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SGW-60577
Revision 0

Engineering Evaluation Report for Single-Shell Tank Waste Management Area S-SX 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

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

S-2-4 WMA S-SX
attached to: 1250188, 1250189, 1250190, 1250192

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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 S-SX Groundwater Monitoring, SGW-60577, 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).

July 23, 2018

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

Date

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Contents

1 Introduction 1-1

2 Supporting Historical Information 2-1

2.1 Background 2-1

2.1.1 Facility Description 2-1

2.1.2 Operational History 2-4

2.1.3 SSTs and Liquid Handling Structures within WMA S-SX 2-4

2.1.4 Unplanned Releases 2-11

2.2 Regulatory Basis 2-11

2.3 Waste Characteristics 2-13

2.4 Interim Status Monitoring Network and Sampling History 2-14

3 Geology and Hydrogeology 3-1

3.1 Stratigraphy 3-1

3.2 Hydrogeology 3-7

3.3 Groundwater Flow 3-7

3.3.1 Hydrologic Conditions Prior to 200 West P&T Operations 3-8

3.3.2 Hydrologic Conditions Due to Operation of the P&T Remedy 3-8

4 Contaminant Migration Conceptual Model 4-1

4.1 Vadose Zone 4-1

4.2 Soil Moisture Factors 4-1

4.3 Hydrogeologic Considerations 4-2

4.4 Groundwater Chemistry 4-3

4.5 Summary of Vertical Contaminant Distribution 4-4

5 Groundwater Flow Simulations 5-1

5.1 Central Plateau Groundwater Model 5-1

5.2 Simulation Scenarios 5-1

6 Calculations 6-1

6.1 Principal Assumptions and Inputs 6-1

6.2 Particle Tracking 6-2

6.2.1 Particle Pathlines 6-3

6.2.2 Relative Detectability Calculations 6-3

6.3 Transport Calculations 6-5

7 Simulation Results and Conclusions 7-1

7.1 Breakthrough Curves and Release Unit Plume Maps 7-2

7.2 Particle-Tracking and Relative Detectability Maps 7-33

7.3 Modeling Conclusions 7-40

8 Identification of Site-Specific Monitoring Constituents 8-1

8.1 Selection Process for Monitoring Constituents 8-1

8.1.1 Hanford Facility RCRA Permit Part A Form Dangerous Wastes 8-1

8.1.2 Interim Status Groundwater Monitoring Results 8-1

8.1.3 Final Monitoring Constituent Evaluation 8-2

8.2 Results of Selection of Groundwater Monitoring Constituents 8-3

9 Groundwater Monitoring 9-1

9.1 Final Status Groundwater Monitoring Program Determination 9-1

9.2 Point of Compliance Monitoring 9-1

9.3 Proposed Monitoring Well Network 9-2

9.3.1 Groundwater Monitoring Well 299-W23-20 9-5

9.3.2 Groundwater Monitoring Well 299-W23-21 9-5

9.3.3 Groundwater Monitoring Well 299-W22-80 9-6

9.3.4 Groundwater Monitoring Well 299-W22-81 9-7

9.3.5 Groundwater Monitoring Well 299-W22-84 9-8

9.3.6 Groundwater Monitoring Well 299-W22-85 9-8

9.3.7 Groundwater Monitoring Well 299-W22-93 9-9

9.3.8 Groundwater Monitoring Well 299-W22-94 9-10

9.3.9 Groundwater Monitoring Well 299-W22-113 9-11

9.3.10 Groundwater Monitoring Well 299-W22-115 9-12

9.3.11 Groundwater Monitoring Well 299-W22-116 9-13

9.3.12 Groundwater Monitoring Well 299-W23-19 9-14

9.4 Constituent List and Frequency 9-15

9.5 Concentration Limits 9-25

9.6 Compliance Period 9-25

9.7 Statistical Method 9-25

10 Routine Evaluation of the Monitoring Network 10-1

11 References 11-1

Appendices

A Interim Status Data Summary ..... A-i

B Identification of Site-Specific Monitoring Constituents for Waste Management Area S-SX – ECF-200UP1-17-0221 ..... B-i

C Topographic Map ..... C-i

D Plume Maps ..... D-i

E Well As-Built Diagrams ..... E-i

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

G Groundwater Flow and Migration Calculations to Support Assessment of WMA S-SX Monitoring Network – ECF-200W-17-0076 .....G-i

H Statistical Method Determination.....H-i

Figures

Figure 1-1. Location Map for WMA S-SX 1-3
Figure 2-1. Location of WMA S-SX within the 200 West Area 2-2
Figure 2-2. SST Schematics from the Hanford Facility RCRA Permit Part A Application.....2-3
Figure 2-3. WMA S-SX 2-8
Figure 2-4. Wells Used During Interim Status Monitoring of WMA S-SX.....2-16
Figure 3-1. General Stratigraphy at the Hanford Site.....3-2
Figure 3-2. North to South Cross Section for WMA S-SX 3-3
Figure 3-3. East to West Cross Section for WMA S-SX.....3-4
Figure 3-4. Water Elevation Contour in June 2012 Prior to Startup of the 200 West P&T 3-5
Figure 3-5. March 2016 Water Elevation Map for WMA S-SX 3-6
Figure 4-1. Wells Used during Interim Status Monitoring Including Vertical Contaminant Characterization Well Locations 4-5
Figure 4-2. Vertical Contaminant Distribution Well 299-W22-47 4-6
Figure 4-3. Vertical Contaminant Distribution Well 299-W22-72 4-7
Figure 4-4. Vertical Contaminant Distribution Well 299-W22-86 4-8
Figure 4-5. Vertical Contaminant Distribution Well 299-W22-89 4-9
Figure 4-6. Vertical Contaminant Distribution Well 299-W22-94 4-10
Figure 5-1. Interim Status Groundwater Monitoring Network.....5-2
Figure 5-2. Locations and Average Pumping Rates (for December 2016) of 200 West P&T System Wells 5-5
Figure 6-1. Location of Calculation Subgrid in Relation to 200 West Area Facilities Evaluated in Appendix F 6-4
Figure 7-1. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-47.....7-3
Figure 7-2. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-69.....7-3
Figure 7-3. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-72.....7-4
Figure 7-4. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-80.....7-4
Figure 7-5. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-81.....7-5
Figure 7-6. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-82.....7-5

Figure 7-7. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-83 7-6
Figure 7-8. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-84 7-6
Figure 7-9. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-85 7-7
Figure 7-10. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-86 7-7
Figure 7-11. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-89 7-8
Figure 7-12. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-93 7-8
Figure 7-13. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-94 7-9
Figure 7-14. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-95 7-9
Figure 7-15. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-113 7-10
Figure 7-16. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-115 7-10
Figure 7-17. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-116 7-11
Figure 7-18. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-19 7-11
Figure 7-19. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-20 7-12
Figure 7-20. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-21 7-12
Figure 7-21. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-236 7-13
Figure 7-22. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-47 7-16
Figure 7-23. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-69 7-16
Figure 7-24. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-72 7-17
Figure 7-25. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-80 7-17
Figure 7-26. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-81 7-18
Figure 7-27. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-82 7-18
Figure 7-28. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-83 7-19

Figure 7-29. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-84 7-19
Figure 7-30. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-85 7-20
Figure 7-31. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-86 7-20
Figure 7-32. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-89 7-21
Figure 7-33. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-93 7-21
Figure 7-34. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-94 7-22
Figure 7-35. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-95 7-22
Figure 7-36. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-113 7-23
Figure 7-37. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-115 7-23
Figure 7-38. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-116 7-24
Figure 7-39. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-19 7-24
Figure 7-40. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-20 7-25
Figure 7-41. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-21 7-25
Figure 7-42. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-236 7-26
Figure 7-43. Release Concentration Breakthrough Curves at Monitoring Wells, Scenario 3 7-29
Figure 7-44. Release Unit Plume Map, Scenario 1, Sub-Scenario A 7-30
Figure 7-45. Release Unit Plume Map, Scenario 2, Sub-Scenario A 7-31
Figure 7-46. Release Unit Plume Map, Scenario 3 7-32
Figure 7-47. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 1, Sub-Scenario A 7-34
Figure 7-48. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 2, Sub-Scenario A 7-35
Figure 7-49. Particle Pathlines, Scenario 3 7-36
Figure 7-50. Relative Detectability of Release, Scenario 1 7-37
Figure 7-51. Relative Detectability of Release, Scenario 2 7-38
Figure 7-52. Relative Detectability of Release, Scenario 3 7-39
Figure 7-53. Proposed Final Status Groundwater Monitoring Network with Combined Relative Detectability and Release Unit Plume Results 7-41
Figure 9-1. Proposed Final Status Groundwater Monitoring Network for WMA S-SX 9-3

Tables

Table 1-1. Pertinent Requirements 1-5
Table 2-1. Nonradiological Waste Profile for WMA S-SX SSTs During Leaks 2-5
Table 2-2. Dangerous Wastes in the SST System Hanford Facility RCRA Permit Application Part A Application 2-13
Table 2-3. Interim Status Monitoring Plans 2-14
Table 5-1. Simulation Scenarios 5-3
Table 6-1. Properties Assumed for Transport Calculations Using the CPGWM 6-2
Table 7-1. Range of Unit Concentrations of Injected Treated Water Dilution Breakthrough Curves 7-13
Table 7-2. Range of Unit Concentrations of Release Concentration Breakthrough Curves 7-26
Table 8-1. Proposed Groundwater Monitoring Constituents for WMA S-SX 8-3
Table 9-1. Attributes for Wells in the WMA S-SX Groundwater Monitoring Network 9-4
Table 9-2. Monitoring Wells and Sample Schedule for WMA S-SX 9-16
Table 9-3. Proposed Groundwater Monitoring Constituents for WMA S-SX 9-18
Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring 9-20

Terms

AEA	*Atomic Energy Act of 1954*
API	American Petroleum Institute
CCU	Cold Creek unit
CPGWM	Central Plateau Groundwater Model
DOE	U.S. Department of Energy
DWMU	dangerous waste management unit
DWS	drinking water standard
ECF	environmental calculation file
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FY	fiscal year
ICN	interim change notice
K_d	distribution coefficient
OU	operable unit
P&T	pump and treat
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	reduction-oxidation
SST	single-shell tank
TDS	total dissolved solid
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
TSD	treatment, storage, and disposal
UPR	unplanned release
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System
WMA	waste management area

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1 Introduction

This engineering evaluation report provides information to support the proposed final status groundwater monitoring for Waste Management Area (WMA) S-SX based on evaluation of contaminants associated with WMA S-SX, the expected migration behavior of contaminants in the WMA, and historical observations and measurements of groundwater contamination at WMA S-SX. This evaluation includes results of groundwater transport simulations conducted using the Central Plateau Groundwater Model (CPGWM) (CP-47631, *Model Package Report: Central Plateau Groundwater Model Version 8.3.4*). WMA S-SX 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 S-SX 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 S-SX is located in the 200 West Area of the Hanford Site in Washington State and overlies the 200-UP-1 Groundwater Operable Unit (OU) (Figure 1-1). WMA S-SX includes 27 SSTs and ancillary equipment of the 241-S and 241-SX Tank Farms that received high-level waste from S Plant and other facilities.

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

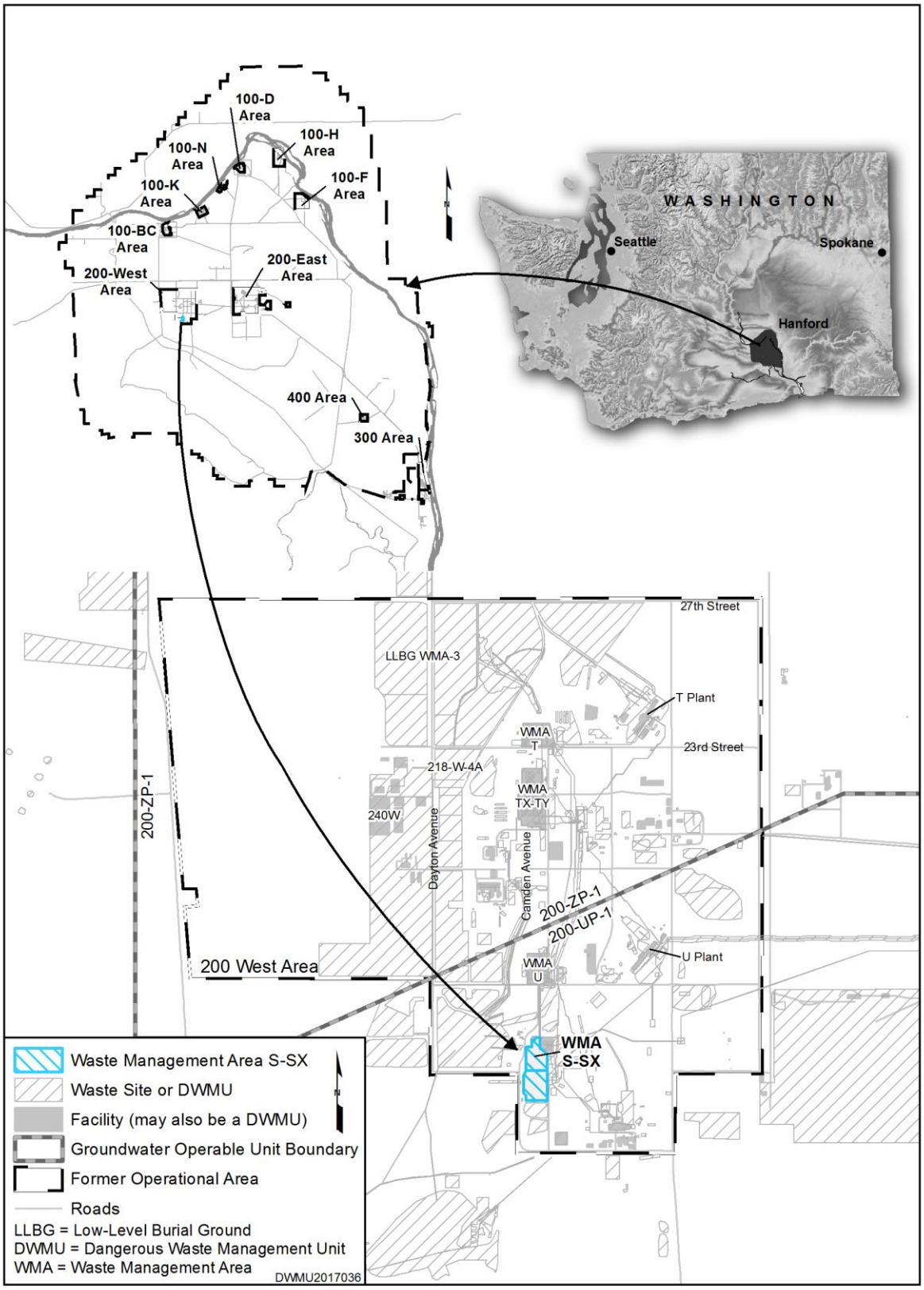


Figure 1-1. Location Map for WMA S-SX

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 S-SX.
- 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 S-SX 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 environmental calculation file (ECF) (ECF-200UP1-17-0221, *Identification of Site-Specific Monitoring Constituents for Waste Management Area S-SX*).
- Appendix C contains the topographic map.
- Appendix D contains regional plume maps in the vicinity of WMA S-SX.
- Appendix E contains well as-built diagrams.
- 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 S-SX modeling ECF (ECF-200W-17-0076, *Groundwater Flow and Migration Calculations to Support Assessment of the WMA S-SX 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 S-SX 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 S-SX and its operations, regulatory basis, waste characteristics, and interim status groundwater monitoring history.

