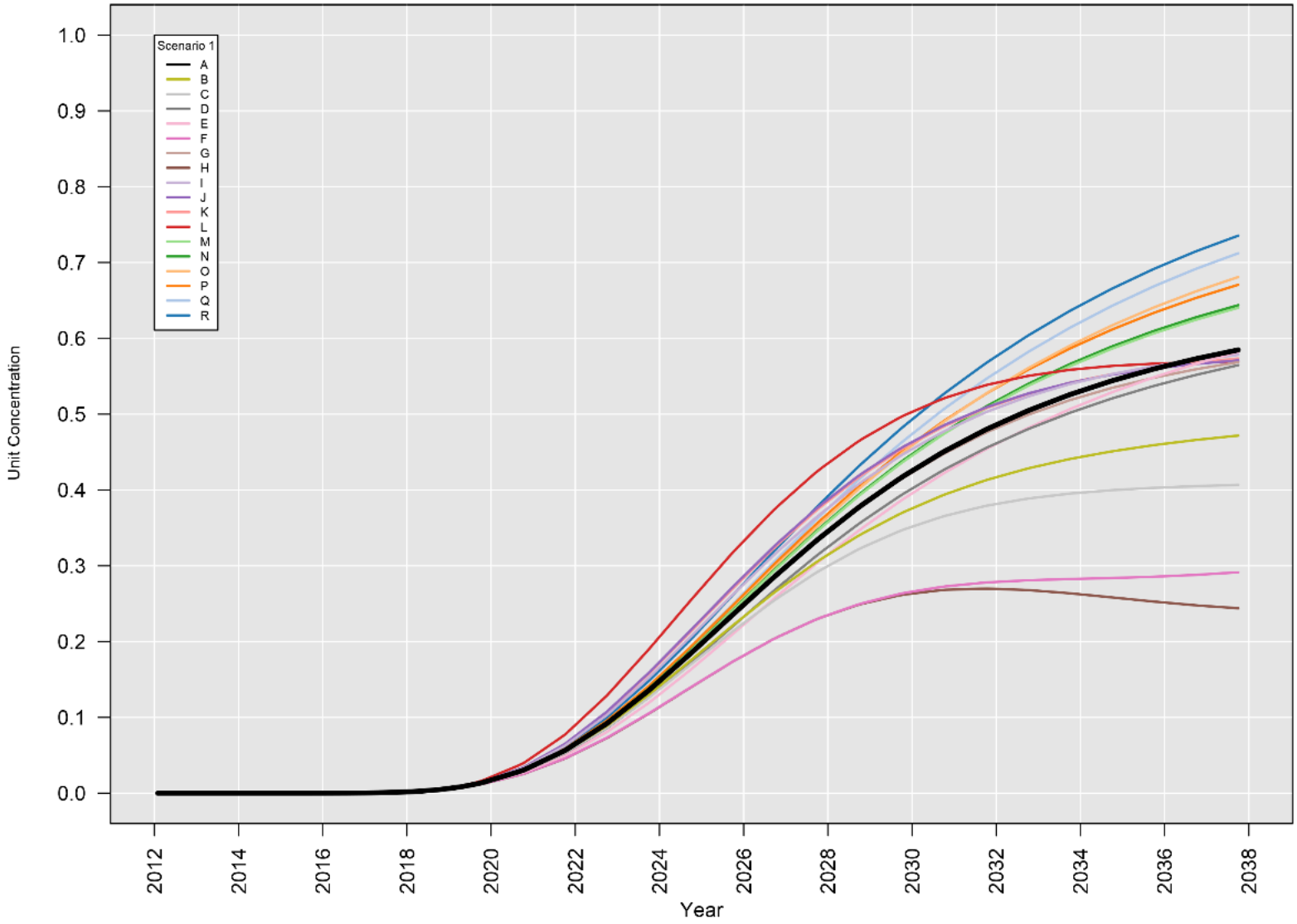

Figure 7-33. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well WMA T_PW3

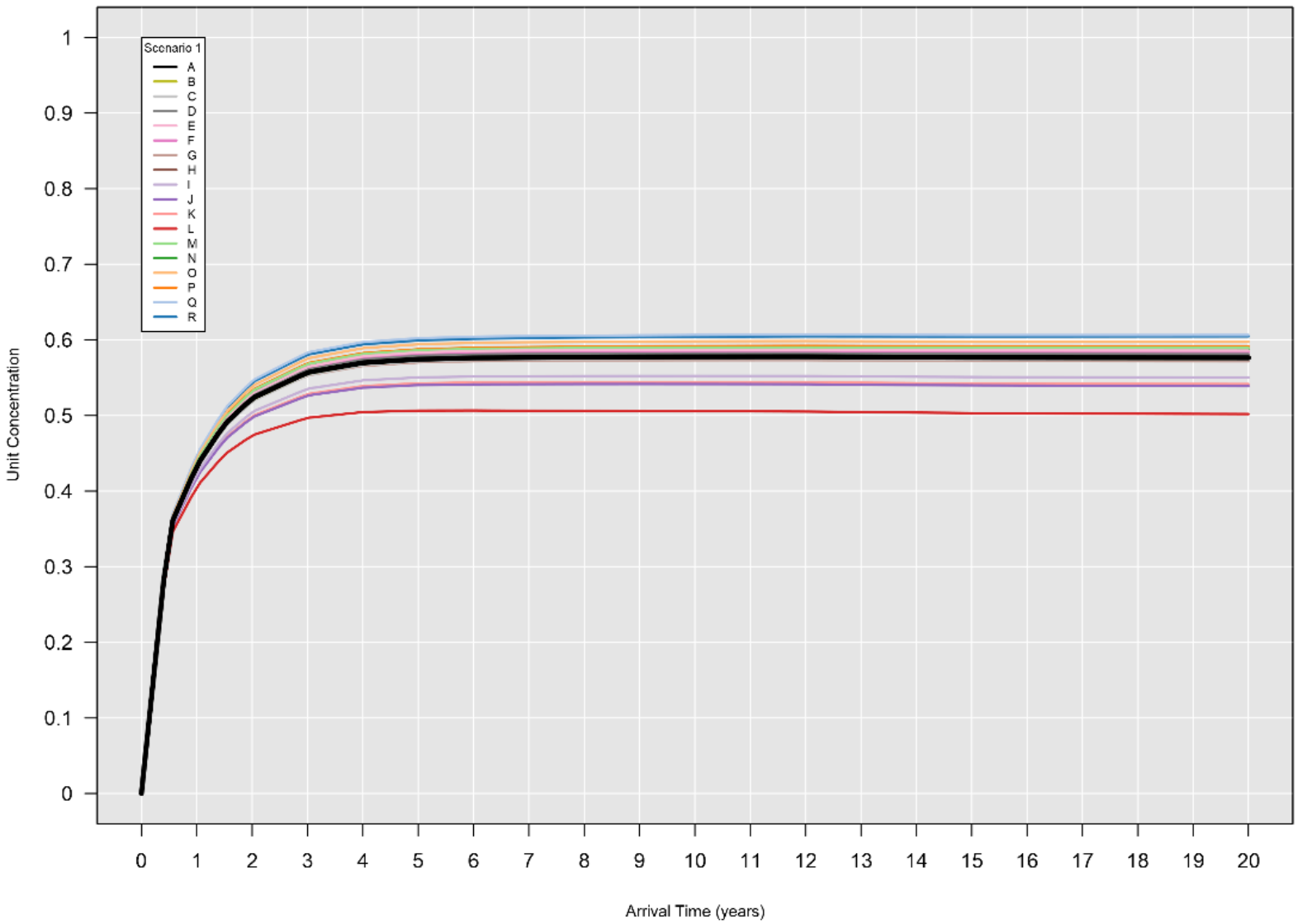

Figure 7-34. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well WMA T_PW1

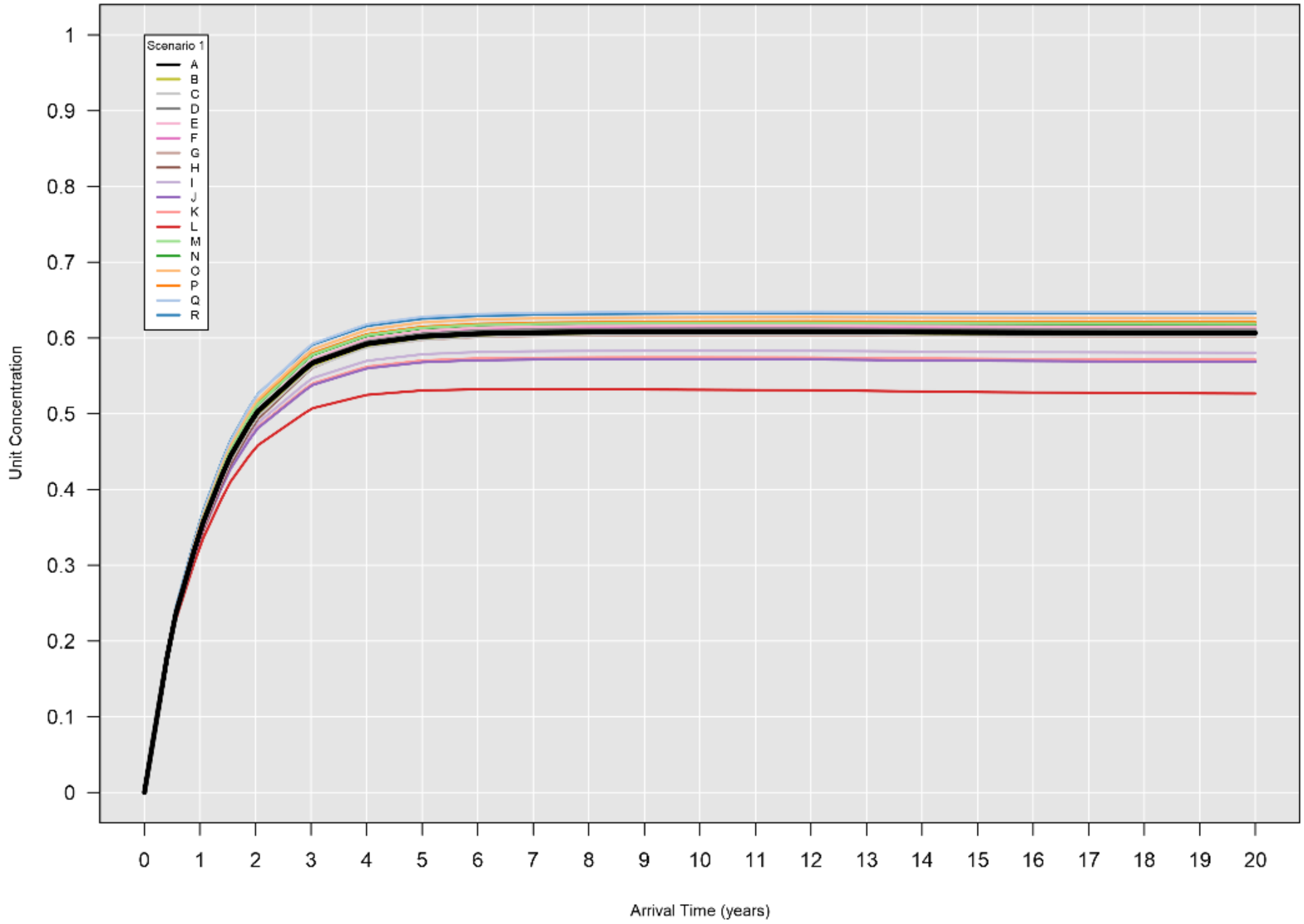

Figure 7-35. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well WMA T_PW2

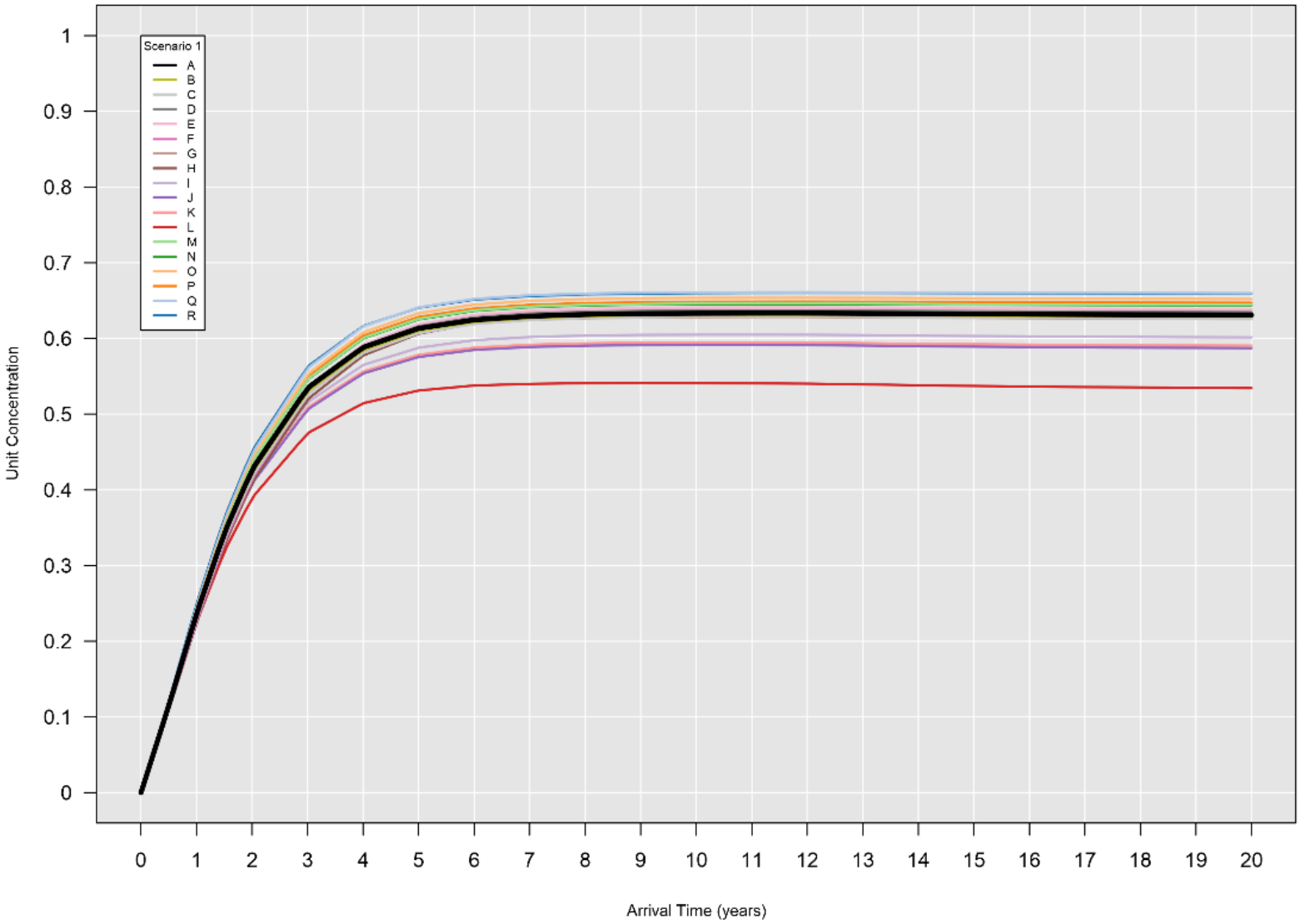

Figure 7-36. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well WMA T_PW3

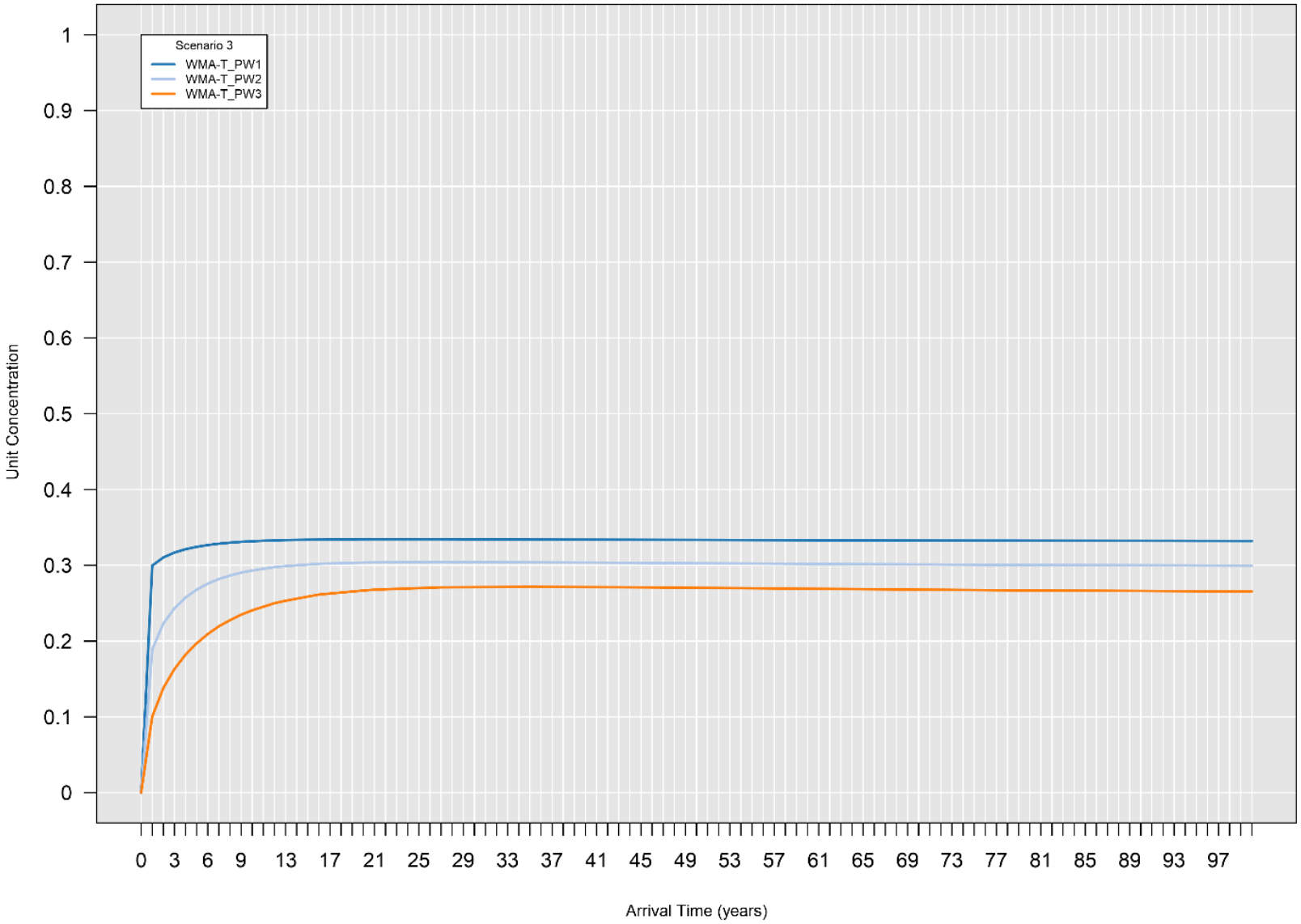

Figure 7-37. Release Concentration Breakthrough Curves, Scenario 3, Proposed Monitoring Wells WMA T_PW1, WMA T_PW2, and WMA T_PW3

Table 7-3. Range of Unit Concentrations of Injected Treated Water Dilution Breakthrough Curves

Well Name	Scenario	Minimum Unit Concentration	Maximum Unit Concentration	Weighted Average
WMA-T_PW1	1	0.217	0.752	0.586
	2	0.225	0.761	0.615
WMA-T_PW2	1	0.233	0.746	0.586
	2	0.241	0.759	0.617
WMA-T_PW3	1	0.244	0.735	0.580
	2	0.252	0.751	0.613

Table 7-4. Range of Unit Concentrations of Release Concentration Breakthrough Curves

Well Name	Scenario	Minimum Unit Concentration	Maximum Unit Concentration	Weighted Average	Scenario 3
WMA-T_PW1	1	0.502	0.606	0.576	0.332
	2	0.502	0.608	0.577	
WMA-T_PW2	1	0.527	0.634	0.606	0.300
	2	0.527	0.635	0.606	
WMA-T_PW3	1	0.534	0.660	0.630	0.265
	2	0.534	0.661	0.630	

7.4 Modeling Conclusions

The proposed final status groundwater monitoring network for WMA T includes retaining existing upgradient well 299-W10-28; retaining existing downgradient wells 299-W10-24, 299-W11-39, 299-W11-40, 299-W11-41, and 299-W11-42; eliminating existing upgradient well 299-W10-1, and eliminating existing downgradient wells 299-W11-45 and 299-W11-47. New downgradient wells WMA T_PW1, WMA T_PW2, and WMA T_PW3 are proposed for the final status monitoring well network. The proposed final status monitoring network is based on the results of the simulation scenarios presented in Appendix G and summarized herein.

Figure 7-38 shows the final status monitoring network wells compared to the combined extents of relative detectability greater than 0.01 for scenarios 1, 2, and 3 from particle tracking; and the combined extents of release unit plumes greater than 0.1 for sub-scenario A of scenarios 1 and 2, and scenario 3 from transport modeling.

The simulations indicate that, under the scenarios evaluated the seven downgradient groundwater monitoring wells of the interim status groundwater monitoring network (wells 299-W10-24, 299-W11-39, 299-W11-40, 299-W11-41, 299-W11-42, 299-W11-45, and 299-W11-47) are well placed for detection of a release to the water table from WMA T under the scenarios evaluated. However, various wells are proposed to be removed from the monitoring network. Well 299-W11-45 is recommended for removal from the monitoring network. This well is a far-field well and is downgradient of other interim status monitoring wells. Well 299-W11-47 is also recommended for removal from the network because it is a deep well and is located in proximity to well 299-W11-41.

In the interim status groundwater monitoring network, well 299-W10-23 is classified as an assessment well. The particle-tracking simulations for scenarios 1 and 2 indicate that well 299-W10-23 is cross-gradient and outside of the detectable area. This well is not recommended for the final status monitoring network.

In addition, the interim status groundwater monitoring network has two upgradient wells (299-W10-1 and 299-W10-28). Upgradient well 299-W10-1 is not constructed according to WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." As such, it also was removed from the recommended monitoring network.

The release concentration breakthrough curves for the recommended downgradient monitoring network wells indicate a range of dilution of less than 7%[1] to approximately 50%[2] for the release unit concentrations. After completion of the 200 West P&T system operations (scenario 3), this dilution range becomes approximately 5% to 72%[3]. Each well is discussed further in Section 9.3.

[1] 7% dilution corresponds to a release unit concentration of approximately 0.93 for sub-scenario L of scenario 1 at monitoring well 299-W11-40 (Figure 7-16).

[2] 50% dilution corresponds to a release unit concentration of approximately 0.5 for sub-scenario L of scenario 1, at proposed monitoring well WMA T_PW1 (Figure 7-34).

[3] 5%-72% dilution for scenario 3 corresponds to a release unit concentration of approximately 0.95 and approximately 0.27 for wells 299-W10-24 and WMA T_PW3, respectively (Figures 7-21 and 7-37).

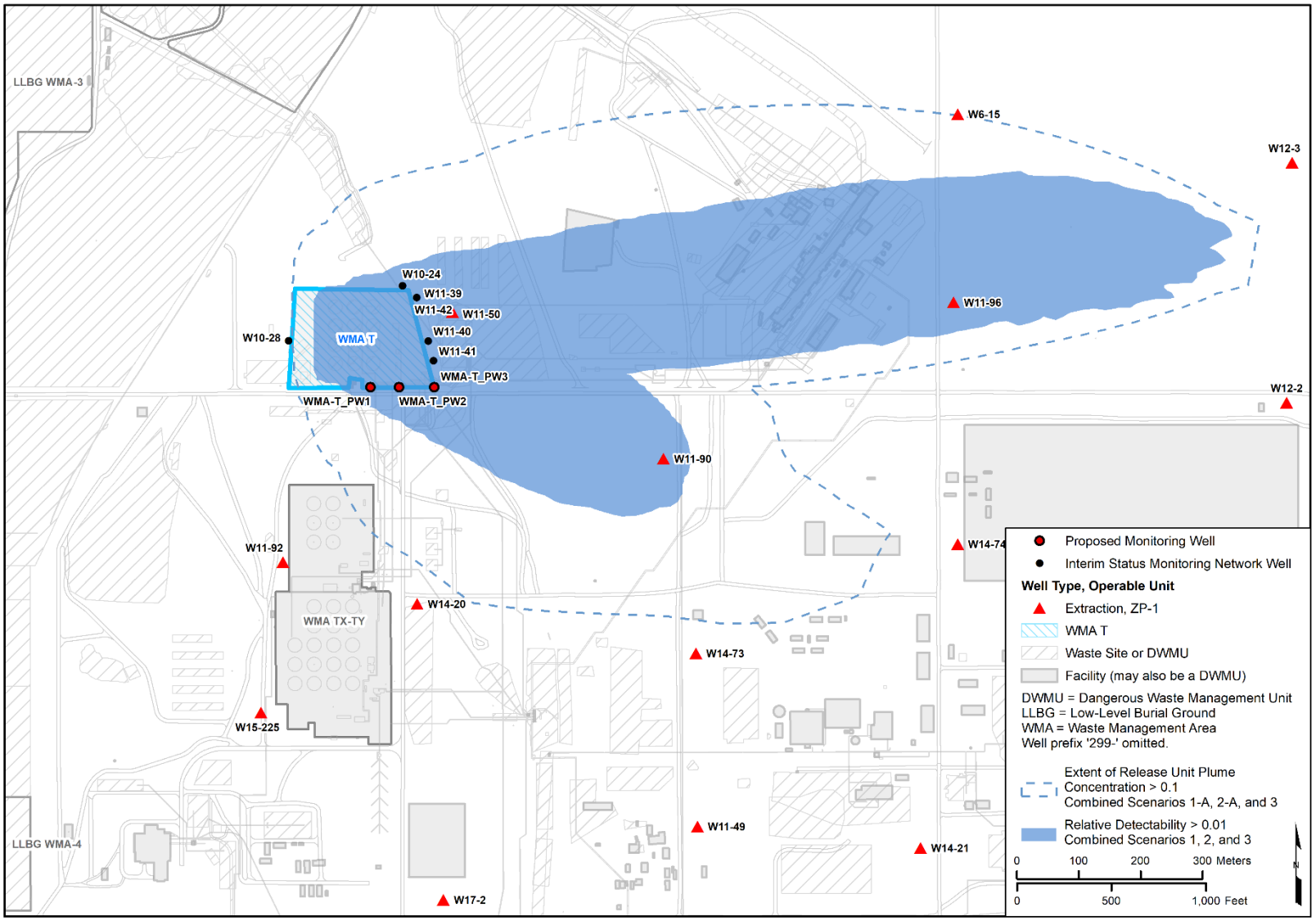

Figure 7-38. Proposed Final Status Groundwater Monitoring Network with Combined Relative Detectability and Release Unit Plume Results

8 Identification of Site-Specific Monitoring Constituents

An evaluation of the waste constituents associated with WMA T and as identified in the RCRA Part A Application, and constituents that were detected in groundwater during interim status monitoring was performed to identify the proposed groundwater monitoring constituents to include in the final status groundwater monitoring program. The evaluation process and the resulting proposed constituents for monitoring are summarized in this chapter and detailed in Appendix B.

8.1 Selection Process for Monitoring Constituents

The data sets comprising the waste constituents associated with WMA T were evaluated and screened in accordance with the summary descriptions provided in Subsections 8.1 through 8.3. Additional details of the methodology are provided in Chapter 3 of Appendix B with assumptions documented in Section 4.1 of Appendix B.

The dangerous wastes identified in the Hanford Facility RCRA Permit SST Part A Permit Application for the SST System and the groundwater sample results collected for WMA T during interim status monitoring comprise the data sets used to identify potential monitoring constituents. The use of the Part A Permit Application information and groundwater sample data are discussed in the following subsections.

