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SGW-60576
Revision 0

Engineering Evaluation Report for Single-Shell Tank Waste Management Area TX-TY 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

ch2m

P.O. Box 1600
Richland, Washington 99352

WMA-TX-TY

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APPROVED
By Mary P. Curry at 6:20 pm, Jul 23, 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 TX-TY Groundwater Monitoring, SGW-60576, 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 23, 2018

Leonard D. Habel, P.E.
~~Sr. Principal Engineer~~
North Wind Infrastructure and Technology, LLC

Date

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Terms

AEA	*Atomic Energy Act of 1954*
CAS	Chemical Abstracts Service
CCU	Cold Creek unit
CCUc	Cold Creek unit calcic paleosols
COC	Cold Creek unit silts and sands
CPGWM	Central Plateau Groundwater Model
DOE	U.S. Department of Energy
DWMU	dangerous waste management unit
DWS	drinking water standard
EBF	electromagnetic borehole flow
ECF	environmental calculation file
ECN	engineering change notice
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FY	fiscal year
H1	Hanford 1
H2	Hanford 2
H3	Hanford 3
HEIS	Hanford Environmental Information System
HSU	hydrostratigraphic unit
ICP	inductively coupled plasma
K_d	distribution coefficient
LLBG	Low-Level Burial Grounds
MT3DMS	Modular Three-Dimensional Multi-Species Transport Model
OU	operable unit
P&T	pump and treat
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction Facility

RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	reduction-oxidation
RFI/CMS	RCRA Facility Investigation/Corrective Measures Study
RLM	Ringold lower mud
SST	single-shell tank
SVOC	semivolatile organic constituents
TBP	tributyl phosphate
TCE	trichloroethylene
TDS	total dissolved solids
TOC	total organic carbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
UPR	unplanned release
VOC	volatile organic constituents
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) TX-TY based on evaluation of contaminants associated with WMA TX-TY, the expected migration behavior of contaminants in the WMA, and historical observations and measurements of groundwater contamination at WMA TX-TY. 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 TX-TY 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 TX-TY 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 TX-TY 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 TX-TY includes 24 SSTs and ancillary equipment of the 241-TX and 241-TY Tank Farms that were used to support the bismuth phosphate process and the uranium-recovery program. Some of the tanks in WMA TX-TY also received waste from Reduction-Oxidation (REDOX) Plant (located in 200 West Area) and Plutonium-Uranium Extraction (PUREX) Plant (located in 200 East Area) operations.

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 TX-TY 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 TX-TY. Details of the operational, regulatory, and groundwater monitoring history can be found in Chapter 2.

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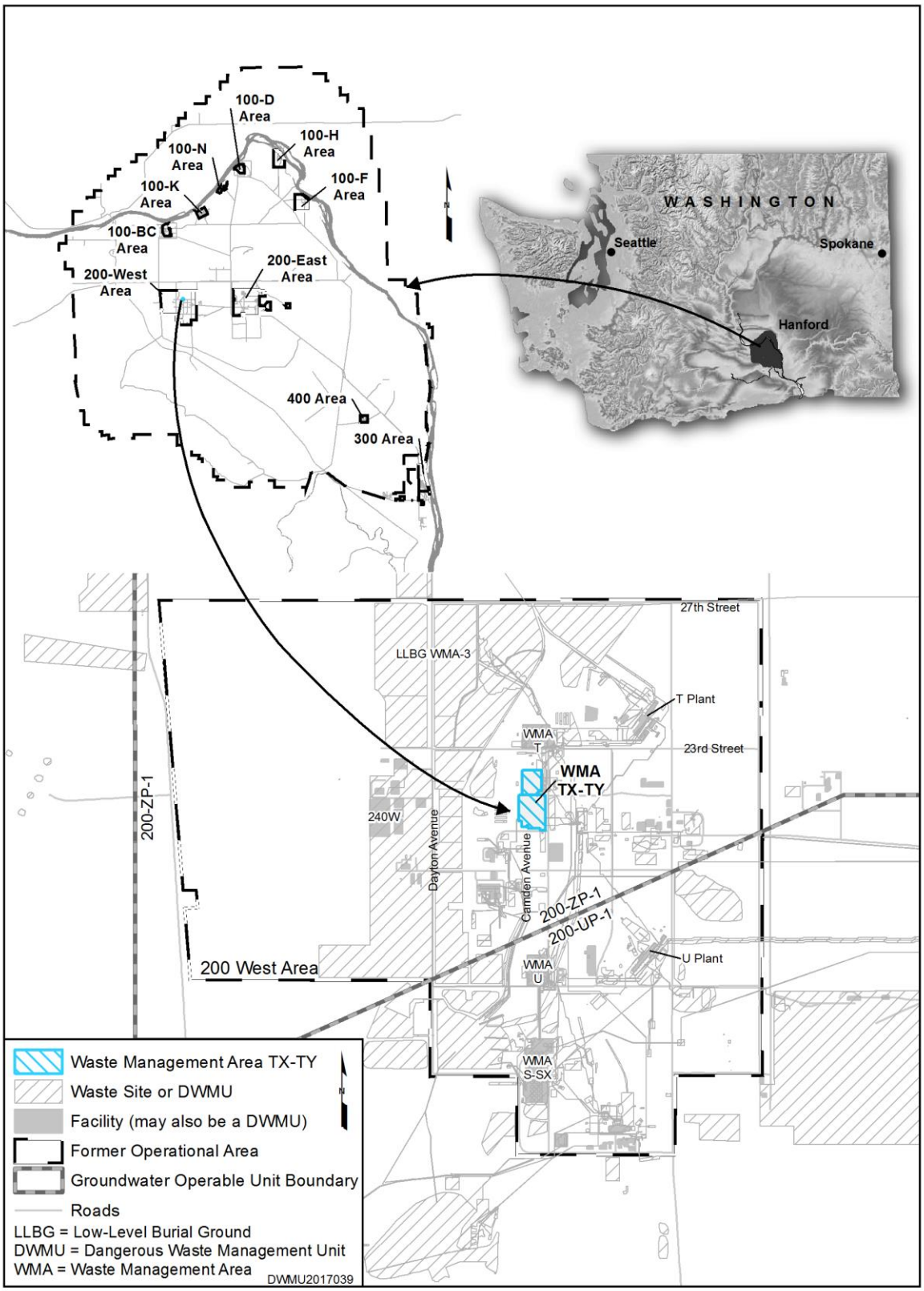


Figure 1-1. Location Map for WMA TX-TY

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 TX-TY.
- 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 TX-TY 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-200ZP1-17-0204, *Identification of Site-Specific Monitoring Constituents for Waste Management Area TX-TY*).
- Appendix C contains the topographic map.
- Appendix D contains regional plume maps in the vicinity of WMA TX-TY.
- 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 TX-TY modeling ECF (ECF-200W-17-0071, *Groundwater Flow and Migration Calculations to Support Assessment of the WMA TX-TY 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 TX-TY 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 TX-TY and its operations, regulatory basis, waste characteristics, and interim status groundwater monitoring history.

2.1.1 Facility Description

WMA TX-TY, which includes the 241-TX and 241-TY Tank Farms, is located in the northern portion of the 200 West Area (Figure 2-1). WMA TX-TY contains 24 underground SSTs constructed in 1947 and 1948 for the 241-TX Tank Farm and in 1951 and 1952 for the 241-TY Tank Farm. Each tank has a capacity of 2.84 million L (750,000 gal). The 18 tanks in the 241-TX Tank Farm are arranged in three 4-tank cascades and two 3-tank cascades. The six tanks in the 241-TY Tank Farm are arranged in three two-tank cascades. Tank cascades are sets of tanks that were constructed with elevation differences between tanks, which allows gravity-driven flow of the waste stream cascading from one tank to another. This allowed cooling and precipitation of radionuclides and solids to occur in each tank of the cascade. In addition to the tanks, diversion boxes and ancillary pumps, valves, and pipes are included in the 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 for the SST system. (DOE/RL-2009-67, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*, Rev. 1)

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 extending 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 TX-TY began receiving waste in 1949 and were used to support the bismuth phosphate process and the uranium-recovery program. Some of the tanks in WMA TX-TY also received waste from REDOX Plant and PUREX Plant operations. The tanks in WMA TX-TY have not received waste since November 1980 (Section 1.0 in WHC-SD-EN-AP-132, *Interim-Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Areas T and TX-TY*).

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. Pumpable liquid has been removed from the WMA TX-TY SSTs, and the tanks have been interim stabilized. Each tank currently contains less than 181,844 L (40,000 gal) of drainable interstitial liquid and less than 40,915 L (9,000 gal) of supernatant liquid (Section 4.1 in HNF-EP-0182, *Waste Tank Summary Report for Month Ending May 31, 2017*).

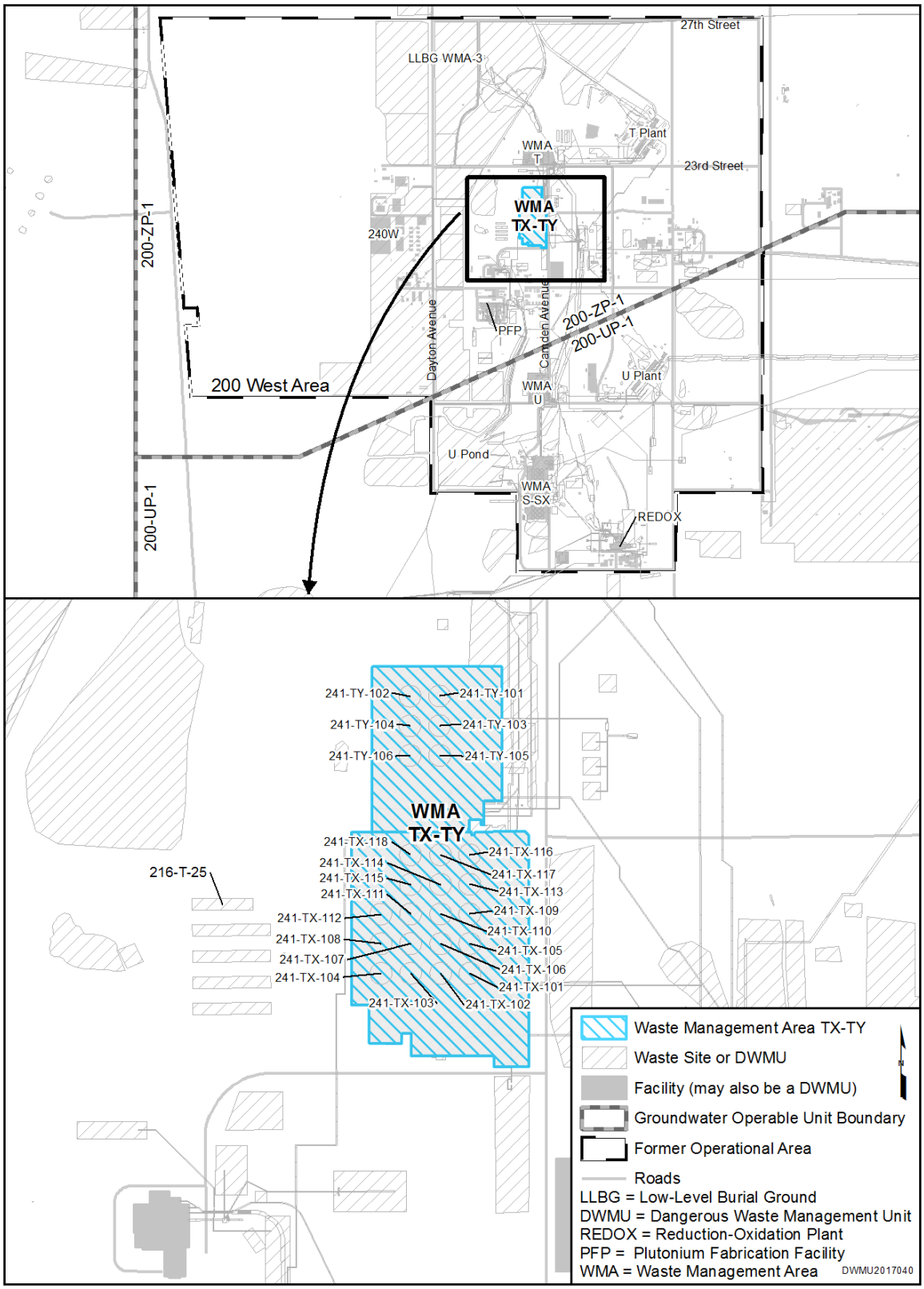
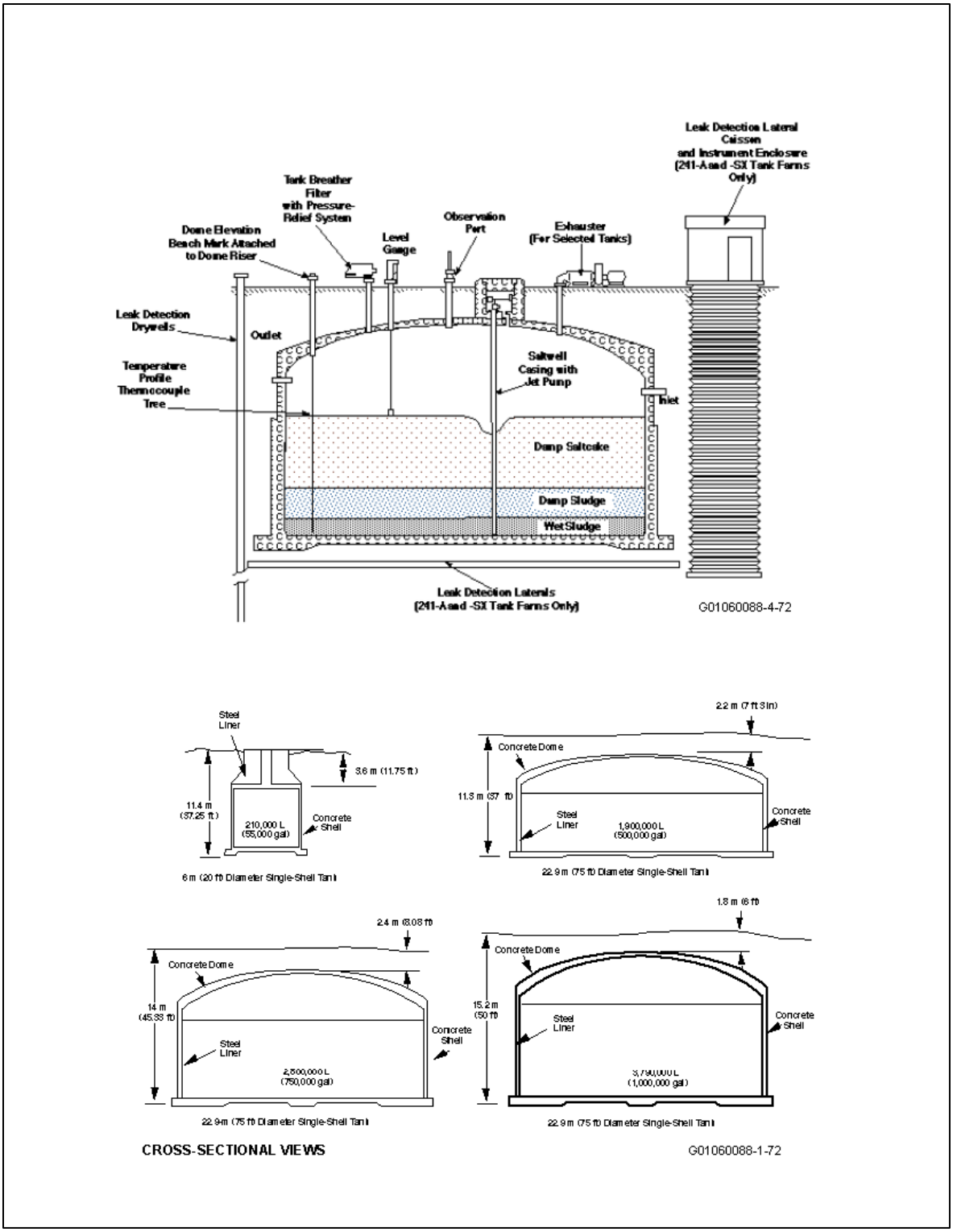


Figure 2-1. Location of WMA TX-TY Within the 200 West Area



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

Initial corrective actions have been implemented at WMA TX-TY. Berms were constructed around the 241-TX and 241-TY Tank Farms in 2001 to stop run-on of natural precipitation and known water lines leading to the tank farms were cut and capped at that time. In 2010, a modified asphalt interim surface barrier was constructed over the 241-TY Tank Farm ground water contaminant plume 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*).

2.1.3 Single-Shell Tanks and Liquid Handling Structures within Waste Management Area TX-TY

Of the 24 tanks located within WMA TX-TY (Figure 2-1), 13 are assumed leakers: 241-TX-105, 241-TX-107, 241-TX-110, 241-TX-113, 241-TX-114, 241-TX-115, 241-TX-116, 241-TX-117, 241-TY-101, 241-TY-103, 241-TY-104, 241-TY-105, and 241-TY-106 (Section 4.0 in HNF-EP-0182). HNF-EP-0182 provides estimated leak volumes for each of the assumed leakers except for tanks 241-TX-105, 241-TX-110, 241-TX-113, 241-TX-114, 241-TX-115, 241-TX-116, and 241-TX-117. In regards to tanks 241-TX-110, 241-TX-113, 241-TX-114, 241-TX-115, 241-TX-116, and 241-TX-117, neither spectral gamma logging data nor waste transfer records provide evidence of leaks; however, the spectral gamma logging data suggests extensive near-surface leaks, possibly from waste transfer piping (Section 2.2.10 in RPP-7218, *Preliminary Inventory Estimates for Single-Shell Tank Leaks in T, TX, and TY Tank Farms*). Although classified as "sound" in HNF-EP-0182, a 2013 assessment of 241-TX-104 and 241-TX-118 (RPP-RPT-50870, Hanford 241-TX Farm Leak Inventory Assessment Report) has identified leak volumes associated with the SST (241-TX-104) or associated equipment (241-TX-118)

Contamination associated with the major leaks from each tank within WMA TX-TY and estimated waste composition during the time of the leaks is discussed below. The discussion refers to the radiation activity and radioactive constituents and components of released material; however, these constituents and components are not subject to dangerous waste regulations and are included here for the sole purpose of identifying releases from tanks.

Tank 241-TX-104 is classified as "sound" in HNF-EP-0182; however, the leak assessment results in RPP-RPT-50870 found that uranium measured in drywells near 241-TX-104 was not associated with known leaks from 241-TX-107, an assumed leaking tank (Section 4.9.2). The report concluded that the uranium contamination may be the result of a spare inlet overflow or cascade line release, and/or a tank liner leak, and that the 241-TX-104 tank leak classification of "sound" should be reassessed (Section 4.9.3 in RPP-RPT-50870). The report estimated a total leak volume between 31,400 and 94,600 L (8,300 and 25,000 gal) (Table ES-1 and Section 4.9.3 in RPP-RPT-50870).

Tank 241-TX-105 was categorized as an assumed leaker in 1977; however, it does not have an estimated leak volume in HNF-EP-0182. It was categorized as an assumed leaker due to three reported decreases in the liquid level of the tank. Although two of these leaks were attributed to false equipment readings, the third decrease could not be determined (Section 10.2.5 in GJO-97-13-TAR, *Hanford Tank Farms Vadose Zone TX Tank Farm Report*).

The presence of uranium-235 and uranium-238 indicates that the origin of the contamination around tank 241-TX-105 is likely to be metal waste from the bismuth phosphate process that originated from waste piping, as this tank was used to store metal waste, REDOX waste, and evaporator bottoms (Section 2.2.8 in RPP-7218). Section 4.1.2 in RPP-RPT-50870 identified that process data showed the tank was overfilled in 1952 and between 1961 and 1964, and that waste may have been released from the spare inlets. Uranium contamination reported in drywells suggested that waste may have been released in the early 1950's. The report concluded that the tank leak classification of "sound" should be reassessed, and

estimated a total leak volume between 189,000 and 473,000 L (50,000 and 125,000 gal) (Table ES-1 and Section 4.1.3 in RPP-RPT-50870).

Tank 241-TX-107 was categorized as an assumed leaker in 1984 and has a total leak volume of 11,365 L (2,500 gal) (Section 4.0 in HNF-EP-0182). As tank 241-TX-107 was used as the 242-T Evaporator tank, waste transfer records are uncertain; however, gamma plumes around the tank indicate a substantial leak volume (Section 2.2.9 in RPP-7218). Section 2.2.9 in RPP-7218 indicates a leak volume of 36,369 L (8,000 gal) but acknowledges that the leak volume is uncertain. The nonradiological waste profile for the tank during the timeframe of the leak is provided in Table 2-1.

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

Analyte	241-TX-107 during 1984 Leak (kg)	241-TY-103 during 1973 Leak (kg)	241-TY-105 during 1960 Leak (kg)	241-TY-106 during 1959 Leak (kg)
Aluminum	8.72 E+02	3.24 E+02	0.00 E+00	0.00 E+00
Bismuth	1.04 E+0l	4.83 E+00	0.00 E+00	0.00 E+00
Butanol	2.62 E+01	8.55 E+00	3.07E-01	1.73 E-01
Calcium	3.41 E+01	1.29 E+01	4.85 E+01	2.73 E+01
Carbonate	6.57 E+02	1.97 E+02	1.56 E+03	8.78 E+02
Chlorine	1.98 E+02	6.60 E+01	4.62 E+02	2.61 E+02
Chromium	1.31 E+02	4.57 E+01	2.28 E+01	1.28 E+01
Dibutyl phthalate	7.43 E+01	2.42 E+01	8.72 E-01	4.91 E-01
Fluoride	4.66 E+01	2.18 E+01	0.00 E+00	0.00 E+00
Iron	1.39 E+0l	4.40 E+00	1.50 E+01	8.49 E+01
Lanthanum	3.44 E-06	1.10 E-06	0.00 E+00	0.00 E+00
Lead	5.50 E+00	2.39 E+00	0.00 E+00	0.00 E+00
Manganese	3.51 E+00	1.04 E+00	0.00 E+00	0.00 E+00
Mercury	5.73 E-02	2.60 E-02	0.00 E+00	0.00 E+00
Nickel	9.37 E+00	3.64 E+00	1.28 E+01	7.22 E+00
Nitrate	7.56 E+03	2.67 E+03	2.16 E+04	1.21 E+04
Nitrite	2.13 E+03	7.86 E+02	1.30 E+03	7.31 E+02
Normal paraffin hydrocarbon	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Phosphate	2.60 E+02	1.14 E+02	1.69 E+03	9.50 E+02
Potassium	5.68 E+01	2.06 E+01	8.40 E+01	4.74 E+01
Silicon	4.90 E+01	1.68 E+01	0.00 E+00	0.00 E+00
Sodium	7.05 E+03	2.41 E+03	1.22 E+04	6.81 E+03
Strontium	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Sulfate	5.90 E+02	2.08 E+02	1.86 E+03	1.05 E+03
Tributyl phosphate	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Uranium	5.54 E+01	2.24 E+01	4.98 E+01	2.79 E+01

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

Analyte	241-TX-107 during 1984 Leak (kg)	241-TY-103 during 1973 Leak (kg)	241-TY-105 during 1960 Leak (kg)	241-TY-106 during 1959 Leak (kg)
Zirconium	9.79 E-01	4.76 E-01	0.00 E+00	0.00 E+00

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

Tank 241-TX-110 was categorized as an assumed leaker in 1977 and does not have a listed 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-TX-110 and no inventory estimates exist; however, the spectral gamma logging data suggest extensive near-surface leaks, possibly from waste transfer piping (Section 2.2.10 in RPP-7218).

Tank 241-TX-113 was categorized as an assumed leaker in 1974 and does not have an estimated leak volume (HNF-EP-0182, Section 4.0). Neither spectral gamma logging data nor waste transfer records show evidence of a leak from 241-TX-113 and no inventory estimates exist; however, the spectral gamma logging data suggest extensive near-surface leaks, possibly from waste transfer piping (Section 2.2.10 in RPP-7218).

Tank 241-TX-114 was categorized as an assumed leaker in 1974 and does not have an estimated leak volume (Section 4.0 in HNF-EP-0182). Spectral gamma logging data suggest extensive near-surface leaks, possibly from waste transfer piping (Section 2.2.10 in RPP-7218). Section 4.5.1 of RPP-RPT-50870 identified that historical transfer records show the tank was filled above the cascade outlet as a result of plugging of the cascade lines. In-tank photographs show the waste level was well above the cascade line, indicating the potential for releases from the cascade lines or spare inlets. Elevated cesium-137 was found between the surface and 6.1 m (20 ft) below surface in two drywells, and was attributed to cascade line leaks, near-surface transfer line leaks and spills during operations. The report assumed that the contamination migrated from the tank bottom, along the top of the sediments below 241-TX-114, to the drywells. The assessment concluded that based on the drywell data, the contamination source was likely a 241-TX-114 liner leak, and estimated a total leak volume of 26,500 L (7,000 gal) (Table ES-1 and Section 4.5.3 in RPP-RPT-50870).

Tank 241-TX-115 was categorized as an assumed leaker in 1977 and 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-TX-115 and no inventory estimates exist; however, the spectral gamma logging data suggest extensive near-surface leaks, possibly from waste transfer piping (Section 2.2.10 in RPP-7218).

Tank 241-TX-116 was categorized as an assumed leaker in 1977 and 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-TX-116 and no inventory estimates exist; however, the spectral gamma logging data suggest extensive near-surface leaks, possibly from waste transfer piping (Section 2.2.10 in RPP-7218).

Tank 241-TX-117 was categorized as an assumed leaker in 1977 and 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-TX-117 and no inventory estimates exist; however, the spectral gamma

logging data suggest extensive near-surface leaks, possibly from waste transfer piping (Section 2.2.10 in RPP-7218).

Tank 241-TX-118 is classified as “sound” in HNF-EP-0182; however, the leak assessment results in RPP-RPT-50870 (Section 4.10.2) found that cesium-137 and cobalt-60 measured in a drywell near the tank suggested there has been a subsurface transfer line leak or a surface spill, from which contamination infiltrated to the tank dome and flowed down the sides of the tank. The report concluded that the tank appears “sound” (no liner leak), as classified in HNF-EP-0182; however, drywell data shows that waste was released on the east side of the tank near the cascade and transfer lines (Section 4.10.3 in RPP-RPT-50870). Designating the waste release as an unplanned release (UPR) was recommended (Section 4.10.3 in RPP-RPT-50870). The report estimated a total release volume of 6,660 L (1,760 gal) (Section 4.10.3 in RPP-RPT-50870).

Tank 241-TY-101 was categorized as an assumed leaker in 1973 and has an estimated leak volume of <4,546 L (<1,000 gal) (Section 4.0 in HNF-EP-0182). While waste transfer records indicate that approximately 159,113 L (35,000 gal) of tributyl phosphate (TBP) waste was lost in 1965 and 1966, no responses to a tank leak were documented; therefore, it is assumed that the loss is a recordkeeping mistake (Section 2.2.11 in RPP-7218). Due to limited drywell coverage around tank 241-TY-101, spectral gamma logging data do not indicate a leak from the tank has occurred; however, it does not provide sufficient insight into the extent of the vadose zone contamination around the tank (Section 2.2.11 in RPP-7218). No waste inventory estimates exist for tank 241-TY-101 (Section 2.2.11 in RPP-7218).

Tank 241-TY-103 was categorized as an assumed leaker in 1973 and has an estimated leak volume of 13,638 L (3,000 gal) (Section 4.0 in HNF-EP-0182). Spectral gamma logging data from drywells indicate both cesium-137 and cobalt-60 contamination near the tank that suggests the contamination originated from a TBP waste that was stored in the tank from 1957 to 1964 (Section 2.2.12 in RPP-7218). From 1968 through 1973, tank 241-TY-103 stored PUREX and B Plant wastes (Section 2.2.12 in RPP-7218). The nonradiological waste profile for the tank during the timeframe of the leak is provided in Table 2-1.

Tank 241-TY-104 was categorized as an assumed leaker in 1981 and has an estimated leak volume of 6,365 L (1,400 gal) (Section 4.0 in HNF-EP-0182). Neither spectral gamma logging data nor waste transfer records show evidence of a leak from 241-TY-104 and no inventory estimates exist, although the spectral gamma logging data indicate near-surface leaks that suggest waste transfer piping as a possible source of the contamination (Section 2.2.13 in RPP-7218). The supernatant inventory is 3,800 L (1,000 gal) (Section 4.0 in HNF-EP-0182).

Tank 241-TY-105 was categorized as an assumed leaker in 1960 and has an estimated leak volume of 159,113 L (35,000 gal) (Section 4.0 in HNF-EP-0182). Waste records for 241-TY-105 indicate that the 159,131 (35,000 gal) leak comprised TBP waste, the only waste type added to this tank, which is supported by the presence of cesium-137 and cobalt-60 in spectral gamma logging records (Section 2.2.14 in RPP-7218). The nonradiological waste profile for the tank during the timeframe of the leak is provided in Table 2-1.

Tank 241-TY-106 was categorized as an assumed leaker in 1959 and has an estimated leak volume of 90,922 L (20,000 gal) (Section 4.0 in HNF-EP-0182). Tank 241-TY-106 received TBP wastes from tank 241-TY-105 through a cascade line (Section 2.2.15 in RPP-7218). While records indicate the 90,922 L (20,000 gal) loss occurred in 1959, gamma profiles surrounding the tank do not support tank 241-TY-106 being classified as an assumed leaker (Section 2.2.15 in RPP-7218). The nonradiological waste profile for the tank during the timeframe of the leak can be found in Table 2-1.

Other liquid-handling structures within WMA TX-TY, 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 identified as waste sites in the Waste Information Data System (WIDS) and included in the Hanford Facility RCRA Permit Part A Form for WMA TX-TY, is provided below.

- There are five diversion box waste sites associated with WMA TX-TY. 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. At the 241-TX-154 diversion box, leaks occurred in 1953, 1955, and 1956 (discussed in Section 2.1.4). At the 241-TX-155 diversion box, multiple leaks occurred in 1953, 1954, and 1977, resulting in contamination around the structure (discussed in Section 2.1.4).
- There are 43 valve pits listed in the Hanford Facility RCRA Permit Part A Form that are associated with WMA TX-TY. 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, which was designed to shut down operations if a leak in the pit were detected.
- There are seven catch tanks associated with WMA TX-TY. 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. Catch tanks 241-TX-302B and 241-TX-302BR have unplanned releases (UPRs) associated with their operation that occurred in 1953 (discussed in Section 2.1.4). Catch tank 241-TX-302C was associated with UPRs that occurred in 1953, 1955, and 1956 (discussed in Section 2.1.4).
- Pipeline structures associated with WMA TX-TY 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. There are UPRs that occurred in 1954 and 1955 associated with piping at WMA TX-TY documented in WIDS (discussed in Section 2.1.4).

These liquid handling structures within WMA TX-TY carried or contained waste effluent (e.g., mixed waste solutions and decontamination solutions) associated with the tanks. Therefore, impacts to groundwater from these structures will be assessed using the constituents identified from the tank waste.

2.1.4 Unplanned Releases

The following information about UPRs associated with WMA TX-TY is from Table 2.6 in DOE/RL-91-61, *T Plant Source Aggregate Area Management Study Report*, and WIDS. The locations of UPRs associated with WMA TX-TY are shown in Figure 2-3. In addition to the previously discussed documented leaks from SSTs, 12 UPR waste sites are associated with WMA TX-TY, 2 of which are located within the WMA TX-TY boundary:

- UPR-200-W-5 occurred in 1950 at the 241-TX-155 diversion box east of Camden Avenue and the 241-TX Tank Farm. The diversion box overflowed and the spilled materials ran down the hillside to the west, resulting in soil contamination. No information related to the radioactive substances that spilled to the ground is available, although soil samples taken in 1970 found less than detectable contamination levels and the area was released from radiological controls.

- UPR-200-W-17 occurred in 1952 to the south of the 241-TX Tank Farm when a temporary pump transferred waste from tank 241-TX-106 to tank 241-TX-114. This caused a release that covered an area of 91 by 183 m (300 by 600 ft). Highly contaminated areas were stabilized with emulsified asphalt.

- UPR-200-W-21 occurred in 1953 at the 241-TX-154 diversion box east of 221-T when a cave-in occurred above a process line near the diversion box. This caused an area of contamination on both sides of the diversion box, between 221-T and 222-T. The affected area was covered with blacktop in 1953.

- UPR-200-W-29 occurred in November 1954 at a cave-in 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 the 241-T-105 SST was released with dose rates of 11.5 rem/hr at 5 cm (2 in.). The area was sprayed 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-38 occurred in 1955 on the southeast side of T Plant (221-T), between the 241-TX-154 diversion box and the 241-TX-302 catch tank. An underground transfer line between the 241-TX-154 diversion box and the 241-TX-302 catch tank failed and flooded an area approximately 139 m^2 (1,500 ft^2) with radioactive metal waste solution that was assumed to be several thousand gallons in volume. Contamination was spread during cleanup activities and increased the size of the contaminated area to approximately 372 m^2 (4,000 ft^2). Prior to this incident, the area had been covered with asphalt because of a previous event. The spilled liquid was forced up through several feet of soil and pooled on top of this asphalt. An unreported thickness of soil was backfilled onto the area to prevent further contamination spread.

- UPR-200-W-63 occurred in September 1966 along 23rd Street at the 241-TX-153 diversion box. 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.

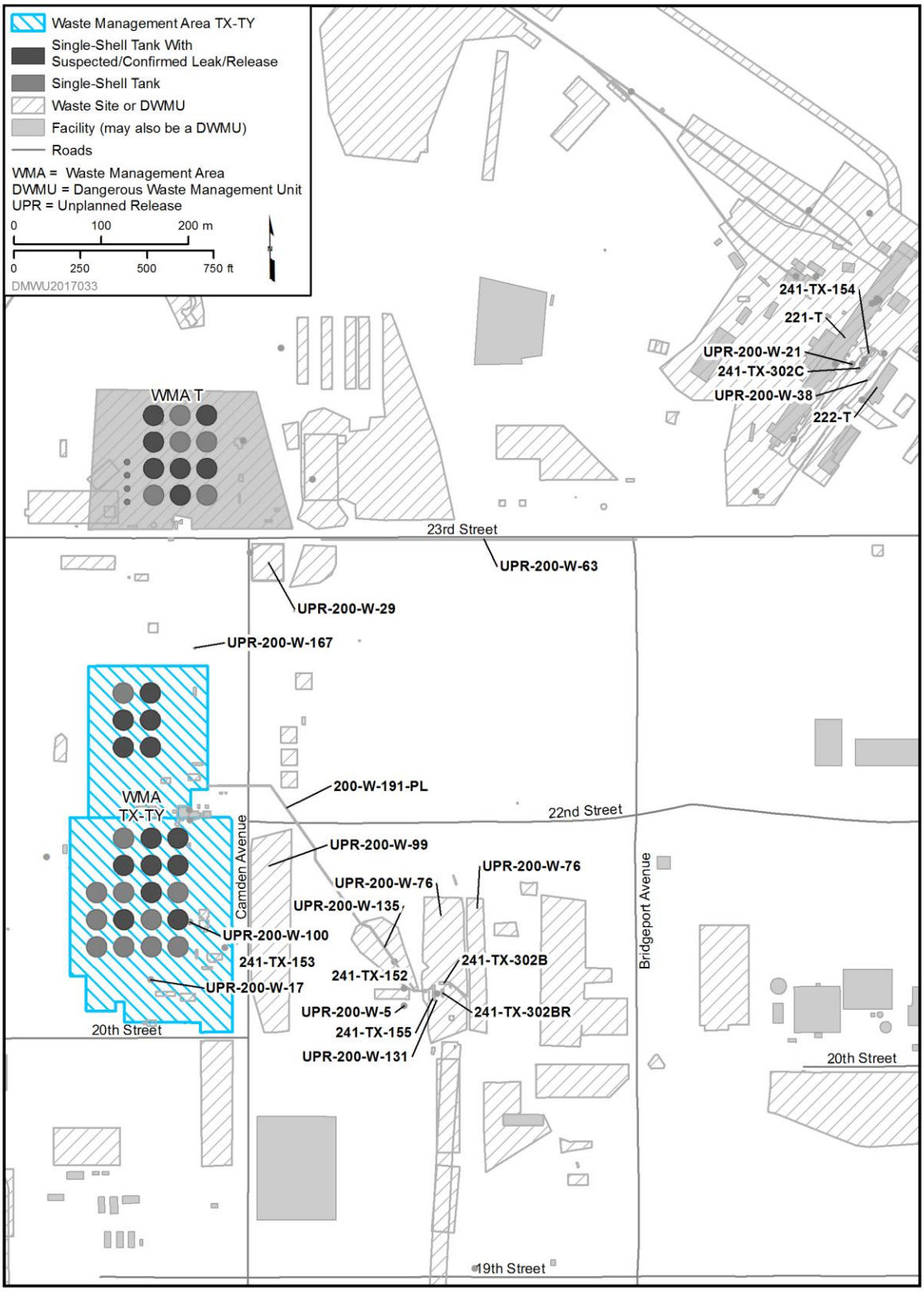


Figure 2-3. WMA TX-TY and UPRs

- UPR-200-W-76 occurred in 1977 near the 241-TX-302B catch tank and the 241-TX-155 and 241-TX-152 diversion boxes to the east of Camden Avenue. Contaminated rabbit feces that were discovered over an area extending in a 152 m (500 ft) radius from the 241-TX-155 diversion box were subsequently analyzed and found to be contaminated with cesium-137. The contamination was subsequently traced to leaks from the 241-TX-155 diversion box. Contaminated feces were removed and the area was covered in a layer of clean gravel.

- UPR-200-W-99 occurred in 1966 when two plumes of airborne contamination from the 241-TX-153 diversion box traveled to the northeast and southeast from the diversion box. The release contaminated the ground and road on both sides of Camden Avenue, covering an area 228 m (750 ft) to the north and south and 91 m (300 ft) to the east of Camden Avenue. The road contamination was covered with a new tar mat and the sides of the road were fixed with tar. In 1976, a road grader was used on the soil east of Camden Avenue to push the contamination into windrows. The area east of Camden Avenue was surface stabilized in 1990 with clean backfill and grass, while the area on the west side of Camden Avenue, adjacent to the tank farm fence, was covered with gravel.

- UPR-200-W-100 occurred in 1954 inside of the 241-TX Tank Farm fence to the east of tank 241-TX-105. A waste transfer line between tanks 241-TX-105 and 241-TX-108 was found to be leaking first-cycle, high-salt, neutral to basic waste containing approximately 10 Ci of fission products. The leak covered an area of approximately 30 by 38 m (100 by 125 ft). As the 241-TX Tank Farm is surrounded with a chain link fence and has been stabilized with gravel, the release was not separately marked or remediated.

- UPR-200-W-131 occurred in 1953 near the 241-TX-155 diversion box, located east of Camden Avenue and east of the 241-TX Tank Farm when a leak in the TBP feed jumper caused the catch tank to become full with acidic wastes that were going to be pumped through an overground line to a diversion box in order to empty the tank. As a result of a pump failure, 90.7 kg (200 lb) of soda ash was added to the catch tank and, while flushing the soda ash with water, a fine stream of solution erupted out of the 2.5 cm (1 in.) electrode riser, causing ground contamination. After plugging the riser, another bag of soda ash was added to a 30 cm (12 in.) riser and a foamy solution percolated out this riser and a second riser, causing ground contamination. Information related to the catch tanks indicate that catch tank 241-302BR was damaged by acid and that catch tank 241-TX-302B was used following the damage. Contaminated areas were covered with clean gravel.

- UPR-200-W-135 occurred in 1954 on transfer line 200-W-191-PL, directly west of the 241-TX-155 diversion box. While preparing to begin the 241-TX-302B catch tank replacement, a cave-in with a diameter of 0.6 m (2 ft) was noted along the encased pipeline connecting the 241-TX-155 diversion box to the 241-TY Tank Farm. A jumper connection in the diversion box had failed and allowed liquid to collect inside the diversion box and drain to the catch tank, which had a known leak. The liquid leaked out of the catch tank and flowed along the pipeline encasement, resulting in a soil cave-in approximately 46 m (150 ft) downhill from the 241-TX-155 diversion box. A liquid run-off path was noted that measured approximately 12 m (40 ft) long. The area was stabilized with soil and grass.

- UPR-200-W-167 occurred in 1985 adjacent to the 241-TY Tank Farm, extending to the east and north of the fence line, covering an area of 8,400 m^2 (90,417 ft^2). The original soil contamination site identified in 1985 was excavated and removed in 1986; however, in 2000, contaminated ant hills and vegetation were discovered on top of a transfer line located outside the eastern tank farm fence. Three contamination areas were later identified covering areas approximately 12 by 12 m (40 by 40 ft), 2 by

2 m (8 by 8 ft), and 24 by 18 m (80 by 60 ft). The three contamination areas were covered with gravel.

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 the 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 TX-TY. Under interim status, groundwater monitoring at WMA TX-TY 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, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks*, Rev. 0) was initiated in 1989 at WMA TX-TY 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 TX-TY was placed into a groundwater quality assessment program in accordance with 40 CFR 265.93(d), "Preparation, Evaluation, and Response." The groundwater quality assessment was required because specific conductance results in downgradient wells 299-W10-17 and 299-W14-12 had exceeded the upgradient critical mean in November 1992 (Section 4.2 in WHC-SD-EN-AP-132).

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 TX-TY, the report concluded that elevated technetium-99, nitrate, calcium, and magnesium concentrations in well 299-W14-12 were consistent with a source within WMA TX-TY, and that there was no direct evidence of an upgradient source for the elevated technetium-99, nitrate, calcium, and magnesium (Section 4.2.2 in PNNL-11809). Subsequent drilling and sampling of well 299-W15-40 (located between the 216-T-25 Trench and the WMA) eliminated the 216-T-25 Trench as a possible source of contamination downgradient of the WMA (Section 2.2 in DOE/RL-2009-67, Rev. 1).

In 2001, a revised assessment plan (PNNL-12072, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site*) was issued that addressed monitoring for WMA TX-TY only (WMA T continued in assessment under a separate plan). Based on the findings from the phase I assessment report for WMAs 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 assessing 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 TX-TY under Tri-Party Agreement Change Request M-45-98-03. 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).

A second assessment report, issued in 2002, did not eliminate WMA TX-TY as a source for the downgradient chromium contamination (Section 7.0 in PNNL-14004, *RCRA Groundwater Quality Assessment Report for Single-Shell Tank Waste Management Area TX-TY (January 1998 through December 2001)*). The presence of the dangerous waste constituent chromium in groundwater required continued groundwater assessment monitoring at WMA TX-TY (Summary in PNNL-14004, and Table 4.11-3 in DOE/RL-94-136, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1994*).

Under Revision 9 of the Hanford Facility Dangerous Waste Permit, the SST System treatment, storage and disposal (TSD) unit, which includes WMA TX-TY, 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

Two basic chemical-processing operations were the source of most of the dangerous waste transferred to the 241-TX and 241-TY Tank Farms: the bismuth phosphate process and the TBP process. Lesser quantities of waste from the REDOX and PUREX processes were also sent to the tank farms. The bismuth phosphate, REDOX, and PUREX processes were chemical separations programs used to recover plutonium from irradiated reactor fuels. The TBP process recovered uranium metal in waste generated by the bismuth phosphate process. Waste from the processes was made alkaline for storage in the tanks (Section 2.3 in DOE/RL-2009-67, Rev. 1).

The dangerous wastes identified on the SST System Part A Application are presented in Table 2-2. The nonradiological waste profiles for tank 241-TX-107 during its 1984 leak, tank 241-TY-103 at the time of its 1973 leak, tank 241-TY-105 at the time of its 1960 leak, and tank 241-TY-106 at the time of its 1959 leak 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: 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.

* 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 TX-TY. Figure 2-4 provides the locations of wells discussed in this section. Appendix A contains the interim status data collected at WMA TX-TY 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* ECN 150201[b]	1989 1991	Indicator Evaluation Program
WHC-SD-EN-AP-012, Rev. 1, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks* ECN 150144 ECN 172204 ECN 618171	1991 1992 1993 1994	Indicator Evaluation Program
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-12072, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site* ICN-PNNL-12072.1	2001 2002	Groundwater Quality Assessment Program
PNNL-16005, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY*	2007	Groundwater Quality Assessment Program
DOE/RL-2009-67, Rev. 0, I*nterim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*	2011	Groundwater Quality Assessment Program
DOE/RL-2009-67, Rev. 1, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*	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 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 15021 is also incorporated as part of the Rev. 1 plan.

ECN = engineering change notice

ICN = interim change notice

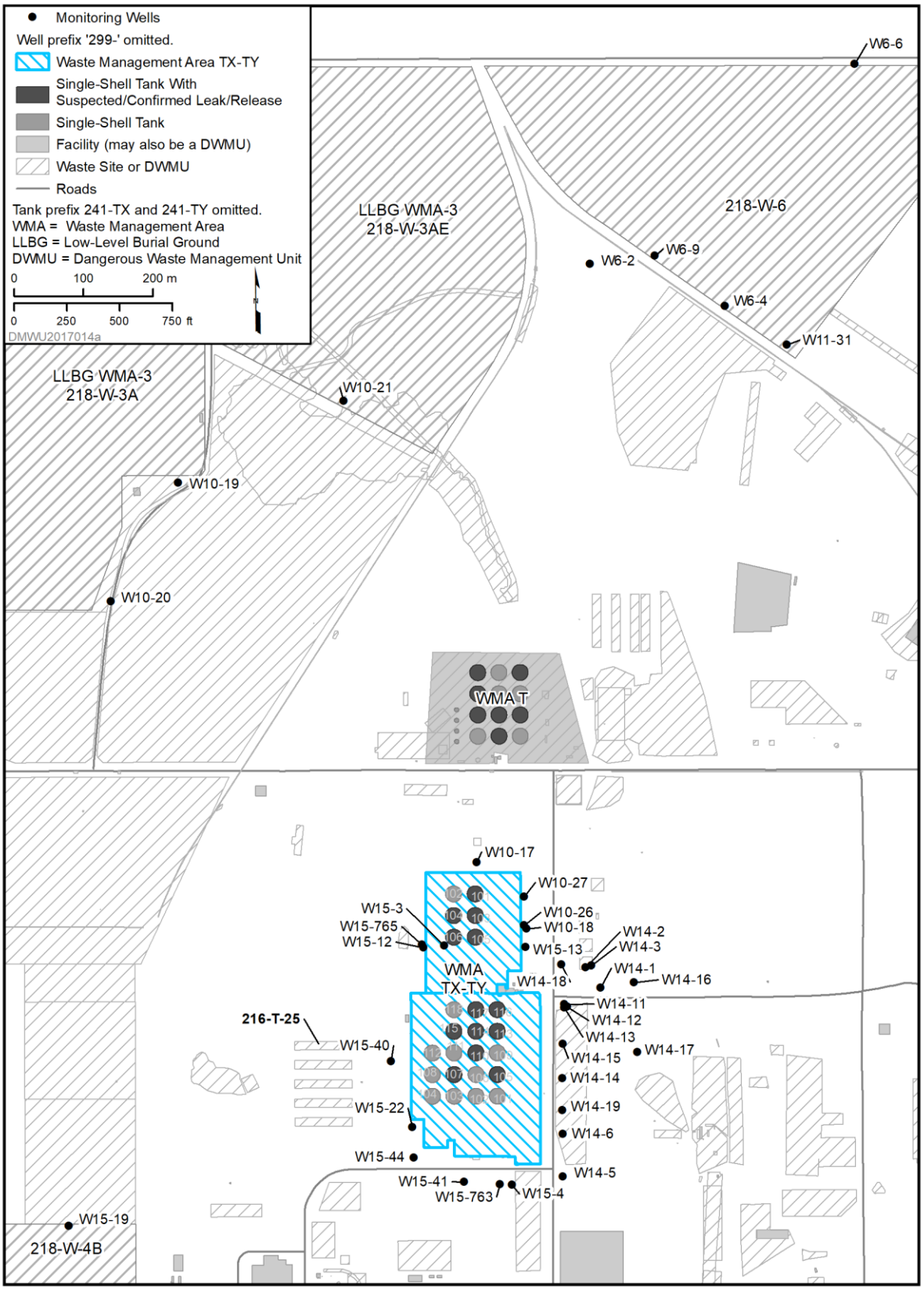


Figure 2-4. Wells Used During Interim Status Monitoring of WMA TX-TY

In 1989, the DOE, Richland Operations Office, initiated an interim status groundwater monitoring program at WMA TX-TY 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 TX-TY, the plan identified one planned upgradient well (299-W15-19) and four existing downgradient wells (299-W10-17, 299-W10-18, 299-W15-3, and 299-W15-13) (Table 3.8 in WHC-SD-EN-AP-012, Rev. 0). While existing wells were identified for the network, the wells were to be evaluated for their ultimate use (e.g., sample collection or water-level measurements only) (p. 110 in WHC-SD-EN-AP-012, Rev. 0). Wells 299-W14-1, 299-W14-2, 299-W14-3, 299-W14-5, 299-W14-6, and 299-W15-12 (crossgradient to WMA TX-TY) were included for water-level information only (Table 3.8 and Chapter 3.0, p. 125 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), "Sampling and Analysis." 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 (SVOCs), 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 TX-TY are shown in Figure 2-4.

In 1990, DOE/RL-91-03, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1990*, identified the monitoring network as upgradient well 299-W15-22 with downgradient wells 299-W10-17, 299-W10-18, 299-W15-3, and 299-W15-13 (new well) as well as the crossgradient wells 299-W14-1, 299-W14-2, 299-W14-3, and 299-W15-12 (Table 15-1 in DOE/RL-91-03). Although, upgradient well 299-W15-19 was included in the monitoring plan (WHC-SD-EN-AP-012, Rev. 0), it was not included in the WMA TX-TY network in subsequent annual groundwater monitoring reports (i.e., Table 15-1 in DOE/RL-91-03).

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*). Sampling at WMA TX-TY began in July 1991 (Section 16.1.2 in DOE/RL-92-03).

In 1991, WHC-SD-EN-AP-012 for the SST WMAs was revised (Rev. 1 and engineering change notice [ECN] 150201, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev. 000 Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*) to modify the well networks and constituent lists, and report information obtained from recently installed wells. The compliance sampling network comprised one upgradient well (299-W15-22) and two downgradient wells (299-W10-17 and 299-W10-18) (Table 3-8 in WHC-SD-EN-AP-012, *40 CFR 265 Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks*, Rev. 1). Downgradient wells 299-W15-3 and 299-W15-13 were included for water-level measurements and either radionuclide sampling or limited nonradionuclide constituents (Table 3-8 in WHC-SD-EN-AP-012, Rev. 1). Three crossgradient wells (299-W14-2, 299-W14-3, and 299-W14-5) were included for water-level measurements only. Crossgradient wells 299-W14-1 and 299-W14-6 were included for water-level measurements and radionuclide sampling (Table 3-8 in WHC-SD-EN-AP-012, Rev. 1). Crossgradient well 299-W15-12 was included for water-level measurements and limited nonradionuclide constituents (Table 3-8 in WHC-SD-EN-AP-012, Rev. 1). One new well (299-W14-12) was planned (Table 3-2 in WHC-SD-EN-AP-012, Rev. 1). Site-specific parameters (cesium-137, strontium-90, total uranium, total plutonium, gamma scan, and tritium) were added as monitoring constituents (Section 3.4.1.12 and Table 3-11 in WHC-SD-EN-AP-012, Rev. 1).

Table 16.1 in DOE/RL-92-03 identified the WMA TX-TY network as the one upgradient well 299-W15-22 and three downgradient wells 299-W10-17, 299-W10-18, and 299-W14-12 (new well). The previously sampled wells 299-W15-3, 299-W15-12, and 299-W15-13 were used for water-level measurements only.

Monitoring of the WMA TX-TY well network began in February 1990; however, 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), and quarterly sampling continued until July 1992 when background monitoring at WMA TX-TY was completed (Section 4.3 in WHC-SD-EN-AP-132).

Three ECNs to WHC-SD-EN-AP-012, Rev. 1, were issued in 1992 and 1993. In 1992, Section 12 in ECN-150144, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 001 Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*, updated the WMA TX-TY well network to include well 299-W14-12. The 1993 ECN-172204, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev. 1 Interim Status Groundwater Monitoring Plan for Single-Shell Tanks,* 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 TX-TY.

In November 1992, downgradient wells 299-W10-17 and 299-W14-12 exceeded the critical mean for specific conductance, although only three quarters of data existed at the time (Section 4.4.3 in WHC-SD-EN-AP-132,). A similar exceedance was measured at a downgradient WMA T well. In July 1993, WMA TX-TY entered a groundwater quality assessment program 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 combined 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, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*).

The groundwater quality assessment plan included sampling for the contamination indicator parameters, groundwater quality parameters, and 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) with 299-W15-22 as the upgradient well and 299-W10-17, 299-W10-18, and 299-W14-12 as the downgradient wells. However, the network was to expand beyond WMAs T and TX-TY to 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 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 TX-TY were evaluated for incorporation into an expanded monitoring network (Section 4.11.1.2 in DOE/RL-94-136). The monitoring well network was unchanged in 1994; however, well 299-W15-3 was no longer used for water-level measurements (Table 4.11-1 in DOE/RL-94-136). Beginning in 1996, results from the expanded well network that included downgradient wells 299-W6-2, 299-W6-4, 299-W6-6, 299-W6-9, 299-W10-19, 299-W10-20, 299-W10-21, and 299-W11-31 were reported for WMA TX-TY, while wells 299-W15-12 and

299-W15-13 were used for water-level measurements only (Table 6.1-13 in PNNL-11470, *Groundwater Monitoring for Fiscal Year 1996*).

In 1997, Section 5.9.2.1 in PNNL-11793, *Hanford Site Groundwater Monitoring for Fiscal year 1997,* found that assessment results indicated that the elevated specific conductance, tritium, iodine-129, technetium-99, and cobalt-60 results in well 299-W10-17 were a result of contamination outside of WMA TX-TY; however, contaminants at well 299-W14-12 indicated a source within WMA TX-TY (Section 5.9.2.1 in PNNL-11793). Due to a lack of upgradient sources, 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). Four new wells were planned for WMA TX-TY.

In 1998, a phase I assessment report for WMA T and TX-TY was issued (PNNL-11809). For WMA TX-TY, the report attributed elevated technetium-99, nitrate, calcium, and magnesium coupled with low sodium in well 299-W14-12 to a source within WMA TX-TY while also stating that there was no direct evidence of an upgradient source (Section 4.2.2 in PNNL-11809). The elevated sodium and nitrate that were the cause of the elevated specific conductance in well 299-W10-17, along with the elevated tritium, were attributed to sources outside of WMA TX-TY (Section 4.2.1 in PNNL-11809). However, WMA TX-TY was identified as the most likely source for contamination in well 299-W14-12, which included nitrate, tritium, technetium-99, and chromium above the drinking water standard (DWS) (Section 5.0 in PNNL-11809).

Because the phase I assessment did not attribute the contaminants in well 299-W14-12 to another source, the assessment was to move into another phase (phase II), in which the role of upgradient sources was to be evaluated (Section 5.1.3 in PNNL-11809). However, a phase II report was not issued for WMA TX-TY.

Historically, the groundwater flow direction underneath WMA TX-TY was primarily to the north when the groundwater mound beneath U Pond developed; however, when U Pond was decommissioned in 1985, the groundwater flow began shifting eastward (Section 3.6.3.2 in PNNL-12086, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*). In 1998, the groundwater flow direction was to the east in the northern half of WMA TX-TY and to the south or southwest in the southern half (Section 3.6.3.2 in PNNL-12086,). The southern half was most affected by the interim action 200-ZP-1 OU pump and treat (P&T) operations located south of WMA TX-TY as groundwater flowed toward the P&T extraction wells (Section 3.6.3.2 in PNNL-12086). The P&T was implemented in a three-phased approach beginning in August 1994, as an interim action under the *Superfund Record of Decision: Hanford 200-Area (USDOE) OU 200-ZP-1* (EPA/ROD/R10-95/114) to address carbon tetrachloride contamination (Section 5.9.4.2 in PNNL-12086).

Well 299-W6-6 was removed from the network in 1998 (Table A-19b in PNNL-12086,). In fiscal year (FY) 1998, wells 299-W10-23 and 299-W10-24 were drilled and added to the monitoring well network (Section 5.9.2.1 in PNNL-12086). Well 299-W10-26 replaced 299-W10-18 on the northeastern side of WMA TX-TY; well 299-W14-13 replaced 299-W14-12 on the eastern side of WMA TX-TY; well 299-W14-14 was drilled on the east side of WMA TX-TY to provide monitoring coverage from changes in flow direction; and well 299-W15-40 was drilled as a replacement for upgradient well 299-W15-22 and to monitor the 241-T-25 Trench (considered a potential source for contaminants in 299-W14-12) (Section 5.9.2.1 in PNNL-12086 and Section 2.8.2.12 in PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*). One additional well was planned south of WMA TX-TY (Section 5.9.2.1 in PNNL-12086) (this well was later identified as 299-W15-41). Section 5.9.2.1 in

PNNL-12086 observed that the monitoring wells in WMA TX-TY were going dry rapidly due to declining water levels as a result of the cessation of effluent discharges to groundwater in 1995.

In 1999, the well network was considered inadequate for assessment monitoring (Section A.7.3 in PNNL-13116). The average distance between monitoring wells along the southeastern margin of WMA TX-TY was approximately 70 m (230 ft), and a plume could pass through undetected. Well 299-W14-12 was expected to go dry, and no wells were located at intermediate or farther distances to track plume movement. Upgradient well 299-W15-22 was identified as dry, leaving no upgradient wells in the network (Table A.12 in PNNL-13116). Downgradient wells 299-W6-2, 299-W6-4, 299-W6-9, 299-W10-19, 299-W10-20, 299-W10-21, and 299-W11-31 were removed from the network, and 299-W10-26 (new well), 299-W14-2, 299-W14-5, 299-W14-6, 299-W14-13 (new well), 299-W14-14 (new well), 299-W15-4, and 299-W15-40 (new well) were included in the network (Table A.12 in PNNL-13116).

In FY 2000, new downgradient well 299-W15-41 was included in the monitoring well network (Table A.11 in PNNL-13404, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*). Wells 299-W10-18, 299-W14-12, and 299-W15-22 were not reported as part of the network (Table A.11 in PNNL-13404). In late FY 2000 and early FY 2001, five new downgradient wells were drilled. Three wells, including a replacement for well 299-W15-4, were installed along the southern margin of WMA TX-TY, and two intermediate field wells were installed farther downgradient (Section 2.8.2.12 in PNNL-13404). The network in 2000 had no upgradient well and consisted of downgradient wells 299-W10-17, 299-W10-26, 299-W14-2, 299-W14-5, 299-W14-6, 299-W14-13, 299-W14-14, 299-W14-15, 299-W15-40, and 299-W15-41 (Table A.11 in PNNL-13404). Wells 299-W15-4 and 299-W15-12 were listed as downgradient but identified as dry (last sampled in October 1999 and May 2000, respectively) (Table A.11 in PNNL-13404,).

In 2001, a revised assessment plan (PNNL-12072) was issued that addressed monitoring for WMA TX-TY only (WMA T continued in assessment under a separate plan). The WMA T and WMA TX-TY plans were divided as a result of the Tri-Party Agreement Change Request M-45-98-03 where it was determined that ongoing groundwater quality assessment at the WMAs would be conducted under separate but coordinated plans (Section 1.1 in PNNL-12072). The well network included the one upgradient well (299-W15-40) and eight downgradient wells (299-W10-17, 299-W10-26, 299-W14-2, 299-W14-5, 299-W14-6, 299-W14-13, 299-W14-14, and 299-W15-41) (Table 3.1a in PNNL-12072). The constituents included temperature, specific conductance, pH, inductively coupled plasma (ICP) metals, anions, alkalinity, TDS, total organic carbon (TOC), gross alpha, gross beta, technetium-99, tritium, iodine-129, strontium-90, gamma scan, ruthenium-101, selenium-79, americium-241, and neptunium-237 (Table 3.2 in PNNL-12072). Five new downgradient wells were planned for installation in 2000 and nine new wells were planned for 2001, including eight downgradient (including several deep wells) and one upgradient well to replace 299-W15-12 (Tables 3.1a and 3.1b in PNNL-12072). No groundwater flow direction for WMA TX-TY was provided due to uncertainty in downhole flow measurements and trend-surface analysis had been completed for only three network wells (Section 3.4 in PNNL-12072).

In 2001, the five new downgradient wells 299-W10-27, 299-W14-15, 299-W14-16, 299-W14-17, 299-W14-18, and 299-W15-763 and the one new upgradient well 299-W15-765 were included in the network (Table A.39 in PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*). Downgradient well 299-W14-2 was reported as dry (last sampled in February 2001) (Table A.39 in PNNL-13788). The groundwater flow direction was presented and described as generally toward the east in the northern part (241-TY Tank Farm), toward the southeast in the central part (north portion of the 241-TX Tank Farm), and toward the south or slightly west of south in the southern part (south portion of

the 241-TX Tank Farm) (Section 2.8.2.12 in PNNL-13788). Flow direction at that time was influenced by the 200-ZP-1 interim action P&T system, which was located south of the 241-TX Tank Farm (Section 2.8.2.12 in PNNL-13788).