2.1.1 Facility Description

WMA S-SX, which includes the SSTs and ancillary equipment of the 241-S and 241-SX Tank Farms, is located in the southern portion of the 200 West Area, near the Reduction-Oxidation (REDOX) Plant (Figure 2-1). SSTs in WMA S-SX received high-level waste from the S Plant Aggregate Area and other facilities (Section 2.3.1.1.1 in DOE/RL-91-60, *S Plant Aggregate Area Management Study Report*). The 241-S Tank Farm contains 12 underground SSTs constructed between 1950 and 1951. In 1951, the 241-S Tank Farm began receiving waste from the REDOX Plant. In the summer of 1952, waste in some of the tanks began to boil due to radioactive decay heat load (Section 2.1.2 in HNF-4936, *Subsurface Conditions Description for the S-SX Waste Management Area*). Therefore, when the 241-SX Tank Farm was constructed between 1953 and 1954, 10 of the 15 underground SSTs (tanks 241-SX-105 and 241-SX-107 through 241-SX-115) were designed to handle self-boiling wastes (Section 2.1.2 in HNF-4936). The WMA S-SX SSTs are 100-series tanks (241-S-101 through 241-S-112 and 241-SX-101 through 241-SX-115), which are 23 m (75 ft) in diameter and have capacities of 2,870,000 L (758,000 gal) and 3,785,000 L (1,000,000 gal), respectively (Section 2.3.2 in DOE/RL-91-60) (Figure 2-1). The bases of the 241-S and 241-SX SSTs are approximately 13.7 m (45 ft) and 15.2 m (50 ft) below ground surface, respectively (Figure 2.1 in WHC-SD-EN-AP-012, Rev. 0, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks*, Rev. 0).

The tanks in each farm are divided into sets of three tanks each (e.g., tanks 241-S-101, 241-S-102, and 241-S-103) with cascade lines attaching each set so that waste would flow from east to west by gravity feed (Section 1.2 in RPP-7884, *Field Investigation Report for Waste Management Area S-SX*). The cascade lines were not used in the 241-SX Tank Farm (Section 1.2 in RPP-7884). The WMA also contains equipment used to manage tank waste during operations, including waste transfer lines, leak detection systems, and ancillary tank equipment.

Multiple drywells are located between and around each 100-series SST, generally installed to depths between 22.8 m (75 ft) and 45.7 m (150 ft) (Section 1.2.1 in RPP-7884). The drywells are open-bottom, 15 cm (6 in.) or 20 cm (8 in.) steel casings placed vertically around the tank perimeters. Beginning in the 1960s, the drywells were monitored with gross gamma and other radiation logging tools as a secondary means of leak detection (Section 3.3.1.2 in RPP-7884). For additional leak monitoring capability, horizontal laterals were installed below 10 of the 15 tanks in the 241-SX Tank Farm. These horizontal pipes were installed approximately 3.1 m (10 ft) below the base of each tank and radiated from a central caisson (Section 3.3.1.2 in RPP-7884) (Figure 2-2). Figure 2-2 depicts SST schematics from WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Rev. 8c (hereinafter referred to as the Hanford Facility RCRA Permit) Part A Application for the SST System.

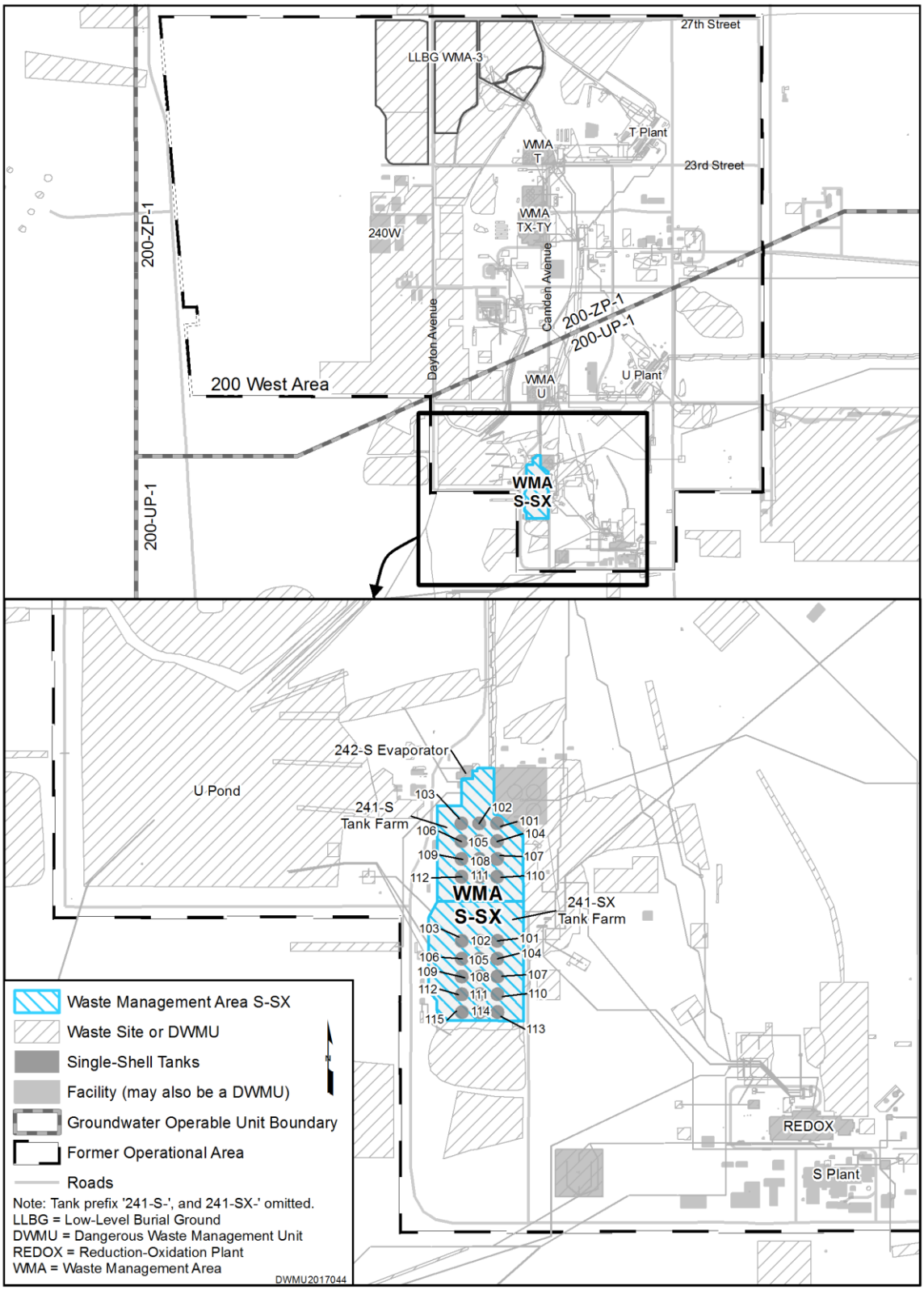
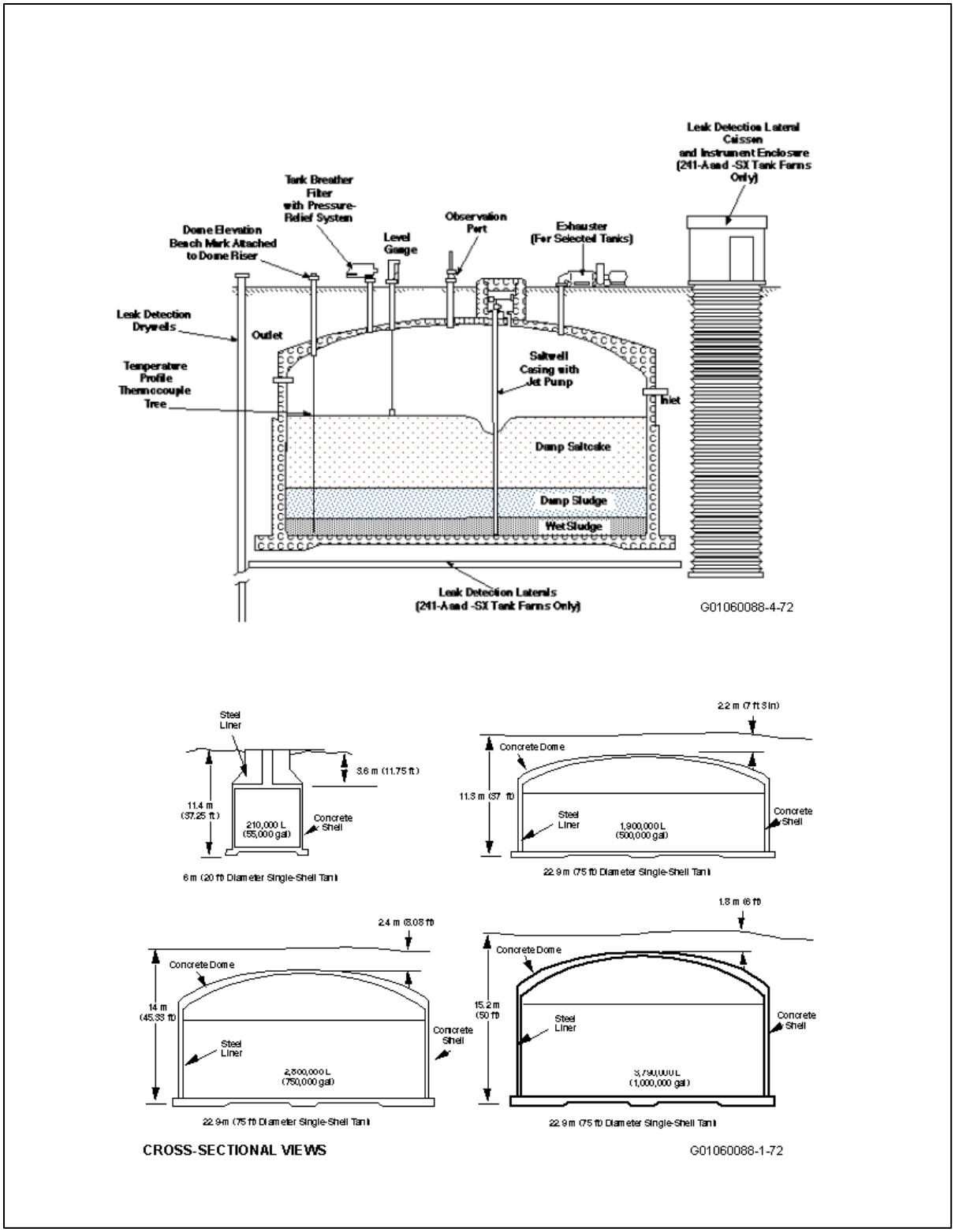


Figure 2-1. Location of WMA S-SX within the 200 West Area



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

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

2.1.2 Operational History

WMA S-SX SSTs received high-activity waste from the REDOX process that occurred at the S Plant from 1952 to 1966 (Section 2.1.1 in PNNL-11810, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas S-SX at the Hanford Site*). After shutdown of REDOX operations, the 241-S Tank Farm received evaporator waste product solids from the 242-S Evaporator (Section 2.1.2 in HNF-4936; Section 3.1 in RPP-RPT-48589, *Hanford 241-S Farm Leak Assessment Report*). Tanks in WMA S-SX were removed from service in the late 1970s to early 1980s. The tanks were subsequently interim stabilized (by saltwell pumping) and isolation activities were performed (Section 2.1.2 in HNF-4936; Section 2.3.2 in DOE/RL-91-60).

The WMA S-SX SSTs received aqueous waste from REDOX chemical process, which involved the chemical extraction of plutonium from the matrix of irradiated nuclear fuel used in the plutonium production reactors (Section 2.1.1 in PNNL-11810). The process involved treating the fuel with various chemicals to enhance separation, dissolution, and settling of the plutonium from solution. The waste stream entering the SSTs in the 241-S and 241-SX Tank Farms was highly acidic from the addition of aluminum nitrate and was over-neutralized with sodium hydroxide (Section 2.1.1 in PNNL-11810). The process in use at S Plant generated a much smaller volume of waste than that generated by the older bismuth phosphate process used at T Plant, resulting in higher concentrations of fission product (Section 2.1.1 in PNNL-11810). Although the chemical process producing the waste stored at WMA S-SX is known, waste management operations created a complex intermingling of tank wastes. Waste was transferred between diversion boxes and tanks throughout the operational history, and, as a result, there is considerable uncertainty about the exact composition of waste in the tanks at any particular time (Section 3.3.2 in RPP-7884). In addition, natural processes caused settling, stratification, and segregation of waste components. As a result, it is difficult to estimate the composition of the waste remaining in the tanks using the operational records.

The SSTs at WMA S-SX have been interim stabilized (Figure 1-3 in HNF-EP-0182, *Waste Tank Summary Report for Month Ending May 31, 2017*). This process involved pumping the supernate and interstitial liquids from the SSTs into double-shell tanks until no more than 189,270 L (50,000 gal) of drainable interstitial liquid and less than 19,000 L (5,000 gal) of supernatant liquid remained in each tank (Appendix A in HNF-EP-0182).

Additional interim measures were implemented in 2001 and 2002 to reduce upgradient surface water run-on to reduce infiltration and subsequent migration of contaminants through the vadose zone to groundwater. Berms were constructed around the WMA S-SX to stop run-on of natural precipitation; known water lines were cut, capped, or pressure tested to prevent leaks; and wells and drywells identified as potential preferential pathways for downward contaminant migration were decommissioned (Section 3.5.1 in RPP-7884).

2.1.3 SSTs and Liquid Handling Structures within WMA S-SX

This section discusses tank leaks at specific SSTs. Inventory and composition estimates of the chemical waste contents of tanks 241-S-104, 241-SX-107, 241-SX-108, 241-SX-109, 241-SX-110, 241-SX-111, 241-SX-112, 241-SX-113, 241-SX-114, and 241-SX-115 at the suspected time of their respective leaks are included in Table 2-1 (Table C.1 in RPP-7884). Discussion in this section refers to the radiation activity and radioactive constituents and components of released material; however, these constituents and components are not subject to dangerous waste regulation and are included here for the sole purpose of identifying releases from tanks.