8.1.1 Hanford Facility RCRA Permit Part A Form Dangerous Wastes

The Hanford Facility RCRA Permit Part A Form for the SST System identifies the dangerous wastes codes associated with the TSD unit, which includes the WMA T SSTs. A list of dangerous wastes and their corresponding Chemical Abstracts Service (CAS) numbers was compiled using the waste codes and represents the Part A Permit Application dangerous waste data set. The dangerous wastes identified in the SST Part A Permit Application are presented in Table 2-2.

The specified dangerous wastes were screened to identify mobile constituents by comparing literature reference values for constituent distribution coefficients (K_d) to a Hanford Site-derived K_d value of 0.8 mL/g that was developed and applied to a known mobile constituent in Hanford Site vadose soils (hexavalent chromium) (Section 6.1 in ECF-Hanford-11-0165, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100 Area*). Constituents with a $K_d \leq 0.8$ mL/g were identified as mobile constituents and further evaluated as potential monitoring constituents (Appendix B, Tables 1 and 3). If no reference K_d value was available for a constituent, the constituent was conservatively retained for further evaluation as a potential monitoring constituent.

8.1.2 Interim Status Groundwater Monitoring Results

Appendix A includes a summary of the interim status groundwater monitoring history at WMA T, including the changes to the wells network and monitoring constituents. In addition, groundwater sample results collected under interim status monitoring plans are presented for each well. The sample data were retrieved from the Hanford Environmental Information System (HEIS) database and presented in separate Microsoft® Excel® workbooks.

The nonradiological sample data for each well (excluding wells used for information purposes only) were evaluated to determine the maximum measurement result for each detected chemical constituent. Sample data that were qualified with either “U” or an “R” qualifier[4] were not considered in the evaluation. Field parameters (e.g., dissolved oxygen, pH, specific conductance, temperature, turbidity), alkalinity

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[4] Data flagged with a “U” qualifier are analyzed for but not detected. Data flagged with an “R” qualifier are determined during formal data reviews as not valid for any use.

measurements, and non analyte-specific measures (e.g., TOC and TOX) were not considered in the evaluation. The maximum result for each detected chemical was compared to the Hanford Site 90th percentile groundwater background values, as appropriate (Table ES-1 in DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*) (Appendix B, Tables 2 and 4). Constituents that were detected above background values and non-naturally occurring constituents that do not have background values, were retained as potential monitoring constituents.

8.1.3 Final Monitoring Constituent Evaluation

The constituents retained as potential monitoring constituents in Sections 8.1.1 and 8.1.2 were compiled for the final evaluation described in this section. A final evaluation was performed to identify potential monitoring constituents to be included as proposed monitoring constituents to detect and monitor wastes from WMA T that impact groundwater. The initial step of this final evaluation identified those potential monitoring constituents that are also listed in Appendix 5 of Ecology Publication No. 97-407. As monitoring for the dangerous wastes in Appendix 5 of Ecology Publication No. 97-407 is already prescribed for WMA T (Section 9.4), these constituents were identified as proposed monitoring constituents.

The remaining potential monitoring constituents were evaluated in two groups:

- The first group comprised the potential monitoring constituents identified from the SST System Part A Permit Application (Section 8.1.1) that are not identified in Appendix 5 of Ecology Publication No. 97-407. Each of these constituents is a dangerous waste.
- The second group comprised the potential monitoring constituents identified from evaluation of the interim status groundwater results (Section 8.1.2) that were not listed in Appendix 5 of Ecology Publication No. 97-407 and were not identified from the Part A Permit Application.

The potential monitoring constituents in the first group (Part A Permit Application) were evaluated for availability of analysis. Any constituent that is not routinely analyzed by commercial laboratories was removed from consideration. The potential monitoring constituents in the first group that were not excluded due to unavailability of analysis were identified as proposed monitoring constituents.

The potential monitoring constituents in the second group (from interim status groundwater results) that were not already identified as proposed monitoring constituent through the preceding evaluation of the Part A constituents were evaluated as follows:

- Constituents were evaluated to determine if any are dangerous wastes. Any constituent identified as a dangerous waste was identified as a proposed monitoring constituent.
- The remaining constituents were evaluated individually for one or more of the following:
  - Identifying related chemicals (e.g., parent compounds and isomers) that were already identified as proposed monitoring constituents (evaluated on a case-by-case basis).
  - Identifying any potential monitoring constituent that is not routinely analyzed by commercial laboratories. Any potential monitoring constituent that is not routinely analyzed by commercial laboratories was removed from consideration as a proposed monitoring constituent.
  - Comparing the maximum groundwater concentration of the potential monitoring constituent to the federal or state action level (evaluated on a case-by-case basis).

- Determining if a potential monitoring constituent was identified as present in the WMA T SSTs during leak events (Table 2-1) (evaluated on a case-by-case basis).

8.2 Results of Selection of Groundwater Monitoring Constituents

Based on the evaluation of the dangerous wastes identified from the SST System Part A Permit Application and groundwater data collected for WMA T under interim status monitoring plans, 66 waste constituents are identified as proposed monitoring constituents to detect and monitor any groundwater impacts from dangerous waste releases at WMA T (Table 8-1). Of the 66 waste constituents, 7 are nondangerous waste constituents that were quantified in groundwater above the applicable action level and were identified in the waste profile for the WMA T SSTs during leak events. Details of the constituent screening and selection process are provided in Chapter 7 of Appendix B of this document.

Table 8-1. Proposed Groundwater Monitoring Constituents for WMA T

Waste Constituent	CAS Number
Dangerous Waste Constituents	
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
1,1,2-Trichloroethane	79-00-5
1,1-Dichloroethylene	75-35-4
1,2,4-Trichlorobenzene	120-82-1
1,2-Dichloroethane	107-06-2
1,2-Dichloroethene (Total)	540-59-0
1,4-Dichlorobenzene	106-46-7
2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	93-72-1
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2-Nitropropane	79-46-9
4,4'-DDT (Dichlorodiphenyltrichloroethane)	50-29-3
Acetone	67-64-1
Aldrin	309-00-2
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Benzene	71-43-2

Table 8-1. Proposed Groundwater Monitoring Constituents for WMA T

Waste Constituent	CAS Number
Bis(2-ethylhexyl) phthalate	117-81-7
Bromodichloromethane	75-27-4
Cadmium	7440-43-9
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroform	67-66-3
Chromium	7440-47-3
Cobalt	7440-48-4
Copper	7440-50-8
Cyanide	57-12-5
Cyclohexanone	108-94-1
Ethyl acetate	141-78-6
Ethyl ether	60-29-7
Ethylbenzene	100-41-4
Hexavalent chromium	18540-29-9
Isobutanol	78-83-1
Lead	7439-92-1
Mercury	7439-97-6
Methanol	67-56-1
Methyl ethyl ketone	78-93-3
Methyl isobutyl ketone	108-10-1
Methylene chloride	75-09-2
N-butyl alcohol	71-36-3
Nickel	7440-02-0
Nitrobenzene	98-95-3
Ortho-dichlorobenzene	95-50-1
Pyridine	110-86-1
Silver	7440-22-4

Table 8-1. Proposed Groundwater Monitoring Constituents for WMA T

Waste Constituent	CAS Number
Sulfide	18496-25-8
Tetrachloroethene	127-18-4
Thallium	7440-28-0
Tin	7440-31-5
Toluene	108-88-3
Trichloroethylene	79-01-6
Trichlorofluoromethane	75-69-4
Vanadium	7440-62-2
Vinyl chloride	75-01-4
Xylene (total)	1330-20-7
Zinc	7440-66-6
Nondangerous Waste Constituents	
Aluminum	7429-90-5
Fluoride	16984-48-8
Iron	7439-89-6
Manganese	7439-96-5
Nitrate	14797-55-8
Nitrite	14797-65-0
Sulfate	14808-79-8

CAS = Chemical Abstracts Service

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9 Groundwater Monitoring

This chapter includes a description of the proposed final status groundwater monitoring program and identifies the monitoring network, constituents to be sampled and analyzed, and the sample frequency. A detailed groundwater monitoring plan will include corresponding details (e.g., sampling protocols, quality assurance project plan) necessary to meet the requirements of WAC 173-303-806(4)(xx)(E) and (G)(V).

9.1 Final Status Groundwater Monitoring Program Determination

The appropriate groundwater monitoring program (i.e., detection monitoring, compliance monitoring, corrective action monitoring) is determined using the requirements in WAC 173-303-645(2)(a). If there is no statistically significant evidence of a release (contamination) at the point of compliance, the DWMU is monitored under WAC 173-303-645(9), "Detection Monitoring Program." If groundwater monitoring has shown statistically significant evidence of a release (contamination) at the point of compliance, the DWMU is monitored under WAC 173-303-645(10), "Compliance Monitoring Program." If the groundwater protection standard (which may be defined at the time of permit issuance, or when dangerous constituents from a regulated unit have been detected [WAC 173-303-645(3)]) is exceeded, a corrective action program is implemented and the DWMU is monitored under WAC 173-303-645(11), "Corrective Action Program."

To date, a release to the environment (statistically significant evidence of contamination at the point of compliance) of hexavalent chromium and nitrate has been observed at WMA T. Therefore, WMA T will be in compliance monitoring under WAC 173-303-645(10) when WMA T becomes a final status closure unit group in Revision 9 of the Hanford Facility Dangerous Waste Permit.

9.2 Point of Compliance Monitoring

The point of compliance is defined in WAC 173-303-645(6)(a) as "…a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units." WAC 173-303-645(6)(b) further states, "The waste management area is the limit projected in the horizontal plane of the area on which waste will be placed during the active life of a regulated unit. The waste management area includes horizontal space taken up by any liner, dike, or other barrier designed to contain waste in a regulated unit. If the facility contains more than one regulated unit, the waste management area is described by an imaginary line circumscribing the several regulated units."

The results of the modeling described in Chapter 7 indicate that the locations of the eight downgradient wells proposed for the monitoring well network (existing wells 299-W10-24, 299-W11-39, 299-W11-40, 299-W11-41, and 299-W11-42 and proposed wells WMA T_PW1, WMA T_PW2, and WMA T_PW3) span the range of particle distribution as released from WMA T. The well placement is suitable for detecting releases to the water table from WMA T under the evaluated range of conditions. The proposed well locations are intended to comply with the intent of WAC 173-303-645(6), which is to detect waste constituents released and to detect increases of contamination from the facility that would pose a potential risk to ground and surface water. The downgradient wells are proposed as the point of compliance wells. Additional details regarding selection of these wells are presented in Chapter 7. In order to monitor the vertical contamination distribution at the point of compliance, data from available deep wells will be evaluated from other groundwater monitoring programs in the immediate area of the DWMU. These additional wells will be defined in the groundwater monitoring plan and added to the monitoring well network for the DWMU.

9.3 Proposed Groundwater Monitoring Network

The proposed groundwater monitoring network for WMA T consists of one background (upgradient) and eight point of compliance (downgradient) wells to monitor for releases to the water table and detection of increases of contamination from WMA T (Figure 9-1). The monitoring well locations were evaluated under a range of 200 West P&T system operating conditions, or scenarios, presented in Table 5-1, including conditions after shutdown of P&T operations. Results of the simulations of the various scenarios are presented in Chapter 7.

Well attributes are summarized in Table 9-1 and Appendix E. Each of the proposed network wells have been, or will be, constructed according to WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells.". Each well is, or will be, screened in the upper unconfined aquifer in order to yield sufficient groundwater for representative sampling. Sections 9.3.1 through 9.3.9 provide details supporting the selection of each of the proposed locations. Based on the results of the API calculator (Section 7.5 of Appendix G), the depths of the monitoring wells, which are screened across the top of the water table, are appropriate.

Where possible, the groundwater monitoring network is intended to meet the requirements of WAC 173-303-645(8)(a). Groundwater conditions on the Central Plateau have been impacted in different ways throughout the history of the Hanford Site. A description of the impacts to groundwater flow direction pertaining to WMA T is presented in Section 3.3. WAC 173-303-645(8)(a)(i) states that wells must be appropriately sited to, "Represent the quality of background groundwater that has not been affected by leakage from a regulated unit." To meet the intent of WAC 173-303-645(8)(a)(i), a background (upgradient) well has been selected that would be representative of ambient conditions under the currently operating 200 West P&T remedy. It does not however, represent groundwater not affected by Hanford Site operations. Characterization of the contaminated groundwater, including concentrations of dangerous constituents and parameters, will be performed after sufficient samples have been collected in the first 2 years of monitoring to conduct statistical analyses.

WAC 173-303-645(8)(g) states, "In detection monitoring or where appropriate in compliance monitoring, data on each dangerous constituent specified in the permit will be collected from background wells and at the compliance point(s). The number and kinds of samples collected to establish background must be appropriate for the form of statistical test employed, following generally accepted statistical principles. The sample size must be as large as necessary to ensure with reasonable confidence that a contaminant release to groundwater from a facility will be detected…." However, since WAC 173-303-645(8)(h)(v) allows that, "Another statistical test method may be submitted by the owner or operator and approved by the department." The process for selection of a statistical method is found in Appendix H. Selection of the statistical method for use in WMA T is discussed in Section 9.7.

Based on current groundwater flow direction to the east-southeast(DOE/RL-2016-66, Section 3.5) and predictions of future groundwater flow direction toward the east-northeast over time (Figure 7-93 in Appendix G), the selected point of compliance wells will provide representative samples of the quality of groundwater passing the point of compliance (WAC 173-303-645(8)(a)(ii)). These locations allow for the detection of contamination when dangerous waste or dangerous constituents have migrated from the WMA to the uppermost aquifer (WAC 173-303-645(8)(a)(iii)). Using the API calculator to assess the vertical component of contaminant migration indicates that the wells, which are screened in the top of the uppermost unconfined aquifer are suitable for monitoring (Section 7.5 of Appendix G) and determination of compliance with groundwater protection standards (WAC 173-303-645(10)(a)).

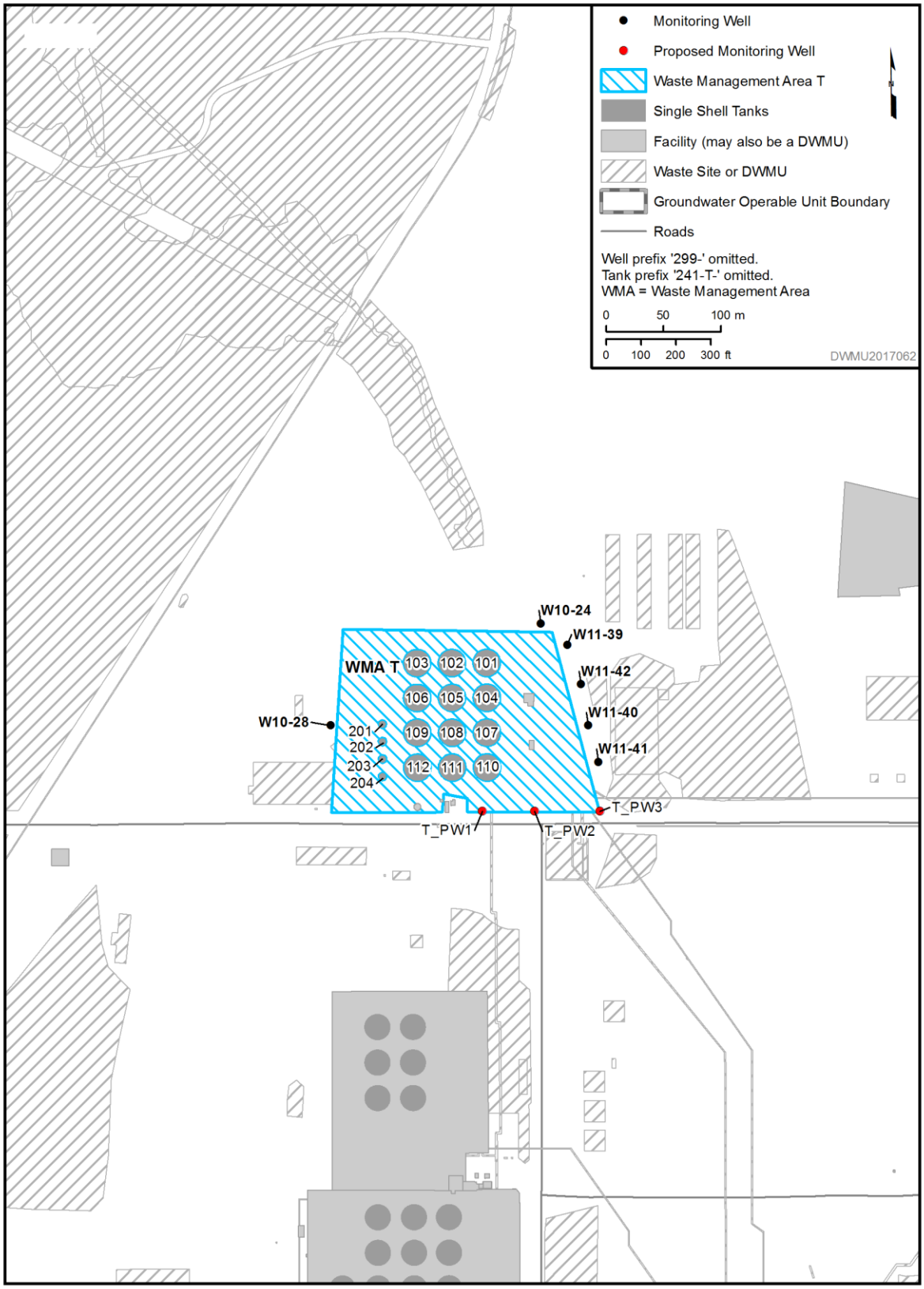

Figure 9-1. Proposed Final Status Groundwater Monitoring Network for WMA T

Table 9-1. Attributes for Wells in the WMA T Groundwater Monitoring Network

Well Name	Completion Date	Northing* (m)	Easting* (m)	Top of Casing Elevation (m [ft]) (NAVD88)	Water Table Elevation (m [ft]) (NAVD88) (amsl)	Water Depth (m [ft] bgs)	Depth of Water in Screen (m [ft])	Water-Level Date
299-W10-24	10/21/1998	136798.8	566885.4	209.7 (688.0)	131.1 (430.1)	77.9 (255.4)	3.8 (12.5)	3/12/2017
299-W10-28	10/17/2001	136709.9	566701.6	206.8 (678.5)	131.9 (432.7)	74.2 (243.4)	5.1 (16.6)	3/12/2017
299-W11-39	12/19/2000	136779.9	566908.4	210.6 (690.9)	130.9 (429.4)	79 (259.3)	4.5 (14.9)	3/12/2017
299-W11-40	10/09/2000	136709.7	566926.8	210.4 (690.3)	131.0 (429.8)	78.7 (258.1)	4.5 (14.8)	8/14/2017
299-W11-41	8/22/2000	136677.8	566935.5	210.6 (690.9)	131.0 (429.8)	78.6 (258)	4.2 (13.9)	8/14/2017
299-W11-42	9/13/2000	136745.7	566920.4	211.1 (692.6)	131.2 (430.4)	79 (259.2)	3.9 (12.9)	8/14/2017
WMA-T_PW1	TBD	136634.7	566834.0	TBD	TBD	TBD	TBD	TBD
WMA-T_PW2	TBD	136634.7	566879.8	TBD	TBD	TBD	TBD	TBD
WMA-T_PW3	TBD	136634.9	566936.7	TBD	TBD	TBD	TBD	TBD

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

amsl = above mean sea level

bgs = below ground surface

TBD = to be determined. Information will be obtained after well construction.

* Coordinates are in Washington State Plane (south zone), NAD83, *North American Datum of 1983*; 1991 adjustment.

Note: Proposed well coordinates, elevations, and projected well design are estimates and are subject to modification based on final well location survey and conditions encountered during drilling.

9.3.1 Groundwater Monitoring Well 299-W10-28

Groundwater monitoring well 299-W10-28 is proposed as a background well. It was constructed in 2001 to the standards of WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA T. The well is upgradient and screened from elevation 137.52 m (451.18 ft) to elevation 126.85 m (416.18 ft) (Appendix E). Based on 2017 water elevation data, well 299-W10-28 is screened across the upper 5.05 m (16.6 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction at well 299-W10-28 is predominantly to the east (Figure 3-14); however, future groundwater flow direction may be impacted by ongoing 200 West P&T operations (i.e., changes in operating conditions). Particle tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release. The results of particle tracking calculations (Figures 7-25 through 7-27) and the results of transport calculations (Figures 7-22 through 7-24) indicate that this well will remain upgradient of WMA T under the scenarios evaluated. The modeling performed for the most likely future 200 West P&T system operating conditions for scenario 1 calculates that the injection of treated water associated with the final 200 West P&T system could dilute the water at this location by as much as 61% for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.61 shown on the injection injected treated water dilution breakthrough curve in Figure 7-4).

9.3.2 Groundwater Monitoring Well 299-W10-24

Groundwater monitoring well 299-W10-24 is proposed as a point of compliance well. It was constructed in 1998 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA T. The well is downgradient of WMA T and is screened from elevation 137.96 m (452.62 ft) to elevation 127.29 m (417.62 ft) (Appendix E). Based on 2017 water elevation data, well 299-W10-24 is screened across the upper 3.81 m (12.5 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the southeast at this well (Figure 3-14); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-22 through 7-24) indicate that the location of this well is suited for detecting releases from the facility. The results of particle-tracking calculations (Figures 7-25 through 7-27) indicate this well is slightly outside of the area of particle tracks for scenarios 1 and 2 but is within the area of interest in scenario 3. The results of the relative detectability evaluation (Figures 7-28 through 7-30) indicate that this well is located to the north of the detectable area for scenarios 1 and 2 and at the northern extent of the estimated area of detectability for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well for scenario 1 (Figure 7-13) indicate some dilution of the release concentration is expected at the well location during 200 West P&T

system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 34% (corresponding to a release unit concentration of approximately 0.66 as shown in Figure 7-13) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 69% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.69 shown on the injection injected treated water dilution breakthrough curve in Figure 7-3). This could result in further dilution of the release concentration by some amount up to but likely less than 69%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination and of increases in contamination should there be a release from WMA T under the range of operating conditions evaluated.

9.3.3 Groundwater Monitoring Well 299-W11-39

Groundwater monitoring well 299-W11-39 is proposed as a point of compliance well. It was constructed in 2000 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA T. The well is downgradient of WMA T and is screened from elevation 137.04 m (449.60 ft) to elevation 126.37 m (414.60 ft) (Appendix E). Based on 2017 water elevation data, well 299-W11-39 is screened across the upper 4.53 m (14.9 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the southeast at this well (Figure 3-14); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-22 through 7-24) and the results of particle-tracking calculations (Figures 7-25 through 7-27) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-28 through 7-30) indicate that this well is located to the north of the detectable area for scenarios 1 and 2 and located centrally in the estimated area of detectability for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well for scenario 1 (Figure 7-15) indicate some dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 35% (corresponding to a release unit concentration of approximately 0.65 shown in Figure 7-15) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 67% of the water

at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.67 shown on the injection injected treated water dilution breakthrough curve in Figure 7-5). This could result in further dilution of the release concentration by some amount up to but likely less than 67%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination and of increases in contamination should there be a release from WMA T under the range of operating conditions evaluated.

9.3.4 Groundwater Monitoring Well 299-W11-40

Groundwater monitoring well 299-W11-40 is proposed as a point of compliance well. It was constructed in 2000 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA T. The well is downgradient of WMA T and is screened from elevation 137.15 m (449.98 ft) to elevation 126.49 m (414.98 ft) (Appendix E). Based on 2017 water elevation data, well 299-W11-40 is screened across the upper 4.51 m (14.8 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the southeast at this well (Figure 3-14); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-22 through 7-24) and the results of particle-tracking calculations (Figures 7-25 through 7-27) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-28 through 7-30) indicate this well is located centrally in the estimated area of detectability for all the scenarios evaluated. The release concentration breakthrough curves for this well for scenario 1 (Figure 7-16) indicate minimal dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 14% (corresponding to a release unit concentration of approximately 0.86 as shown in Figure 7-16) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 62% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.62 shown on the injection injected treated water dilution breakthrough curve in Figure 7-6). This could result in further dilution of the release concentration by some amount up to but likely less than 62%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations

of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination and of increases in contamination should there be a release from WMA T under the range of operating conditions evaluated.

9.3.5 Groundwater Monitoring Well 299-W11-41

Groundwater monitoring well 299-W11-41 is proposed as a point of compliance well. It was constructed in 2000 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA T. The well is downgradient of WMA T and is screened from elevation 137.43 m (450.88 ft) to elevation 126.76 m (415.88 ft) (Appendix E). Based on 2017 water elevation data, well 299-W11-41 is screened across the upper 4.24 m (13.9 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the southeast at this well (Figure 3-14); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-22 through 7-24) and the results of particle-tracking calculations (Figures 7-25 through 7-27) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-28 through 7-30) indicate this well is located centrally in the estimated area of detectability for all the scenarios evaluated. The release concentration breakthrough curves for this well for scenario 1 (Figure 7-17) indicate very little dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 20% (corresponding to a release unit concentration of approximately 0.80 as shown in Figure 7-17) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 60% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.60 shown on the injection injected treated water dilution breakthrough curve in Figure 7-7). This could result in further dilution of the release concentration by some amount up to but likely less than 60%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination and of increases in contamination should there be a release from WMA T under the range of operating conditions evaluated.

9.3.6 Groundwater Monitoring Well 299-W11-42

Groundwater monitoring well 299-W11-42 is proposed as a point of compliance well. It was constructed in 2000 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA T. The well is downgradient of WMA T and is screened from elevation 137.94 m (452.56 ft) to elevation 127.27 m (417.56 ft) (Appendix E). Based on 2017 water elevation data, well 299-W11-42 is screened across the upper 3.93 m (12.9 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the southeast at this well (Figure 3-14); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-22 through 7-24) and the results of particle-tracking calculations (Figures 7-25 through 7-27) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-28 through 7-30) indicate this well is located centrally in the estimated area of detectability for all the scenarios evaluated. The release concentration breakthrough curves for this well for scenario 1 (Figure 7-18) indicate very little dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 26% (corresponding to a release unit concentration of approximately 0.74 as shown in Figure 7-18) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 65% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.65 shown on the injection injected treated water dilution breakthrough curve in Figure 7-8). This could result in further dilution of the release concentration by some amount up to but likely less than 65%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination and of increases in contamination should there be a release from WMA T under the range of operating conditions evaluated.

9.3.7 Groundwater Monitoring Well WMA-T_PW1

Groundwater monitoring well WMA-T_PW1 is a proposed point of compliance well. If the well location is approved, it will be constructed according to WAC 173-160. The proposed location for the well is downgradient of WMA T. The well will be constructed with 10.7 m (35 ft) of screen placed from approximately 1.5 m (5 ft) above and extending to 9.1 m (30 ft) below the uppermost portion of the unconfined aquifer. The proposed screened interval is anticipated to yield sufficient groundwater for representative sampling when constructed.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the southeast at this proposed well location; however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-22 through 7-24) and the results of particle-tracking calculations (Figures 7-25 through 7-27) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-28 through 7-30) indicate that this well is located at the southern edge of the detectable area for scenarios 1 and 2 and located south of the estimated area of detectability for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well for scenario 1 (Figure 7-34) indicate some dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 42% (corresponding to a release unit concentration of approximately 0.58 as shown in Figure 7-34) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 59% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.59 shown on the injection injected treated water dilution breakthrough curve in Figure 7-31). This could result in further dilution of the release concentration by some amount up to but likely less than 59%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination and of increases in contamination should there be a release from WMA T under the range of operating conditions evaluated.