In 2002, the network wells and monitoring constituents in the groundwater quality assessment plan were updated (ICN-PNNL-12072.1, *Interim Change Notice to RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site*). The well network contained the 2 upgradient wells 299-W15-40 and 299-W15-765 and the 13 downgradient wells 299-W10-17, 299-W10-26, 299-W10-27, 299-W14-5, 299-W14-6, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-16, 299-W14-17, 299-W14-18, 299-W15-41, and 299-W15-763 (p. 2 and Table R1.3.1a in ICN-PNNL-12072.1). Dry well 299-W14-2 was removed from the network (p. 2 and Table R1.3.1a in ICN-PNNL-12072.1). TDS was removed as a monitoring constituent as it was found to be a poor indicator parameter, and TOC was removed due to the potential for the carbon tetrachloride plume from the Plutonium Finishing Plant (PFP) underlying WMA TX-TY to mask any organic releases from WMA TX-TY (p. 2 in ICN-PNNL-12072.1). In 2003, existing well 299-W14-19 and new well 299-W15-44 were included as downgradient wells (Table B.38 in PNNL-14548, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*). In 2004, wells 299-W10-17 and 299-W14-5 (dry) were not reported as part of the network (Table B.36 in PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*).

In 2005, new downgradient well 299-W14-11 was drilled to 36 m (118 ft) below the water table to delineate the vertical extent of contamination and was screened from 11.6 to 14.3 m (38.1 to 46.9 ft) below the water table (Section 2.8.3.4 in PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*). Also in 2005, three of the WMA TX-TY network wells (upgradient wells 299-W15-765 and 299-W15-40 and downgradient well 299-W15-44) were converted to extraction wells for the 200-ZP-1 P&T system (Section 2.8.3.4 in PNNL-15670). The inclusion of these wells in the P&T system was expected to reverse the flow from an east direction to a west direction in the northern part of WMA TX-TY and to reinforce flow toward the south and southwest beneath the southern part of WMA TX-TY (Section 2.8.3.4 in PNNL-15670).

In 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 WMA 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 (Chapter 7 in RPP-23752).

In 2006, the designation of network well 299-W15-44 (located southwest of WMA TX-TY) changed from downgradient to upgradient while the well continued as an extraction well for the 200-ZP-1 P&T system (Table B.36 in PNNL-16346, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*).

In 2007, a revised assessment monitoring plan was issued, which updated the well network and monitoring constituents (PNNL-16005, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY*). The well network included the 2 upgradient wells 299-W15-40 and 299-W15-765 and the 12 downgradient wells 299-W10-26, 299-W10-27, 299-W14-6, 299-W14-11, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-18, 299-W14-19, 299-W15-41, 299-W15-44, and 299-W15-763 (Table A.1 in PNNL-16005). Two additional wells (299-W14-16 and 299-W14-17) were included as mid-field (used to determine lateral extent of contamination beyond the downgradient wells) (Table A.1 in PNNL-16005). The monitoring constituents included constituents of concern (chromium [filtered] and nitrate), constituents of interest (technetium-99, tritium, iodine-129, gamma scan, gross beta, and gross alpha), and supporting groundwater quality constituents (metals [aluminum bismuth, chromium, manganese, sodium, magnesium, potassium, and calcium], anions [nitrite, nitrate, chloride, sulfate, and fluoride], alkalinity, pH, specific conductance, turbidity, temperature, and oxidation-reduction potential) and strontium-90 (Tables 3.3 and A.1 in PNNL-16005). The sampling frequency for several radionuclides was reduced to semiannually or annually (Table A.1 in PNNL-16005).

The designation for well 299-W15-44, an extraction well for the 200-ZP-1 P&T system, continued to fluctuate. The designation was revised to downgradient in the 2007 monitoring plan; however, it was designated as an upgradient well in the 2007 (Table B.36 in DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*) and 2008 annual reports (Table B-36 in DOE/RL-2008-66, 2009, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*). The designation changed again in 2009 to downgradient (Table C-35 in DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009*). In August 2010, 299-W15-44 was taken out of service as an extraction well and converted to a downgradient monitoring well (Table 3.3 in DOE/RL-2009-67, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*, Rev. 0).

In 2011, a revised assessment monitoring plan was issued that updated the well network and monitoring constituents (DOE/RL-2009-67, Rev. 0). The plan identified the dangerous constituents found in groundwater at WMA TX-TY as chromium, carbon tetrachloride, and trichloroethylene (TCE) (DOE/RL-2009-67, Rev. 0, Section 2.5.1). The origin of carbon tetrachloride and TCE was attributed to PFP; however, chromium was attributed to WMA TX-TY (DOE/RL-2009-67, Rev. 0, Section 2.5.1). Nitrate above the DWS was also present but was attributed primarily to nearby past-practice liquid disposal facilities, although contribution from WMA TX-TY was possible (Section 2.5.1.2 in DOE/RL-2009-67, Rev. 0). The well network included the 2 upgradient wells 299-W15-40 and 299-W15-765 and the 11 downgradient wells 299-W10-26, 299-W10-27, 299-W14-11, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-18, 299-W14-19, 299-W15-41, 299-W15-44, and 299-W15-763 (Table 3-2 in DOE/RL-2009-67, Rev. 0). Two additional wells (299-W14-16 and 299-W14-17) were included as far-field wells (used to determine lateral extent of contamination beyond the downgradient wells) (Table 3-2 in DOE/RL-2009-67, Rev. 0). Downgradient well 299-W14-6 was removed from the network as it went dry in 2010 and well 299-W15-41 was expected to be dry in 2011 or 2012 (Section 3.2 in DOE/RL-2009-67, 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-2009-67, 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-2009-67, Rev. 0). Any detected constituents that were not attributable to another source or were measured above upgradient or background concentrations were to be included for routine sampling.

The sampling frequency in DOE/RL-2009-67, Rev. 0 was revised to either quarterly or semiannually, with upgradient wells and wells located within higher chromium and nitrate plume areas to be sampled quarterly while remaining wells were to be sampled semiannually. Hexavalent chromium was added for quarterly or semiannual sampling at downgradient wells, and for semiannual sampling at upgradient wells. This change eliminated analyses for filtered metals, so only unfiltered metals would be sampled (Sections 3.1 and 3.3 in DOE/RL-2009-67, Rev. 0).

In 2011, downgradient well 299-W15-41 was dry and the two upgradient extraction wells 299-W15-40 and 299-W15-765 were taken offline due to low water levels (Table B-40 in DOE/RL-2011-01, *Hanford Site Groundwater Monitoring Report for 2010*). Well 299-W15-765 was planned for conversion to a monitoring well to provide upgradient monitoring (Section 3.2.10.2 in DOE/RL-2011-118).

A revised monitoring plan (DOE/RL-2009-67, Rev. 1) was issued in 2012 to update the monitoring network and sampling frequency. Downgradient well 299-W15-41 (dry) and upgradient well 299-W15-40 were removed from the network, leaving the 1 upgradient well (299-W15-765), 10 downgradient wells (299-W10-26, 299-W10-27, 299-W14-11, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-18, 299-W14-19, 299-W15-44, and 299-W15-763), and 2 far-field wells (299-W14-16 and 299-W14-17) (Table 3-2 in DOE/RL-2009-67, Rev. 1). Sampling for far-field wells was changed to an annual frequency and sampling for the upgradient well was changed to semiannual (Table 3-2 in DOE/RL-2009-67, Rev. 1).

In 2015, wells in the monitoring network continued to have exceedances for chromium and nitrate, while well 299-W10-27 had exceedances for pH (Table 3-18 in DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*). Due to the 200 West P&T System, groundwater velocity and flow direction is changing in the well network again, and these parameters are expected to stabilize once the 200 West P&T System monitoring and assessment has been completed (Section 3.6 in DOE/RL-2016-12,).

As of 2016, the 200 West P&T extraction wells on the east, west, and south sides of WMA TX-TY continue to alter the groundwater flow direction and hydraulic gradients (Section 3.6 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*). The groundwater flow direction is generally eastward, although the extraction wells on the west side of the WMA disrupt the flow locally, and current groundwater and contaminant flow rates beneath WMA TX-TY are estimated to be in the range of 0.003 to 0.890 m/d (0.01 to 2.92 ft/d) (Section 3.6 in DOE/RL-2016-66). Monitoring well water levels increased 0.33 to 0.79 m (1.0 to 2.6 ft) in 2016, except in well 299-W14-15 where the water level decreased 0.36 m (1.2 ft) (Section 3.6 in DOE/RL-2016-66). Elevated levels of hexavalent chromium, nitrate, carbon tetrachloride, and TCE were observed in 2016 (Section 3.6 in DOE/RL-2016-66). While the carbon tetrachloride, TCE, and some of the nitrate contamination is attributed to PFP, WMA TX-TY is known to be a source of hexavalent chromium and nitrate due to past leaks from SSTs and waste pipelines, although other cribs and trenches in the area are contributors to the nitrate contamination as well (Section 3.6 in DOE/RL-2016-66).

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3 Geology and Hydrogeology

This chapter describes of the geology and hydrology beneath WMA TX-TY. The geology specific to this WMA was first described in ARH-LD-136, *Geology of the 241-TX Tank Farm*; ARH-LD-137, *Geology of the 241-TY Tank Farm*; and later in WHC-SD-EN-AP-012. Summaries of the geology at WMA TX-TY 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 and TX-TY Waste Management Areas*; and RPP-7578, *Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMAs T and TX-TY*.

More recently, the WMA TX-TY geology has been summarized in the following: 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*; DOE/RL-2009-67, Rev. 1; RPP-23752 Rev.0-A, *Field Investigation Report for Waste Management Areas T and TX-TY Data Package*; and PNNL-15873, *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 TX-TY, including hydrogeologic observations made during the installation of new wells in the area.

3.1 Stratigraphy

The geology beneath WMA TX-TY consists of basalt basement overlain by nine sedimentary sequences. Figure 3-1 shows a generalized stratigraphic column for the Hanford Site and WMA TX-TY area. Geologic cross sections are shown in Figures 3-2 and 3-3. The geologic sequence below WMA TX-TY from top to bottom is described as follows.

- 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 a 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-136; and Section – Backfill Material, p. 10 in ARH-LD-137) from the gravel-dominated sequence of the Hanford formation.

- Hanford formation – Cataclysmic flood deposits equivalent to hydrostratigraphic unit (HSU) 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, 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 those 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 WMA TX-TY.

  – Hanford formation gravel-dominated sequence (H1) - The Hanford formation gravel-dominated sequence varies from approximately 9 to 18 m (30 to 60 ft) thick in the WMA TX-TY 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.

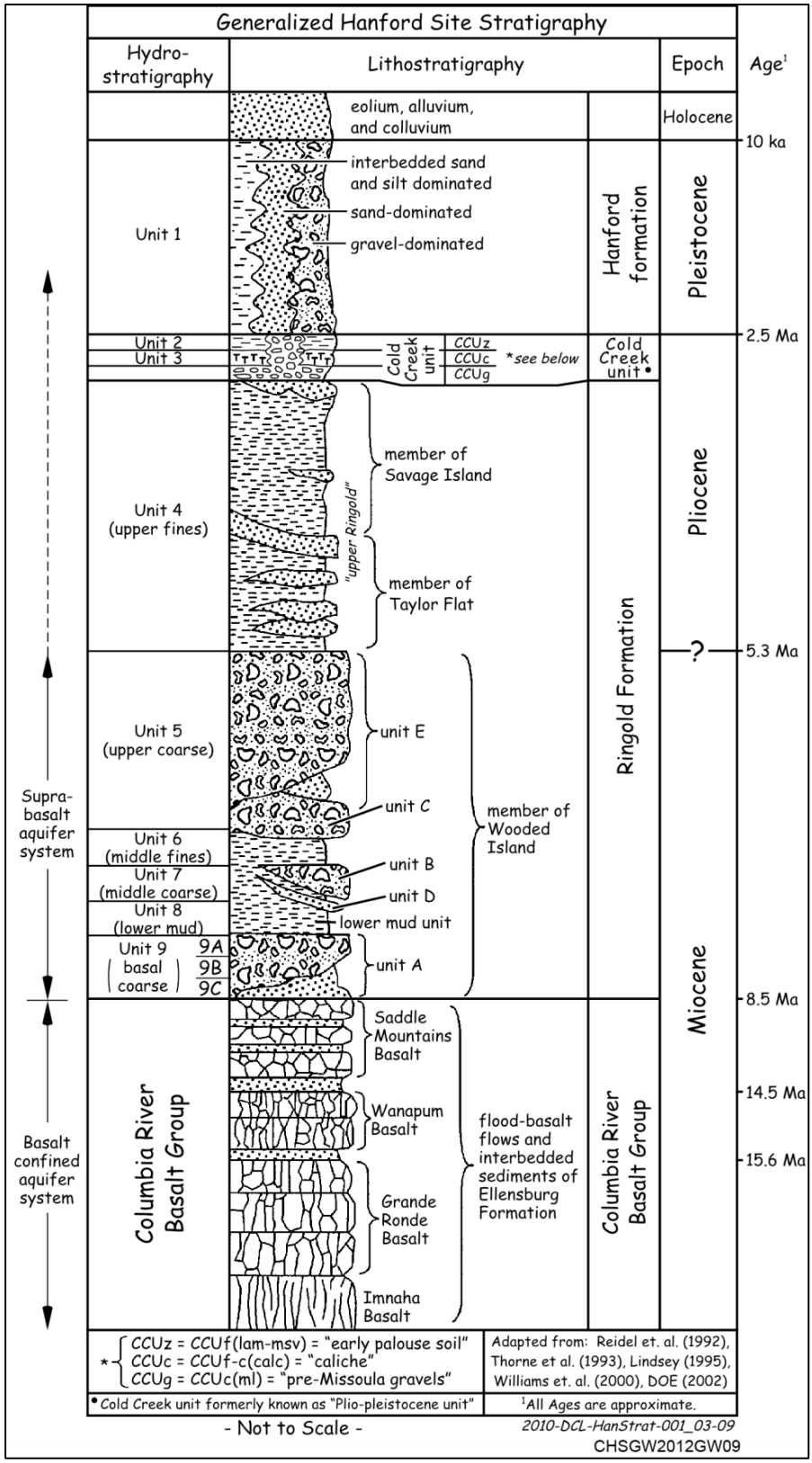


Figure 3-1. General Stratigraphy at the Hanford Site

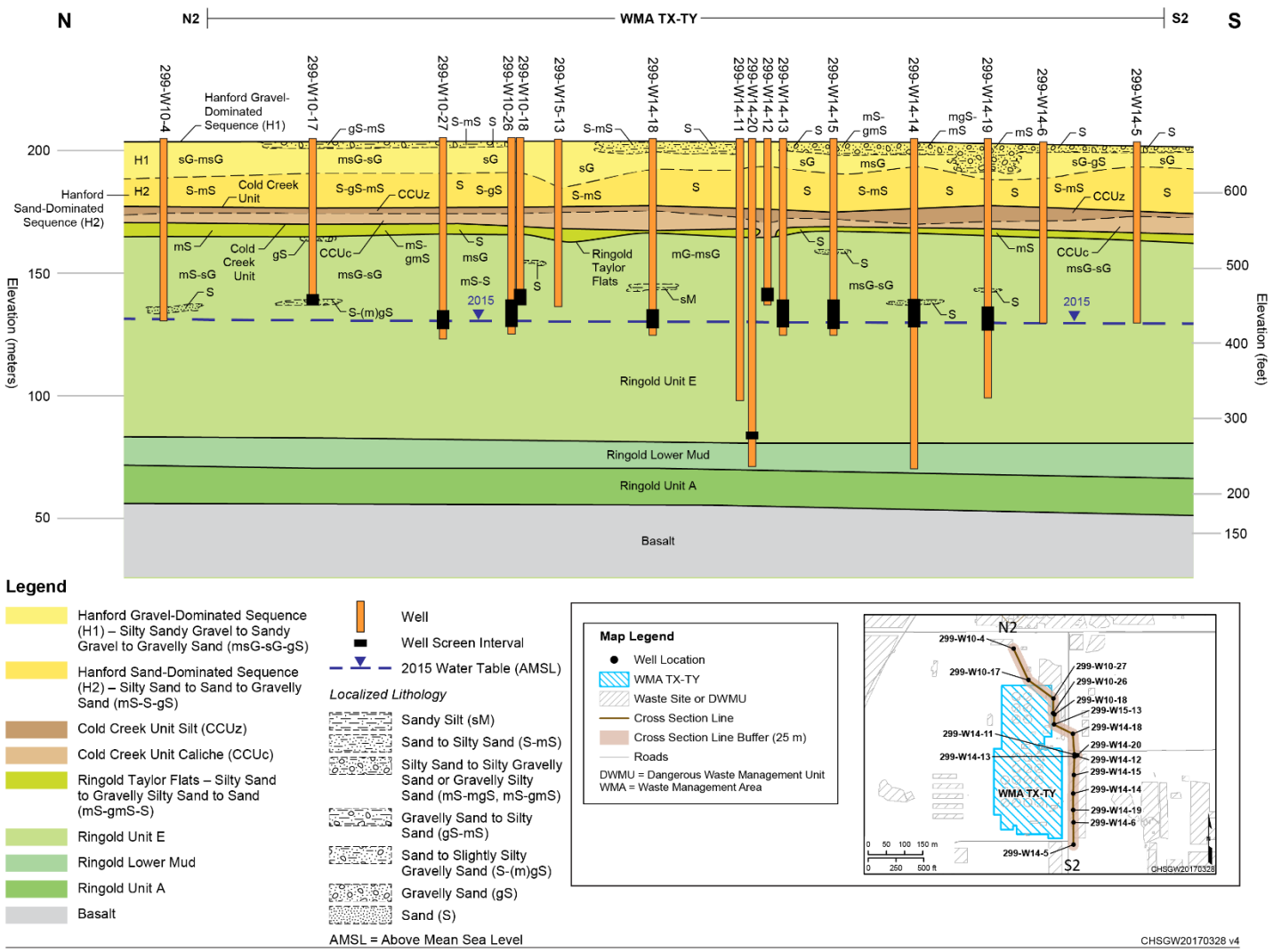


Figure 3-2. North to South Cross Section for the East Side of WMA TX-TY

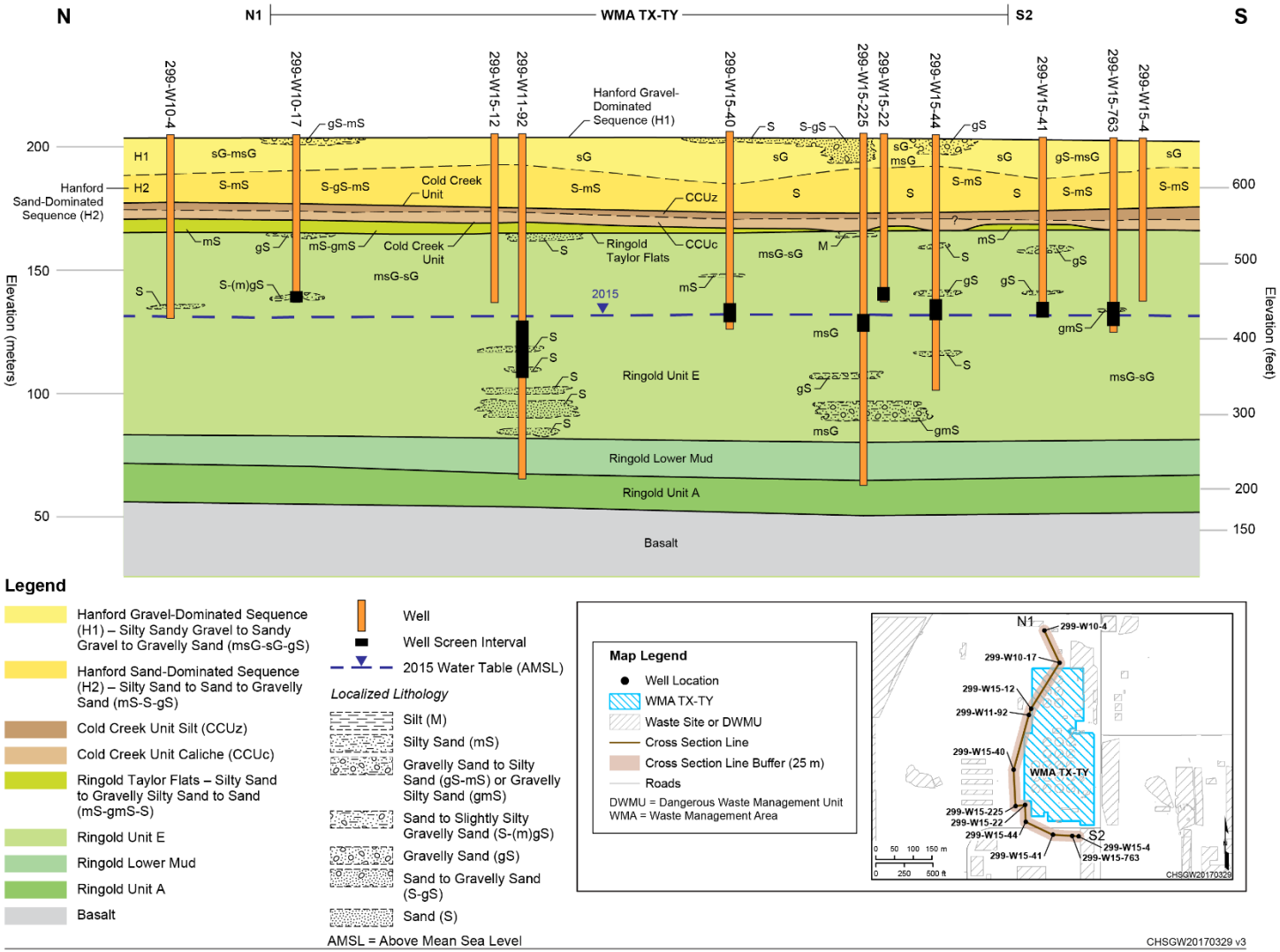


Figure 3-3. North to South Cross Section for the West Side of WMA TX-TY

  - Hanford formation sand-dominated sequence (H2) - The Hanford formation sand sequence ranges from about 4 to 20 m (13 to 66 ft) and averages 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. A Hanford formation sand-dominated sequence overlies the Cold Creek fluvial sediments beneath WMA TX-TY.

- 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 TX-TY. 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 1 and 6 m (3 to 20 ft) in thickness and averages 3 m (10 ft) thick at WMA TX-TY.
  - 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 CCUc sequence occurs in all wells at WMA TX-TY. The sequence ranges in thickness from 1 to 15 m (3 to 49 ft) with an average thickness of 6 m (20 ft) in the vicinity of 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 where as in other places no calcium carbonate exists. The member of Taylor Flats ranges in thickness from 2 to 8 m (6 to 26 ft) at WMA TX-TY, but is generally thicker than 3 m (10 ft) and averages 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 TX-TY from approximately 82 to 85 m (269 to 279 ft). The water table occurs within Ringold Unit E (Figures 3-2 and 3-3).
- 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, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*). 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 TX-TY area indicate 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 3-4).

- 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 and ranges in thickness from 15 to 18 m (48 to 60 ft) beneath WMA TX-TY (Figure 3-5).
- 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 TX-TY area. Regional mapping of the Saddle Mountain Basalt surface indicates a dip to the southwest into the Cold Creek syncline (Figure 3-6).

ARH-LD-136 (Section – Clastic Dikes, p. 10) and ARH-LD-137 (Section – Clastic Dikes, p. 10) state that clastic dikes were detected in the 241-TX and 241-TY Tank Farms during construction, although they could not be mapped.

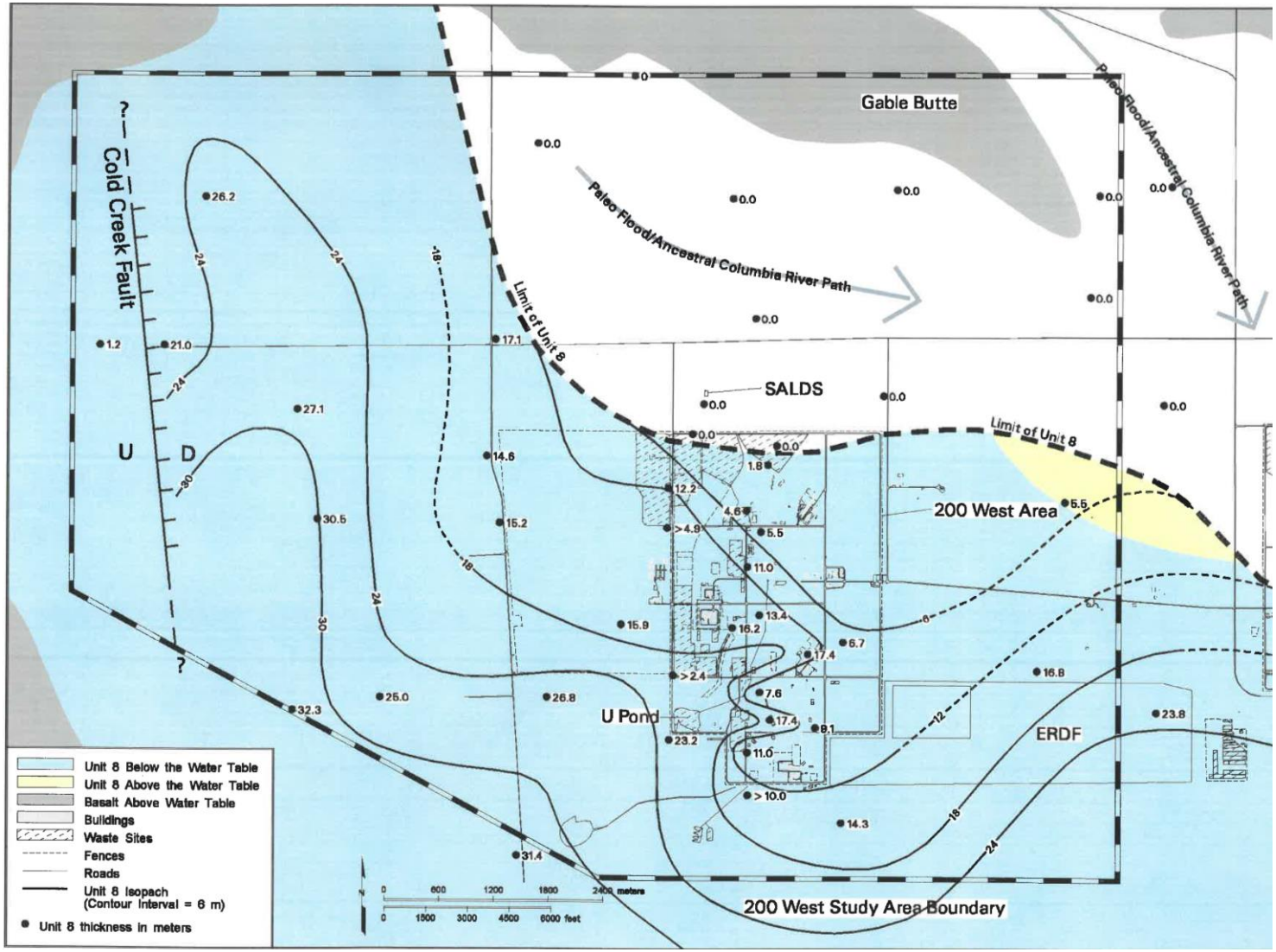
3.2 Hydrogeology

Groundwater beneath WMA TX-TY 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 70.9 m (232.7 ft) to 75.5 m (247.6 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 and 3-3). The unconfined aquifer increases in thickness toward the southwest and is estimated to range in thickness from approximately 48.5 and 56.5 m (159 to 185 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 and 3-3). Deeper confined aquifers occur between the basalt flows.

Additional descriptions of the hydrogeology of WMA TX-TY 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.

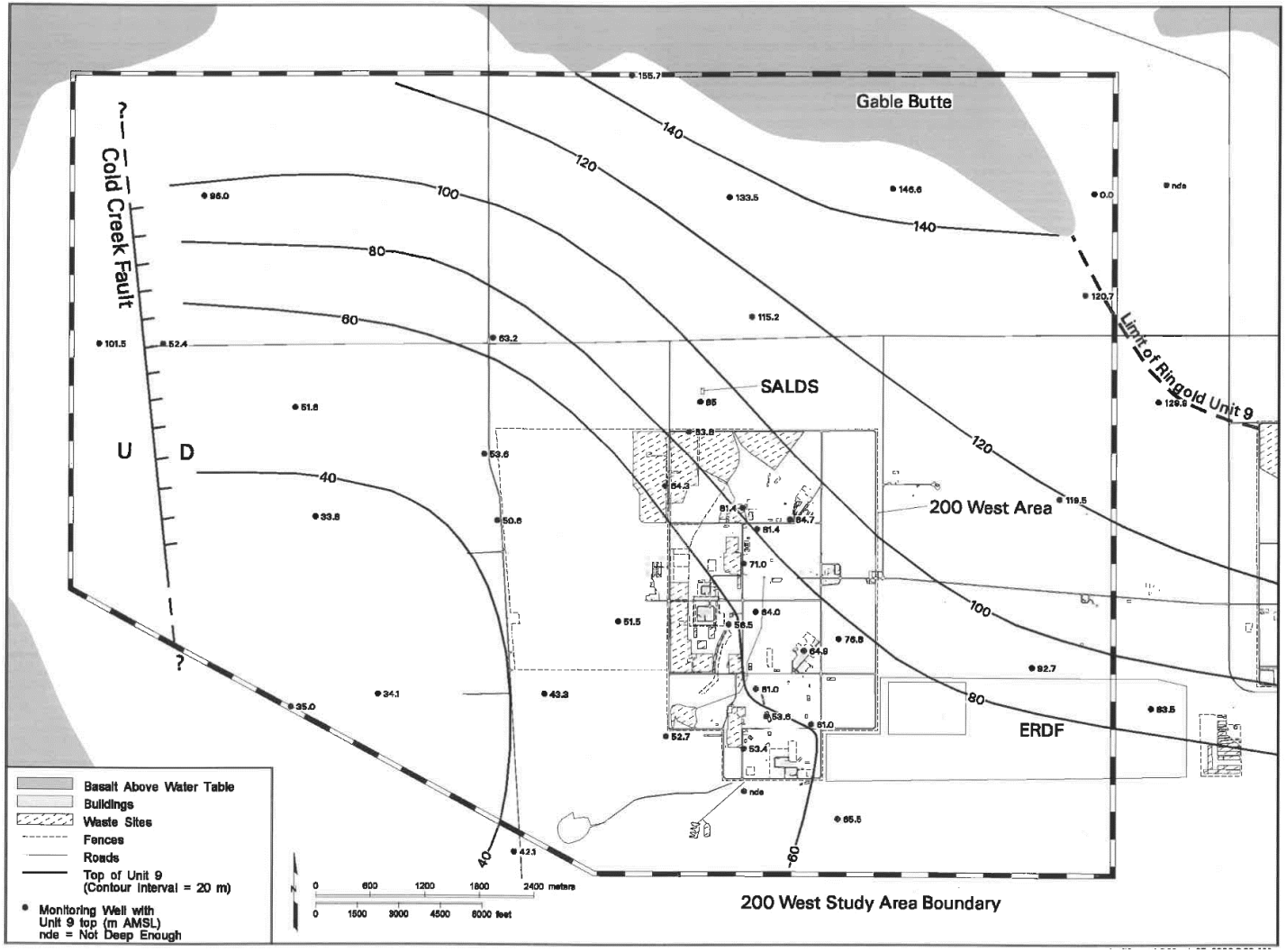
Aquifer tests have been performed on new wells at WMA TX-TY since 1999. The details of the tests, data analysis, and test results are provided in the following:

- PNNL-13378, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 1999*
- PNNL-13514, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2000*
- PNNL-14113, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 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-18279, *Aquifer Testing Recommendations for Well 299-W15-225: Supporting Phase 1 of the 200-ZP-1 Groundwater Operable Unit Remedial Design*



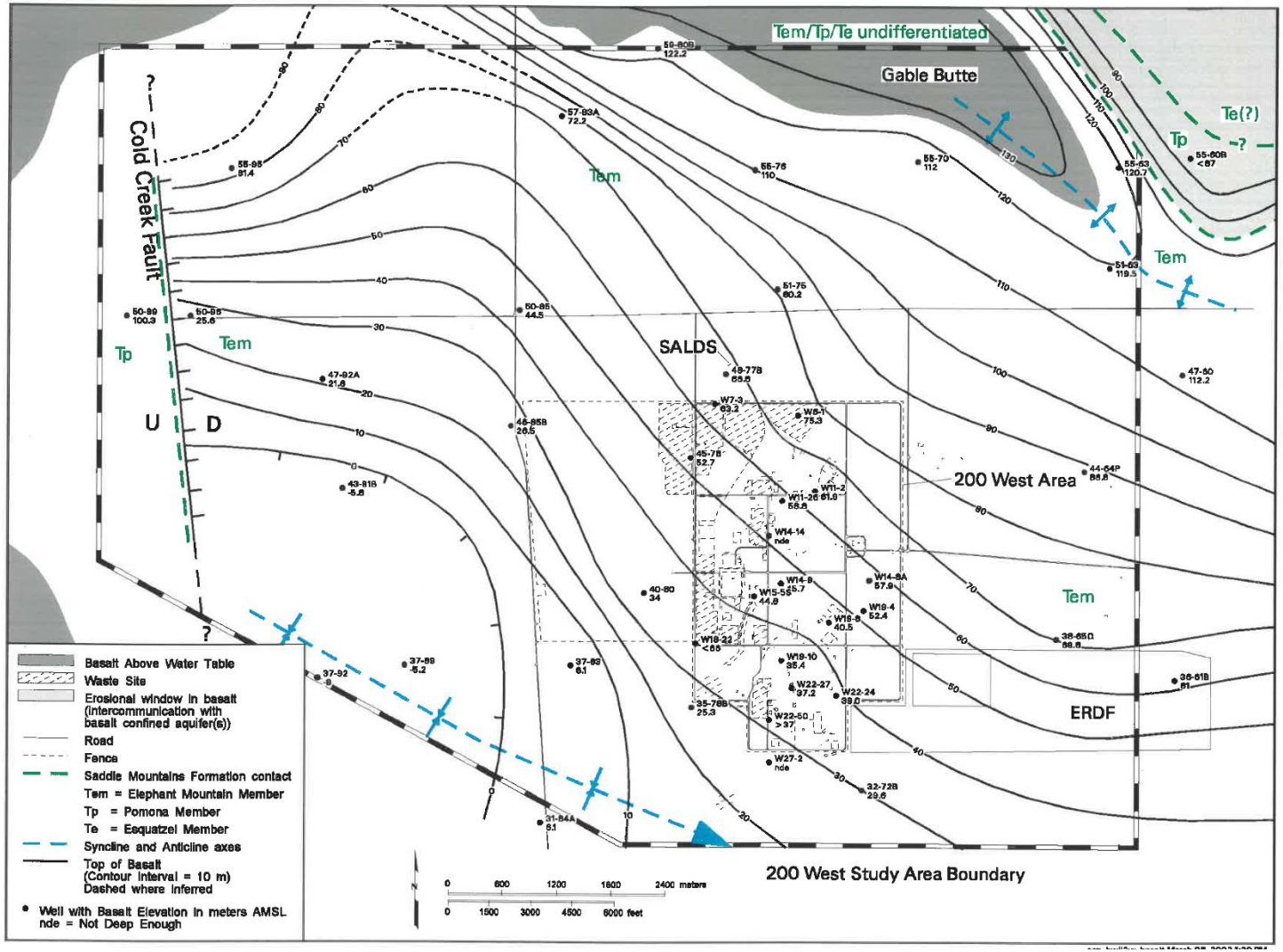
Source: PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington.*

Figure 3-4. Isopach Map Showing Extent of the RLM (Unit 8) in the Vicinity of the 200 West Area and Underlying WMA TX-TY



Source: PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington.*

Figure 3-5. 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 TX-TY



Source: PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington.*

Figure 3-6. Structure Contour Map Showing Dip Direction of the Saddle Mountain Basalt Surface in the Vicinity of the 200 West Area and Underlying WMA TX-TY

The salient results are listed below using the pertinent historical or latest compiled data from the previously listed documents:

- The saturated hydraulic conductivity of the Ringold E unit underlying WMA TX-TY is 5 m/d (16.4 ft/d) (Table 4-9 in CP-47631). Section 2.0 in PNNL-18279, *Aquifer Testing Recommendations for Well 299-W15-225: Supporting Phase I of the 200-ZP-1 Groundwater Operable Unit Remedial Design*, gives saturated hydraulic conductivities ranging from between approximately 0.07 and 19.9 m/d (0.23 and 65.3 ft/d), with a geometric mean of 2.20 m/d (7.22 ft/d) based on field measurements. Vertical heterogeneities in hydraulic conductivity exist among wells and within individual well screens.

- The in-well, upward, vertical groundwater flow conditions were measured in 2005 in monitoring well 299-W14-11, which has a screened interval of 3 m (10 ft) and is located approximately 14 m (46 ft) below the water table. Vertical flow was measured in the borehole using electromagnetic borehole flow (EBF) meter surveys. Maximum vertical flow velocity recorded by the EBF was 0.014 to 0.027 m/m.

- In-well, downward, vertical groundwater flow conditions were measured in well 299-W14-13 in 2002 using vertical-flow tracer tests and EBF surveys. This well is screened across the water table, and the bottom of the screened interval is approximately 7 m (23 ft) below the water table. Well 299-W14-13 is located 6 m (19 ft) south of well 299-W14-11. Average vertical downward flow velocities were 0.011 to 0.012 m/m and were reproducible over a 9-month period during testing.

- 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.

A major stratigraphic change is the top of the CCU. This unit, located between 26 m (85.3 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. 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, contamination in immediate downgradient wells is sourced from WMA TX-TY (Section 12.10.2 in DOE/RL-2016-67). 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.

Downgradient well 299-W14-13 was installed in 1998 and was screened from water table to a depth of approximately 35 ft below the water table. In 2002, a vertical gradient survey of the well was completed via vertical tracer and electronic borehole flow (EBF) measurements. Results indicated a downward vertical gradient of 0.011 to 0.012 m/m which was confirmed by both vertical tracer and EBF results (PNNL-13378). In 2005, well 299-W14-11 was installed adjacent to 299-W14-13 to evaluate vertical contaminant distribution in the aquifer down gradient of WMA TX-TY (PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*, Section 2.8.3.4); and constructed with a 10 ft screened interval 37.7 to 47.7 ft below the water table. In 2005, a vertical gradient survey was completed within 299-W14-11. Results indicated an upward gradient of 0.014 to 0.027 m/m, evaluated by EBF measurements only, although results were approaching the limits of detection of the equipment (PNNL-17348).

Although at first glance, the observation of vertical gradients in opposite directions in two wells in close proximity seems anomalous, there are likely causes for the observed conditions. The vertical gradients observed likely resulted from operation of groundwater remedial extraction wells in the general vicinity. Examination of inferred water table elevation contours at the time of both vertical gradient measurements indicates that operating extraction wells had imposed artificial gradients in the vicinity of WMA TX-TY. Different sets of extraction wells were operating during both vertical gradient measurement studies and the two measured wells are screened over different portions of the shallow unconfined aquifer. In 2002, during the vertical gradient measurement at well 299-W14-13, extraction wells 299-W15-34 and 299-W15-35 were in operation and the inferred water table map indicates a capture zone at the southern portion of WMA TX-TY, which extends toward well 299-W14-13. This could account for the observed slight downward vertical gradient at that well.

During the 2005 vertical gradient measurement at well 299-W14-11, additional remedial extraction wells were in operation (i.e., 299-W15-40, 299-W15-43, 299-W15-44, and 299-W15-765). Again, inspection of inferred water table elevation maps during that time period indicates artificial gradients were present at that time. The nearest extraction wells (i.e., 299-W15-765 and 299-W15-40) were screened across the water table with bottom-of-screen elevations that are above the top-of-screen elevation in well 299-W14-11. This condition could account for the observed slight upward vertical gradient in that well. In both instances, the observed vertical gradients are small in magnitude and the wells were in the area of influence of operating groundwater extraction wells; both observed vertical gradient conditions are consistent with apparent groundwater behavior under extraction. The difference between the two well observations most likely result from the temporal difference between the two measurement studies, the difference in well completion elevations, and the operation of different extraction wells during the gradient measurement events.

3.3 Groundwater Flow System

Groundwater flow conditions in the 200 West Area and, more specifically, in the region surrounding WMA TX-TY have varied greatly over the past several decades due to changing wastewater disposal practices and, more recently, P&T operations. The following subsections discuss changes in the hydrologic condition the occurred proceeding and subsequent to operation of the interim 200-ZP-1 and 200 West P&T Systems.

3.3.1 Hydrologic Conditions Prior to 200 West P&T Operations

Water levels in the unconfined aquifer increased as much as 14 m (46 ft) above the pre-Hanford Site natural water table beneath WMA TX-TY due to artificial recharge from liquid waste disposal operations active between the mid-1940s and 1995 (Figure 3-7). Between 1950 and 1996, the groundwater flow direction beneath the WMA varied between east (pre-Hanford Site direction), southeast, north, and northeast depending primarily on effluent disposal volumes to the former 216-T Pond to the north of the WMA T and the former 216-U Pond to the southwest (Section 2.4.2 in PNNL-16005). Prior to startup of Phase I of the 200-ZP-1 OU interim P&T system in 1994, large changes occurred in groundwater flow direction beneath WMA TX-TY during Hanford Site operations. Groundwater could have traveled and carried contaminants from WMA TX-TY and nearby past-practice disposal facilities. The approximate travel directions identified in PNNL-16005 are south (between 1954 and 1956), northeast (between 1957 and 1982), and north or northwest (between 1983 and 1995). Since 1995, groundwater flow direction has been primarily toward the east, except where influenced by the 200-ZP-1 OU interim P&T system. These changes in the groundwater flow direction could have contributed to relatively widespread contaminant distribution.

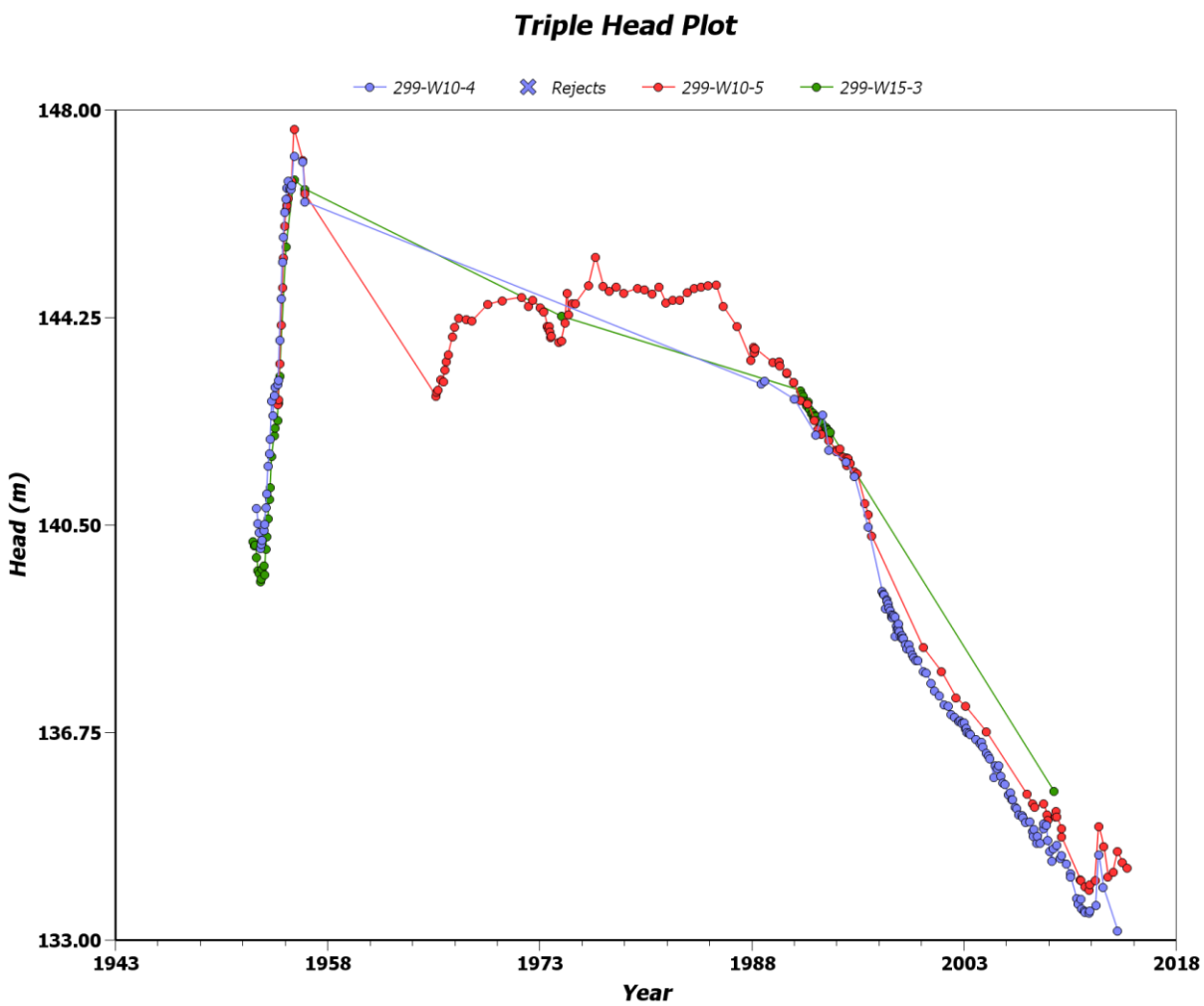


Figure 3-7. Historical Water Table Elevation Changes in the 200 West Area in the Vicinity of WMA TX-TY

Phase I of the 200-ZP-1 OU interim P&T system was installed in 1994 and was expanded with Phases II and III in 1996 and 1997, respectively. The three phases included a total of six extraction wells. The first impact to groundwater flow at WMA TX-TY was observed in 1998 and was associated with installation of extraction wells 299-W15-34 and 299-W15-35 to the southwest of WMA TX-TY (Section 3.6.3.2 in PNNL-12086). Wells 299-W15-34 and 299-W15-35 shifted groundwater flow within the southern portion of WMA TX-TY from a northeast to a south-southwest direction. Beginning in 2002, separate groundwater gradients were reported within the northern and southern portions of WMA TX-TY and were 0.001 m/m and 0.007 m/m respectively; an increase from 0.00079 m/m in 1998. In 2005, Phase IV of the 200-ZP-1 OU interim P&T system was installed and included converting wells located upgradient of WMA TX-TY to extraction wells (299-W15-40, 299-W15-42, 299-W15-43, and 299-W15-765) (Section 2.8.1.1 in PNNL-15670). 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. 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. Beginning in 2005, groundwater flow in the northern portion of the WMA began to shift from east to west, resulting in possible stagnation points beneath the WMA. Therefore, it must be assumed that the water table gradient was variable beneath WMA TX-TY due to influences from P&T system extraction wells.

Groundwater monitoring remained predominantly consistent through the implementation of the 200-ZP-1 OU interim P&T system, and the groundwater monitoring plan was updated in 2011 and 2012 to reflect the associated impact the groundwater flow and transition to the 200 West P&T remedy. The water table map prior to the start of the full-scale 200 West P&T remedy in 2012 is presented in Figure 3-8.

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

This section addresses conditions after full-scale operation of the 200 West P&T began in July 2012. The initial treatment addressed 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 (COCs) 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 3-9). 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 as flow-path control in Section 4.3.3 in EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*, and in Section 1.2.3 in DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*). Mounding of groundwater in the aquifer from these injection wells slows the natural eastward flow and keeps the majority of the COCs 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 3-8 and 3-10 depict groundwater elevation contours computed using water-level mapping. Figure 3-8 depicts the water table during July 2012, before the 200 West P&T remedy was operating. Figure 3-10 shows the water table during March 2016, with the 200 West P&T and 200-UP-1 remedies operating in the 200 West Area. Comparison of Figures 3-8 and 3-10 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. Figure 3-9 shows a well-defined area of convergent hydraulic gradients centered on the extraction wells to the east and west of WMA TX-TY. With subsequent P&T shutdown, groundwater monitoring will continue on at least an every 5-year frequency to support evaluation of contaminant rebound (Section 4.1.3 in DOE/RL-2009-115, Rev. 2).

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 129.5 m (424.9 ft) to 131.0 m (427.8 ft) across the WMA TX-TY area. In 2016 the water table increased beneath WMA TX-TY due to changes in 200 West P&T extraction and injection (Figure 3-11). The increase in water table levels at WMA TX-TY wells in 2016 ranged from 0.33 to 0.79 m (1.0 to 2.6 ft), except in well 299-W14-15 where the water level decreased 0.36 m (1.2 ft). The decrease in average water level for 2016 in 299-W14-15 was due to a low water level elevation measurement collected in November of 2016. The water level measurement has been evaluated, but has been retained based on similar historic water table fluctuations in the well. However, overall water level trending in the well is generally consistent with other network wells.

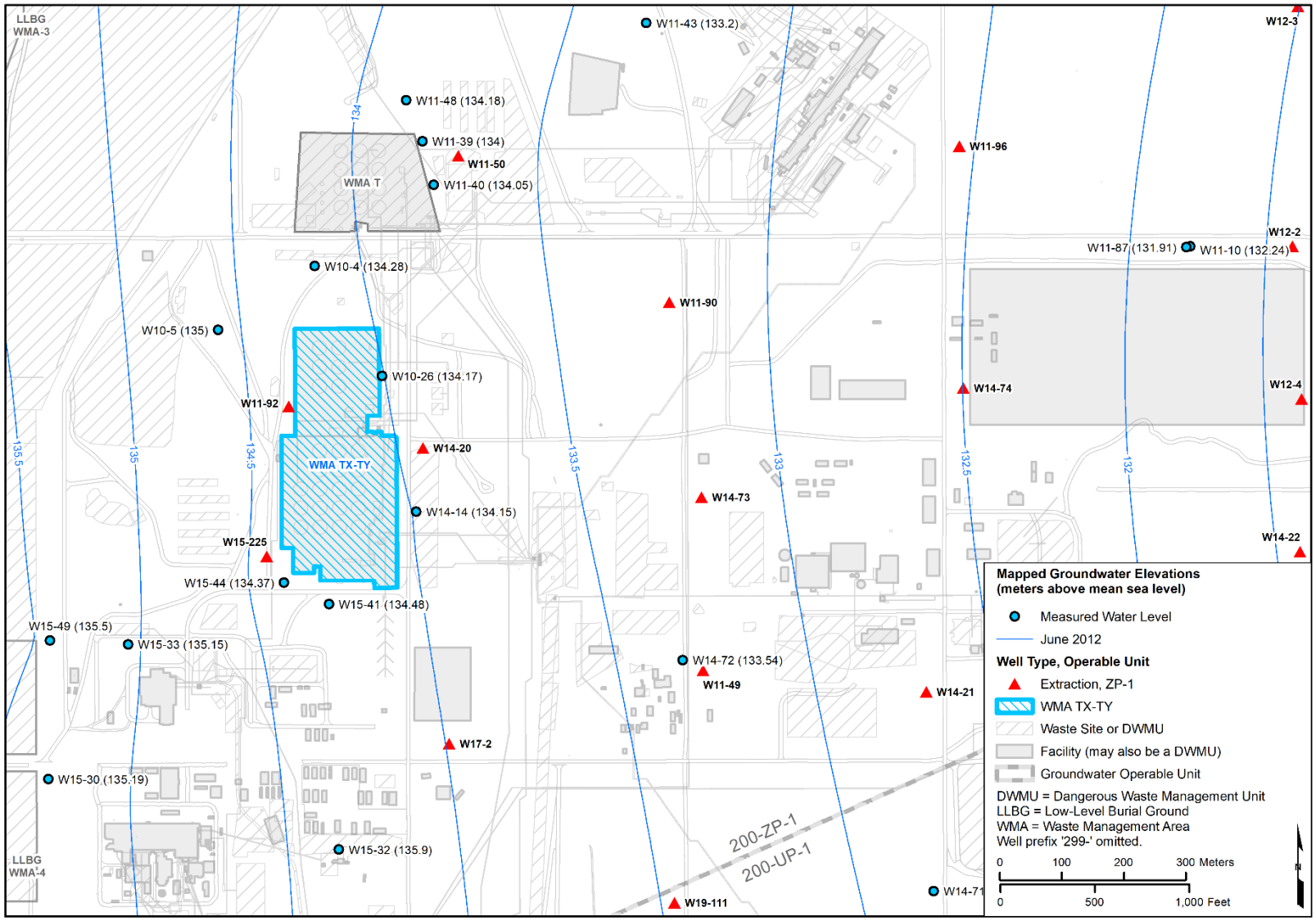


Figure 3-8. Groundwater Elevation Contours Computed Using Water-Level Mapping above the RLM in June 2012 Prior to Full-Scale 200 West P&T Operations

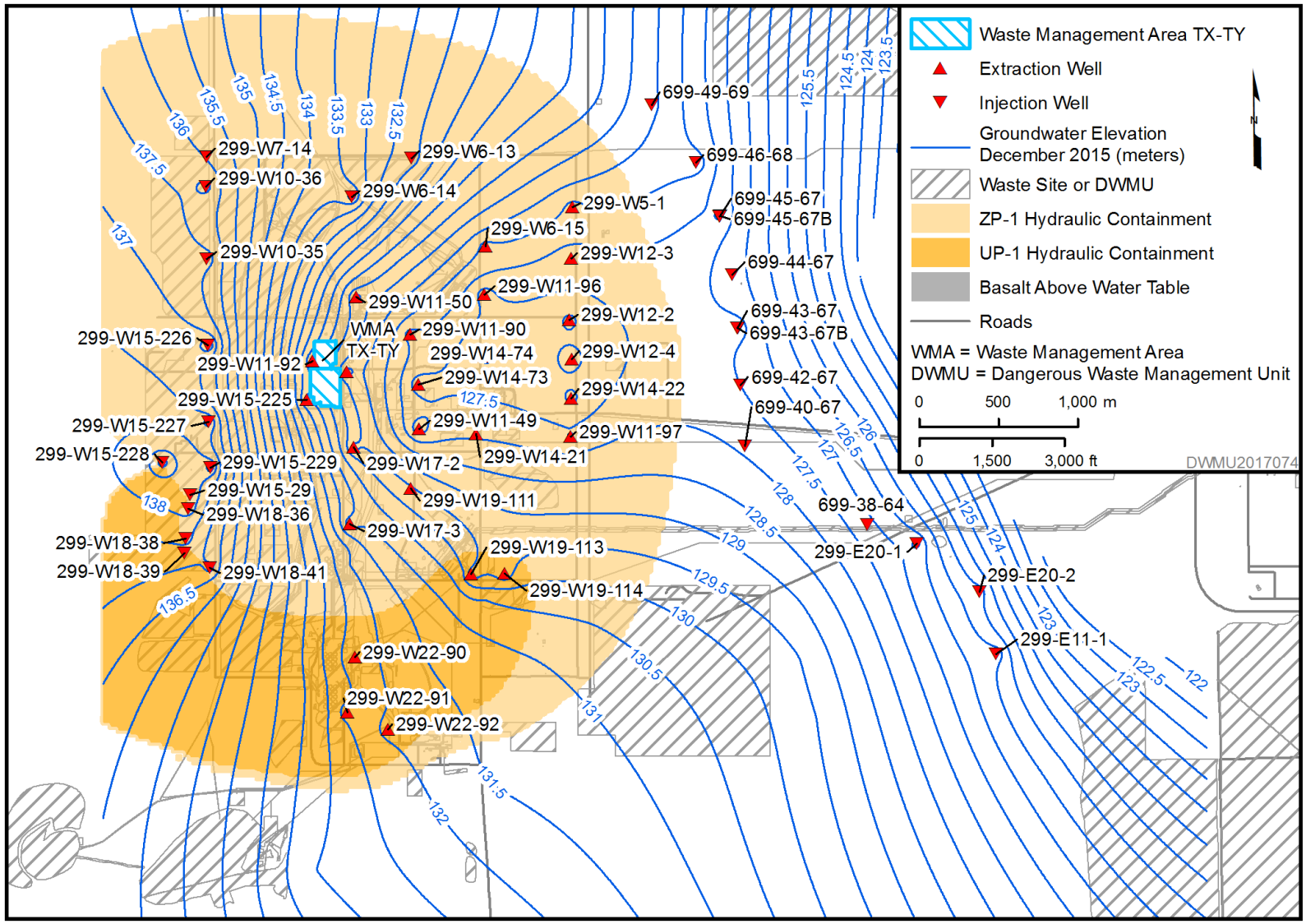


Figure 3-9. 200-ZP-1 and 200-UP-1 P&T Extraction and Injection Wells Showing Extent of Hydraulic Containment Computed for December 2015

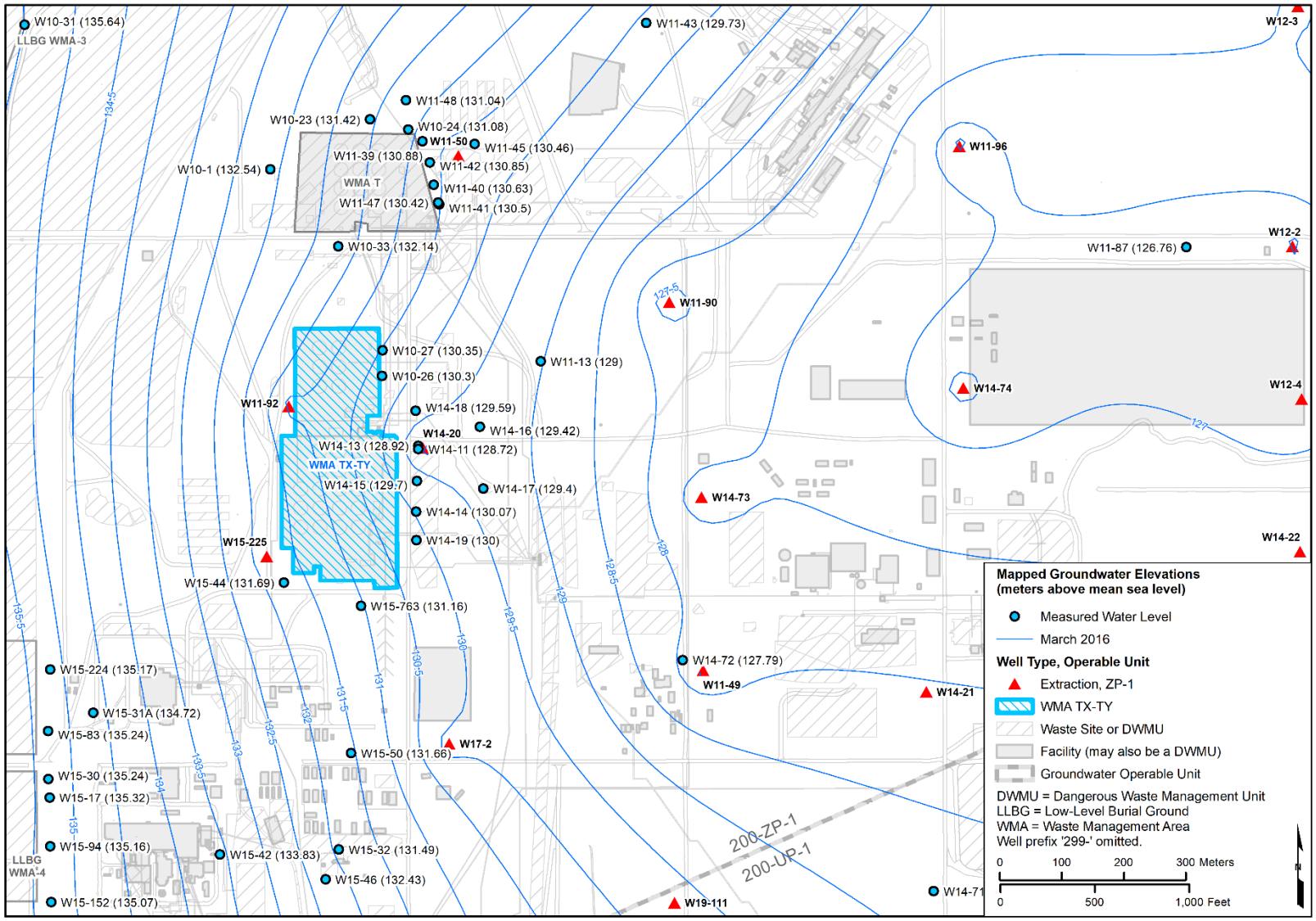


Figure 3-10. Groundwater Elevation Contours Computed Using Water-Level Mapping above the RLM in March 2016 during Active 200 West P&T Operations

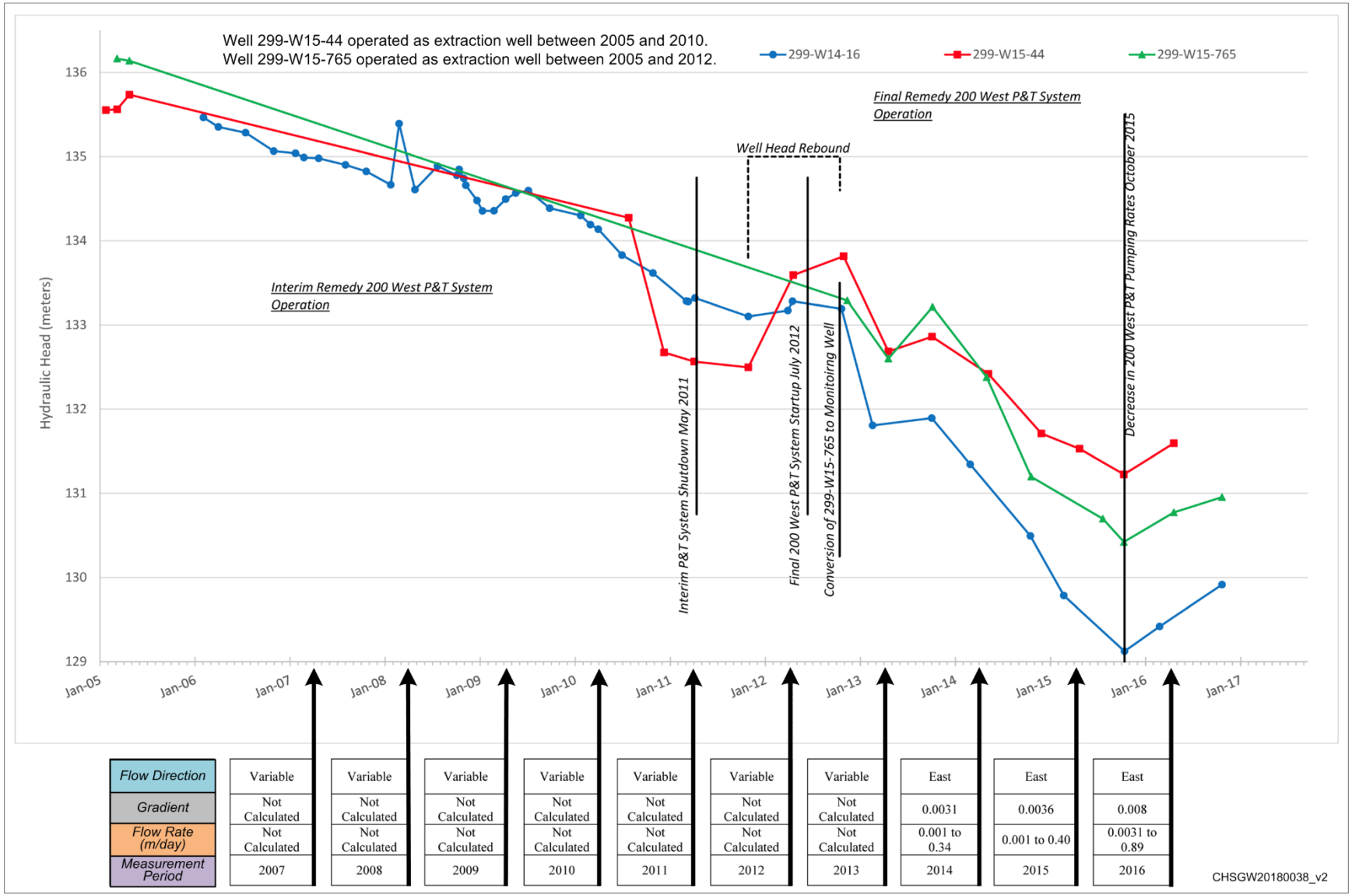


Figure 3-11. Change in Water Table Elevation, Flow Direction, Gradient, and Flow Rate at WMA TX-TY from 2007 through 2016

Figure 3-11 shows the changes in water table elevation both upgradient (wells 299-W15-44 and 299-W15-765) and downgradient (well 299-W14-16) of WMA TX-TY resulting from implementation of the 200 West P&T system that started operation in 2012. The declining regional water table generally remained on trend during the 2006 through 2015 time period (Figure 3-11). Impact of the 200 West injection and extraction system operations in the WMA TX-TY area beginning in July 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 3-11).