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

Analyte	241-S-104 during 1965 Leak (mol/L)	241-SX-107 during 1964 to 1967 Leak (mol/L)	241-SX-108 during 1965 to 1966 Leak (mol/L)	241-SX-109 during 1964 to 1967 Leak (mol/L)	241-SX-110 during 1974 Leak (mol/L)	241-SX-111 during 1973 Leak (mol/L)	241-SX-112 during 1969 Leak (mol/L)	241-SX-113 during 1962 Leak (mol/L)	241-SX-114 during 1972 Leak (mol/L)	241-SX-115 during 1964 Leak (mol/L)
Sodium	8.671E+00	1.873E+01	1.960E+01	1.519E+01	6.068E+00	5.310E+00	1.319E+01	7.982E+00	8.852E+00	3.593E+00
Aluminum	1.556E+00	3.273E+00	3.361E+00	2.560E+00	7.336E-01	5.270E-01	2.167E+00	1.267E+00	9.692E-01	8.258E-01
Total Iron	3.543E-03	6.878E-03	7.209E-03	5.598E-03	4.216E-03	5.323E-03	3.542E-03	2.967E-03	7.436E-03	2.111E-03
Chromium	1.647E-01	3.919E-01	4.128E-01	3.211E-01	6.793E-02	5.862E-02	2.065E-01	1.712E-01	1.015E-01	5.088E-02
Bismuth	8.951E-09	0.000E+00	0.000E+00	0.000E+00	1.139E-04	1.179E-04	6.395E-06	0.000E+00	1.475E-04	6.627E-08
Lanthanum	2.205E-14	0.000E+00	0.000E+00	0.000E+00	8.532E-10	1.326E-09	1.575E-11	0.000E+00	1.720E-09	1.632E-13
Mercury	3.541E-06	1.154E-07	1.966E-09	0.000E+00	1.518E-06	1.586E-06	1.006E-06	0.000E+00	1.864E-06	6.293E-06
Zirconium	8.935E-10	0.000E+00	0.000E+00	0.000E+00	1.953E-05	1.614E-05	6.383E-07	0.000E+00	1.959E-05	6.615E-09
Lead	5.666E-04	1.846E-05	3.146E-07	0.000E+00	2.093E-04	2.206E-04	1.596E-04	0.000E+00	2.569E-04	1.007E-03
Nickel	3.101E-03	6.187E-03	6.488E-03	5.038E-03	2.012E-03	1.942E-03	3.187E-03	2.671E-03	3.005E-03	1.732E-03
Strontium	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Manganese	6.515E-08	0.000E+00	0.000E+00	0.000E+00	2.254E-03	3.538E-03	4.655E-05	0.000E+00	4.565E-03	4.824E-07
Calcium	1.595E-02	3.096E-02	3.245E-02	2.520E-02	1.012E-02	9.760E-03	1.594E-02	1.336E-02	1.505E-02	9.502E-03
Potassium	3.069E-02	6.989E-02	7.386E-02	5.763E-02	2.632E-02	2.451E-02	5.094E-02	3.106E-02	3.951E-02	1.105E-02
Free Hydroxide	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Hydroxide	9.009E+00	1.980E+01	2.049E+01	1.571E+01	4.745E+00	3.510E+00	1.331E+01	7.968E+00	6.429E+00	4.171E+00
Nitrate	3.006E+00	4.891E+00	5.464E+00	4.485E+00	1.714E+00	1.534E+00	3.486E+00	2.818E+00	2.476E+00	1.197E+00
Nitrite	1.638E+00	4.485E+00	4.418E+00	3.225E+00	1.256E+00	1.131E+00	3.132E+00	1.336E+00	1.864E+00	7.840E-01
Carbonate	1.596E-02	3.096E-02	3.245E-02	2.520E-02	1.802E-01	2.263E-01	2.055E-02	1.336E-02	3.169E-01	9.550E-03
Phosphate	5.792E-07	0.000E+00	0.000E+00	0.000E+00	1.140E-02	1.317E-02	4.138E-04	0.000E+00	1.791E-02	4.288E-06
Sulfate	3.206E-02	9.299E-02	9.229E-02	6.775E-02	9.641E-02	1.226E-01	6.646E-02	2.879E-02	1.714E-01	1.920E-02

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

Analyte	241-S-104 during 1965 Leak (mol/L)	241-SX-107 during 1964 to 1967 Leak (mol/L)	241-SX-108 during 1965 to 1966 Leak (mol/L)	241-SX-109 during 1964 to 1967 Leak (mol/L)	241-SX-110 during 1974 Leak (mol/L)	241-SX-111 during 1973 Leak (mol/L)	241-SX-112 during 1969 Leak (mol/L)	241-SX-113 during 1962 Leak (mol/L)	241-SX-114 during 1972 Leak (mol/L)	241-SX-115 during 1964 Leak (mol/L)
Silicon	2.806E-02	9.803E-02	9.334E-02	6.561E-02	3.481E-02	3.425E-02	5.563E-02	2.229E-02	5.508E-02	1.279E-02
Fluorine	4.617E-07	0.000E+00	0.000E+00	0.000E+00	5.400E-03	5.272E-03	3.299E-04	0.000E+00	6.534E-03	3.418E-06
Chlorine	1.412E-01	3.215E-01	3.397E-01	2.651E-01	1.017E-01	8.848E-02	2.215E-01	1.429E-01	1.488E-01	5.071E-02
Citrate	4.771E-07	0.000E+00	0.000E+00	0.000E+00	1.810E-02	2.602E-02	3.408E-04	0.000E+00	3.548E-02	3.532E-06
EDTA	1.858E-08	0.000E+00	0.000E+00	0.000E+00	3.213E-04	4.655E-04	1.328E-05	0.000E+00	5.988E-04	1.376E-07
HEDTA	1.543E-08	0.000E+00	0.000E+00	0.000E+00	5.799E-04	9.256E-04	1.102E-05	0.000E+00	1.202E-03	1.142E-07
Glycolate	6.734E-07	0.000E+00	0.000E+00	0.000E+00	3.077E-02	1.215E-02	4.811E-04	0.000E+00	3.811E-02	4.985E-06
Acetate	6.989E-08	0.000E+00	0.000E+00	0.000E+00	2.233E-04	5.419E-05	4.993E-05	0.000E+00	3.255E-05	5.175E-07
Oxalate	2.888E-14	0.000E+00	0.000E+00	0.000E+00	1.118E-09	1.738E-09	2.063E-11	0.000E+00	2.253E-09	2.138E-13
DBP	4.231E-07	0.000E+00	0.000E+00	0.000E+00	1.082E-02	1.686E-02	3.023E-04	0.000E+00	2.136E-02	3.133E-06
Butanol	4.231E-07	0.000E+00	0.000E+00	0.000E+00	1.082E-02	1.686E-02	3.023E-04	0.000E+00	2.136E-02	3.133E-06
Ammonia	2.051E-02	1.122E-01	1.051E-01	7.226E-02	3.248E-02	3.205E-02	6.916E-02	2.123E-02	5.011E-02	1.305E-02
Ferricyanide	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Note: This table provides the nonradiological waste content and relative abundance for the subject tanks as it is presented in Table C.1 of RPP-7784, *Field Investigation Report for Waste Management Area S-SX*, Table C.1. This information is presented to identify the historical nonradiological content only.

DBP = dibutylphosphate

EDTA = ethylenediaminetetraacetic acid

HEDTA = hydroxyethylenediaminetetraacetic acid

One out of 12 tanks in the 241-S Tank Farm and 10 out of 15 tanks in the 241-SX Tank Farm (Figure 2-3) were classified "assumed or confirmed leakers": 241-S-104, 241-SX-104, and 241-SX-107 through 241-SX-115 (Section A-1.4.13 in DOE/RL-91-60). Leaks from two tanks, 241-SX-104 and 241-SX-110, were later determined unlikely (Table ES-1 in RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*). Both tanks were reclassified as "sound" based on subsequent leak assessments issued in 2010 and 2011 (Tables 4-1 and 6-1 in HNF-EP-0182).

Estimated leak volumes range from 1,900 to 7,600 L (500 to 2,000 gal) in tank 241-SX-111 to 190,000 L (50,000 gal) in tank 241-SX-115 (Table 4-2 in HNF-EP-0182). Each of the major listed leaks is discussed below to evaluate the severity of the contamination.

Tank 241-S-104 was categorized as an assumed leaker in 1968 with a total estimated leak volume of 90,800 L (24,000 gal) (Table 4-2 in HNF-EP-0182). Tank 241-S-104 was suspected of a leak based on a 10 cm (4 in.) liquid level decrease measured from 1966 to 1970 and increased gamma activity in a nearby drywell. However, the 241-S Tank Farm leak assessment report (Section 4.1 in RPP-RPT-48589) found that the tank was overfilled during the time of the liquid level decrease (1966 to 1970), and waste was released to soil by overflow through a spare inlet nozzle, rather than a tank leak. The report recommended that the 241-S-104 classification of "assumed leaker" be reassessed (Section 4.7 in RPP-RPT-48589).

Tank 241-SX-104 was categorized as an assumed leaker in 1988 due to a gradual liquid level decrease measured over the previous 3-year period (Section 5.1.2.2. in RPP-ENV-39658). The assumed worst-case total estimated leak volume for the tank is 22,700 L (6,000 gal) (Table 4-2 in HNF-EP-0182). Later, the assumed liquid level decreases from 1994 to 1998 and 1998 to 2008 were determined not to be due to tank leaks (Section 5.1.3 in RPP-ENV-39658). An assessment performed in 2010 determined that the observed liquid level decrease from 1984 to 1988 was likely due to evaporation and that it was reasonably certain that the tank was sound (Section 5.1.3 in RPP-ENV-39658). The tank was reclassified as sound based on a subsequent leak assessment (Tables 4-1 and 6-1 in HNF-EP-0182).

Tank 241-SX-107 (unplanned release [UPR]-200-W-140) was categorized as an assumed leaker in 1964 with an estimated leak volume of less than 19,000 L (5,000 gal) (Table 4-2 in HNF-EP-0182). In 1964, increases in radioactivity were observed, but no loss of material was documented. In 1968, new evidence of leakage was observed as increased gamma activity in laterals and drywells and the tank was removed from service (Section 5.2.1.1 in RPP-ENV-39658). The total leak volume of less than 19,000 L (5,000 gal) was estimated in Table 3-6 of PNL-4688, *Assessment of Single-Shell Tank Residual Liquid Issues at Hanford Site, Washington*, although no technical basis for the leak volume was stated.

Tank 241-SX-108 (UPR-200-W-141) was categorized as an assumed leaker in 1962, a confirmed leaker in 1964, and has an estimated leak volume of 9,000 to 130,000 L (2,400 to 35,000 gal) (Table 4-2 in HNF-EP-0182; Section 5.3.1.2 in RPP-ENV-39658). The first indications of a waste leak from the tank were recorded in 1962 based on minor amounts of radiation in laterals beneath the tank (Section 5.3.2.1 in RPP-ENV-39658). However, the tank was believed to have self-sealed and remained in service until 1964, when a steady increase in radiation was detected in the laterals (Sections 5.3.2.1 and 5.3.2.2 in RPP-ENV-39658). The lower end of the total leak volume estimate is based on the initial period of leakage from 1962 to 1964 (Section 5.3.2.2 in RPP-ENV-39658). The higher end is based on a 61 cm (24 in.) liquid level change observed in photographs taken of the inside of the tank from March 1967 to August 1968, though the decrease may be due to evaporation and discharge to the tank exhaust ventilation system (Section 5.3.2.2 in RPP-ENV-39658).

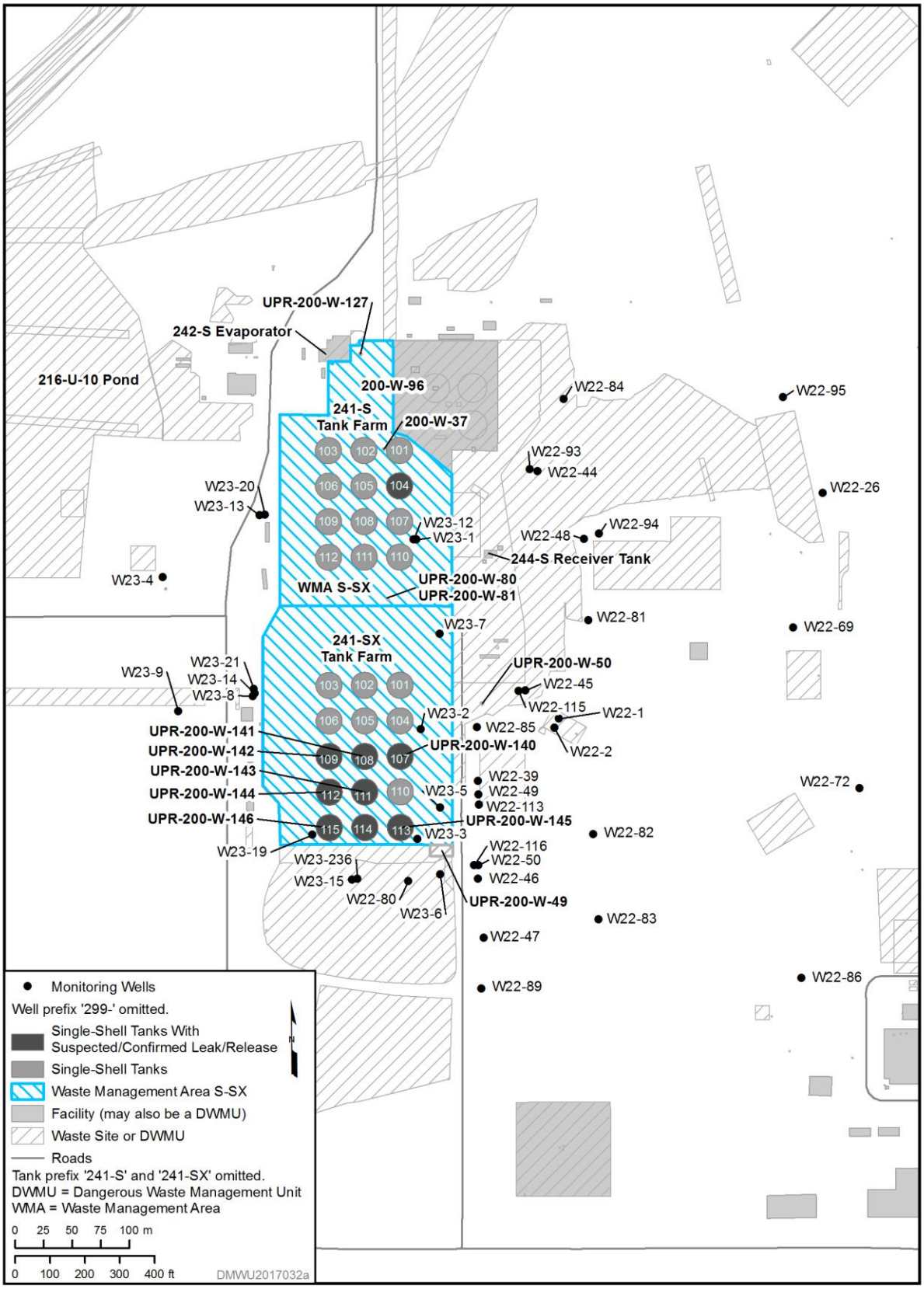


Figure 2-3. WMA S-SX

Tank 241-SX-109 (UPR-200-W-142) was categorized as an assumed leaker in 1965 and has an unknown estimated leak volume, likely less than 38,000 L (10,000 gal) (Table 4-2 in HNF-EP-0182). The first indications of a waste leak were recorded in 1965 from radioactivity in one lateral beneath the tank (Section 5.4.1.2 in RPP-ENV-39658). The average liquid level was observed to be dropping from 1965 to 1973. Some of the average decrease can be attributable to evaporation (Section 5.4.1.2 in RPP-ENV-39658). The total leak volume was reevaluated in 1992 by comparing the contaminated area and radiation levels to the leak impact from 241-SX-108 (Section 5.4.1.2 in RPP-ENV-39658). The current total leak volume of less than 38,000 L (10,000 gal) is based on that evaluation.