9.3.8 Groundwater Monitoring Well WMA-T_PW2

Groundwater monitoring well WMA-T_PW2 is a proposed point of compliance well. If the well location is approved, it will be constructed according to WAC 173-160. The proposed location for the well is downgradient of WMA T. The well will be constructed with 10.7 m (35 ft) of screen placed from approximately 1.5 m (5 ft) above and extending to 9.1 m (30 ft) below the uppermost portion of the unconfined aquifer. The proposed screened interval is anticipated to yield sufficient groundwater for representative sampling when constructed.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the southeast at this proposed well location; however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario,

the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of the relative detectability evaluation (Figures 7-28 through 7-30) indicate that this well is located centrally in the estimated area of detectability for scenarios 1 and 2 and located south of the detectable area for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well for scenario 1 (Figure 7-35) indicate some dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 39% (corresponding to a release unit concentration of approximately 0.61 as shown in Figure 7-35) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 59% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.59 shown on the injection injected treated water dilution breakthrough curve in Figure 7-32). This could result in further dilution of the release concentration by some amount up to but likely less than 59%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination and of increases in contamination should there be a release from WMA T under the range of operating conditions evaluated.

9.3.9 Groundwater Monitoring Well WMA-T_PW3

Groundwater monitoring well WMA-T_PW3 is a proposed point of compliance well. If the well location is approved, it will be constructed according to WAC 173-160. The proposed location for the well is downgradient of WMA T. The well will be constructed with 10.7 m (35 ft) of screen placed from approximately 1.5 m (5 ft) above and extending to 9.1 m (30 ft) below the uppermost portion of the unconfined aquifer. The proposed screened interval is anticipated to yield sufficient groundwater for representative sampling when constructed.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the southeast at this proposed well location; however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of the relative detectability evaluation (Figures 7-28 through 7-30) indicate that this well is located centrally in the estimated area of detectability for scenarios 1 and 2 and located south of the detectable area for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well for scenario 1 (Figure 7-36) indicate some dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-

scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 37% (corresponding to a release unit concentration of approximately 0.63 as shown in Figure 7-36) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 59% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.59 shown on the injection injected treated water dilution breakthrough curve in Figure 7-33). This could result in further dilution of the release concentration by some amount up to but likely less than 59%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination and of increases in contamination should there be a release from WMA T under the range of operating conditions evaluated.

9.4 Constituent List and Frequency

The proposed WMA T final status groundwater monitoring network detailed in this report consists of one upgradient well (299-W10-28) and eight downgradient wells (existing wells 299-W10-24, 299-W11-39, 299-W11-40, 299-W11-41, and 299-W11-42 and proposed wells WMA-T_PW1, WMA-T_PW2, and WMA-T_PW3). The upgradient well (299-W10-28) and downgradient wells (299-W10-24, 299-W11-39, 299-W11-40, 299-W11-41, and 299-W11-42) are part of the WMA T interim status groundwater monitoring network (Table 3-2 in DOE/RL-2009-66, Rev. 1) and are shown in Figure 9-1.

For a compliance monitoring program, WAC 173-303-645(10)(a) requires, “The owner or operator monitor the groundwater to determine whether regulated units are in compliance with the groundwater protection standard under subsection (3) of this section. The department will specify the groundwater protection standard in the facility permit, including: (i) A list of the dangerous constituents and parameters identified under subsection (4) of this section; (ii) Concentration limits under subsection (5) of this section, for each of those dangerous constituents and parameters; (iii) The compliance point under subsection (6) of this section; and (iv) The compliance period under subsection (7) of this section.” Based on the analysis in Chapter 8, 66 waste constituents were selected to detect and monitor groundwater impacts from dangerous waste releases at WMA T.

Table 9-2 identifies the proposed monitoring network and sampling frequency for WMA T. The proposed site-specific monitoring constituents (Table 9-3) will be sampled quarterly for the first 2 years of monitoring. After background concentrations are determined, the proposed monitoring constituents will be sampled semi-annually. Field measurements (pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature, and turbidity) will be collected each time a well is sampled. Water-level measurements at each monitoring well will be determined each time a sample is obtained (WAC 173-303-645(8)(f)). Analytical performance, data evaluation, reporting, sampling protocols, and quality assurance requirements will be specified in the final status groundwater monitoring plan to be prepared for WMA T.

In accordance with 16-NWP-090, performing 1 year of background monitoring for WAC 173-303-110(3)(c) and (7) constituents was established. WAC 173-303-110(3)(c) references

Ecology Publication No. 97-407, and WAC 173-303-110(7) references Appendix 5 of Ecology Publication No. 97-407. Accordingly, the constituents identified in Appendix 5 of Ecology Publication No. 97-407 (Table 9-4) will be sampled for background monitoring. However, to support collection of sufficient samples to perform statistical testing (e.g., eight samples) and establish background concentrations, sampling for Ecology Publication No. 97-407 Appendix 5 constituents will be extended to a 2-year period and performed on a quarterly basis. Section 9.7 provides details on the number of sample data required to determine a statistical method.

Statistical evaluation of sampling results will be performed for site-specific monitoring constituents (Table 9-3) and the Appendix 5 dangerous wastes (Table 9-4), as appropriate. Information on the statistical method is provided in Section 9.7.

When the groundwater monitoring plan for WMA T is incorporated into the Hanford Facility Dangerous Waste Permit, it will replace any other groundwater monitoring plan(s) associated specifically with this DWMU under interim status.

Table 9-2. Monitoring Wells and Sample Schedule for WMA T

Well Name	Purpose	WAC Compliant	Water Level	Site-Specific Constituents to Detect and Monitor Groundwater Impacts from Releases at Regulated Unit[a]									Dangerous Wastes[b]	Field Parameters[h]
				Cyanide	Hexavalent Chromium	Sulfide	Metals[c]	Anions[d]	Volatile Organic Compounds[e]	Semivolatile Organic Compounds[f]	Methanol	Herbicides/Pesticides[g]	Table 9-4	
299-W10-28	Upgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W10-24	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W11-39	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W11-40	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W11-41	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W11-42	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
WMA-T_PW1	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
WMA-T_PW2	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
WMA-T_PW3	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S

Note: Complete reference citations are provided in Chapter 11.

a. Monitoring constituents will be sampled quarterly for the first 2 years of monitoring to determine background concentrations. After background concentrations are determined, these constituents will be monitored semiannually.

b. To establish background concentrations in accordance with 16-NWP-090 and to support collection of sufficient samples to perform statistical testing (e.g., eight samples), quarterly sampling for Ecology Publication No. 97-407 Appendix 5 constituents will be performed for a 2-year period. Sampling after this 2-year period will be performed annually, in accordance with WAC 173-303-645(10)(g).

Table 9-2. Monitoring Wells and Sample Schedule for WMA T

Well Name	Purpose	WAC Compliant	Water Level	Site-Specific Constituents to Detect and Monitor Groundwater Impacts from Releases at Regulated Unit[a]									Dangerous Wastes[b]	Field Parameters[h]
				Cyanide	Hexavalent Chromium	Sulfide	Metals[c]	Anions[d]	Volatile Organic Compounds[e]	Semivolatile Organic Compounds[f]	Methanol	Herbicides/Pesticides[g]	Table 9-4	

c. Metals are provided in Table 9-3 and include aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, thallium, tin, vanadium, and zinc.

d. Anions are provided in Table 9-3 and include fluoride, nitrate, nitrite, and sulfate.

e. Volatile organic compounds are provided in Table 9-3 and include 1-butanol, 1,1-dichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloro-1,2,2-trifluoroethane, 1,1,2-trichloroethane, 1,2-dichloroethane, 1,2-dichloroethene (total), 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, 2-butanone (methyl ethyl ketone), 2-nitropropane, 2-propanone (acetone), 4-methyl-2-pentanone (methyl isobutyl ketone),benzene, bromodichloromethane, carbon disulfide, carbon tetrachloride, chlorobenzene, chloroform, cyclohexanone, ethyl acetate, ethyl ether, ethylbenzene, isobutanol, methylene chloride, tetrachloroethene, toluene, trichloroethylene (TCE), trichlorofluoromethane, vinyl chloride (chloroethene), and xylene (total).

f. Semivolatile organic compounds are provided in Table 9-3 and include 1,2-dichlorobenzene (o-dichlorobenzene); 2,4-dinitrophenol; 2,4-dinitrotoluene; bis(2-ethylhexyl) phthalate; nitrobenzene; and pyridine.

g. Herbicides and pesticides are provided in Table 9-3 and include 2,4,5-TP(2-(2,4,5-trichlorophenoxy)propionic acid)Silvex, 4,4'-DDT (dichlorodiphenyltrichloroethane), and aldrin.

h. Field parameters include pH, dissolved oxygen, oxidation-reduction potential, specific conductance, temperature, and turbidity. Field parameters will be measured at each sample event (quarterly for the first 2 years of monitoring and semiannually thereafter).

A = annually

E = each time the well is sampled

Q = quarterly

S = semiannually

WAC = *Washington Administrative Code*

Y = well is, or will be, constructed as a resource protection well (WAC 173-160, “Minimum Standard for Construction and Maintenance of Wells”)

Table 9-3. Proposed Groundwater Monitoring Constituents for WMA T

Waste Constituent	CAS Number
Dangerous Waste Constituents	
Inorganics	
Cyanide	57-12-5
Hexavalent chromium	18540-29-9
Sulfide	18496-25-8
Metals	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Copper	7440-50-8
Lead	7439-92-1
Mercury	7439-97-6
Nickel	7440-02-0
Silver	7440-22-4
Thallium	7440-28-0
Tin	7440-31-5
Vanadium	7440-62-2
Zinc	7440-66-6
Volatile Organic Compounds	
1-Butanol (n-Butyl alcohol)	71-36-3
1,1-Dichloroethylene	75-35-4
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
1,1,2-Trichloroethane	79-00-5
1,2-Dichloroethane	107-06-2

Table 9-3. Proposed Groundwater Monitoring Constituents for WMA T

Waste Constituent	CAS Number
1,2-Dichloroethene (Total)	540-59-0
1,4-Dichlorobenzene	106-46-7
1,2,4-Trichlorobenzene	120-82-1
2-Butanone (Methyl ethyl ketone)	78-93-3
2-Nitropropane	79-46-9
2-Propanone (Acetone)	67-64-1
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1
Benzene	71-43-2
Bromodichloromethane	75-27-4
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroform	67-66-3
Cyclohexanone	108-94-1
Ethyl acetate	141-78-6
Ethyl ether	60-29-7
Ethylbenzene	100-41-4
Isobutanol (Isobutyl alcohol)	78-83-1
Methylene chloride	75-09-2
Tetrachloroethene	127-18-4
Toluene	108-88-3
Trichloroethylene (TCE)	79-01-6
Trichlorofluoromethane	75-69-4
Vinyl chloride (Chloroethene)	75-01-4
Xylene (total)	1330-20-7
Semivolatile Organic Compounds	
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1
2,4-Dinitrophenol	51-28-5

Table 9-3. Proposed Groundwater Monitoring Constituents for WMA T

Waste Constituent	CAS Number
2,4-Dinitrotoluene	121-14-2
Bis(2-ethylhexyl) phthalate	117-81-7
Nitrobenzene	98-95-3
Pyridine	110-86-1
Alcohols/Ketones	
Methanol	67-56-1
Herbicides	
2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	93-72-1
Pesticides	
4,4'-DDT (Dichlorodiphenyltrichloroethane)	50-29-3
Aldrin	309-00-2
Nondangerous Waste Constituents	
Anions	
Fluoride	16984-48-8
Nitrate	14797-55-8
Nitrite	14797-65-0
Sulfate	14808-79-8
Metals	
Aluminum	7429-90-5
Iron	7439-89-6
Manganese	7439-96-5

CAS = Chemical Abstracts Service

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
Inorganic Constituents			
Antimony	7440-36-0	Mercury	7439-97-6
Arsenic	7440-38-2	Nickel	7440-02-0
Barium	7440-39-3	Selenium	7782-49-2
Beryllium	7440-41-7	Silver	7440-22-4
Cadmium	7440-43-9	Sulfide	18496-25-8
Chromium	7440-47-3	Thallium	7440-28-0
Cobalt	7440-48-4	Tin	7440-31-5
Copper	7440-50-8	Vanadium	7440-62-2
Cyanide	57-12-5	Zinc	7440-66-6
Lead	7439-92-1	-	-
Volatile Organic Compounds			
1,1-Dichloroethane	75-34-3	Carbon tetrachloride	56-23-5
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	Chlorobenzene	108-90-7
1,1,1-Trichloroethane	71-55-6	Chloroethane	75-00-3
1,1,1,2-Tetrachloroethane	630-20-6	Chloroform	67-66-3
1,1,2-Trichloroethane	79-00-5	Chloroprene	126-99-8
1,1,2,2-Tetrachloroethane	79-34-5	Dibromochloromethane	124-48-1
1,2-Dibromo-3-chloropropane	96-12-8	p-Dichlorobenzene (1,4-Dichlorobenzene)	106-46-7
1,2-Dibromoethane	106-93-4	Dichlorodifluoromethane	75-71-8
1,2-Dichloroethane	107-06-2	Ethylbenzene	100-41-4
1,2-Dichloropropane	78-87-5	Ethyl methacrylate	97-63-2
trans-1,2-Dichloroethylene	156-60-5	Isobutanol (Isobutyl alcohol)	78-83-1
1,2,3-Trichloropropane	96-18-4	Methacrylonitrile	126-98-7
cis-1,3-Dichloropropene	10061-01-5	Methyl bromide (Bromomethane)	74-83-9
trans-1,3-Dichloropropene	10061-02-6	Methyl chloride (Chloromethane)	74-87-3
trans-1,4-Dichloro-2-butene	110-57-6	Methyl iodide (Iodomethane)	74-88-4

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
2-Butanone (Methyl ethyl ketone; MEK)	78-93-3	Methyl methacrylate	80-62-6
2-Propanone (acetone)	67-64-1	Methylene bromide (Dibromomethane)	74-95-3
2-Hexanone (Methyl butyl ketone)	591-78-6	Methylene chloride	75-09-2
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1	Propionitrile (Ethyl cyanide)	107-12-0
Acetonitrile (Methyl cyanide)	75-05-8	Styrene	100-42-5
Acrolein	107-02-8	Tetrachloroethene	127-18-4
Acrylonitrile	107-13-1	Toluene	108-88-3
Allyl chloride	107-05-1	Trichloroethylene (TCE)	79-01-6
Benzene	71-43-2	Trichlorofluoromethane	75-69-4
Bromodichloromethane	75-27-4	Vinyl acetate	108-05-4
Bromoform	75-25-2	Vinyl chloride (Chloroethene)	75-01-4
Carbon disulfide	75-15-0	Xylenes (total)	1330-20-7
Semivolatile Organic Compounds			
1-Naphthylamine	134-32-7	Dimethyl phthalate	131-11-3
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	Di-n-butyl phthalate	84-74-2
1,2,4-Trichlorobenzene	120-82-1	m-Dinitrobenzene	99-65-0
1,2,4,5-Tetrachlorobenzene	95-94-3	Di-n-octylphthalate	117-84-0
1,4-Dioxane	123-91-1	Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	88-85-7
1,4-Naphthoquinone	130-15-4	Diphenylamine	122-39-4
2-Acetylaminofluorene	53-96-3	Disulfoton	298-04-4
2-Chloronaphthalene	91-58-7	Ethyl methanesulfonate	62-50-0
2-Chlorophenol	95-57-8	Famphur	52-85-7
2-Methylphenol (o-cresol)	95-48-7	Fluoranthene	206-44-0
2-Methylnaphthalene	91-57-6	9H-Fluorene (Fluorene)	86-73-7
2-Naphthylamine	91-59-8	Hexachlorobenzene	118-74-1
2-Nitrophenol (o-Nitrophenol)	88-75-5	Hexachlorobutadiene	87-68-3
2-Picoline	109-06-8	Hexachlorocyclopentadiene	77-47-4

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
2,3,4,6-Tetrachlorophenol	58-90-2	Hexachloroethane	67-72-1
2,4-Dichlorophenol	120-83-2	Hexachlorophene	70-30-4
2,4-Dimethylphenol	105-67-9	Hexachloropropene	1888-71-7
2,4-Dinitrophenol	51-28-5	Indeno(1,2,3-cd)pyrene	193-39-5
2,4-Dinitrotoluene	121-14-2	Isodrin	465-73-6
2,4,5-Trichlorophenol	95-95-4	Isophorone	78-59-1
2,4,6-Trichlorophenol	88-06-2	Isosafrole	120-58-1
2,6-Dichlorophenol	87-65-0	Kepone	143-50-0
2,6-Dinitrotoluene	606-20-2	Methapyrilene	91-80-5
3-Methylcholanthrene	56-49-5	Methyl methanesulfonate	66-27-3
3-Methylphenol (m-Cresol)	108-39-4	Methyl parathion	298-00-0
4-Methylphenol (p-cresol)	106-44-5	Naphthalene	91-20-3
3,3′-Dichlorobenzidine	91-94-1	Nitrobenzene	98-95-3
3,3′-Dimethylbenzidine	119-93-7	o-Nitroaniline (2-Nitroaniline)	88-74-4
4-Aminobiphenyl	92-67-1	m-Nitroaniline (3-Nitroaniline)	99-09-2
4-Bromophenyl phenyl ether	101-55-3	p-Nitroaniline (4-Nitroaniline)	100-01-6
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7	p-Nitrophenol (4-Nitrophenol)	100-02-7
4-Chlorophenyl phenyl ether	7005-72-3	N-Nitrosodi-n-butylamine	924-16-3
4-Nitroquinoline 1-oxide	56-57-5	N-Nitrosodiethylamine	55-18-5
4,6-Dinitro-o-cresol (4,6-Dinitro-2-methyl phenol)	534-52-1	N-Nitrosodimethylamine	62-75-9
5-Nitro-o-toluidine	99-55-8	N-Nitrosodiphenylamine	86-30-6
7,12-Dimethylbenz[a]anthracene	57-97-6	n-Nitroso-di-n-dipropylamine (N-Nitrosodipropylamine; Di-n-propylnitrosamine)	621-64-7
Acenaphthene	83-32-9	N-Nitrosomethylethalamine	10595-95-6
Acenaphthylene	208-96-8	n-Nitrosomorpholine	59-89-2
Acetophenone	98-86-2	N-Nitrosopiperidine	100-75-4
Aniline	62-53-3	N-Nitrosopyrrolidine	930-55-2
Anthracene	120-12-7	Parathion	56-38-2

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
Aramite	140-57-8	Pentachlorobenzene	608-93-5
Benz[a]anthracene (Benzo[a]anthracene)	56-55-3	Pentachloroethane	76-01-7
Benz[e]acephenanthrylene (Benzo[b]fluoranthene)	205-99-2	Pentachloronitrobenzene	82-68-8
Benzo[k]fluoranthene	207-08-9	Pentachlorophenol	87-86-5
Benzo[ghi]perylene	191-24-2	Phenacetin	62-44-2
Benzo[a]pyrene	50-32-8	Phenanthrene	85-01-8
Benzyl alcohol	100-51-6	Phenol	108-95-2
Bis(2-chloroethoxy)methane	111-91-1	p-Phenylenediamine	106-50-3
Bis(2-chloroethyl)ether	111-44-4	Phorate	298-02-2
Bis(2-chloro-1-methylethyl) ether (2,2'-Oxybis(1-chloropropane))	108-60-1	Pronamide	23950-58-5
Bis(2-ethylhexyl) phthalate	117-81-7	Pyrene	129-00-0
Butylbenzylphthalate	85-68-7	Pyridine	110-86-1
p-Chloroaniline (4-Chloroaniline)	106-47-8	Safrole	94-59-7
Chlorobenzilate	510-15-6	Tetraethyl dithiopyrophosphate	3689-24-5
Chrysene	218-01-9	o-Toluidine	95-53-4
Diallate	2303-16-4	O,O,O-Triethyl phosphorothioate	126-68-1
Dibenz[a,h]anthracene	53-70-3	sym-Trinitrobenzene	99-35-4
Dibenzofuran	132-64-9	Aroclor 1016	12674-11-2
m-Dichlorobenzene (1,3-Dichlorobenzene)	541-73-1	Aroclor 1221	11104-28-2
Diethyl phthalate	84-66-2	Aroclor 1232	11141-16-5
O,O-Diethyl O-2-pyrazinyl phosphorothioate	297-97-2	Aroclor 1242	53469-21-9
Dimethoate	60-51-5	Aroclor 1248	12672-29-6
p-(Dimethylamino)azobenzene	60-11-7	Aroclor 1254	11097-69-1
alpha, alpha-Dimethylphenethylamine	122-09-8	Aroclor 1260	11096-82-5

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
Pesticides			
4,4′-DDD	72-54-8	Endosulfan I	959-98-8
4,4′-DDE	72-55-9	Endosulfan II	33213-65-9
4,4′-DDT	50-29-3	Endosulfan sulfate	1031-07-8
Aldrin	309-00-2	Endrin	72-20-8
alpha-BHC	319-84-6	Endrin aldehyde	7421-93-4
beta-BHC	319-85-7	Heptachlor	76-44-8
delta-BHC	319-86-8	Heptachlor epoxide	1024-57-3
gamma-BHC (Lindane)	58-89-9	Methoxychlor	72-43-5
Chlordane	57-74-9	Toxaphene	8001-35-2
Dieldrin	60-57-1		
Herbicides			
2,4-D; 2,4-Dichlorophenoxyacetic acid	94-75-7	Silvex; 2,4,5-TP	93-72-1
2,4,5-T; 2,4,5-Trichlorophenoxyacetic acid	93-76-5	-	-
Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans			
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	Polychlorinated dibenzofurans	N/A
Polychlorinated dibenzo-p-dioxins	N/A	-	-

Note: This table identifies the dangerous waste constituents listed in Appendix 5 of Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste, WAC 173-303-090 & -100*.

CAS = Chemical Abstracts Service

N/A = not applicable

9.5 Concentration Limits

Under WAC 173-303-645(5), Ecology will specify in the facility permit the concentrations limits that are part of the groundwater protection standard of WAC 173-303-645(3). Concentration limits will be proposed in the final status groundwater monitoring plan.

9.6 Compliance Period

Under WAC 173-303-645(7)(a), Ecology will specify in the facility permit the compliance period during which the groundwater protection standard of WAC 173-303-645(3) applies. The compliance period is the number of years equal to the active life of the WMA (including any waste management activity prior to permitting, and the closure period). Per WAC 173-303-645(7)(b), the compliance period begins when the owner or operator initiates a compliance monitoring program meeting the requirements of WAC 173 303-645(10).

For WMA T, the compliance period will begin when the compliance monitoring program under WAC 173 303-645(10) begins. The compliance monitoring program will begin when WMA T is permitted as a final status unit in the future Hanford Facility Dangerous Waste Permit. Because WMA T has not yet been closed, the compliance period cannot yet be determined.

9.7 Statistical Method

Under the most recent (2011) interim status monitoring plan (DOE/RL-2009-66, Rev. 0), samples for site-specific constituents that are identified as proposed monitoring constituents (i.e., hexavalent chromium and nitrate) were collected at varying frequencies at WMA T. Hexavalent chromium was collected annually at upgradient wells and quarterly at downgradient wells. Other supporting parameters (including metals) were collected annually at upgradient wells and either annually or semiannually at other network wells. EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, requires a minimum of eight samples to be able to define background. While the minimum number of samples are available, these samples were collected over a period of 6 years (as of 2017) at wells sampled annually. With the need to provide an adequate representation of current baseline conditions given the fluctuating groundwater beneath WMA T due to the 200 West P&T system (Section 3.3.2), an accelerated sampling program will be conducted.

An accelerated sampling program is recommended to obtain sufficient samples to define baseline and determine a statistical method. This accelerated sampling program will monitor each constituent in Table 9-4 at a quarterly frequency for 2 years. Quarterly monitoring will allow for sufficiently long enough time between samples so as to not cause a problem with autocorrelation of samples (i.e., resampling the same water). After 2 years of sampling is completed, the statistical test method can be determined using the decision matrix included in Appendix H. In addition to this methodology, hydrogeology of the area also will be considered. To date, there has not been an impact from 200 West P&T injected water at WMA T, but an impact is anticipated to begin after 2020 (Figures 7-1 through 7-10). The impact of this event will be considered in the evaluation of the statistical method. Following this initial monitoring period and determination of the statistical method, the statistical method will be periodically reassessed.

10 Routine Evaluation of the Monitoring Network

The groundwater flow regime will evolve over time. The scenarios that were simulated (as described in Chapters 5, 6, and 7) are intended to be representative of the range of plausible conditions, but actual conditions may differ from the scenarios evaluated. The CPGWM is updated and run annually as part of the 200 West P&T program. Because of this, the CPGWM is maintained up to date to reflect recent operating conditions and can be used to model proposed changes to the operating conditions.

Throughout the year, water-level measurements are also taken as part of routine sampling, and annually for water-level mapping. Analysis of groundwater elevation, using universal kriging for water-level maps, and hydraulic gradient mapping will be used to interpret changes in the groundwater flow regime. Additionally, re-evaluation of the monitoring network will be performed annually in conjunction with the WAC 173-303-645(10)(e) determination of groundwater flow direction and rate in the uppermost aquifer. If the analysis suggests a change in the flow regime (e.g., changes resulting from modifications to the 200 West P&T system operations) that indicates that the likely migration direction of any hypothetical release is outside of or on the margins of the monitoring network for a DWMU, then the model will be used to re-evaluate the monitoring network for that DWMU.

Results of the re-evaluation of the monitoring network may result in a proposal to add additional monitoring well locations. In a given year, the results may show that there is no impact to a DWMU, in which case no action would be taken. If an impact to a DWMU is shown, the network would be re-evaluated and documented in an update to this engineering evaluation report, shared with Ecology, and placed in the operating record. An update to the engineering report would not necessarily result in an update to the associated groundwater monitoring plan if there is no resulting change needed to the groundwater monitoring network. If a change in the groundwater monitoring network is determined, a permit modification with a revised groundwater monitoring plan would be performed in accordance with WAC 173-303-815, “Facility specific permit conditions.”

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11 References

11-NWP-054, 2011, "Approval of the Single-Shell Tank System Dangerous Waste Permit Application Part A Form, Revision 13" (letter to Scott L. Samuelson, U.S. Department of Energy, Office of River Protection, and Charles G. Spencer, Washington River Protection Solutions, LLC, from Jane A. Hedges), Washington State Department of Ecology, Richland, Washington, June 3. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1106130183.

16-NWP-090, 2016, "Groundwater Monitoring Requirements for 200 West Area Single-Shell Tank (SST) Farms Final Status Groundwater Monitoring Plan" (letter to Kevin W. Smith, U.S. Department of Energy, Office of River Protection, and Mark A. Lindholm, Washington River Protection Solutions, from Cheryl Whalen), Washington State Department of Ecology, Richland, Washington, May 16. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0076949H.

10 CFR 962, "Byproduct Material," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=24aad4966ac52acbeba416c2c1114889&mc=true&node=pt10.4.962&rgn=div5.

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=2cd7465519114fb3472b4864a0e3c42b&node=pt40.26.265&rgn=div5.

265.90, "Applicability."

265.91, "Ground-Water Monitoring System."

265.92, "Sampling and Analysis."

265.93, "Preparation, Evaluation, and Response."

265.94, "Recordkeeping and Reporting."

Subpart F, "Ground-Water Monitoring."

ARH-LD-135, 1976, *Geology of the 241-T Tank Farm*, Informal Report, Atlantic Richfield Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0009071.

Atomic Energy Act of 1954, as amended, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919. Available at: https://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap23-divsnA.htm.

BHI-00184, 1995, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0083482H.

BNWL-B-360, 1974, *Selected Water Table Contour Maps and Well Hydrographs for the Hanford Reservation, 1944-1973*, Pacific Northwest Laboratories, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196069236.