During Phase IV of the interim ZP-1 P&T system operations in 2006, the groundwater flow direction beneath WMA TX-TY was determined to be variable and no gradient was calculated (Table B.1 in PNNL-16346). Subsequent to implementation of the 200 West P&T system in 2012, groundwater flow has continued to be influenced by the extraction and injection well network. In 2016, 200 West P&T extraction wells on the east, west, and south sides of the WMA altered the groundwater flow direction and hydraulic gradients (Section 3.6 in DOE/RL-2016-66, Rev. 0). Based on March 2016 water-level data, the flow direction is generally eastward, although the extraction wells on the west side of the WMA disrupt the flow locally. Estimates of groundwater and contaminant flow rates beneath WMA TX-TY range from 0.003 to 0.890 m/d (0.01 to 2.92 ft/d) (Table 3-1). Monitoring well water levels increased 0.33 to 0.79 m (1.0 to 2.6 ft) in 2016, except in well 299-W14-15 where the water level decreased 0.36 m (1.2 ft). The groundwater flow rate and direction are further described in Section 4.3.

Table 3-1. Groundwater Velocity at WMA TX-TY (March 2016)

Flow Direction	East
Flow Rate (m/d)	0.0031 to 0.89
Hydraulic Conductivity (m/d) (Source)	0.07 to 19.9
Effective Porosity	0.18
Gradient (m/m)	8.0×10^{-3}
Comments	Gradient and direction estimated from March 2016 water table map; velocity calculated from the Darcy equation

Source: Table 3-18 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 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 the groundwater pathway conceptual model in detail that includes specific aspects related to the 241-TX and 241-TY Farms. Section 2.6 in DOE/RL-2009-67, Rev. 1 describes the vadose zone and groundwater conceptual model for WMA TX-TY.

4.1 Vadose Zone

The vadose zone beneath WMA TX-TY is between approximately 66 and 70 m (216 and 229 ft) thick and consists of the Hanford formation, the CCU, the Taylor Flats member of the Ringold Formation, and the upper portion of unit E of the Wooded Island member of the Ringold Formation.

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 the WMA 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 TX-TY 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 (Table 3-1) 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 2.6.3 in DOE/RL-2009-67, Rev. 1).

Improperly sealed wells can act as a preferential pathway through the vadose zone. Documentation in Section 2.6.3 in DOE/RL-2009-67, Rev. 1, indicates that 6 of the 95 vadose wells in the 241-TX and none of the wells in 241-TY Tank Farms (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 that the remaining wells have an annular seal. Therefore, the potential exists for unsealed wells to promote vertical moisture migration in WMA TX-TY.

Evidence suggests that past tank and piping leaks from WMA TX-TY have migrated through the vadose zone to the groundwater (Section 3.6 in DOE/RL-2016-66). Any remaining contamination in the vadose zone resulting from tank leaks, pipeline leaks or overfill events remains a source of possible future groundwater contamination (RPP-23752, Section 3.3 and DOE/RL-2009-67, Rev.1, Section 2.6).

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 nearby 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.

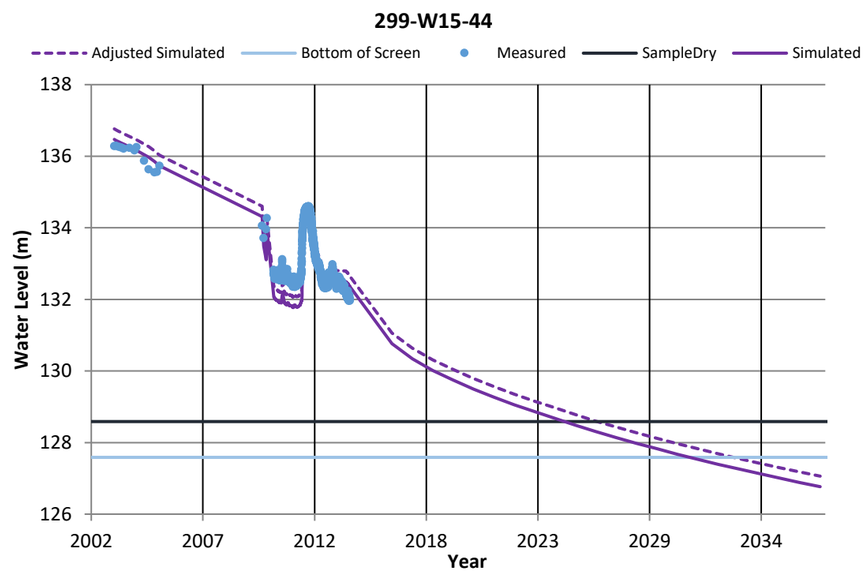
The migration process occurred, for the most part, in partially saturated soils because leak/release volumes were not sufficient to fill the soil pore spaces for an appreciable length of time or very far from the point of entry. This condition is referred to as "unsaturated flow." Infiltration of natural precipitation remains the likely principal driver to mobilize vadose zone contamination. Steps have been taken to reduce infiltration or precipitation at WMA TX-TY. Berms have been erected around the tank farms to stop run-on of rain and melting snow, and an interim cap has been placed over tanks in Tank Farm TY to inhibit remobilization of leaks.

4.3 Hydrogeologic Considerations

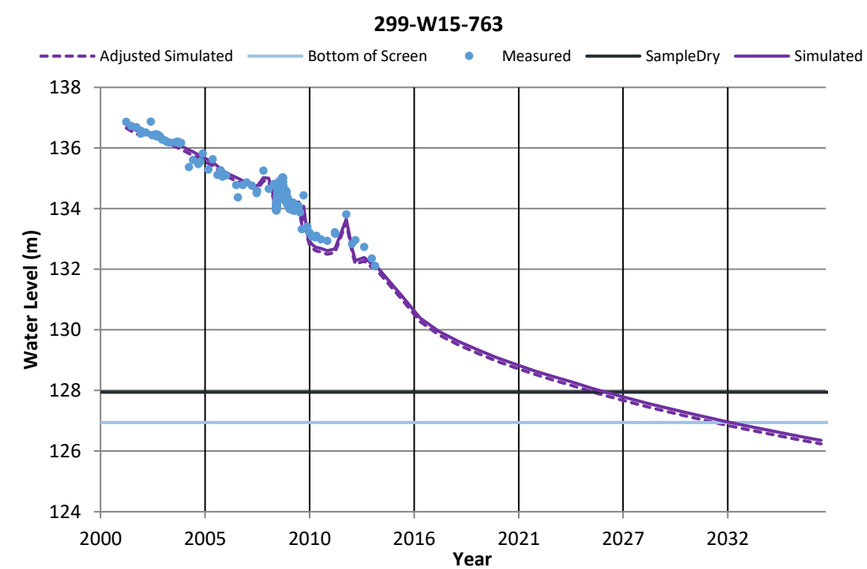
Large changes have occurred in the groundwater flow direction beneath WMA TX-TY due to past operations in the 200 West Area. Analyses of historic hydraulic gradients suggest that groundwater could have traveled and carried contaminants from WMA TX-TY and nearby past-practice disposal facilities. Historic flow directions are discussed in Section 2.6.4 in DOE/RL-2009-67, Rev. 1. Pre-Hanford Site (circa 1942) groundwater flow direction was toward the east (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 1957, groundwater flow direction changed again and started flowing 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 early 1980s and mid-1990s is probably a result of the discharges to the 216-U-14 Ditch, located southwest of WMA TX-TY, 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-TX and 241-TY Tank Farms diminished in 1995. Consequently, the flow direction changed again in about 1995 and began to return toward an eastward direction through 2012. With implementation of the 200 West P&T System in July 2012, groundwater flow direction changed to northeast in the southern portion, east in the central portion, and southeast in the northern portion (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 3-7). 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 TX-TY. The magnitude of the impact was most pronounced when system operations at the 200 West Facility were initiated in 2012 (Figure 3-11). 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 TX-TY is shown in Figure 4-1.

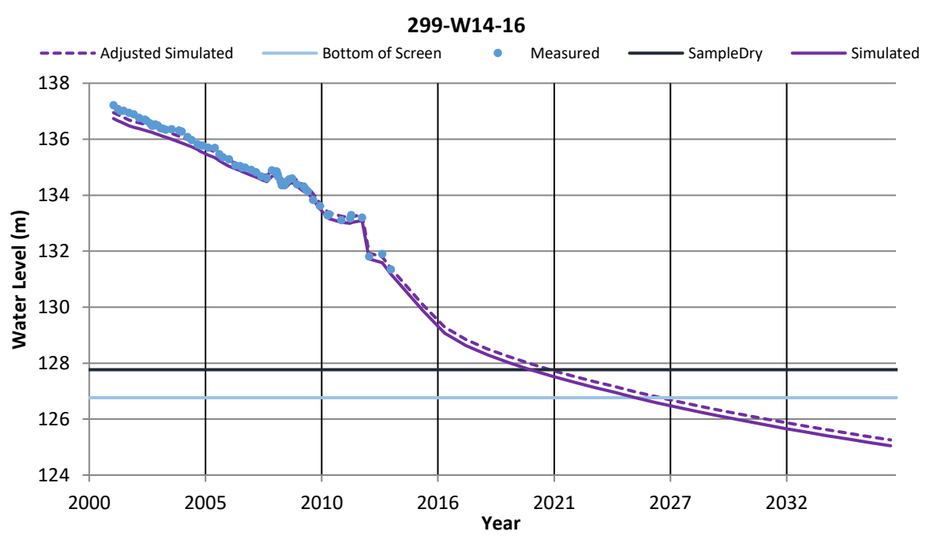
Upgradient Well



Crossgradient Well



Downgradient Well



Far-Field Downgradient Well

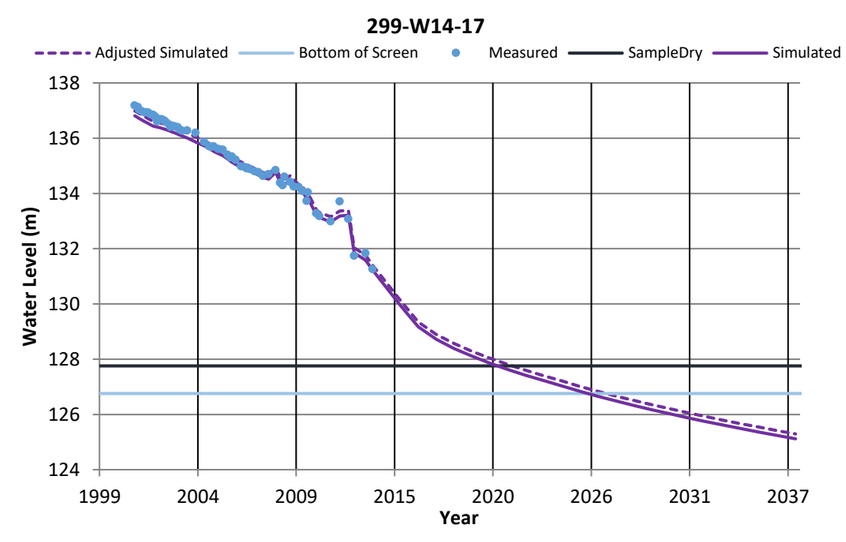


Figure 4-1. Hydrographs Showing the Projected Impact of P&T Operations on the Rate of Water-Level Decline for Wells Adjacent to WMA TX-TY

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P&T operations are expected to continue in this region until 2037. After completion of active groundwater remediation 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 TX-TY in the simulations described in Chapters 5 through 7 of this report.

4.4 Groundwater Chemistry

Dangerous waste groundwater contaminants sourced from WMA TX-TY are limited to chromium (Section 2.5.1 in DOE/RL-2012-67, Rev. 1). Regional carbon tetrachloride and trichloroethene are also present, but are associated with releases from the PFP operations and not WMA TX-TY. Nitrate is also present in groundwater beneath WMA TX-TY. Plume maps for all of these constituents are provided in DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*.

In addition to the dangerous waste constituents, technetium-99 and tritium are found in groundwater at WMA TX-TY. 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 TX-TY is shown in 2016 plume maps (DOE/RL-2016-67, Figures 12-5, 12-9, 12-14, 12-18, 12-22, and 12-24). Concentration trending during the period 2011 through 2016 associated with hexavalent chromium, trichloroethene, carbon tetrachloride and nitrate for upgradient well (299-W15-765) and for downgradient or far-field wells (299-W14-11 and 299-W14-18) 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 TX-TY (Section 2.6.5 in DOE/RL-2009-67, Rev. 1).

The portion of the chromium immediately downgradient of WMA TX-TY 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 the PFP and not from WMA TX-TY. The extensive nitrate plume in the area has multiple sources, but some contribution is associated with release(s) from WMA TX-TY (Section 3.1 in DOE/RL-2009-67, Rev. 1).

4.5 Summary of Vertical Contaminant Distribution

Eleven completed wells in the vicinity of WMA TX-TY have available data for vertical distribution of contaminants in groundwater collected during drilling or special study. Identified wells include: 299-W11-92, 299-W14-11, 299-W14-13, 299-W14-14, 299-W14-19, 299-W14-20, 299-W15-40, 299-W15-44, 299-W15-225, and 299-W15-765, located near the perimeter of WMA TX-TY; and 299-W15-34 located distally from WMA TX-TY. See Figure 4-11 for general well location in relation to WMA TX-TY. 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 WMA TX-TY operation. In addition, a CERCLA P&T remedial action is currently in operation in the vicinity of these wells.

Vertically separated samples collected from wells 299-W15-40 and 299-W15-765 include samples collected from the water table via bailer and routine extraction pump discharge. Samples collected via bailer in well 299-W15-40 are noted as not being representative of aquifer conditions and are not further evaluated. Well 299-W15-34 includes samples collected from the extraction pump discharge at two separate depths in 2005 (79 m (259 ft) and 86 m (282 ft) below top of casing); however, samples were not

collected for vertical characterization purposes, and the well was not further evaluated. See Figures 4-12 through 4-19 for observed vertical distribution of identified contaminants.

Evaluated constituents were limited to available nonradiological vertical data associated with the surrounding wells and limited to the following: carbon tetrachloride, nitrate, hexavalent chromium, and fluoride. Where hexavalent chromium was not analyzed, filtered or unfiltered chromium were included where available. During drilling of the wells, groundwater samples were collected from the boreholes at selected depths and analyzed by laboratory methods. Vertical characterization samples were collected from the active well 299-W14-13 during a special study in 2002. Vertical characterization samples from well 299-W14-13 were collected at elevations above the 2017 water table elevations. Vertical zones of increased contaminant concentrations are indicated within the figures and are based on visual observation of the vertical trends and are for visual reference only.

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. Evaluated wells show indications of highest contaminant concentrations within approximately the upper 3 to 20 m (10 to 67 ft) of the unconfined aquifer. A second zone of an increased contaminant concentrations beginning about 85 m (279 ft) and extending to 114 m (374 ft) below ground surface was identified during drilling in all wells except 299-W11-92 located immediately west of WMA TX-TY. Well 299-W11-92 shows a second zone of increased contamination beginning about 105 m (345 ft) and extending to 121 m (397 ft) below ground surface during drilling.

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

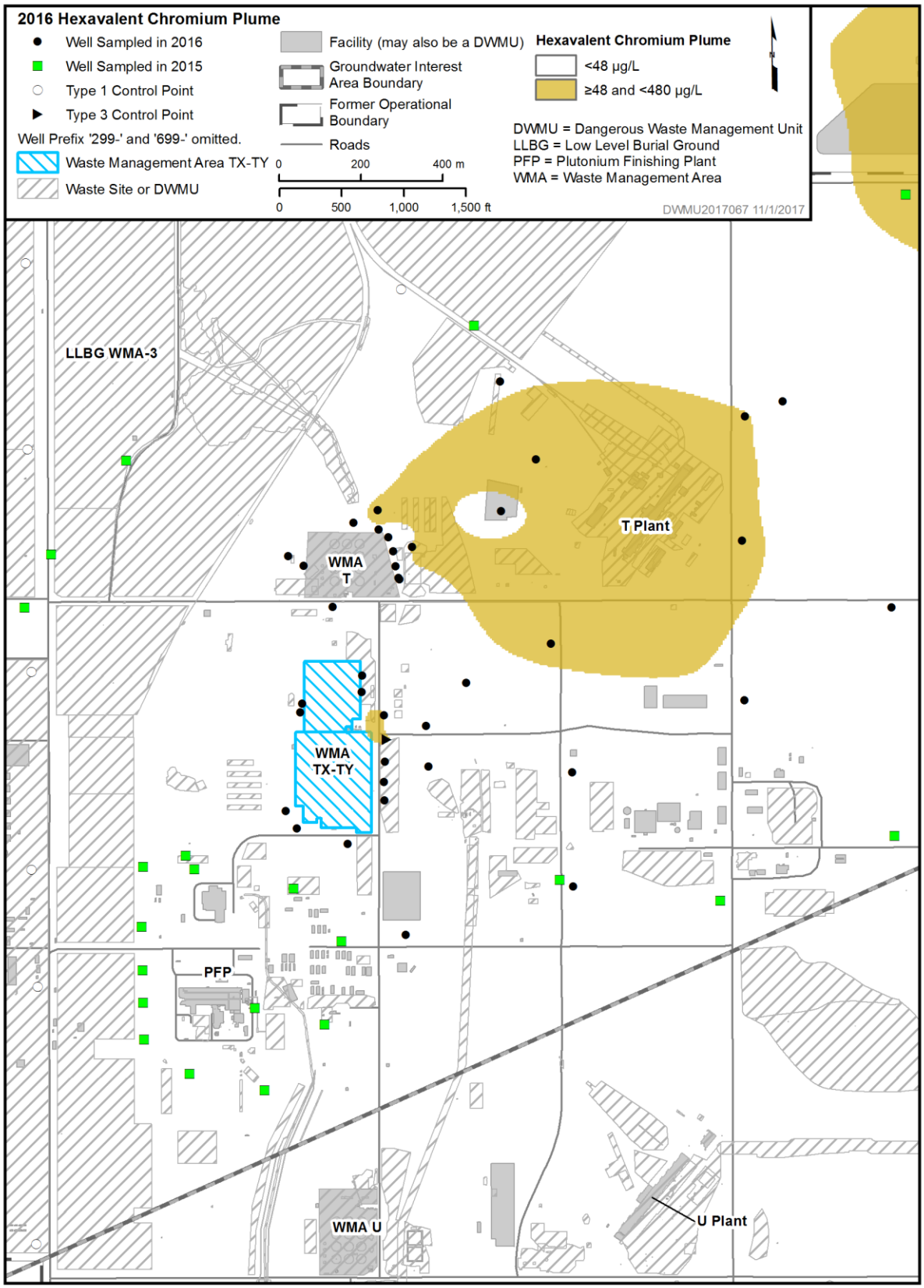


Figure 4-2. Hexavalent Chromium Plume in the Vicinity of WMA TX-TY

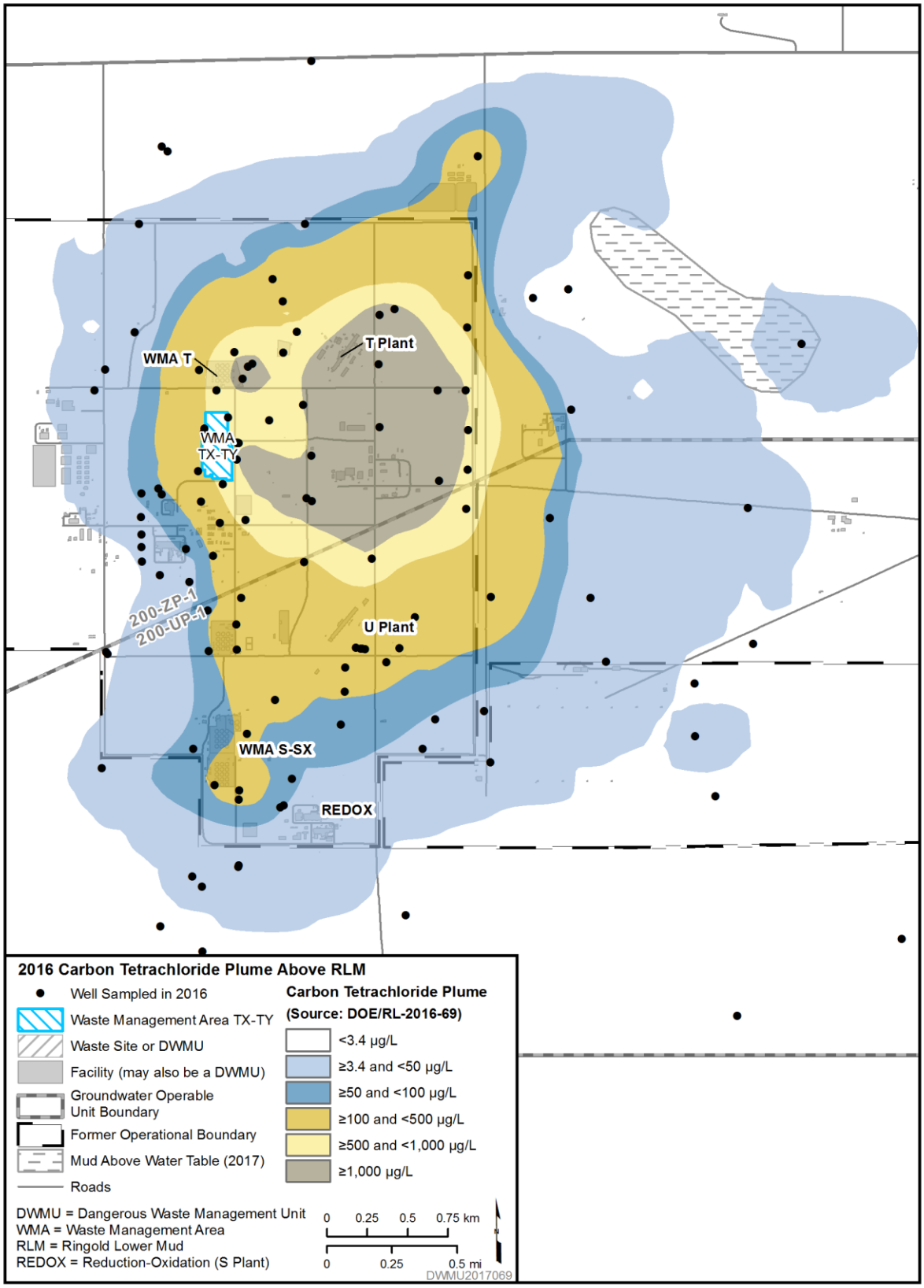


Figure 4-3. 2016 Contaminant Plume Map for Carbon Tetrachloride Above the RLM

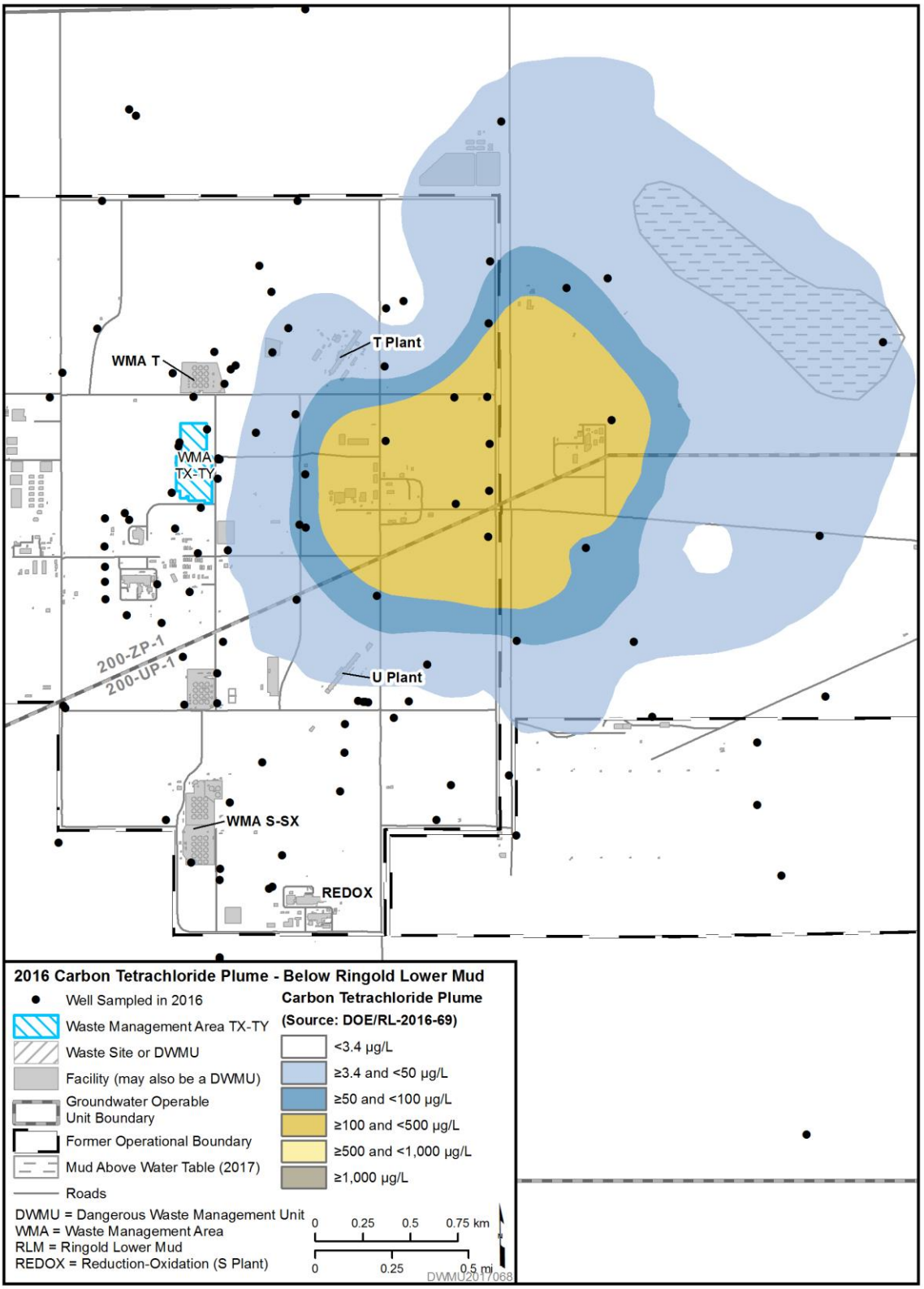


Figure 4-4. 2016 Contaminant Plume Map for Carbon Tetrachloride Below the RLM

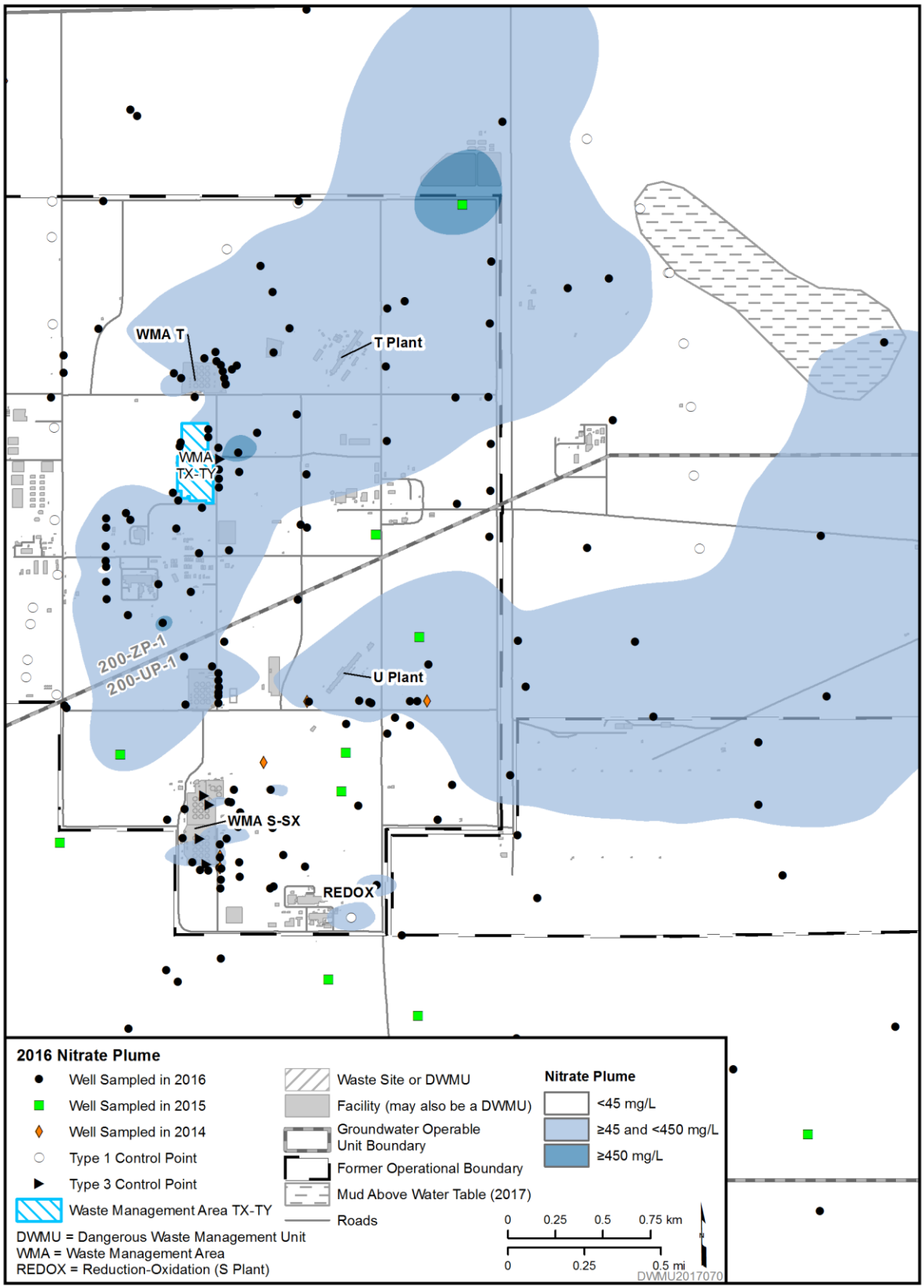


Figure 4-5. Nitrate Plume in the Vicinity of WMA TX-TY

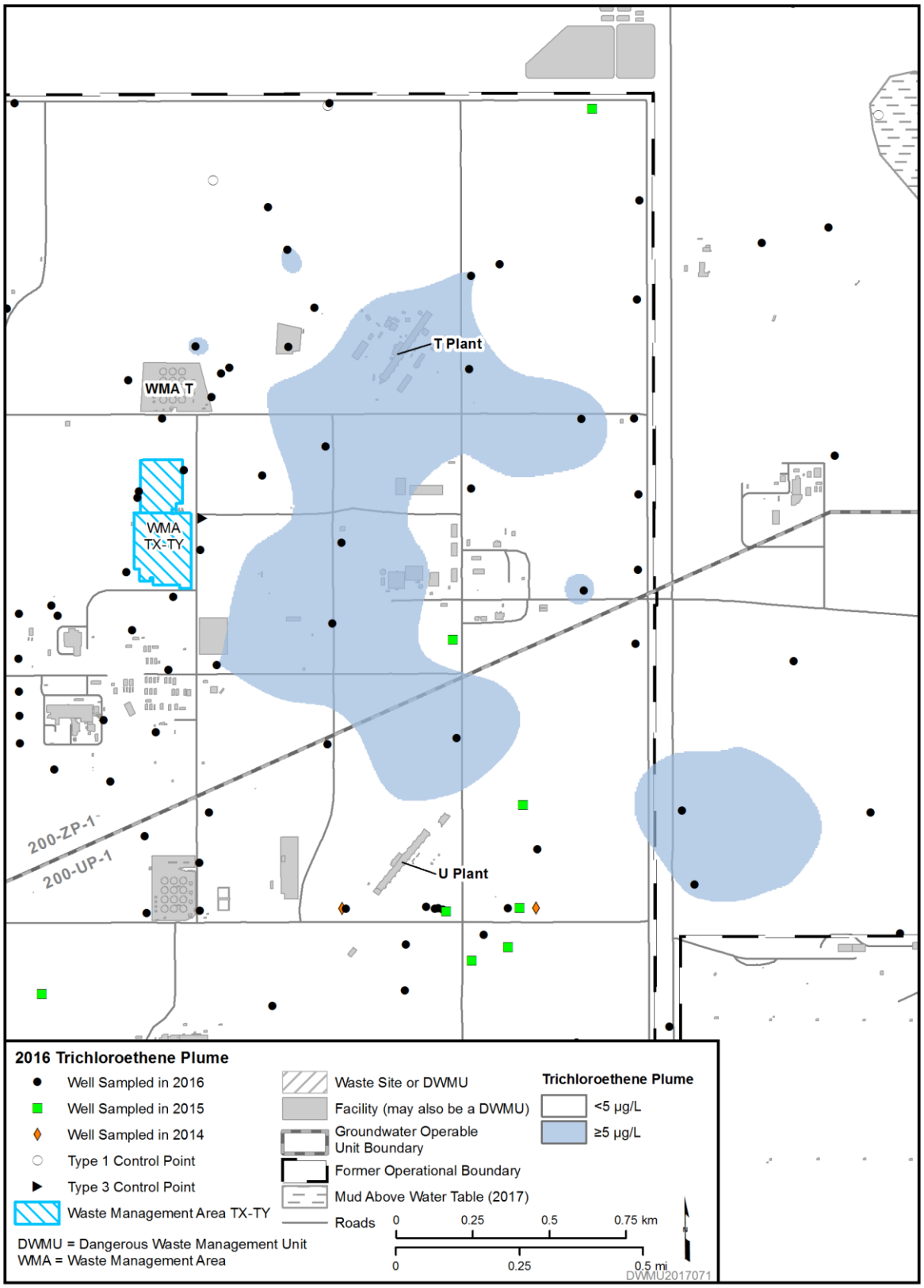
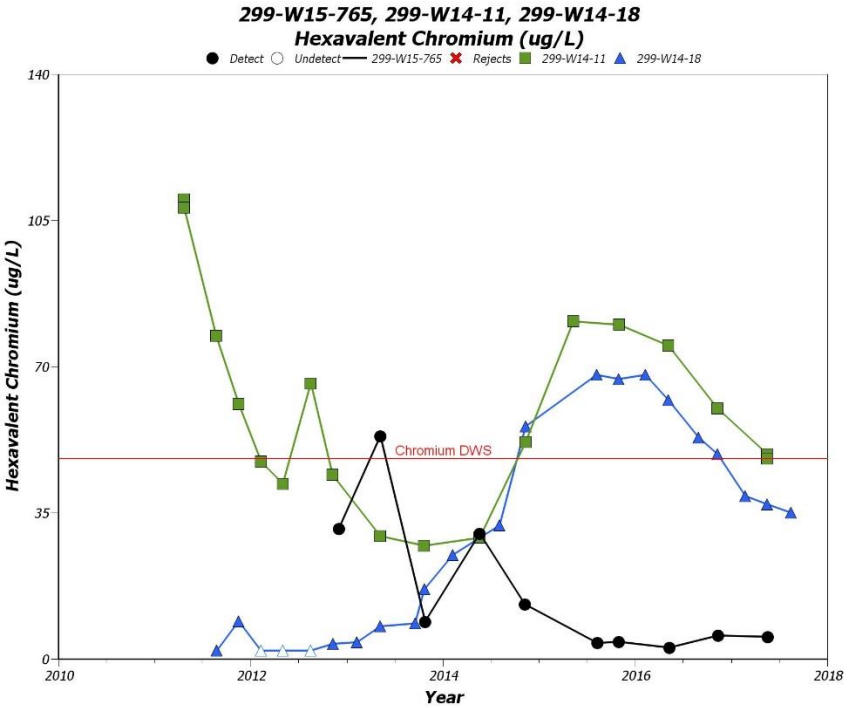
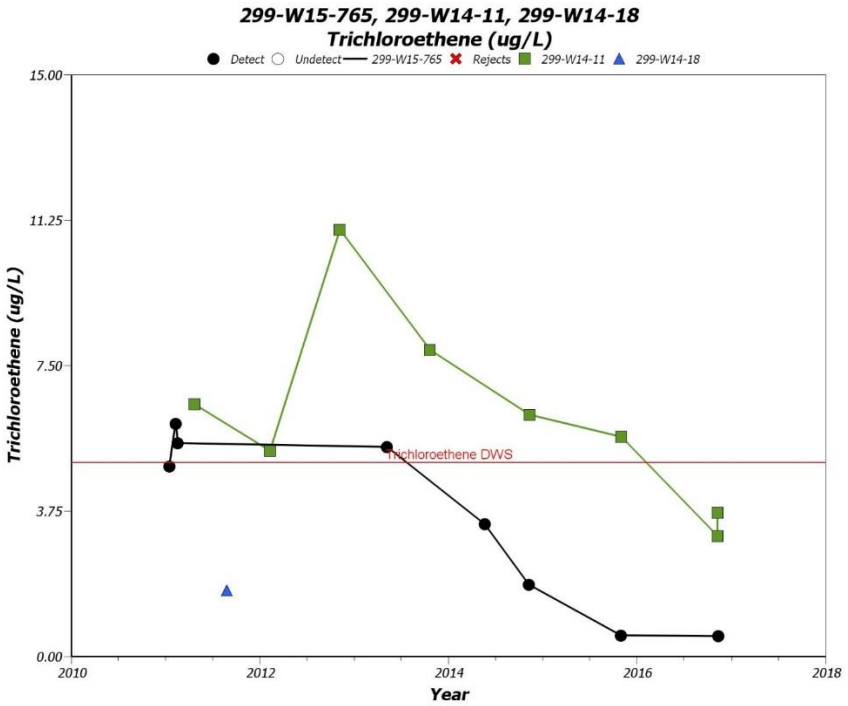


Figure 4-6. Trichloroethene Plume in the Vicinity of WMA TX-TY



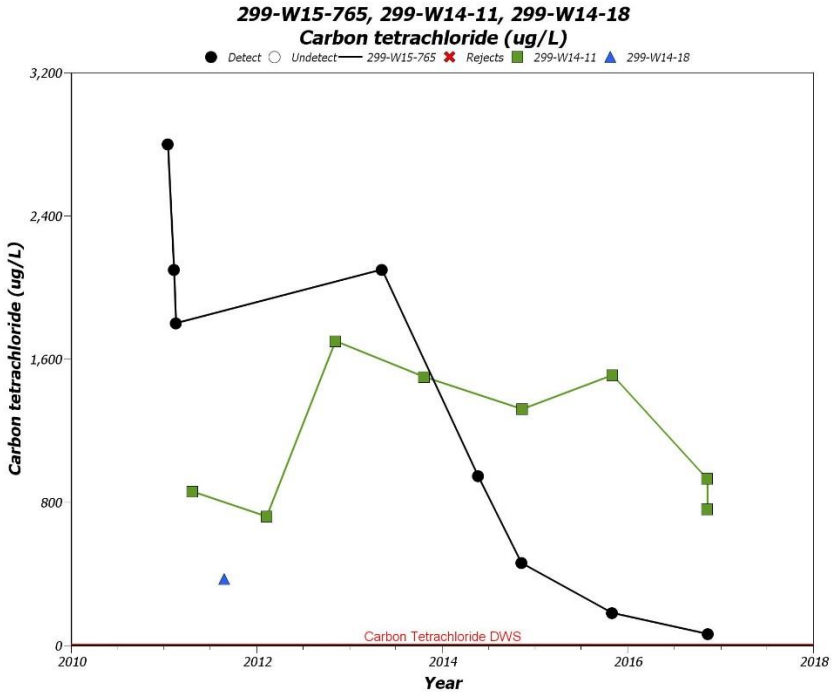
DWS = drinking water standard

Figure 4-7. Hexavalent Chromium Concentration Trending for Upgradient Well 299-W15-765 and Downgradient Wells 299-W14-11 and 299-W14-18



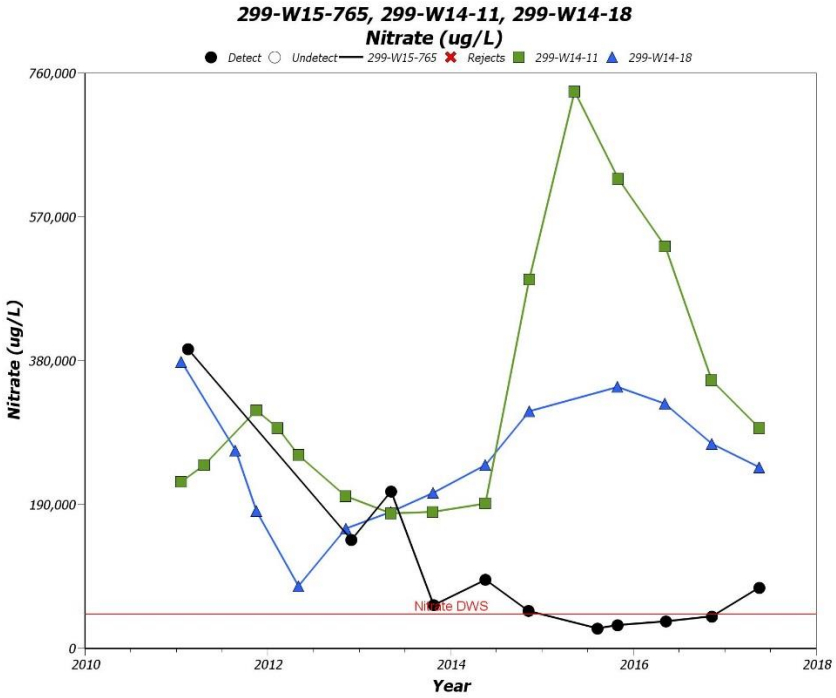
DWS = drinking water standard

Figure 4-8. Trichloroethene Concentration Trending for Upgradient Well 299-W15-765 and Downgradient Wells 299-W14-11 and 299-W14-18



DWS = drinking water standard

Figure 4-9. Carbon Tetrachloride Concentration Trending for Upgradient Well 299-W15-765 and Downgradient Wells 299-W14-11 and 299-W14-18



DWS = drinking water standard

Figure 4-10. Nitrate Concentration Trending for Upgradient Well 299-W15-765 and Downgradient Wells 299-W14-11 and 299-W14-18