Tank 241-SX-110 was categorized as an assumed leaker in 1976 with an estimated leak volume of 20,800 L (5,500 gal) (Table 4-2 in HNF-EP-0182). The status of the tank was reclassified as sound based on a subsequent leak assessment (Tables 4-1 and 6-1 in HNF-EP-0182). The original determination was the result of an apparent unexplained 1.9 cm (0.75 in.) liquid level decrease in 1976 (Section 5.5.1.2 in RPP-ENV-39658). The liquid level drop was within the normal limits of loss to evaporation, and no increase in radioactivity was detected in nearby drywells or laterals (Sections 5.5.2.1 and 5.5.2.2 in RPP-ENV-39658).

Tank 241-SX-111 (UPR-200-W-143) was categorized as an assumed leaker in 1974 with an estimated leak volume of 2,000 to 10,600 L (500 to 2,800 gal) based on both radiation readings/estimation (2,000 to 8,000 L [500 to 2,000 gal) and the observed liquid level decline measurement (10,600 L [2,800 gal]) (Table 4-2 in HNF-EP-0182, and Section 5.6.2.1 in RPP-ENV-39658). The basis for leak declaration was an observed liquid level decline of approximately 10 cm (4 in.) from March to May 1974, and an increase in radiation detected in a lateral below the tank in April and May 1974 (Sections 5.6.1.4 and 5.6.2.1 in RPP-ENV-39658). Based on radiation readings and estimations of contamination plume dimensions, estimates of tank loss range from 2,000 to 8,000 L (500 to 2,000 gal) (Section 5.6.1.4 in RPP-ENV-39658). However, based on the liquid level decrease, the estimate of tank loss is approximately 10,600 L (2,800 gal) (Section 5.6.2.1 in RPP-ENV-39658).

Tank 241-SX-112 (UPR-200-W-144) was categorized as an assumed leaker in 1969 with an estimated leak volume of 114,000 L (30,000 gal) (Table 4-2 in HNF-EP-0182). A gradual liquid level decrease occurred in 1969, shortly followed by an increase in radiation from leak detection laterals (Table 5.7-1 in RPP-ENV-39658). Photographs of the interior of the tank reportedly showed twisted and broken pipes and equipment, apparently from a raised bulging liner (Table 5.7-1 in RPP-ENV-39658). Later photographs from 1974 showed an apparent crack in the sidewall of the tank (Table 5.7-1 in RPP-ENV-39658).

Tank 241-SX-113 (UPR-200-W-145) was categorized as an assumed leaker in 1962 with an estimated leak volume of 57,000 L (15,000 gal) (Table 4-2 in HNF-EP-0182). Shortly after the tank received waste in 1958, a bulge in the tank liner and subsequent collapse of the liner was recorded (Section 5.8.1.1 in RPP-ENV-39658). No apparent loss of liquid was determined from this event and radiation readings in laterals beneath the tank did not indicate a leak. Following this event, two leak tests were performed in 1962 with salt waste transferred from tank 241-SX-114. The first was determined to be inconclusive, but the second indicated a loss of 57,000 L (15,000 gal) to the ground when the tank liquid level was raised (Section 5.8.1.1 in RPP-ENV-39658). Laterals beneath the tank had increased radiation readings following the tests (Section 5.8.1.4 in RPP-ENV-39658).

Tank 241-SX-114 was categorized as an assumed leaker in 1972 with an unknown total leak volume (Table 4-2 in HNF-EP-0182). Following observation of increased gamma activity in a nearby drywell in 1972, the tank was removed from service in 1975. A leak volume from the tank was not determined as no liquid level decreases were measured in the tank associated with the leak detection event (Section 5.9.2.5 in RPP-ENV-39658). A leak from ancillary equipment and pipelines in the vicinity of the drywell was determined unlikely. An evaluation of the tank designation using conceptual leak modeling confirmed 241-SX-114 leaked (Section 5.9.2.5 in RPP-ENV-39658). Since no liquid level decrease was measured, the leak was likely less than 8,000 L (2,000 gal), within the uncertainty of liquid level measurements (Section 5.9.3 in RPP-ENV-39658).

Tank 241-SX-115 (UPR-200-W-146) was categorized as an assumed leaker in 1965 with an estimated leak volume of 190,000 L (50,000 gal) (Table 4-2 in HNF-EP-0182). A liquid level decrease of approximately 46 cm (18 in.) was observed from February 24 through March 3, 1965 (Section 5.10.2.4 in RPP-ENV-39658). However, a leak from 241-SX-115 may have occurred as early as 1963, given results of gamma scan logging in laterals beneath the tank (Section 5.10.2.4 in RPP-ENV-39658). The liquid level decline in conjunction with increased gamma activity in the laterals beneath the tank resulted in a tank classification of a confirmed leaker in 1965. The liquid loss in 1965 was sodium nitrate solution derived from leaching the REDOX high-level sludge (Section 5.10.3 in RPP-ENV-39658).

Other liquid handling structures within WMA S-SX, including diversion boxes, valve pits, a catch tank, and process pipelines, were used to transport or contain liquid waste associated with the tank farms. Information for the structures associated with WMA S-SX identified as waste sites in the Waste Information Data System (WIDS) is provided below.

- There are three diversion box waste sites within WMA S-SX. 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 transferred low-level and high-level mixed waste solutions from processing and decontamination operations between the various liquid handling structures within and outside of WMA S-SX (Sections 2.3.7.7 and 2.3.7.8 in DOE/RL-91-60).
- There are six separate valve pits in WMA S-SX as well as a valve pit associated with each tank. 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 is one catch tank within WMA S-SX. The catch tank is an underground, horizontal, cylindrical steel tank designed to receive diversion box leaks during transfers and drainage operations.
- Pipeline structures in WMA S-SX transferred effluent or condensate waste from the tank farm to surface liquid waste facilities. The pipelines were constructed of either carbon steel or stainless steel. Pipelines were either direct buried or encased in concrete. The pipelines delivered process fluids or condensate and were either gravity or pressurized lines.

These liquid handling structures within WMA S-SX 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 within the site boundary of WMA S-SX is from Table 5.11-1 in RPP-ENV-39658, Table 2-1 in HNF-4936, and WIDS. The UPRs that occurred within the site boundary of WMA S-SX have been consolidated into the 200-W-96 waste site (Figure 2-3). The 200-W-96 waste site includes the soil inside and adjacent to the boundary of WMA S-SX. In addition to the UPRs associated with tank leaks described previously (UPR-200-W-140 through UPR-200-W-146), the following UPRs were consolidated into 200-W-96:

- UPR-200-W-49 consists of contaminated surface soil from windborne contamination near 241-SX-111 and 241-SX-113. Contamination was identified in 1958 in an area approximately 465 m^2 (5,000 ft^2) (Table 5.11-1 in RPP-ENV-39658).
- UPR-200-W-50 was also caused by windborne contaminated soil from the 241-SX Tank Farm in 1958. Contaminated steam venting from risers in the pump pit at 241-SX-113 was spread by high wind and contamination deposited to the ground (WIDS). An area of approximately 2 acres was contaminated.
- UPR-200-W-80 was identified in 1978 at the 244-S Receiver Tank construction site during a radiological survey. The release was suspected to be the result of windborne contaminated soil, possibly from leaking vent lines or an old spill area that was not adequately stabilized in the 241-S and 241-SX Tank Farms. While the contaminated area was outside the 241-S and 241-SX Tank Farm boundaries in 1978, the perimeter fence was moved in 1996 and enclosed the area.
- UPR-200-W-81 is the same area as UPR-200-W-80, but was discovered to again be the site of surface contamination approximately 1 month after stabilization of the previous surface contamination was identified. Like the original UPR, windborne surface contamination from the 241-S and 241-SX Tank Farms was assumed to be the source of contamination. Decontamination and containment efforts were implemented in 1979.
- UPR-200-W-127 consisted of a liquid release to the ground surface from the 242-S Evaporator (north of the 241-S Tank Farm) in 1980. Monitoring determined that radiation levels were elevated around the building and the area was later covered with clean dirt.
- 200-W-37 is the location of a section of contaminated tubing found buried under 0.3 m (1 ft) of soil near tank 241-S-101. The tubing was likely used in the flushing of plugged transfer lines in the 241-S Tank Farm. The time of discovery of the tubing is unknown, but was prior to 1994 when the contamination area was first documented.

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 S-SX. Under interim status, groundwater monitoring at WMA S-SX has been conducted in accordance with WAC 173-303-400(3), “Dangerous Waste Regulations,” “Interim Status Facility Standards” (and, by reference, 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and

Disposal Facilities," 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 detection level groundwater monitoring program (WHC-SD-EN-AP-012, Rev. 0) was initiated in 1989 at WMA S-SX in accordance with 40 CFR 265, Subpart F (as referenced by WAC 173-303-400[3]). The indicator parameter monitoring program continued until 1996 when WMA S-SX was placed into a groundwater quality assessment monitoring program under 40 CFR 265.93(d). The program change was initiated by Ecology after evaluation of elevated technetium-99 in groundwater indicated that WMA S-SX had contaminated the groundwater and that specific conductance values in three downgradient wells (299-W23-15, 299-W22-39, and 299-W22-46) exceeded the upgradient background (critical mean) value, as recalculated using results from one of the two upgradient wells (Appendix A in WHC-SD-EN-AP-191, *Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area S-SX*).

In 1998, an assessment report was issued (PNNL-11810) that identified elevated concentrations of chromium, nitrate, and technetium-99 in downgradient wells (Section 3.1). The report concluded that groundwater contamination, likely from multiple sources, exists within WMA S-SX (Section 4.0 in PNNL-11810). Three wells exceeded the drinking water standard (DWS) for technetium-99 (299-W22-46, 299-W23-6, and 299-W23-1) and one well exceeded the DWS for nitrate (299-W23-46). The downgradient well with the highest concentrations of technetium-99, nitrate, and chromium (299-W22-46) had shown declining concentrations since May 1997. Based on these results, a phase II investigation was needed to determine the nature, extent, and source of groundwater contamination. An updated assessment plan was subsequently issued in 1999 (PNNL-12114, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*).

Two groundwater quality assessment reports were issued for WMA S-SX. In 2001, PNNL-13441, *RCRA Groundwater Quality Assessment Report for Waste Management Area S-SX (November 1997 through April 2000)*, reported that groundwater contamination attributable to tank leaks or spills continued to persist in both the 241-S and 241-SX Tank Farms, with the highest contaminant concentration (technetium-99 at 63,700 pCi/L relative to the DWS of 900 pCi/L) found near the 241-SX-115 SST in the southwest end of 241-SX (Summary in PNNL-13441). Contaminant plume migration was estimated to occur very slowly (30 to 50 [98 to 164 ft] m/yr) and the plume at the south end of 241-SX Tank Farm was estimated to be relatively small. Sampling results suggested that mobile tank waste contaminants (nitrate, technetium-99, and tritium) were in the upper 5 m (16 ft) of the aquifer in downgradient wells on the southeast site of the 241-SX Tank Farm.

In 2002, PNNL-13801, *Groundwater Quality Assessment Report for Waste Management Area S-SX (April 2000 through December 2001)*, reported that concentrations of technetium-99 and associated mobile tank waste contaminants were rapidly increasing in two 241-S Tank Farm wells (299-W22-44 and 299-W22-48) (Summary in PNNL-13801). Interim corrective measures (cutting and capping water lines near tank 241-SX-115 and surface run-on control), had been performed in 2001 and decreases in

technetium-99 concentrations were anticipated. Eight new monitoring wells had been installed and no new significant contamination was discovered.

Interim status groundwater monitoring at WMA S-SX has since continued under a groundwater quality assessment program. Updated assessment monitoring plans and revisions were issued as needed to update the well network as wells went dry due to declining water levels and to modify the monitoring constituents and sampling frequency. The most recent interim status monitoring plan was issued in 2011 (DOE/RL-2009-73, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX*).

Under Revision 9 of the Hanford Facility Dangerous Waste Permit, the SST System treatment, storage, and disposal (TSD) unit, which includes WMA S-SX, will become a final status closure unit group. 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 compliance monitoring program 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

WMA S-SX received high-level waste from the REDOX process that occurred at S Plant, followed by evaporator waste product solids from the 242-S Evaporator (241-S Tank Farm), and tank farm interim stabilization (saltwell pumping) and isolation activities (Section 2.1.1 in PNNL-11810; Section 2.1.2 in HNF-4936; and Figure 1-3 in HNF-EP-0182).

The dangerous wastes identified on the SST System Part A Application are presented in Table 2-2. The nonradiological waste profiles for SST 241-S-104 and SSTs 241-SX-107 through 241-SX-115 at the time of historical leak events (between 1962 and 1974) are presented in Table 2-1.

Table 2-2. Dangerous Wastes in the SST System Hanford Facility RCRA Permit Application 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 non-halogenated solvents

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

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
D018	Benzene	F004	Spent non-halogenated solvents
D019	Carbon tetrachloride	F005	Spent non-halogenated 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, "Approval of the Single-Shell Tank System Dangerous Waste Permit Application Part A Form, Revision 13."

* 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 S-SX. Figure 2-4 provides the locations of wells discussed in this section. A summary of the monitoring history for WMA S-SX is presented in Appendix A. Appendix A also contains the interim status groundwater monitoring data collected at WMA S-SX 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-191, Rev. 0, *Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area S-SX*	1996	Groundwater Quality Assessment Program
PNNL-12114, Rev. 0, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*	1999	Groundwater Quality Assessment Program

Table 2-3. Interim Status Monitoring Plans

Document	Date Issued	Monitoring Program[a]
PNNL-12114-ICN-1	2000	
ICN-PNNL-12114-September 1999.2	2002	
PNNL-12114-ICN-3	2006	
PNNL-12114-ICN-4	2006	
DOE/RL-2009-73, Rev. 0, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX*	2011	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 satisfies the requirements of 40 CFR 265.93(d)(3) through (e), "Preparation, Evaluation, and Response."

b. ECN 150201, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 000 Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*, is associated with WHC-SD-EN-AP-012, Rev. 0 and identifies changes that were incorporated in the Rev. 1 plan. Although it references the Rev. 0 plan, ECN 15021 is also incorporated as part of the Rev. 1 plan.