CP-47631, 2016, *Model Package Report: Central Plateau Groundwater Model Version 8.3.4*, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0069098H.

DOE/RL-91-03, 1991, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1990*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196047080.

DOE/RL-91-61, 1992, *T Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196124788.

DOE/RL-92-03, 1992, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196089863.

DOE/RL-93-88, 1994, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196094135.

DOE/RL-94-136, 1995, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1994*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196037232.

DOE/RL-96-01, 1996, A*nnual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1995*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196064360.

DOE/RL-96-61, 1997, *Hanford Site Background: Part 3, Groundwater Background*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D197226378.

DOE/RL-2002-39, 2002, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081471H.

DOE/RL-2007-28, 2008, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0808050315. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=00098828.

DOE/RL-2008-01, 2008, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=00098824.

DOE/RL-2008-56, 2012, *200 West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081011H.

DOE/RL-2008-66, 2009, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0905131281. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0905131282.

DOE/RL-2009-115, 2016, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*, Rev. 2 Draft B, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075555H.

DOE/RL-2009-66, 2011, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1103070709.

DOE/RL-2009-66, 2012, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091408.

DOE/RL-2010-11, 2010, *Hanford Site Groundwater Monitoring and Performance Report for 2009 Volumes 1 & 2*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084237.

DOE/RL-2011-118, 2012, *Hanford Site Groundwater Monitoring for 2011*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091795.

DOE/RL-2013-14, 2013, *Calendar Year 2012 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087669.

DOE/RL-2013-22, 2013, *Hanford Site Groundwater Monitoring Report for 2012*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087974.

DOE/RL-2014-32, 2014, *Hanford Site Groundwater Monitoring Report for 2013*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084842.

DOE/RL-2016-09, 2016, *Hanford Site Groundwater Monitoring Report for 2015*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075314H.

DOE/RL-2016-12, 2016, *Hanford Site RCRA Groundwater Monitoring Report for 2015*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0073391H.

DOE/RL-2016-20, 2016, *Calendar Year 2015 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump and Treat Operations*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0074339H.

DOE/RL-2016-66, 2017, *Hanford Site RCRA Groundwater Monitoring Report for 2016*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0072146H.

DOE/RL-2016-67, 2017, *Hanford Site Groundwater Monitoring Report for 2016*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0068229H.

ECF-200W-17-0070, 2018, *Groundwater Flow and Migration Calculations to Support Assessment of the Hanford Central Plateau 200 West Area Facilities Monitoring Network*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065259H.

ECF-200W-17-0075, 2018, *Groundwater Flow and Migration Calculations to Support Assessment of the WMA T Monitoring Network*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065250H.

ECF-200ZP1-13-0006, 2013, *Description of Groundwater Modeling Calculations for the Calendar Year 2012 (CY2012) 200 Areas Pump-and-Treat Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078751H.

ECF-200ZP1-17-0203, 2018, *Identification of Site-Specific Monitoring Constituents for Waste Management Area T*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065257H.

ECF-Hanford-11-0165, 2012, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100 Area*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087250.

ECF-Hanford-16-0138, 2017, *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2016 (CY2016) Hanford Site Groundwater Monitoring Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0068826H.

ECN 150144, 1992, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 001 Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196103640.

ECN 150201, 1991, *Engineering Change Notice to the WHC-SD-EN-AP-012, Rev 000 Interim Status Groundwater Monitoring Plan for Single Shell-Tanks*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0015957.

ECN 172204, 1993, *Engineering Change Notice to the WHC-SD-EN-AP-012 Rev 1 Interim Status Groundwater Monitoring Plan for Single Shell-Tanks*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196110007.

ECN 618171, 1994, *Engineering Change Notice to the WHC-SD-EN-AP-012 Rev 1 Interim Status Groundwater Monitoring Plan for Single Shell-Tanks*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196046459.

Ecology Publication No. 97-407, 2014, *Chemical Test Methods For Designating Dangerous Waste, WAC 173-303-090 & -100*, Hazardous Waste and Toxics Reduction Program, Washington State Department of Ecology, Olympia, Washington. Available at: https://fortress.wa.gov/ecy/publications/documents/97407.pdf.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

EPA 530/R-09-007, 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, Office of Resource Conservation and Recovery, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10055GQ.TXT.

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/index.cfm/viewDoc?accession=00098825.

GJO-99-101-TAR, 1999, *Hanford Tank Farms Vadose Zone T Tank Farm Report*, U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0069093H.

Hantush, M.S., 1964, "Hydraulics of wells," *Advances in Hydroscience*, V.T. Chow (editor), Academic Press, New York, pp. 281-442.

HNF-2603, 1998, *A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination*, Rev. 0, Lockheed Martin Hanford, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0076055H.

HNF-EP-0182, 2017, *Waste Tank Summary Report for Month Ending May 31, 2017*, Rev. 353, Washington River Protection Solutions, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0069268H.

HW-17088, 1953 (declassified 1971), *The Underground Disposal of Liquid Wastes at the Hanford Works, Washington*, General Electric Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0082587H.

ICN-PNNL-12057.1, 2002, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T at the Hanford Site, Interim Change Notice*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2761176.

Konikow, L.F., G.Z. Hornberger, K.J. Halford, and R.T. Hanson, 2009, *Revised Multi-Node Well (MNW2) Package for MODFLOW Ground-Water Flow Model*, Techniques and Methods 6A-30, U.S. Geological Survey, Reston, Virginia.

NAD83, 1991, *North American Datum of 1983*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

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

PNL-7498, *Evaluation of Hanford Site Water-Table Changes 1980 to 1990*, Pacific Northwest Laboratory, Richland, Washington. Available at: https://www.osti.gov/servlets/purl/6178671.

PNL-8337, 1992, *Summary and Evaluation of Available Hydraulic Property Data for the Hanford Site Unconfined Aquifer System*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199061221.

PNL-8800, 1993, *Hanford Wells*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/10105933.

PNL-8971, 1993, *Three-Dimensional Conceptual Model for the Hanford Site Unconfined Aquifer System, FY 1993 Status Report*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199061223.

PNL-10886, 1995, *Development of a Three-Dimensional Ground-Water Model of the Hanford Site Unconfined Aquifer System: FY 1995 Status Report*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/195772.

PNNL-11470, 1997, *Groundwater Monitoring for Fiscal Year 1996*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199132964.

PNNL-11793, 1998, *Hanford Site Groundwater Monitoring for Fiscal year 1997*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199132962.

PNNL-11801, 1997, *Three-Dimensional Analysis of Future Groundwater Flow Conditions and Contaminant Plume Transport in the Hanford Site Unconfined Aquifer System: FY 1996 and 1997 Status Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/servlets/purl/572724-1bqL0a/webviewable/572724.pdf.

PNNL-11803, 1998, *Hanford Site Environmental Surveillance Master Sampling Schedule*, Pacific Northwest Laboratory, Richland, Washington, Available at: https://www.osti.gov/scitech/servlets/purl/572727.

PNNL-11809, 1998, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas T and TX-TY at the Hanford Site*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D198175199.

PNNL-12057, 2001, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T at the Hanford Site*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D1662358.

PNNL-12072, 2001, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D1665266.

PNNL-12086, 1999, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199091099.

PNNL-12261, 2000, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0906180659.

PNNL-13116, 2000, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2736610. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2736978.

PNNL-13378, 2001, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 1999*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13378.PDF.

PNNL-13404, 2001, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2743868. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2786917.

PNNL-13788, 2002, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2737262. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2740450.

PNNL-13858, 2002, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*, Pacific Northwest Laboratory, Richland, Washington, Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13858.pdf.

PNNL-14113, 2002, *Results of Detailed Hydrologic Characterization Tests—Fiscal Year 2001*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14113.pdf.

PNNL-14186, 2003, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2002*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14186.pdf.

PNNL-14187, 2003, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2752375. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2755548.

PNNL-15301, 2006, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T*, Pacific Northwest Laboratory, Richland, Washington. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-15301.pdf.

PNNL-15670, 2006, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084078.

PNNL-15837, 2007, *Data Package for Past and Current Groundwater Flow and Contamination Beneath Single-Shell Tank Waste Management Areas*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0911240061.

PNNL-15955, 2007, *Geology Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15955rev1.pdf.

PNNL-16069, 2006, *Development of Historical Water Table Maps of the 200 West Area of the Hanford Site (1950-1970)*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16069.pdf.

PNNL-16346, 2007, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084077.

PNNL-17348, 2008, *Results of Detailed Hydrologic Characterization Tests—Fiscal and Calendar Year 2005*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17348.pdf.

PNNL-17732, 2008, *Analysis of the Hydrologic Response Associated with Shutdown and Restart of the 200-ZP-1 WMA T Tank Farm Pump-and-Treat System*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17732.pdf.

PNNL-19772, 2010, *T-TY Tank Farm Interim Surface Barrier Demonstration-Vadose Zone Monitoring Plan*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19772.pdf.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*, Olympia, Washington. Available at: http://apps.leg.wa.gov/RCW/default.aspx?cite=70.105.

RPP-7123, 2001, *Subsurface Conditions Description of the T-TX-TY Waste Management Areas*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0911240297.

RPP-7218, 2000, *Preliminary Inventory Estimates for Single-Shell Tank Leaks in T, TX, and TY Tank Farms*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0069094H.

RPP-7578, 2002, *Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMAs T and TX-TY*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D9111930.

RPP-23403, 2016, *Single-Shell Tank Component Closure Data Quality Objectives*, Rev. 6, Washington River Protection Solutions LLC, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075162H.

RPP-23748, 2006, *Geology, Hydrogeology, Geochemistry, and Mineralogy Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079752H.

RPP-23752, 2005, *Field Investigation Report for Waste Management Areas T and TX-TY*, Rev. 0-A, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1001051156. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1001051157. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0911240516.

RPP-RPT-50799, 2015, *Suspect Water Intrusion in Hanford Single-Shell Tanks*, Rev. 2, Washington River Protection Solutions, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0069095H.

RPP-RPT-54916, 2014, *Hanford Single-Shell Tank Leak Causes and Locations – 241-T Farm*, Rev. 0, Washington River Protection Solutions, Richland, Washington. Available at: https://www.osti.gov/servlets/purl/1132516/.

RPP-RPT-55084, 2013, *Hanford 241-T Farm Leak Inventory Assessment Report*, Rev. 0, Washington River Protection Solutions, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065968H.

SGW-55438, 2013, *Hanford Site Groundwater Monitoring for 2012: Supporting Information*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087999.

SGW-60338, 2017, *Historical Changes in Water Table Elevation and Groundwater Flow Direction at Hanford: 1944 to 2014*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0072270H.

TPA CN M-45-98-03, *Agreement Commitments Regarding Initial Single-Shell Tank Waste Management Area (WMA) Corrective Actions, Vadose Zone and Groundwater Characterization, Assessment, and the Integration of Vadose Zone and Groundwater Activities at Specified Associated Sites*, U.S. Department of Energy and U.S. Environmental Protection Agency, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D8685796.

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.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

303-090, "Dangerous Waste Characteristics."

303-104, "State-Specific Dangerous Waste Numbers."

303-110, "Sampling, Testing, Methods and Analytes."

303-400, "Interim Status Facility Standards."

303-640, "Tank Systems."

303-645, "Releases from Regulated Units."

303-665, "Landfills."

303-806, "Final Facility Permits."

303-815, "Facility Specific Permit Conditions."

303-9904, "Dangerous Waste Sources List."

WHC-EP-0698, 1994, *Groundwater Impact Assessment Report for the 216-U-14 Ditch*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196093455.

WHC-MR-0391, 1992, *Field Trip Guide to the Hanford Site*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D196136627.

WHC-SD-EN-AP-012, 1989, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks*, Rev. 0, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D195063122.

WHC-SD-EN-AP-012, 1991, *Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks*, Rev. 1, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196071250.

WHC-SD-EN-AP-132, 1993, *Interim-Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Areas T and TX-TY*, Rev. 0, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0069096H.

Zheng, C., and P.P. Wang, 1999, *MT3DMS: A Modular Three-Dimensional Multispecies Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide*, Report SERDP-99-1, U.S. Army Engineer Research and Development Center, U.S. Army Corps of Engineers, Vicksburg, Mississippi. Available at: http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA373474.

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Appendix A

Interim Status Data Summary

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A1 Introduction

Section 2.4 of the main document summarizes the groundwater monitoring history at Waste Management Area (WMA) T. An interim status indicator parameter groundwater monitoring program under 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" was initiated in 1989. The indicator parameter monitoring program continued until 1993 when WMA T was placed into a groundwater quality assessment monitoring program in accordance with 40 CFR 265.93(d), "Preparation, Evaluation, and Response." WMA T has been monitored under a groundwater quality assessment program since 1993.

The interim status groundwater monitoring history of WMA T through 2016 was compiled. Information from annual reporting documents and groundwater monitoring plans were utilized to compile a summary of wells in the WMA T network, groundwater flow direction and rate, monitoring constituents, statistical comparison values (e.g., critical means), and a summary of comparison value exceedances or other contaminants (e.g., plumes from upgradient sources) in a Microsoft® Excel® workbook. Sampling data through December 31, 2016 for each well is presented in separate Microsoft Excel workbooks. Sample data for each well was retrieved from the Hanford Environmental Information System database. The workbooks are contained in electronic files to accompany this report.

A2 References

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr264_main_02.tpl.

Appendix IX, "Ground-Water Monitoring List."

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=2cd7465519114fb3472b4864a0e3c42b&node=pt40.26.265&rgn=div5.

265.92, "Sampling and Analysis."

265.93, "Preparation, Evaluation, and Response."

Appendix III, "EPA Interim Primary Drinking Water Standards."

DOE/RL-91-03, 1991, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1990*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196047080.

DOE/RL-92-03, 1992, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196089863.

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DOE/RL-93-09, 1993, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196136826.

DOE/RL-93-88, 1994, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196094135.

DOE/RL-94-136, 1995, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1994*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196037232.

DOE/RL-96-01, 1996, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1995*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196064360.

DOE/RL-2008-01, 2008, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=00098824.

DOE/RL-2008-66, 2009, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0905131281. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0905131282.

DOE/RL-2009-66, 2011, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1103070709.

DOE/RL-2009-66, 2012, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091408.

DOE/RL-2010-11, 2010, *Hanford Site Groundwater Monitoring and Performance Report for 2009 Volumes 1 & 2*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084237.

DOE/RL-2011-01, 2011, *Hanford Site Groundwater Monitoring Report for 2010*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093693.

DOE/RL-2011-118, 2012, *Hanford Site Groundwater Monitoring for 2011*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington, Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091795.

DOE/RL-2013-22, 2013, *Hanford Site Groundwater Monitoring Report for 2012*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington, Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087974.

DOE/RL-2014-32, 2014, *Hanford Site Groundwater Monitoring Report for 2013*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084842.

DOE/RL-2015-07, 2015, *Hanford Site Groundwater Monitoring Report for 2014*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0080600H.

DOE/RL-2016-09, 2016, *Hanford Site Groundwater Monitoring Report for 2015*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075314H.

DOE/RL-2016-12, 2016, *Hanford Site RCRA Groundwater Monitoring Report for 2015*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0073391H.

DOE/RL-2016-66, 2017, *Hanford Site RCRA Groundwater Monitoring Report for 2016*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0072146H.

ECN 150144, 1992, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 001 Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196103640.

ICN-PNNL-12057.1, 2002, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T at the Hanford Site, Interim Change Notice*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2761176.

PNNL-11470, 1997, *Hanford Site Groundwater Monitoring for Fiscal Year 1996*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199132964.

PNNL-11793, 1998, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199132962.

PNNL-12057, 2001, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T at the Hanford Site*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D1662358.

PNNL-12086, 1999, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199091099.

PNNL-13116, 2000, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2736610. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2736978.

PNNL-13404, 2001, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2743868. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2786917.

PNNL-13788, 2002, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2737262. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2740450.

PNNL-14187, 2003, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2752375. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2755548.

PNNL-14548, 2004, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14548.pdf.

PNNL-15070, 2005, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15070.pdf.

PNNL-15301, 2006, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T*, Pacific Northwest Laboratory, Richland, Washington. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-15301.pdf..

PNNL-15670, 2006, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084078.

PNNL-16346, 2007, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084077.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf.

SGW-55438, 2013, *Hanford Site Groundwater Monitoring for 2012: Supporting Information*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087999.

WHC-SD-EN-AP-012, 1989, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D195063122.

WHC-SD-EN-AP-012, 1991, *40 CFR 265 Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks*, Rev. 1, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196071250.

WHC-SD-EN-AP-132, 1993, *Interim-Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Areas T and TX-TY*, Rev. 0, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0069096H.

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Appendix B

Identification of Site-Specific Monitoring Constituents for Waste Management Area T – ECF-200ZP1-17-0203

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The calculation ECF-200ZP1-17-0203, *Identification of Site-Specific Monitoring Constituents for Waste Management Area T*, was performed evaluate the waste constituents associated with Waste Management Area T and constituents detected during interim status groundwater monitoring to identify proposed groundwater monitoring constituents. The calculation is available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065257H.

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Appendix C

Topographic Map

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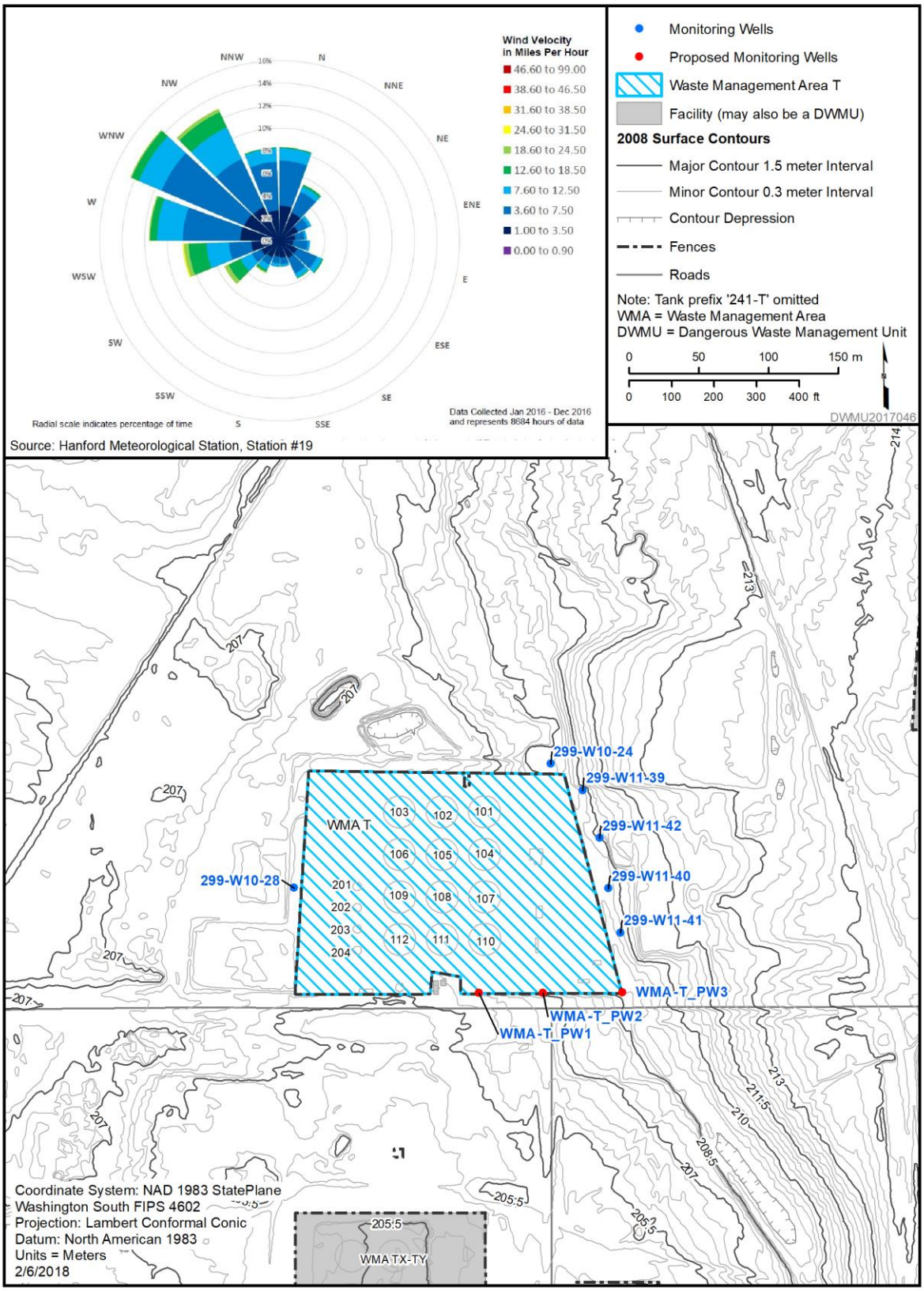

Figure C-1. Topographic Map

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Appendix D

Plume Maps

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D1 Plume Maps

This appendix presents regional plume maps in the vicinity of Waste Management Area (WMA) T (Figures D-1 through D-3). These plumes do not originate solely from WMA T, but rather WMA T has likely contributed to the overall plumes.

In accordance with WAC 173-303-806(4)(a)(xx)(D), the maximum, detected result above background from each constituent sampled in 2016 from the WMA T monitoring well network (Table 3-14 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*) are presented (Figures D-4 through D-6). WAC 173-303-806(4)(a)(xx)(D)(II) defines the constituents to be those listed in Appendix "Ground-Water Monitoring List" in *Chemical Testing Methods for Designating Dangerous Waste*, which is incorporated at WAC 173-303-110(3)(c) and (7), and any other constituents not listed there which have caused a managed waste to be regulated. WAC 173-303-110(3)(c) references Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, and WAC 173-303-110(7) references Appendix 5 of Ecology Publication No. 97-407. Accordingly, the constituents identified in Appendix 5 of Ecology Publication No. 97-407 were evaluated for inclusion in these figures. Additionally, other chemical constituents that are not included in Appendix 5 of Ecology Publication No. 97-407, but were detected in 2016 samples from network wells, were evaluated for inclusion.

The maximum result for each detected constituent was compared to the Hanford Site 90th percentile groundwater background values, as appropriate (Table ES-1 in DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*). Dangerous waste constituents that were detected above background values, as well as those without background values, are presented in Figures D-4 and D-5. Figure D-6 presents chemical constituents that are nondangerous wastes and were detected above background values.