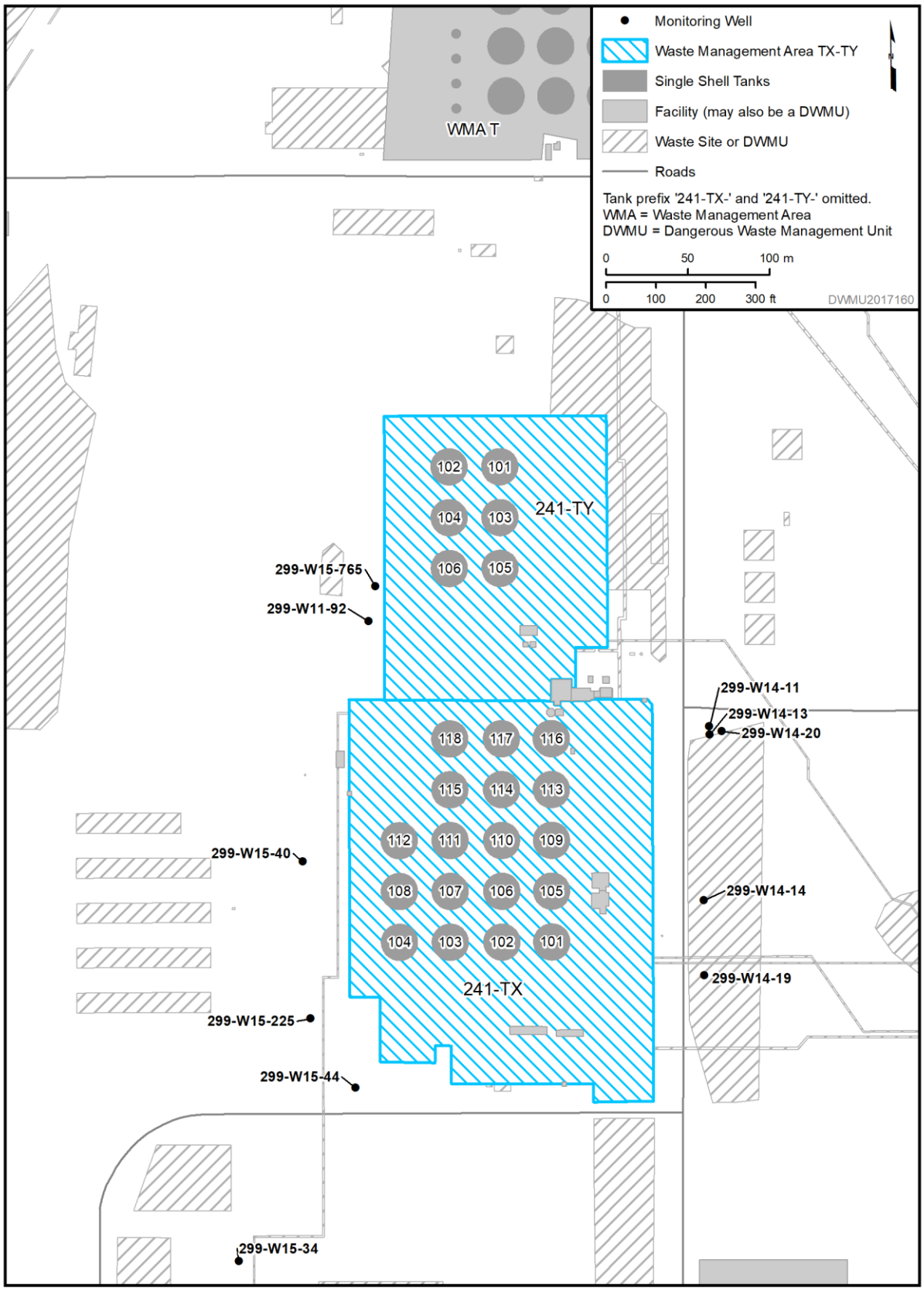


Figure 4-11. Vertical Contaminant Characterization Well Location Map

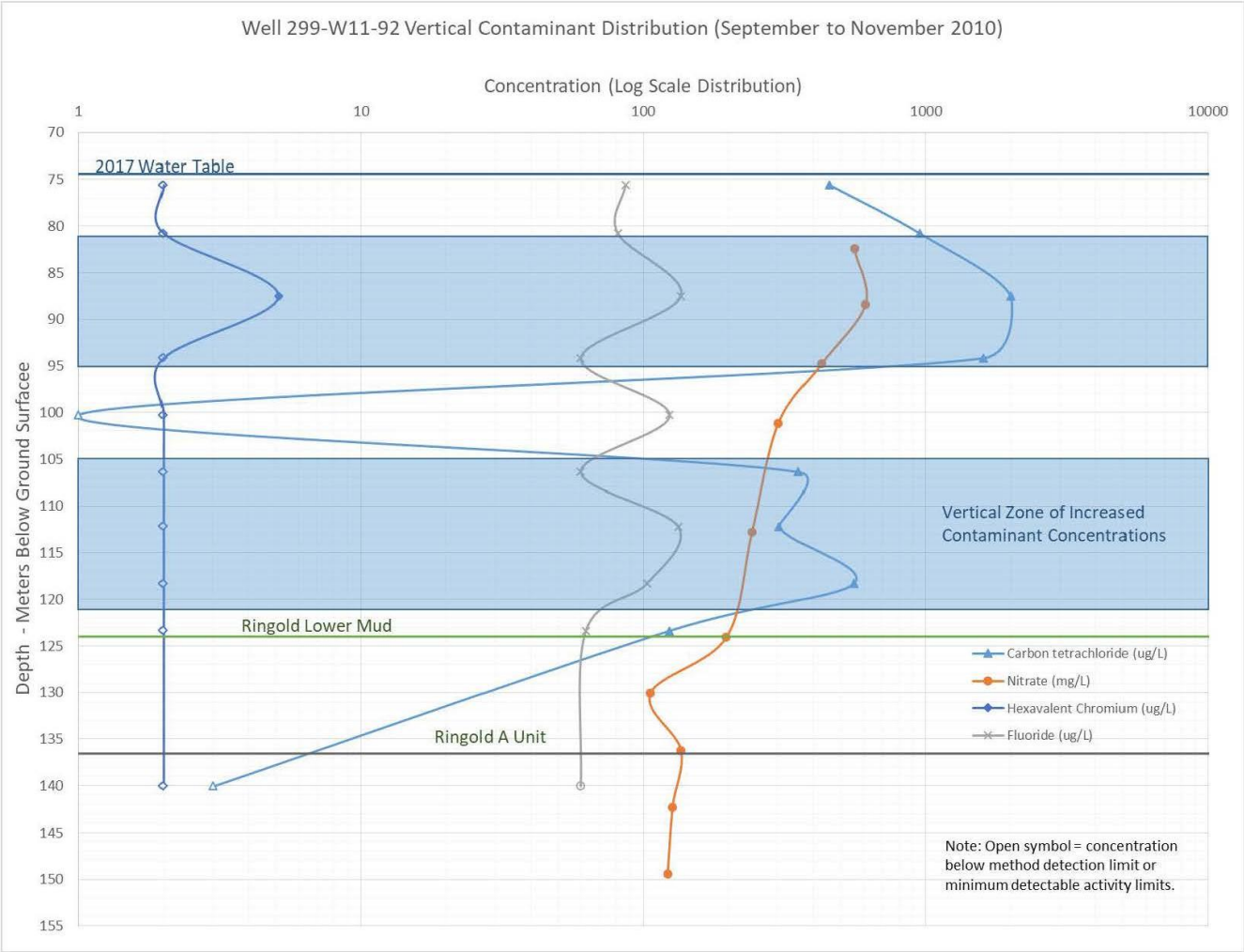


Figure 4-12. Vertical Contaminant Distribution Well 299-W11-92

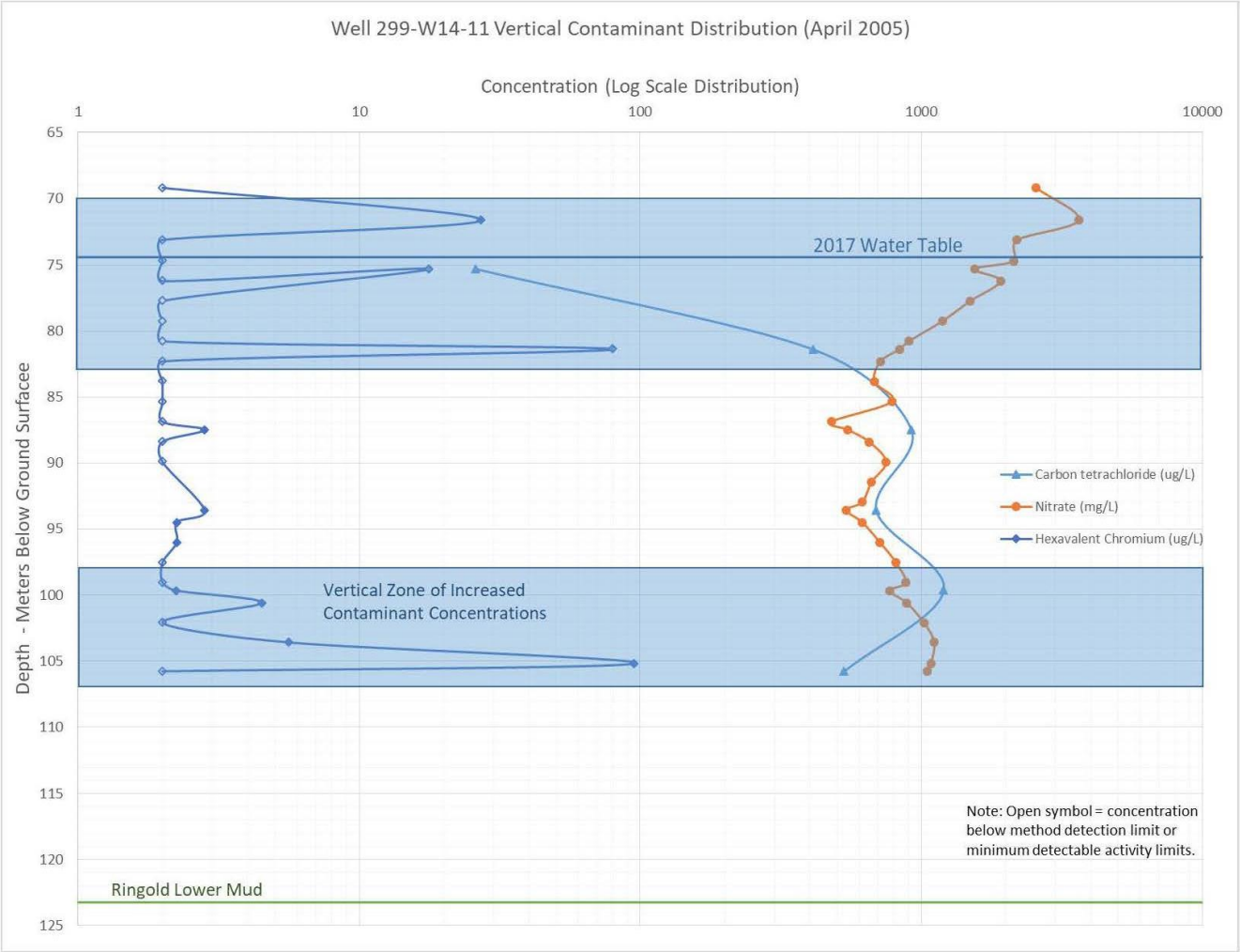


Figure 4-13. Vertical Contaminant Distribution Well 299-W14-11

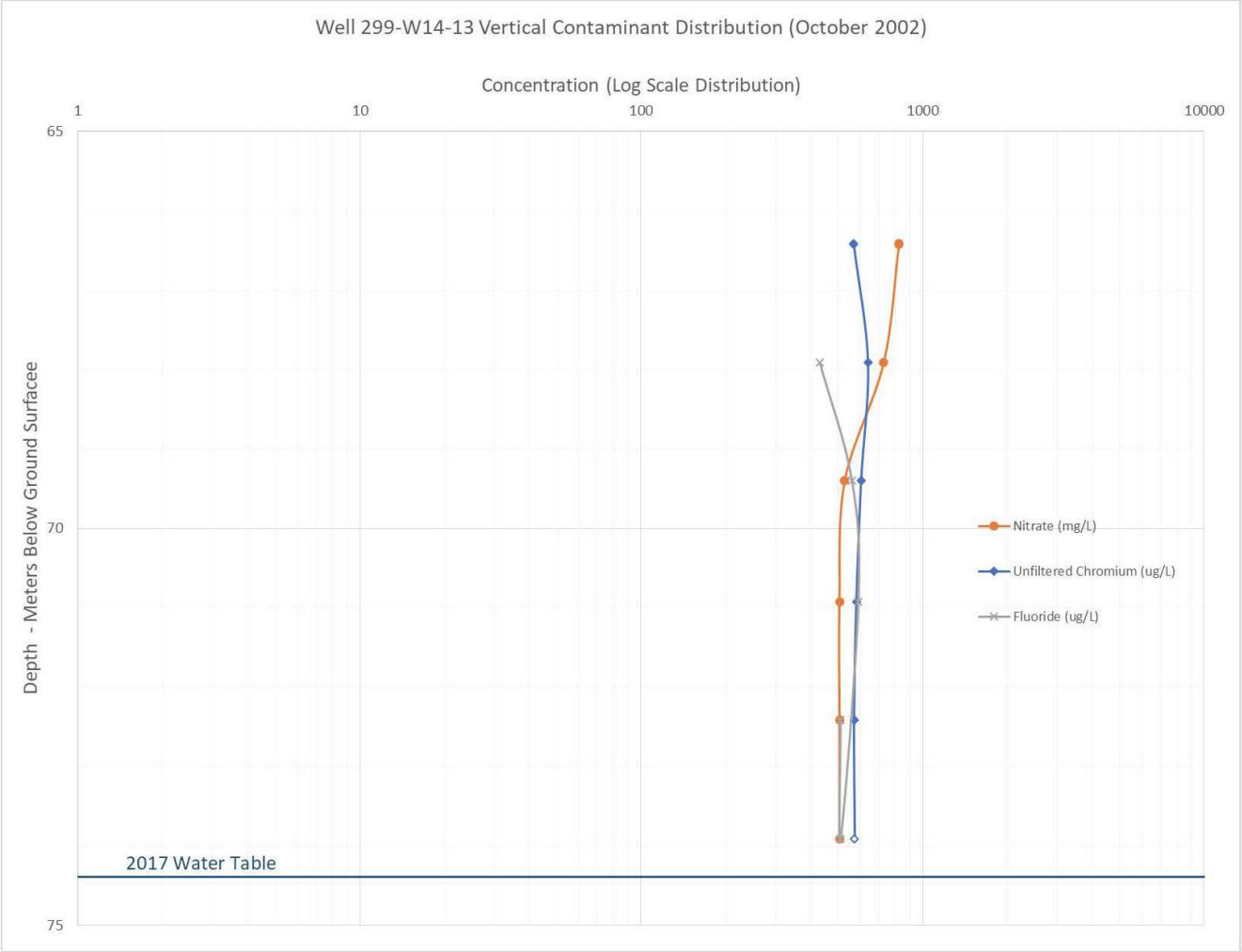


Figure 4-14. Vertical Contaminant Distribution Well 299-W14-13

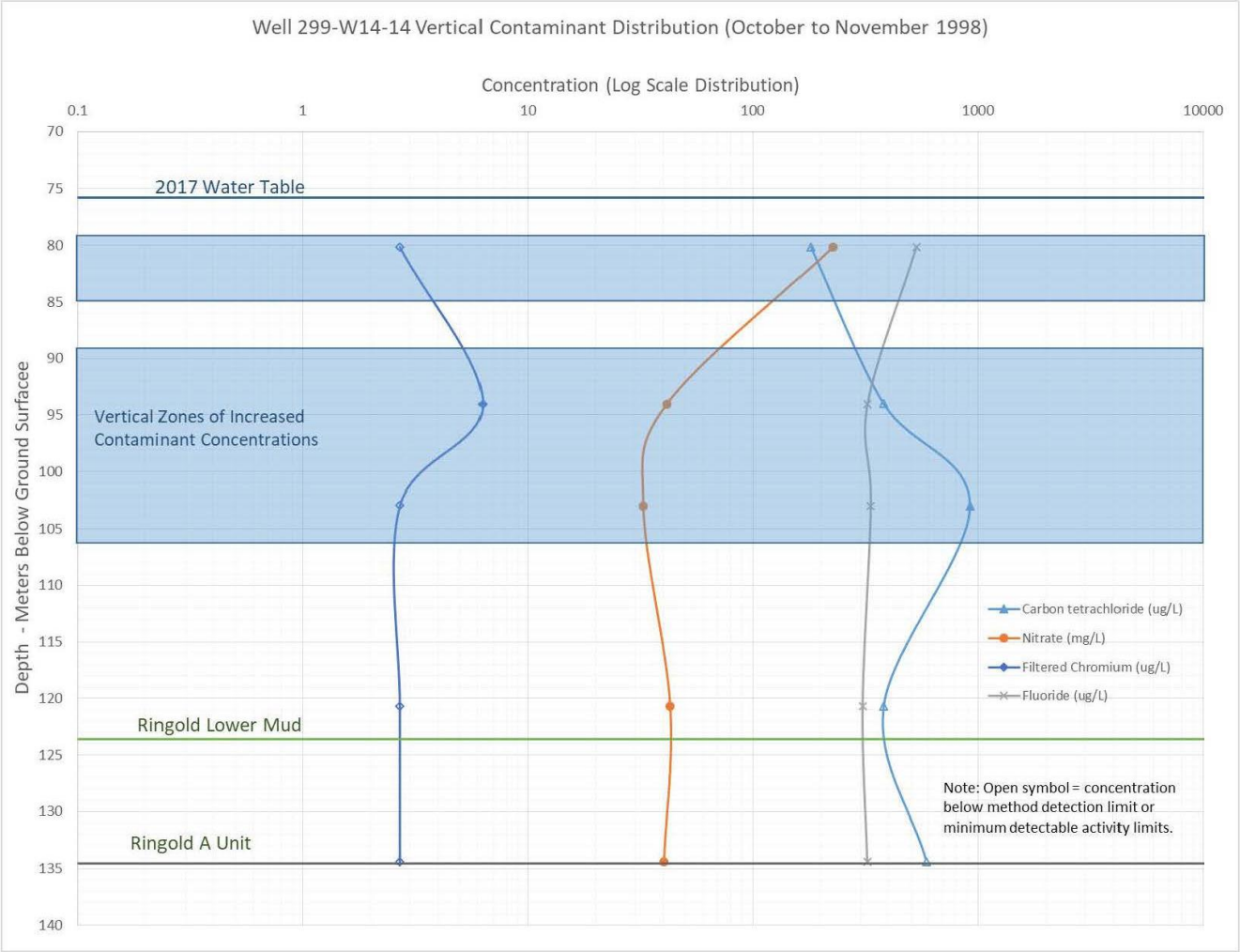


Figure 4-15. Vertical Contaminant Distribution Well 299-W14-14

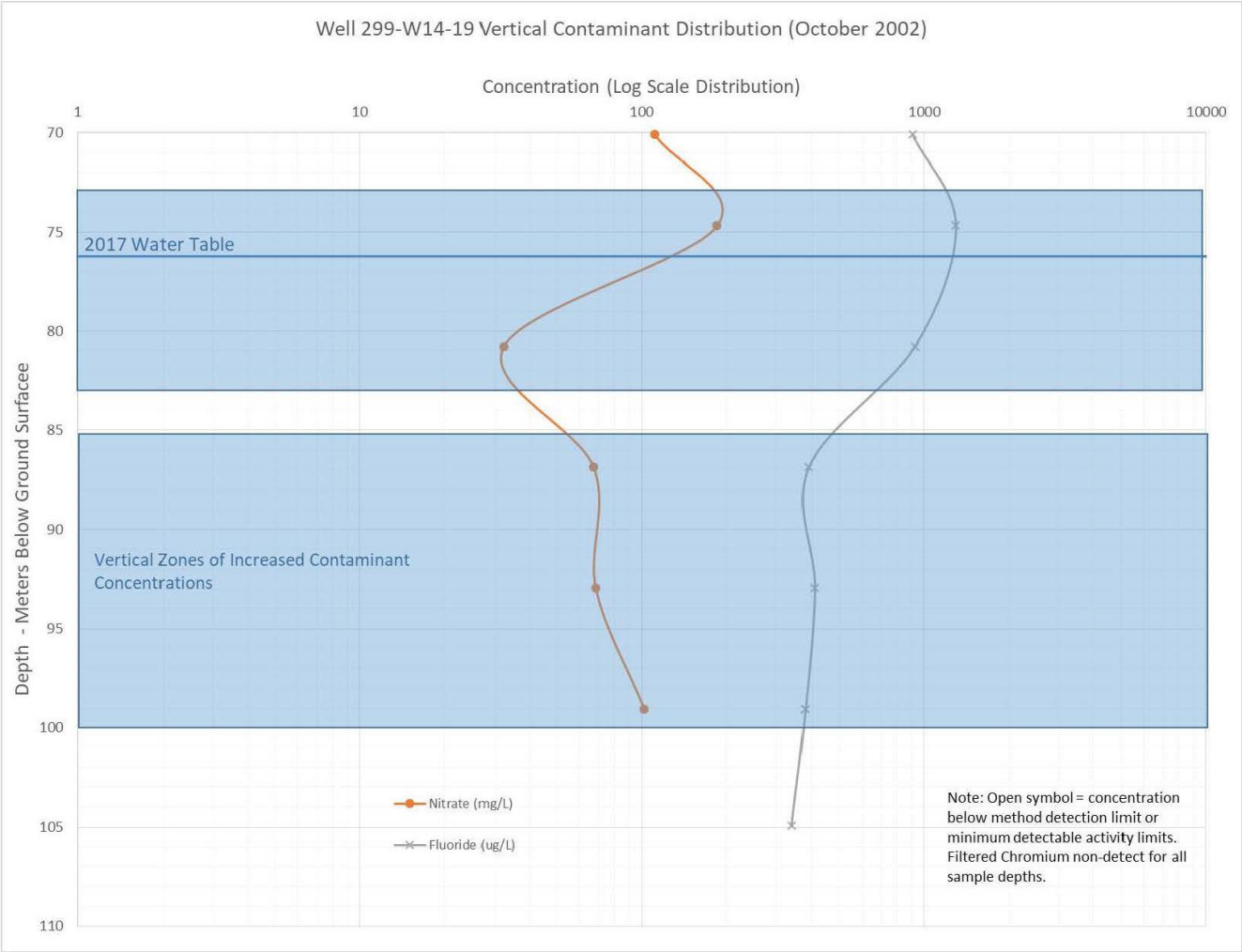


Figure 4-16. Vertical Contaminant Distribution Well 299-W14-19

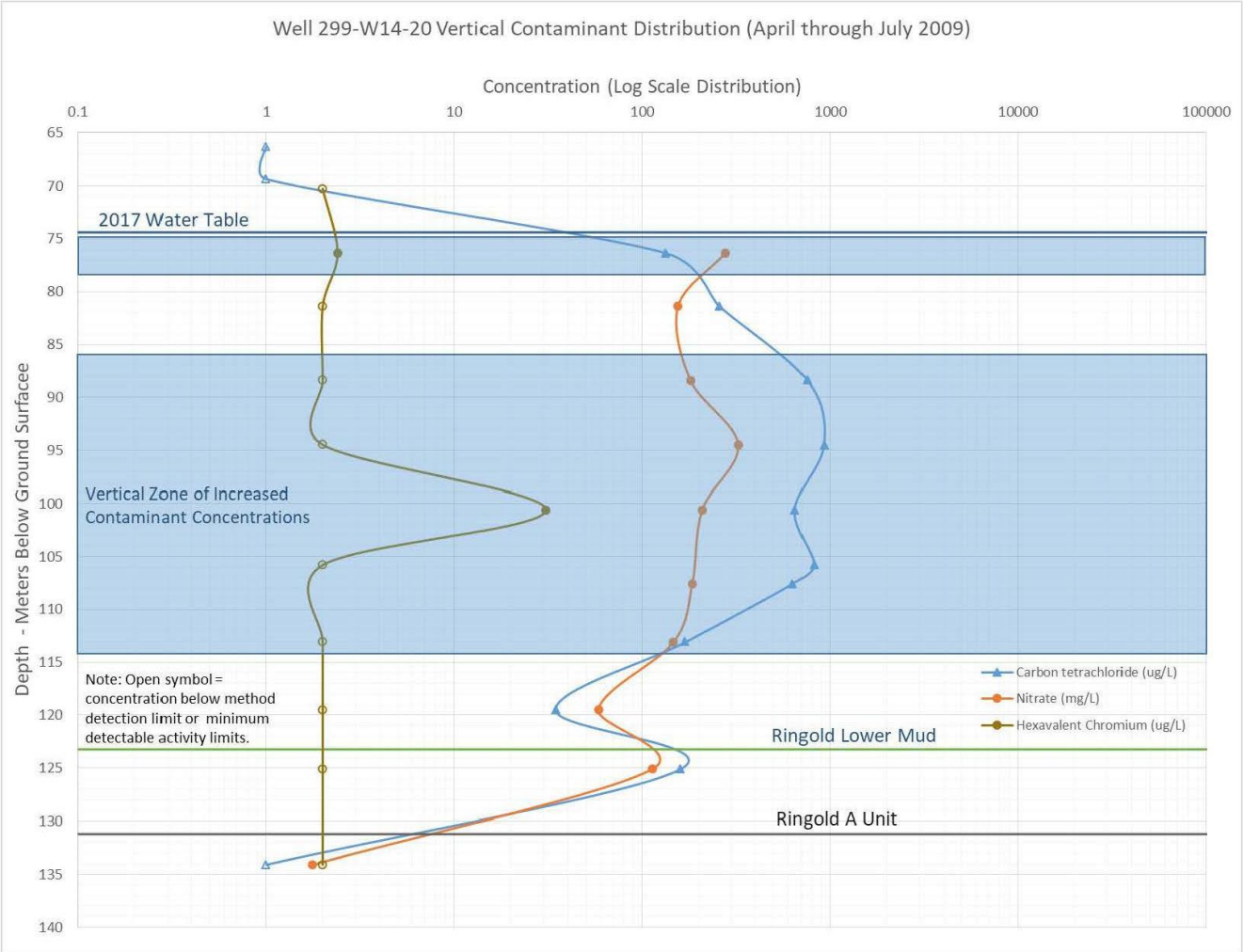


Figure 4-17. Vertical Contaminant Distribution Well 299-W14-20

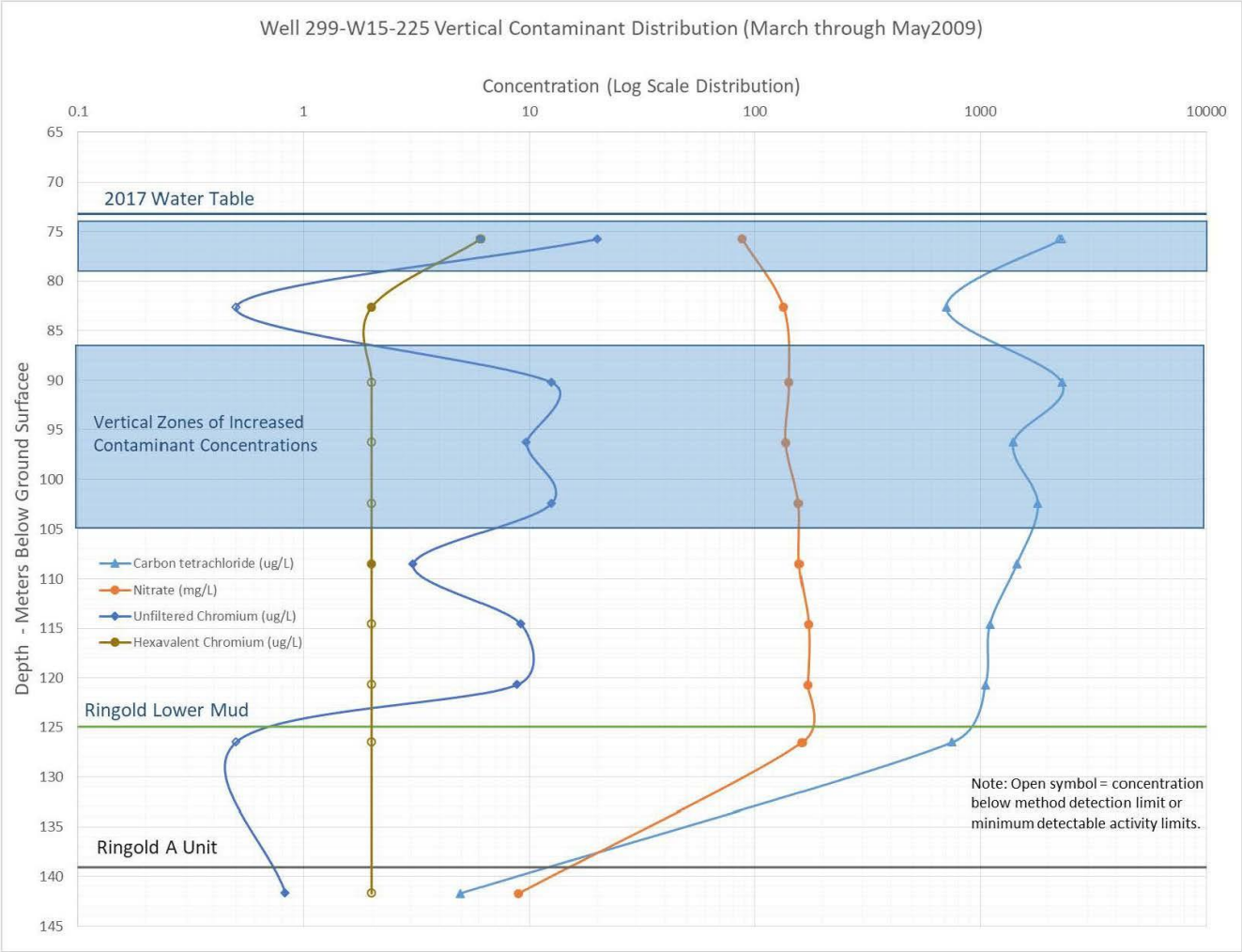


Figure 4-18. Vertical Contaminant Distribution Well 299-W15-225

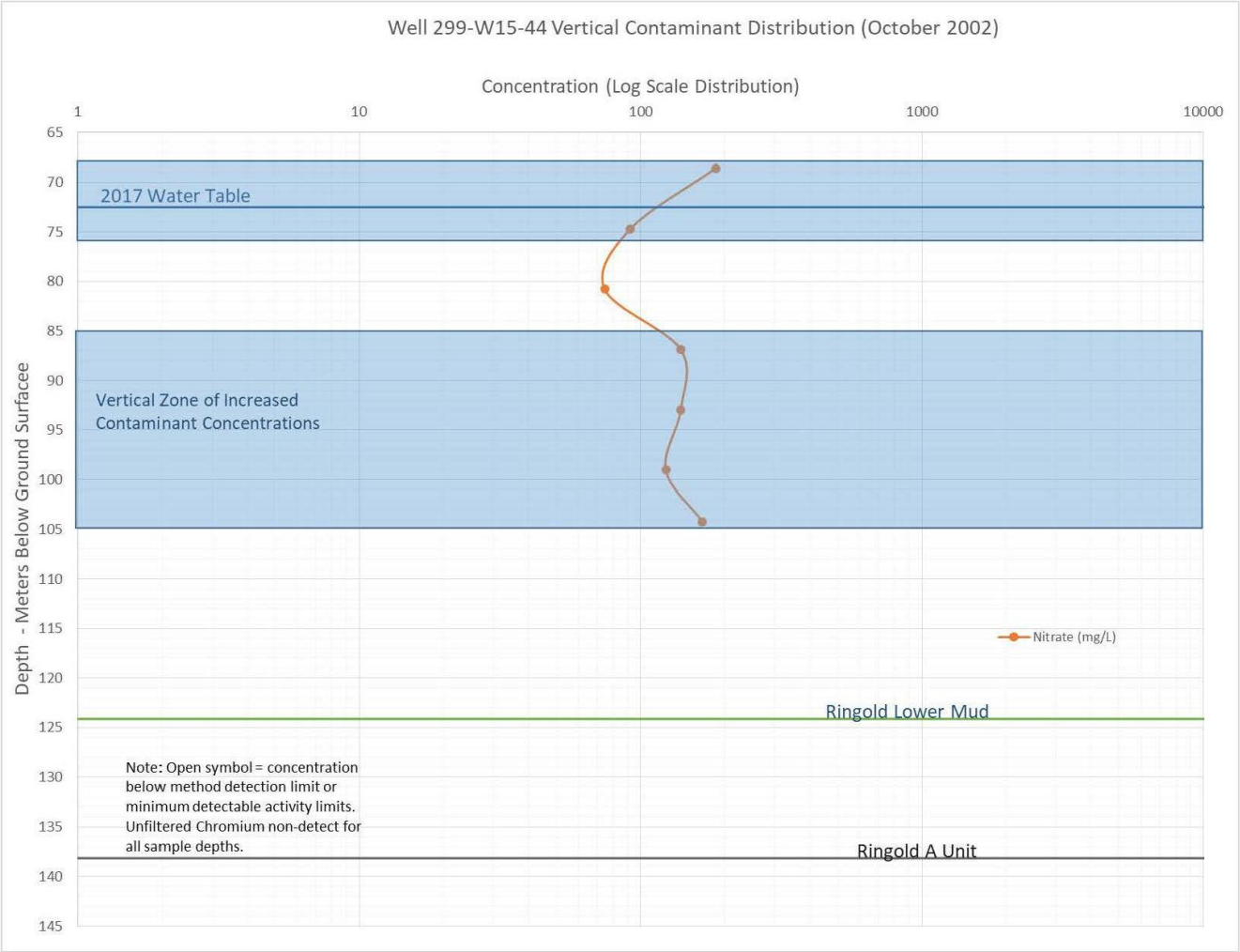
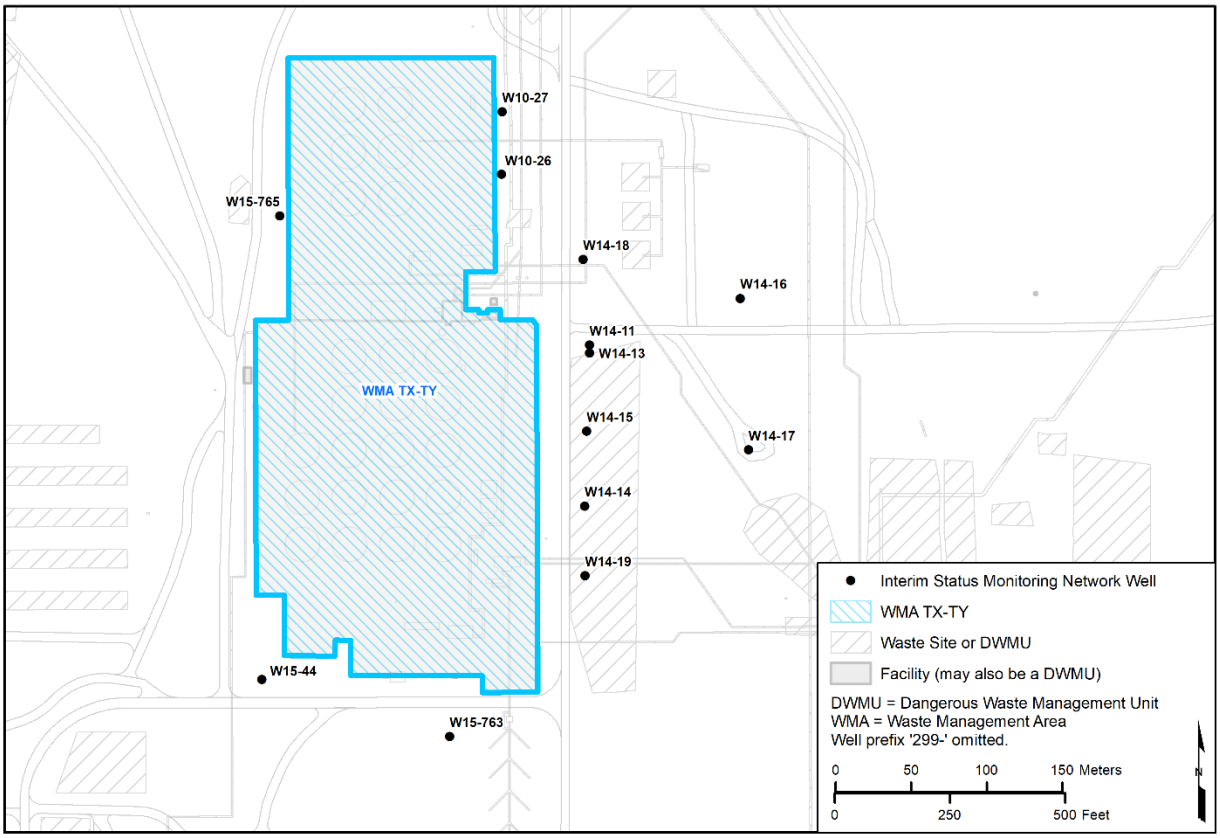


Figure 4-19. Vertical Contaminant Distribution Well 299-W15-44

5 Groundwater Flow Simulations

Groundwater flow simulations were conducted to evaluate the groundwater monitoring network for WMA TX-TY (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 3-17 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 TX-TY.



Source: Table 3-17 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*

Figure 5-1. Interim Status Groundwater Monitoring Network

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.

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.

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 TX-TY and to assist in determining whether adjustment to the monitoring network is needed.

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
		F	Injection wells 299-W10-35 and 299-W15-226 not operating.	1

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)	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 (comprised 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 (comprised 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.

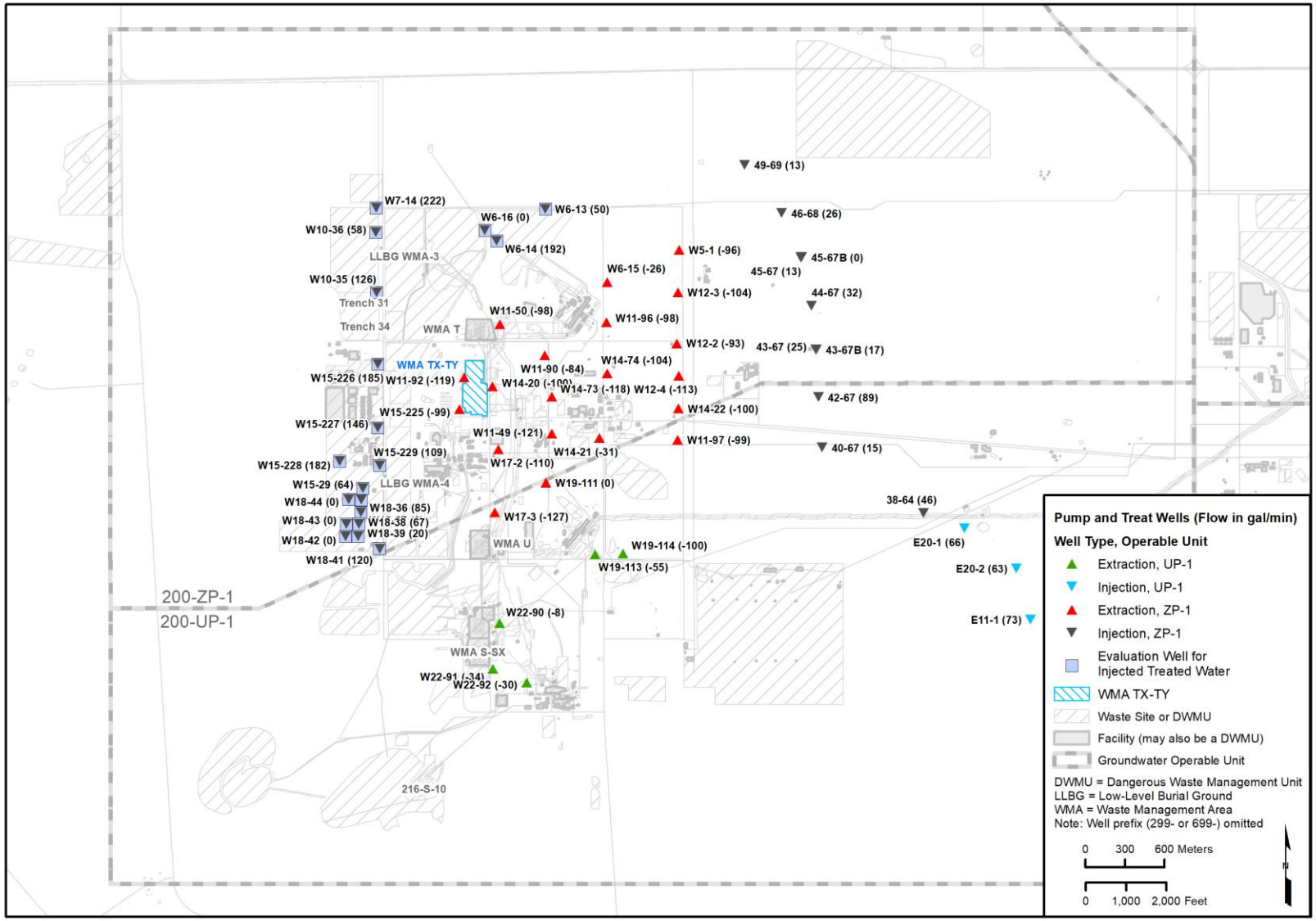


Figure 5-2. Locations and Average Pumping Rates (for December 2016) of 200 West P&T System Wells

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 TX-TY. The results of those simulations were used to evaluate the efficacy of the groundwater monitoring network to detect hypothetical releases from WMA TX-TY.

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 TX-TY. 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 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 TX-TY 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 TX-TY 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 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 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 predominantly 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/day	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 TX-TY, 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 12 SSTs located in WMA TX-TY. The particle release locations are shown in Figure 6-1 in Appendix G. These "focused releases" reflect hypothetical 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 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 within 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 TX-TY 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 TX-TY 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. 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 TX-TY 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.

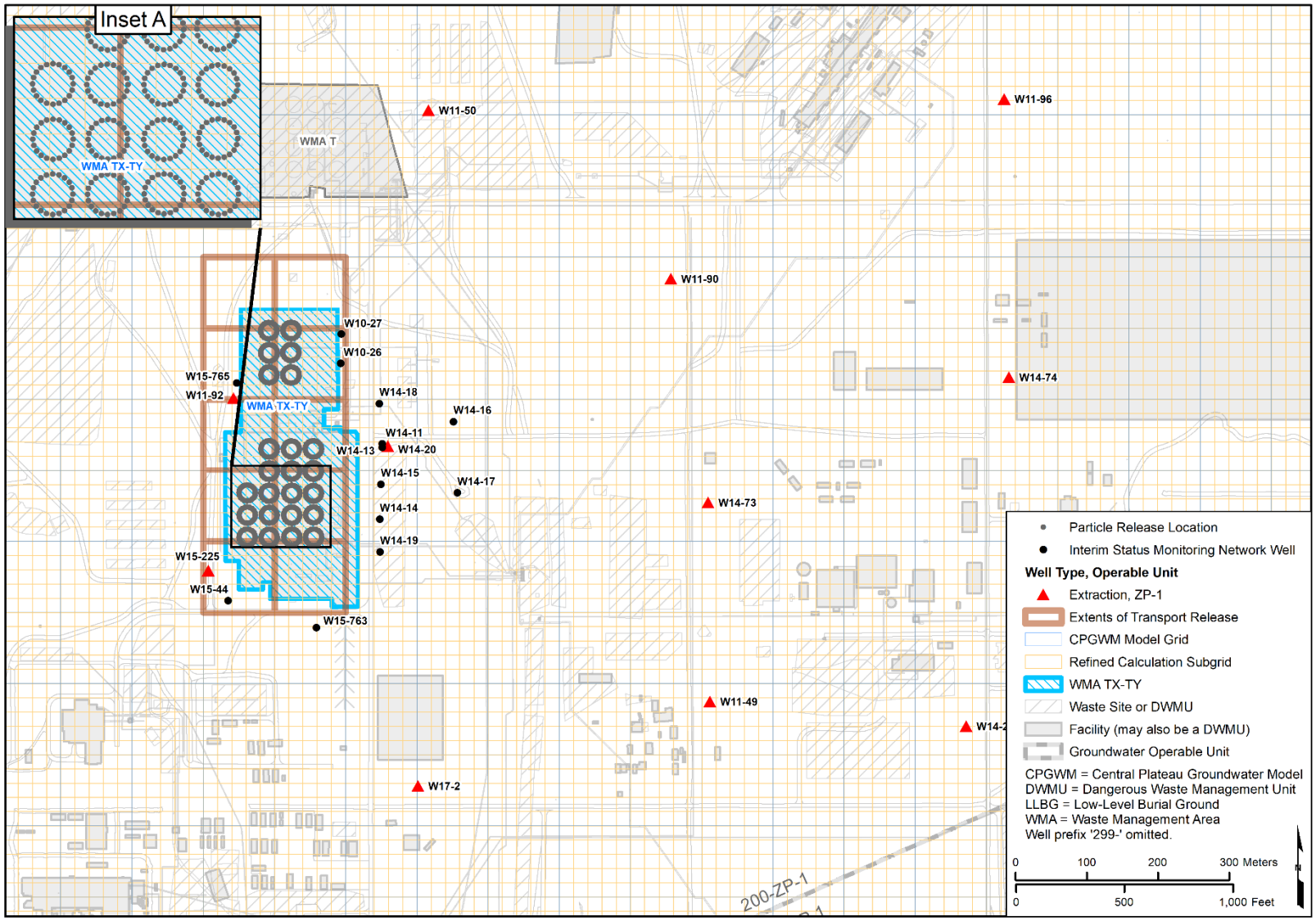


Figure 6-1. Location of Calculation Subgrid in Relation to 200 West Area Facilities Evaluated in Appendix F

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 TX-TY 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 TX-TY, unit concentrations representing the hypothetical contaminant release were released at the water table in ten model grid cells representing WMA TX-TY (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 TX-TY and to detect increases in contamination from known releases from the facility 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 facility's 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 the facility.

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 have higher dilutions from injected treated water and which are likely to have more detectable concentrations from releases from the facility. 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 of 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 TX-TY would most likely migrate and be detectable. The relative detectability maps are discussed in Section 7.2. Section 7.3 presents an evaluation of the proposed 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-W10-26, 299-W10-27, 299-W14-11, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-16, 299-W14-17, 299-W14-18, 299-W14-19, 299-W15-44, 299-W15-763, and 299-W15-765 (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 injected 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 7-13 show the injected treated water dilution breakthrough curves for monitoring wells 299-W10-26, 299-W10-27, 299-W14-11, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-16, 299-W14-17, 299-W14-18, 299-W14-19, 299-W15-44, 299-W15-763, and 299-W15-765, 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.

Each well and each sub-scenario has a unique injected treated water dilution breakthrough curve. The treated water breakthrough curves for the southern monitoring wells are generally consistent for the various sub-scenarios whereas the curves for the northern monitoring wells vary significantly. This result suggests that varying the injection well operations influences the treated water observed at the northern monitoring wells, but has little influence for the southern monitoring wells. This is likely due to the significant distance between the majority of the injection wells and the WMA TX-TY monitoring network wells. For all the evaluated monitoring well locations, the curves for sub-scenarios N and R, which represent extreme operational conditions in southernmost injection wells, were the primary outliers. These sub-scenarios have weights of 3% and 1%, respectively, indicating relatively low probability of occurrence. The results for scenario 2 (included in Appendix G) were similar to those for scenario 1.

At WMA TX-TY, the zero starting point in 2012 for the injected treated water dilution breakthrough curves in Figures 7-1 through 7-13 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.

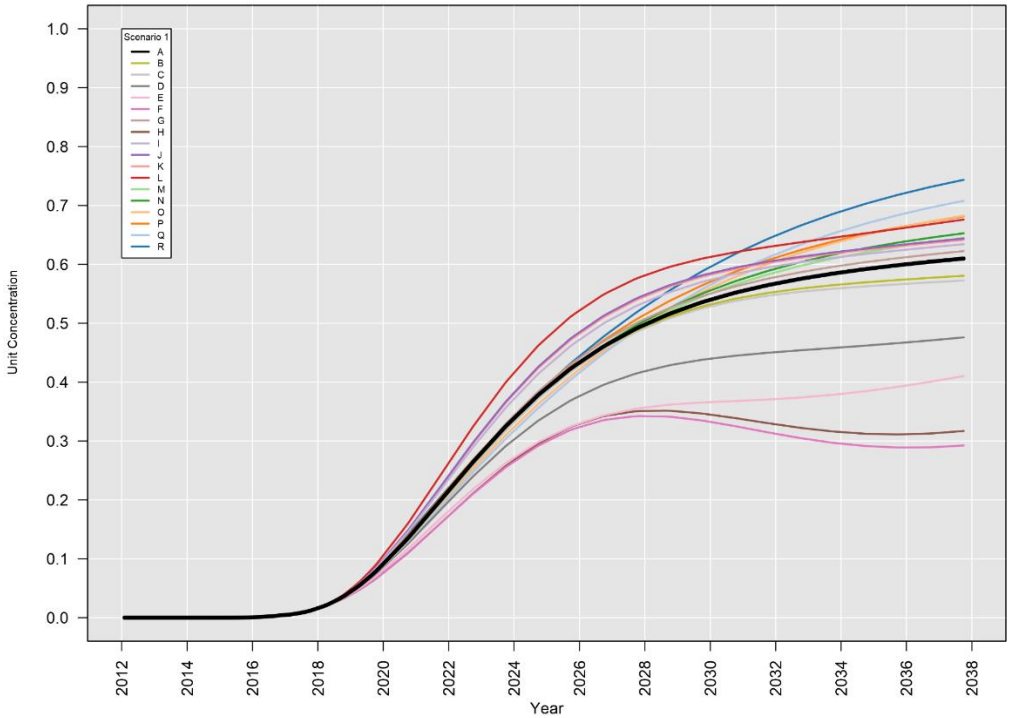


Figure 7-1. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W10-26

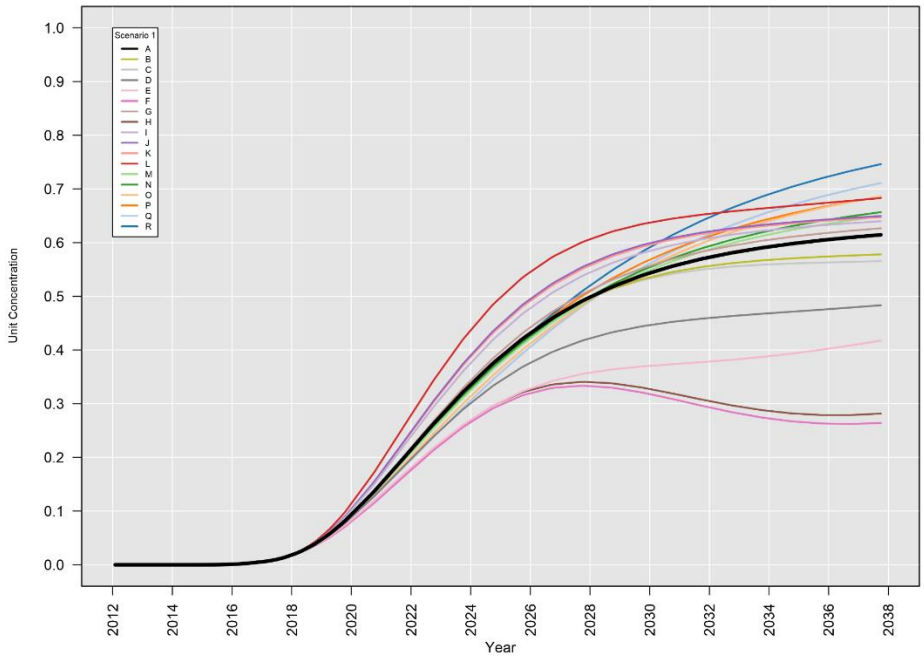


Figure 7-2. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W10-27

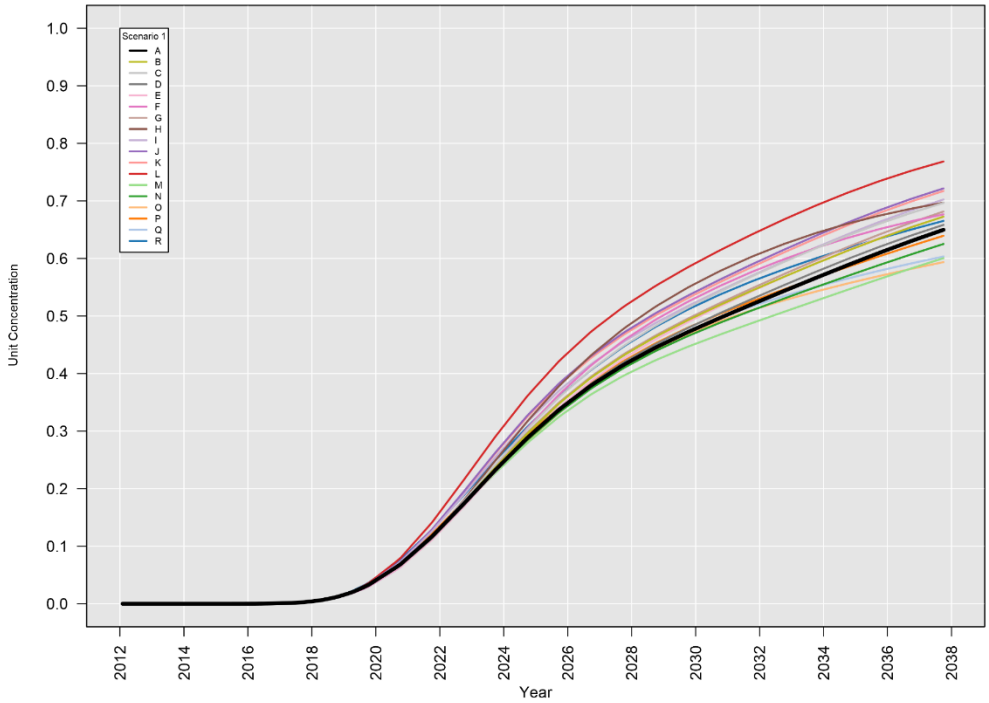


Figure 7-3. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W14-11

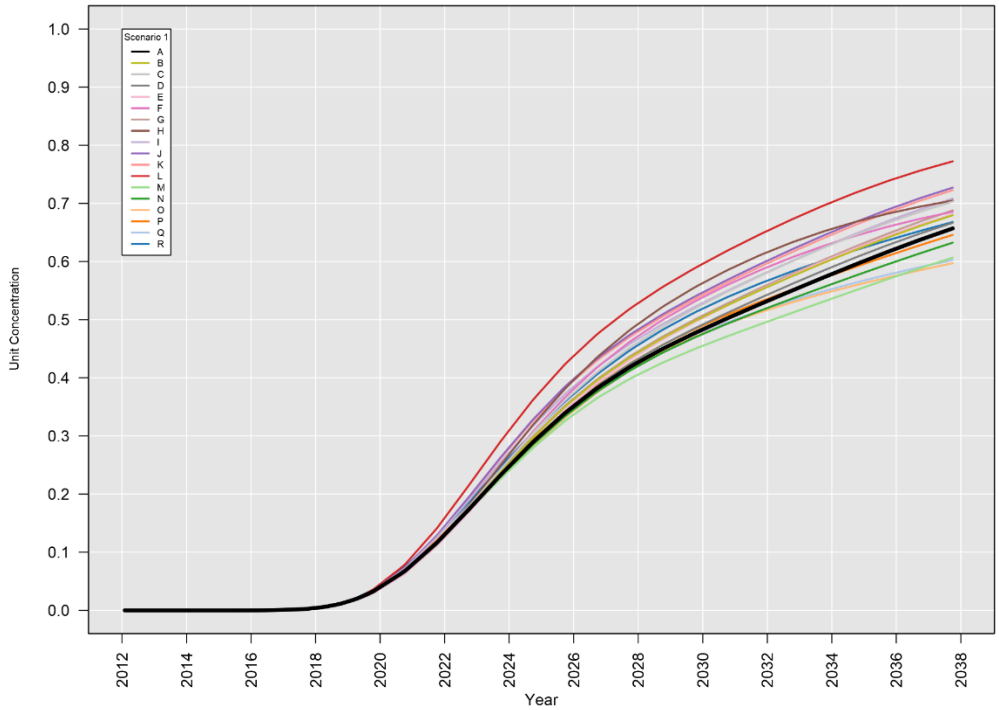


Figure 7-4. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W14-13

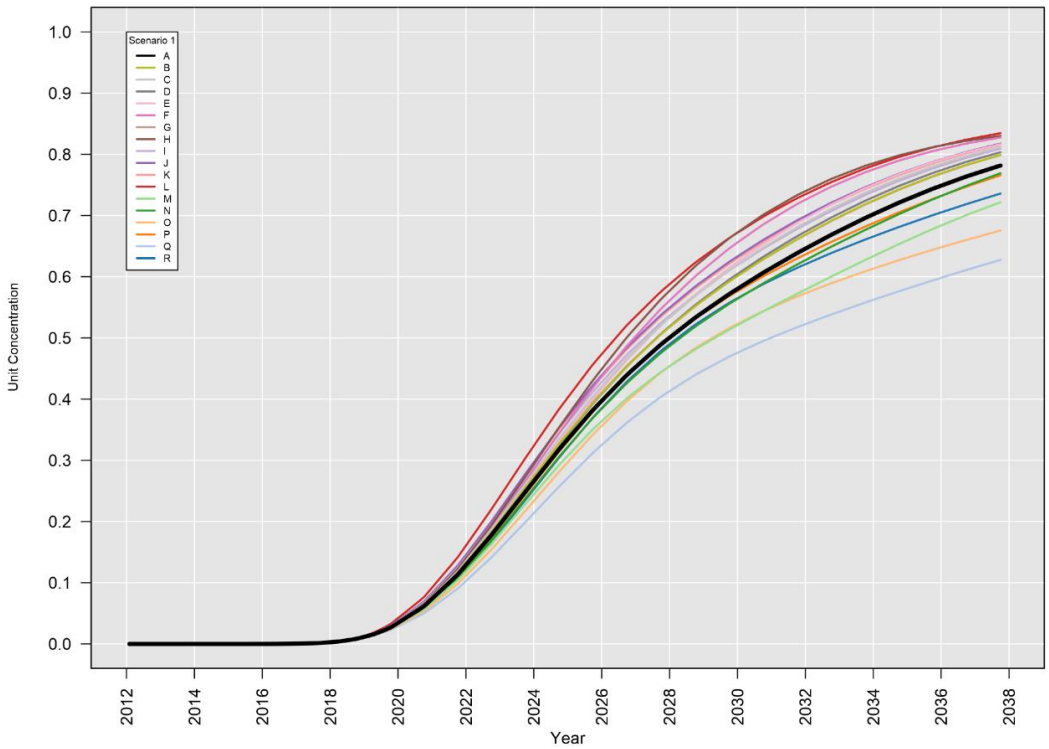


Figure 7-5. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W14-14

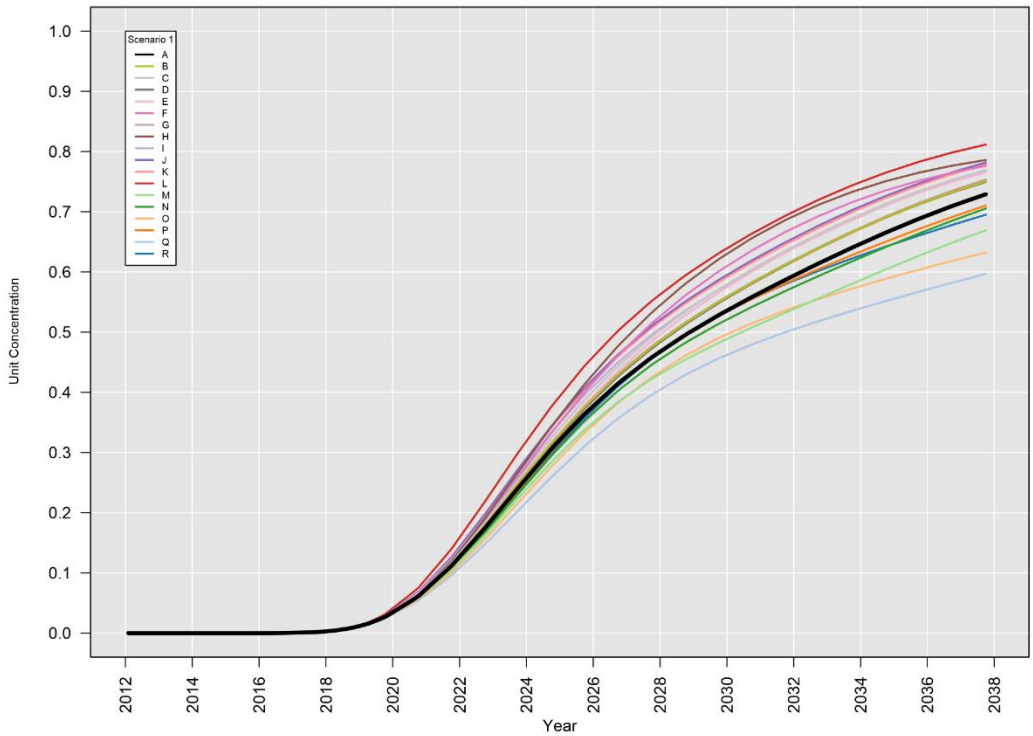


Figure 7-6. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W14-15

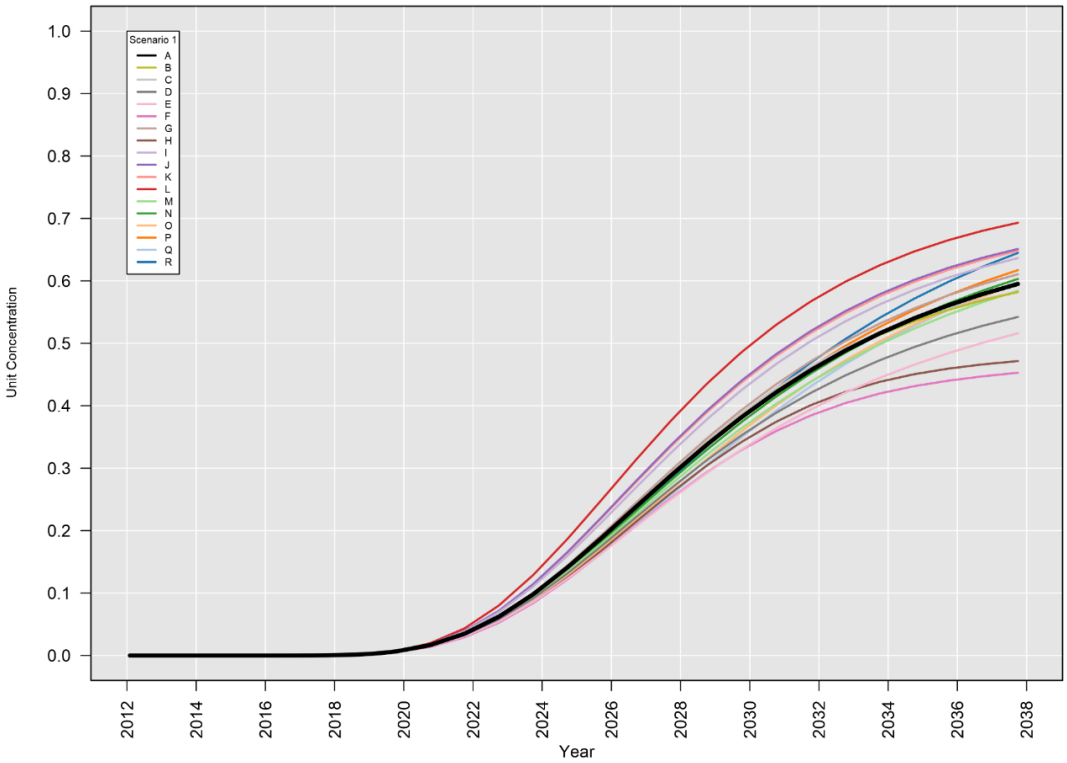


Figure 7-7. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W14-16

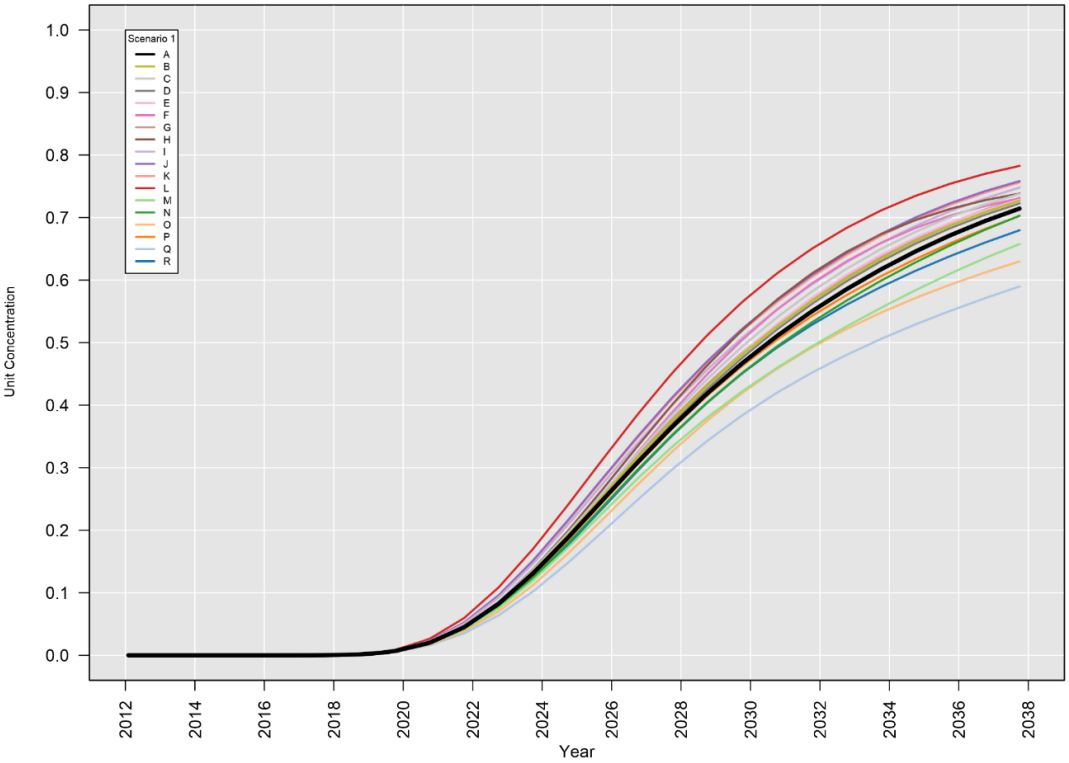


Figure 7-8. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W14-17

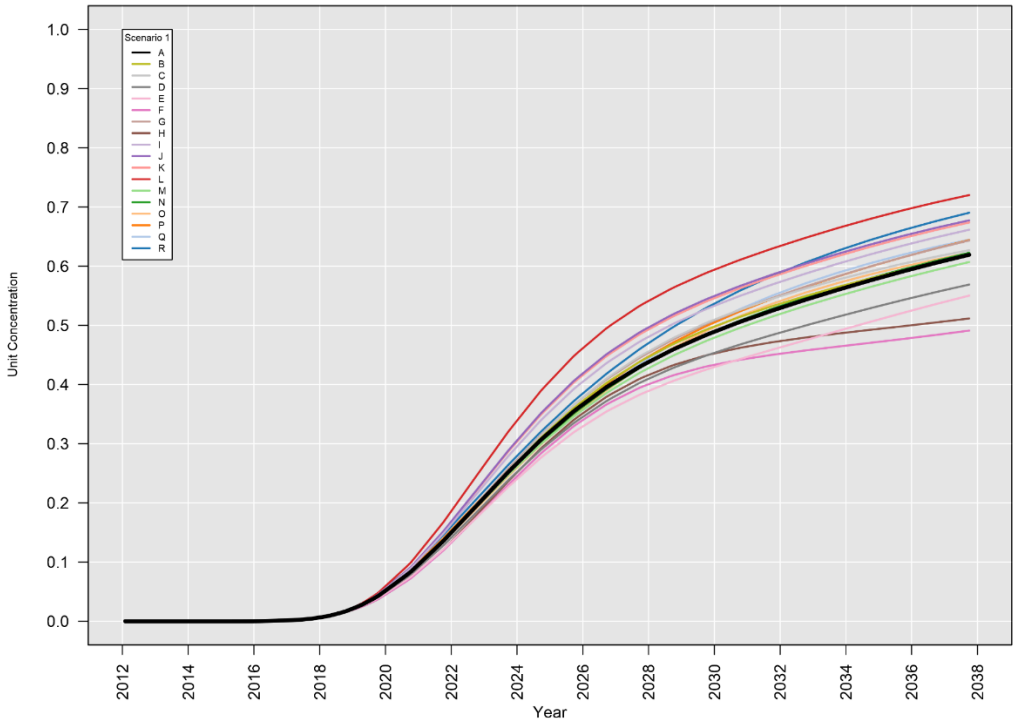


Figure 7-9. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W14-18

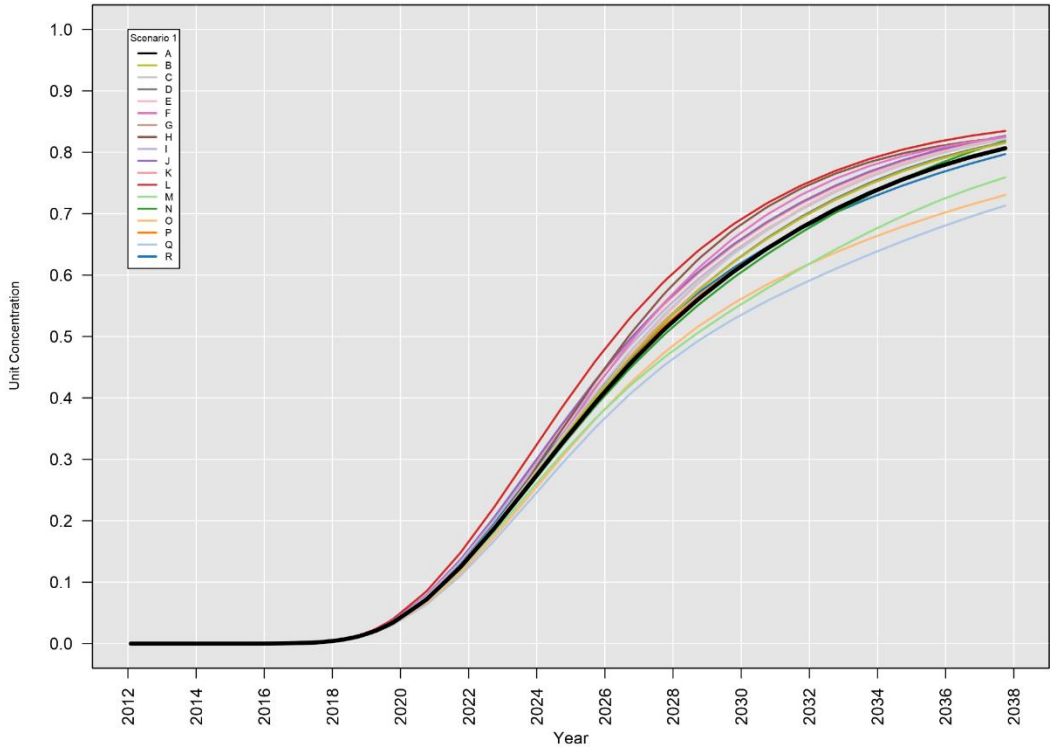


Figure 7-10. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W14-19

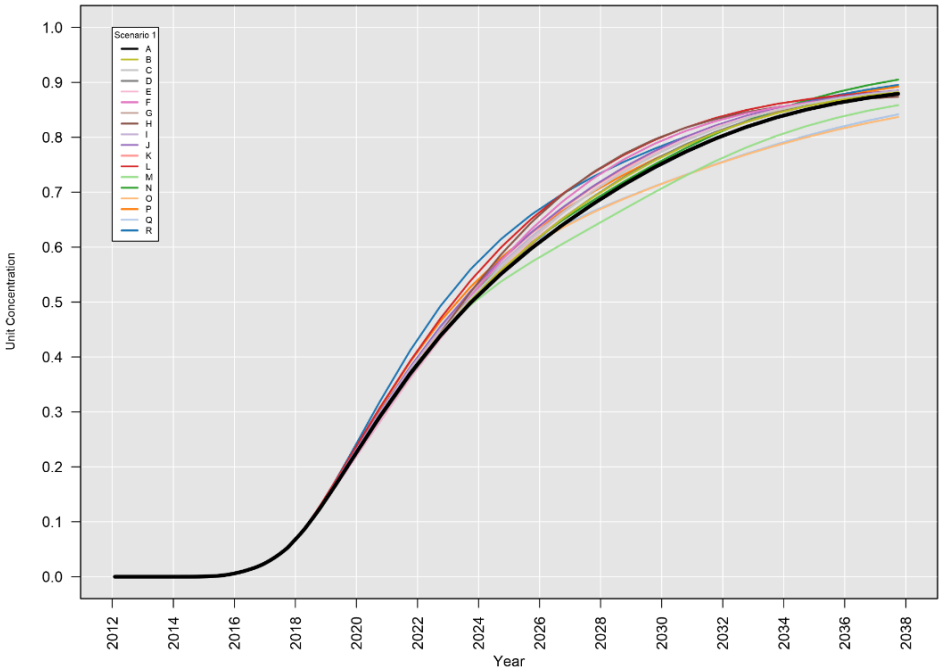


Figure 7-11. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W15-44

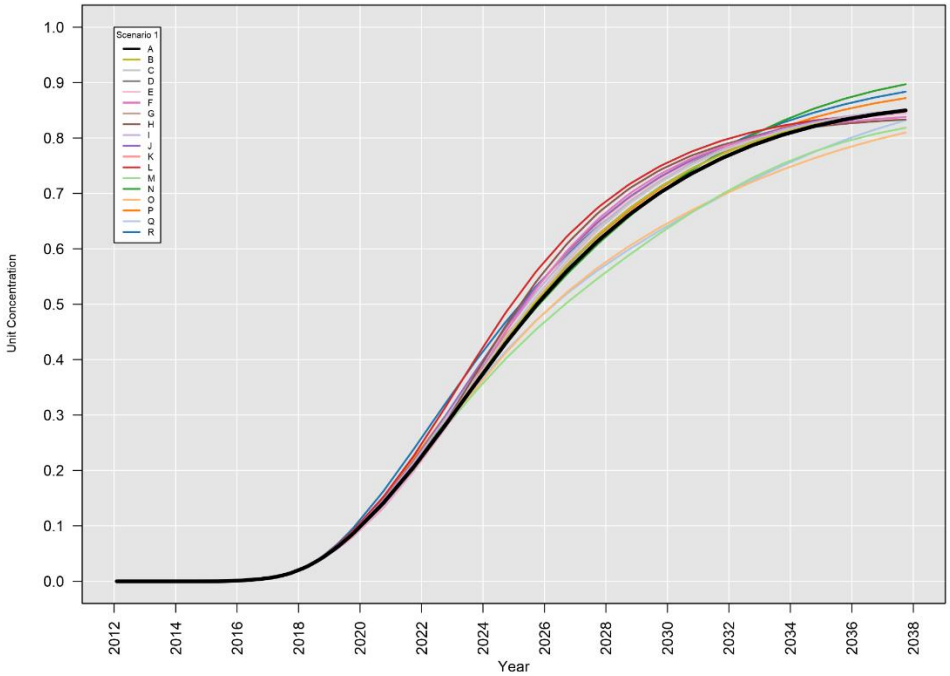


Figure 7-12. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W15-763

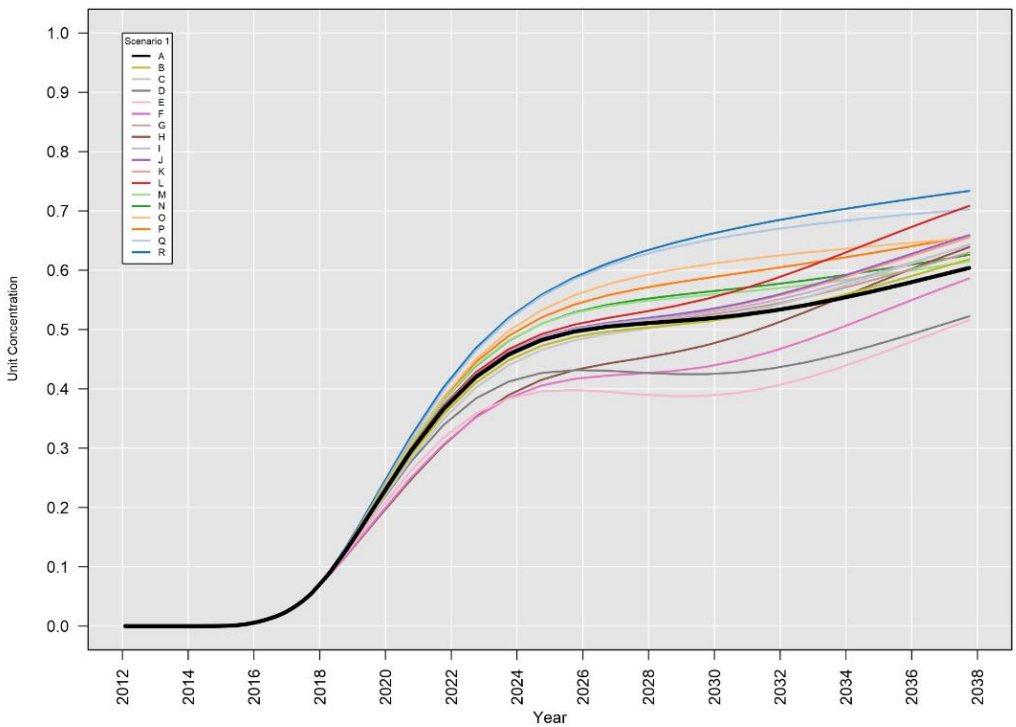


Figure 7-13. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Monitoring Well 299-W15-765

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-W10-26	1	0.292	0.744	0.606
	2	0.332	0.744	0.630
299-W10-27	1	0.264	0.746	0.610
	2	0.296	0.746	0.632
299-W14-11	1	0.594	0.768	0.656
	2	0.625	0.795	0.691
299-W14-13	1	0.597	0.772	0.663
	2	0.628	0.798	0.697
299-W14-14	1	0.628	0.835	0.780
	2	0.666	0.847	0.807
299-W14-15	1	0.597	0.812	0.730
	2	0.634	0.830	0.762
299-W14-16	1	0.453	0.693	0.595
	2	0.484	0.715	0.627
299-W14-17	1	0.590	0.783	0.714
	2	0.632	0.799	0.745

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-W14-18	1	0.491	0.720	0.622
	2	0.528	0.745	0.652
299-W14-19	1	0.713	0.835	0.805
	2	0.749	0.851	0.825
299-W15-44	1	0.837	0.905	0.879
	2	0.858	0.923	0.889
299-W15-763	1	0.810	0.897	0.849
	2	0.831	0.916	0.859
299-W15-765	1	0.516	0.734	0.615
	2	0.556	0.744	0.647

The release concentration breakthrough curves for monitoring wells 299-W10-26, 299-W10-27, 299-W14-11, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-16, 299-W14-17, 299-W14-18, 299-W14-19, 299-W15-44, 299-W15-763, and 299-W15-765 for all sub-scenarios of scenario 1 are shown in Figures 7-14 through 7-26, respectively. The figures, which depict the simulated breakthrough of a unit source release to the groundwater table from WMA TX-TY, 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.