ECN = engineering change notice

ICN = interim change notice

In 1989, the DOE-Richland Operations Office initiated an interim status groundwater monitoring program at WMA S-SX 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 S-SX, the plan identified three upgradient wells (299-W23-4, 299-W23-8, and 299-W23-13) and nine downgradient wells (299-W23-1, 299-W23-2, 299-W23-3, 299-W23-5, 299-W23-6, 299-W23-7, 299-W23-12, 299-W22-1, and 299-W22-2) (WHC-SD-EN-AP-012, Rev. 0, Table 3.6) (Figure 2-4). These were existing wells, with the exception of 299-W23-13, which was installed in 1990. While existing wells were identified for the network, the construction dates varied with the oldest well (299-W23-1) constructed in 1952. 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). Monitoring constituents included the contamination indicator parameters, groundwater quality parameters, and drinking water parameters required by 40 CFR 265.92(b). In addition, each well was to be sampled one time during the first year of monitoring for an expansive list of metals, anions, pesticides, herbicides, volatile organic compounds (VOCs), semivolatile organic compounds, polychlorinated biphenyls, cyanide, phenol, total dissolved solids (TDS), hydrazine, ammonium ion, dioxins, tritium, uranium, and gamma scan (p. 110, Table 3.1, and Appendix C in WHC-SD-EN-AP-012, Rev. 0).

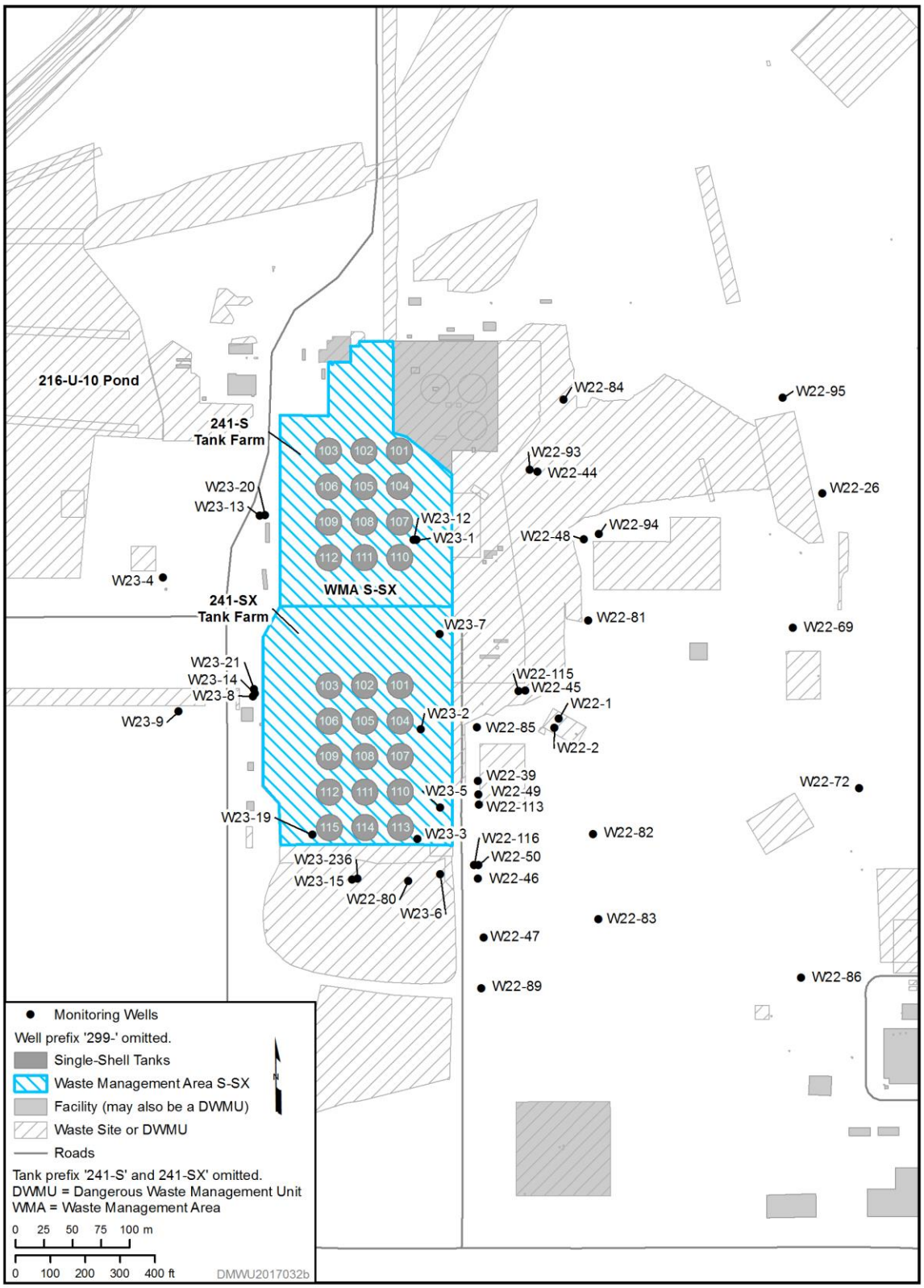


Figure 2-4. Wells Used During Interim Status Monitoring of WMA S-SX

Groundwater sampling was temporarily discontinued in June 1990 due to cancelation of the analytical laboratory contract. The Hanford Site 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 S-SX began in October 1991 (Section 16.2.2 in DOE/RL-92-03).

In 1991, WHC-SD-EN-AP-012 was revised (Rev. 1 and 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 network and constituent list. Two wells installed in 1991 (downgradient 299-W22-39 and upgradient 299-W23-14) were added to the WMA S-SX network (Table 3-6 in WHC-SD-EN-AP-012, Rev. 1). The compliance sampling network comprised two upgradient wells (299-W23-13 and 299-W23-14) and one downgradient well (299-W22-39) (Table 3-6 in WHC-SD-EN-AP-012, Rev. 1). Upgradient wells (299-W23-4 and 299-W23-8) and downgradient wells (299-W22-1, 299-W22-2, 299-W22-39, 299-W23-1, 299-W23-2, 299-W23-3, 299-W23-5, 299-W23-6, 299-W23-7, and 299-W23-12) were included for water-level measurements and sampling of either radionuclide or limited nonradionuclide constituents (Table 3-6 in WHC-SD-EN-AP-012, Rev. 1). Four proposed wells were included (299-W22-44, 299-W22-45, 299-W22-46, and 299-W23-15) (Table 3-2 in WHC-SD-EN-AP-012, Rev. 1). The constituent list was revised to add site-specific parameters (cesium-137, strontium-90, total uranium, total plutonium, gamma scan, and tritium) (Section 3.4.1.12 and Table 3-11 in WHC-SD-EN-AP-012, Rev. 1).

The groundwater flow direction in the area was influenced by the regional west-to-east gradient and the declining groundwater mound beneath the former 216-U-10 Pond (U Pond) (Section 4.11.4.1.2 in DOE/RL-94-136, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1994*). The groundwater flow direction at WMA S-SX trended from southeast (Section 2.0 in WHC-SD-EN-AP-012, Rev. 1) to south-southeast by 1995 (Section 4.11.4.1.2 in DOE/RL-94-136) due to the decline of the U Pond groundwater mound. The hydraulic gradient calculated from June 1994 water level data was 0.003 (Section 4.11.4.1.2 in DOE/RL-94-136). Flow direction changes were not significant enough to result in changes to upgradient and downgradient well designations.

In 1992, ECN 150144, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 001 Interim Status Groundwater Monitoring Plan for Single-Shell Tanks* (Section 12) added new downgradient wells 299-W22-44, 299-W22-46, and 299-W23-15 to the WMA S-SX network. Well 299-W23-5 had become dry and was removed from the plan (Table 3-6 in ECN 150144). Groundwater monitoring constituents were revised in 1992, adding total organics, cobolt-60, and iodine-129 (Table 16-2 in DOE/RL-93-09, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992*). In 1993, ECN 172204, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 001 Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*, to WHC-SD-EN-AP-012, Rev. 1, added iodine-129, technetium-99, and TDS (Table 3-11). In 1994, the monitoring constituents were revised in ECN 618171, *Engineering Change Notice to WHC-SD-EN-AP-012 Rev 001 Interim Status Groundwater Monitoring Plan for Single-Shell Tanks*, to WHC-SD-EN-AP-012, Rev. 1 with the removal of several radionuclides (cesium-137, cobalt-60, strontium-90, total uranium, total plutonium, and gamma scan), mercury, and metals and the addition of TDS and alkalinity (Table 3-11). Though not removed from the monitoring network until 1996, older wells 299-W23-1, 299-W23-2, 299-W23-3, 299-W23-4, 299-W23-5, 299-W23-6, 299-W23-7, 299-W23-8, and 299-W23-12 (drilled between 1953 and 1982) were designated as only for measurement of water levels by 1993 (Table 4.13-1 in DOE/RL-93-88, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*). The interim status monitoring network included upgradient wells 299-W23-13 and 299-W23-14 and downgradient wells 299-W22-39, 299-W22-44, 299-W22-45, 299-W22-46, and 299-W23-15 (Table 4.13-1 of DOE/RL-93-88).

In 1996, WMA S-SX transitioned from an indicator parameter evaluation program to a groundwater quality assessment program per direction from Ecology (Appendix A in WHC-SD-EN-AP-191). Ecology had recalculated the critical means for previous monitoring years using only one of the two upgradient monitoring wells (299-W23-14). The other upgradient well (299-W23-13) had a consistently higher specific conductance than 299-W23-14 and removal of 299-W23-13 from the calculation resulted in exceedances of the critical mean by downgradient wells since 1991. The monitoring network in the groundwater quality assessment was optimized to remove older wells and wells which had become dry. The revised network consisted of two upgradient wells (299-W23-13 and 299-W23-14) and five downgradient wells (299-W22-39, 299-W22-44, 299-W22-45, 299-W22-46, and 299-W23-15) (Section 4.1 in WHC-SD-EN-AP-191). The constituent list included one round of sampling for cesium-137, technetium-99, and strontium-90 for wells 299-W23-1, 299-W23-2, and 299-W23-3 (Table 2, Task B in WHC-SD-EN-AP-191). Mobile trace metal constituents (chromium, isotopes of ruthenium and molybdenum), anions, technetium-99, and tritium were identified for analysis in wells 299-W23-14, 299-W23-15, 299-W22-39, and 299-W22-45. Sampling of pH, specific conductance, reduction-oxidation potential, dissolved oxygen, and alkalinity were included at each well to be sampled and VOCs (chloroform) were included at selected wells (Table 2, Task B in WHC-SD-EN-AP-191).

The first determination report for WMA S-SX, PNNL-11810, identified uncertainties in the initial Phase I investigation. An updated groundwater assessment plan (PNNL-12114) was issued in 1999 to address the proposed Phase II investigation objectives, revise the well network, and revise the monitoring constituents. The monitoring network included 299-W22-39, 299-W22-44, 299-W22-45, 299-W22-46, 299-W23-1, 299-W23-2, 299-W23-3, 299-W23-4, 299-W23-7, 299-W23-9, 299-W23-13, 299-W23-14 299-W23-15, and the temporarily completed borehole, 41-09-39 (Section A.1.1.7 in PNNL-12114). The constituent list included anions (nitrate, chloride, bromide, and fluoride), metals (chromium, sodium, calcium, magnesium, potassium, manganese, iron, and aluminum), uranium, pH, specific conductance, alkalinity, TDS, volatile organics, gross alpha, gross beta, technetium-99, and tritium (Section A.1.1.7 in PNNL-12114).

By 1998, the declining U Pond groundwater mound caused additional wells to go dry and allowed the groundwater flow direction to continue to shift east to an east-southeast direction (Table A.2 in PNNL-12086, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*). Although groundwater flow direction was described as east in Table A.2 of PNNL-13404, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*, it was listed as east to southeast the following year (Table A.2 in PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*) and remained east to southeast until 2011 (Table B-1 in DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*). By 2000, older wells 299-W23-1, 299-W23-2, 299-W23-3, and 299-W23-7 had gone dry (Table A.2 and Figure A.4 in PNNL-12086). Two new upgradient wells (299-W23-20 and 299-W23-21) and one new downgradient well (299-W22-80) were drilled in 2000 (Table A.9 in PNNL-13404).

In 2000, PNNL-12114-ICN-1, *Interim Change Notice to PNNL-12114 RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site* revised the network to include the changes to the well network (Section A.1.1.7 in PNNL-12114-ICN-1). In 2002, ICN-PNNL-12114-September 1999.2, *Interim Change Notice to PNNL-12114 RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*, removed nine dry wells (299-W23-1, 299-W23-2, 299-W23-3, 299-W23-4, 299-W23-7, 299-W23-9, 299-W23-13, 299-W23-14, and 299-W23-39) from the monitoring plan and added two additional upgradient wells (299-W23-20, and 299-W23-21) and six additional downgradient wells (299-W22-80, 299-W22-81, 299-W22-82, 299-W22-83, 299-W22-84, 299-W22-85) drilled in 2000 and 2001 (Table R2.1 in ICN-PNNL-12114-September 1999.2). Monitoring parameters were also revised to include alkalinity, anions, metals, turbidity, and tritium; with gamma scan and gross beta conducted at 299-W23-19 only.

In 2005, one well went dry (299-W22-46) and one was drilled (299-W22-47) (Table B.34 in PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*). PNNL-12114-ICN-3, *Interim Change Notice to PNNL-12114 RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*, updated PNNL-12114 to reflect these changes to the monitoring network and changed the parameter list to remove non-RCRA co-contaminants from the monitoring program (gross beta, gamma scan, technetium-99, tritium, and uranium). In 2006, the fourth and final interim change notice to PNNL-12114 added downgradient monitoring wells drilled in 2006 (299-W22-69, 299-W22-72, and 299-W22-86) to the network (Table R4.1 of PNNL-12114-ICN-4, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*).

The latest interim status groundwater quality assessment plan for WMA S-SX was issued in 2011. DOE/RL-2009-73 captured changes to the monitoring well network from 2006 to 2011, including the addition of 299-W22-26 back to the monitoring network in 2008 and the drilling of downgradient well 299-W22-89 in 2010 (Table 3-2 in DOE/RL-2009-73). The revised monitoring list included chromium, nitrate, alkalinity, anions (chloride, nitrate, and sulfate), metals (calcium, magnesium, potassium, and sodium), and field parameters (pH, specific conductance, temperature, turbidity, and water levels) (Table 3-2 and Section 3.1 in DOE/RL-2009-73). 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 No. 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-2009-73). Any detected constituents that were not attributable to another source, or measured above upgradient or background concentrations, were to be included for routine sampling.

In July 2012, two new pump and treat (P&T) systems began operating within the 200 West Area; a final-remedy system addressing contamination at the 200-ZP-1 OU, and an interim action system in the 200-UP-1 OU addressing plumes from the 241-S and 241-SX Tank Farms. The 200 West Area P&T system was designed to remove carbon tetrachloride, chromium, iodine-129, nitrate, technetium-99, and trichloroethene from groundwater (p. CP-7 in DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*). By the end of 2012, 18 extraction wells and 14 injection wells for the 200 West Area were in use. In 200-UP-1, three extraction wells (299-W22-90, 299-W22-91, and 299-W22-92) were located at the 241-S and 241-SX Tank Farms that addressed local chromium and technetium-99 groundwater plumes, a local nitrate plume from the tank farms and the 216-S-25 Crib, and a portion of the larger carbon tetrachloride plume originating from the 200-ZP-1 OU.