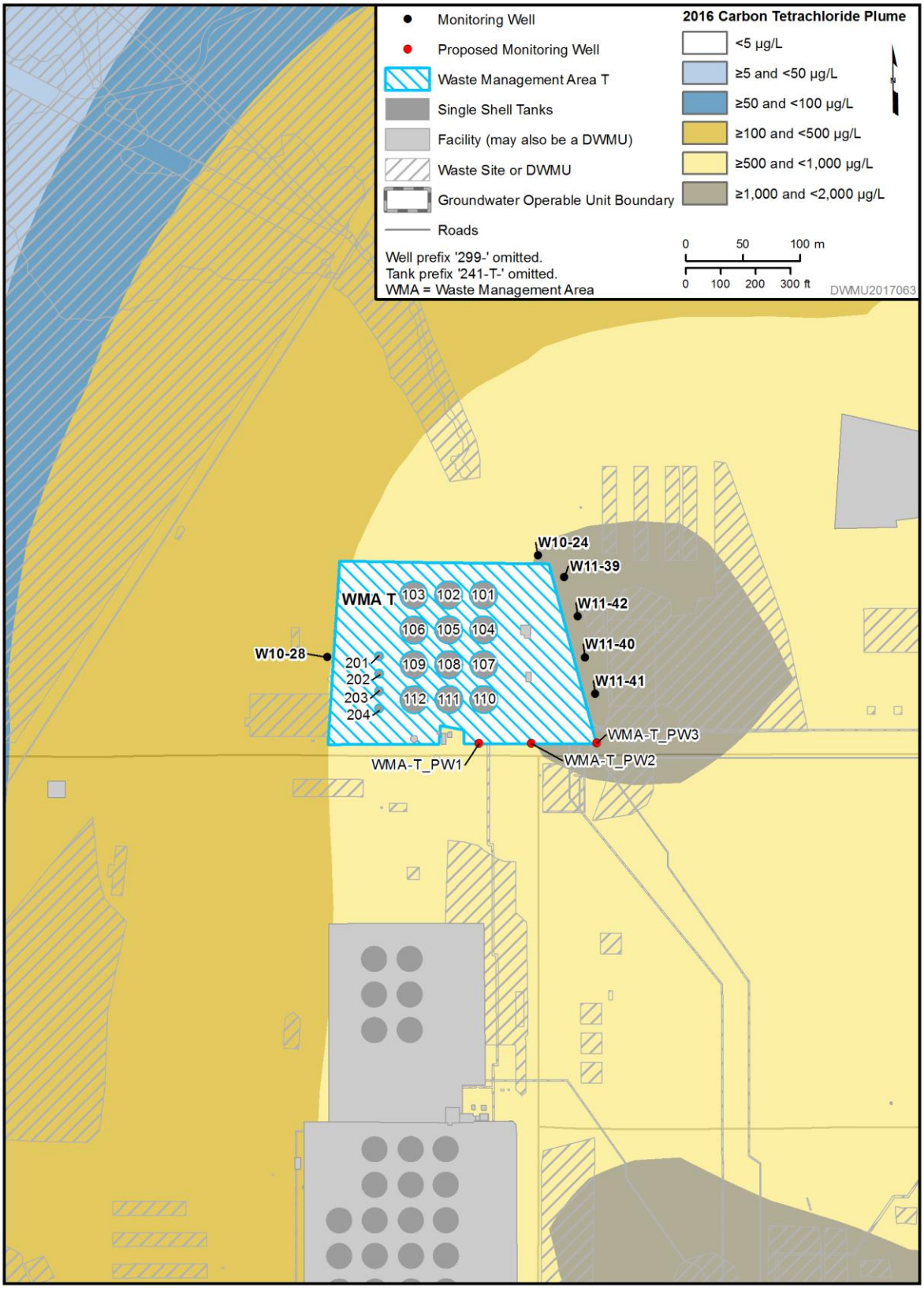

Figure D-1. Regional Carbon Tetrachloride Plume at WMA T

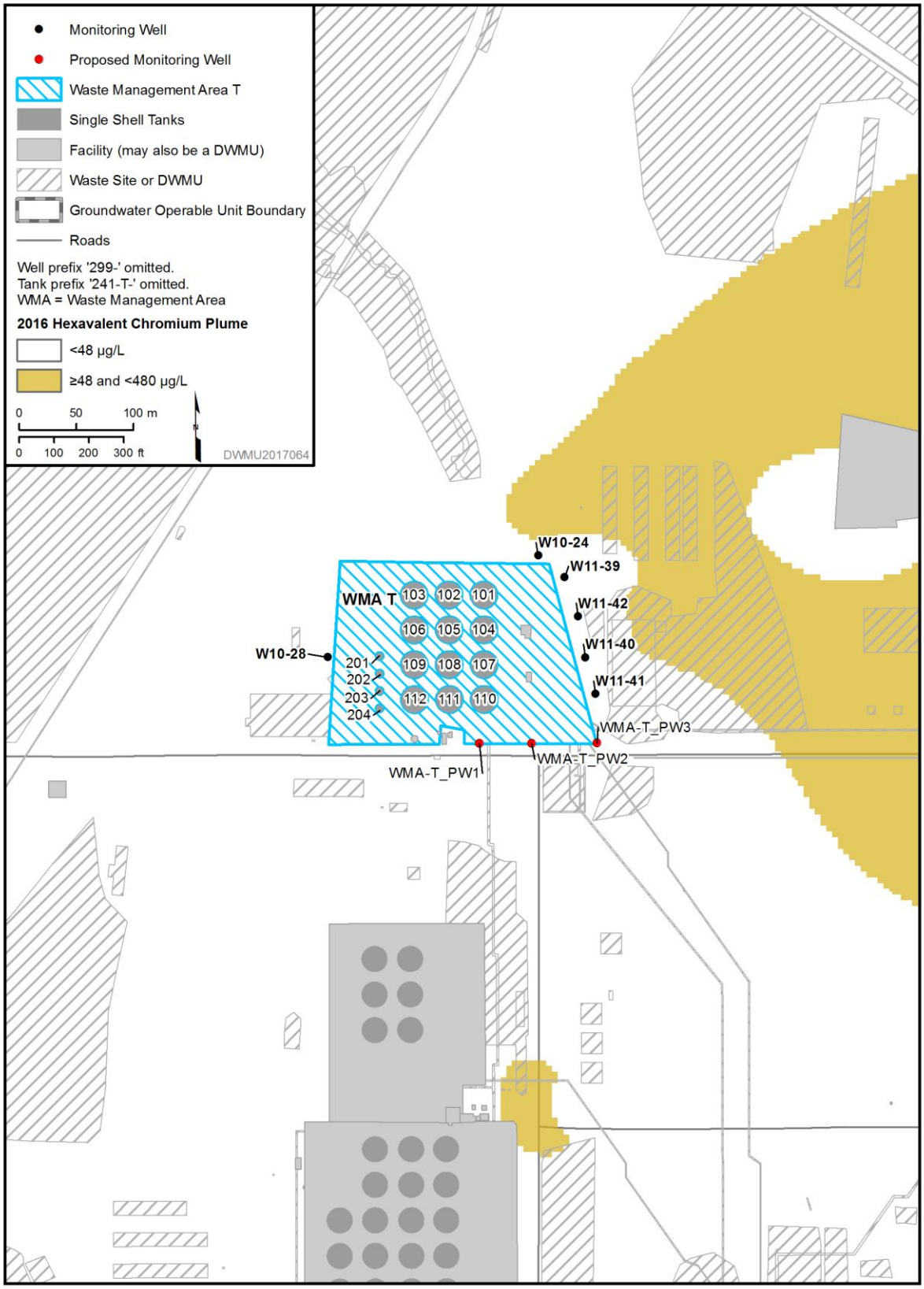

Figure D-2. Regional Hexavalent Chromium Plume at WMA T

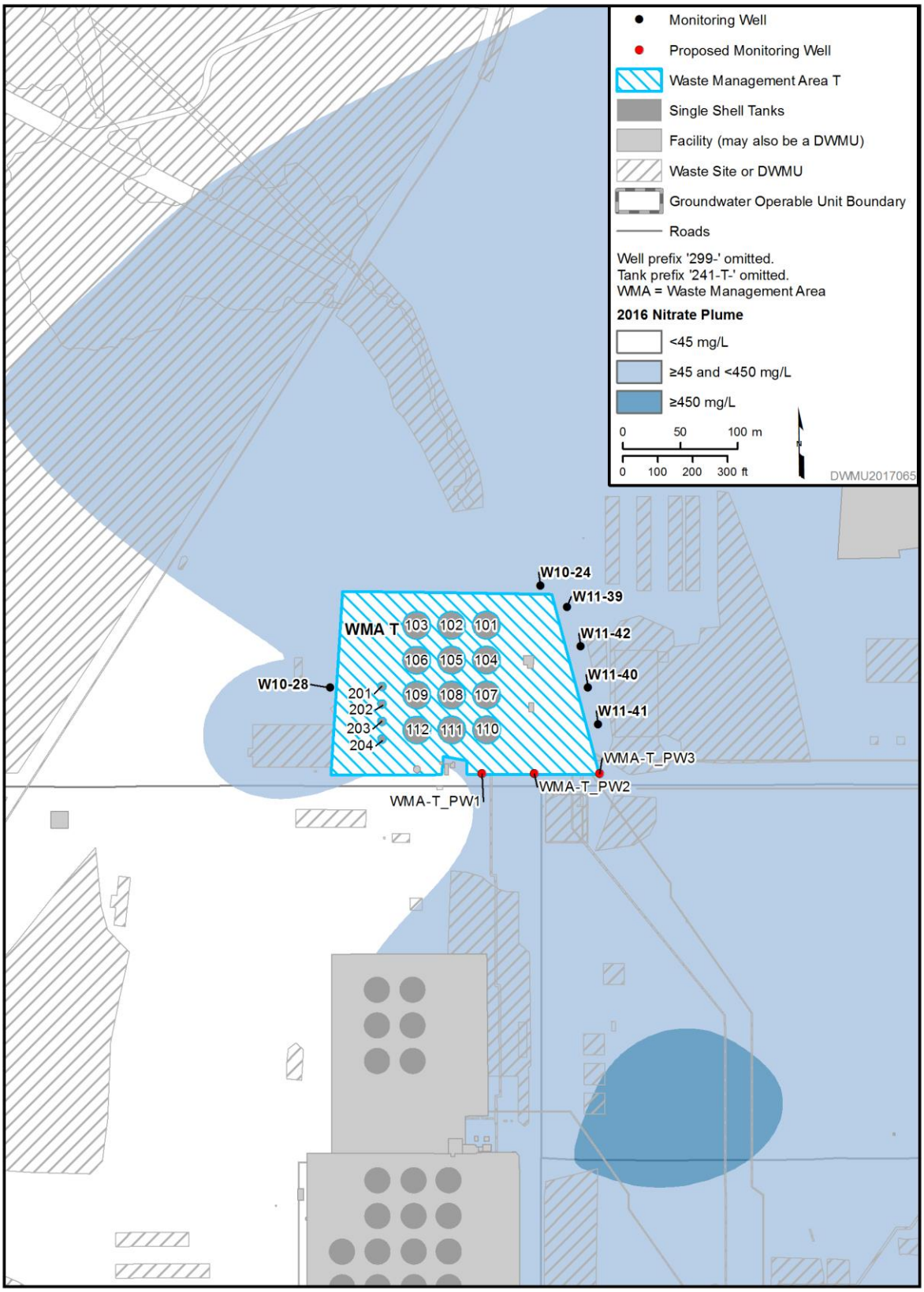

Figure D-3. Regional Nitrate Plume at WMA T

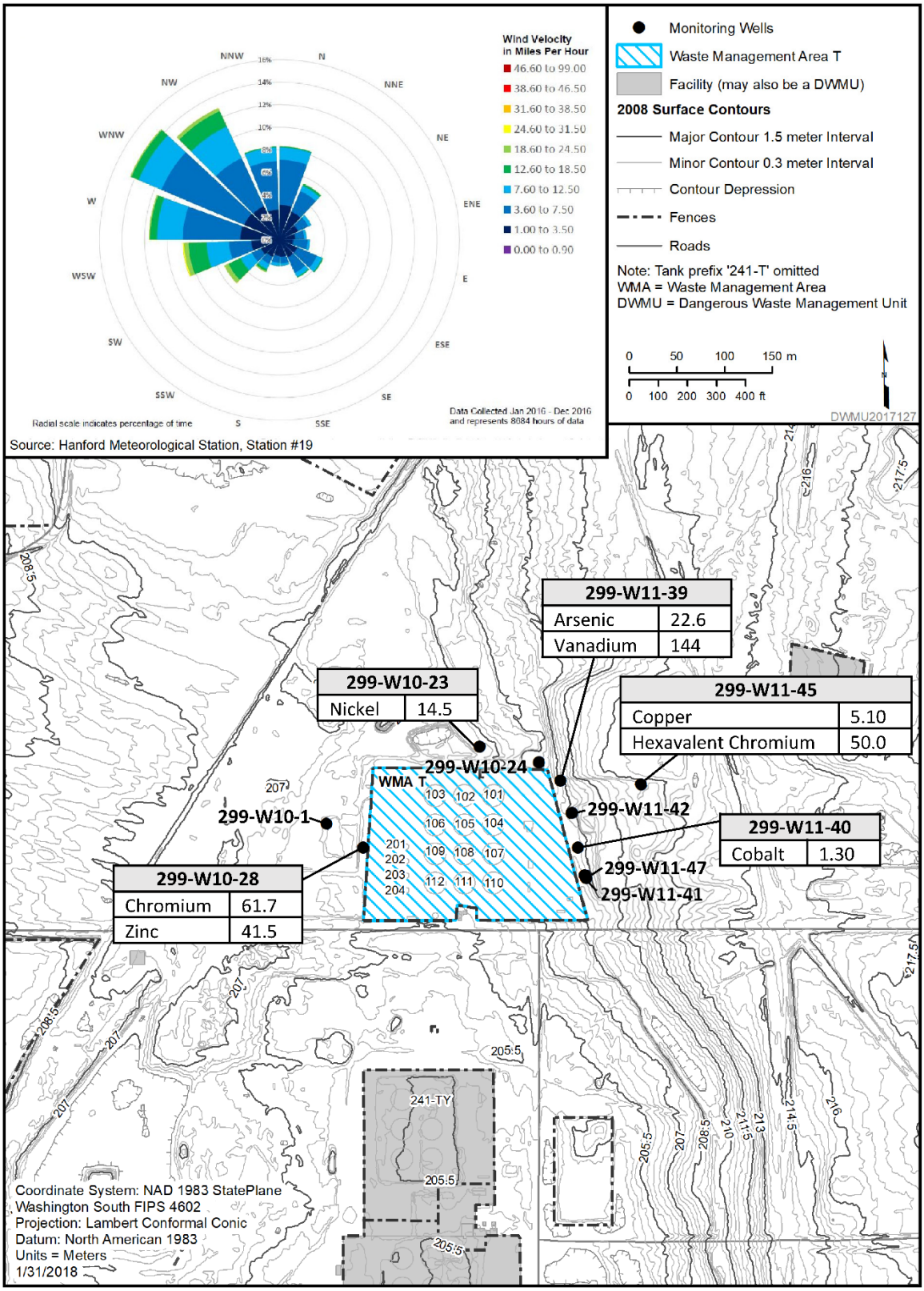

Figure D-4. 2016 Maximum Detected Groundwater Results of Metals and Inorganics in WMA T Network Wells (µg/L)

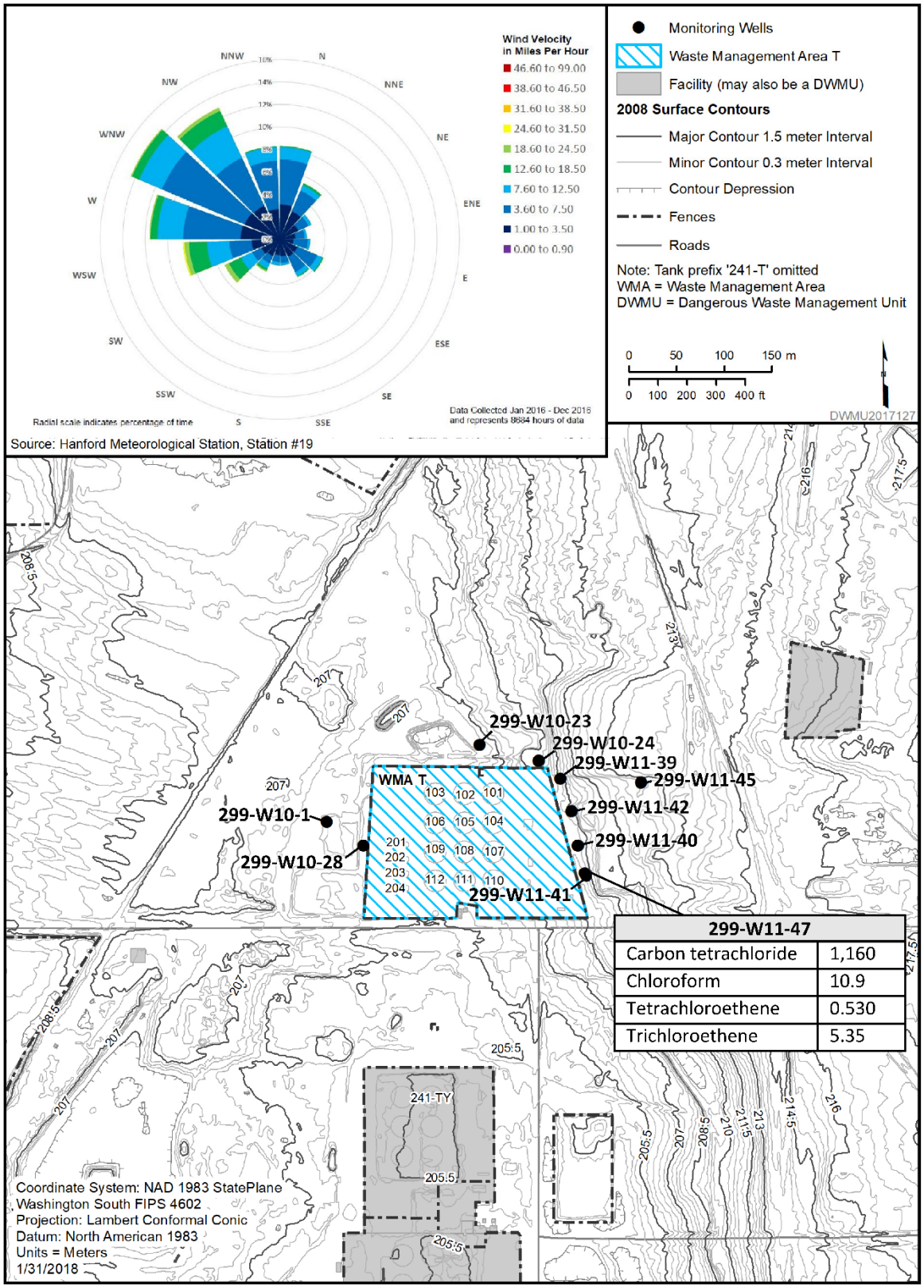

Figure D-5. 2016 Maximum Detected Groundwater Results of Organics in WMA T Network Wells (µg/L)

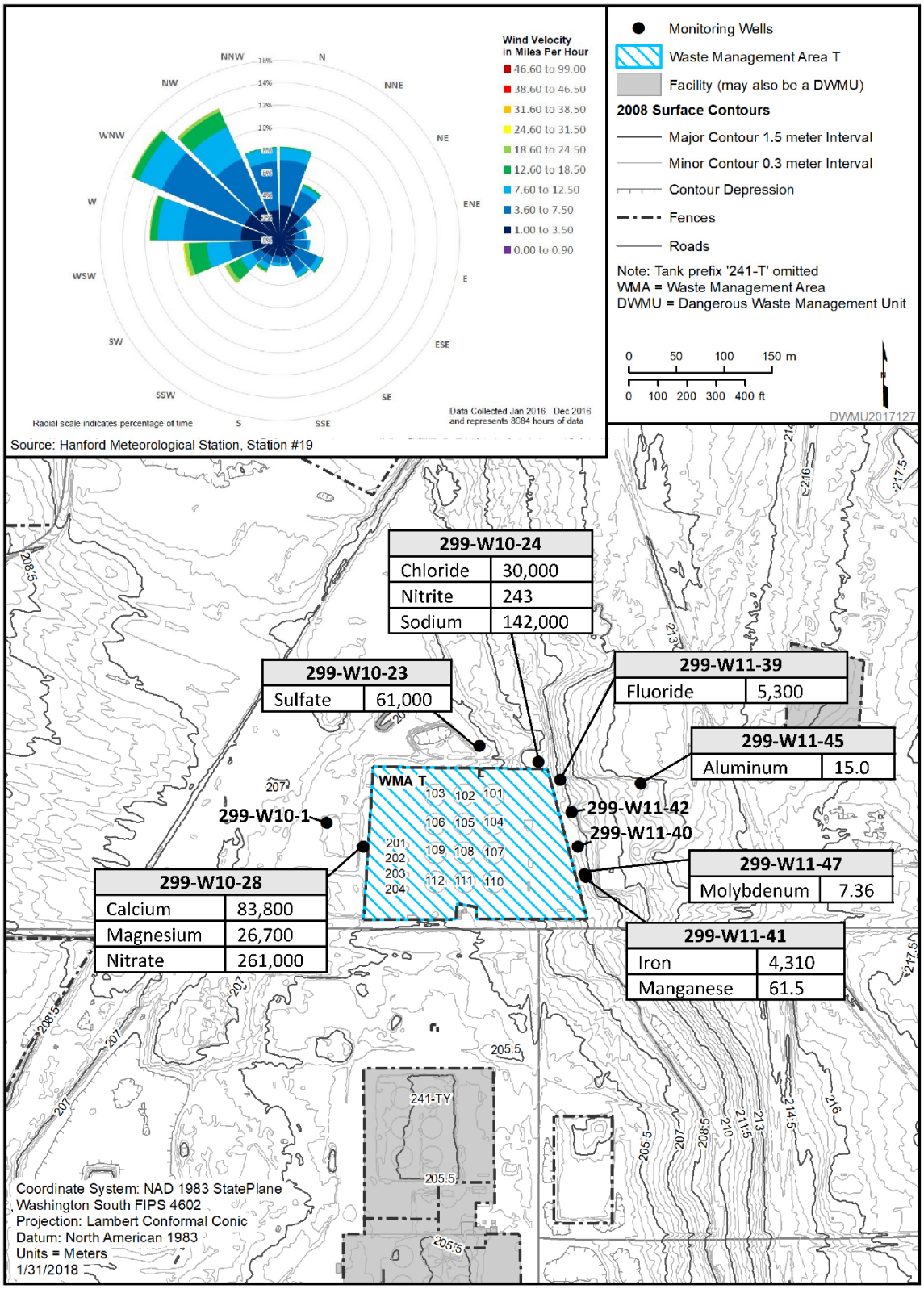

Figure D-6. 2016 Maximum Detected Groundwater Results of Nondangerous Constituents in WMA T Network Wells (µg/L)

D2 References

DOE/RL-96-61, 1997, *Hanford Site Background: Part 3, Groundwater Background*, Rev. 0, United States Department of Energy, Richland, Washington. Available at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D197226378.

DOE/RL-2016-66, 2017, *Hanford Site RCRA Groundwater Monitoring Report for 2016*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0072146H.

Ecology Publication No. 97-407, 2014, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, Hazardous Waste and Toxics Reduction Program, Washington State Department of Ecology, Olympia, Washington. Available at: https://fortress.wa.gov/ecy/publications/documents/97407.pdf.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

303-110, "Sampling, Testing, Methods and Analytes."

303-806, "Final Facility Permits."

Appendix E

Well As-Built Diagrams and Proposed Well Design Information

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E1 Introduction

This appendix provides the following information for the existing Waste Management Area (WMA) T groundwater monitoring wells:

- Well name
- Hydrogeologic unit monitored (the aquifer portion at the well screen-perforation) (Table E-1)
- The following sampling interval information, as provided in Table E-2:
  - Elevation at the top of the screen or perforated interval
  - Elevation at the bottom of the screen or perforated interval
  - Open interval length (i.e., difference between the top and bottom screen-perforation elevations)
  - Drilling method

For proposed wells, the following design information is provided in Table E-3:

- Well location
- Drill depth
- Well diameter
- Screen interval depth
- Sump and end cap interval

Figures E-1 through E-6 provide construction and completion summaries for the existing network wells.

Table E-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
TU	**Top of Unconfined.** Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.

Table E-2. Sampling Interval Information for Wells within the WMA T Network

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft] NAVD88)	Elevation Bottom of Open Interval (m [ft] NAVD88)	Open Interval Length (m [ft])	Drilling Method
299-W10-24	TU	137.96 (452.62)	127.29 (417.62)	10.67 (35.00)	Cable tool/air rotary
299-W10-28	TU	137.52 (451.18)	126.85 (416.17)	10.67 (35.00)	Cable tool
299-W11-39	TU	137.04 (449.61)	126.37 (414.60)	10.67 (35.00)	Cable tool
299-W11-40	TU	137.15 (449.97)	126.49 (414.99)	10.67 (35.00)*	Cable tool/air rotary
299-W11-41	TU	137.43 (450.88)	126.76 (415.88)	10.67 (35.00)	Cable tool/air rotary
299-W11-42	TU	137.94 (452.56)	127.27 (417.55)	10.67 (35.00)	Air rotary

Table E-2. Sampling Interval Information for Wells within the WMA T Network

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft] NAVD88)	Elevation Bottom of Open Interval (m [ft] NAVD88)	Open Interval Length (m [ft])	Drilling Method

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

* = Due to rounding and conversion of metric units, the computed open interval length based on the top and bottom elevations may differ slightly from the actual open interval length reported in the Summary Sheets below.

TU = Top of Unconfined, as described in Table E-1

Table E-3. Planned Location, Depth, and Screen Interval for Proposed Wells within the WMA T Network

Well ID	Northing (m)	Easting (m)	Surface Elevation (m [ft] NAVD88)	Water Table Elevation (m [ft] NAVD88)	Depth to Water (m [ft] bgs)	Drill Depth (m [ft] bgs)	Final Well Diameter (cm [in.])	Screen Interval (m [ft] bgs)	Sump and End Cap Interval (m [ft] bgs)
WMA-T_PW1	136634.7	566834.0	206.03 (675.95)	131.33 (430.87)	74.7 (245.08)	85.06 (279.08)	10.16 (4)	73.18 (240.08) to 83.84 (275.08)	83.84 (275.08) to 84.76 (278.08)
WMA-T_PW2	136634.7	566879.8	206.79 (678.44)	131.07 (430.02)	75.72 (248.43)	86.08 (282.43)	10.16 (4)	74.2 (243.43) to 84.87 (278.43)	84.87 (278.43) to 85.78 (281.43)
WMA-T_PW3	136634.9	566936.7	208.46 (683.92)	130.81 (429.17)	77.65 (254.76)	88.01 (288.76)	10.16 (4)	76.13 (249.76) to 86.79 (284.76)	86.79 (284.76) to 87.71 (287.76)

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

Note: Well coordinates, elevations, and projected well design are estimates and are subject to modification based on final well location survey and conditions encountered during drilling.

bgs = below ground surface

0502369

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon	WELL NUMBER: 299-W10-24 B8546	TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Reverse Air	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Randy Wraspir	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Start Card #:	Not Available
Date Started:	07Oct98	Date Completed:	21Oct98	Elevation Ground Surface:	Brass Marker

Depth to Water: 231.41 ft 21Oct98
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log & Geophysical Logs

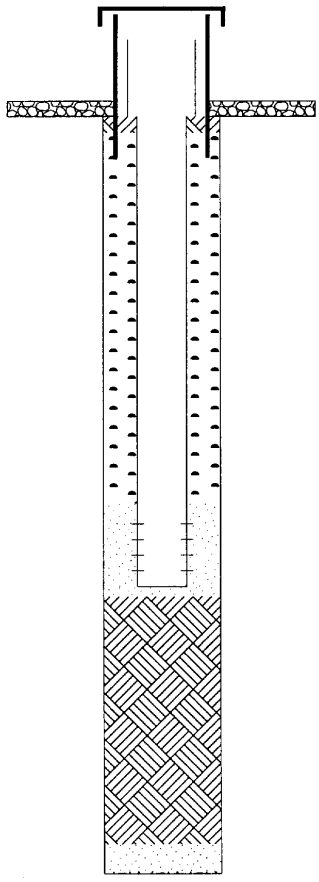
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 9.1 ft

Type of Surface Seal: 4x4 Concrete Pad

0 - 2 ft : Backfill - cobbles, sand, & silt
2 - 5 ft : Silty Sandy Gravel (msG)
5 - 7 ft : Sasnd (s)
7 - 36 ft : Silty Sandy Gravel
36 - 39 ft : Gravelly Sand (gS)
39 - 42 ft : Sandy Gravel (sG)
42 - 59 ft : Sand
59 - 83.2 ft : Sandy Gravel
83.2 - 84 ft : Silty Sand (mS)
84 - 86 ft : Sand
86 - 98 ft : Silty Sand
98 - 108 ft : Caliche (calc. sand)
108 - 119 ft : Sand
119 - 128 ft : Sand
128 - 148 ft : Sandy Gravel
148 - 190 ft : Silty Sandy Gravel
190 - 228 ft : Silty Sandy Gravel
228 - 305 ft : Sandy Gravel
305 - 355 ft : Gravel (G)
355 - 409 ft : Sandy Gravel
409 - 413 ft : SIL. (M)
413 - 432.5 ft : Gravel (G)



Fill	*Casing*	*Screen*
0 - 9.1 ft : 9.125-inch hole Cement Surface Seal	0 - 232.94 ft : 4 inch 4" Sch. 5 SS Csg.	
9.1 - 218.5 ft : 9.125-inch hole Med. Bentonite Chunks		
218.5 - 221 ft : 9.125-inch hole 3/8" Bentonite Pellets (Pel Plug)		232.94 - 268.03 ft : 4 inch 4" SS Wire Wrap .010 Slot Screen
221 - 260.2 ft : 9.125-inch hole 20/40 Silica Sand	268.03 - 268.35 ft : 4 inch 4" SS End Cap	
260.2 - 268.35 ft : 9.125-inch hole 10/20 and 8/16 Silica Sand		
268.35 - 274 ft : 9.125-inch hole 10/20 and 8/16 Silica Sand		
274 - 415.6 ft : 9.125-inch hole Cement Grout Seal		
415.6 - 431.5 ft : 9.125-inch hole 10/20 Silica Sand		
431.5 - 432.5 ft : 9.125-inch hole Slough		

432.5 ft : Borehole drilled depth

0 - 432.5 ft : 9.125-in. TUBEX w/8-5/8" Temp. carbon steel csg.