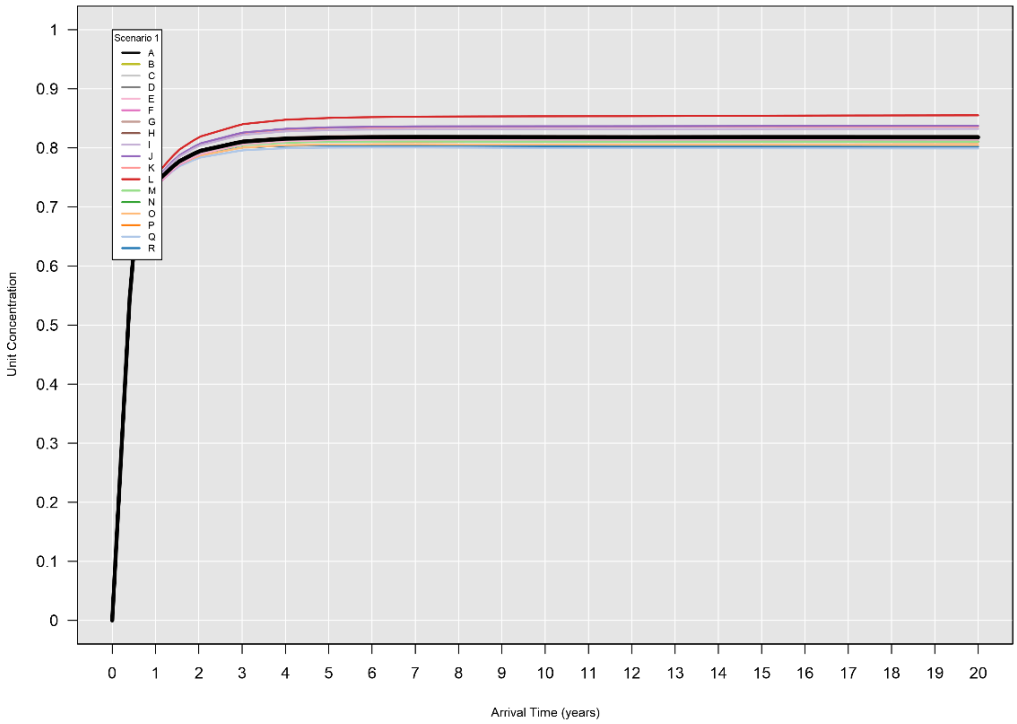


Figure 7-14. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W10-26

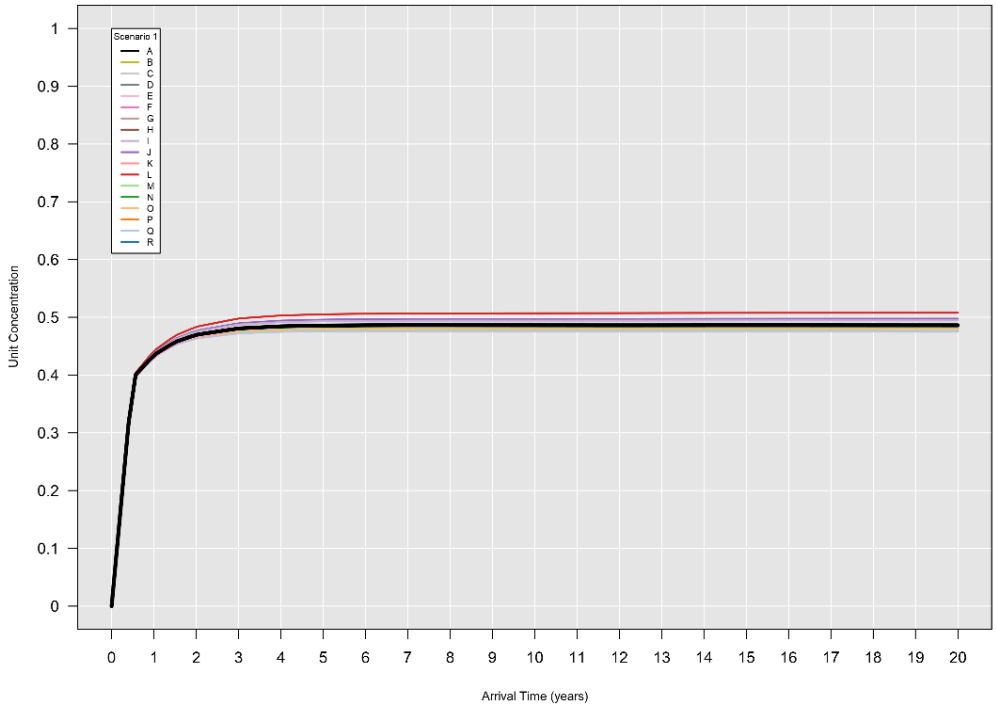


Figure 7-15. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W10-27

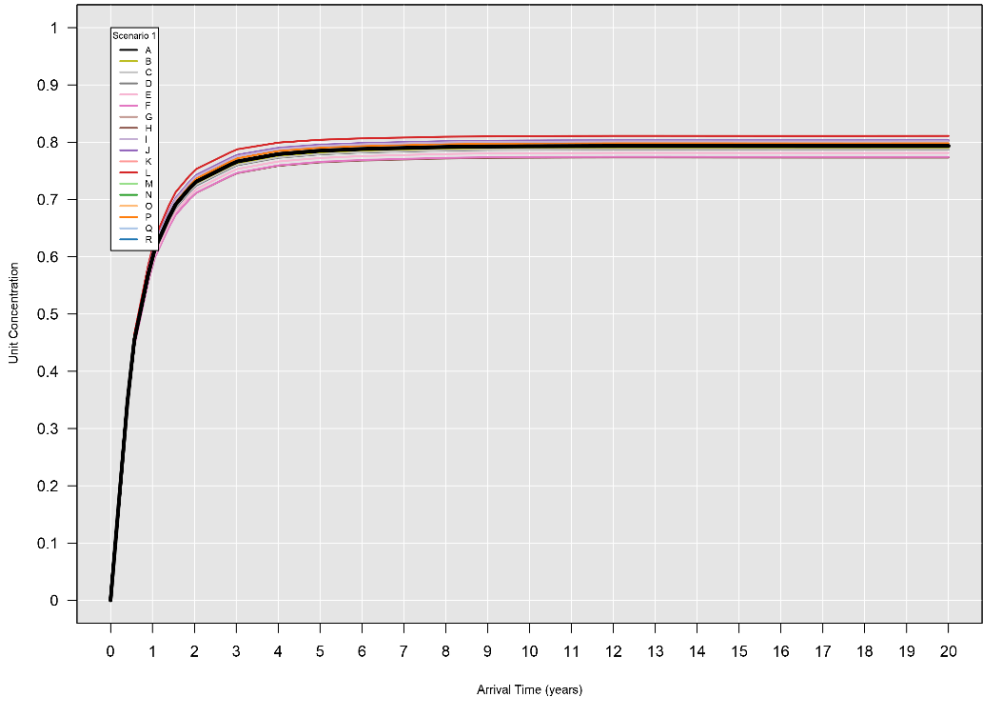


Figure 7-16. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W14-11

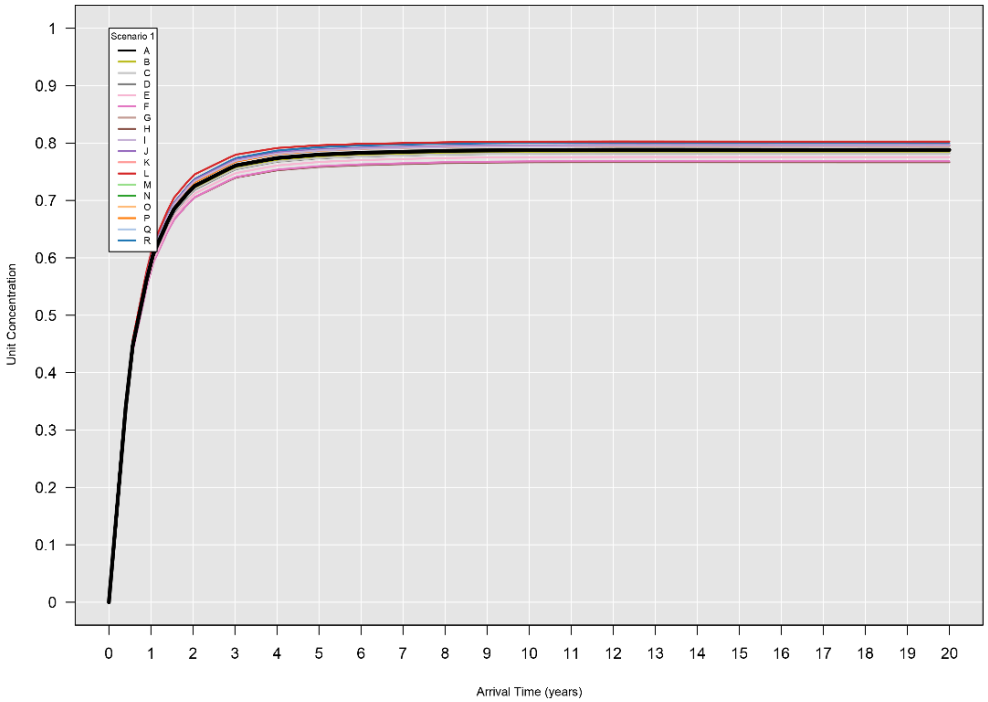


Figure 7-17. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W14-13

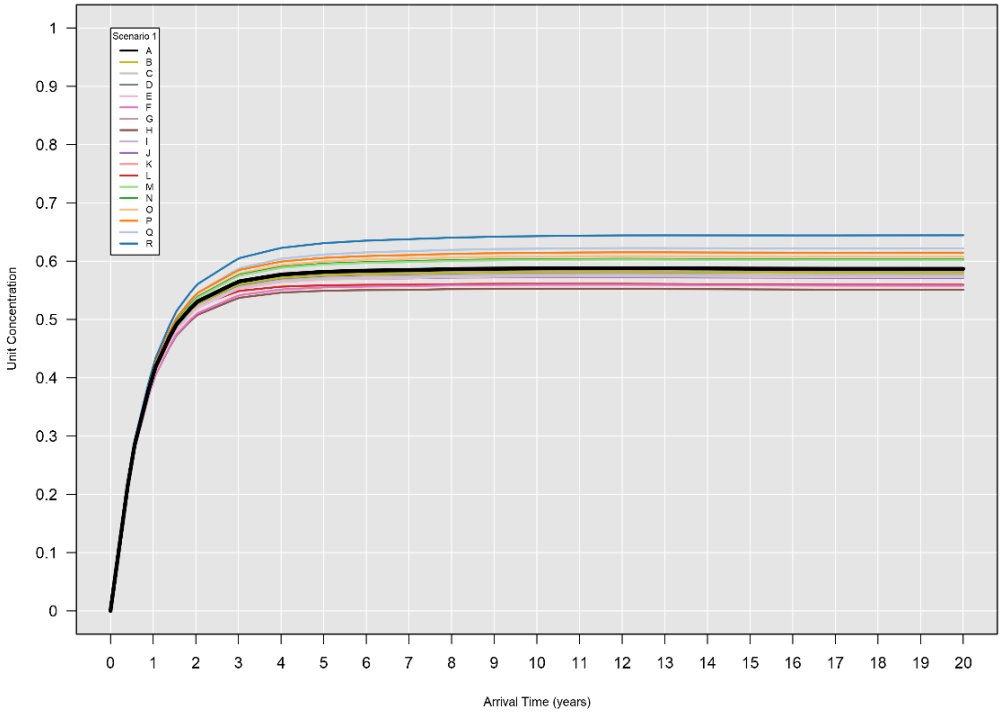


Figure 7-18. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W14-14

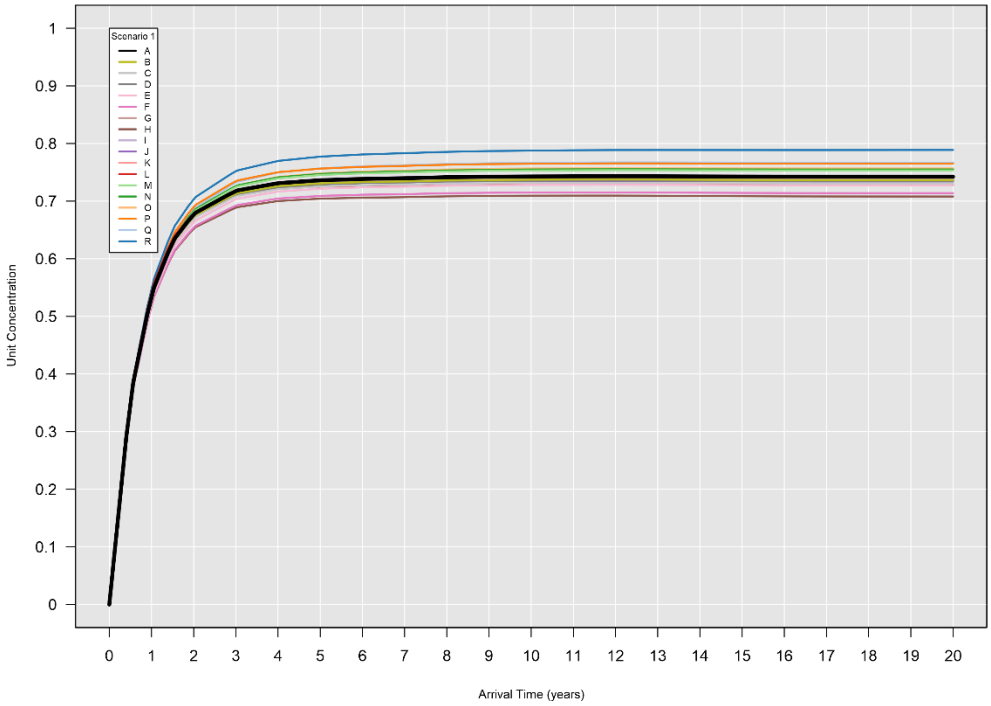


Figure 7-19. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W14-15

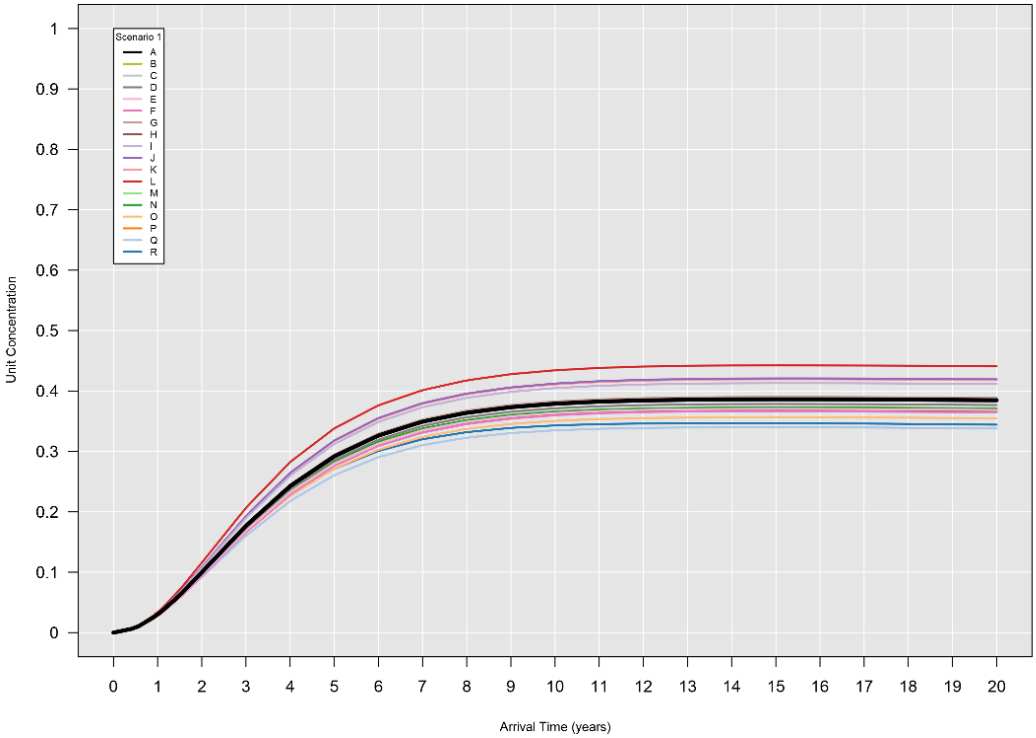


Figure 7-20. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W14-16

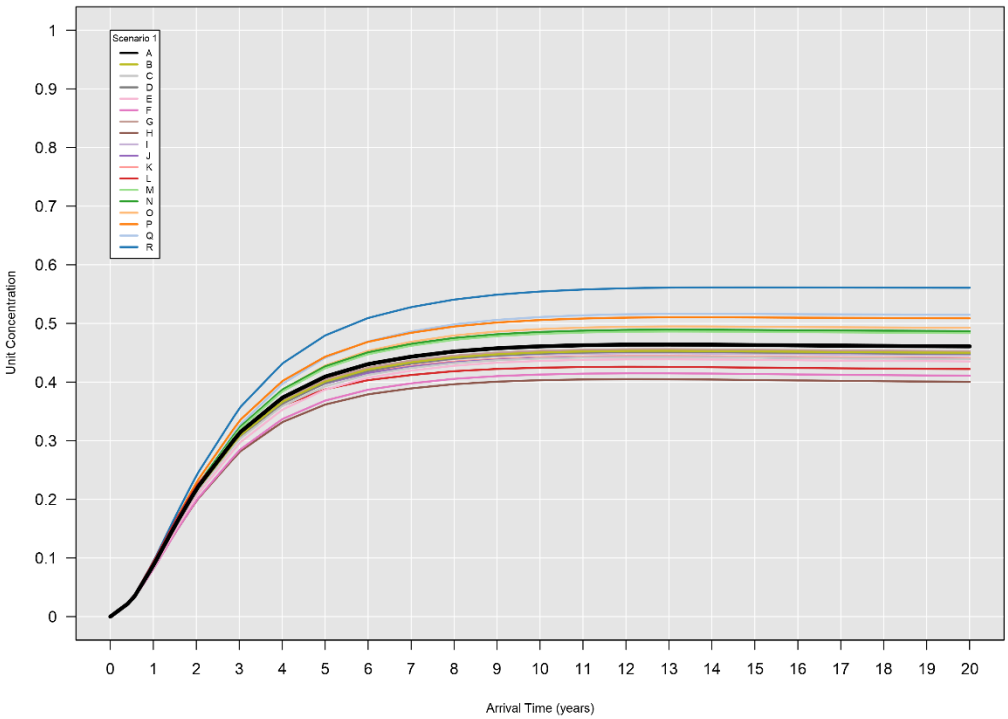


Figure 7-21. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W14-17

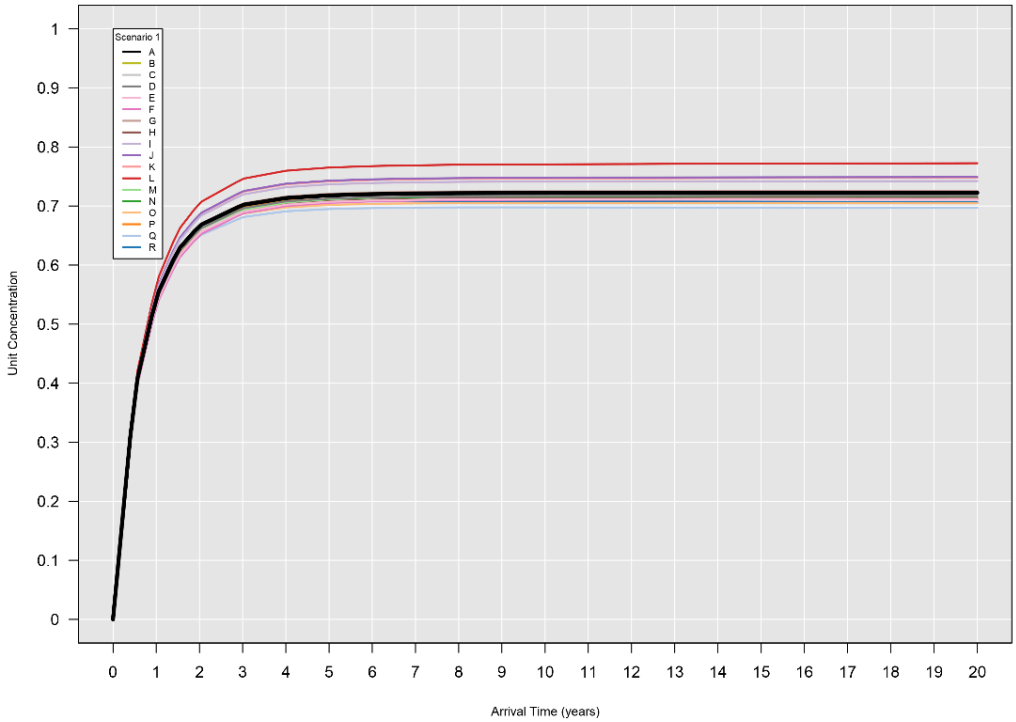


Figure 7-22. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W14-18

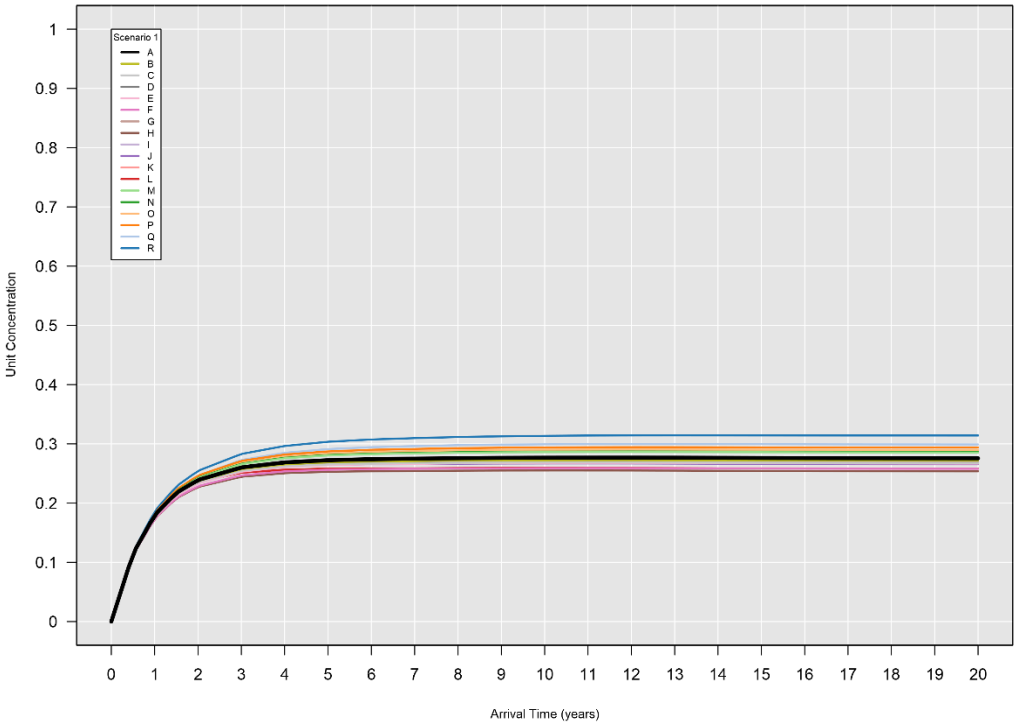


Figure 7-23. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W14-19

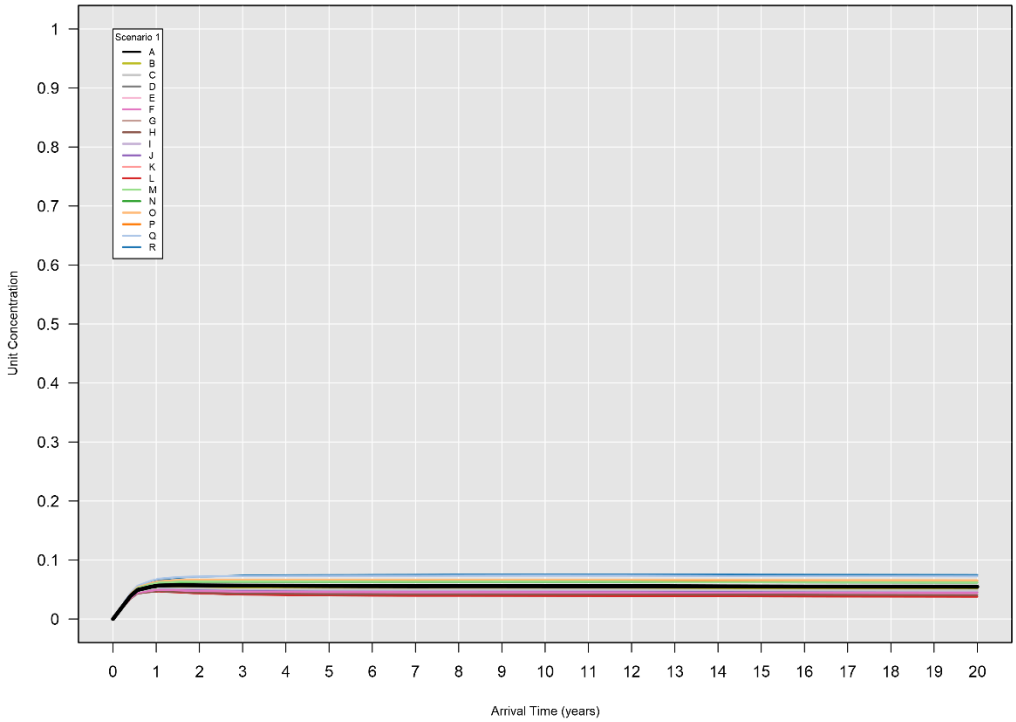


Figure 7-24. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W15-44

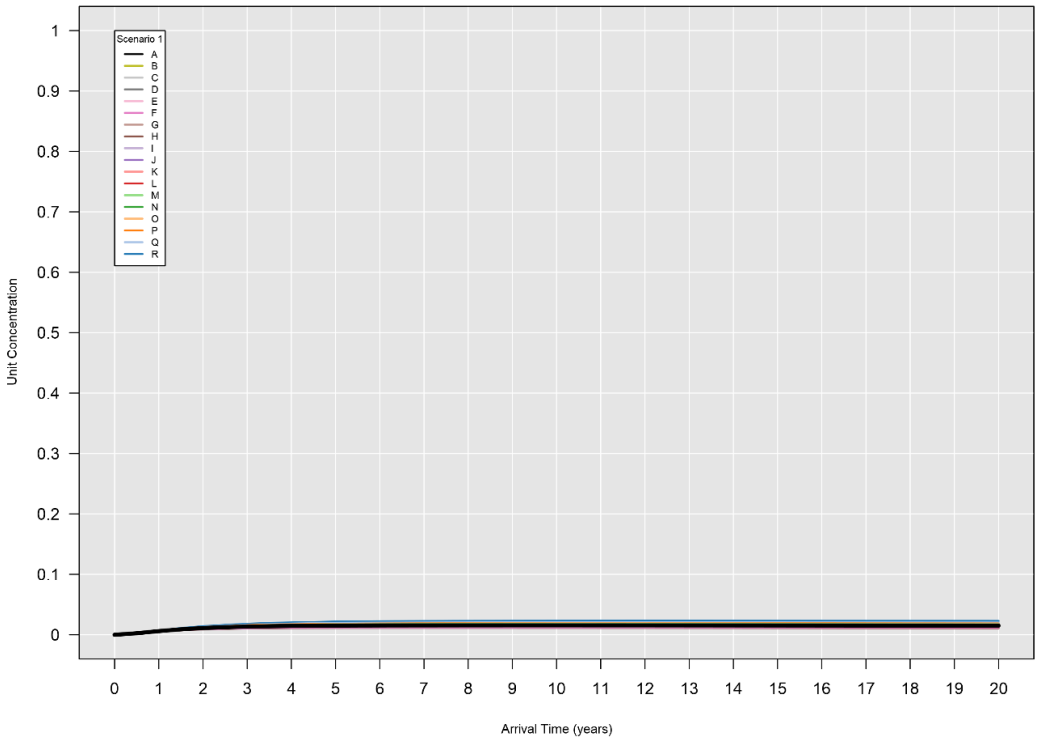


Figure 7-25. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W15-763

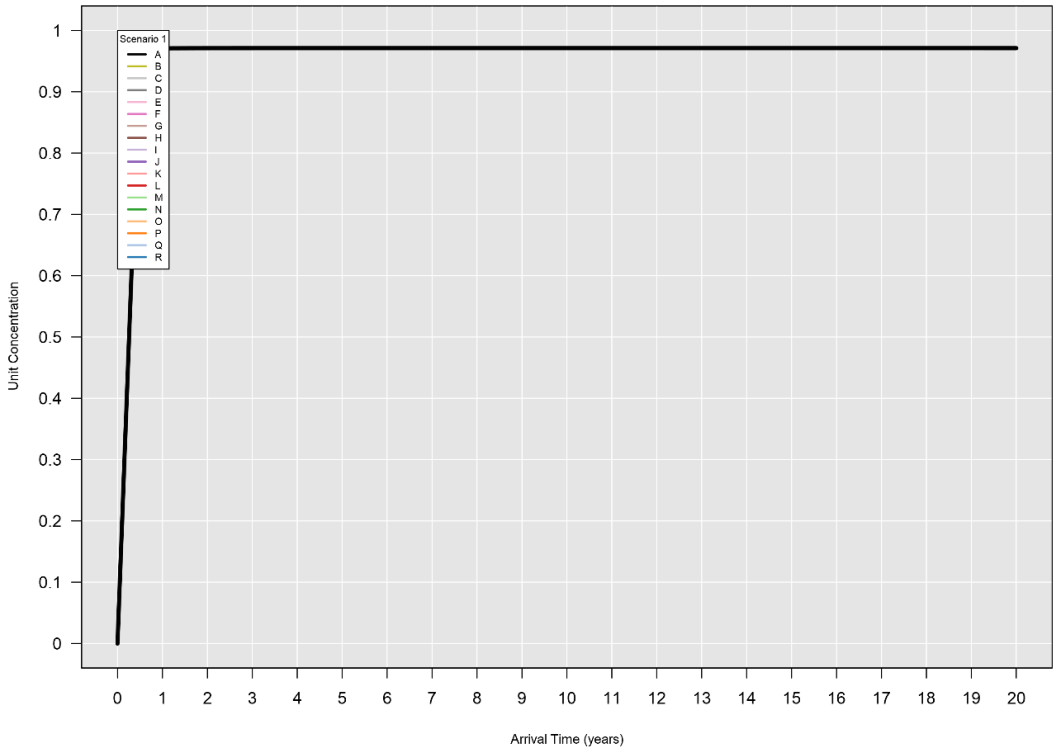


Figure 7-26. Release Concentration Breakthrough Curves Scenario 1, Monitoring Well 299-W15-765

Figures 7-14 through 7-26 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. Release concentration breakthrough curves for wells 299-W15-44 and 299-W15-763 indicate a unit concentration of near zero due to the wells being located upgradient and cross-gradient of the facility, respectively. The curves for well 299-W14-19, located south of the other monitoring well locations, indicates relatively more dilution (less of the original release concentration) and, therefore, less likely to detect releases for all the operating scenarios relative to the other monitoring well locations. Wells 299-W14-16 and 299-W14-17 indicate lower unit concentrations as well as delayed breakthrough times for all the operating scenarios relative to the majority of the other monitoring well locations. The breakthrough curve for upgradient well 299-W15-765 indicates a high unit concentration, while this is, in part, a result of the large CPGWM grid size the well location in proximity to a 200 West P&T extraction well may also influence this result. This is discussed in more detail in relation to the release unit plume maps below. The results, in general, indicate the wells in the monitoring network are located in areas having high potential for detecting releases from WMA TX-TY. 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 7-27) indicate most wells have higher release unit concentrations after cessation of the 200 West P&T system operations. Similar to scenario 1 results, monitoring wells 299-W15-44 and 299-W15-763 are near zero, and monitoring well 299-W15-765 indicates high unit concentrations that are due, in part, to the size of the CPGWM grid cells, as discussed below. The release time for scenario 3 (represented on the figure as arrival time year 0) corresponds to October 1, 2037.

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-W10-26	1	0.799	0.855	0.818	0.960
	2	0.798	0.855	0.817	
299-W10-27	1	0.475	0.508	0.486	0.672
	2	0.474	0.508	0.486	
299-W14-11	1	0.773	0.811	0.793	0.895
	2	0.771	0.810	0.792	
299-W14-13	1	0.767	0.803	0.788	0.890
	2	0.765	0.801	0.786	
299-W14-14	1	0.551	0.644	0.587	0.662
	2	0.548	0.644	0.585	
299-W14-15	1	0.708	0.789	0.743	0.841
	2	0.705	0.789	0.741	
299-W14-16	1	0.338	0.441	0.383	0.818
	2	0.333	0.436	0.378	
299-W14-17	1	0.400	0.561	0.462	0.677
	2	0.392	0.561	0.454	
299-W14-18	1	0.697	0.773	0.722	0.915
	2	0.695	0.772	0.721	
299-W14-19	1	0.254	0.314	0.276	0.295
	2	0.252	0.314	0.274	
299-W15-44	1	0.038	0.075	0.055	0.005
	2	0.037	0.075	0.054	
299-W15-763	1	0.011	0.023	0.015	0.004
	2	0.011	0.023	0.015	
299-W15-765	1	0.971	0.971	0.971	0.971
	2	0.971	0.971	0.971	

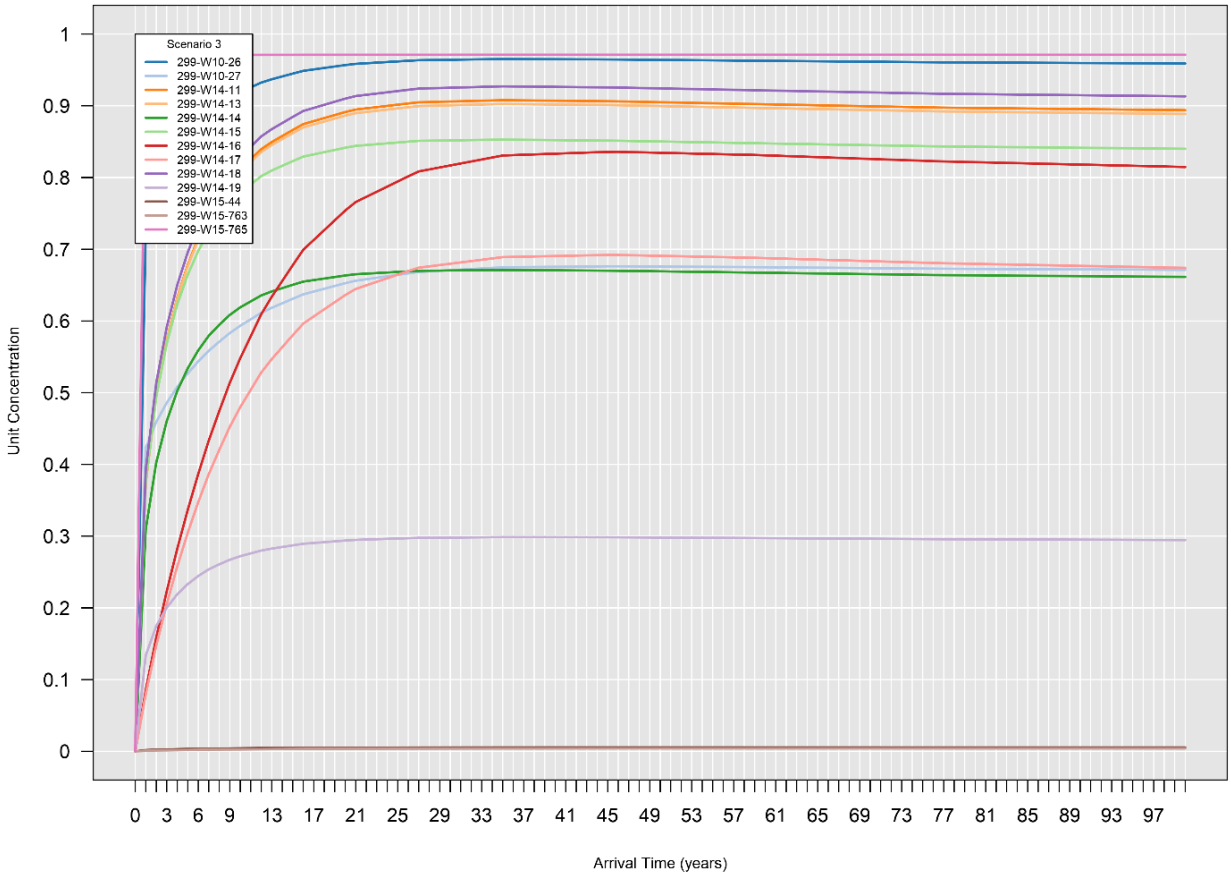


Figure 7-27. Release Concentration Breakthrough Curves at Monitoring Wells for Scenario 3

Figures 7-28 through 7-30 show plume maps of release unit concentrations based on transport modeling representing conditions at the end of the 200 West P&T system operations in 2037 for scenarios 1 and 2 and in 2137 for scenario 3. Figures 7-28 and 7-29 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.

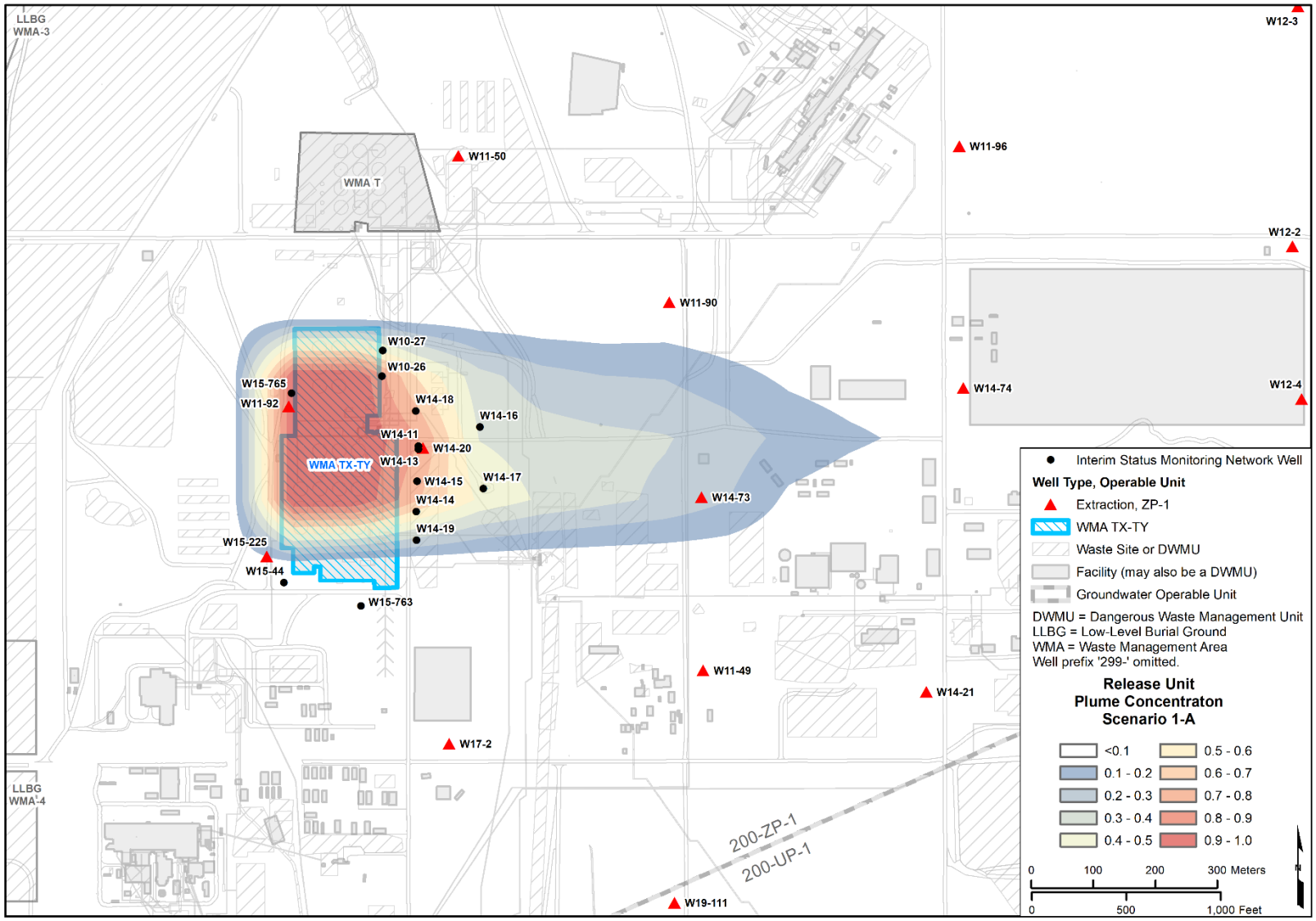


Figure 7-28. Release Unit Plume Map Scenario 1, Sub-Scenario A

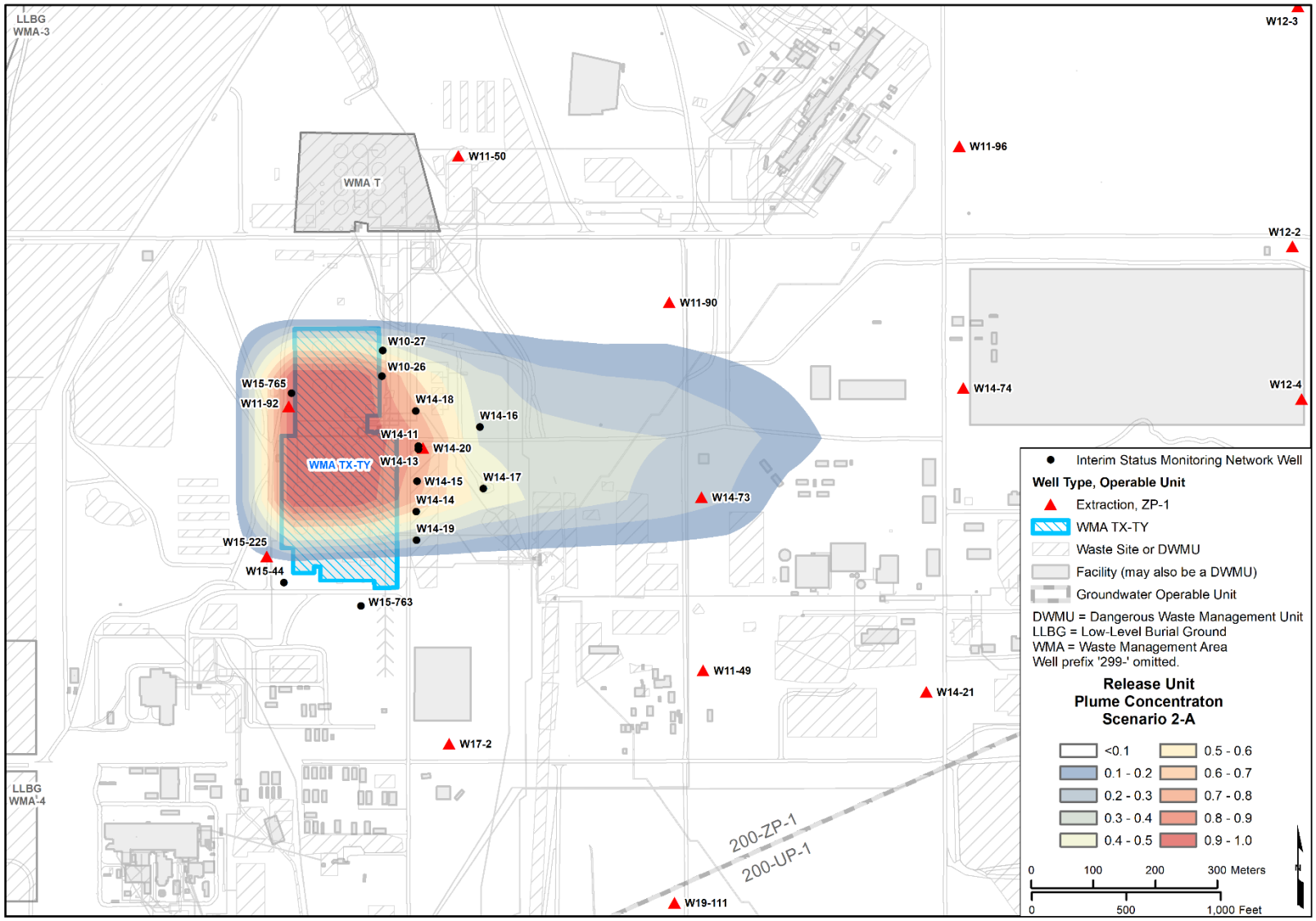


Figure 7-29. Release Unit Plume Map Scenario 2, Sub-Scenario A

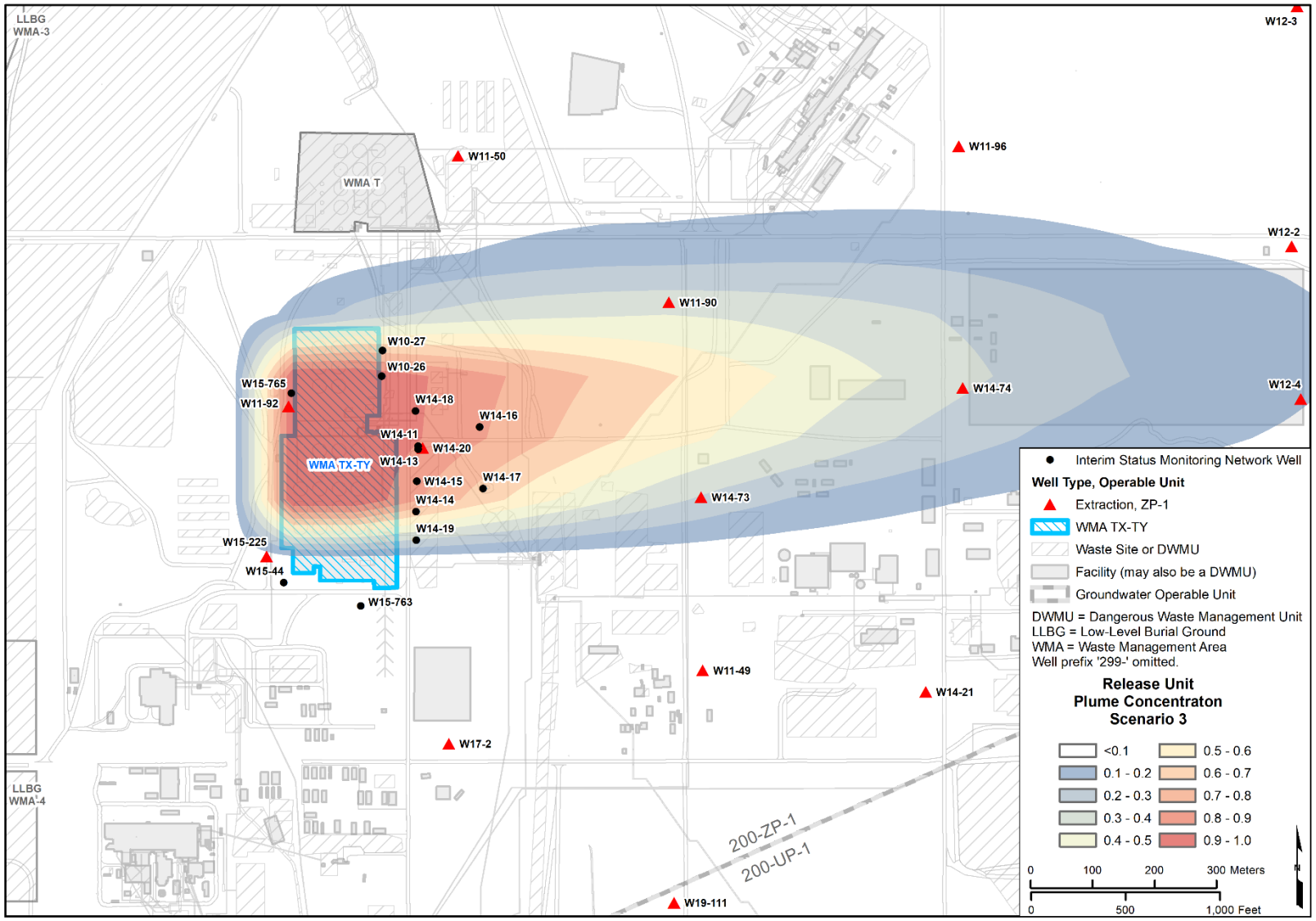


Figure 7-30. Release Unit Plume Map Scenario 3

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 TX-TY, upgradient well 299-W15-765 is shown in an area with significant release unit concentration. This is partly a result of the size of the grid cells representing the facility (in which the unit concentration of 1 was released). Upgradient well 299-W15-765 is located within one of the model grid cells that is used to represent the facility. This results in the transport modeling indicating a unit concentration near 1. The particle-tracking results for releases from the WMA TX-TY tanks shown in subsequent sections indicate this well remains upgradient of the potential release. However, this well's proximity to the 200 West P&T extraction well, 299-W11-92, makes it unsuitable for use as an upgradient well.

Figures 7-28 through 7-30 show that downgradient wells are generally well located for detecting releases from WMA TX-TY. These conclusions 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 TX-TY. 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 7-31 and 7-32 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 map for scenario 3 (Figure 7-33) represents conditions after cessation of the 200 West P&T system operations and therefore does not have an injected treated water component.

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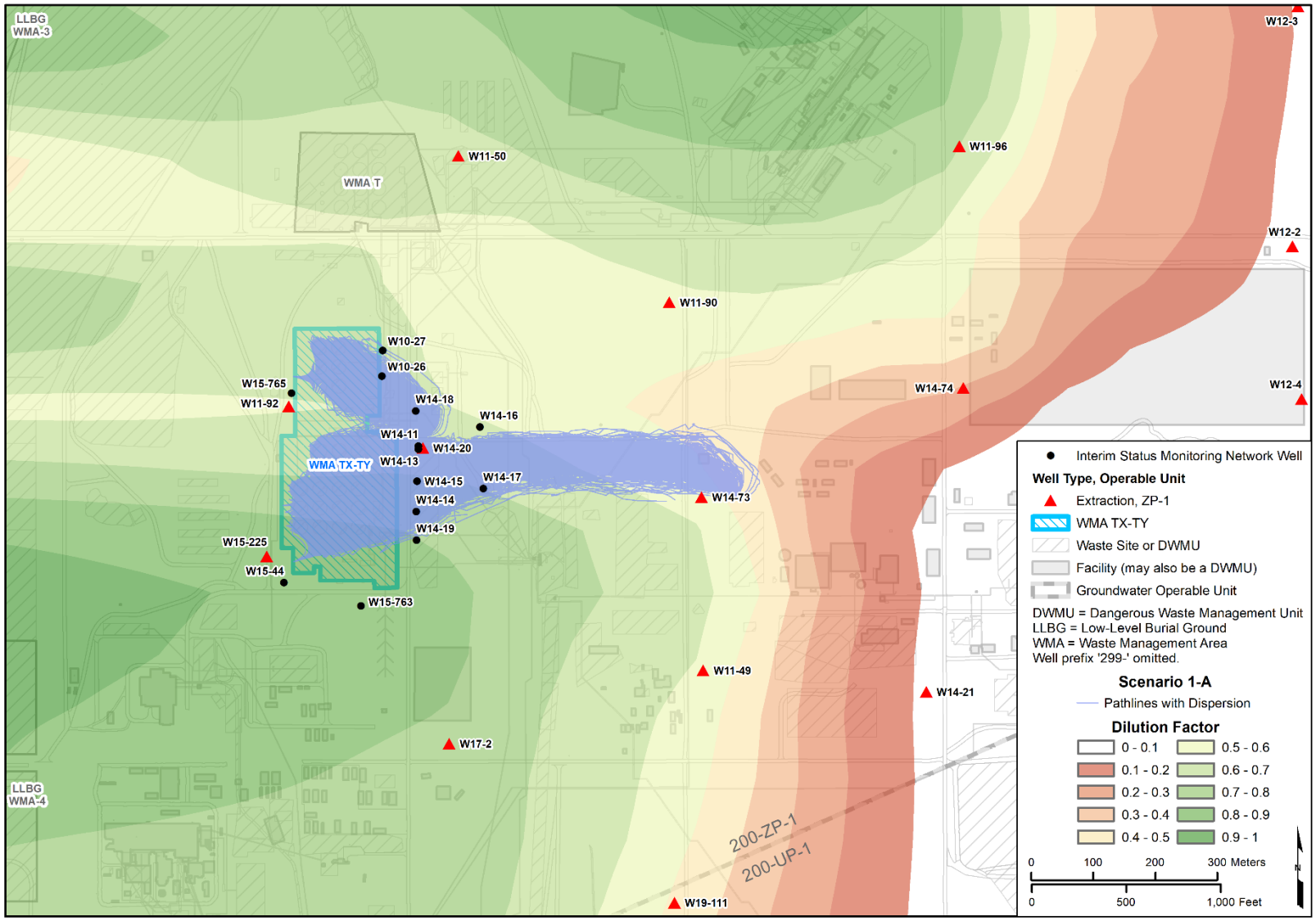

Figure 7-31. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 1, Sub-Scenario A

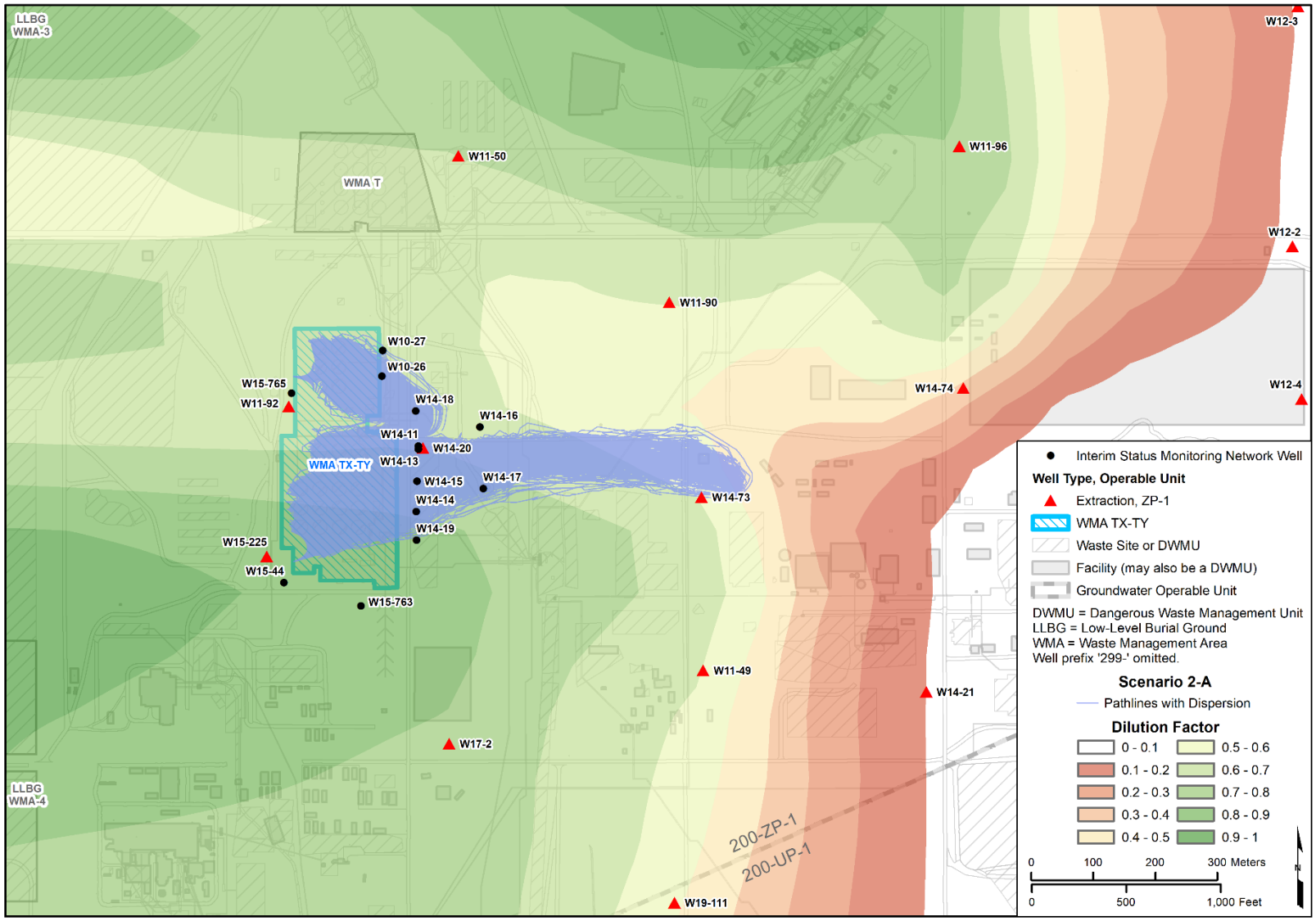

Figure 7-32. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 2, Sub-Scenario A

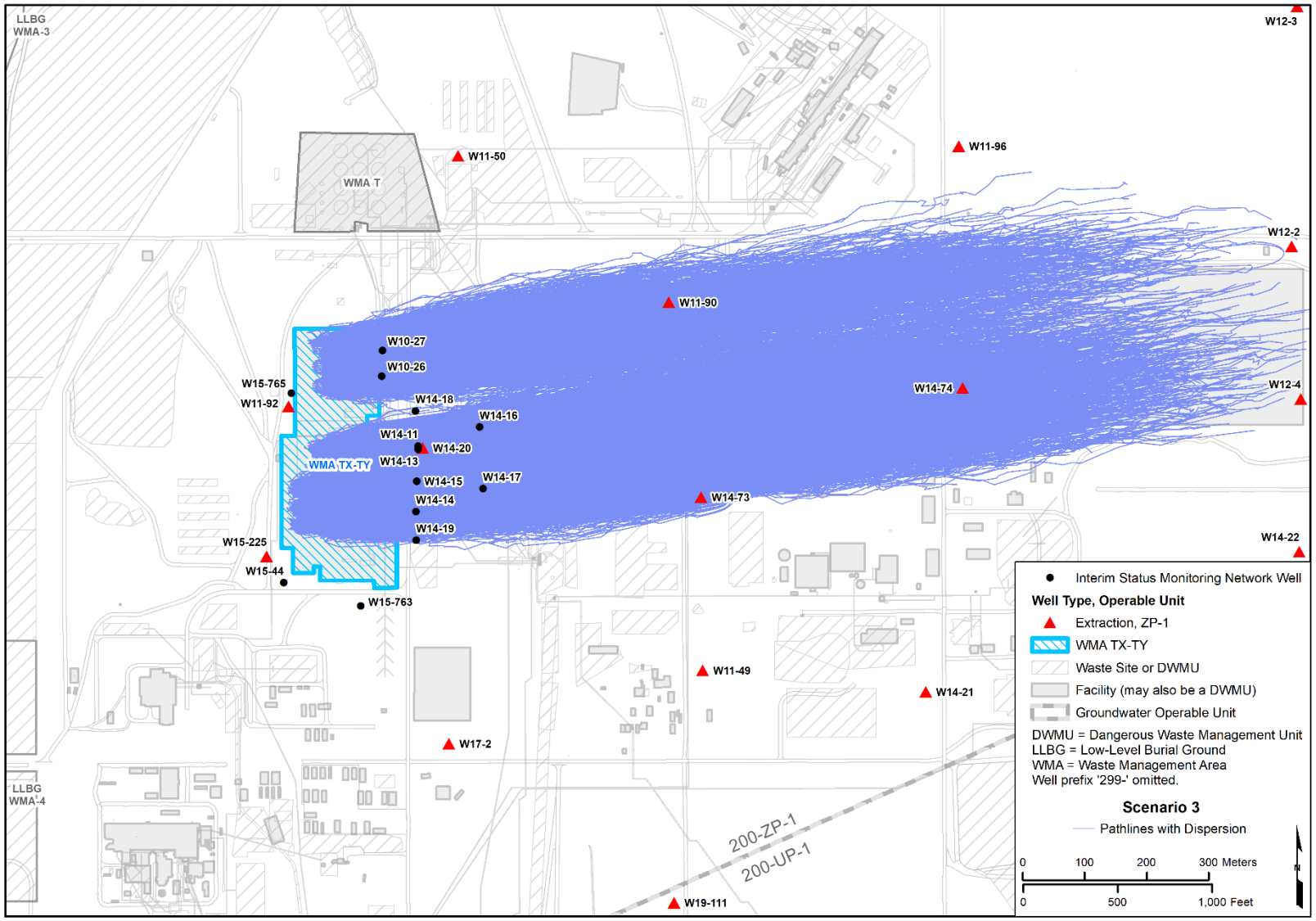

Figure 7-33. Particle Pathlines, Scenario 3

The particle tracking indicates that the downgradient monitoring wells generally are well located for detecting releases from the facility. Wells 299-W10-27, 299-W14-19, and 299-W14-16 are beyond the extent of the release particle pathlines for scenarios 1 and 2 but are within the extents of the particle tracking after cessation of the 200 West P&T system operations (scenario 3). Wells 299-W15-44 and 299-W15-765 are upgradient and 299-W15-763 is cross-gradient of the release particle pathlines in all scenarios.