In 2012, the groundwater flow direction at WMA S-SX was reported as east (Table 3-1 in SGW-55438, *Hanford Site Groundwater Monitoring for 2012: Supporting Information*), and no further changes in direction have been documented. Between 2012 and 2014, a number of wells were reported as dry or drying while new wells were drilled. Wells 299-W22-26 and 299-W22-48 were reported as dry in 2012 (Table 3-41 in SGW-55438). Downgradient well 299-W22-44 was reported dry and two downgradient wells (299-W22-94 and 299-W22-95) were drilled in 2013 (Table B.75 in DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). In 2014, downgradient wells 299-W22-49 and 299-W22-50 went dry and one replacement well was drilled (299-W22-113) (Table B-77 in DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*). In 2015, two downgradient wells were identified as drying (299-W22-45 and 299-W23-15) and four new downgradient wells were installed (299-W22-93, 299-W22-115, 299-W22-116, and 299-W23-236) (Table 3-10 in DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*).

The 2012 annual Hanford Site groundwater report (DOE/RL-2013-22) reported that chromium and nitrate (and technetium-99) contamination at WMA S-SX were attributed to two primary sources.

Technetium-99 and a portion of the chromium contamination were attributed to an overfill event of 91,000 L (24,000 gal) from tank 241-S-104 (Sections 3.7.2 and 4.6 in RPP-RPT-48589) (pp. UP-9 and UP-23 in DOE/RL-2013-22). Nitrate and technetium-99 contamination were attributed to a 190,000 L (50,200 gal) leak from tank 241-SX-115 during 1965 (Section 4.5 in RPP-ENV-39658, as reported in pp. UP-7 and UP-19 in DOE/RL-2013-22). Because chromium and nitrate are highly mobile in the aquifer, the average migration rate (toward the east) for these constituents was reported as equal to the calculated average groundwater flow rate of 0.12 m/d (0.40 ft/d) (45 m/yr [148 ft/yr]) (p. UP-40 in DOE/RL-2014-32).

In 2016, the WMA S-SX network comprised 2 upgradient wells (299-W23-20 and 299-W23-21) and 19 downgradient wells (299-W22-47, 299-W22-69, 299-W22-72, 299-W22-80, 299-W22-81, 299-W22-82, 299-W22-83, 299-W22-84, 299-W22-85, 299-W22-86, 299-W22-89, 299-W22-93, 299-W22-94, 299-W22-95, 299-W22-113, 299-W22-115, 299-W22-116, 299-W23-19, and 299-W23-236) (Table 3-11 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*). The groundwater flow direction in 2016 continued to the east. The average 2016 flow rate (0.18 m/d [0.59 ft/d]) was consistent with the 2015 average rate of 0.17 m/d (0.54 ft/d) (Table 3-12 in DOE/RL-2016-66, and Table 3-11 in DOE/RL-2016-12).

Groundwater extraction wells 299-W22-90, 299-W22-91, and 299-W22-92, within the WMA S-SX plumes, began pumping in July 2012. Extraction well operation has altered the chromium plume migration. Instead of moving eastward, some of the chromium is captured by the extraction wells. Chromium concentrations have declined in several network wells due to the extraction system. Of the six wells that had baseline chromium above 48 µg/L prior to the P&T operation, chromium decreased in 299-W22-47, 299-W22-83, 299-W22-86, 299-W22-93, and 299-W23-19 and increased in 299-W22-116 (Section 3.4 in DOE/RL-2016-66). The increase in 299-W22-116 indicates that chromium is migrating toward the adjacent extraction well 299-W22-91. The chromium in 299-W22-95 has been increasing since it was drilled in 2013; concentrations in June 2016 were 45 µg/L (filtered) and 47 µg/L (unfiltered). This is consistent with migration of the 241-S Tank Farm portion of the plume downgradient from extraction well 299-W22-90. At well 299-W23-19, inside the 241-SX Tank Farm, chromium concentration declined from 205 µg/L in December 2015 to 141 µg/L in September 2016. This well has the maximum chromium concentrations at the WMA because it is located in the source area.

3 Geology and Hydrogeology

This chapter briefly describes the local geology and hydrogeology beneath the 200 West Area, specifically the area of the 241-S and 241-SX Tank Farms, including stratigraphy (Figure 3-1), cross sections (Figures 3-2 and 3-3), and groundwater flow conditions before and after the start of P&T operations (Figures 3-4 and 3-5). This information is summarized from PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*, and DOE/RL-2009-73.

3.1 Stratigraphy

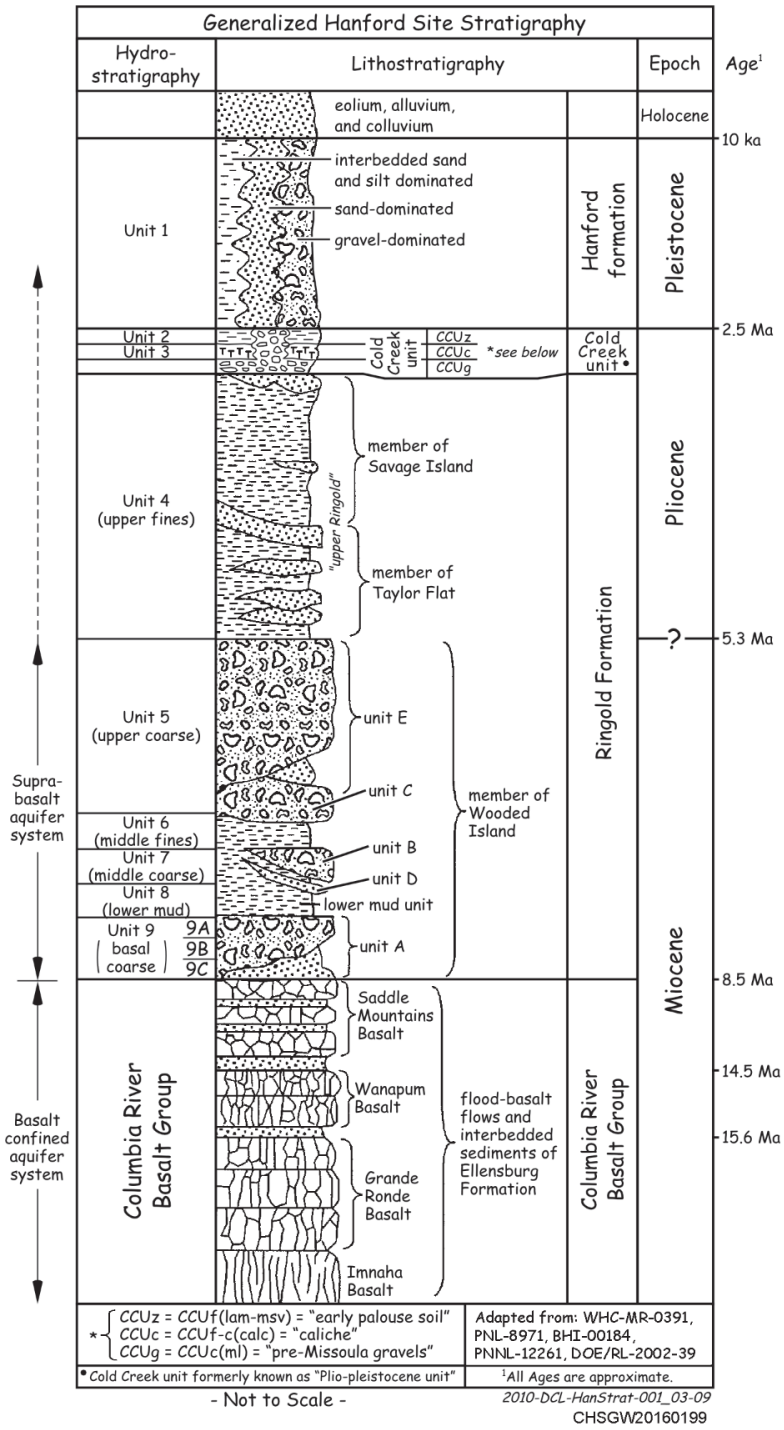
The generalized stratigraphy of the Hanford Site is shown in Figure 3-1. The local stratigraphy beneath WMA S-SX consists of unconsolidated to semi-consolidated sediments overlying basalt bedrock of the Columbia River Basalt Group. The sedimentary units present, in descending sequence, include the following:

- Sand and gravel backfill
- Sand and gravel of the Hanford formation
- Fine-grained Cold Creek unit (CCU)
- Fine-grained Ringold Formation member of Taylor Flat
- Sand and gravel of the Ringold Unit E
- Fine-grained Ringold lower mud unit
- Sand and gravel of Ringold Unit A (which overlies the basalt)

The Ringold Formation consists of Miocene-Pliocene fluvial and lacustrine elastic sediment deposited by the ancestral Columbia River system. The sediment rests unconformably on the Miocene-age Columbia River Basalt Group. Using a depositional environment approach, a number of facies within the Ringold Formation were identified (BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*). The Ringold Formation was divided into three informal members using facies associations (Section 4.2 in BHI-00184). The Ringold Formation underlying WMA S-SX belongs to the member of Taylor Flat and the underlying member of Wooded Island. The Member of Wooded Island is divided into five gravel-dominated fluvial depositional units, separated by widespread overbank, paleosol, and lacustrine deposits. The lower mud unit, a thick lacustrine deposit, separates gravel Unit A from the overlying deposits. The fluvial Ringold Formation member of Taylor Flat (Ringold Taylor Flat) where present, separates the CCU from the Ringold Unit E. It is present in the northern portion of WMA S-SX and is absent in the lower half (Figures 3-2 and 3-3).

The CCU, which separates the Ringold Formation from the Hanford formation, is divided into two distinct sequences. The upper sequence of thinly laminated silts was identified as lacustrine deposits. Calcium carbonate-rich strata characterize the lower sequence. This lower interval consists of locally derived basaltic detritus, silt-rich eolian deposits, reworked Ringold material, and calcium carbonate-rich paleosols. The calcium carbonate occurs as thin (<2.5 cm [1 in.]) layers, nodules, and coatings on clasts.

The Hanford formation is an informal stratigraphic unit made up of uncemented gravel, sand, and silt deposited by the late Pleistocene Missoula glacial floods. The Hanford formation can be described in terms of three gradational facies: gravel dominated, sand dominated, and silt dominated (Figure 3-1). At WMA S-SX the Hanford formation is sand dominated with interspersed lenses of gravel, sandy gravel, silty sand and sandy silt and has a total thickness of approximately 45 m (147 ft).



Note: Complete reference citations are provided in Chapter 11.