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	JEA
Reference:	Hanford Wells
Revision:	0
Revision Date:	22Oct98
Print Date:	28Dec98

Figure E-1. Well 299-W10-24 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W10-24

WELL DESIGNATION	:	**299-W10-24**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**432.5 ft**
MEASURED DEPTH (GS)	:	**268.35 21Oct98**
AVAILABLE LOGS	:	**Geologist & Geophysical Logs**
DATE EVALUATED	:	**Data not available**
EVAL RECOMMENDATION	:	**Data not available**
LISTED USE	:	**RCRA Groundwater Monitoring**
CURRENT USER	:	**RCRA & Operations**
PUMP TYPE	:	**Hydrostar**
MAINTENANCE	:	**Data not available**
COMMENTS	:	**Air Rotary TUBEX w/Reverse Air drilled - 8-5/8" csg. to 432.5 ft.**
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	**JEA**
Reference:	**Hanford Wells**
Revision:	**0**
Revision Date:	**22Oct98**
Print Date:	**28Dec98**

Figure E-1. Well 299-W10-24 Construction and Completion Summary (continued)

0540437

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W10-28 G3400
Drilling Fluid Used:	none	Additives Used:	none reported	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	G. Howell	WA State Lic Nr:	1930	Coordinates: N	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	10Sep01	Date Completed:	17Oct01	Start Card #:	R037816
				Elevation Ground Surface:	

Depth to Water: **225.51 ft. ft 17Oct01**
(Ground surface)

Elevation of Reference Point: **m**

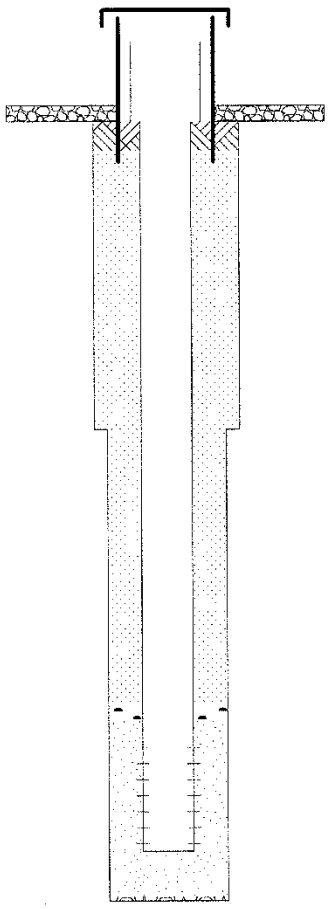
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.3 ft.**

Type of Surface Seal: **4x4 Concrete Pad**

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 3 ft : Silty Sandy Gravel
3 - 14 ft : Sand
14 - 24 ft : Sandy Gravel
24 - 27.5 ft : Sand
27.5 - 50 ft : Sandy Gravel
50 - 79.9 ft : Sand
79.9 - 84.5 ft : Silt & Sand
84.5 - 87 ft : Sand
87 - 96.5 ft : Sandy Silt
96.5 - 101 ft : Caliche
112 - 114 ft : Sandy Silt
114 - 121 ft : Sand w/occasioal silt lenses
121 - 129 ft : Sandy Silt
129 - 131 ft : Silty Sandy Gravel
131 - 142 ft : Gravelly Sandy Silt
142 - 173 ft : Silty Sandy Gravel
173 - 274 ft : Silty Sandy Gravel more cemented than from 142-173 ft
274 - 274.5 ft : Silty Sand
274.5 - 280 ft : Gravelly Sand



280 ft : Borehole drilled depth

0 - 111 ft : 11-in. Cable Tool 10-5/8" CS Temp csg
111 - 280 ft : 9-in. Cable Tool 8-5/8" CS Temp csg

Fill	*Casing*	*Screen*
0 - 10.3 ft : 11-inch hole Cement Surface Seal	0 - 225.19 ft : 4 inch 304L SS sch 5 csg	
10.3 - 111 ft : 11-inch hole Granular Bentonite		
111 - 209.4 ft : 9-inch hole Granular Bentonite		
209.4 - 215.3 ft : 9-inch hole 3/8" Bentonite pELLETS		225.19 - 260.19 ft : 4 inch 304L SS Wire Wrap .020 slot scrn
215.3 - 262.19 ft : 9-inch hole 10/20 Silica Sand		
262.19 - 271.6 ft : 9-inch hole 10/20 Silica Sand	260.19 - 262.19 ft : 4 inch 304L SS Sump	
271.6 - 273.9 ft : 9-inch hole 3/8" Bentonite Hole Plug		
273.9 - 278.3 ft : 9-inch hole 10/20 Silica Sand		
278.3 - 280 ft : 9-inch hole Slough		

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **08Nov01**
Print Date: **08Nov01**

Report Form: WELLS Project File: WELLS.GPJ

Figure E-2. Well 299-W10-28 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W10-28

WELL DESIGNATION	:	**299-W10-28**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**280.0 ft**
MEASURED DEPTH (GS)	:	**262.19 17Oct01**
AVAILABLE LOGS	:	**Geologist & Geophysical**
DATE EVALUATED	:	**Data not available**
EVAL RECOMMENDATION	:	**Data not available**
LISTED USE	:	**RCRA Monitoring**
CURRENT USER	:	**RCRA & Operations**
PUMP TYPE	:	**Not Documented**
MAINTENANCE	:	**Data not available**
COMMENTS	:	**Cable Tool 11-3/4" CS Temp csg to 111 ft. - 8-5/8" CS Temp csg to 280 ft.**
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	**JEA**
Reference:	**Hanford Wells**
Revision:	**0**
Revision Date:	**08Nov01**
Print Date:	**08Nov01**

Figure E-2. Well 299-W10-28 Construction and Completion Summary (continued)

0532876

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W11-39 C3117
Drilling Fluid Used:	none	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	M. Wraspir	WA State Lic Nr:	1909	Coordinates: N	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	09Nov00	Date Completed:	18Dec00	Start Card #:	Not Available
				Elevation Ground Surface:	

Depth to Water: **237.31 ft** **18Dec00**
(Ground surface)

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 5.5 ft : Backfill
5.5 - 33.5 ft : Sandy GRAVEL

33.5 - 57 ft : Gravelly SAND

57 - 63 ft : SAND
63 - 82.5 ft : Gravelly SAND

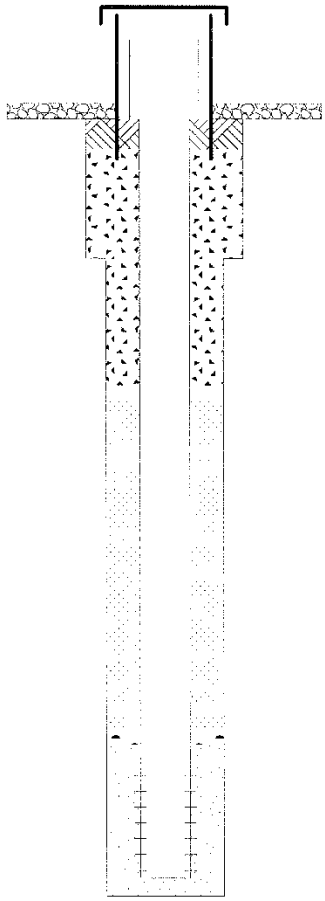
82.5 - 90 ft : SAND
90 - 112 ft : Silty SAND

112 - 127 ft : Slightly Silty SAND

127 - 131 ft : Slightly Silty Gravelly SAND
131 - 145 ft : Silty Sandy GRAVEL

145 - 150 ft : Sandy GRAVEL
150 - 265 ft : Silty Sandy GRAVEL (Sandy GRAVEL at 265)

265 - 282.31 ft : Silty Sandy GRAVEL



282.31 ft : Borehole drilled depth

0 - 50.94 ft : 12-in. Cable Tool 11-3/4 CS Temp. csg.
50.94 - 282.31 ft : 9-in. Cable Tool 8-5/8 CS Temp. csg.

Elevation of Reference Point: **m**

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.9 ft.**

Type of Surface Seal: **4x4 Concrete Pad**

Fill	*Casing*	*Screen*
0 - 10.9 ft : 12-inch hole Cement Surface Seal	0 - 238.6 ft : 4 inch 4" 304 SS sch 5 csg.	
10.9 - 50.94 ft : 12-inch hole Bentonite Chips		
50.94 - 96.5 ft : 9-inch hole Bentonite Chips		
96.5 - 222.47 ft : 9-inch hole Granular Bentonite		
222.47 - 227.15 ft : 9-inch hole 1/4" & 1/2" Bentonite pellets		238.6 - 273.66 ft : 4 inch 4" SS Wire Wrap .020 Slot scrn.
227.15 - 275.66 ft : 9-inch hole 10/20 Silica Sand	273.66 - 275.66 ft: 4 inch 4" SS Sump	
275.66 - 282.31 ft : 9-inch hole 10/20 Silica Sand		

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **20Mar01**
Print Date: **20Mar01**

Report Form: WELLS Project File: WELLS.GPJ

Figure E-3. Well 299-W11-39 Construction and Completion Summary

0532874

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool & A. R. Drl & Drive	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W11-40 C3118	TEMPORARY WELL NO:	Not Allowed
Drilling Fluid Used:	Air	Additives Used:	None	Coordinates: N	Not documented		
Driller's Name:	K. Cowden	WA State Lic Nr:	Not Available	Coordinates: E	Not documented		
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Start Card #:	Not Available		
Date Started:	26Sep00	Date Completed:	09Oct00	Elevation Ground Surface:			

Depth to Water: 237.05 ft 06Oct00
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 2 ft : Silty Sandy GRAVEL
2 - 6.5 ft : Slightly Silty SAND
6.5 - 32 ft : Sandy GRAVEL

32 - 43 ft : SAND

43 - 46 ft : Gravelly SAND
46 - 64 ft : SAND

64 - 70 ft : Gravelly SAND
70 - 88 ft : SAND

88 - 92 ft : Slightly Silty SAND
92 - 103 ft : Sandy SILT

103 - 117 ft : Gravelly Silty SAND

117 - 122 ft : Gravelly SAND
122 - 133 ft : Silty SAND

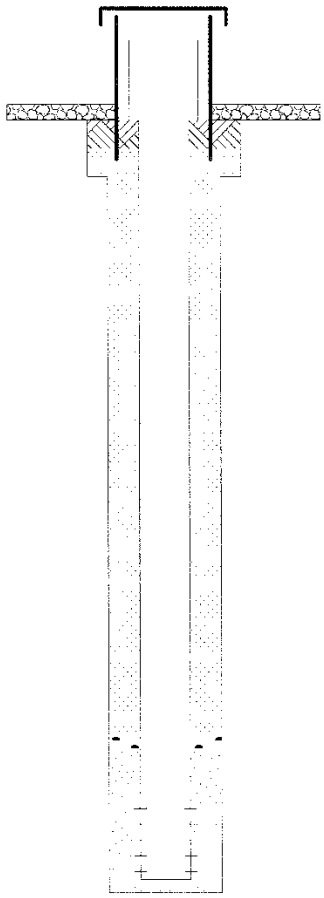
133 - 142 ft : Silty Sandy GRAVEL

142 - 163 ft : Sandy GRAVEL

163 - 170 ft : Silty Sandy GRAVEL
170 - 198 ft : Sandy GRAVEL

198 - 222 ft : Silty Sandy GRAVEL

222 - 280 ft : Sandy GRAVEL



Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.2 ft

Type of Surface Seal: 4x4 Concrete Pad

Fill	*Casing*	*Screen*
0 - 10.2 ft : 11.75-inch hole Cement Surface Seal	0 - 238.08 ft : 4 inch 4" 304L SS csg.	
10.2 - 20.5 ft : 11.75-inch hole Granular Bentonite		
20.5 - 222.2 ft : 8.625-inch hole Granular Bentonite		
222.2 - 228.6 ft : 8.625-inch hole 3/8" Bentonite pellets		238.08 - 273.13 ft : 4 inch 4" 304 SS Wire wrap .020 slot scrn
228.6 - 275.18 ft : 8.625-inch hole 10/20 Silica Sand		
275.18 - 280 ft : 8.625-inch hole 10/20 Silica Sand	273.12 - 275.18 ft : 4 inch 4" 304L SS csg.	

280 ft : Borehole drilled depth

0 - 20.5 ft : 11.75-in. 11-3/4" CS Temp. csg set w/Cable Tool
20.5 - 280 ft : 8.625-in. 8-5/8" CS Temp. csg. set w/A.R. Drl & Drive

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 19Mar01
Print Date: 19Mar01

Figure E-4. Well 299-W11-40 Construction and Completion Summary

0526560

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool/Air Rotary	Sample Method:	Grab/Split Spoon	WELL NUMBER.	299-W11-41 C3119
Drilling Fluid Used:	NA/Air	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	M. Wraspir	WA State Lic Nr:	1909	Coordinates: N	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	04Aug00	Date Completed:	22Aug00	Start Card #:	R037802
				Elevation Ground Surface:	

Depth to Water: 236.6 ft. ft 22Aug00
(Ground surface)

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 12.9 ft.

Type of Surface Seal: 4x4 Concrete Pad

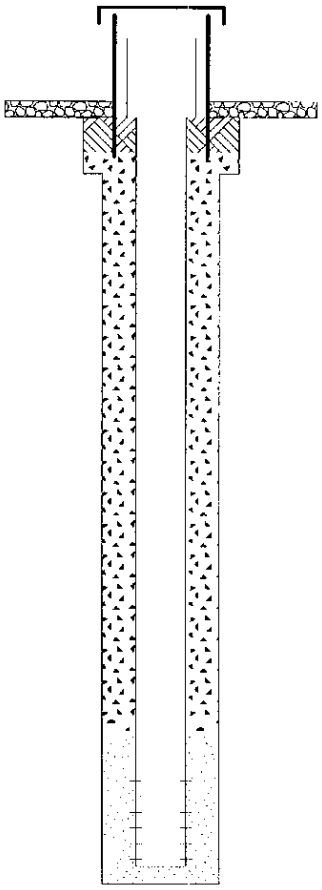
GENERALIZED STRATIGRAPHY Geologist's Log

0 - 4 ft : Silty Sandy GRAVEL
4 - 7 ft : Slightly Silty SAND
7 - 33 ft : Silty Sandy GRAVEL

33 - 37 ft : Gravelly SAND
37 - 39 ft : Sandy GRAVEL
39 - 44 ft : SAND
44 - 94 ft : Sand

94 - 98 ft : Silty SAND (calcareous)
98 - 118 ft : Slightly Silty SAND - trace of caliche 103-106 ft

118 - 122 ft : SAND
123 - 133 ft : Sandy SILT
133 - 144 ft : Gravelly Silty SAND
144 - 158 ft : Silty Sandy GRAVEL
158 - 169 ft : Sandy GRAVEL
169 - 173 ft : Gravelly SAND
173 - 198 ft : Sandy GRAVEL
198 - 208 ft : Silty Sandy GRAVEL
208 - 213 ft : Sandy GRAVEL
213 - 218 ft : Gravelly SAND
218 - 246 ft : Sandy GRAVEL
246 - 270 ft : Silty Sandy GRAVEL
270 - 280 ft : Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 12.9 ft : 12-inch hole Cement Surface Seal	0 - 236.7 ft : 4 inch 4" 304L SS Sch 5 csg	
12.9 - 20.6 ft : 12-inch hole Bentonite Crumbles		
20.6 - 218.8 ft : 9-inch hole Bentonite Crumbles		
218.8 - 226 ft : 9-inch hole Bentonite Pellets		236.7 - 271.7 ft : 4 inch 4" 304L SS Wire Wrap .020 slot scrn.
226 - 273.7 ft : 9-inch hole 10/20 Silica Sand		
273.7 - 280 ft : 9-inch hole 10/20 Silica Sand	271.7 - 273.7 ft : 4 inch 4" SS Sump	

280 ft : Borehole drilled depth

0 - 20.6 ft : 12-in. 11-3/4" CS Temp. csg set w/Cable Tool
20.6 - 280 ft : 9-in. 8-5/8" CS Temp. csg set w/Air Rotary csg hammer

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	JEA
Reference:	Hanford Wells
Revision:	0
Revision Date:	22Sep00
Print Date:	22Sep00

BECHTEL

Figure E-5. Well 299-W11-41 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W11-41

WELL DESIGNATION	:	**299-W11-41**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**280.0 ft**
MEASURED DEPTH (GS)	:	**280 22Aug00**
AVAILABLE LOGS	:	**Geologist**
DATE EVALUATED	:	**Data not available**
EVAL RECOMMENDATION	:	**Data not available**
LISTED USE	:	**RCRA monitoring/sampling**
CURRENT USER	:	**RCRA & Operations**
PUMP TYPE	:	**Hydrostar**
MAINTENANCE	:	**Data not available**
COMMENTS	:	**Cable tool to 20.6 ft w/11-3/4" CS csg Air Rotary from 20.6 to 280 ft w/8-5/8" CS csg.**
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	**JEA**
Reference:	**Hanford Wells**
Revision:	**0**
Revision Date:	**22Sep00**
Print Date:	**22Sep00**

Figure E-5. Well 299-W11-41 Construction and Completion Summary (continued)

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary Csg. Hammer	Sample Method:	Grab/Split Spoon
Drilling Fluid Used:	Air	Additives Used:	None
Driller's Name:	M. Wraspir	WA State Lic Nr:	1909
Drilling Company:	RSI	Company Location:	Woodland, Ca.
Date Started:	10Sep00	Date Completed:	13Sep00

WELL NUMBER:	299-W11-42	C3242	TEMPORARY WELL NO: Not Allowed
Coordinates: N	Not documented		
Coordinates: E	Not documented		
Start Card #:	Not Available		
Elevation Ground Surface:			

Depth to Water: 238.06 ft 13Sep00
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 8 ft : Slightly Silt Gravel Sand (m)gS
8 - 39 ft : Sandy Gravel

39 - 62 ft : Slightly Silty Sand (m)S

62 - 69 ft : Sand S
69 - 74 ft : Gravelly Sand gS
74 - 91 ft : Slightly Silty Sand (m)S

91 - 100 ft : Silty Sand mS

100 - 117 ft : Slightly Silty Sand (m)S w/caliche

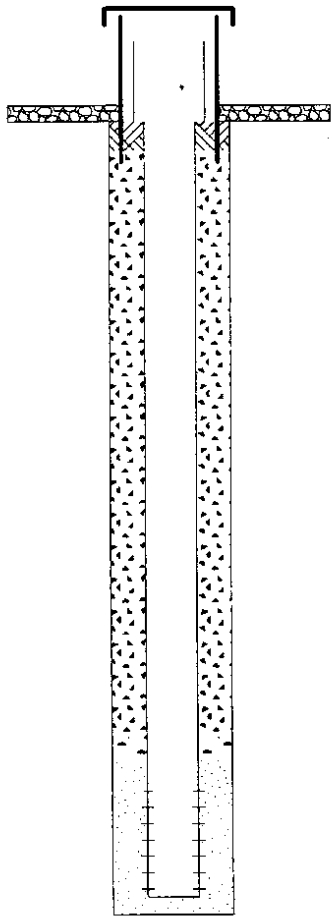
117 - 121 ft : Gravelly Sand gS
121 - 128 ft : Sandy Silt sM
128 - 134 ft : Slightly Silty Sand (m)S
134 - 140 ft : Silty Sandy Gravel msG
140 - 179 ft : Sandy Gravel sG

179 - 188 ft : Silty Sandy Gravel msG

188 - 200 ft : Sandy Gravel sG

200 - 223 ft : Silty Sandy Gravel msG

223 - 280 ft : Sandy Gravel sG



Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.2 ft.

Type of Surface Seal: 4x4 Concrete Pad

Fill	*Casing*	*Screen*
0 - 10.2 ft : 9-inch hole Cement Surface Seal	0 - 236.76 ft : 4 inch 4" 304L SS Sch 5 Csg	
10.2 - 217.8 ft : 9-inch hole Bentonite Crumbles		
217.8 - 225.5 ft : 9-inch hole Bentonite Pellets		
225.5 - 273.77 ft : 9-inch hole 10/20 Silica Sand		236.76 - 271.77 ft : 4 inch 4" 304L SS Wire Wrap .020 slot scrn.
273.77 - 280 ft : 9-inch hole 10/20 Silica Sand	271.77 - 273.77 ft : 4 inch 4" 304L SS Sump	

280 ft : Borehole drilled depth

0 - 280 ft : 9-in. 8-5/8" CS Temp. csg. set Air Rotary Casing Hammer

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 26Sep00
Print Date: 27Sep00

Report Form: WELLS Project File: WELLS.GPJ

Figure E-6. Well 299-W11-42 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W11-42

WELL DESIGNATION	:	**299-W11-42**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**280.0 ft**
MEASURED DEPTH (GS)	:	**273.77 13Sep00**
AVAILABLE LOGS	:	**Geologist**
DATE EVALUATED	:	**Data not available**
EVAL RECOMMENDATION	:	**Data not available**
LISTED USE	:	**RCRA monitoring/sampling**
CURRENT USER	:	**RCRA & Operations**
PUMP TYPE	:	**Hydrostar**
MAINTENANCE	:	**Data not available**
COMMENTS	:	**8-5/8" CS Temp. csg w/Air Rotary Casing Hammer. Replacement well for C3116.**
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **26Sep00**
Print Date: **27Sep00**

Figure E-6. Well 299-W11-42 Construction and Completion Summary (continued)

E2 Reference

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

Appendix F

Groundwater Flow and Migration Calculations to Support Assessment of the Hanford Central Plateau 200 West Area Facilities Monitoring Network – ECF-200W-17-0070

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The calculation ECF-200W-17-0070, *Groundwater Flow and Migration Calculations to Support Assessment of the Hanford Central Plateau 200 West Area Facilities Monitoring Network*, was performed to evaluate the suitability of the current groundwater monitoring networks to detect hypothetical releases and, where appropriate, to evaluate the efficacy of the monitoring networks to detect the presence of, or significant increases in, groundwater contamination from the dangerous waste management units that are located in the 200 West Area of the Central Plateau. The calculation is available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065259H.

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Appendix G

Groundwater Flow and Migration Calculations to Support Assessment of the WMA T Monitoring Network – ECF-200W-17-0075

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The calculation ECF-200W-17-0075, *Groundwater Flow and Migration Calculations to Support Assessment of the WMA T Monitoring Network*, was performed to evaluate monitoring well locations for the Waste Management Area T groundwater monitoring network. The calculation is available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065250H.

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Appendix H

Statistical Method Determination

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Figure H-8. Chart Legend H-9

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H1 Introduction

An accelerated sampling program will be conducted to obtain a minimum of eight samples. The accelerated sampling program will monitor the constituents listed in Table 9 4 (Appendix 5 of Ecology Publication No. 97-407) of the main body at a quarterly frequency for two years. After 2 years of sampling is completed, the statistical test method can be determined using the flow charts presented in this appendix.

The flow charts (Figures H-1 through H-7) below represent a series of statistical analyses, consistent with EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, that describe basic methodology for determining the type of statistical test that would be most appropriate for implementation in a groundwater monitoring plan for regulated waste. These flow charts guide the user through tests to identify potential outliers, and evaluate statistical distributions, spatial variance, temporal trends and equality of variance for background and compliance wells. EPA 530/R-09-007 should be consulted for conditional data handling requirements related to normality of distribution for Rosner's, Modified Dixson's, and ANOVA tests. Based on these series of tests, the user is directed towards the type of test, interwell or intrawell, that is most appropriate based on the available data. The flow charts do not proclaim to provide every detail of every process but are to be used as a guide.

Figure H-8 provides a chart legend applicable to Figures H-1 through H-7.