Maps of relative detectability identify areas of the aquifer where a hypothetical release that impacts the water table beneath WMA TX-TY 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 for each sub-scenario were generated and are included as Appendix A in Appendix G. Using the particle counts, relative detectability 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 7-34 through 7-36 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 are located in areas of detectability for particle releases from WMA TX-TY, except northern monitoring well 299-W10-27, far-field well W14-16, and southern monitoring well 299-W14-19, which are located at or beyond the extents of the relative detectability area. After the cessation of 200 West P&T system operations, however, the shift in the groundwater flow in the northeastern direction results in these wells being within the relative detectability extents for scenario 3.

7.3 Breakthrough Curves for Proposed Wells

Though the results of particle tracking calculations indicated wells 299-W15-765 and 299-W15-44 were upgradient of WMA TX-TY, the release unit plume maps indicated that upgradient well 299-W15-765 was within an area with a high release unit concentration. Both well 299-W15-765 and 299-W15-44 are also in close proximity to 200 West P&T system extraction wells and the flow to these extraction wells would preclude these wells from being considered appropriate upgradient monitoring locations. For these reasons, two new upgradient monitoring wells are proposed for the final status monitoring well network. The proposed locations for these wells are shown in Figures 7-34 through 7-36.

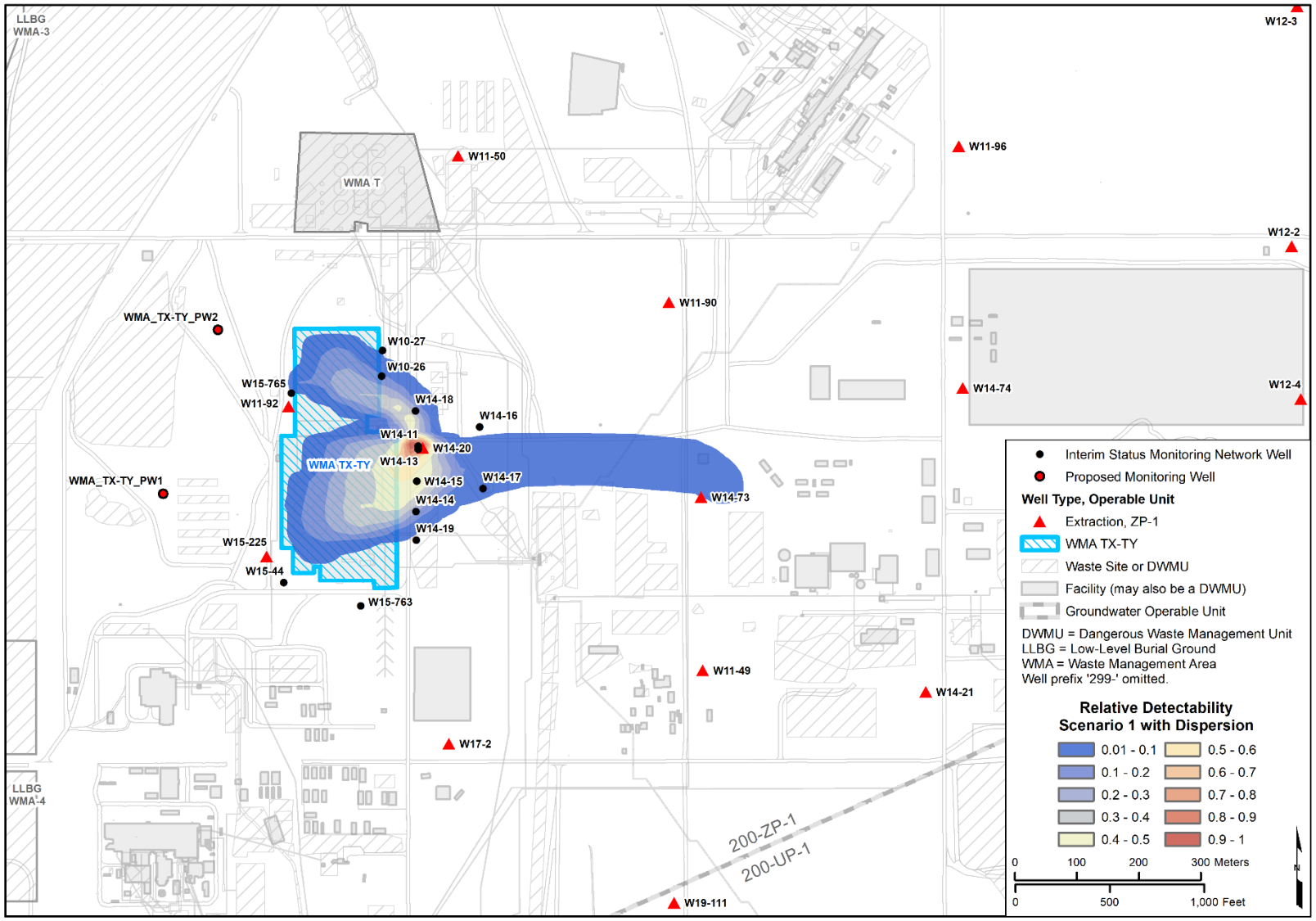

Figure 7-34. Relative Detectability of Release, Scenario 1

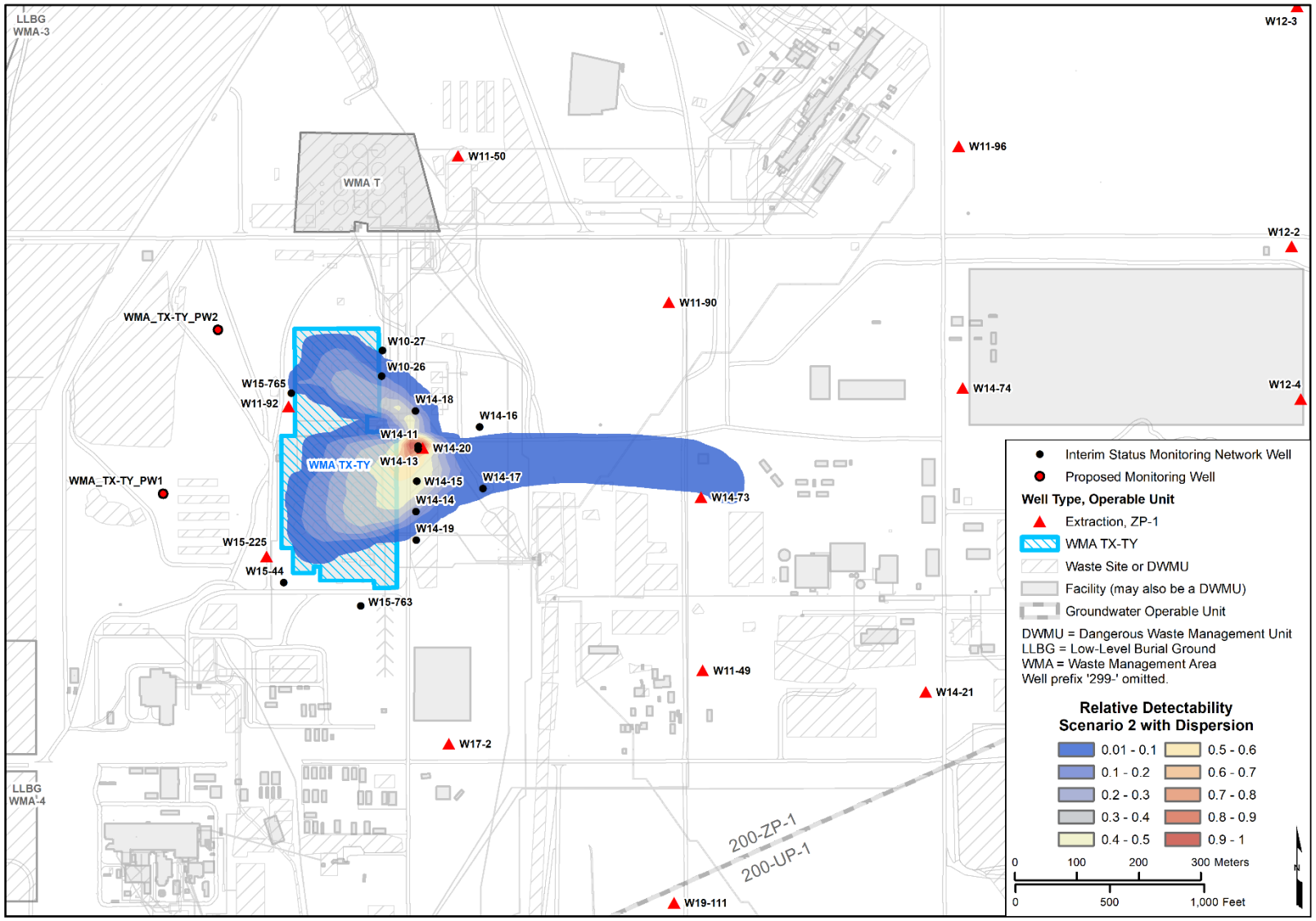

Figure 7-35. Relative Detectability of Release, Scenario 2

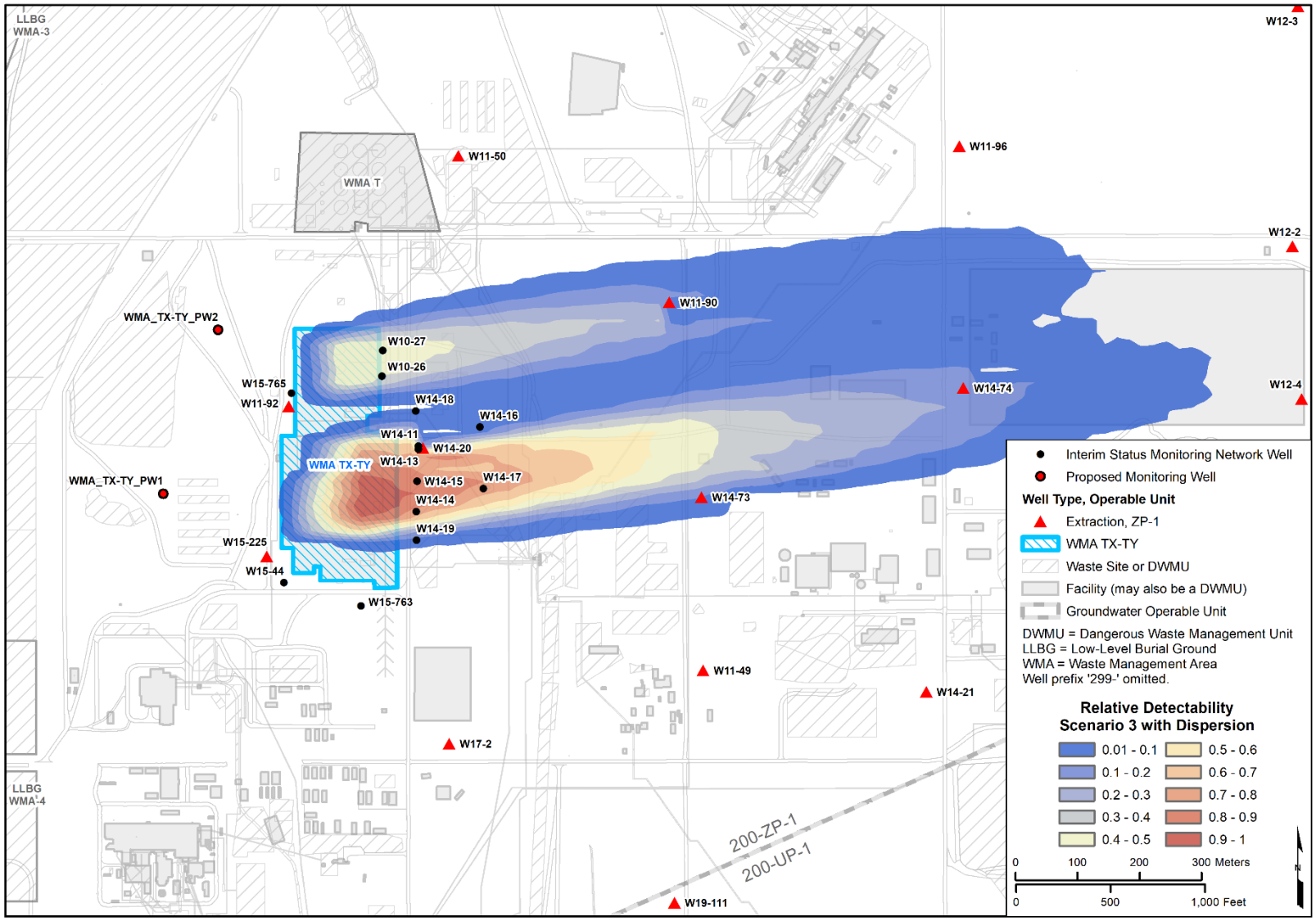

Figure 7-36. Relative Detectability of Release, Scenario 3

7-30

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 (upgradient wells, WMA_TX-TY_PW1 and WMA_TX-TY_PW2). Figures 7-37 and 7-38 show injected treated water dilution breakthrough curves for the proposed wells for scenario 1. The breakthrough curves for scenario 2 for the proposed wells are included in Appendix G.

The injected treated water breakthrough curves for the proposed wells indicate sensitivity to variations in 200 West P&T system injection operations. Results for scenario 2 were similar to the results shown for scenario 1. Table 7-3 shows the range of the injected treated water dilution breakthrough curves for the proposed wells for scenarios 1 and 2.

The release concentration breakthrough curves for scenarios 1, 2, and 3 included in Appendix G show a unit concentration of zero for the release at the proposed well locations, indicating that these wells remain upgradient in the scenarios evaluated.

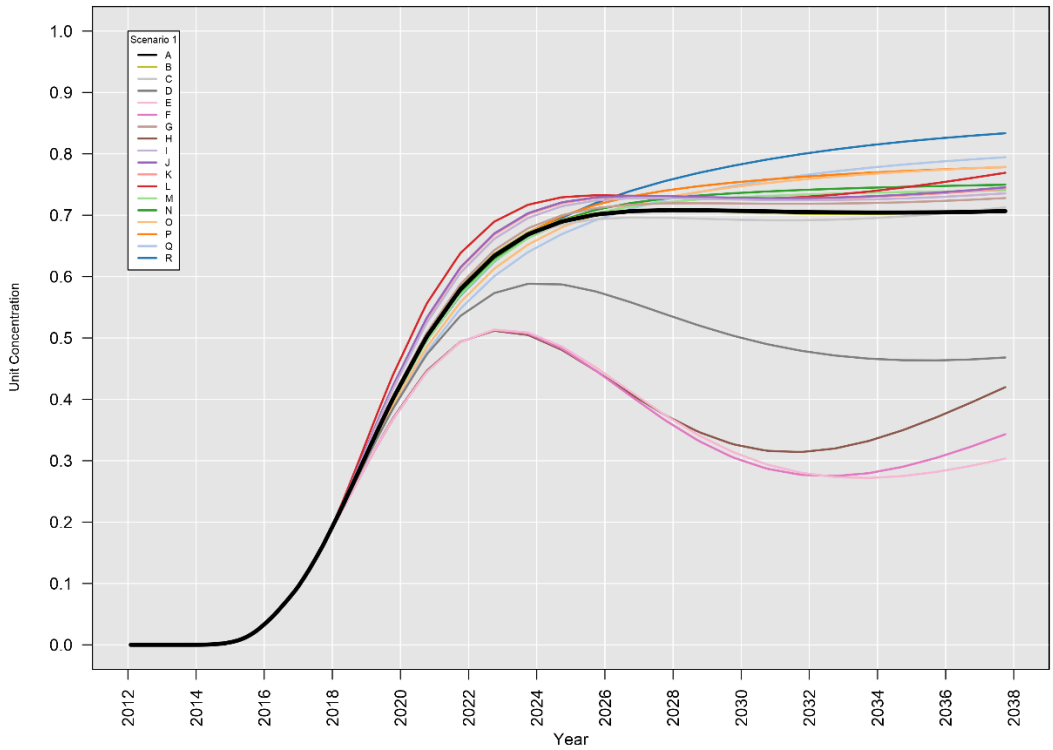

Figure 7-37. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Proposed Monitoring Well WMA_TX-TY_PW1

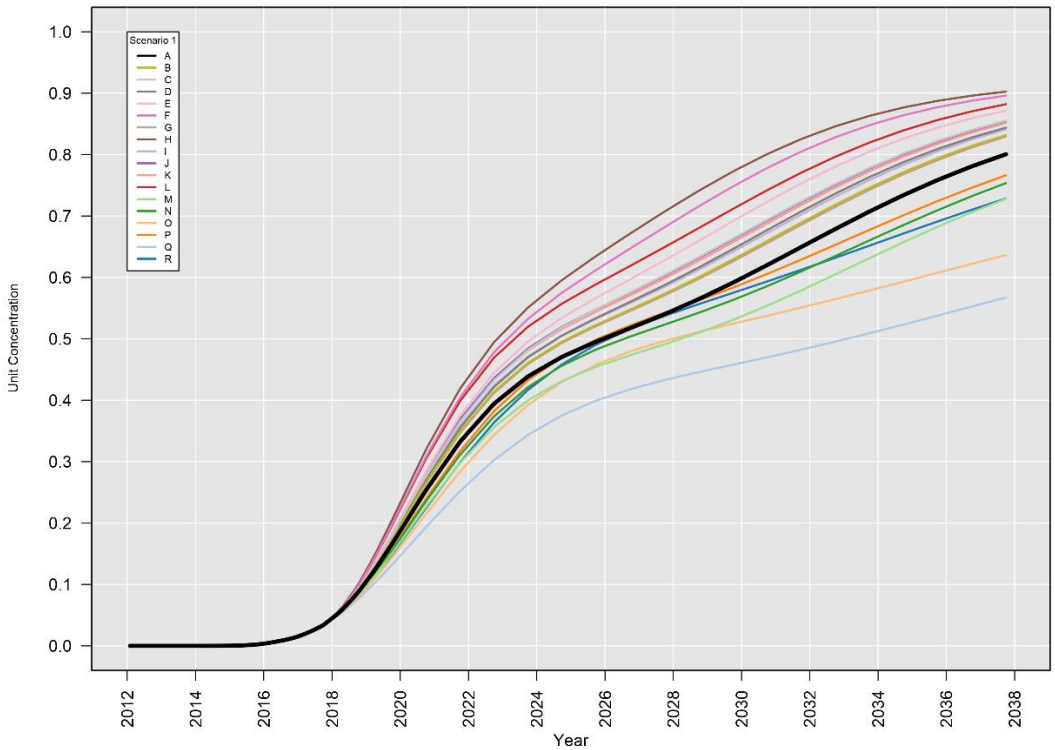

Figure 7-38. Injected Treated Water Dilution Breakthrough Curves Scenario 1, Proposed Monitoring Well WMA_TX-TY_PW2

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-TX-TY_PW1	1	0.303	0.834	0.697
	2	0.303	0.834	0.697
WMA-TX-TY_PW2	1	0.567	0.903	0.799
	2	0.567	0.903	0.799

7.4 Modeling Conclusions

The proposed final status groundwater monitoring network for WMA TX-TY includes retaining existing downgradient wells 299-W10-26, 299-W10-27, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-18, and 299-W14-19 and adding proposed upgradient wells WMA_TX-TY_PW1 and WMA_TX-TY_PW2. Wells not included in the final status monitoring network include upgradient well 299-W15-765, downgradient wells 299-W15-44 and 299-W14-11(deep well) and far-field wells 299-W14-16 and 299-W14-17. The deep and far-field wells were not included for monitoring. Wells 299-W15-44 and 299-W15-765 were replaced by new upgradient wells due to their proximity to 200 West P&T system extraction wells. Also, downgradient monitoring well 299-W15-763, located upgradient/cross-gradient, is not retained because a third upgradient well is not needed and it has poor upgradient coverage.

The proposed final status monitoring well network is based on the results of the simulation scenarios presented in Appendix G and summarized herein. Figure 7-39 shows the final status monitoring network wells compared to the combined extents of a 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 the two upgradient monitoring wells, WMA_TX-TY_PW1 and WMA_TX-TY_PW2, along with the seven downgradient groundwater monitoring wells that will be retained (299-W10-26, 299-W10-27, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-18, and 299-W14-19) are well placed for detection of increases in concentration due to a release to the water table from WMA TX-TY under the scenarios evaluated.

The release concentration breakthrough curves for the recommended downgradient monitoring network wells indicate a range of dilution of approximately 15%[1] to less than 75%[2] for the release unit concentrations. After cessation of the 200 West P&T system operations (scenario 3), this dilution range becomes less than 4% to approximately 70%[3]. Additional discussion regarding each well is provided in Section 9.3.

[1] 15% dilution corresponds to a release unit concentration of approximately 0.85 for sub-scenario L of scenario 1 at monitoring well 299-W10-26 (Figure 7-14).

[2] 75% dilution corresponds to a release unit concentration of over 0.25 for sub-scenario H of scenario 1, at monitoring well 299-W14-19 (Figure 7-23).

[3] 5%-70% dilution for scenario 3 corresponds to a release unit concentration of over 0.95 and approximately 0.30 for wells 299-W10-26 and 299-W14-19, respectively (Figure 7-27).

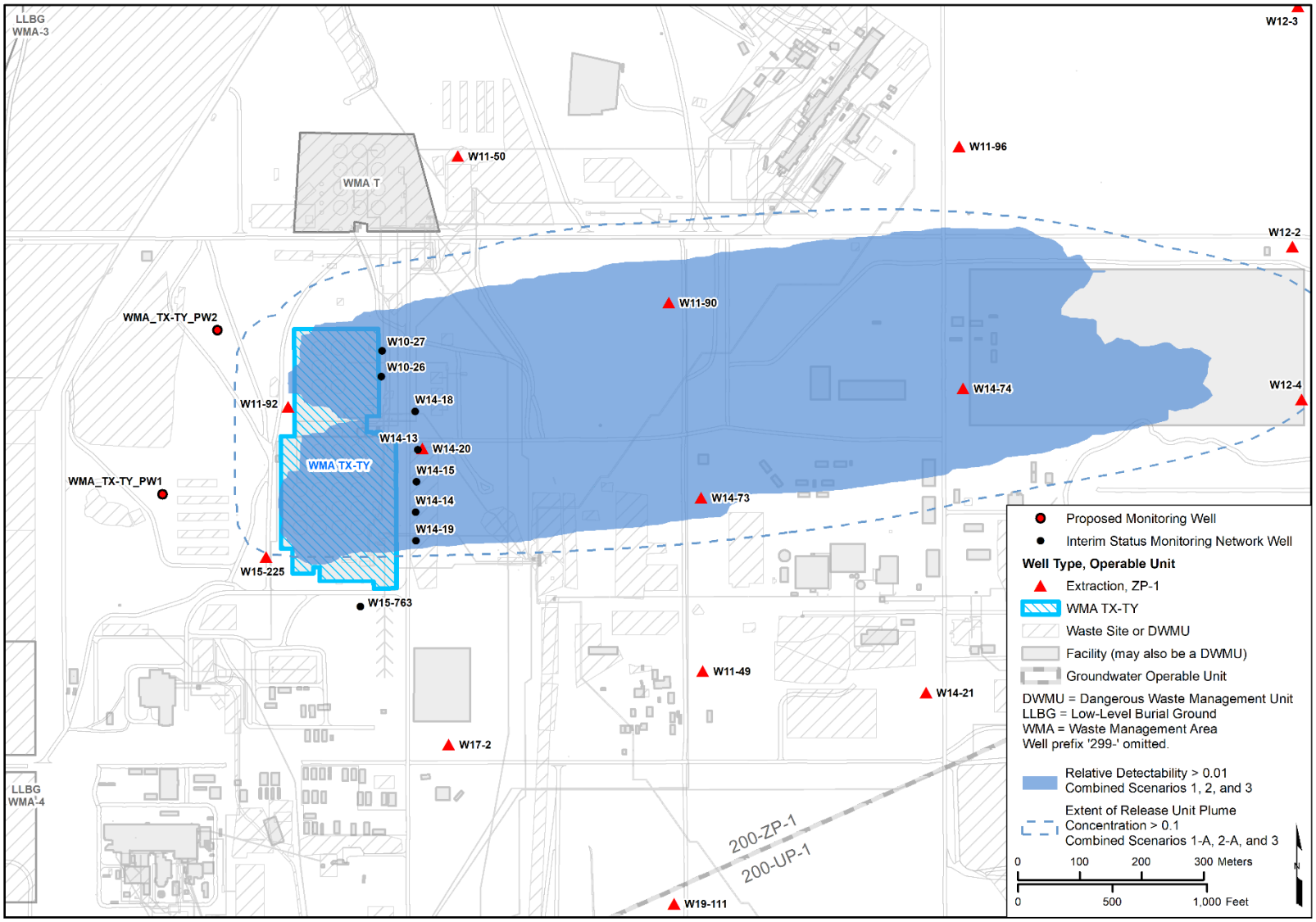

Figure 7-39. Proposed Final Status Groundwater Monitoring Network with Combined Relative Detectability and Release Unit Plume Results

8 Identification of Site-Specific Monitoring Constituents

An evaluation of the waste constituents associated with WMA TX-TY, 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 TX-TY 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 TX-TY 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 treatment, storage, and disposal unit, which includes the WMA TX-TY 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 TX-TY, 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.

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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, etc.), alkalinity 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 TX-TY 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 TX-TY (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).

[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.

- 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 TX-TY SSTs during leak events (Table 2-1) (evaluated on a case-by-case basis).

The results from the final monitoring constituent evaluation are detailed in Appendix B (Section 7.3).

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 TX-TY under interim status monitoring plans, 74 waste constituents are identified as proposed monitoring constituents to detect and monitor any groundwater impacts from dangerous waste releases at WMA TX-TY (Table 8-1). Of the 74 waste constituents, 8 are nondangerous waste constituents that were quantified in groundwater above the applicable action level and were identified in the waste profile for the WMA TX-TY 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 TX-TY

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-Dichloroethene	75-35-4
1,2-Dichloroethane	107-06-2
1,4-Dichlorobenzene	106-46-7
1,4-Dioxane	123-91-1
1-Butanol	71-36-3
2,4-Dimethylphenol	105-67-9
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2-Butanol	78-92-2
2-Butanone	78-93-3
2-Nitropropane	79-46-9

Table 8-1. Proposed Groundwater Monitoring Constituents for WMA TX-TY

Waste Constituent	CAS Number
2-Propanol (isopropyl alcohol)	67-63-0
Acetone	67-64-1
Acetonitrile	75-05-8
Ammonia	7664-41-7
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Benzene	71-43-2
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
cis-1,2-Dichloroethylene	156-59-2
Cobalt	7440-48-4
Copper	7440-50-8
Cresols	1319-77-3
Cyanide	57-12-5
Cyclohexanone	108-94-1
Diethylphthalate	84-66-2
Ethyl acetate	141-78-6
Ethyl benzene	100-41-4
Ethyl ether	60-29-7
Hexavalent Chromium	18540-29-9

Table 8-1. Proposed Groundwater Monitoring Constituents for WMA TX-TY

Waste Constituent	CAS Number
Hydrazine	302-01-2
Isobutanol	78-83-1
Lead	7439-92-1
Mercury	7439-97-6
Methanol	67-56-1
Methyl isobutyl ketone	108-10-1
Methylene chloride	75-09-2
Nickel	7440-02-0
Nitrobenzene	98-95-3
Ortho-dichlorobenzene	95-50-1
Phenol	108-95-2
Pyridine	110-86-1
Silver	7440-22-4
Sulfide	18496-25-8
Tetrachloroethene	127-18-4
Tetrahydrofuran	109-99-9
Thallium	7440-28-0
Tin	7440-31-5
Toluene	108-88-3
Trichloroethene	79-01-6
Trichlorofluoromethane	75-69-4
Vanadium	7440-62-2
Vinyl chloride	75-01-4
Xylene	1330-20-7
Zinc	7440-66-6

Table 8-1. Proposed Groundwater Monitoring Constituents for WMA TX-TY

Waste Constituent	CAS Number
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
Phosphorus	7723-14-0
Sulfate	14808-79-8

CAS = Chemical Abstracts Service

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 chromium and nitrate has been observed at WMA TX-TY. Therefore, WMA TX-TY will be in compliance monitoring under WAC 173-303-645(10) when WMA TX-TY 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 seven downgradient wells proposed for the monitoring well network (299-W10-26, 299-W10-27, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-18, and 299-W14-19) span the range of particle distribution as released from WMA TX-TY. The well placement is suitable for detecting releases to the water table from WMA TX-TY 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 TX-TY consists of two background (upgradient) and seven point of compliance (downgradient) wells to monitor for releases to the water table and detection of increases of contamination from WMA TX-TY (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 TX-TY 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), background (upgradient) wells have been selected that would be representative of ambient conditions under the currently operating 200 West P&T remedy. They do 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 TX-TY is discussed in Section 9.7.

Based on current groundwater flow direction generally to the east (Section 12.10.2 in DOE/RL-2016-67) and predictions of future groundwater flow direction toward the east-northeast over time (Appendix G, Figure 7-93), 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)). Using the API calculator to assess the vertical component of contaminant migration indicates that the wells 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)).

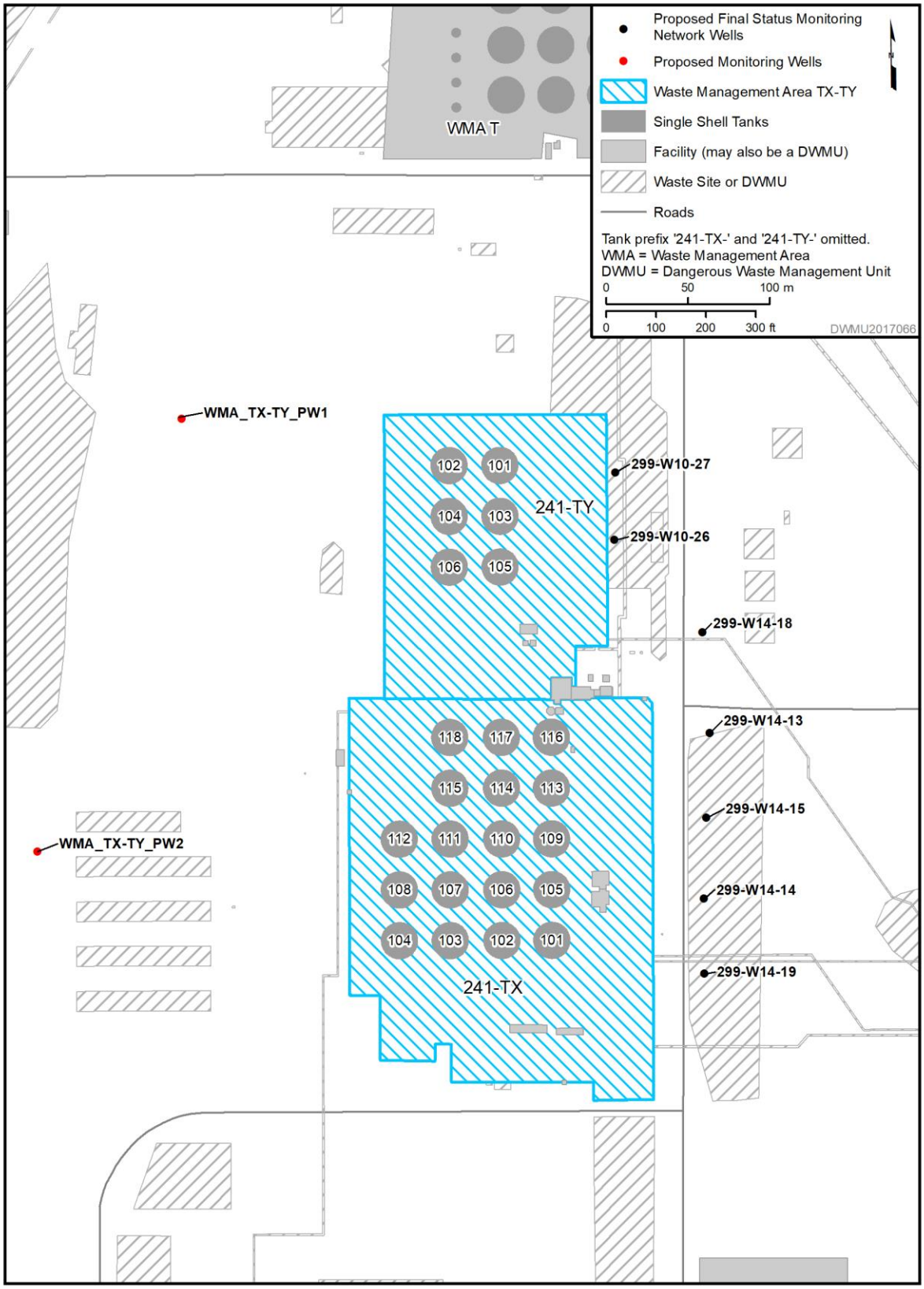

Figure 9-1. Proposed Final Status Groundwater Monitoring Network for WMA TX-TY

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

Well Name	Completion Date	Easting* (m)	Northing* (m)	Top of Casing Elevation (m [ft]) (NAVD88)	Water Table Elevation (m [ft]) (NAVD88)	Water Depth (m [ft] bgs)	Depth of Water in Screen (m [ft])	Water-Level Date
299-W10-26	8/25/1998	566843.40	136400.59	205.45 (674.06)	130.72 (428.87)	73.95 (242.63)	2.86 (9.38)	8/15/2017
299-W10-27	3/23/2001	566843.97	136441.78	205.62 (674.62)	130.76 (428.99)	74.14 (243.25)	3.88 (12.75)	8/15/2017
299-W14-13	8/31/1998	566901.72	136282.38	205.11 (672.92)	129.39 (424.52)	74.95 (245.91)	1.85 (6.08)	8/14/2017
299-W14-14	11/12/1998	566898.39	136181.05	205.43 (673.99)	130.1 (426.82)	74.53 (244.51)	2.29 (7.5)	7/20/2017
299-W14-15	11/8/2000	566899.69	136230.65	205.35 (673.73)	130.1 (426.84)	74.48 (244.36)	3.24 (10.64)	8/15/2017
299-W14-18	11/1/2001	566897.47	136344.15	205.02 (672.63)	130.07 (426.73)	74.2 (243.43)	2.92 (9.57)	8/15/2017
299-W14-19	11/13/2002	566898.60	136135.06	205.61 (674.58)	130.37 (427.73)	74.53 (244.51)	4.41 (14.48)	5/18/2017
WMA_TX-TY_PW1	TBD	136474.8	566578.6	TBD	TBD	TBD	TBD	TBD
WMA_TX-TY_PW2	TBD	136210.0	566490.1	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 WMA_TX-TY_PW1

Groundwater monitoring well WMA_TX-TY_PW1 is proposed as a background well to replace well 299-W10-5, which is dry. If the well location is approved it will be constructed according to WAC 173-160. The proposed location for the well is upgradient of WMA TX-TY and, conceptually, it 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 at this location is predominantly to the east; 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 (Appendix G and Chapter 7) to evaluate the impacts of 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. 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 7-28 through 7-30) and the results of particle-tracking calculations (Figures 7-31 through 7-33) indicate that this well will remain upgradient of WMA TX-TY under the scenarios evaluated. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) 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 70% for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.7 shown on the injection injected treated water dilution breakthrough curve in Figure 7-37).

9.3.2 Groundwater Monitoring Well WMA_TX-TY_PW2

Groundwater monitoring well WMA_TX-TY_PW2 is proposed as a background well to replace well 299-W15-43 which is dry. If the well location is approved it will be constructed according to WAC 173-160. The proposed location for the well is upgradient of WMA TX-TY and, conceptually, it 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 at this location is predominantly to the east; 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 (Appendix G and Chapter 7) to evaluate the impacts of 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. 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 7-28 through 7-30) and the results of particle-tracking calculations (Figures 7-31 through 7-33) indicate that this well will remain upgradient of WMA TX-TY under the scenarios evaluated. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) 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 80% for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.8 shown on the injection injected treated water dilution breakthrough curve in Figure 7-38).

9.3.3 Groundwater Monitoring Well 299-W10-26

Groundwater monitoring well 299-W10-26 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 TX-TY. The well is downgradient of WMA TX-TY and is screened from elevation 138.53 m (454.50 ft) to elevation 127.86 m (419.50 ft) (Appendix E). Based on 2017 water elevation data, well 299-W10-26 is screened across the upper 2.86 m (9.38 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 east-southeast at this well (Figure 3-10); 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 (Appendix G and Chapter 7) 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. 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 7-28 through 7-30) and the results of particle-tracking calculations (Figures 7-31 through 7-33) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-34 through 7-36) indicate that this well is located within the northern extent of the estimated area of detectability for scenarios 1 and 2 and is 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 (Figures 7-14 and 7-27) indicate very little dilution of the release concentration is expected at the well location. 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 about approximately 18% (corresponding to a release unit concentration of approximately 0.82 shown in Figure 7-14) 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 61% 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 0.61 shown on the injection injected treated water dilution breakthrough curve in Figure 7-1). This could result in further dilution of the release concentration by some amount up to but likely less than 61%, 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 TX-TY under the range of operating conditions evaluated.

9.3.4 Groundwater Monitoring Well 299-W10-27

Groundwater monitoring well 299-W10-27 is proposed as a point of compliance well. It was constructed in 2001 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA TX-TY. The well is downgradient of WMA TX-TY and is screened from elevation 137.54 m (451.24 ft) to elevation 126.87 m (416.24 ft) (Appendix E). Based on 2017 water

elevation data, well 299-W10-27 is screened across the upper 3.88 m (12.75 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 east-southeast at this well (Figure 3-10); 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 (Appendix G and Chapter 7) 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. 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 7-28 through 7-30) and the results of particle-tracking calculations (Figures 7-31 through 7-33) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-34 through 7-36) indicate that this well is located to the north of the estimated area of detectability for scenarios 1 and 2 and within the northern extent of the detectable area for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well (Figures 7-15 and 7-27) indicate some dilution of the release concentration is expected at the well location. 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 about 52% (corresponding to a release unit concentration of approximately 0.48 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 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 7-2). 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 TX-TY under the range of operating conditions evaluated.

9.3.5 Groundwater Monitoring Well 299-W14-13

Groundwater monitoring well 299-W14-13 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 TX-TY. The well is downgradient of WMA TX-TY and is screened from elevation 138.20 m (453.43 ft) to elevation 127.54 m (418.43 ft) (Appendix E). Based on 2017 water elevation data, well 299-W14-13 is screened across the upper 1.85 m (6.08 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 east at this well (Figure 3-10); 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 (Appendix G and Chapter 7) 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. 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 7-28 through 7-30) and the results of particle-tracking calculations (Figures 7-31 through 7-33) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-34 through 7-36) indicate that this well is located centrally in the estimated area of detectability for all scenarios.
The release concentration breakthrough curves for this well (Figures 7-17 and 7-27) indicate very little dilution of the release concentration is expected at the well location. 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 about 21% (corresponding to a release unit concentration of approximately 0.79 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 66% 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 0.66 shown on the injection injected treated water dilution breakthrough curve in Figure 7-4). This could result in further dilution of the release concentration by some amount up to but likely less than 66%, 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 TX-TY under the range of operating conditions evaluated.

9.3.6 Groundwater Monitoring Well 299-W14-14

Groundwater monitoring well 299-W14-14 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 TX-TY. The well is downgradient of WMA TX-TY and is screened from elevation 138.48 m (454.33 ft) to elevation 127.81 m (419.33 ft) (Appendix E). Based on 2017 water elevation data, well 299-W14-14 is screened across the upper 2.29 m (7.51 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 east-northeast at this well (Figure 3-10); 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 (Appendix G and Chapter 7) 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. 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 7-28 through 7-30) and the results of particle-tracking calculations (Figures 7-31 through 7-33) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-34 through 7-36)

indicate that this well is located in the southern extent of the estimated area of detectability for scenarios 1 and 2 and in the center 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 (Figures 7-18 and 7-27) indicate some dilution of the release concentration is expected at the well location. 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 about 42% (corresponding to a release unit concentration of approximately 0.58 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 78% 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 0.78 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 78%, 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 TX-TY under the range of operating conditions evaluated.

9.3.7 Groundwater Monitoring Well 299-W14-15

Groundwater monitoring well 299-W14-15 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 TX-TY. The well is downgradient of WMA TX-TY and is screened from elevation 137.53 m (451.21 ft) to elevation 126.86 m (416.21 ft) (Appendix E). Based on 2017 water elevation data, well 299-W14-15 is screened across the upper 3.24 m (10.64 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 northeast at this well (Figure 3-10); 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 (Appendix G and Chapter 7) 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. 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 7-28 through 7-30) and the results of particle-tracking calculations (Figures 7-31 through 7-33) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-34 through 7-36) indicate that this well is located centrally in the estimated area of detectability for all scenarios.
The release concentration breakthrough curves for this well (Figures 7-19 and 7-27) indicate very little dilution of the release concentration is expected at the well location. 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 about 25% (corresponding to a release unit concentration of approximately 0.75 shown in Figure 7-19) 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 73% 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 0.73 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 73%, 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 TX-TY under the range of operating conditions evaluated.

9.3.8 Groundwater Monitoring Well 299-W14-18

Groundwater monitoring well 299-W14-18 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 TX-TY. The well is downgradient of WMA TX-TY and is screened from elevation 137.82 m (452.15 ft) to elevation 127.15 m (417.15 ft) (Appendix E). Based on 2017 water elevation data, well 299-W14-18 is screened across the upper 2.92 m (9.57 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 3-10); 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 (Appendix G and Chapter 7) 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. 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 7-28 through 7-30) and the results of particle-tracking calculations (Figures 7-31 through 7-33) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-34 through 7-36) indicate that this well is located centrally in the estimated area of detectability for all scenarios.
The release concentration breakthrough curves for this well (Figures 7-22 and 7-27) indicate very little dilution of the release concentration is expected at the well location. 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 about 27% (corresponding to a release unit concentration of approximately 0.73 shown in Figure 7-22) 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 7-9). 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 TX-TY under the range of operating conditions evaluated.

9.3.9 Groundwater Monitoring Well 299-W14-19

Groundwater monitoring well 299-W14-19 is proposed as a point of compliance well. It was constructed in 2002 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA TX-TY. The well is downgradient of WMA TX-TY and is screened from elevation 136.62 m (448.24 ft) to elevation 125.96 m (413.24 ft) (Appendix E). Based on 2017 water elevation data, well 299-W14-19 is screened across the upper 4.41 m (14.48 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 east-northeast at this well (Figure 3-10); 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 (Appendix G and Chapter 7) 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. 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 7-28 through 7-30) and the results of particle-tracking calculations (Figures 7-31 through 7-33) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-34 through 7-36) indicate that this well is located to the south of the estimated area of detectability for scenarios 1 and 2 and at the southern extent of the detectable area for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well (Figures 7-23 and 7-27) indicate significant dilution of the release concentration is expected at the well location. 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 about 73% (corresponding to a release unit concentration of approximately 0.27 shown in Figure 7-23) 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 81% 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 0.81 shown on the injection injected treated water dilution breakthrough curve in Figure 7-10). This could result in further dilution of the release concentration by some amount up to but likely less than 81%, 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 TX-TY under the range of operating conditions evaluated.

9.4 Constituent List and Frequency

The proposed WMA TX-TY final status groundwater monitoring network detailed in this report consists of two upgradient (WMA_TX-TY_PW1 and WMA_TX-TY_PW2) and seven downgradient wells (299-W10-26, 299-W10-27, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-18, and 299-W14-19). Wells 299-W10-26, 299-W10-27, 299-W14-13, 299-W14-14, 299-W14-15, 299-W14-18, and 299-W14-19 are part of the WMA TX-TY interim status groundwater monitoring network (Table 3-2 in DOE/RL-2009-67, 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, 74 waste constituents were selected to detect and monitor groundwater impacts from dangerous waste releases at WMA TX-TY.

Table 9-2 identifies the proposed monitoring network and sampling frequency for WMA TX-TY. 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, dissolved oxygen, specific conductance, 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 TX-TY.

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

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[g]
				Ammonia	Cyanide	Hexavalent Chromium	Hydrazine	Sulfide	Metals[c]	Anions[d]	Volatile Organic Compounds[e]	Semivolatile Organic Compounds[f]	Methanol	Table 9-4	
WMA_TX-TY_PW1	Upgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
WMA_TX-TY_PW2	Upgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W10-26	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W10-27	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W14-13	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W14-14	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W14-15	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W14-18	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W14-19	Downgradient	Y	E	Q/S	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., 8 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).

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

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

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[g]
				Ammonia	Cyanide	Hexavalent Chromium	Hydrazine	Sulfide	Metals[c]	Anions[d]	Volatile Organic Compounds[e]	Semivolatile Organic Compounds[f]	Methanol	Table 9-4	

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; 1,4-dichlorobenzene; 1,4-dioxane; 2-butanol; 2-butanone (methyl ethyl ketone); 2-nitropropane; 2-propanol (isopropyl alcohol); 2-propanone (acetone); 4-methyl-2-pentanone (methyl isobutyl ketone); acetonitrile; benzene; bromodichloromethane; carbon disulfide; carbon tetrachloride; chlorobenzene; chloroform; cis-1,2-dichloroethylene; cyclohexanone; ethyl acetate; ethyl ether; ethylbenzene; isobutanol; methylene chloride; tetrachloroethene; tetrahydrofuran; 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-dimethylphenol; 2,4-dinitrophenol; 2,4-dinitrotoluene; bis(2-ethylhexyl) phthalate; cresols; diethylphthalate; nitrobenzene; phenol; and pyridine.

g. Field parameters include pH, dissolved oxygen, 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
WAC = *Washington Administrative Code*
Q = quarterly
S = semiannually
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 TX-TY

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-Dichloroethene	75-35-4
1,2-Dichloroethane	107-06-2
1,4-Dichlorobenzene	106-46-7
1,4-Dioxane	123-91-1
1-Butanol	71-36-3
2,4-Dimethylphenol	105-67-9
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2-Butanol	78-92-2
2-Butanone	78-93-3
2-Nitropropane	79-46-9
2-Propanol (isopropyl alcohol)	67-63-0
Acetone	67-64-1
Acetonitrile	75-05-8
Ammonia	7664-41-7
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Benzene	71-43-2
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

Table 9-3. Proposed Groundwater Monitoring Constituents for WMA TX-TY

Waste Constituent	CAS Number
Chloroform	67-66-3
Chromium	7440-47-3
cis-1,2-Dichloroethylene	156-59-2
Cobalt	7440-48-4
Copper	7440-50-8
Cresols	1319-77-3
Cyanide	57-12-5
Cyclohexanone	108-94-1
Diethylphthalate	84-66-2
Ethyl acetate	141-78-6
Ethyl benzene	100-41-4
Ethyl ether	60-29-7
Hexavalent chromium	18540-29-9
Hydrazine	302-01-2
Isobutanol	78-83-1
Lead	7439-92-1
Mercury	7439-97-6
Methanol	67-56-1
Methyl isobutyl ketone	108-10-1
Methylene chloride	75-09-2
Nickel	7440-02-0
Nitrobenzene	98-95-3
Ortho-dichlorobenzene	95-50-1
Phenol	108-95-2
Pyridine	110-86-1
Silver	7440-22-4
Sulfide	18496-25-8
Tetrachloroethene	127-18-4
Tetrahydrofuran	109-99-9

Table 9-3. Proposed Groundwater Monitoring Constituents for WMA TX-TY

Waste Constituent	CAS Number
Thallium	7440-28-0
Tin	7440-31-5
Toluene	108-88-3
Trichloroethene	79-01-6
Trichlorofluoromethane	75-69-4
Vanadium	7440-62-2
Vinyl chloride	75-01-4
Xylene	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
Phosphorus	7723-14-0
Sulfate	14808-79-8

CAS = Chemical Abstracts Service

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.

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	Trichloroethene (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

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 TX-TY 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.

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 TX-TY, 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 TX-TY is permitted as a final status unit in the future Hanford Facility Dangerous Waste Permit. Because WMA TX-TY has not yet been closed, the compliance period cannot yet be determined.

9.7 Statistical Method

Under the most recent (2012) interim status monitoring plan (DOE/RL-2009-67, Rev. 1), 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 TX–TY. Hexavalent chromium and supporting parameters (including nitrate and metals) were collected semiannually at the upgradient well and quarterly or semiannually at downgradient 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 of the constituents in Table 9-2 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 as Appendix H. In addition to this methodology, hydrogeology of the area also will be considered. Following this initial monitoring period and determination of the statistical method, the statistical method will be reassessed every 5 years thereafter.

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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. The proposed changes to the operating conditions of the active 200 West P&T remedy impact the vertical distribution of contamination in groundwater. Additional monitoring of wells throughout the 200 West Area is performed through performance monitoring associated with the 200 West P&T remedy. The assessment performed using the CPGWM uses all the available groundwater data under any program and will be used to assess the adequacy of the monitoring well network.

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-136, 1976, *Geology of the 241-TX Tank Farm*, Informal Report, Atlantic Richfield Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=E0009072.

ARH-LD-137, 1976, *Geology of the 241-TY Tank Farm*, Informal Report, Atlantic Richfield Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=E0009073.

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/ORP-2008-01, 2009, *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1001051140.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1001051141.

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-96-61, 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-2009-67, 2011, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1103070710.

DOE/RL-2009-67, 2012, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091411.

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-2010-11, 2010, *Hanford Site Groundwater Monitoring and Performance Report for 2009*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093693.

DOE/RL-2011-01, 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-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: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0068229H.

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 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 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 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.

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.

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-17-0071, 2018, *Groundwater Flow and Migration Calculations to Support Assessment of the WMA TX-TY Monitoring Network*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065256H

ECF-200ZP1-17-0204, 2018, *Identification of Site-Specific Monitoring Constituents for Waste Management Area TX-TY*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065256H.

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.

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 et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=00098825.

EPA/ROD/R10-95/114, 1995, *Superfund Record of Decision: Hanford 200-Area (USDOE) OU 200-ZP-1, Benton County, WA*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9100NWA2.txt.

GJO-97-13-TAR, 1997, *Hanford Tank Farms Vadose Zone TX 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=0069092H.

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

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.

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.

ICN-PNNL-12072.1, 2002, *Interim Change Notice to RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2761142.

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-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-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-12072, 2001, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site*, Pacific Northwest 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-13514, 2001, Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2000, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13514.pdf.

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 National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13858.pdf.

PNNL-14004, 2002, *RCRA Groundwater Quality Assessment Report for Single-Shell Tank Waste Management Area TX-TY (January 1998 through December 2001)*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2756624.

PNNL-14113, 2002, *Results of Detailed Hydrologic Characterization Tests—FY 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-14548, 2004, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*, Pacific Northwest 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-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-15873, 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://www.pnl.gov/main/publications/external/technical_reports/PNNL-15837.pdf.

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-16005, 2007, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16005.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-18279, 2009, *Aquifer Testing Recommendations for Well 299-W15-225: Supporting Phase I of the 200-ZP-1 Groundwater Operable Unit Remedial Design*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18279.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 and 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-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-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-RPT-50870, 2013, *Hanford 241-TX Farm Leak Inventory Assessment Report*, Rev. 0, Washington River Protection Solutions, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0066754H.

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."

303-9904, "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, *40 CFR 265 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, Westinghouse Hanford Company, 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*, Contract 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.

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 WMA TX-TY. 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 TX-TY was placed into a groundwater quality assessment monitoring program in accordance with 40 CFR 265.93(d), "Preparation, Evaluation, and Response." WMA TX-TY has been monitored under a groundwater quality assessment program since 1993.

The interim status groundwater monitoring history of WMA TX-TY through 2016 was compiled. Information from annual reporting documents and groundwater monitoring plans were utilized to compile a summary of wells in the WMA TX-TY 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: http://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-2009-67, 2011, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1103070710.

DOE/RL-2009-67, 2012, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091411.

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-12072.1, 2002, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site, Interim Change Notice*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2761142.

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-12072, 2001, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site*, Pacific Northwest 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 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-14004, 2002, *RCRA Groundwater Quality Assessment Report for Single-Shell Tank Waste Management Area TX-TY (January 1998 through December 2001)*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2756624.

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-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-16005, 2007, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16005.pdf.

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 TX-TY - ECF-200ZP1-17-0204

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The calculation ECF-200ZP1-17-0204, *Identification of Site-Specific Monitoring Constituents for Waste Management Area TX-TY*, was performed evaluate the waste constituents associated with Waste Management Area TX-TY 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=0065256H.

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Appendix C

Topographic Map

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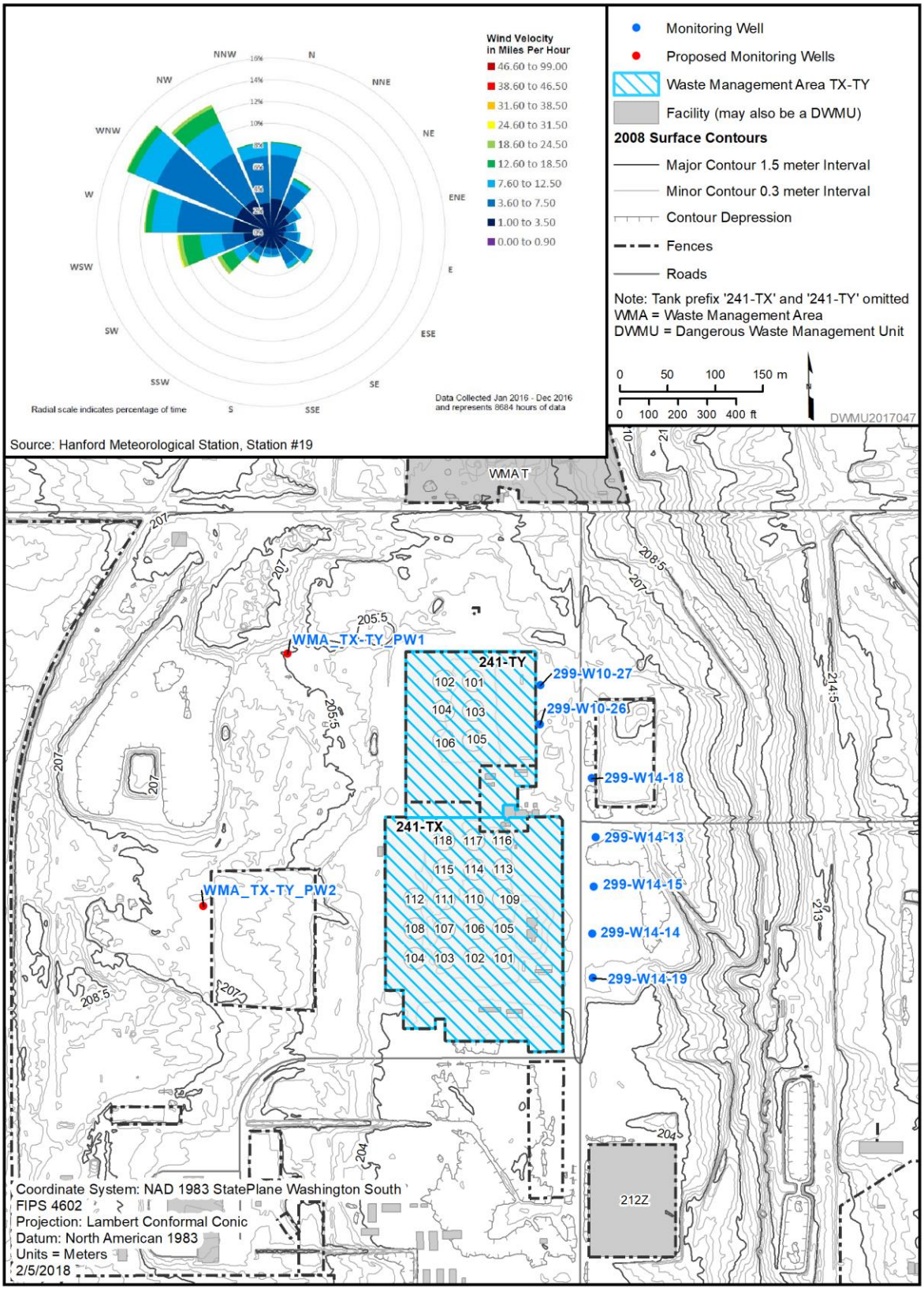

Figure C-1. Topographic Map

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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) TX-TY (Figures D-1 through D-5). These plumes do not originate solely from WMA TX-TY but rather WMA TX-TY 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 TX-TY monitoring well network (Table 3-17 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*) are presented (Figures D-6 through D-8) 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-6 and D-7. Figure D-8 presents chemical constituents that are nondangerous wastes and were detected above background values.