Figure 3-1. General Stratigraphy at the Hanford Site

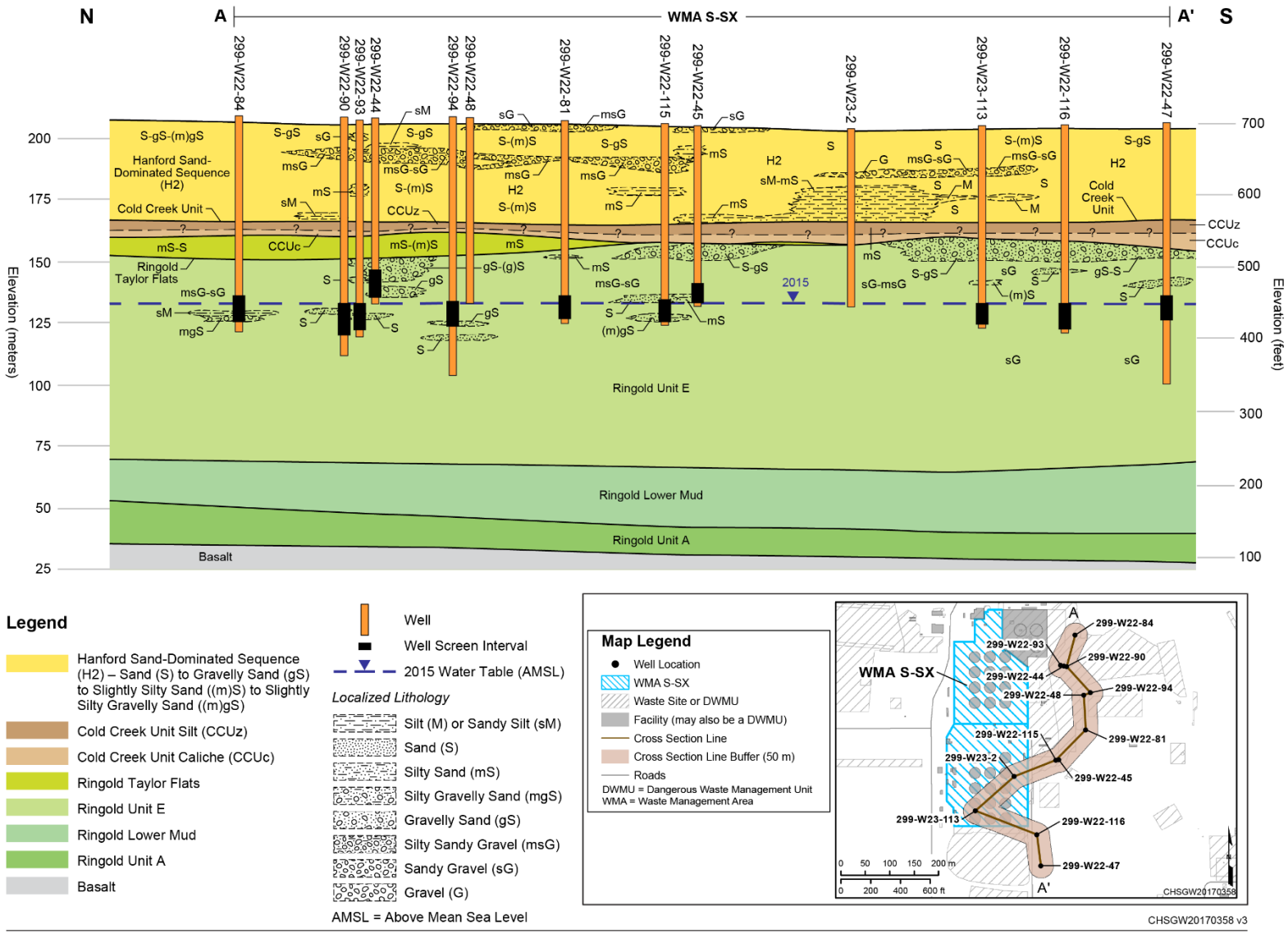


Figure 3-2. North to South Cross Section for WMA S-SX

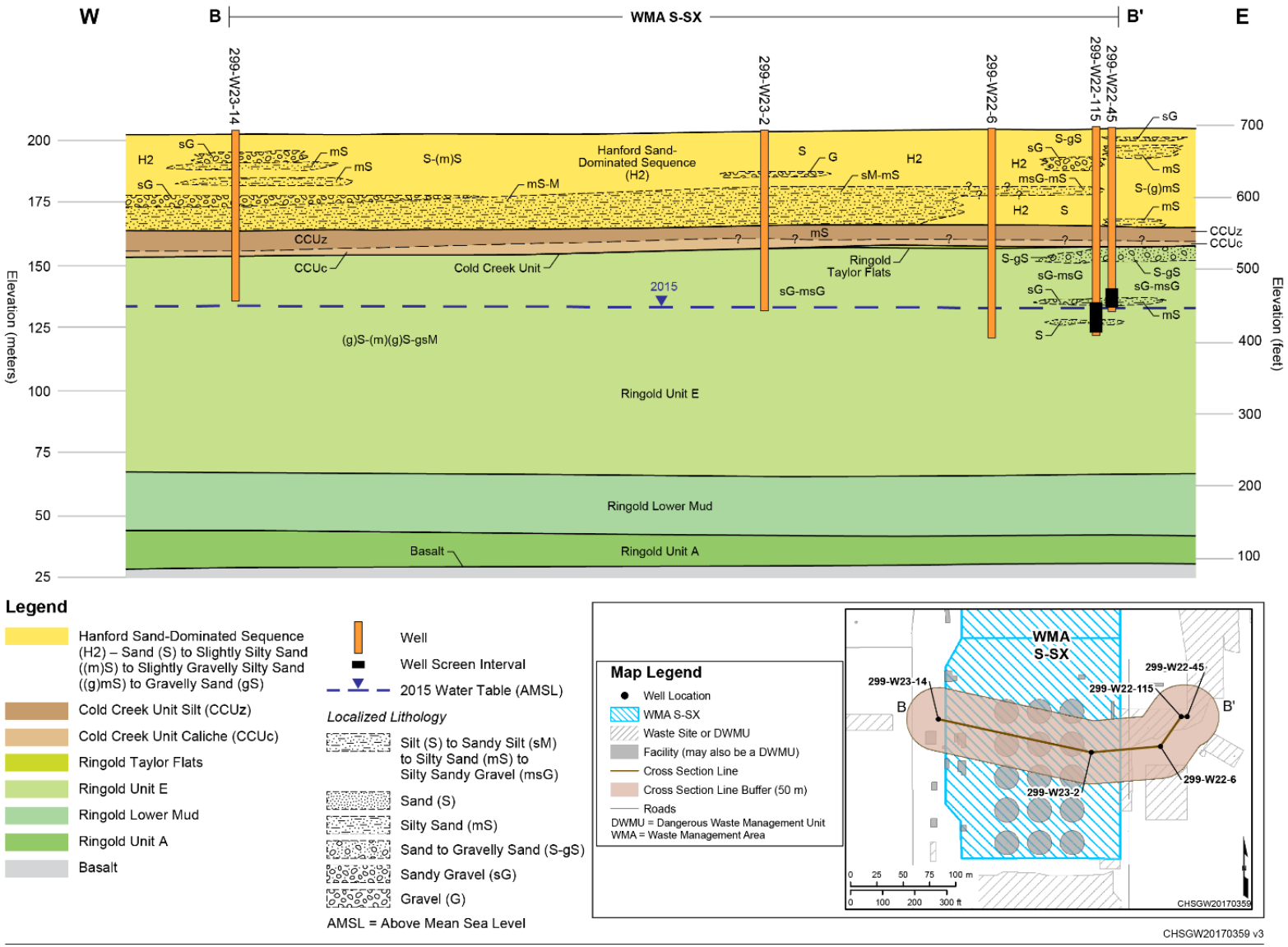


Figure 3-3. East to West Cross Section for WMA S-SX

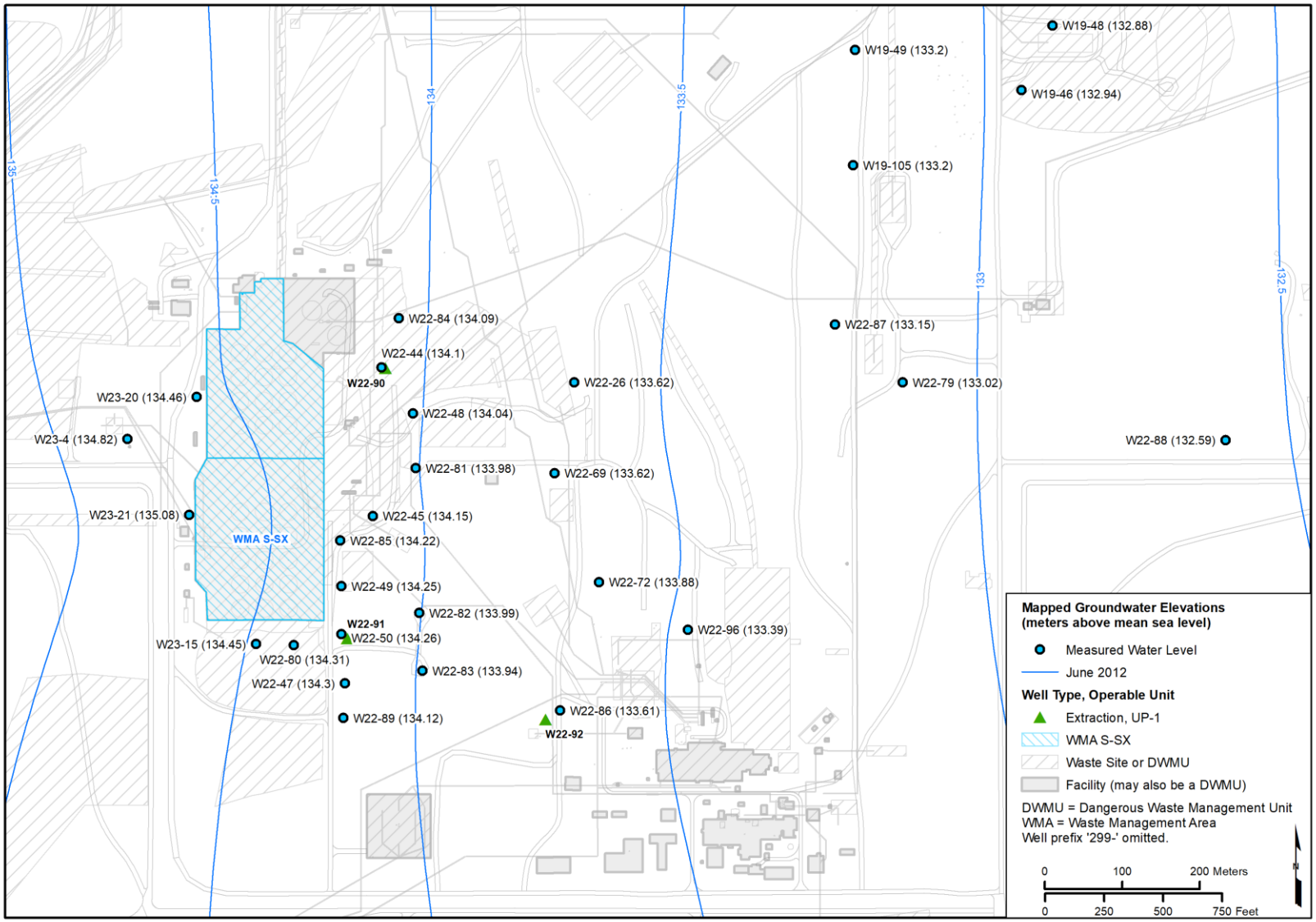


Figure 3-4. Water Elevation Contour in June 2012 Prior to Startup of the 200 West P&T

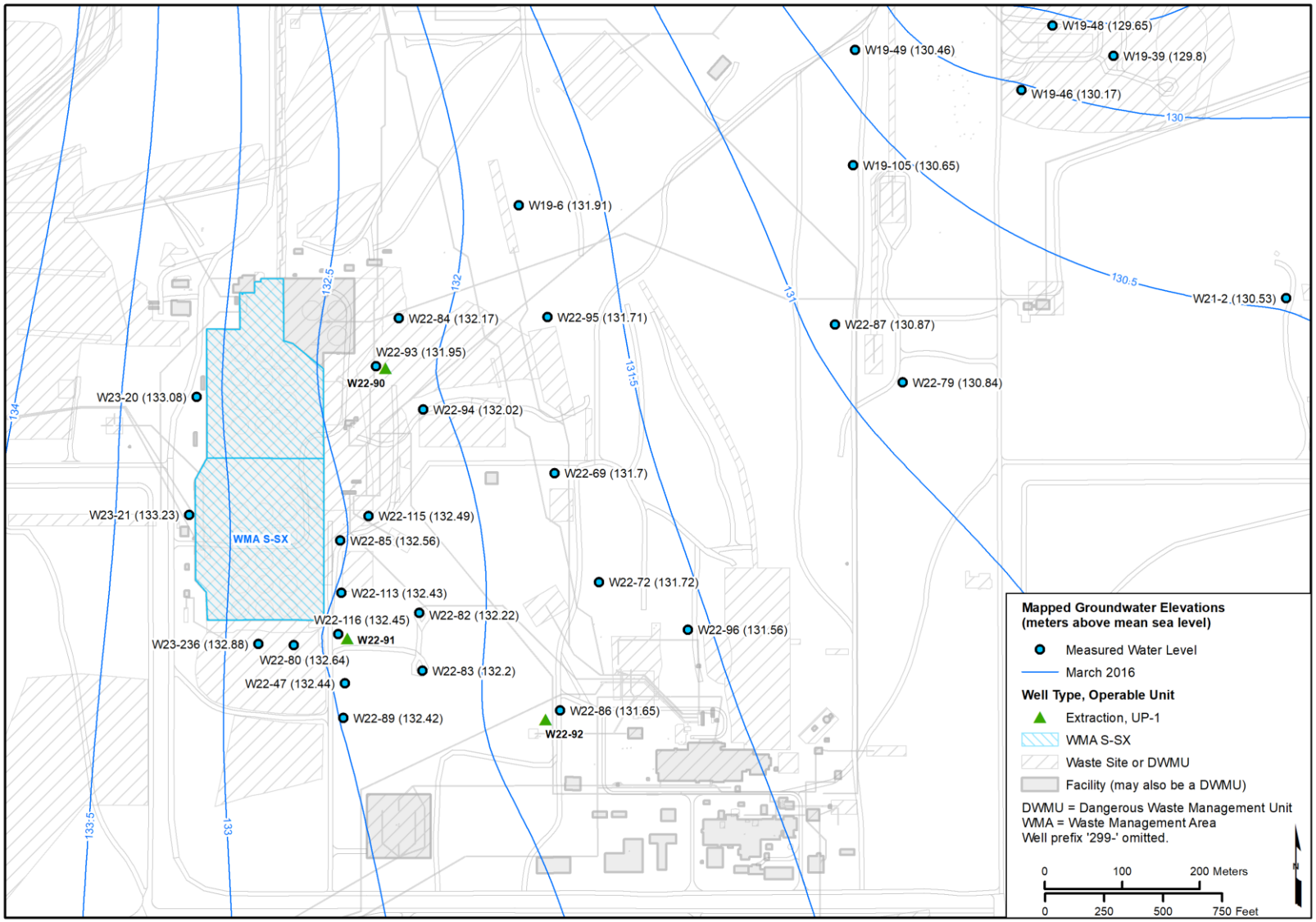


Figure 3-5. March 2016 Water Elevation Map for WMA S-SX

3.2 Hydrogeology

Groundwater beneath the Central Plateau flows generally from west to east, although the 200 West P&T system disrupts this pattern locally. Natural recharge to the unconfined aquifer comes from the Cold Creek Valley, Dry Creek Valley, Rattlesnake Hills, and infiltrating precipitation. Groundwater velocity generally ranges from a few millimeters to tenths of a meter per day.

The water table beneath the WMA occurs within Ringold Unit E (Figures 3-2 and 3-3), and the vadose zone is approximately 77 m (253 ft) thick. The base of the unconfined aquifer is the top of the fine-grained Ringold lower mud unit. The water table elevation is approximately 132 m (433 ft) (NAVD88, *North American Vertical Datum of 1988*). The unconfined aquifer is approximately 67 m (220 ft) thick. The uppermost confined aquifer occurs in the Ringold Unit A and is confined above by the lower mud unit and below by basalt. The lower aquifer is considerably thinner than the unconfined aquifer beneath WMA S-SX and there is no evidence of hydraulic connectivity between the two aquifers in the immediate vicinity of the site. Deeper confined aquifers occur between the basalt flows.

Figure 3-5 shows the March 2016 water table map for the WMA and vicinity. The groundwater flow direction is toward the east beneath the WMA at an average hydraulic gradient of 3.5×10^{-3} (Section 3.4 in DOE/RL-2016-66). The average flow direction beneath WMA S-SX is almost due east at approximately 86 degrees azimuth. Analysis of water-level data indicates that the average groundwater flow rate beneath the WMA is approximately 66 m/yr (216 ft/yr).

The saturated hydraulic conductivity of the Ringold E unit underlying WMA S-SX is 5 m/d (16.4 ft/d) (Table 4-9 in CP-47631). Table B-1 in Appendix B of PNNL-17348, *Results of Detailed Hydrologic Characterization Tests – Fiscal and Calendar Year 2005*, gives an average hydraulic conductivity of 7.5 m/d (24.6 ft/d) based on field measurements. Soil properties of the CCU and Ringold Taylor Flat indicate that these horizons will likely slow the rate of downward movement and promote lateral spreading in the vadose zone. The Ringold lower mud and basalt are considered aquitards relative to other sediments beneath WMA S-SX because of the units' very low hydraulic conductivities (Section 5.0 in PNNL-13858).

There is no significant difference in the hydraulic gradient magnitude between the 241-S and 241-SX Tank Farms. Between January 2004 and 2011, water levels in the monitoring wells have been declining at rates from 0.21 to 0.27 m/yr (0.69 to 0.89 ft/yr), with an average decline of 0.25 m/yr (0.82 ft/yr) (Section 2.4 in DOE/RL-2009-73). The rate of water level decline decreased from 0.36 m/yr (1.17 ft/yr) to 0.18 m/yr (0.60 ft/yr) between 2015 and 2016, respectively (Section 3.4 in DOE/RL-2016-66). The stark decrease in the water-level decline rate was likely due to lower extraction well flow rates between September and December 2016 than the previous year. The 200 West P&T system operated at a lower average rate during 2016 (Section 3.4 in DOE/RL-2016-66), which would also moderate water table decline rates.

3.3 Groundwater Flow

Elements of the groundwater flow system beneath WMA S-SX are described in the following subsections. These elements include the effects of historical anthropogenic discharges to ground in the 200 West Area, resulting in changes in groundwater elevation and flow direction and velocity, and more recently, implementation of groundwater remediation using P&T systems that remove, treat, and replace water into the aquifer.

3.3.1 Hydrologic Conditions Prior to 200 West P&T Operations

Groundwater flow conditions at WMA S-SX have varied greatly over the past several decades due to changing wastewater disposal in areas near the WMA. Between 1950 and 1970, the groundwater flow direction beneath the WMA varied between approximately due south to several degrees in the southeasterly direction, depending on effluent disposal volumes to the former 216-T-4 Pond to the north of the WMA and the former 216-U-10 Pond to the southwest (Sections 3 and 4 in PNNL-16069, *Development of Historical Water Table Maps of the 200 West Area of the Hanford Site (1950-1970)*). The most noticeable shift in direction (from approximately due south to east-southeast) was observed to have occurred between 1951 and 1954 after large discharges began at U Pond. Peak discharge to U Pond was between 1965 and 1985 (Figure 2.7 in WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*). Between March 2010 and March 2011, the water table elevation declined by an average of 0.19 m (0.62 ft) in the southern portion of the 200 West Area and is expected to decline another 3 to 5 m (9.8 to 16.4 ft) before reaching equilibrium (Section 3.3 in DOE/RL-2011-118).