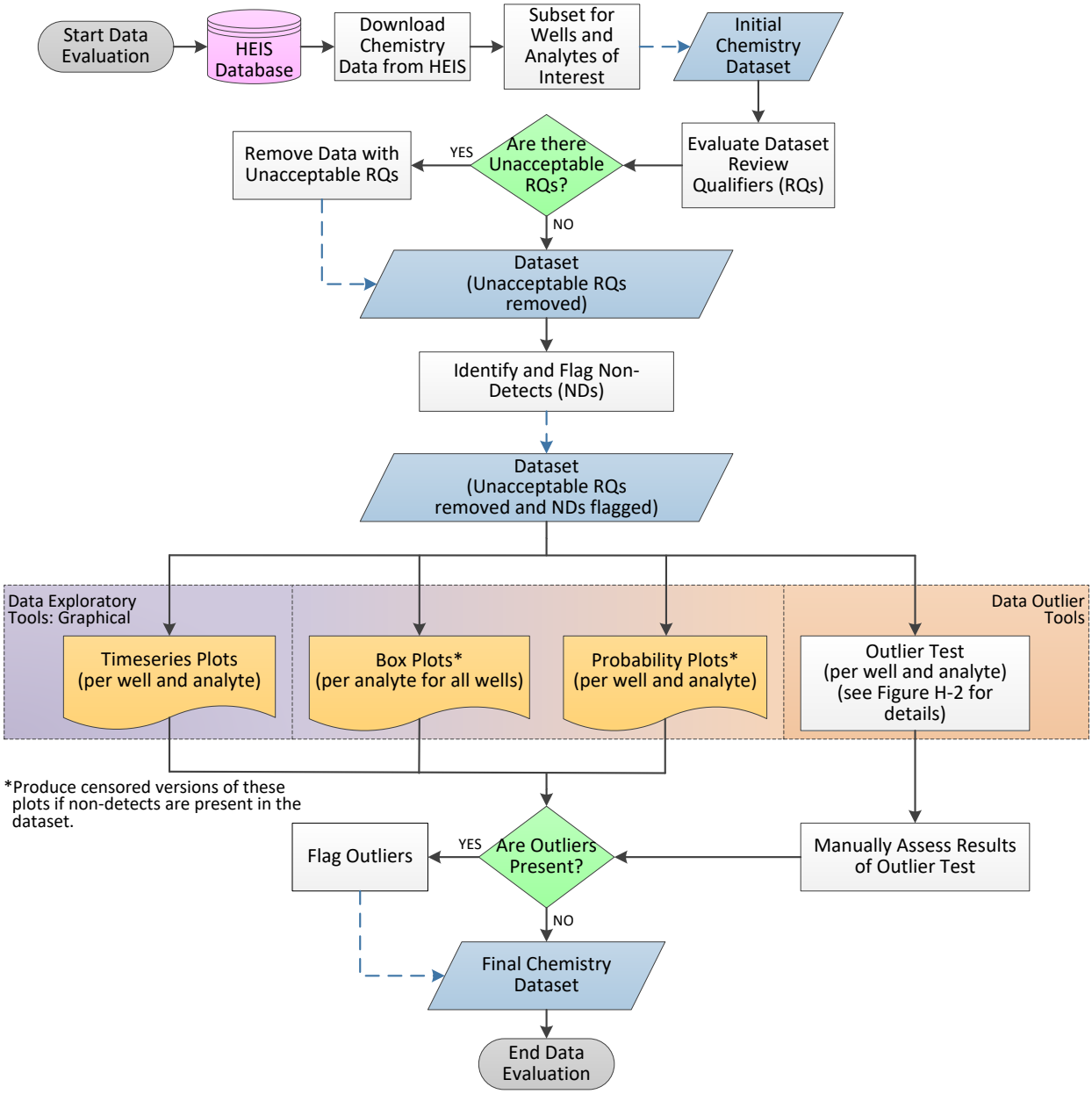

Figure H-1. Data Evaluation

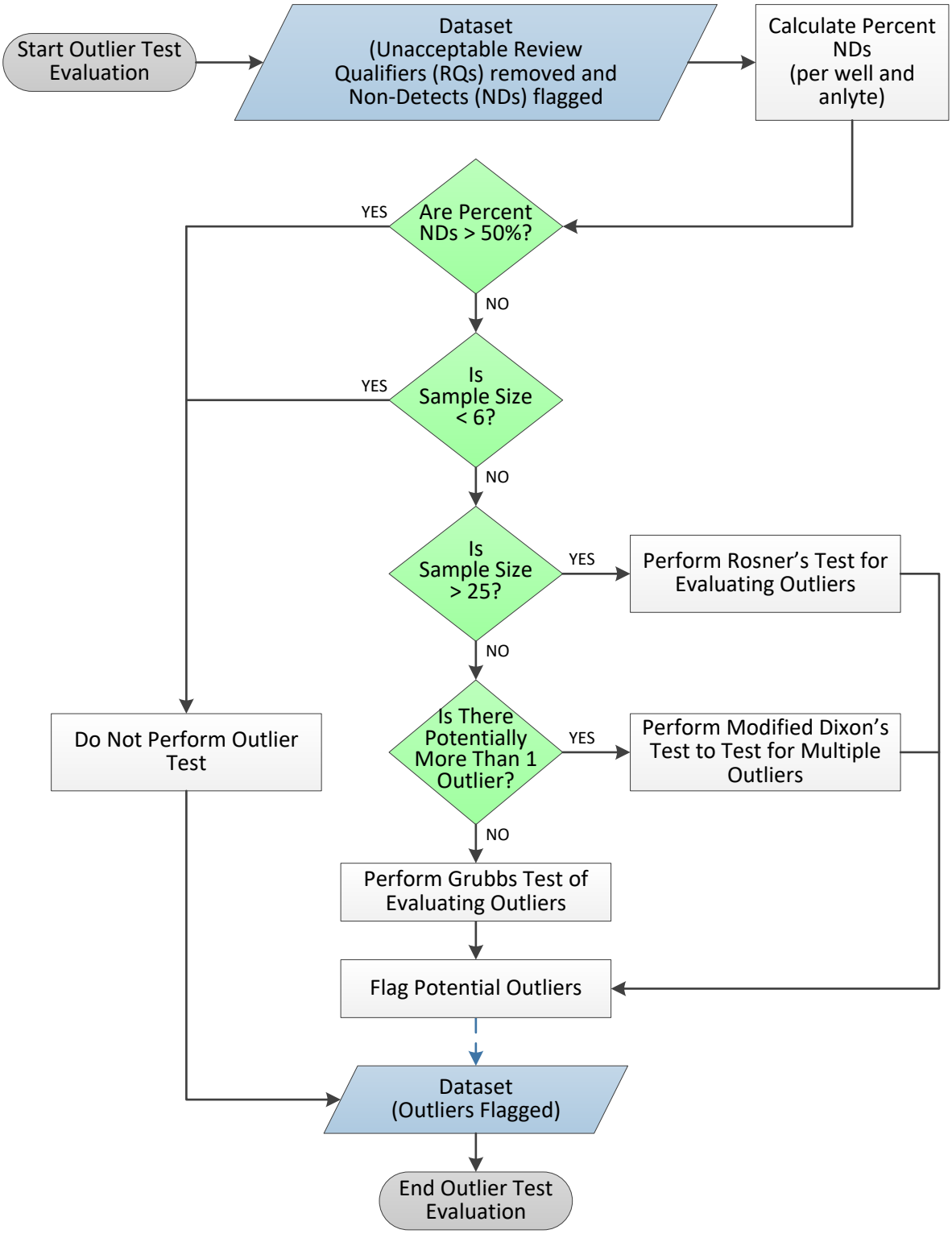

Figure H-2. Outlier Test Evaluation

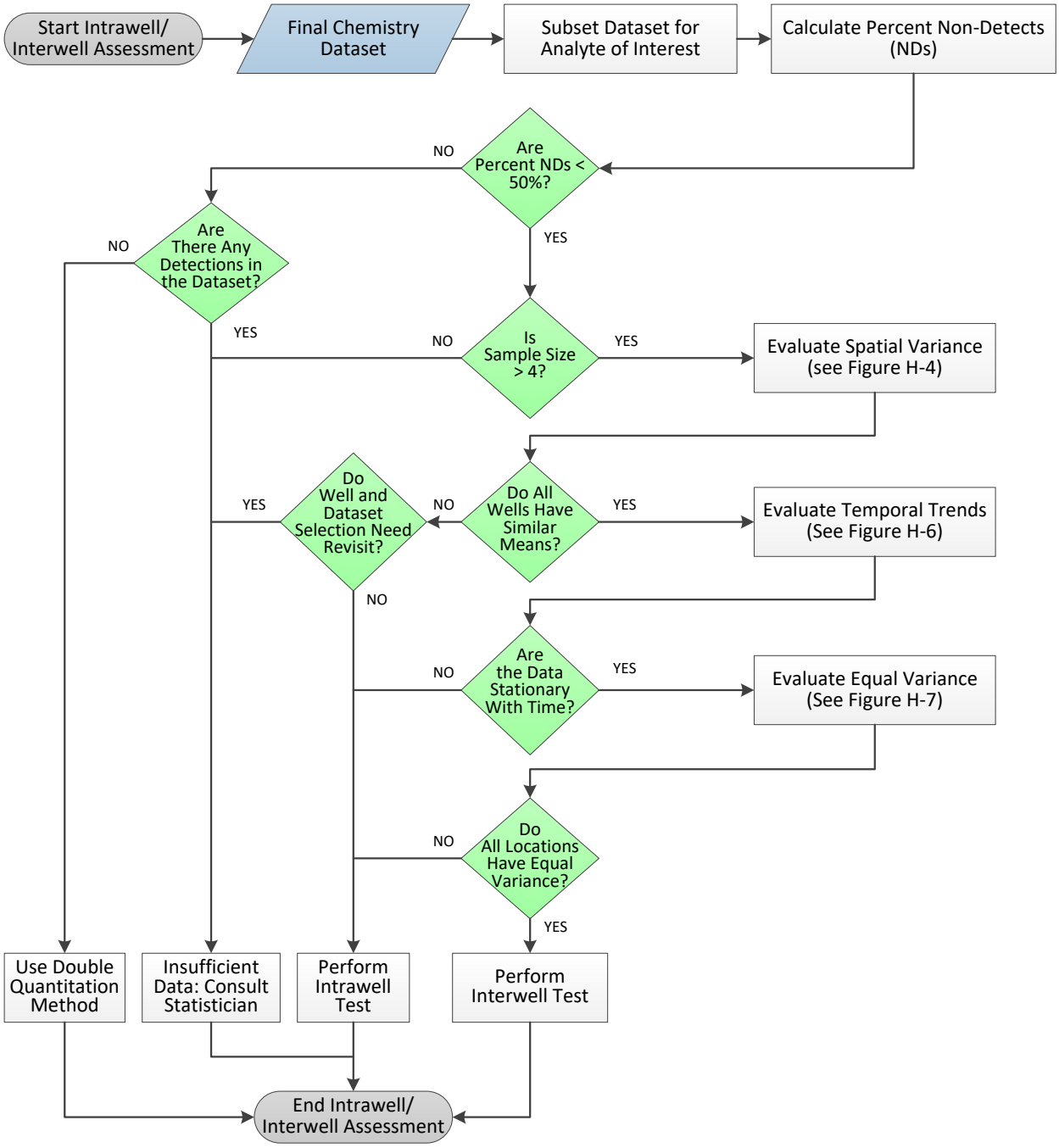

Figure H-3. Intrawell/Interwell Assessment

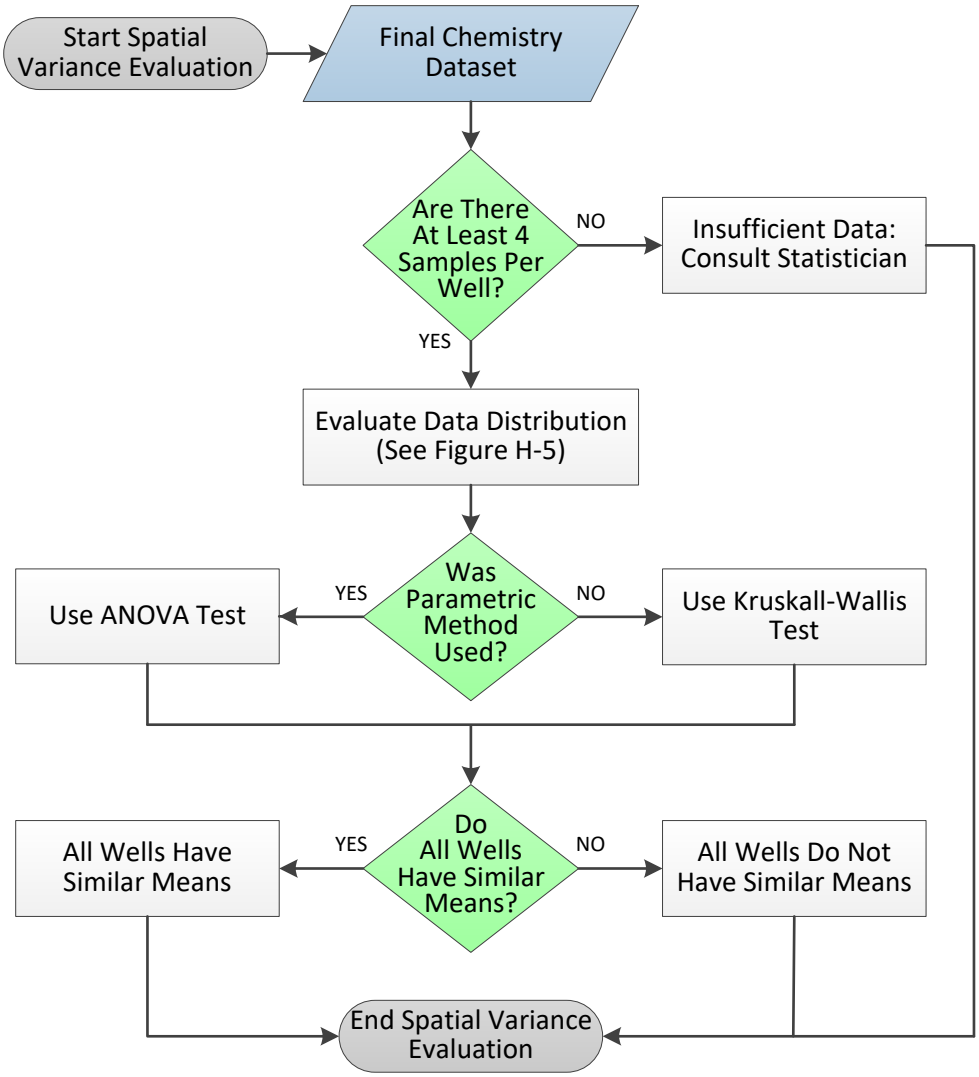

Figure H-4. Spatial Variance Evaluation

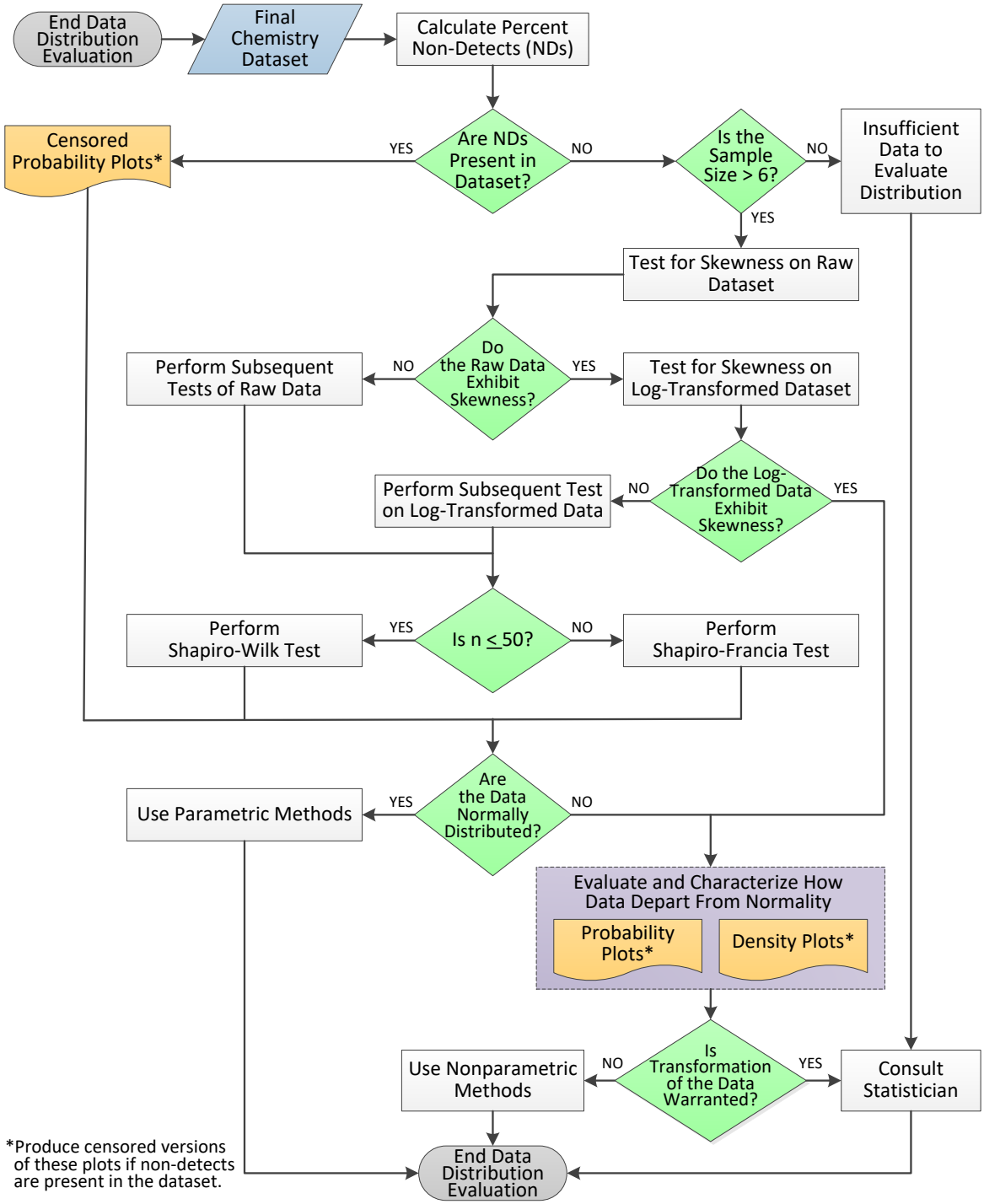

Figure H-5. Data Distribution Evaluation

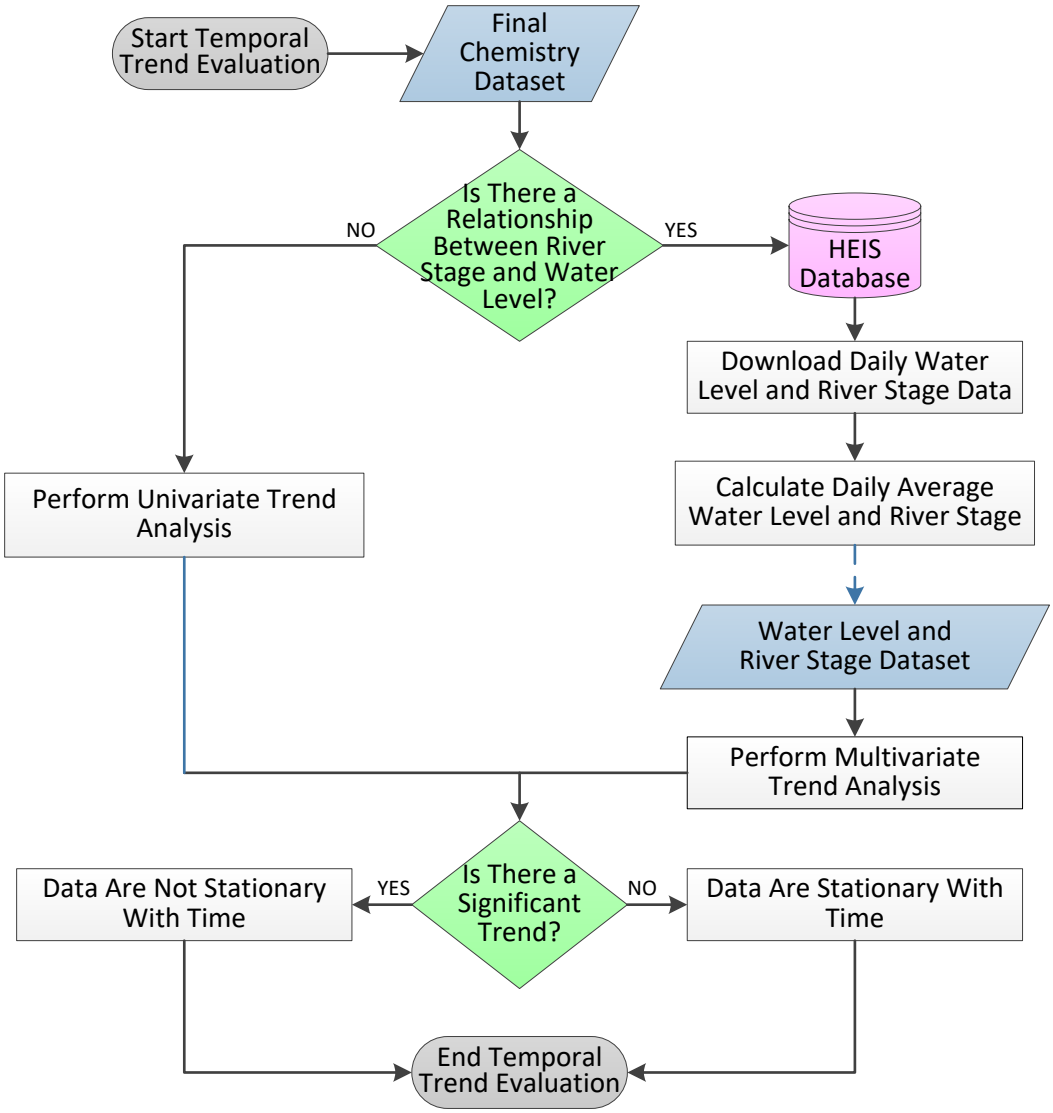

Figure H-6. Temporal Trend Analysis

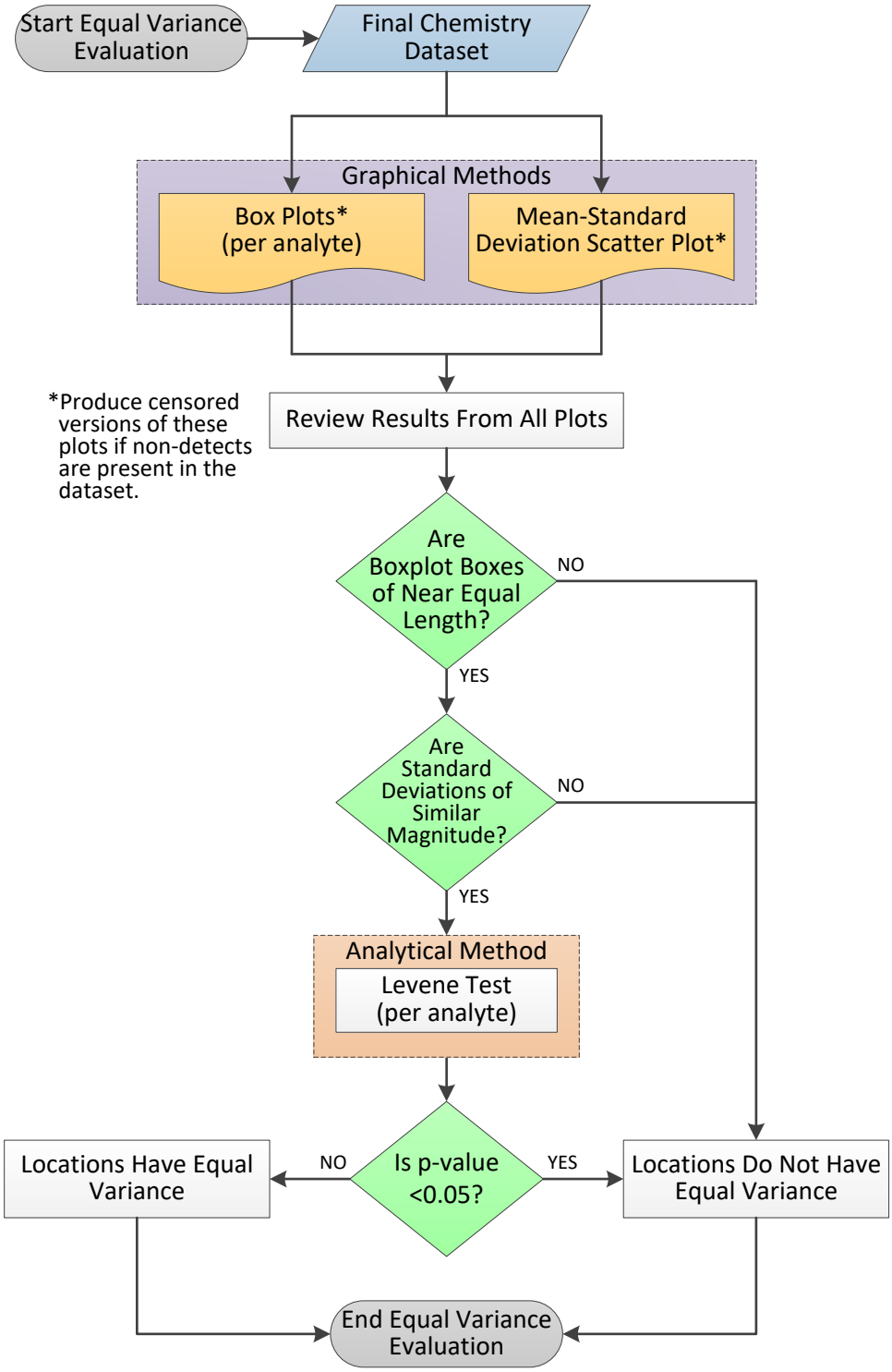

Figure H-7. Equal Variance Evaluation

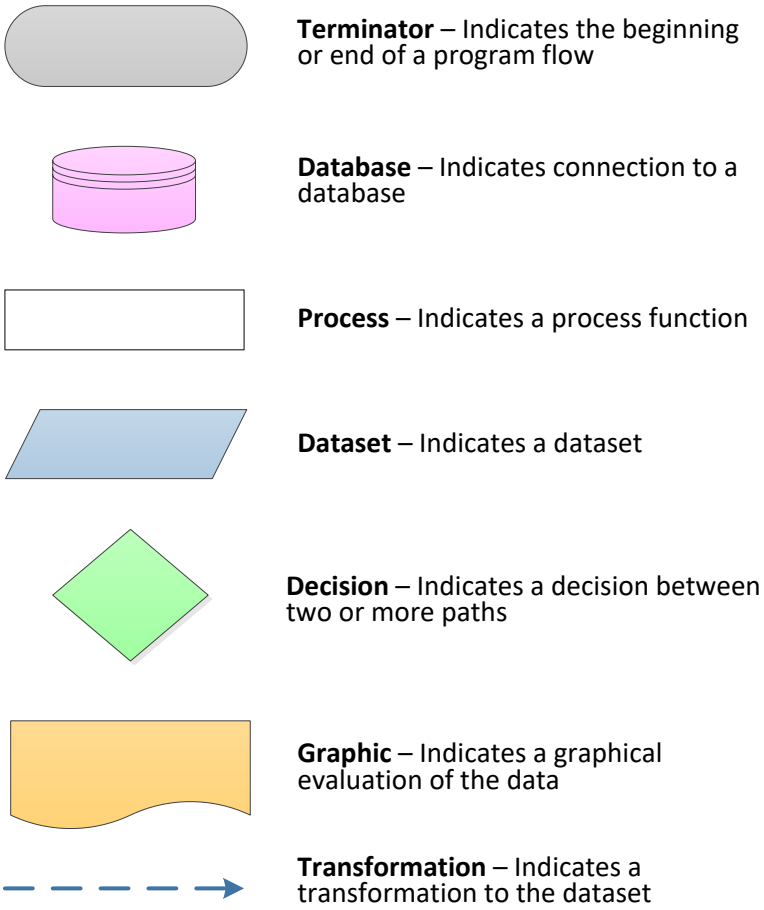

Figure H-8. Chart Legend

H2 Reference

EPA 530/R-09-007, 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, Office of Resource Conservation and Recovery, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10055GQ.TXT.

Review Comment Record	Washington State Department of Ecology Nuclear Waste Program Cleanup Section/ER Project	RECEIVED SEP 18 2018 EDMC	Received: December 5, 2017 Dispositions: January 26/31, 2018, February 2, 2018 RCR Closed: March 8, 2018 Page 1 of 13

Document Title(s)/Number(s): Engineering Evaluation report for Single-Shell Tank Waste Management Area T Groundwater Monitoring/SGW-60575

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Item # Page # Section # Line/¶ #s	Comment and Basis/Justification	Modification Needed	DOE Response	Ecology Response	O/C	Reviewer (Initials)
Item 1 General	Please incorporate all comments made on WMA U EER Basis/Justification: Previous relevant comments need to be incorporated into this document.		Accept.	Accept. Ecology reviewed during meeting on 1/26/2018	C 1/26/2018 Redline reviewed.	DC/DG/SL
Item 2 General	It seems the monitoring wells of the existing network have been impacted by water level fluctuations, flow direction, gradient as well as by the flow rates. Figure 3-10 depicts these fluctuations and changes observed. The text should cover the impact of these changes in the wells especially on the groundwater data covering how the data should be interpreted with reference to these changes. Also, include its impact on the background data as well as the upgradient data.	Include explanation on the results and the changes due to the mentioned parameters observed in the field.	Acknowledged. The data will be evaluated every quarter and communicated to DOE and then the Department of Ecology with interpretation. After the analysis in the first several quarters a follow on assessment will be necessary to determine the appropriate path forward. This will need to be addressed in the GWMP. It is not directly addressed in the EER.	Accept.	C 1/31/2018 No change.	DG and other HGs
Item 3 General	Provide explanations of any sudden spike of water level elevation as seen in well (e.g. well 299-W11-40 in Figure 3-10 and similar observation in any TSDs. Sampling data collected in such field condition from such wells may not be representative. Provide technical explanation how to interpret these data under such field conditions.	Provide necessary explanations per the comment	Acknowledged. The data will be evaluated every quarter and communicated to DOE and then the Department of Ecology with interpretation. After the analysis in the first several quarters a follow on assessment will be necessary to determine the appropriate path forward. This will need to be addressed in the GWMP. It is not directly addressed in the EER.	Accept.	C 1/31/2018 No change.	DG
Item 4 General	Provide why RPP-RPT-55084, Hanford 241-T Farm Leak Inventory Assessment Report, Rev. 0 was not used as a reference. Basis/Justification: This document is the leak inventory that has been released to the soil and is what is migrating currently to groundwater	Provide why RPP-RPT-55084 was not used as a reference document.	Accept with modification. This document was not available in the AR at the time this report was drafted. The sentence "Additional information on tank leak inventories can be found in RPP-RPT-55084 (ref)." Affects all EERs	Discussion was had that this is the most recent document for tank leak inventories and it's the current process being used. Agreed that in this	C 1/26/2018 Redline reviewed.	DC

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				case it is appropriate to send the reader to another source of information.		
Item 5 P: 1-7, S: First row	This states that the requirements of WAC 173-303-645(8)(a) regarding the monitoring system are addressed in Section 9.3 Section 9.3 does not address the requirement that wells be installed at appropriate locations and **depths**…" Basis/Justification: Location includes not only areal but also vertical coordinates.	Provide information in the report on the need (or not) to address potential vertical contamination, and the basis.	1/25/2018: Accepted in WMA U RCR Item 2 There is existing contamination that includes a vertical component being addressed under CERCLA. Focus of this analysis on recent or future release A technical memo has been drafted addressing the vertical component of contaminant movement in the aquifer for the particle tracking, and text from the technical memo regarding vertical movement to be added as a section to the 200 West Regional ECF. The following text has been added to Section 6.1 "Analysis" presented in Section 7.4 of Appendix F shows that, based on present conditions, no significant vertical migration is expected in the 200 West Area. The vertical movement that is likely to occur is limited to areas near extraction wells. Section 7.4 of Appendix F also concludes that the American Petroleum Institute (API) calculator can be used to verify the appropriateness of the depths of the well screens for monitoring wells. In addition to confirming the use of the API calculator, the results of the analysis of particle vertical distribution agrees with the conclusion of Hantush, 1964, "Hydraulics of Wells," that the flows at locations that are a distance greater than approximately 1.5 to 3 times the saturated thickness from extraction wells are predominantly horizontal. The facility-specific results of the API calculator are presented in Section 7.5 of Appendix G. The following text has been added to Section 9.3 "Based on the API calculator (discussed in Appendix F), the depths of the monitoring wells, screened across the top of the water table, are appropriate. Would affect all EERs.		C 1/26/2018 Redline Reviewed.	SL
Item 6 P: 2-1 S: 2.1.2	Provide the reference document that supports placing an interim surface barrier over Tank T-106. In 1973 was when this tank was identified as a known leaker and	Either provide the reference for this statement of an interim surface barrier or correct the text as to	Accept.		C	DC