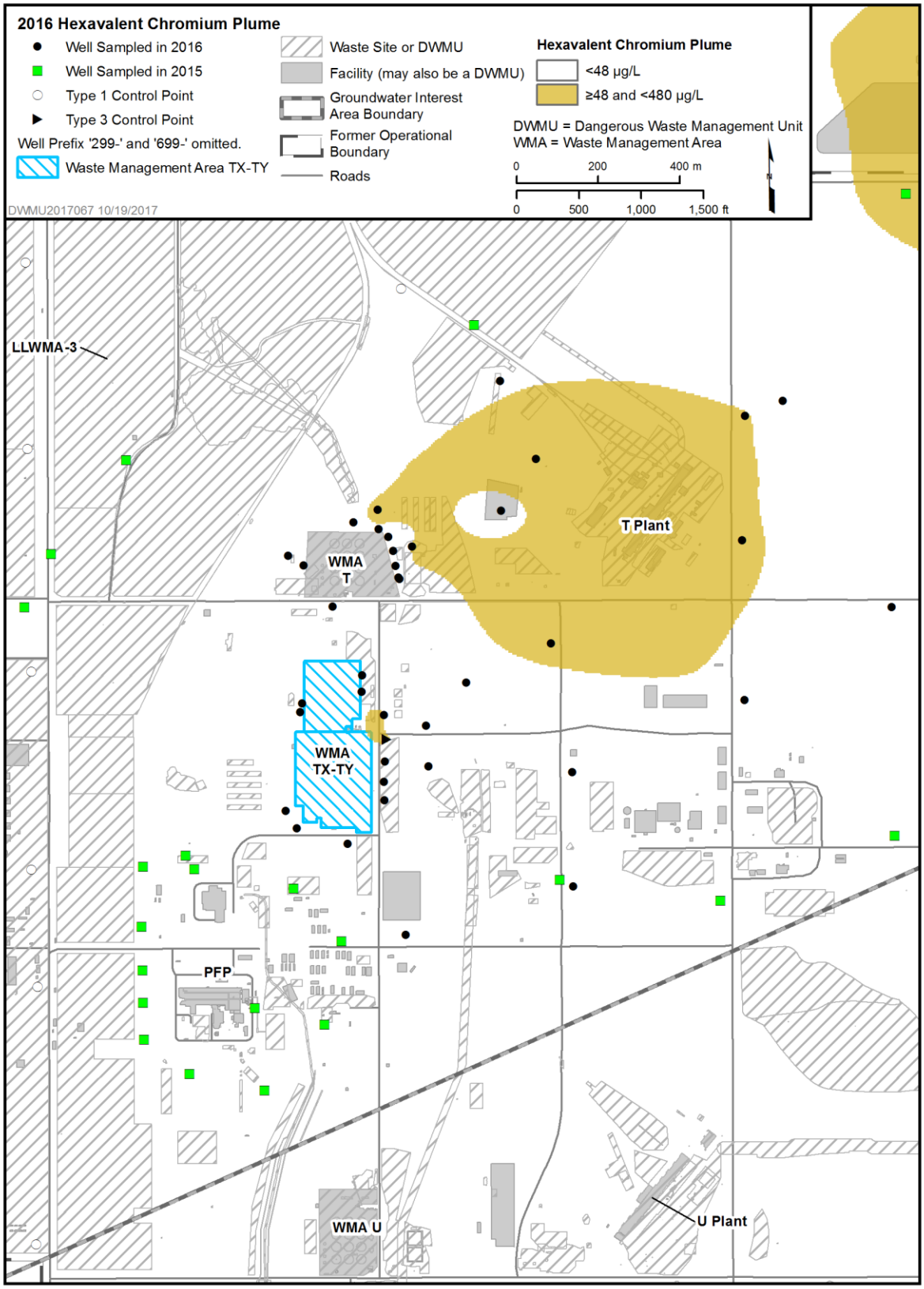


Figure D-1. Regional Hexavalent Chromium Plume at Waste Management Area TX-TY

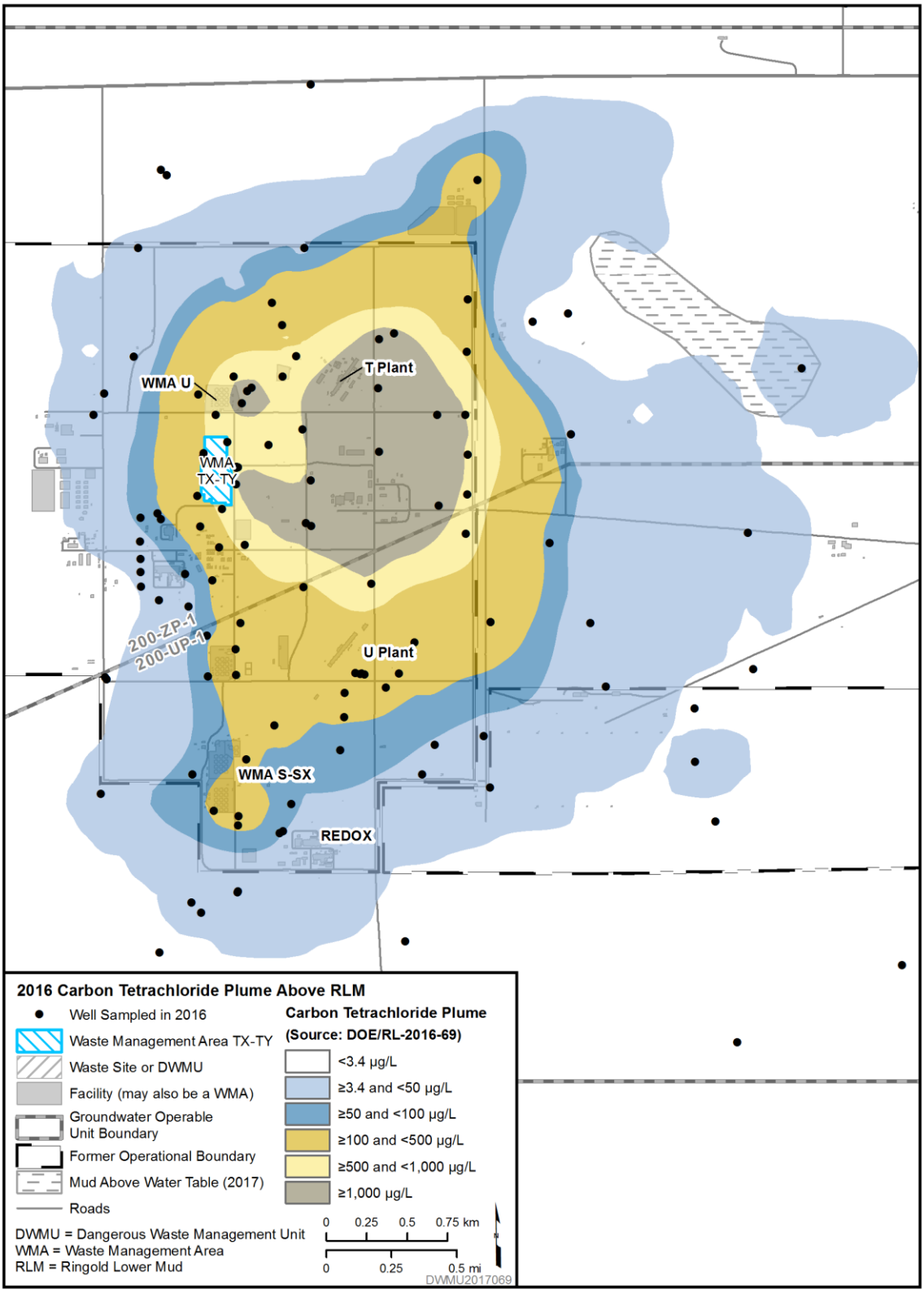


Figure D-2. 2016 Contaminant Plume Map for Carbon Tetrachloride Above Ringold Lower Mud

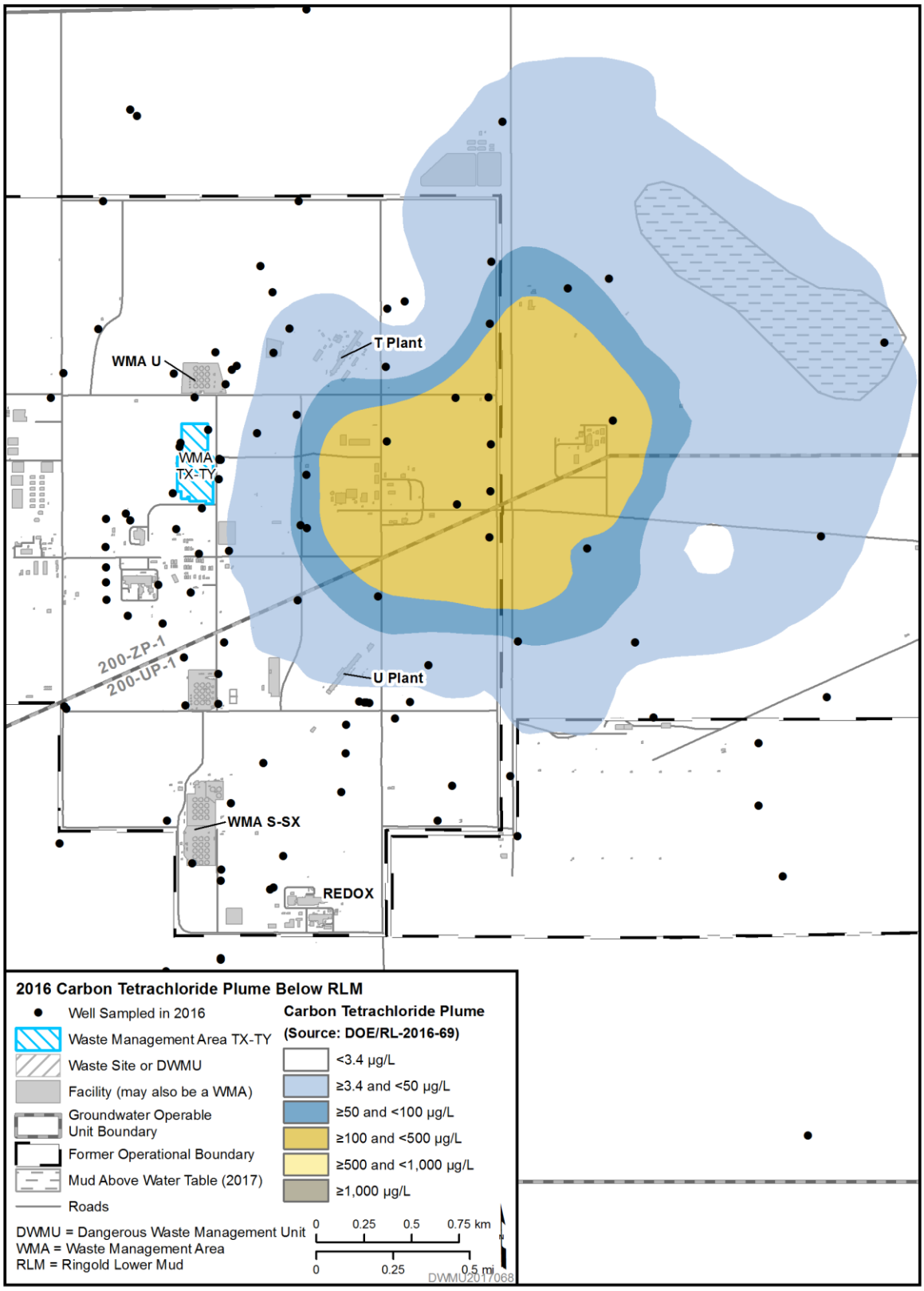


Figure D-3. 2016 Contaminant Plume Map for Carbon Tetrachloride Below Ringold Lower Mud

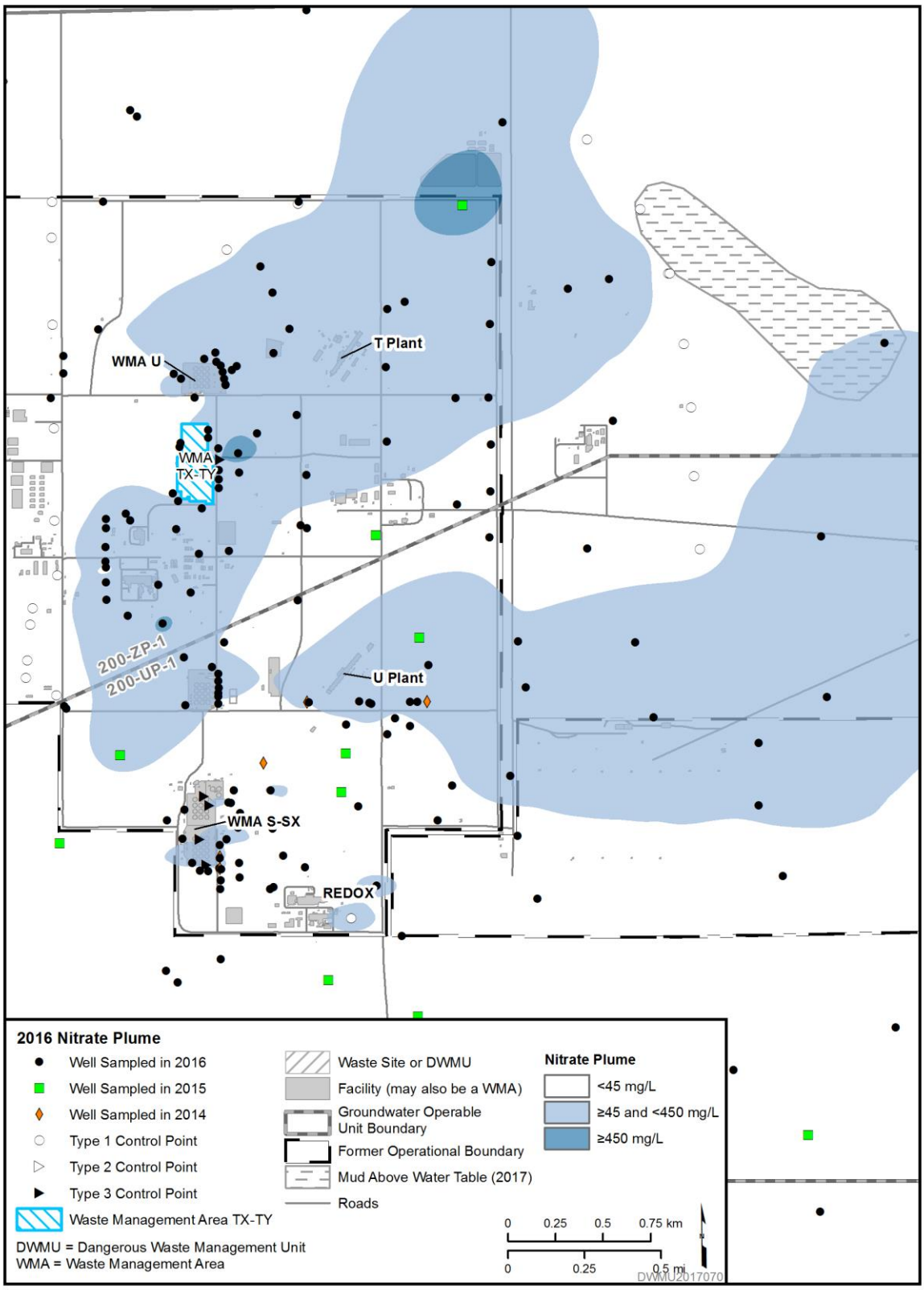


Figure D-4. Regional Nitrate Plume at Waste Management Area TX-TY

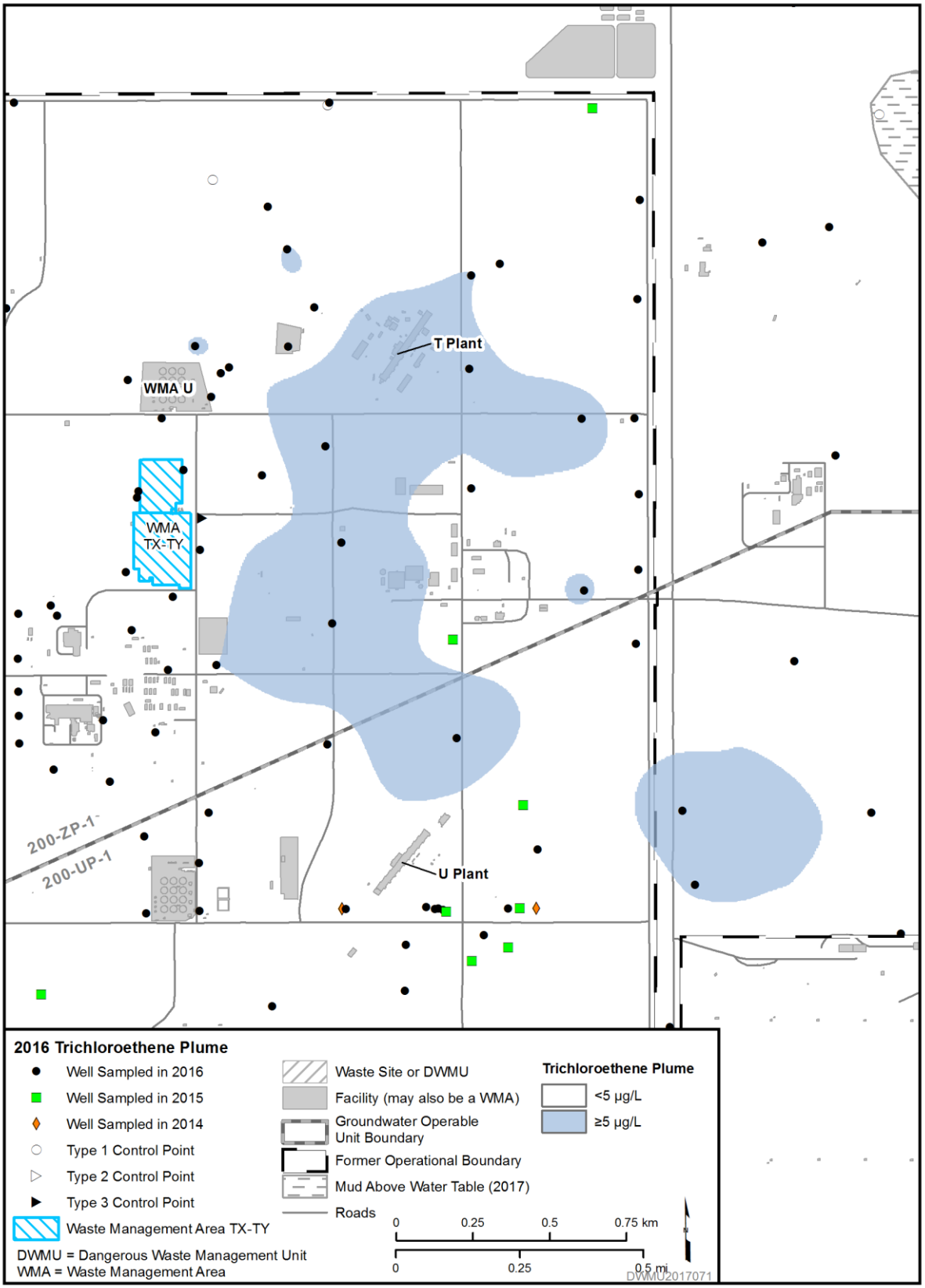


Figure D-5. Regional Trichloroethene Plume at Waste Management Area TX-TY

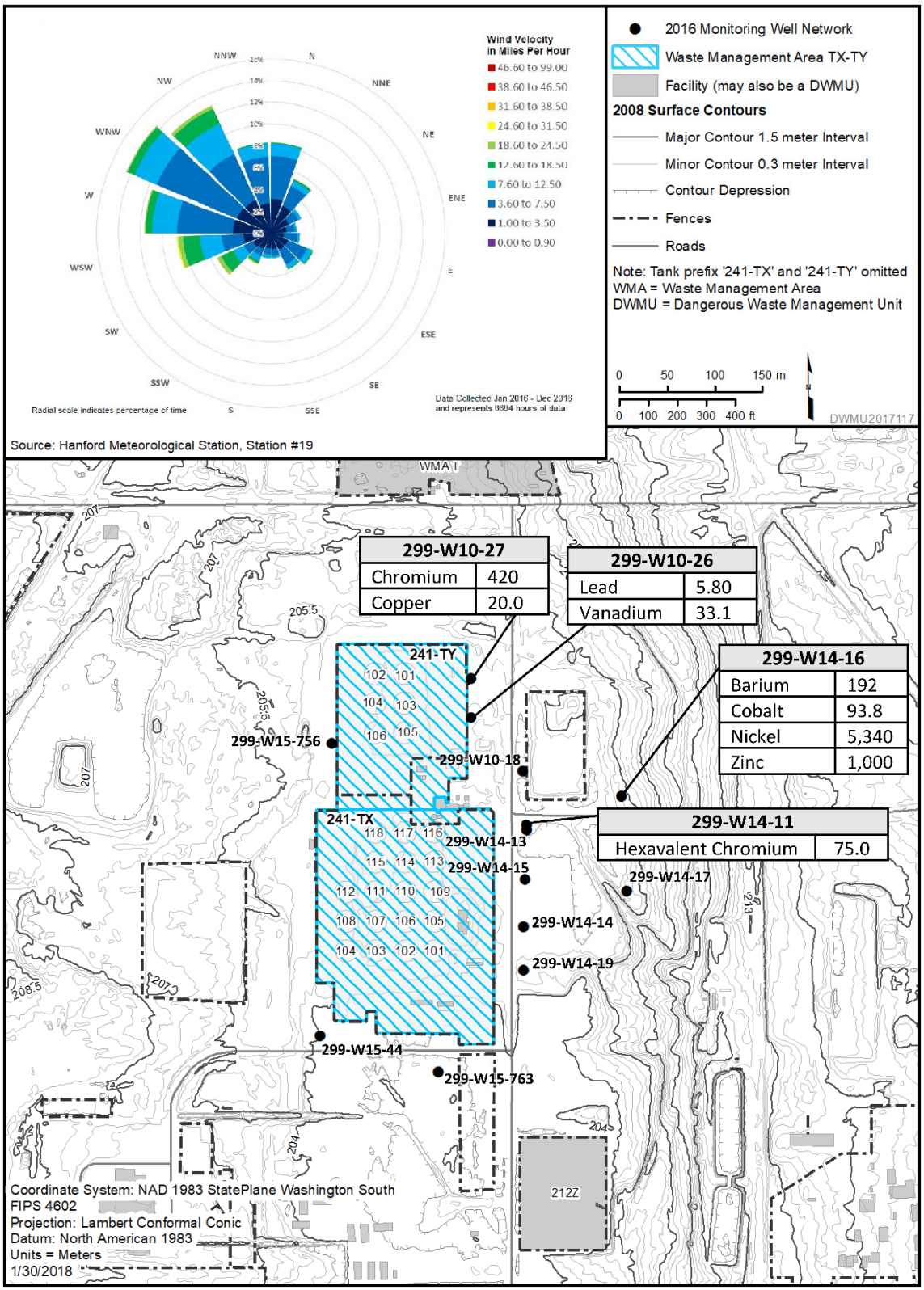
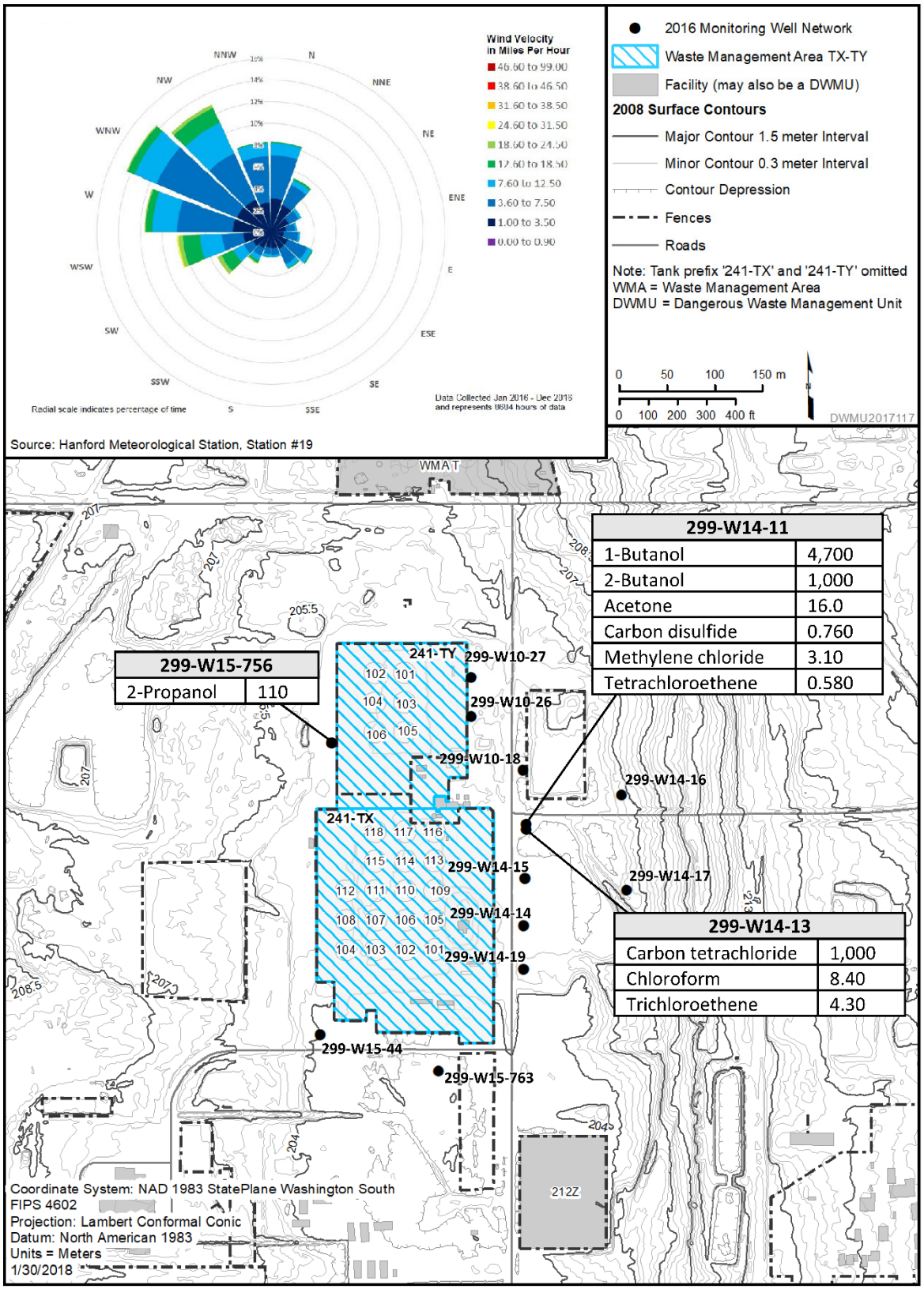


Figure D-6. 2016 Maximum Detected Groundwater Results of Metals and Inorganics in WMA TX-TY Network Wells (µg/L)



299-W15-756	
2-Propanol	110

299-W14-11	
1-Butanol	4,700
2-Butanol	1,000
Acetone	16.0
Carbon disulfide	0.760
Methylene chloride	3.10
Tetrachloroethene	0.580

299-W14-13	
Carbon tetrachloride	1,000
Chloroform	8.40
Trichloroethene	4.30

Figure D-7. 2016 Maximum Detected Groundwater Results of Organics in WMA TX-TY Network Wells (µg/L)

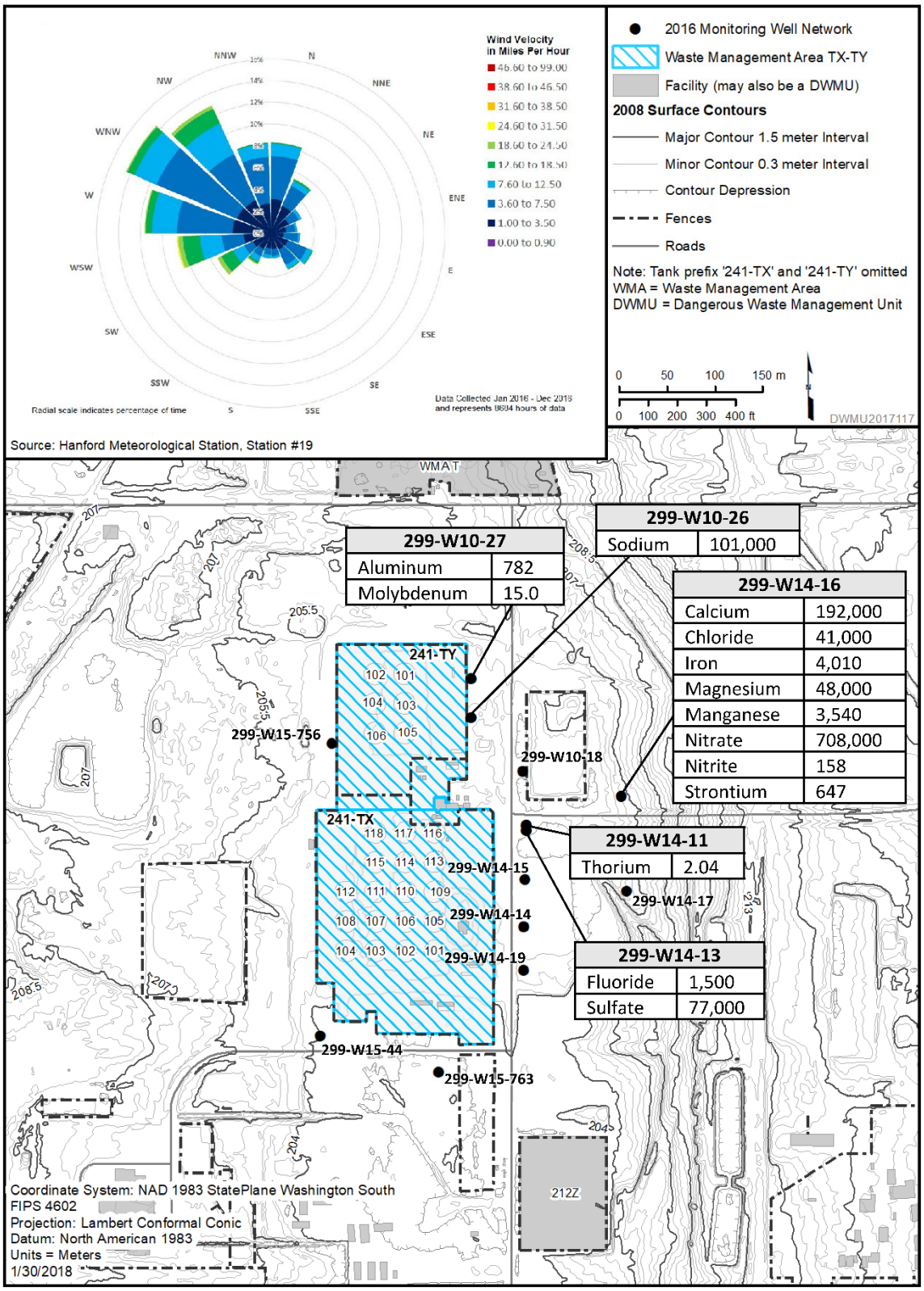


Figure D-8. 2016 Maximum Detected Groundwater Results of Nondangerous Constituents in WMA TX-TY Network Wells (µg/L)

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: http://www.ecy.wa.gov/pubs/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) TX-TY 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-7 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 TX-TY 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-W10-26	TU	138.53 (454.50)	127.86 (419.50)	10.67 (35.01)	Air Rotary
299-W10-27	TU	137.54 (451.24)	126.87 (416.24)	10.67 (35.01)	Cable Tool
299-W14-13	TU	138.20 (453.43)	127.54 (418.43)	10.66 (34.97)	Air Rotary
299-W14-14	TU	138.48 (454.33)	127.81 (419.33)	10.67 (35.01)	Air Rotary
299-W14-15	TU	137.53 (451.21)	126.86 (416.21)	10.67 (35.01)	Air Rotary/ Cable Tool
299-W14-18	TU	137.82 (452.15)	127.15 (417.15)	10.67 (35.01)	Cable Tool
299-W14-19	TU	136.62 (448.24)	125.96 (413.24)	10.66 (34.97)	Becker Hammer

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

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 TX-TY 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-TX-TY_PW1	136474.8	566578.6	205.21 (673.26)	132.82 (435.76)	72.39 (237.5)	82.75 (271.5)	10.16 (4)	70.87 (232.5) to 81.53 (267.5)	81.53 (267.5) to 82.45 (270.5)
WMA-TX-TY_PW2	136210.0	566490.1	206.6 (677.82)	133.57 (438.22)	73.03 (239.6)	83.39 (273.6)	10.16 (4)	71.51 (234.6) to 82.17 (269.6)	82.17 (269.6) to 83.09 (272.6)

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

0502371

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W10-26 B8548
Drilling Fluid Used:	Reverse Air	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	Willie Franklin	WA State Lic Nr:	Not Available	Coordinates: N	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Coordinates: E	Not documented
Date Started:	20Aug98	Date Completed:	25Aug98	Start Card #:	Not Available
				Elevation Ground Surface:	Brass Marker

Depth to Water: **216.8 ft 25Aug98**
(Ground surface)

GENERALIZED STRATIGRAPHY **Geologist's Log & Geophysical Logs**

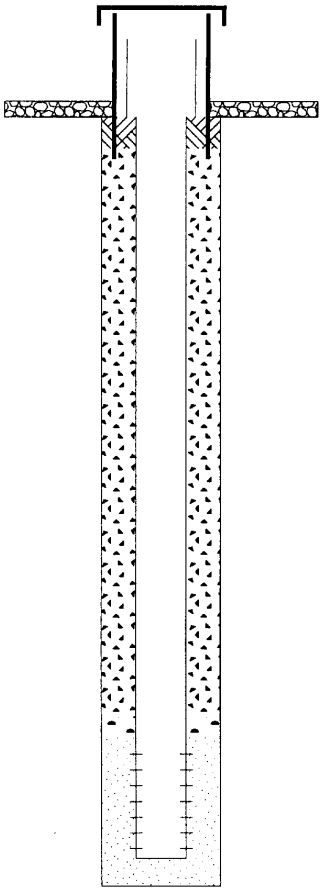
Elevation of Reference Point: **m**

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.5 ft.**

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

0 - 4 ft : Backfill
4 - 9 ft : Sand
9 - 22 ft : Gravel
22 - 42.5 ft : Sandy gravel
42.5 - 64 ft : Sand
64 - 89 ft : Gravelly sand
89 - 102 ft : Silty sand - calcareous (97-100: Caliche)
102 - 108 ft : Sand (108-110: caliche)
108 - 114 ft : Silty sand
114 - 116 ft : Sand
116 - 124 ft : Silty sand
124 - 127 ft : Sand
127 - 159 ft : Silty sandy gravel (152-156: large cobbles)
159 - 161 ft : Gravelly sand
161 - 205 ft : Sandy gravel
205 - 262 ft : Silty sandy gravel



262 ft : Borehole drilled depth

0 - 262 ft : 9.125-in. 8-5/8" Temp. carbon steel csg.

Fill	*Casing*	*Screen*
0 - 10.5 ft : 9.125-inch hole Cement Seal		
10.5 - 204.5 ft : 9.125-inch hole Bentonite Chips		
204.5 - 211 ft : 9.125-inch hole Bentonite Pellets 211 - 217.04 ft : 9.125-inch hole 20-40 Silica Sand 217.04 - 252.13 ft : 9.125-inch hole 20-40 Silica Sand	217.04 - 0 ft : 4 inch 4" SS Sch. 5 Csg.	217.04 - 252.13 ft : 4 inch 4" Wire Wrap SS .010 Slot Screen
252.13 - 262 ft : 9.125-inch hole 20-40 Silica Sand	252.13 - 252.45 ft : 4 inch 4" SS End Cap	

Drawing By: **TGB**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **21Sep98**
Print Date: **28Dec98**

Report Form: WELLS Project File: WELLS.GPJ

Figure E-1. Well 299-W10-26 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W10-26

WELL DESIGNATION	:	**299-W10-26**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**262.0 ft**
MEASURED DEPTH (GS)	:	
AVAILABLE LOGS	:	**Data not available**
DATE EVALUATED	:	**Data not available**
EVAL RECOMMENDATION	:	**Data not available**
LISTED USE	:	**Data not available**
CURRENT USER	:	**RCRA & Operations**
PUMP TYPE	:	**Data not available**
MAINTENANCE	:	**Data not available**
COMMENTS	:	**8-5/8" TUBEX Sys. 4-1/2" Reverse Cir. Drl. Pipe with Interchange**
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	**TGB**
Reference:	**Hanford Wells**
Revision:	**0**
Revision Date:	**21Sep98**
Print Date:	**28Dec98**

Figure E-1. Well 299-W10-26 Construction and Completion Summary (continued)

0532883

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W10-27 C3125
Drilling Fluid Used:	none	Additives Used:	water	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:	22Jan01	Date Completed:	23Mar01	Start Card #:	Not Available
				Elevation Ground Surface:	

Depth to Water: **220.63 ft ft 23Mar01**
(Ground surface)

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**

GENERALIZED STRATIGRAPHY **Geologist's Log**

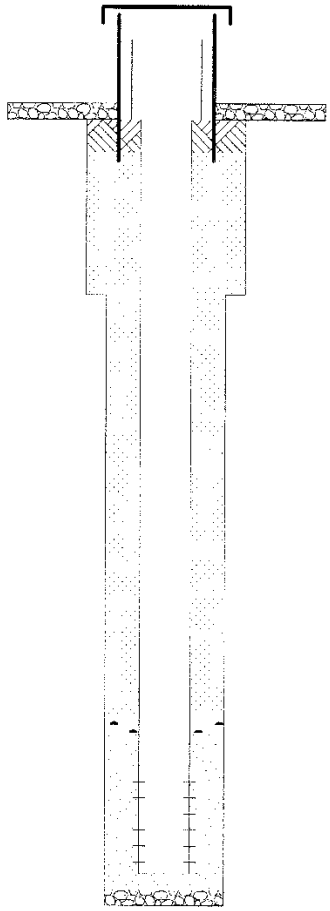
0 - 1 ft : Construction gravel
1 - 4.5 ft : Silty SAND (mS)
4.5 - 8.5 ft : SAND (S)
8.5 - 24 ft : Sandy GRAVEL (sG)
24 - 38 ft : Silty Sandy GRAVEL (msG)

38 - 41.5 ft : Sandy GRAVEL (sG)
41.5 - 89 ft : SAND (S)

89 - 98.2 ft : Silt (M) Plio Pleistene top

98.2 - 102 ft : Caliche in Silty SAND (mS)
102 - 108 ft : Silty SAND (mS)
108 - 112 ft : Caliche in SAND(s)
112 - 117.5 ft : SAND (S)
117.5 - 120.5 ft : SILT (M(
120.5 - 124.5 ft : SAND (S)
124.5 - 220 ft : Silty Sandy GRAVEL (msG)-
Ringold E top

220 - 225 ft : Slightly Silty Gravelly SAND
225 - 268.7 ft : Silty Sandy Gravel (msg)



Fill	*Casing*	*Screen*
0 - 10.9 ft : 12-inch hole Cement Surface Seal	0 - 256 ft : 4 inch 4" 304 SS sch 5 csg.	
10.9 - 60 ft : 12-inch hole Grannular Bentonite		
60 - 204.6 ft : 9-inch hole Grannular Bentonite		
204.6 - 210 ft : 9-inch hole 1/4" Bentonite Pellets		221 - 256 ft : 4 inch 4" 304 SS .020 Slot wirewrap scrn
210 - 257.76 ft : 9-inch hole 10/20 Silica Sand		
257.76 - 268.7 ft : 9-inch hole 10/20 Silica Sand	256 - 257.86 ft : 4 inch 4" 304L SS Sump	
263.3 - 268.7 ft : 9-inch hole Slough		

268.7 ft : Borehole drilled depth

0 - 60 ft : 12-in. 11-3/4" CS Temp. csg set w/cable tool
60 - 268.7 ft : 9-in. 8-5/8" CS Temp. csg set w/ cable tool

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **16Apr01**
Print Date: **16Apr01**

Report Form: WELLS Project File: WELLS.GPJ

Figure E-2. Well 299-W10-27 Construction and Completion Summary

0502372

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-13 B8549
Drilling Fluid Used:	Reverse Air	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	Willie Franklin	WA State Lic Nr:	Not Available	Coordinates: N	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Coordinates: E	Not documented
Date Started:	26Aug98	Date Completed:	31Aug98	Start Card #:	Not Available
				Elevation Ground Surface:	Brass Marker

Depth to Water: 215.8 ft 31Aug98
(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: 9.6 ft.

Type of Surface Seal: 4x4 Concrete Pad

0 - 4 ft : Construction fill
4 - 14 ft : Sand
14 - 33 ft : Sandy gravel

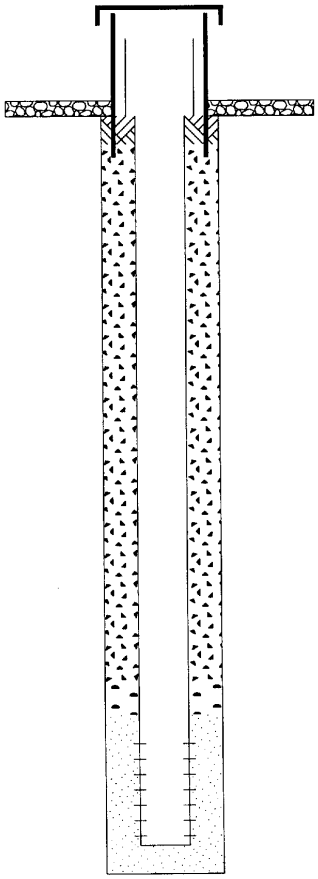
33 - 95 ft : Sand

95 - 98 ft : Sand, sl calcareous
98 - 101 ft : Caliche
101 - 112 ft : Sandy gravel sl calcareous
112 - 125 ft : Sand

125 - 163 ft : Silty sandy gravel

163 - 210 ft : Sandy gravel

210 - 262 ft : Sandy gravel



Fill	*Casing*	*Screen*
0 - 9.6 ft : 9.125-inch hole Cement Seal	0 - 216.62 ft : 4 inch 4" SS Sch. 5 Csg.	
9.6 - 195.1 ft : 9.125-inch hole Bentonite Chips		
195.1 - 206.4 ft : 9.125-inch hole Bentonite Pellets		216.62 - 251.73 ft : 4 inch 4" Wire Wrap SS .010 Slot Screen
206.4 - 252.05 ft : 9.125-inch hole 20-40 Silica Sand		
252.05 - 262 ft : 9.125-inch hole 20-40 Silica Sand	251.73 - 252.05 ft : 4 inch 4" SS End Cap	

262 ft : Borehole drilled depth

0 - 262 ft : 9.125-in. 8-5/8" CS Temp. Csg.

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: TGB
Reference: Hanford Wells
Revision: 0
Revision Date: 21Sep98
Print Date: 28Dec98

Figure E-3. Well 299-W14-13 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-13

WELL DESIGNATION	:	**299-W14-13**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**262.0 ft**
MEASURED DEPTH (GS)	:	
AVAILABLE LOGS	:	**Data not available**
DATE EVALUATED	:	**Data not available**
EVAL RECOMMENDATION	:	**Data not available**
LISTED USE	:	**Data not available**
CURRENT USER	:	**RCRA & Operations**
PUMP TYPE	:	**Data not available**
MAINTENANCE	:	**Data not available**
COMMENTS	:	**8-5/8" TUBEX Sys. 4-1/2" Reverse Cir. Drl. Pipe with Interchange**
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	**TGB**
Reference:	**Hanford Wells**
Revision:	**0**
Revision Date:	**21Sep98**
Print Date:	**28Dec98**

Figure E-3. Well 299-W14-13 Construction and Completion Summary (continued)

0502370

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-14 B8547
Drilling Fluid Used:	Reverse Air	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	Randy Smith	WA State Lic Nr:	Not Available	Coordinates: N	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Coordinates: E	Not documented
Date Started:	08Oct98	Date Completed:	12Nov98	Start Card #:	Not Available
				Elevation Ground Surface:	Brass Marker

Depth to Water: 216 ft 24Oct98
(Ground surface) 217.42 ft 14Nov98

GENERALIZED STRATIGRAPHY Geologist's Log & Geophysical Logs

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 9.3 ft.

Type of Surface Seal: 4x4 Concrete Pad

0 - 4.5 ft : Backfill - Sand and gravel
4.5 - 7 ft : Silty Gravelly SAND
7 - 14.5 ft : Silty SAND
14.5 - 16.5 ft : Silty Sandy GRAVEL
16.5 - 33 ft : Sandy GRAVEL
33 - 86.5 ft : SAND

86.5 - 93.5 ft : SAND (trace of caliche @ 86')
93.5 - 123 ft : Silty SAND (Caliche 108 to 110')

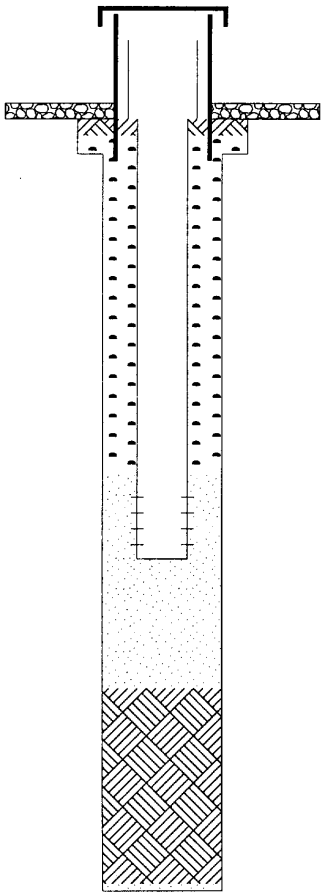
123 - 145 ft : Sandy GRAVEL

145 - 209 ft : Sandy GRAVEL

209 - 217 ft : Gravelly SAND
217 - 360 ft : Silty Sandy GRAVEL

360 - 402 ft : Sandy GRAVEL

402 - 412 ft : Silty CLAY
412 - 415.5 ft : SILT
415.5 - 424 ft : SILT (trace of gravel)
424 - 428 ft : GRAVEL
428 - 438 ft : SILT
438 - 443 ft : Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 9.3 ft : 13-inch hole Cement Seal	0 - 216.98 ft : 9.125 inch 4" SS Sch. 5 Csg.	
9.3 - 20 ft : 13-inch hole Medium Bentonite Chunks		
20 - 202.3 ft : 9.125-inch hole Medium Bentonite Chunks		
202.3 - 203.8 ft : 9.125-inch hole 3/8 Bentonite Pellets		216.98 - 252 ft : 4 inch 4" SS Wire Wrap Screen - .010 Slot
203.8 - 252.3 ft : 9.125-inch hole 20-40 Silica Sand	252 - 252.3 ft : 9.125 inch 4" SS End Cap	
252.3 - 257.3 ft : 9.125-inch hole 20-40 Silica Sand		
257.3 - 326.6 ft : 9.125-inch hole 4-10, 6-9, 8-12, 8-16 & 10-20 Silica Sand		
326.6 - 438.8 ft : 9.125-inch hole Cement Grout		
438.8 - 443 ft : 9.125-inch hole 8-16 & 10-20 Silica Sand		

443 ft : Borehole drilled depth

0 - 20 ft : 13-in. 12-3/4" Temp. Csg. set w/Cable Tool
20 - 443 ft : 9.125-in. 8-5/8" Temp. Csg. Set w/Tubex air rotary-rev. air 4-1/2" Drl. Pipe

Drawing By:	JEA
Reference:	Hanford Wells
Revision:	0
Revision Date:	16Oct98
Print Date:	28Dec98

Report Form: WELLS Project File: WELLS.GPJ

Figure E-4. Well 299-W14-14 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-14

WELL DESIGNATION	:	**299-W14-14**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**443.0 ft**
MEASURED DEPTH (GS)	:	**252.30 06Nov98**
AVAILABLE LOGS	:	**Geologist & Geophysical Logs**
DATE EVALUATED	:	**Data not available**
EVAL RECOMMENDATION	:	**Data not available**
LISTED USE	:	**RCRA Monitoring**
CURRENT USER	:	**RCRA & Operations**
PUMP TYPE	:	**Hydrostar**
MAINTENANCE	:	**Data not available**
COMMENTS	:	**12" Temp. Csg. to 20 ft.- Cable Tool. 20 ft. to 443 ft. 8-5/8" Temp. Csg.- Tubex Rev. Air w/4-1/2" D.P.**
TV SCAN COMMENTS	:	

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **16Oct98**
Print Date: **28Dec98**

Report Form: WELLS Project File: WELLS.GPJ

Figure E-4. Well 299-W14-14 Construction and Completion Summary (continued)

0526562

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool/Air Rotary	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-15 C3114
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:	17Aug00	Date Completed:	01Sep00	Start Card #:	Ro37802
				Elevation Ground Surface:	

Depth to Water: 219.8 ft 05Sep00
(Ground surface)

Elevation of Reference Point: m

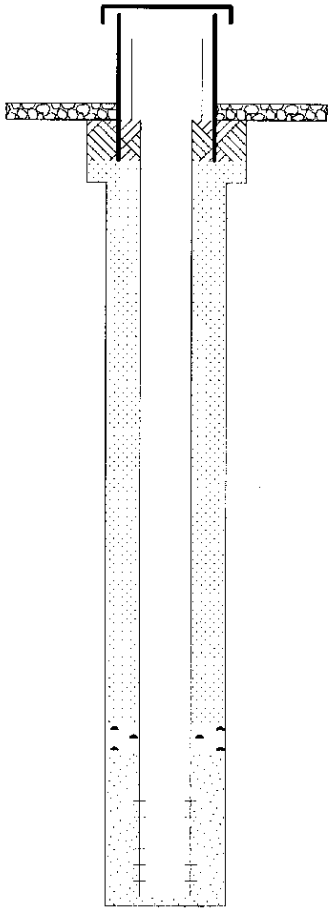
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 13.5 ft.

Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 2 ft : Silty SAND
2 - 19 ft : Gravelly Silty SAND
19 - 37 ft : Silty Sandy GRAVEL
37 - 68 ft : SAND
68 - 74 ft : Silty SAND
74 - 88 ft : SAND
88 - 103 ft : Silty SAND
103 - 118 ft : Slightly Silty Gravelly SAND
118 - 123 ft : Slightly Silty SAND
123 - 142 ft : Silty Sandy GRAVEL
142 - 143 ft : SAND
143 - 175 ft : Sandy GRAVEL
175 - 221 ft : Sandy GRAVEL
221 - 260 ft : Silty Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 13.5 ft : 12-inch hole Cement Surface Seal	0 - 219.75 ft : 4 inch 4" 304 SS Sch 5 well csg.	
13.5 - 20.7 ft : 12-inch hole Granular Bentonite		
20.7 - 199.3 ft : 9-inch hole Granular Bentonite		
199.3 - 209.9 ft : 9-inch hole Bentonite Pellets		219.75 - 254.62 ft : 4 inch SS Wire Wrap .020 slot scrn.
256.7 - 209.9 ft : 9-inch hole 10/20 Silica Sand		
260 - 256.7 ft : 9-inch hole 10/20 Silica Sand	254.62 - 256.7 ft : 4 inch 4" SS Sump	

260 ft : Borehole drilled depth

0 - 20.7 ft : 12-in. 11-3/4" CS Temp. csg. drl w/cable tool
20.7 - 260 ft : 9-in. 8-5/8" CS Temp. csg. drl w/air rotary (csg hammer)

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

Report Form: WELLS Project File: WELLS.GPJ

Figure E-5. Well 299-W14-15 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-15

WELL DESIGNATION	:	**299-W14-15**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**260.0 ft**
MEASURED DEPTH (GS)	:	**260.0 05Sep00**
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 20.7 ft w/11-3/4" CS csg Air Rotary from 20.7 to 260 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-W14-15 Construction and Completion Summary (continued)

0540441

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-18 C3396
Drilling Fluid Used:	None	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	M. Waspir	WA State Lic Nr:	1909	Coordinates: N	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	30Aug01	Date Completed:	01Nov01	Start Card #:	R037816
				Elevation Ground Surface:	

Depth to Water: **220.45 ft** **07Nov01**
(Ground surface)

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 0.5 ft : Drill Pad Material
0.5 - 8 ft : Silty Sand
8 - 13 ft : Sand
13 - 34 ft : Sandy Gravel

34 - 88.5 ft : Sand

88.5 - 114 ft : Sandy Silt

114 - 120 ft : Silty Sand
120 - 125 ft : Sandy Silt
125 - 145 ft : Gravelly Silt

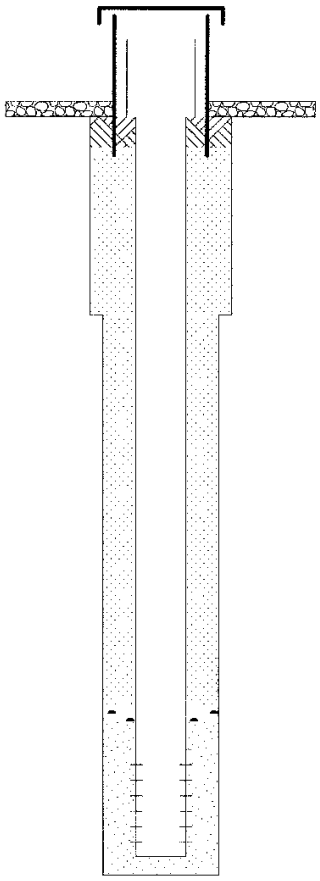
145 - 155 ft : Silty Gravel

155 - 160 ft : Gravelly Silt
160 - 165 ft : Silty Gravel
165 - 190 ft : Gravelly Silt

190 - 200 ft : Sandy Silt

200 - 205 ft : Gravelly Sandy Silt
205 - 210 ft : Silty Gravel
210 - 215 ft : Sandy Silt
215 - 220 ft : Gravelly Silt
220 - 235 ft : Gravelly Sandy Silt

235 - 240 ft : Gravelly Silt
240 - 261.5 ft : Gravelly Sandy Silt



Elevation of Reference Point: **m**

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.5 ft**

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

Fill	*Casing*	*Screen*
0 - 10.5 ft : 11-inch hole Cement Surface Seal	0 - 218.06 ft : 4 inch 304L SS sch 5 csg	
10.5 - 68.6 ft : 11-inch hole Granular Bentonite		
68.6 - 203.3 ft : 9-inch hole Granular Bentonite		
203.3 - 208.4 ft : 9-inch hole 1/4" Bentonite Pellets		218.06 - 253.05 ft : 4 inch 304L SS Wire Wrap .020 slot scrn
208.4 - 255.05 ft : 9-inch hole 10/20 Silica Sand		
255.05 - 261.5 ft : 9-inch hole 10/20 Silica Sand	253.05 - 255.05 ft : 4 inch 304L SS Sump	

261.5 ft : Borehole drilled depth

0 - 68.6 ft : 11-in. Cable Tool 10-3/4" CS Temp csg to 68.6 ft
68.6 - 261.5 ft : 9-in. Cable Tool 8-5/8" CS Temp csg to 261.5 ft

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **13Nov01**
Print Date: **13Nov01**

Report Form: WELLS Project File: WELLS.GPJ

Figure E-6. Well 299-W14-18 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-18

WELL DESIGNATION	:	**299-W14-18**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**261.5 ft**
MEASURED DEPTH (GS)	:	**255.05 07Nov01**
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 10-3/4" CS csg to 68.6 ft & 8-5/8" CS csg to 261.5 ft**
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	JEA
Reference:	Hanford Wells
Revision:	0
Revision Date:	13Nov01
Print Date:	13Nov01

Figure E-6. Well 299-W14-18 Construction and Completion Summary (continued)

AS-BUILT WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Becker Hammer	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-19 C3957
Drilling Fluid Used:	Air	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	Paul Lodder	WA State Lic Nr:	1628	Coordinates: N	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Coordinates: E	Not documented
Date Started:	24Oct02	Date Completed:	13Nov02	Start Card #:	Not Available
				Elevation Ground Surface:	

Depth to Water: **223.55 ft ft 04Nov02**
(Ground surface)

Elevation of Reference Point: **m**

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **0 ft**

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

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 3 ft : Backfill
3 - 41 ft : silty SAND (mS)

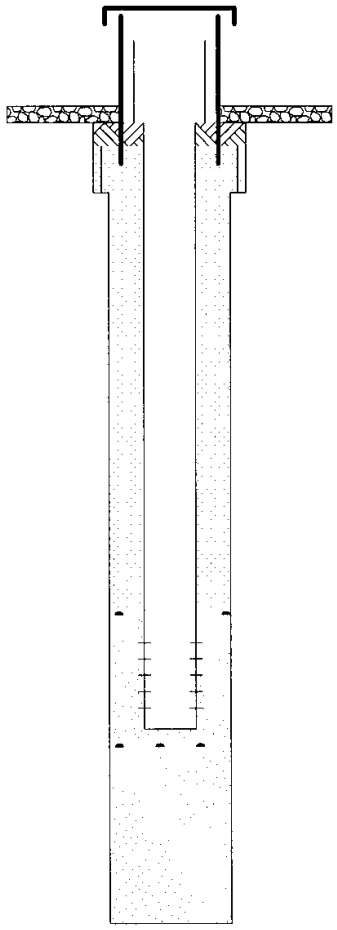
41 - 50 ft : sandy GRAVEL (sG)
50 - 95 ft : SAND (S)

95 - 100 ft : silty SAND (mS)
100 - 109 ft : SILT (m)
109 - 115 ft : CALICHE
115 - 125 ft : silty SAND (mS)
125 - 130 ft : silty sandy GRAVEL (msG)
130 - 135 ft : sandy GRAVEL (sG)
135 - 145 ft : GRAVEL (G)
145 - 150 ft : silty sandy GRAVEL (msG)
150 - 175 ft : sandy GRAVEL (sG)

175 - 185 ft : silty sandy GRAVEL (msG)
185 - 190 ft : sandy GRAVEL (sG)
190 - 200 ft : silty sandy GRAVEL (msG)
200 - 205 ft : SAND (S)
205 - 220 ft : sandy GRAVEL (sG)

220 - 225 ft : silty sandy GRAVEL (msG)
225 - 285 ft : sandy GRAVEL (sG)

285 - 295 ft : silty sandy GRAVEL (msG)
295 - 344 ft : sandy GRAVEL (sG)



Fill	*Casing*	*Screen*
0 - 10 ft : 11.25-inch hole Cement surface seal	0 - 223.5 ft : 4 inch	
10 - 30 ft : 11.25-inch hole Granular Bentonite	10 - 30 ft : 10.75 inch Left in hole	
30 - 208.3 ft : 9-inch hole Granular Bentonite		
208.3 - 213.5 ft : 9-inch hole 1/4" Bentonite Pellets		223.5 - 258.5 ft : 4 inch
213.5 - 260.5 ft : 9-inch hole 10/20 Silica sand		
260.5 - 264.9 ft : 9-inch hole 10/20 Silica sand	258.5 - 260.5 ft : 4 inch 304L SS csg and sump	
264.9 - 269.5 ft : 9-inch hole 1/4" Bentonite Pellets		
269.5 - 344.3 ft : 9-inch hole 4/8 Silica sand		

344.3 ft : Borehole drilled depth

0 - 30 ft : 11.5-in. Auger 10-3/4" Temp CS csg
30 - 344.3 ft : 9-in. Becker Hammer 9" x 7" Temp CS csg

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision:
Revision Date: **16Dec02**
Print Date: **16Dec02**

Figure E-7. Well 299-W14-19 Construction and Completion Summary

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 TX-TY Monitoring Network – ECF-200W-17-0071

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The calculation ECF-200W-17-0071, *Groundwater Flow and Migration Calculations to Support Assessment of the WMA TX-TY Monitoring Network*, was performed to evaluate monitoring well locations for the Waste Management Area TX-TY groundwater monitoring network. The calculation is available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065255H.

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Appendix H

Statistical Method Determination

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Contents

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Figure H-6. Temporal Trend Analysis H-7
Figure H-7. Equal Variance Evaluation H-8
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 2 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.

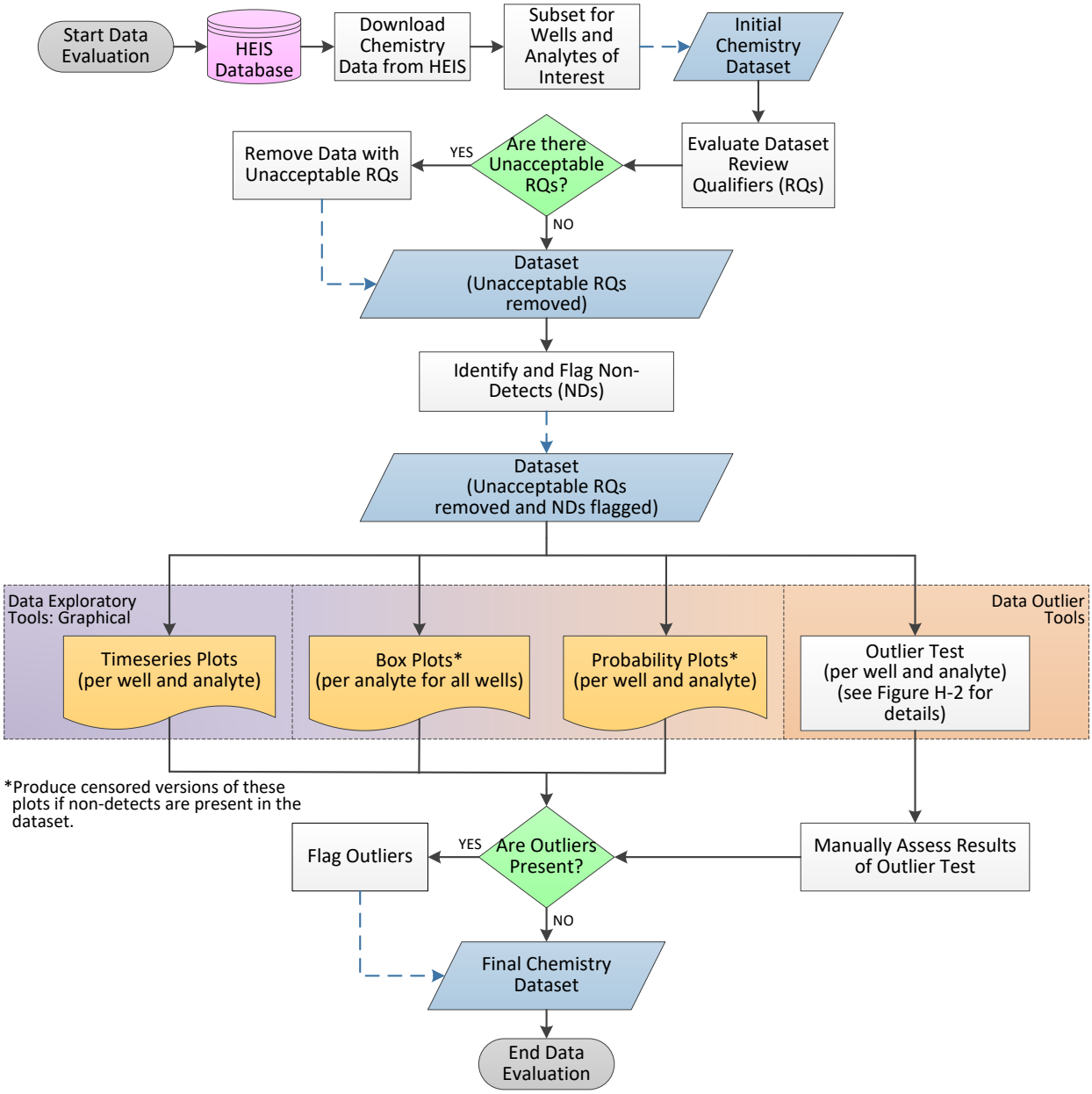

Figure H-1. Data Evaluation

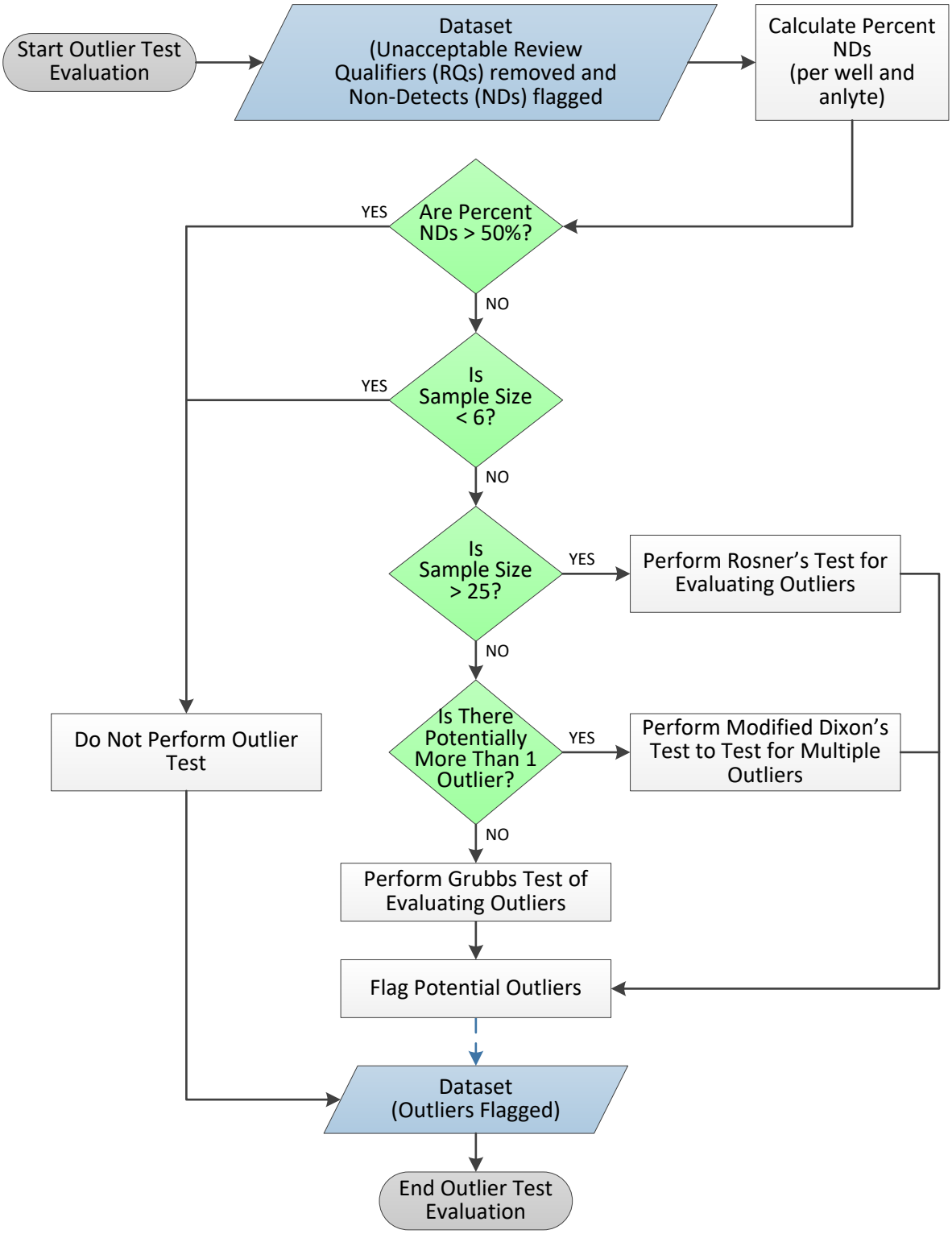

Figure H-2. Outlier Test Evaluation

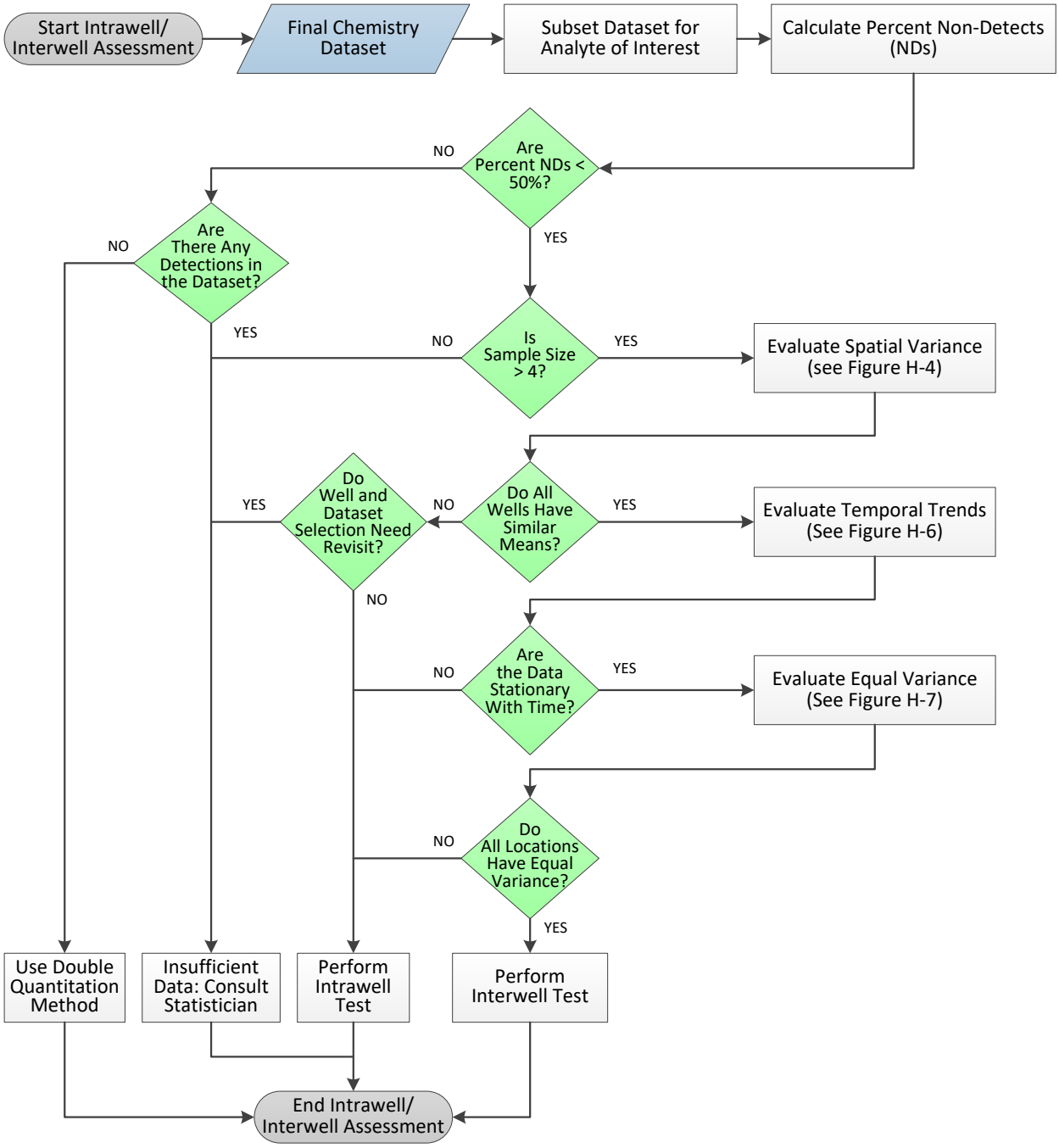

Figure H-3. Intrawell/Interwell Assessment

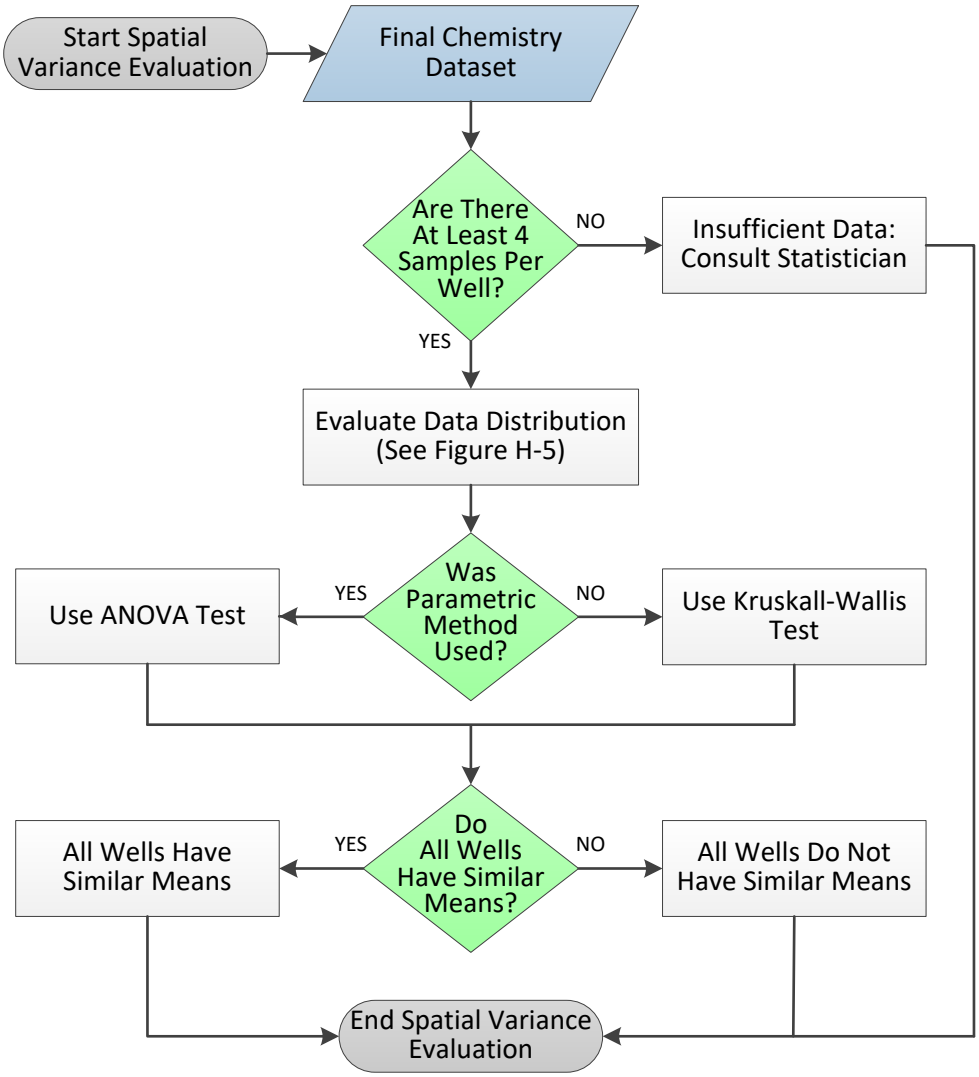

Figure H-4. Spatial Variance Evaluation

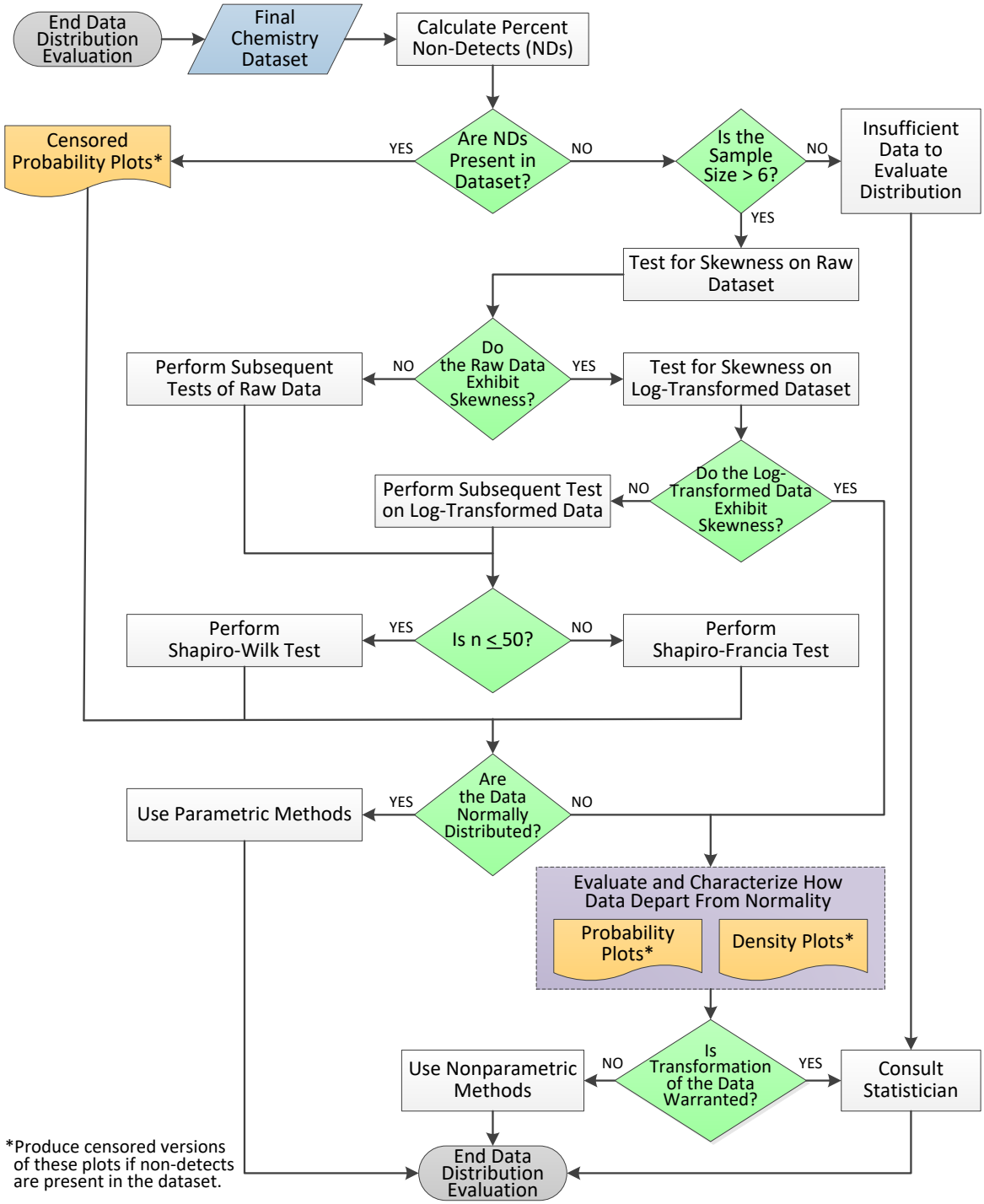

Figure H-5. Data Distribution Evaluation

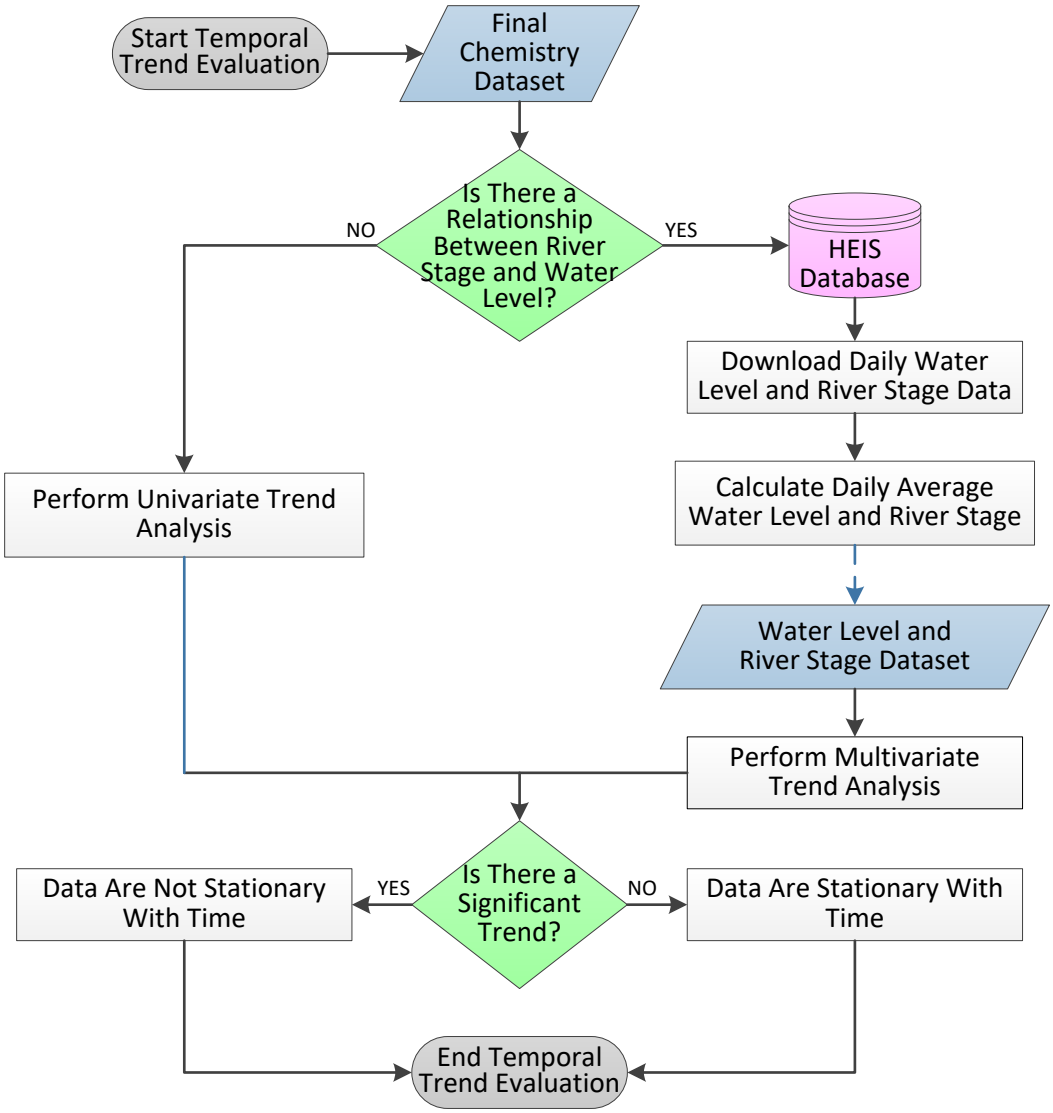

Figure H-6. Temporal Trend Analysis

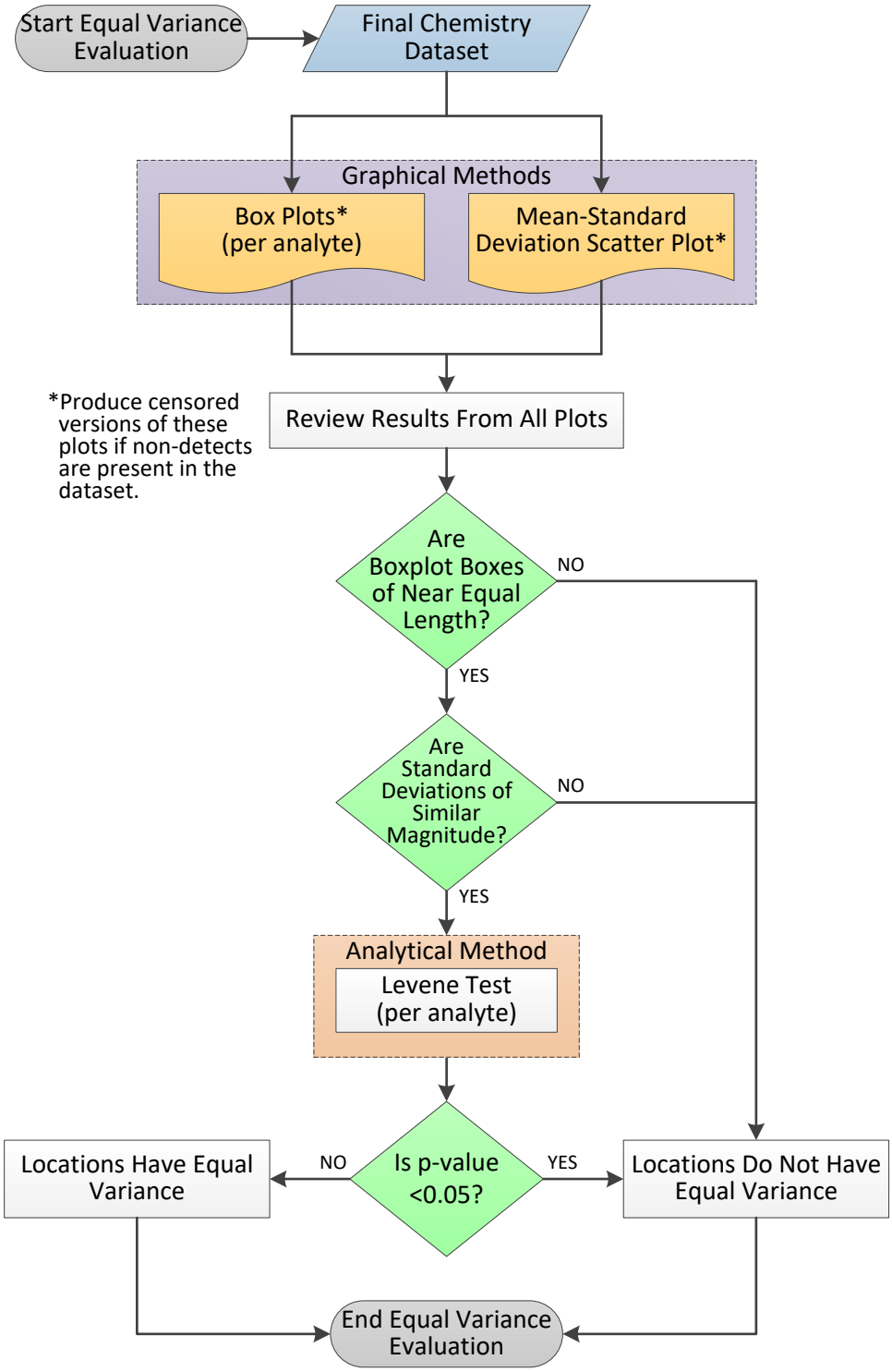

Figure H-7. Equal Variance Evaluation

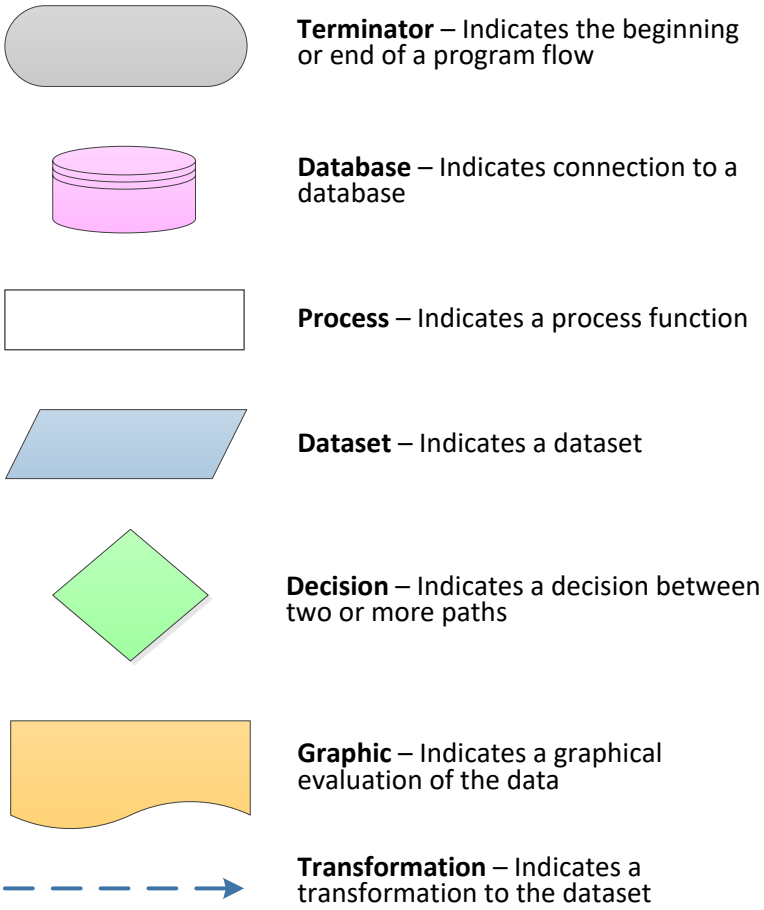

Figure H-8. Chart Legend

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: December 20, 2017 Dispositioned: January 31, 2018 RCR Closed: March 8, 2018 Page 1 of 17

Document Title(s)/Number(s): Engineering Evaluation Report for Single-Shell Tank Waste Management Area TX-TY Groundwater Monitoring/SGW-60576

Document Lead/Phone #/email: Dwayne Crumpler 372-7925 dwayne.crumpler@ecy.wa.gov | **Project Manager/Phone #/email:** Jeff Lyon 372-7914 jeff.lyon@ecy,wa,gov

Item # Page # Section # Line #s	Comment and Basis/Justification	Modification Needed	DOE Response	Ecology Response	O/C	Reviewer (Initials)
Item 1 General	Comment: Please incorporate all comments made on WMAs U and T EERs. Basis/Justification: Previous relevant comments need to be incorporated into this document.		Accept. Modifications made.	Accept.	~~C~~ ~~1/31/2018~~ ~~Pending outstanding changes to documents~~ C 3/8/2018 Redline reviewed.	ALL
Item 2 General	Comment: General comment regarding the approach. The simulations are performed under the assumption that all releases are future. I don't see how compliance monitoring of existing contaminant plumes is addressed by the simulations or the conclusions.	Provide how simulations are performed that take into account existing contaminant plumes and explain in the document including the conclusion section.	Same as item 31 in WMA T. 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." Would affect all EERs.	Accept.	C 2/2/2018 Redline reviewed.	SPL
Item 3 P: 2-1 S: 2 L: 18	Comment: Drywells surround the tanks mostly and are located within the tank farm fence line. They do not surround the "tank farms". Change "Drywells surround the tank farms" to read, "Drywells surround the tanks in a clockwise pattern with a few drywells located within the tank farm fence boundary." Basis/Justification: Clarity, completeness, accuracy.	See comment.	Accept. Agree that text should state that drywells surround the tanks, not the tank farms.	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 4 P: 2 S: 2.1 L: 5-17	Comment: Provide the reference for this material. It appears it originated from RPP-7578 or RPP-7123. Basis/Justification: This is not original material as written. It requires a reference.		Accept. The discussion was taken from Section 2.1 of the current monitoring plan DOE/RL-2009-67, Rev. 1 (2012). Reference has been added to DOE/RL-2009-67, Rev. 1 (2012).	Accept.	C 1/31/2018 Redline reviewed.	DC

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EERs = Engineering Evaluation Reports

Item 5 P: 2-3 Fig 2-2	Comment: Provide the correct tank structure for the tanks. This figure can be taken out of RPP-7578 or RPP-23752. All the various tanks in the tank farm should be represented. Basis/Justification: WAC 173-303-645(8).	Provide the correct tank structures for TX and TY tank farms.	No change to text. The EERs for the tank farm use a standard figure to depict a typical SST. The figure is adapted from the single schematic, "Single-Shell Tank System – Typical Tank," that is provided in the Part A application. The versions used for S-SX and A-AX EERs are modified slightly (per the source figure) to show a leak detection lateral caisson and leak detection laterals.	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 6 P: 2-4 S: 2.1.3	Comment: The report states there is no estimate for an inventory leak loss for this tank and cites Section 2.2.8 in RPP-7218. The Hanford 241-TX Farm Leak Inventory Assessment Report RPP-RPT-50870 Rev.00 composed of Department of Ecology and WRPS developed a process (RPP_32681) to reassess single-shell tank releases and volumes. The report lists a revised estimate of 50,000 to 125,000 gallons for TX-105 along with a revised estimate of 8,300 to 25,000 gallons for TX-104 which is listed as sound in HNF-EP-0182. Leaks were also revised for TX-114 and TX-118 which should be reviewed. The details for the estimates are in the report. The team did ask for a formal D-42 leak assessment be done. The TY tank farm leak assessment report (RPP-RPT-42296) did not have significant changes but should be reviewed. Basis/Justification: Correctness. WAC 173-303-645(8) and WAC 173-303-806(4)(a)(xx).	These new leak estimates from TX should be incorporated in a proper engineering report.	Accept. New and revised text: p. 2-3, lines 16-18: "Although classified as "sound" in HNF-EP-0182, a 2013 assessment of 241-TX-104 and 241-TX-118 (RPP-RPT-50870, *Hanford 241-TX Farm Leak Inventory Assessment Report*) has identified leak volumes associated with the SST (241-TX-104) or associated equipment (241-TX-118). ~~In regards to tank 241-TX-105, neither spectral gamma logging data nor waste transfer records show evidence of a leak; therefore, no inventory estimate exists (Section 2.2.8 in RPP-7218). Additional details of tank 241-TX-105 are presented in the following paragraphs.~~" p. 2-4, lines 6-15: "Tank 241-TX-104 is classified as "sound" in HNF-EP-0182; however, the leak assessment results in RPP-RPT-50870 found that uranium measured in drywells near 241-TX-104 was not associated with known leaks from 241-TX-107, an assumed leaking tank (Section 4.9.2). The report concluded that the uranium contamination may be the result of a spare inlet overflow or cascade line release, and/or a tank liner leak, and that the 241-TX-104 tank leak classification of "sound" should be reassessed (Section 4.9.3 in RPP-RPT-50870). The report estimated a total leak volume between 31,400 and 94,600 L (8,300 and 25,000 gal) (Table ES-1 and Section 4.9.3 in RPP-RPT-50870). Tank 241-TX-105 was categorized as an assumed leaker in 1977; however, it does not have an estimated leak volume in HNF-EP-0182. It was categorized as an assumed leaker due to three reported decreases in the liquid level of the tank. Although two of these leaks were attributed to false equipment readings, the third decrease could not be determined (Section 10.2.5 in GJO-97-13-TAR, *Hanford Tank Farms Vadose Zone TX Tank Farm Report*). ~~Spectral gamma logging data and tank waste~~	Accept.	C 1/31/2018 Redline reviewed.	MB

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			~~transfer records do not provide evidence of a leak from tank 241-TX-105 (Section 2.2.8 in RPP-7218).~~ The presence of uranium-235 and uranium-238 indicates that the origin of the contamination around Tank 241-TX-105 is likely to be metal waste from the bismuth phosphate process that originated from waste piping, as this tank was used to store metal waste, REDOX waste, and evaporator bottoms (Section 2.2.8 in RPP-7218). Section 4.1.2 in RPP-RPT-50870 identified that process data showed the tank was overfilled in 1952 and between 1961 and 1964, and that waste may have been released from the spare inlets. Uranium contamination reported in drywells suggested that waste may have been released in the early 1950's. The report concluded that the tank leak classification of "sound" should be reassessed, and estimated a total leak volume between 189,000 and 473,000 L (50,000 and 125,000 gal) (Table ES-1 and Section 4.1.3 in RPP-RPT-50870)." p. 2-5, paragraph 4: "Tank 241-TX-114 was categorized as an assumed leaker in 1974 and 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-TX-114 and no inventory estimates exist; however, the s~~Spectral gamma logging data suggest extensive near-surface leaks, possibly from waste transfer piping (Section 2.2.10 in RPP-7218). Section 4.5.1 of RPP-RPT-50870 identified that historical transfer records show the tank was filled above the cascade outlet as a result of plugging of the cascade lines. In-tank photographs show the waste level was well above the cascade line, indicating the potential for releases from the cascade lines or spare inlets. Elevated cesium-137 was found between the surface and 6.1 m (20 ft) below surface in two drywells, and was attributed to cascade line leaks, near-surface transfer line leaks and spills during operations. The report assumed that the contamination migrated from the tank bottom, along the top of the sediments below 241-TX-114, to the drywells. The assessment concluded that based on the drywell data, the contamination source was likely a 241-TX-114 liner leak, and estimated a total leak volume of 26,500 L (7,000 gal) (Table ES-1 and Section 4.5.3 in RPP-RPT-50870). p. 2-6, new paragraph at line 16: "Tank 241-TX-118 is classified as "sound" in HNF-EP-0182; however, the leak assessment results in RPP-RPT-50870 (Section 4.10.2) found that cesium-137 and cobalt-60 measured in a drywell near the tank			

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EERs = Engineering Evaluation Reports

			suggested there has been a subsurface transfer line leak or a surface spill, from which contamination infiltrated to the tank dome and flowed down the sides of the tank. The report concluded that the tank appears "sound" (no liner leak), as classified in HNF-EP-0182; however, drywell data shows that waste was released on the east side of the tank near the cascade and transfer lines (Section 4.10.3 in RPP-RPT-50870). Designating the waste release as an unplanned release (UPR) was recommended (Section 4.10.3 in RPP-RPT-50870). The report estimated a total release volume of 6,660 L (1,760 gal) (Section 4.10.3 in RPP-RPT-50870). Added document to Chapter 11: RPP-RPT-50870, 2013, *Hanford 241-TX Farm Leak Inventory Assessment Report*, Rev. 0, Washington River Protection Solutions, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0066754H.			
Item 7 P: 2-4 S: 2.1.3 L: 20	Comment: Section 2.2.9 does not exist in HFN-EP-0182. This section does exist in RPP-7218 and appears to be the correct document to cite. Basis/Justification: Incorrect cited document.	Change from HNF-EP-0182 to RPP-7123.	Accept. Text changed as shown: "Section 2.2.9 in RPP-7218 ~~HNF-EP-0182~~ indicates a leak volume of 36,369 L (8,000 gal)…"	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 8 P: 2-5 S: 2.1.3 L: 12-13	Comment: TX-113 waste volume has been changed as of April 2017. It should be 88,000 gallons of sludge and 546,000 gallons of saltcake. Basis/Justification: Correctness. HNF-EP-0182, Rev. 357.	See comment.	Accept. 1/26/2018: Removed discussion of solids inventory per Item 8 of WMA T RCR.	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 9 P: 2-6 S: 2.1.3 L: 9	Comment: Change Tank TX-116 waste volume to 499,000 gallons of saltcake based on Basis/Justification. Basis/Justification: Correctness. HNF-EP-0182, Rev. 357.	See comment.	Accept. 1/26/2018: Removed discussion of solids inventory per Item 8 of WMA T RCR.	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 10 P: 2-6 S: 2.1.3 L: 39	Comment: For Tank TY-104 add "and 1,000 gallons of supernatant". Basis/Justification: Correctness. HNF-EP-0182, Rev. 357.	See comment.	Accept. Text changed as shown: "The supernatant inventory is 3,800 L (1,000 gal) (Section 4.0 in HNF-EP-0182)."	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 11 P: 2-7 S: 2.1.3	Comment: Change the waste volume in TY-106 for saltcake to 13,000 gallons.		Accept.	Accept.	C	DC

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L: 9	Basis/Justification: Correctness. HNF-EP-0182, Rev. 357.		1/26/2018: Removed discussion of solids inventory per Item 8 of WMA T RCR.		1/31/2018 Redline reviewed.	
Item 12 P: 2-17 S: 2.4 L: 36	Comment: On a map, provide where LLBG WMA 3 and LLBG WMA 5 are located. Basis/Justification: Clarity.	Provide location of LLBG WMA-3 and -5.	Accept. LLBG-5 became Burial Ground 218-W-6. Will revise Figure 2-4 to show 218-W-6. Change sentence to: "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 TX-TY…"	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 13 P: 2-18 S: 2.4 L: 3	Comment: Change Phase 2 to Phase 1. Phase 1 Groundwater Assessment was conducted. A Phase 2 assessment was not. Basis/Justification: Editorial.		No change needed. The text aligns to that of the 1997 reference source (Section 5.9.2.1 in PNNL-11793), "Assessment results for well 299-W14-12 indicate that the contamination is consistent with a source within the WMA; however, upgradient sources remain a possibility. Because there is no direct evidence for upgradient sources, 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 TX-TY.	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 14 P: 2-18 S: 2.4 L: 14	Comment: Chromium is listed twice. Either change one to hexavalent chromium or deleted one of the chromiums. Basis/Justification: Editorial.		Accept. Delete the first instance of chromium as shown: "However, WMA TX-TY was identified as the most likely source for contamination in well 299-W14-12, which included nitrate, tritium, ~~chromium,~~ technetium-99, and chromium above the drinking water standard (DWS) (Section 5.0 in PNNL-11809)."	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 15 P: 2-17 and 2-18	Comment: State on page 2-17, that 200-ZP-1 Pump and Treat began in 1994, otherwise when you get to page 2-18 Lines 25-27, it makes no sense and can be confused with the 200 West Pump and Treat system. Basis/Justification: Clarity.		Accept with modification. The following information has been added as shown: "…The southern half ~~is~~ was most affected by the interim action 200-ZP-1 OU pump and treat (P&T) operations located south of WMA TX-TY as groundwater ~~flows~~ flowed toward the P&T extraction wells (Section 3.6.3.2 in PNNL-12086). The P&T was implemented in a three-phased approach beginning in August 1994, as an interim action under the *Superfund Record of Decision: Hanford 200-Area (USDOE) OU 200-*	Accept.	C 1/31/2018 Redline reviewed.	DC

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			ZP-1 (EPA/ROD/R10-95/114) to address carbon tetrachloride contamination (Section 5.9.4.2 in PNNL-12086)." Add reference: EPA/ROD/R10-95/114, 1995, *Superfund Record of Decision: Hanford 200-Area (USDOE) OU 200-ZP-1, Benton County, WA*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9100NWA2.txt.			
Item 16 P: 2-18 S: 2.4 L: 36	Comment: Provide if this "one additional well" that "was planned south of WMA TX-TY" was drilled or what progress was made in drilling and installing this well? Basis/Justification: Clarity, completeness.		Accept. The well is not identified in the subject document but new well 299-W15-41, drilled in 2000 and located south of WMA TX-TY, is described on p. 2-19, lines 5-6. Revise text: "One additional well was planned south of WMA TX-TY (Section 5.9.2.1 in PNNL-12086) (this well was later identified as 299-W15-41)."	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 17 P: 2-18 S: 2.4 L: 42	Comment: Provide if "WMA TY" is correct. It should be WMA TX-TY or TY tank farm. WMA refers to both TX and TY tank farms combined. Basis/Justification: The WMA is TX-TY.	See comment.	Accept. Change to "WMA TX-TY": "The average distance between monitoring wells along the southeastern margin of WMA TX-TY was approximately…"	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 18 P: 2-19 L: 11-17	Comment: This makes several references to PNNL-15670, section 3.8.3.4 regarding.		No change to text. The comment is incomplete.	Accept.	C 1/31/2018 No change.	SPL
Item 19 P: 2-19 S: 2.4 L: 39-40	Comment: The statement, "Flow direction is influenced by the 200-ZP-1 P&T system, which was located south of the 241-TX Tank Farm." could be stated starting in 1994 or 1995 when the P&T began. Please acknowledge and discuss in the earlier part of this section (Section 2.4) which wells were used through time in the pump and treat system and how it affected flow direction and gradient. This states, "Flow direction is influenced by the 200-ZP-1 P&T system, which was located south of the 241-TX Tank Farm (Section 2.8.2.12 in PNNL-13788)." Should this be reworded to state that "Flow direction at that time was influenced by the 200-ZP-1 …" if this is true.		Accept. See response to Item 15 as info on the interim action ZP-1 P&T will be added preceding subject discussion. Revise text to: "Flow direction at that time was ~~is~~ influenced by the 200-ZP-1 interim action P&T system…"	Accept.	C 1/31/2018 Redline reviewed.	DC/SPL

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	Basis/Justification: WAC 173-303-806(4)(a)(xx)					
Item 20 P: 3-1 S: 3 L: 2	Comment: In the 2nd paragraph, provide whether anything "new" was added in these reports or if they just summarized previous works. Other reports were done like RPP-23752 that add new geologic information to the TX farms. Provide this reference in the document. Provide what new "geology" was provided in DOE/RL-2009-67, Rev. 1. Basis/Justification: Completeness.	Add reference RPP-23752 here and in the reference list.	Accept with modification. More recently, the WMA TX-TY geology has been summarized in the following: RPP-23748, *Geology, Hydrogeology, Geochemistry, and Mineralogy Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*; RPP-23752 Rev.0-A, *Field Investigation Report for Waste Management Areas T and TX-TY Data Package*; PNNL-15955, *Geology Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*; DOE/RL-2009-67, Rev. 1; and PNNL-15873, *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 TX-TY, including hydrogeologic observations made during the installation of new wells in the area.	Accept.	C 2/7/2018 Redline reviewed.	DC
Item 21 P: 3-5 S: 3.1 L: 39-40	Comment: If "Unit" is capitalized for Unit E then it should also be capitalized for "Unit A". Capitalize all Unit A's in the document. Basis/Justification: Consistency. Stratigraphic nomenclature consistency.		Accept.		C 1/31/2018 Redline reviewed.	DC
Item 22 P: 3-6 S: 3.1 L: 3-6	Comment: Provide the thickness of the Ringold Unit A for this report. Basis/Justification: WAC 173-303-645(8) and WAC 173-303-806(4)(a)(xx).		Accept. 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 and ranges in thickness from 15 to 18 m (48 to 60 ft) beneath WMA TX-TY (Figure 3-5).	Accept.	C 2/7/2018 Redline reviewed.	DC
Item 23 P: 3-6 S: 3.1 L: 7-10	Comment: The text implies that no wells have been drilled to basalt. Provide if this is true. Basis/Justification: Clarity. Depth of knowledge of the geology.		No change to text. The closest wells to have tagged basalt are 299-W11-13 and 299-W11-26 located approx. 250m and 225m east and northeast of WMA TX-TY respectively.	Accept.	C 1/31/2018 No change.	DC
Item 24 P: 3-6 S: 3.2 L: 16	Comment: Based on the statement, "The water table occurs in the Ringold Formation Member of the Wooded Island" may be accurate, but it includes two aquifers if not more in this member, the unconfined aquifer in Unit E and the confined aquifer in Unit A.	Provide which "aquifer" is being discussed in this sentence. Provide a discussion of both the unconfined and confined aquifers in this section.	Accept. Revised to include Unit E designation: "The water table occurs in the Ringold Formation Member of Wooded Island Unit E."	Accept.	C 1/31/2018 Redline reviewed.	DC

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	Provide which 'water table" is being discussed if not both. Provide discussion for both aquifers in this section. Basis/Justification: Clarity, Correctness, Consistency. WAC 173-303-645(8) and WAC 173-303-806(4)(a)(xx).					
Item 25 P: 3-10 S: 3.2	Comment: Provide a discussion why various vertical hydraulic characteristics occur in the aquifer 20 feet apart. Provide why the unconfined aquifer vertical gradient is downward in one well and upward in a well 20 feet away. Provide what year these measurements occurred and whether these wells are being influenced by the 200-ZP-1 Pump and Treat system. More explanation is needed and required. Basis/Justification: WAC 173-303-806(4)(a)(xx).	Provide whether communications exist between Ringold Unit E and Ringold Unit A. Provide why upward gradients are found in the unconfined aquifer in the top portion of the aquifer.	<u>Accept</u>. Additional text to add to end of Section 3.2: Down gradient well 299-W14-13 was installed in 1998 and was screened from water table to a depth of approximately 35 ft below the water table. In 2002, a vertical gradient survey of the well was completed via vertical tracer and electronic borehole flow (EBF) measurements. Results indicated a downward vertical gradient of 0.011 to 0.012 m/m which was confirmed by both vertical tracer and EBF results (PNNL-13378). In 2005, well 299-W14-11 was installed adjacent to 299-W14-13 to evaluate vertical contaminant distribution in the aquifer down gradient of WMA TX-TY (PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*, Section 2.8.3.4); and constructed with a 10 ft screened interval 37.7 to 47.7 ft below the water table. In 2005, a vertical gradient survey was completed within 299-W14-11. Results indicated an upward gradient of 0.014 to 0.027 m/m, evaluated by EBF measurements only, although results were approaching the limits of detection of the equipment (PNNL-17348). Although at first glance, the observation of vertical gradients in opposite directions in two wells in close proximity seems anomalous, there are likely causes for the observed conditions. The vertical gradients observed likely resulted from operation of groundwater remedial extraction wells in the general vicinity. Examination of inferred water table elevation contours at the time of both vertical gradient measurements indicates that operating extraction wells had imposed artificial gradients in the vicinity of WMA TX-TY. Different sets of extraction wells were operating during both vertical gradient measurement studies and the two measured wells are screened over different portions of the shallow unconfined aquifer. In 2002, during the vertical gradient measurement at well 299-W14-13, extraction wells 299-W15-34 and 299-W15-35 were in operation and the inferred water table map indicates a capture zone at the southern portion	Accept.	C 2/7/2018 Redline reviewed.	DC

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			of WMA TX-TY, which extends toward well 299-W14-13. This could account for the observed slight downward vertical gradient at that well. During the 2005 vertical gradient measurement at well 299-W14-11, additional remedial extraction wells were in operation (i.e., 299-W15-40, 299-W15-43, 299-W15-44, and 299-W15-765). Again, inspection of inferred water table elevation maps during that time period indicates artificial gradients were present at that time. The nearest extraction wells (i.e., 299-W15-765 and 299-W15-40) were screened across the water table with bottom-of-screen elevations that are above the top-of-screen elevation in well 299-W14-11. This condition could account for the observed slight upward vertical gradient in that well. In both instances, the observed vertical gradients are small in magnitude and the wells were in the area of influence of operating groundwater extraction wells; both observed vertical gradient conditions are consistent with apparent groundwater behavior under extraction. The difference between the two well observations most likely result from the temporal difference between the two measurement studies, the difference in well completion elevations, and the operation of different extraction wells during the gradient measurement events.			
Item 26 P: 3-10 Table 3-1	Comment: These Ks do not represent 200 West hydraulic conductivity on the top end. The Hanford formation is not even saturated in 200 West Area. Provide the 200 West Area hydraulic conductivities and remove Hanford formation and Cold Creek units since they are not a part of the unconfined aquifer in 200 West Area. Basis/Justification:		<u>Accept with modification.</u> Table 3-1 was deleted per WMA U Item 5. Reference for hydraulic conductivity added in earlier bullet; (PNNL-18279). Deleted, "The Hanford formation is highly permeable compared to the Ringold Formation."	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 27 P: 3-10 3rd and 4th bullets	Comment: The 3rd and 4th bullets discuss vertical flow conditions in wells 299-W14-11, which is screened approximately 14 m (46 ft) below the water table, and well 299-W14-13. Are these conditions considered in the model framework and simulations?	Modeling and flow conditions added to numerical simulation to account for vertical flow component.	<u>No change to text.</u> Extraction and injection wells are represented in the model using the multi-node well package (MNW), which will simulate this condition. The majority of monitoring wells are not simulated using this package and as a result this condition would not be simulated for most monitoring wells. Some wells monitoring wells are simulated this way due to the long screen lengths. The wells referenced in the comment are not in the MNW.	Accept.	C 2/2/2018 No change.	

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Item 28 P: 3-11 S: 3.3.1	Comment: Provide the impacts of the 200-ZP-1 P&T system on the RCRA well network from 1994 to 2011. Provide when the operational time periods for the 200-ZP-1 OU P&T to provide context if the system was impacted by flow direction, magnitude. Basis/Justification:	Provide impacts of 200-ZP-1 P&T as it relates to RCRA groundwater monitoring at WMA TX-TY.	Accept. Text modified to read: "Phase I of the 200-ZP-1 OU interim P&T system was installed in 1994 and was expanded with Phases II and III in 1996 and 1997, respectively. The three phases included a total of six extraction wells. The first impact to groundwater flow at WMA TX-TY was observed in 1998 and was associated with installation of extraction wells 299-W15-34 and 299-W15-35 to the southwest of WMA TX-TY (Section 3.6.3.2 in PNNL-12086). Wells 299-W15-34 and 299-W15-35 shifted groundwater flow within the southern portion of WMA TX-TY from a northeast to a south-southwest direction. Beginning in 2002, separate groundwater gradients were reported within the northern and southern portions of WMA TX-TY and were 0.001 m/m and 0.007 m/m respectively; an increase from 0.00079 m/m in 1998. ~~Groundwater flowed east within the northern portion and southwest toward the extraction wells within the southern portion of WMA TX-TY.~~ In 2005, Phase IV of the 200-ZP-1 OU interim P&T system was installed and included converting wells located upgradient of WMA TX-TY to extraction wells (299-W15-40, 299-W15-42, 299-W15-43, and 299-W15-765) (Section 2.8.1.1 in PNNL-15670). 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. Beginning in 2005, groundwater flow in the northern portion of the WMA began to shift from east to west, resulting in possible stagnation points ~~existed in the middle portion of~~ beneath the WMA ~~east of the extraction wells~~. Therefore, it must be assumed that the water table gradient was variable beneath WMA TX-TY due to influences from P&T system extraction wells. Groundwater monitoring remained predominantly consistent through the implementation of the 200-ZP-1 OU interim P&T system, and the groundwater monitoring plan was updated in 2011 and 2012 to reflect the associated impact the groundwater flow and transition to the 200 West P&T remedy. The water table map prior to the start of the full-scale 200 West P&T remedy in 2012 is presented in Figure 3-8."	Accept.	C 3/8/2018 Redline reviewed.	DC
Item 29 P: 3-11 S: 3.1.1 L: 26-37	Comment: Provide what happened between 2005 and 2012 as it relates to the 200-ZP-1 P&T with respect to groundwater monitoring at WMA TX-TY. Basis/Justification: Missing information. Incomplete.	See comment.	Accept. See response and additional text in Item 28.		C 3/8/2018 Redline reviewed.	DC

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Item 30 P: 3-11 S: 3.3.1 L: 32	Comment: Provide what is meant by "converting wells" to "extraction wells". Provide if these wells were originally monitoring wells or injection wells or newly installed. Basis/Justification: Clarity, completeness.	See comment.	Accept. See response and additional text in Item 28.	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 31 P: 3-13 S: Fig. 3-8	Comment: The water table map is impacted by pump and treat operations related to the 200-ZP-1 P&T. As presented it implies this is the natural water table with no effects from a pump and treat system. This is very misleading. Basis/Justification: Inaccuracies with the caption title and its implications.	Change caption title to indicate 200-ZP-1 P&T has impacted this water table.	Accept with modification. Change text to read, "The water table map prior to the start of the full-scale 200 West P&T remedy in 2012 is presented in Figure 3-8."	Accept.	C 1/31/2018 Redline reviewed.	DC
Item 32 P: 3-14 S: 3.3.2 L: 36-37	Comment: Provide why a decrease in water level occur at well 299-W14-15 while the other wells increased. Basis/Justification: Clarity.	See comment.	Accept. 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 129.5 m (424.9 ft) to 131.0 m (427.8 ft) across the WMA TX-TY area. In 2016 the water table increased beneath WMA TX-TY due to changes in 200 West P&T extraction and injection (Figure 3-11). The increase in water table levels at WMA TX-TY wells in 2016 ranged from 0.33 to 0.79 m (1.0 to 2.6 ft), except in well 299-W14-15 where the water level decreased 0.36 m (1.2 ft). The decrease in average water level for 2016 in 299-W14-15 was due to a low water level elevation measurement collected in November of 2016. The water level measurement has been evaluated, but has been retained based on similar historic water table fluctuations in the well. However, overall water level trending in the well is generally consistent with other network wells.	Accept.	C 2/7/2018 Redline reviewed.	DC
Item 33 P: 3-17 S: Fig. 3-11	Comment: Provide the use/purpose of wells 299-W15-44 and 299-W15-765 from 2005 through 2011. It has been stated that 299-W15-765 was used as an extraction well. Provide the period of time this occurred on this figure. Basis/Justification: Clarity and WAC 173-303-806(4)(a)(xx).	See comment.	Accept. Will add information to Figure 3-11. Well 299-W15-44 operated as extraction well between 2005 and 2010 and well 299-W15-765 operated as extraction well between 2005 and 2012. These time intervals correspond to the absence of water level measurements for each of the wells on the figure.	Accept.	~~C~~ ~~2/72018~~ ~~Pending updated figure.~~ C 3/8/2018 Redline reviewed.	DC

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Item 34 P: 3-18 S: 3.3.2 L: 18-19	Comment: These lines (sentence) is a duplicated sentence from p. 3-14 lines 36-37. Please delete here. Basis/Justification: Redundant.	See comment.	No change to text. Additional text was added per Item 32 in this RCR.	Accept.	C 2/8/2018 No change.	DC
Item 35 P: 4-1 S: 4 L: 2-8	Comment: Please review RPP-23752 and provide the conceptual model that is used in this document for WMA TX-TY. Not all the conceptual models represent each WMA adequately as described in DOE/RL-2008-01.	See comment.	Accept. DOE/RL-2008-01 removed as the primary source of information in the introduction to Chapter 4 and replaced with RPP-23752. "~~DOE/ORP-2008-01, *RCRA Field Investigation Report for Hanford Single-Shell Tank Waste Management Areas Data Package*~~ 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 ~~Appendix A of that document presents~~ the groundwater pathway conceptual model in detail that includes specific aspects related to the 241-TX and 241-TY Farms. Section 2.6 in DOE/RL-2009-67, Rev. 1 describes the conceptual model for WMA TX-TY. ~~The following summary additionally includes information derived from Chapters 16 and 20 and Appendix A of DOE/ORP-2008-01.~~"	Accept.	C 2/8/2018 Redline reviewed.	DC
Item 36 P: 4-1 S: 4 L: 6	Comment: Provide if DOE/RL-2009-67 provides groundwater conceptual model or vadose zone conceptual model or contaminant migration through the vadose zone to groundwater conceptual model (geochemical conceptual model). Basis/Justification: Clarity and Completeness.	See comment.	Accept. Add text to Section 4.0, 1st paragraph – "Section 2.6 in DOE/RL-2009-67, Rev. 1 describes the vadose zone and groundwater conceptual model for WMA TX-TY."	Accept.	C 2/7/2018 Redline reviewed.	DC
Item 37 P: 4-1 S: 4.1 L: 34-37	Comment: RPP-23752 states ongoing contamination in the vadose zone will impact groundwater in the future for TX and TY Tank Farms related to releases from past tank leaks. This is not stated in this paragraph. Please update the conceptual model to match the work that has been done to indicate this phenomenon. Basis/Justification: RPP-23752 had regulatory input and is the RFI for WMA TX-TY.		Accept. Evidence suggests that past tank and piping leaks from WMA TX-TY have migrated through the vadose zone to the groundwater (Section 3.6 in DOE/RL-2016-66). Any remaining contamination in the vadose zone resulting from tank leaks, pipeline leaks or overfill events remains a source of possible future groundwater contamination (RPP-23752, Section 3.3 and DOE/RL-2009-67, Rev.1, Section 2.6).	Accept.	C 2/7/2018 Redline reviewed.	DC
Item 38 P: 4-2 S: 4.1 L: 8	Comment: The only interim cap is over TY farm. One is in the planning process, but not built over TX. Please change to read, "…and an interim cap has been placed over tanks in TY tank farm to inhibit remobilization of leaked waste in the soils."		Accept. Text modified to read: "The migration process occurred, for the most part, in partially saturated soils because leak/release volumes were not sufficient to fill the soil pore		C 3/8/2018 Redline reviewed.	DC

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			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 or precipitation at WMA TX-TY. Berms have been erected around the tank farms to stop run-on of rain and melting snow, and an interim cap has been placed over tanks in Tank Farm ~~TX-~~TY to inhibit remobilization of leaks."			
Item 39 P: 4-2 S: 4.1 L: 32	Comment: Change the call out to the figure from "(Figure 3-11)" to (Figure 3-10)". Figure 3-10 shows the map of the water table, while Figure 3-11 shows the hydrographs of the three wells that are not located in the various areas. Basis/Justification: Wrong call-out of figure.		<u>Accept.</u> Section 4.3, first paragraph – Change callout 3-11 to 3-10.	Accept.	C 2/7/2018 Redline reviewed.	DC
Item 40 P: 4-3 S: Fig. 4.1	Comment: Provide what "BOS" means and provide different line colors to distinguish what is "Sample Dry" and "Simulated". Provide what Sample Dry means versus the bottom of the well. Provide if BOS represents bottom of the well. Basis/Justification: Clarity, Completeness.		<u>Accept.</u> Will add note to figure indicating BOS = Bottom of Screen.	Accept.	~~C~~ ~~2/7/2018~~ ~~Pending figure change~~ C 3/8/2018 Redline reviewed.	DC
Item 41 P: 4-2 S: 4.4	Provide plume maps for all constituents that have been detected in WMA TX-TY. Basis/Justification: WAC 173-303-806(4)(a)(xx)(D).		<u>Similar to WMA U Item 45.</u> 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. <u>Would affect all EERs.</u>	Accept.	C 2/2/2018 Redline reviewed.	DC
Item 42 P: 4-5 L: 20-22	Comment: This states "Several lines of evidence show that vertical contaminant concentration gradients exist in the area of WMA TX-TY (Section 2.6.5 in DOE/RL-2009-67, Rev. 1)." The engineering report does not provide any information regarding plans to address the vertical extent of contamination.		<u>Accept with modification.</u> Additional discussion of existing vertical data is being added to Chapter 4 in 200 West as appropriate and available.	Accept.	~~C~~ ~~Pending the additional text added to Chapter 4.~~ C	SPL

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					3/8/2018 Redline reviewed.	
Item 43 P: 7-25 S: 7.3 and Figures 7-34 – 7-36 L: 41-42	Comment: The proposed wells are not shown on Figures 7-34 through 7-36. Provide these wells on Figures 7-34, 7-35 and 7-36. Basis/Justification: No proposed wells on the figures.		Accept. Will add proposed wells to figures.		~~C2/2/2018 Pending changes to figures.~~ C 3/8/2018	DC
Item 44 P: 7-29 S: 7.3	Comment: Provide more explanation on Figures 7-37, 7-38, 7-39 and 7-40. Basis/Justification: No discussion is provided as to what the big dip means in the lower three subscenarios and what these figures imply, why are they in good locations for upgradient wells?		No change to text. In this specific instance, the reason why some of the lines on the treated water re-injection dilution plot drop (such as, Scenario F) is because according to the specifics of the scenarios, simulated well rates change over time. For example, in Scenario F, two of the wells (YJ-4 [299-W10-35] and YJ-5 [299-W15-226]) are shut down according to the proposed Scenario. As a result, both the amount of re-injection in the area reduces, and the groundwater flow directions and rates change as a result of that reduction, which together have the compound effect reducing the dilution effect in that specific Scenario. Similar, but Scenario-specific, changes in the locations and rates of re-injection cause reductions in the dilution curves for some of the other Scenarios.	Accept.	C 2/2/2018 No change.	DC
Item 45 P: 7-31 L: 8-10	Comment: This states that the deep well will not be included in the monitoring network, because "The deep and far-field wells are not required for monitoring under WAC 173-303-645." No basis is provided for this statement, especially considering that hexavalent chromium concentrations in well 299-W14-11 is greater than 48 ug/L and among the highest at TX-TY. Furthermore, extraction well 299-W14-20 is screened deep in the Ringold, which will result in contaminants moving vertically downward.	Provide a basis for removing or add these wells back into the EER.	Accept with modification. Acknowledgement of existing vertical data will be added to the end of Chapter 4. For this revision of the EER we will continue to drop the deep well, removing the language that they are not required. Further analysis on vertical migration and the viability of deep wells will be performed at Ecology's direction, in the next update to the Engineering Report. Text modified to read "The deep and far-field wells were not included ~~are not required~~ for monitoring ~~under WAC 173-303-645~~." This well is sampled annually for nitrate, carbon tetrachloride, chromium and hexavalent chromium under the CERCLA program DOE/RL-2009-115.	Accept.	C 2/7/2018 Redline reviewed.	SPL

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			Additional text added to Section 9.2 "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 as appropriate. "			
Item 46 P: 7-31 L: 15-16	Comment: "The proposed final status monitoring network is based on the results of the simulation scenarios presented in Appendix G and summarized herein." The simulations apparently do not address the current and potential future vertical distribution, but this needs to be addressed in some manner.		Same as Item 2 (this RCR). Same as Item 31 in WMA T. 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." Would affect all EERs.	Accept.	C 2/2/2018 Redline reviewed.	SPL
Item 47 P: 7-33 S: 7.4 L: 1-5	Comment: Provide if these results/conclusions include the effects of treated injection dilution water in the percentage of detectability. Basis/Justification: Clarity.	Provide methodology steps that demonstrate how treated diluted injection water and the release breakthrough curves are combined to produce the detectability figures.	Same as Item 30 WMA T RCR. Accept with modification. Additional text added to 6.2.2. Affects all EERS. "There is no assumption of a concentration, ~~this analysis~~ allowings 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."	Accept.	C 2/2/2018 Redline reviewed.	DC
Item 48 P: 9-4 Table 9-1	Comment: Provide the top of well screen elevation and the bottom of well screen elevation and the water table elevation. Depths to screen/water table,		No change to text. Similar to comment 34 in WMA U RCR.	Accept.	C 1/31/2018	DC

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	although informative for duration of the well does not tell whether it is representative of monitoring the unconfined aquifer or which portion of unconfined aquifer is being monitored. Basis/Justification: Representativeness. WAC 173-303-806(4)(a)(xx).		This table is not intended to be comprehensive. Also this information is provided elsewhere in the document, in both the text and in Appendix E. Would affect all EERs.			
Item 49 P: 9-4 S: 9.3.1 and 9.3.2	Comment: Make these sections similar to other sections in 9.3. These sections are missing. Basis/Justification: Representativeness. WAC 173-303-806(4)(a)(xx).		No change to text. Format difference related to the background template versus point of compliance well text. WMA TX-TY has no existing background wells, both are proposed.	Accept.	C 1/31/2018 No change.	DC
Item 50 S: 9.3.1-9.3.9	Comment: For all of these sections, no discussion of the treated injection dilution is discussed. Provide the percentage of dilution that occurs in these wells at its peak time period and how that will effect a "representative groundwater sample". Basis/Justification: Representativeness. WAC 173-303-806(4)(a)(xx).		Accept with modification. Information on the impact of injection water being added to Sections 9.3.1 and 9.3.2, which are both proposed upgradient wells.		C 3/8/2018, Reviewed U Farm changes.	DC
Item 51 General	Comment: General: The pump and treat operation in the TX-TY area and the nearby vicinity dates back to mid 90's. Since then we have seen huge impact on the concentration profiles of a number of contaminants in the area with significant downward trends. There has been considerable mixing/dilution, dispersion since then. It seems the dilution breakthrough curves does reflect the scenarios in the early stages of the operations. Provide explanations.		Accept with modification. The following text was added to Section 7.1: "At WMA TX-TY, the zero starting point in 2012 for the injected treated water dilution breakthrough curves in Figures 7-1 through 7-13 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." Text will also be adjusted and added to WMA T.	Accept.	C 2/2/2018 Redline reviewed.	DG
Item 52 General	Comment: General: Provide adequate explanations how to interpret groundwater data gathered during the period of declining trends -especially when an insignificant leak (i.e. leak volume and concentration is less than the amount removed through pump and treat) is assumed/happens.		No change to text. A backwards calculation would be possible given some knowledge about the minimum detection levels, to determine how much mass would have to be released to groundwater in order to detect a contaminant, given the volume of water.	Accept.	C 2/2/2018 No change.	DG

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			It would take a relatively large quantity arriving at groundwater to detect a contaminant at a groundwater monitoring well. This does not take into account the distance from the ground surface to groundwater or a transport mechanism under ambient groundwater conditions. In some cases there may not be enough mass available to be detected in groundwater.			

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