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L: 35	numerous soil investigations were conducted. I am unaware of an "interim surface barrier being placed over Tank T-106 until 2008 time frame. No interim barrier was over the tank in the early 2000s, when the Phase 1 investigations were being conducted. Basis/Justification: Dates and events do not correlate. Correctness, accuracy.	what is being discussed and provide the reference for it.	Sentence, "In 1973, an interim surface barrier was placed over tank 241-T-106 and nearby tanks to inhibit infiltration from mobilizing wastes that leaked from the tank," should be deleted. The 2008 surface barrier at WMA T is described in the following sentence.		1/26/2018 Redline reviewed.	
Item 7 P: 2-3 S: 2.1.3 L:6	The amount of total leak volume from T-101 is 7,500 gallons according to Hanlon (HNF-EP-0182, Rev. 357. Please correct accordingly.		Accept Revise sentence as shown: "Tank 241-T-101 was categorized as an assumed leaker in 1991 and has a total leak volume of 28,400 L (7,500 gal) ~~90,922 L (20,000 gal)~~ (Section 4.0 in HNF-EP-0182)."		C 1/26/2018 Redline reviewed.	DC
Item 8 P: 2-5 S: 2.1.3	Provide the total volume and liquid volume in each of these tanks (T-101, T-103, T-106, T-107, T-108, T-109, and T-111 Basis/Justification: Completeness. Remaining amount of waste that can leak to the environment and groundwater.	Provide total and liquid volume of waste in each of the "Assumed Leaker" tanks.	Accept with modification. Deleted last sentence of the first paragraph in 2.1.3, which references the solids inventory in the tanks, no similar information required for liquids.	Accept.	C 1/26/2018 Redline reviewed.	DC
Item 9 P: 2-5 S: 2.1.3	Tank T-107 is a tank with a water intrusion issue. Provide this information in this document. Basis/Justification: Completeness	See comment.	Accept. Text added: Water intrusion into tank 241-T-107 was visually confirmed in 2016 (Section 4.2 in HNF EP 0182)		C 1/26/2018 Redline reviewed.	DC
Item 10 P: 2-13 Figure 2-4	Based on the legend, all tanks are leakers. Please correct the legend to indicate which tanks are assumed leakers and which tanks are sound. The legend reads, "Tank Leaks" and "SSTs w/ Suspected/Confirmed Leaks/Releases" Provide what the difference of these two categories are. Basis/Justification: Clarity, correctness, accuracy.	Provide the "assumed leakers" and the "sound tanks".	Accept. Figure modified. Entries in figure legend revised to match those in Figure 2-3.		C 1/26/2018 Redline reviewed.	DC
Item 11 P: 2-15 S: 2.4 L:14-15	Delete the sentence beginning with "The assessment monitoring plan combined WMA T and WMA TX-TY…" as the sentence is redundant with the previous sentence. Basis/Justification: Redundant	Delete sentence.	Accept. Deleted sentence		C 1/26/2018 Redline reviewed.	DC
Item 12 P: 2-15 S: 2.4 L: 37	Provide where LLBG WMA-5 is located. I know where LLBG WMA 3 and LLBG WMA 4 are located, but not WMA 5	Provide location of LLBG WMA – 5.	Accept LLBG WMA-5 became Burial Ground 218-W-6. Will revise Figure 2-4 to show 218-W-6. Change sentence to:		C 1/26/2018 Redline reviewed.	DC

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	Basis/Justification: Clarity, completeness		"In 1994, wells from LLBG WMA-3 and LLBG WMA-5 (now the 218-W-6 Burial Ground) (Figure 2-4) that were in the vicinity of WMA T…"			
Item 13 P: 2-16 S: 2.4 L: 7	This "phase II assessment" appears it should be "Phase 1 assessment that was done by Fred Hodges. Please change.		No change needed. The text aligns to the 1997 reference source (Section 5.9.2.1 in PNNL-11793), "Assessment findings indicate that contaminants in well 299-WI0-15 are a result of sources external to the WMA. There is strong evidence, however, that contaminants observed in well 299-WI1-27 are a result of sources within the WMA, so a Phase II assessment will be performed." The phase 1 report (PNNL-11809) was issued in 1998. Discussion of a phase II assessment and the phase II assessment objectives for both WMA T and WMA TX-TY were included in the report (Sections 5.0 and 5.1.3 of PNNL-11809). A phase II assessment report was not issued for WMA T.	Accept.	C 1/26/2018 No change.	DC
Item 14 P: 2-19 L: 15	The well name 299-W1-7 is incorrect. Should this be 299-W11-7?	Make correction.	Accept. Change well name to 299-W11-7.		C 1/26/2018 Redline reviewed.	SL
Item 15 P: 3-7 L: 2	Provide what comes after "…hydrogeologic unit 8 of …" Basis/Justification: Incomplete sentence.	See comment.	Accept. Text revised to "Ringold Formation, member of Wooded Island lower mud – The lower mud unit is equivalent to hydrogeologic unit 8 ~~of~~ (Section 3.1.2.2 in PNNL-13858)."		C 1/26/2018 Redline reviewed.	DC
Item 16 P: 3-11 Table 3-1	Provide if the "Estimated Range of Saturated Hydraulic conductivities" corresponds to values in the 200 West Area or if these are over the entire Hanford Site? Provide the values for the range for 200 West Area only. Basis/Justification: Groundwater flow should be focused on the area of interest, not 5 miles away.	Provide 200 West hydraulic conductivity values.	Accepted in WMA U Item 5: Text for WMA T changed consistent with WMA U to read "The saturated hydraulic conductivity underlying WMA T is 5 m/d (16.4 ft/d) (Table 4-9 in CP-47631). Table 5-1 in PNNL-17732, *Analysis of the Hydrologic Response Associated with the Shutdown and Restart of the 200-ZP-1 WMA T Tank Farm Pump and Treat System* gives saturated hydraulic conductivities ranging from between approximately 6.11 to 9.69 m/d (20.1 to 31.8 ft/d) based on field measurements." Would affect all EERs.		C 1/26/2018 Redline reviewed.	DC
Item 17 P: 3-16 S: 3.3.2	We suggest reference to Figure 3-10 be provided in the first couple sentences. Basis/Justification: Better figure to demonstrate topic of section.	See comment.	No change to text. This is a PRC style, information is not missing.		C 1/26/2018 No change.	SL

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Item 18 P: 4-5 Figures 4-2, 4-3, 4-4, 4-5 and 4-6 L: 16-18	The figures do not provide the required information. WAC 173-303-806(4)(xx)(D) requires "A description of any plume of contamination that has entered the groundwater from a regulated unit… that: (II) Identifies the concentration of each constituent throughout the plume or identifies the maximum concentrations of each constituent in the plume…" Neither the concentration of each constituent throughout the plume nor the maximum concentrations are provided. Basis/Justification: WAC 173-303-806(4)(a)(xx)(D)(II).	Provide, at a minimum, the maximum concentration of these constituents.	<u>No change to text.</u> There are plume maps in this chapter to support the text in the chapter. The more formal plume maps are presented in Appendix D to meet this requirement.		C 1/26/2018 No change.	SL/DC
Item 19 P: 4-5 S: 4.4 L: 9-15	Fluoride is a dangerous waste constituent as "Fluorine". Please correct the statement that only "chromium, carbon tetrachloride, and trichloroethene are the only dangerous waste constituents in groundwater…" Basis/Justification: Fluorine was left out of the list.	Include fluorine in the list and monitor for fluoride in Chapter 8 and 9.	<u>No change needed.</u> Fluorine would not typically exist in groundwater.	Discussed and resolved that fluorine does not exist in groundwater.	C 1/26/2018 No change.	DC
Item 20 P: 4-5 Figures 4-7, 4-8, 4-9, and 4-10 L: 20-23	The text does not show some key wells on the figures, such as W11-46, and the graphs are not consistent. The graphs should show results for all the wells mentioned. Basis/Justification: Completeness. WAC 173-303-806(4)(a)(xx)	See comment.	<u>Accept with modification.</u> Separated the concepts of contaminant concentration trends in multiple wells and vertical contamination in specific wells into two separate paragraphs. A figure will not be added for Well W11-46 since it is discussed in the context of vertical contamination.	Accept.	C 1/31/2018 Redline reviewed.	SL
Item 21 P: 4-5 S: 4-4 L: 23-26	The report makes only brief mention of the vertical distribution of contamination, stating: "Several lines of evidence show that vertical contaminant concentration gradients exist in the area of WMA T. Contaminant concentrations increase with depth in the aquifer in some places (i.e., well 299-W11-46)." Chromium contamination that is found in some wells screened below the water table should be more thoroughly discussed. Assessment plans and reports, including PNNL-15301, discuss the three-dimensional aspects of chromium extensively. That plan states, "…in February and March 2005, well 299-W11-25B was drilled to the Ringold Formation lower mud unit and encountered extremely high concentrations of technetium-99, nitrate, and chromium at 10.7 meters below the water table and deeper (Figure 2.21). Other reports also documented the vertical extent of contamination with statements such as,	A much more complete discussion of the chromium contamination, vertically as well as laterally, is necessary. Provide these details, which are necessary to plan an effective compliance groundwater monitoring system.	<u>Accept.</u> Additional text and figures will be added. Discussed in meeting 1/31/2018.		~~C~~ ~~1/31/2018~~ ~~Pending review of additional informatio n and figures~~ C 3/8/2018 Redline reviewed.	SL

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	"The chromium plume extends at least 80 meters downgradient of the WMA to well 299-W11-45, screened between 8.5 and 13 meters below the water table, where the chromium concentration was 132 ug/L during the quarter." Also, provide if this is hexavalent chromium or total chromium or both. The requirements of compliance groundwater monitoring cannot be met without addressing the vertical distribution of contaminants in this section and throughout this engineering evaluation report. Basis/Justification: Lack of information for chromium					
Item 22 P: 4-5 S: 4.4	Provide what the current concentration of fluoride is in the groundwater at WMA T. Provide a fluoride plume map. Basis/Justification: WAC 173-303-806(4)(a)(xx)		Accept. Fluoride will be included in the additional maps provided in Appendix D. Fluoride in November 2017 exceeded the DWS in 299-W10-24 (4.8 mg/L) and 299-W299-W11-39 (4.9mg/L).	Accept.	~~C~~ ~~1/26/2018~~ ~~Pending addition of Appendix D maps~~ C 3/8/2018 Redline reviewed.	DC
Item 23 P: 4-5 S: 4-4 L: 25-26	The reference to wells 299-W10-24 and 299-W14-13 is not warranted. PNNL-15301 states "Such high levels of contaminants at these depths below the water table is contrary to what had been observed at well 299-W10-24 and at well 299-W14-13 at the WMA TX-TY…" Note that these wells are at WMA TX-TY.	Remove the reference to wells 299-W10-24 and 299-W14-13.	Accept. Well 299-W10-24 is located at WMA T. Reference to 299-W14-13 has been deleted.		C 1/26/2018 Redline reviewed.	SL
Item 24 P: 4-5 S: 4-4 L: 27-28	This appears to be the only place in the entire report that associates chromium contamination with the WMA T. There is no substantial discussion on the source, migration, and extent of chromium contamination. Has further work been completed to differentiate possible waste sources other than WMA T?	Expand the discussion on the extent and migration of chromium. PNNL-15301 includes an evaluation and discussion on potential sources (in addition to the WMA) of the contamination in the WMA-T wells, including waste disposed to nearby cribs and trenches.	Accept. Cr and Cr-6 are both proposed as a monitoring constituents. Chromium and/or hexavalent chromium are discussion in multiple places in this report. CHPRC is doing additional work addressing available data on the vertical component of contamination. See also, Item 21		~~C~~ ~~1/31/2018~~ ~~Pending review of additional information and figures~~ C 3/8/2018 Redline reviewed.	SL

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Item 25 P: 4-5 S: 4-4	What is the current understanding of the contaminant (chromium) sources, migration, and extent vertically and laterally? Is the current conceptual model consistent with the previous information such as that discussed in PNNL-15301? For example, that document states: "As was previously concluded (Hartman et al. 2005, Serne et al. 2004), the [contaminant ratios] shows that, after about 1995, groundwater in the northeast part of the WMA (Figure 2.27C), and probably the more recent samples from wells east of the WMA (Figure 2.27D) was impacted by tank waste. However, groundwater in the southwest, west, and north parts of the WMA do not appear to have been influenced to any great extent by waste disposed to the nearby cribs and trenches, east of the WMA, as was previously concluded (Figure 2.27A and B). [I have not provided in the comments the figures that are in PNNL-15301].		Accept. Cr and Cr-6 are both proposed as a monitoring constituents. Chromium and/or hexavalent chromium are discussion in multiple places in this report. CHPRC is doing additional work addressing available data on the vertical component of contamination. See also, Item 21		~~C 1/31/2018 Pending review of additional informatio n and figures~~ C 3/8/2018 Redline reviewed.	SL
Item 26 P: 5-2 L: 23-24	Based on information in the Appendices, Figure 5-2 presents the pumping rates for December, 2016, not the average pumping rates for 2016.	Review and correct this.	Accept. Figure caption revised to read "Locations and Average Pumping Rates (for December 2016) of 200 West Area P&T System Wells"		C 1/26/2018 Redline reviewed.	SL
Item 27 P: 5-6 L: 3-6	The approach here is not well explained. "The CPGWM represents the "as-built" extraction and injection well screened intervals (i.e., top and bottom elevations) and hence the depth below the water table at which injection (or extraction) at each well is focused. The monitoring wells were assumed to be screened across the water table, so that sampling from them focused on the quality of water at or close to the water table." Does this imply the model is constructed with several layers and these wells are somehow represented within these layers? Are vertical effects somehow addressed by this approach? This is especially important if compliance monitoring will need to be performed in deep wells as well as water table wells.	Provide a more complete description how the model actually is constructed to address the injection and monitoring well screen intervals. Discuss how vertical effects of contaminant movement is addressed.	Accepted at WMA U RCR Item 13. Comment response as follows: "Citation to MNW2 package added to the text. https://pubs.usgs.gov/tm/tm6a30/ The flow model is discretized. The reason we went with the particle tracking as the preferred method for determining well locations is that it is quasi-independent/semi-analytical in an X-Y-Z location. The flow model and transport model all utilize a block average. At every step of the particle path it re-calculates where it is in three dimensional space that is nearly grid independent. The respective screen lengths of wells are represented by a line sink only partially penetrating a layer if that is how the well is constructed (MNW2 Package, https://pubs.usgs.gov/tm/tm6a30/)." Would affect all EERs.		C 1/26/2018 Redline reviewed.	SL
Item 28 P: 6-6 L: 26-29	Comment: Is this item written correctly? It seems to suggest that the maps show mixing, rather than relative concentrations.	Explain please.	No change to text.		C 1/31/2018 No change.	SL

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	will be decided after 2 years of baseline data is collected and evaluated.		Deleted, "… the determination of background will be completed on an intra-well basis. Use of intra-well statistical methods eliminates the need for data from a background (upgradient) well not impacted by Hanford Site operations to assess the conditions at the DWMU."		1/26/2018 Redline reviewed.	
Item 38 P: 9-2 L: 32-39	This paragraph generally discusses the justification for wells that are appropriately located, and makes a key point that "…the selected point of compliance wells will provide representative samples of the quality of groundwater passing the point of compliance (WAC 173-303-645(8)(a)(ii)) and allow for the detection of contamination…" The end of this paragraph states, "…since they are immediately downgradient of the facility and are screened in the uppermost unconfined aquifer." This implies that the wells will provide representative samples solely because they are screened in the uppermost unconfined aquifer. Contaminants have been detected at depth, and it is not necessarily true that wells screened in the uppermost aquifer will meet the stated requirements.	Provide evaluation of wells that will be located deeper in the aquifer to evaluate vertical contamination.	From WMA U Item 31: Text modified to read: "Based on current groundwater flow direction to the east-southeast and predictions of future groundwater flow direction toward the east-northeast over time (Table 3-15 in DOE/RL-2016-66), the selected point of compliance wells will provide representative samples of the quality of groundwater passing the point of compliance (WAC 173-303-645(8)(a)(ii)). These locations allow for the detection of contamination when dangerous waste or dangerous constituents have migrated from the waste management area to the uppermost aquifer (WAC 173-303-645(8)(a)(iii)). Assessment of the vertical component of contaminant migration shows that wells screened in the top of the uppermost unconfined aquifer are suitable for monitoring based on the API calculator (discussed in Appendix F) and determination of compliance with groundwater protection standards (WAC 173-303-645(10)(a)).		C 1/26/2018 Redline reviewed.	SL
Item 39 P: 9-2 L: 38-39	The text cites compliance with groundwater protection standards (WAC 173-303-645(10)(a)). I believe the citation should be (WAC 173-303-645(10)(b)).	Review and correct the citation.	Same as WMA U Item 32: No text change needed.		C 1/26/2018 No change.	SL
Item 40 P: 9-4 Table 9-1	This table is lacking some important parameters regarding the well screen placement. Provide all pertinent information regarding well screen placement like bottom of the well screen, bottom of the well (Total Depth). Provide whether well sumps exists on these wells. Basis/Justification: WAC 173-303-806(4)(a)(xx) and 173-303-645(8)	Provide the information on depth to top of screen, and depth to bottom of screen (elevation of bottom of screen) be provided in the table rather than, or in addition to, the text.	Same as WMA U Item 34 No change to the text. This table is not intended to be comprehensive, and also this information is provided elsewhere in the document, in both the text and in Appendix E.		C 1/26/2018 No change.	SL/DC
Item 41 P: 9-4 S: Table 9-1	Provide how long water will remain before new wells will be needed for WMA T. If the water is still dropping, provide the rate of drop and duration of current wells for representative groundwater samples. Basis/Justification: WAC 173-303-645	See comment.	No change to the text. In Section 3.3.2 the statement is made that "The increase in water table levels at WMA T wells in 2016 ranged from approximately 0.1 to 1.9 m (0.3 to 6.3 ft) (Figure 3-10)."		C 1/26/2018 No change.	DC
Item 42 P: 9-22	This refers to Appendix H to determine the statistical test method. Appendix H provides a method to evaluate based	Include here and in Appendix H that the evaluation and	Accept.		C	SL

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	Basis/Justification:					
Item 29 P: 7-1 L: 21, 22	Is this written correctly? This is related to comment 26, that is seems to suggest mixing rather than relative unit concentrations.	Explain.	No change to text.		C 1/31/2018 No change.	SL
Item 30 P: 7-1 S: 7 L: 28-31	Provide if this includes the effects of the injected treated water dilution breakthrough curves in these relative detectability maps. Basis/Justification: Completeness, understanding of the methodology	See comment.	Accept with modification. Additional text added to 6.2.2. "There is no assumption of a concentration, this analysis allows a comparison between scenarios and also geographically between wells as the relative detectability stays the same. The effects of the spreading and reduction of detectability as the result of injection are not applied as a specific element. In each scenario, the groundwater flow rates and resulting migration directions all explicitly include the effects of injection. Across scenarios modeled, the relative detectability calculation allows for the placement of wells in the most likely locations to detect a potential release." Affects all EERS.	Accept.	C 2/2/2018 Redline reviewed.	DC
Item 31 P: 7-18 S: 7-2	How will the particle tracking evaluate contamination that exists presently at depth, and the capability of wells to monitoring this contamination?		Accept with modification. The particle tracking does not do this. The following sentence was added to Chapter 5: "The modeling effort was aimed at potential future releases, and is not intended to address the effect of pre-existing contamination."	Accept.	C 2/2/2018 Redline reviewed.	SL
Item 32 P: 7-18 L: 19-21	Comment: This states that "…particles were released to the water table and particle movement was then predominantly horizontal, with minor components of vertical migration in response to very limited infiltration from groundwater recharge and the operation of nearby extraction and injection wells." This apparently does not consider previous liquid releases to the environment.		Same as Item 31 Accept with modification. The particle tracking does not do this. The following sentence was added to Chapter 5:	Accept.	C 2/2/2018 Redline reviewed.	SL

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	A different approach for sites where contamination has already migrated to the groundwater may need to be applied.		"The modeling effort was aimed at potential future releases, and is not intended to address the effect of pre-existing contamination."			
Item 33 P: 7-18 S: 7-2	What is the vertical discretization of the particle tracking simulations? Since contamination has been detected at depth in the aquifer this needs to be addressed.	Discuss how the vertical aspects of contaminant migration are addressed. Is a given contaminant concentration assumed to be evenly distributed throughout the entire aquifer thickness or only at the top of the aquifer?	WMA U Item 2 Accept. Discussed and text added to 6.1 and 9.3. See also, Items 32 and 33 in this RCR. Sentence added to Chapter 5	Accept.	C 2/2/2018 Redline reviewed.	SL
Item 34 P: 7-29 S: 7.4 L: 12-23	The rationale for removing some wells does not consider either the horizontal or vertical extent of contamination. This will be a compliance groundwater monitoring network, and the goal is to determine if groundwater contamination exceeds the groundwater protection standard. The requirements are not limited to evaluating groundwater just at the water table. Basis/Justification: DNAPL contaminants, WAC 173-303-645(8), WAC 173-303-806	Based on the requirements, identify wells appropriately to monitor contamination at depth as well as laterally.	Accept. Additional evaluation and discussion added to new Section 4.5, "Summary of Vertical Contaminant Distribution."		C 3/8/2018 Redline reviewed.	SL/DC
Item 35 P: 7-29 L: 9-11 and Figure 7-38	The combined extents of the relative detectability and unit plume on the referenced figure are not clearly indicated in this paragraph. It would be helpful to state here that the combined extents are shown for a relative detectability greater than 0.01, and that the unit plume extent is greater than 0.1.	Clarify in this paragraph that results of both the relative detectability extent from particle tracking and the unit plume extent from transport modeling are shown.	WMA U Item 20. Accept. Text changed to read: "Figure 7-38 shows the final status monitoring network wells compared to the combined extents of relative detectability greater than 0.01 for scenarios 1, 2, and 3 from particle tracking; and the combined extents of release unit plumes greater than 0.1 for sub-scenario A of scenarios 1 and 2, and scenario 3 from transport modeling."		C 1/26/2018 Redline reviewed.	SL
Item 36 P: 9-2 L: 7-9	This paragraph states, "Each well is screened in the upper unconfined aquifer in order to yield sufficient groundwater for representative sampling." The report does not address potential vertical contamination.	Address the vertical aspects of the flow system, contaminant migration, and monitoring.	Same comment as Item 29 in WMA U EER RCR. No change needed: Refer to changes made in Sections 6.1 and 9.3 as part of Item 2 in WMA U RCR. Changes have been made to this document.		C 1/26/2018 Redline reviewed.	SL
Item 37 P: 9-2 L: 26-29	This makes the statement that "the determination of background will be completed on an intra-well basis." However, Section 9.7 states that the statistical method	Remove the sentence.	Same as WMA U Item 5a. Accept.		C	SL

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L:32-33	on statistical information only. The evaluation must also consider the site hydrogeology.	determination of the statistical method will also include an evaluation of the hydrogeologic conditions.	WMA U Item 40: Additional sentence added "In addition to this methodology, hydrogeology of the area also will be considered."		1/26/2018 Redline reviewed.	
Item 43 P: 9-22 L: 33-34	The statement, "To date, there has not been an impact from injected water at WMT T" may be misleading. Clarify that this is injected water from the 200-West Pump and Treat system.	Clarify that this is injected water from the 200-West Pump and Treat system.	Accept. Text modified to read, "To date, there has not been an impact from 200 West P&T injected water at WMA T, but an impact is anticipated to begin after 2020 (Figures 7-1 through 7-10)"		C 1/31/2018 Redline reviewed.	SL
Item 44 S: New Section	The WAC 173-303-806(4)(xx)(G) requires, in addition to the compliance monitoring program, "The owner or operator must also submit an engineering feasibility plan for a corrective action program necessary to meet the requirements of WAC 173-303-645(11) except as provided in WAC 173-303-645 (9)(h)(v). Alternatively, the owner or operator can obtain written authorization in advance from the department to submit a proposed permit schedule for development and submittal of such information." This requirement has not been met in this engineering evaluation report.	Provide the required engineering feasibility plan in the permit application materials.	Acknowledged. No change to text. Discussed 1/26/2018, (9)(h)(v) does not exist in the WAC. The owner/operator would "seek written authorization in advance from the department to submit a proposed permit schedule for development and submittal of such information." The engineering feasibility plan could then be a RCRA/CERCLA integrations step and implement CERCLA documents under alternative requirements for groundwater monitoring. RCRA/CERCLA integration is specifically addressed in the TPA. The GWMP would include some of this information.		C 1/31/2018 No change.	SL/DC
Item 45 P: 10-1 S: 10	Provide more detail how this section will provide additional groundwater monitoring related to RPO activities and new wells that may be drilled and installed for WMA T. Basis/Justification: Completeness, WAC 173-303-645	See comment.	No change to text.	Discussed and closed, CERCLA and RPO will be integrated in the future.	C 1/26/2018 No change.	DC
Item 46 Appendix D	Provide all detected dangerous waste constituents. This would include fluoride, chromium, carbon tetrachloride, trichloroethene and any other constituent.		Same as WMA U Item 45 Accept. PRC is preparing additional figures for Appendix D that will provide the maximum detected result in the 2016 data set for each constituent detected above background.		~~C~~ ~~1/26/2018~~ ~~Pending the addition of additional figures~~ C 3/8/2018 Redline reviewed.	DC
Item 47 P: F-32	The statement in the text and on the figure title are misleading. The values on the figure only represent the	Correct the text and figure title.	Same as Item 46 in WMA U RCR:		~~C~~ ~~1/25/2018~~	SL

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Figure 4-1 L: 30-32	rates for December 2016. This seem to be the case for all the values on Figure 4-1 in Appendix F.		Accept.		~~Pending editorial change~~ C 3/8/2018 Redline reviewed.	
Item 48 P: F-48 and F-86	Figures 7-3 and 7-39 showing sub-scenario C injected water plumes with injected water flow pathlines. These indicate flow pathlines radiating from the location of injection well 299-W10-35; however, this injection well is not operating in scenario C. This brings into question the graphical depictions of all the simulations.	Review and correct, or provide an explanation.	Same as WMA U item 47, this appendix is duplicated in each document. Change made in WMA U files. Text added to the end of the first paragraph in 7.1.1. This figure is intended to show a qualitative comparison of the extent and migration of injected water. As such, particles are released around all injection wells regardless of their operating rate.		C 1/25/2018 Redline reviewed in WMA U.	SL
Item 49 P: F-50 and F-88	Figures 7-5 and 7-41 showing sub-scenario E injected water plumes with injected water flow pathlines. These indicate flow pathlines radiating from the location of injection well 299-W15-226; however, this injection well is not operating in scenario E. (It appears that the flow pathlines are superimposed on several figures in the same manner).	Review and correct, or provide an explanation.	Same as WMA U item 48 this appendix is duplicated in each document. Change made in WMA U files. Text added to the end of the first paragraph in 7.1.1. This figure is intended to show a qualitative comparison of the extent and migration of injected water. As such, particles are released around all injection wells regardless of their operating rate.		C 1/25/2018 Redline reviewed in WMA U.	SL
Item 50 P: F-137 Table A-3	The historical monthly extraction rates for well 299-W17-3 provided in Appendix F, Table A-3 range from 8 to 127 gpm. This would suggest that the predicted extraction rate (in App. F, Table A-4) of 132 gpm may not be achievable.	Discuss the likelihood that the predicted extraction rate of 132 gpm in well 299-W17-3 can be maintained.	Same as WMA U Item 49 this appendix is duplicated in each document. Change made in WMA U files. No text change. Table A-3 shows actual extraction rates for 2016—the predicted extraction rate of 132 gpm is achievable, however; the limiting factor is the ability to inject the water due to current operational restrictions.		C 1/25/2018 Redline reviewed in WMA U.	SL
Item 51 P: G-26 S: 4.2.1	As pointed out above, the figure 4-1 does not depict average pumping rates, but just the rate for December 2016.	Review and correct.	Same as WMA U Item 51. Accept. This is a typographical error. Figure callouts should only refer to December 2016, "January through" will be deleted throughout Appendix G.		~~C~~ ~~1/26/2018~~ ~~Pending adjustment of figure captions~~ C 3/8/2018 Redline reviewed.	SL
Item 52 P: G-31 S: 6.1	Item 1 indicates pumping rates from CY2015 and 2016 were calculated on an average monthly basis, and assumed future pumping rates were developed. The	Provide a discussion on this.	Same as WMA U Item 52. No text change:		C 1/25/2018 No change.	SL

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L: 19-23	assumed future rates are not comparable to historical averages.		Table A-4 shows predicted future extraction rates—the limiting factor in the historical averages has been the ability to inject the water due to operational restrictions.			

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