Baseline groundwater levels were evaluated in two dimensions by interpolating water-level data obtained during June 2012, at which time no groundwater remedy was operating. Figure 3-4 shows the 2012 water table map prior to the start of the 200 West P&T remedy. During this time, groundwater flow direction was generally to the east. The hydraulic gradient was estimated to be 2.5×10^{-3} m/m in 2012 with an average linear velocity of 0.089 m/d (0.292 ft/d) (Table 3-1 in SGW-55438).

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

Water levels in the monitoring wells declined an average of 0.54 m/yr (1.79 ft/yr) from 2013 to 2015 (Section 11.13.2 in DOE/RL-2016-09, *Hanford Site Groundwater Monitoring Report for 2015*). Water levels continued to decline in 2016 at an average rate of 0.18 m/yr (0.60 ft/yr) (Section 11.12.1 in DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*). The decline is primarily due to two factors simulated within the CPGWM:

1. The substantial reduction of wastewater discharges to the soil column associated with the cessation of discharges in the mid-1990s.

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

The March 2016 Hanford Site water table map shows groundwater flow direction to the east-northeast beneath WMA S-SX (Figure 3-5). Groundwater flow is affected by the 200 West P&T remedy, which began operating in 2012. The system extracts and treats contaminated groundwater. One extraction well (299-W22-90) is located near WMA S-SX approximately 75 m (246 ft) east of the 241-S Tank Farm. Extraction well 299-W22-91 is located about 30 m (98 ft) southeast of WMA S-SX. The extraction wells are shown on the March 2016 water table map (Figure 3-5). Drawdown around these wells could partially account for the increased gradient at WMA S-SX. The hydraulic gradient beneath WMA S-SX is estimated to be 5.0×10^{-3} m/m based on a trend surface analyses performed on four sets of water-level measurements at WMA S-SX during 2016. The average groundwater flow rate during 2016 of 0.18 m/d (0.59 ft/d) was consistent with the 2015 average rate of 0.19 m/d (0.62 ft/d) (Section 11.12.2 in DOE/RL-2016-67). The groundwater flow rate and direction are further described in Section 4.3.

4 Contaminant Migration Conceptual Model

The following summary of a conceptual model of tank leak/release pathways to the groundwater is derived from site specific information found in Section 3.1 in RPP-7884, Section 4.2 in PNNL-11810, Sections 3 and 4 in PNNL-16069, Section 3.3 in DOE/RL-2011-118, and Section 3.2.3.1 in DOE/RL-2016-09.

4.1 Vadose Zone

The vadose zone at WMA S-SX is approximately 77 m (253 ft) to 74.9 m (246 ft) thick and consists of (from top to bottom) the Hanford formation, the CCU, and the Ringold Formation. The lower hydraulic conductivities of the CCU and Ringold Taylor Flat are likely to slow downward movement of moisture and contaminants because of the finer textured sediments and associated calcium carbonate cementation that result in the small hydraulic conductivities of the units. Although the CCU and Ringold Taylor Flat are clearly restrictions to vertical migration of water (and associated dissolved contaminants) beneath WMA S-SX, they are not impermeable and contaminated water can eventually reach the underlying groundwater. This is indicated by the apparent presence of contaminants from WMA S-SX in groundwater at the site. Percolation through the vadose zone in the northern portion of the site may be more inhibited than in the south from the presence of Ringold Taylor Flat beneath the CCU in the north.

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 contamination eventually reaches the water table. The source of contamination for the WMA is liquid waste released to near-surface or subsurface sediments. These liquids would be expected to move through the sediment under both saturated and unsaturated conditions, depending on the volume of liquid released. In addition to expected vertical distribution in relatively homogeneous portions of the Hanford formation, lateral spreading may occur at changes in soil texture and hydraulic conductivity (i.e. silty lenses). Small volume leaks would tend to be retained in the vadose zone near the leak point. Larger releases would be expected to move deeper in the soil, spreading laterally as the wetting front moves downward.

The results of studies described in RPP-7884 (Sections 3.4.1 and 3.4.2) indicate significant vadose zone contamination in the vicinity of tanks 241-SX-108 and 241-SX-115, which includes the dangerous constituent chromium and the supplemental constituent nitrate. These contaminants were not found at high concentrations below the CCU where boreholes were drilled near tanks 241-SX-108 and 241-SX-115; however, the presence of the mobile tank waste constituents in groundwater adjacent and downgradient to tank 241-SX-115 indicates that breakthrough of these constituents to the groundwater did occur beneath this tank. It is suspected that long-term leaking of utility water lines near the southwestern corner of the WMA provided the driving force for the contaminants to reach groundwater (Section 4.2 in PNNL-11810).

4.2 Soil Moisture Factors

Tank leaks discussed in Sections 2.1.3 and 2.1.4 were likely the main contributors to soil moisture content in the upper and middle vadose beneath WMA S-SX. Conceptually, residual soil moisture content resultant of natural recharge at the Hanford Site is very small in comparison to the post-leak residual soil moisture content. Infiltrating water from tank leaks could have traveled downward through highly transmissive Hanford formation materials high in the vadose zone and then spread laterally upon encountering silty lenses in the lower Hanford formation (Figures 3-2 and 3-3). Further lateral spreading would occur upon contact of the downward infiltration with the fine-grained CCU (and Ringold Taylor Flat in the north). Lower vadose zone moisture content was likely increased (and remains) above natural

background levels because of dissipating groundwater mounding because of cessation of discharge to U Pond (Sections 3 and 4 in PNNL-16069).

Tank leak/release events typically began with rapid discharge of some waste fluid volume into the subsurface from a point of release likely having a small spatial extent (on the order of inches to rarely feet). This discharge temporarily increases the moisture content of the unsaturated soil, particularly at the point of release. Typical release points may include poorly sealed openings in the tank structure, ruptured areas of steel tank liners nearby underlying concrete shell fractures, and breaks in waste transfer lines. Free liquids in soil move downward generally by gravity and move laterally typically by the forces of soil capillarity. The initial rate of liquid movement and the volume of soil that is eventually wetted by any particular release is a function of the volume of the leak, its duration, and the initial moisture content of the surrounding soil. The hydraulic conductivity of damp and/or wet soil is substantially higher than dry soil. Subsurface soil characterization at WMA S-SX demonstrated that moisture contents are elevated above undisturbed soil conditions and matric potential measurements indicate drainage (Section 3.4.2 in RPP-7884). The heterogeneous nature of the soil moisture content distribution beneath the site was not limited to moisture retention characteristics of various lithologies but was impacted by location relative to tank leak sources. Soil moisture characterization showed that tank leaks in the southern site area (e.g., 241-SX-115) resulted in higher soil moisture for the same lithology in other site areas (Section 3.4.2 in RPP-7884).

Migration processes at SST sites are anticipated to occur, 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.” In addition to vertical flow, lateral flow may occur under both saturated and unsaturated conditions due to the effects of capillary action and due to the effects of wetting front encountering zones of varying hydraulic conductivity. In formations such as those encountered in the Hanford Site, soil layers with different hydraulic properties (i.e. silt lenses) tend to be layered more or less horizontally by sediment deposition processes. Consequently, flow in the lateral direction could occur at numerous depth intervals within the vadose zone. Finer grained units will also exhibit higher moisture retention and therefore could potential continuing contamination sources for groundwater if they are contacted by infiltrating water that reaches the water table.

External sources of water or other liquid may drive the contamination further downward. Infiltration of water from precipitation and unintentional, manmade releases such as leaking water lines may move residual waste remaining in the soil downward to the groundwater.

4.3 Hydrogeologic Considerations

Prior to startup of the 200 West P&T system in 2012, the groundwater flow direction under WMA S-SX was east at a calculated velocity (using the Darcy relationship) of 0.10 m/d (0.33 ft/d) (Section 3.3 in DOE/RL-2011-118). In 2016, the groundwater flow direction beneath the WMA was generally east as a result of groundwater extraction and injection for the 200 West P&T. P&T extraction also caused an increase in hydraulic gradient beneath WMA S-SX in 2016. This gradient increase resulted in a calculated average groundwater velocity of 0.1 m/d (0.6 ft/d) (Section 3.2.3.1, p. 3-32 in DOE/RL-2016-09).

Pump and treat 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 S-SX in the simulations described in Chapters 5 through 7 of this report.

4.4 Groundwater Chemistry

The solubility and subsequent mobility of waste constituents in pore fluid depend on the chemical nature of the waste constituents, the volume of water and water contact time with the waste, and natural subsurface geochemical conditions.

Pore fluid and groundwater in the unsaturated and saturated zones beneath WMA S-SX is slightly alkaline (7<pH<9), with appreciable amounts of bicarbonate and very little natural organic material. Vadose soil and groundwater are generally well aerated. The dissolved oxygen concentrations fall into the higher range for groundwater (7 to 10 mg/L). These general conditions favor sorption or retardation of many heavy metals (e.g., lead) and also favor stability of oxy anionic species, which enhance mobility for other metals (e.g., hexavalent chromium). Laboratory sorption studies have documented these effects and related mobility issues in Hanford Site media. These conditions tend to allow chlorinated solvents (e.g., carbon tetrachloride) to remain persistent, as these compounds normally degrade more rapidly in reduced groundwater environments.

Under the current groundwater flow regime, contaminants reaching the groundwater from a release at WMA S-SX would migrate as dissolved contamination plume(s) toward the east with the groundwater flow (Figure 3-4). The average groundwater flow rate for 2016 has been estimated at 0.18 m/d (0.59 ft/d) (Section 3.3.2).

The chromium plume beneath WMA S-SX is attributed to a 91,000 L (24,000 gal) overfill event from tank 241-S-104 in the 241-S Tank Farm (Sections 3.7.2 and 4.6 in RPP-RPT-48589) and a 190,000 L (51,000 gal) leak from tank 241-SX-115 during 1965 in the 241-SX Tank Farm (Section 4.3 of RPP-ENV-39658). Because dissolved chromium (hexavalent chromium) is mobile in the aquifer, it migrates at the same average flow rate (to the east) as groundwater (0.18 m/d [0.59 ft/d]). Depth-discrete sampling while drilling 299-W22-47 indicated that chromium was present within the upper 20 m (65 ft) of the aquifer (Section 3.4 in DOE/RL-2016-66).

The groundwater extraction system has caused chromium to decline in several network wells. Of the six wells that had baseline chromium above the 48 µg/L 200-UP-1 cleanup level prior to the P&T, chromium decreased in wells 299-W22-47, 299-W22-83, 299-W22-86, 299-W22-93, and 299-W23-19 and increased in well 299-W22-116. The increase in 299-W22-116 indicates that chromium is migrating toward the adjacent extraction well 299-W22-91. The chromium in 299-W22-95 has been increasing since it was drilled in 2013; concentrations in June 2016 were 45 µg/L (filtered) and 47 µg/L (unfiltered). This is consistent with migration of the 241-S Tank Farm portion of the plume downgradient from extraction well 299-W22-90. At well 299-W23-19, inside the 241-SX Tank Farm, chromium declined from 205 µg/L in December 2015 to 161 µg/L in December 2016.

Other contaminant plumes associated with WMA S-SX include nitrate, technetium-99 and tritium, and are described as follows.

- Nitrate – The highest concentration of nitrate measured in 2017 was 116,000 µg/L at well 299-W23-19, which is located immediately adjacent to and upgradient of tank 241-SX-115. Lateral spreading by diffusion in saturated sediments at the water table could likely have resulted in the high concentration in this upgradient location.

- Technetium-99 – The highest concentration of technetium-99 measured in 2017 was 13,700 pCi/L at well 299-W23-19, which is located immediately adjacent to and upgradient of tank 241-SX-115. Lateral spreading by diffusion in saturated sediments at the water table could likely have resulted in the high concentration in this upgradient location.

- Tritium – The highest concentration of tritium measured in 2017 was 84,400 pCi/L at well 299-W22-85. This well is downgradient of the 241-SX tanks. The tritium plume underneath WMA S-SX is located under the northernmost 241-SX tanks and extends to the east.

4.5 Summary of Vertical Contaminant Distribution

Evaluation of vertical distribution data is limited to the location of WMA S-SX within the context of regional plumes present in the 200-UP-1 OU including contaminant plumes originating from WMA S-SX. Available vertical distribution data are limited to five wells completed in the vicinity of WMA S-SX and samples collected during drilling. Identified wells are 299-W22-47, 299-W22-72, 299-W22-86, 299-W22-89, and 299-W22-94, all located near WMA S-SX. See Figure 4-1 for general well locations in relation to WMA S-SX. These wells were installed between 2005 and 2013 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 S-SX operation. In addition, a CERCLA P&T remedial action is currently in operation in the vicinity of these wells.

Evaluated constituents were limited to available nonradiological vertical data associated with surrounding wells. Vertical profile samples were analyzed for carbon tetrachloride, nitrate, and sulfate, representing contaminants in the 200-UP-1 OU and present near WMA S-SX. Chromium (total) samples were collected for laboratory analysis, but concentrations were nondetections for each well at each sample depth.

During drilling of the evaluated wells, groundwater samples were collected from the boreholes at selected depths and analyzed by field and/or laboratory methods. Laboratory data were selected where both field and laboratory data were available for each of the vertical contaminant distribution plots. Where duplicate samples were collected at a given interval, resulting values were averaged; nondetect results were included at the reported detection limit. See Figures 4-2 through 4-6 for observed vertical distribution of identified contaminants. 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 within the upper and middle sections of the unconfined aquifer, consistent with the presence of multiple sources and extents of regional plumes. However, vertical zones of increased contaminant concentrations are evident to varying degrees within the wells. Well 299-W22-47 (Figure 4-2), located southeast of WMA S-SX, exhibits an increase in carbon tetrachloride and nitrate concentrations beginning at the (2005) water table and extending to 14 m (46 ft) below the 2017 water table. Well 299-W22-72 (Figure 4-3), located east of the 241-SX Tank Farm, exhibits few measurements for carbon tetrachloride with an increase in concentration at 35 m (115 ft) below the 2017 water table. Well 299-W22-86 (Figure 4-4), located southeast of the 241-SX Tank Farm, exhibits an increase in carbon tetrachloride and nitrate concentrations beginning at the (2006) water table and extending to 6 m (20 ft) below the 2017 water table. Well 299-W22-89 (Figure 4-5), located southeast of the 241-SX Tank Farm, exhibits an increase in nitrate concentration within the upper unconfined aquifer, approximately 4 to 7 m (13 to 23 ft) below the 2017 water table. Well 299-W22-94 (Figure 4-6), located east of the 241-S Tank Farm, exhibits an increase in nitrate and sulfate concentrations at 4 m (13 ft) below the 2017 water table.

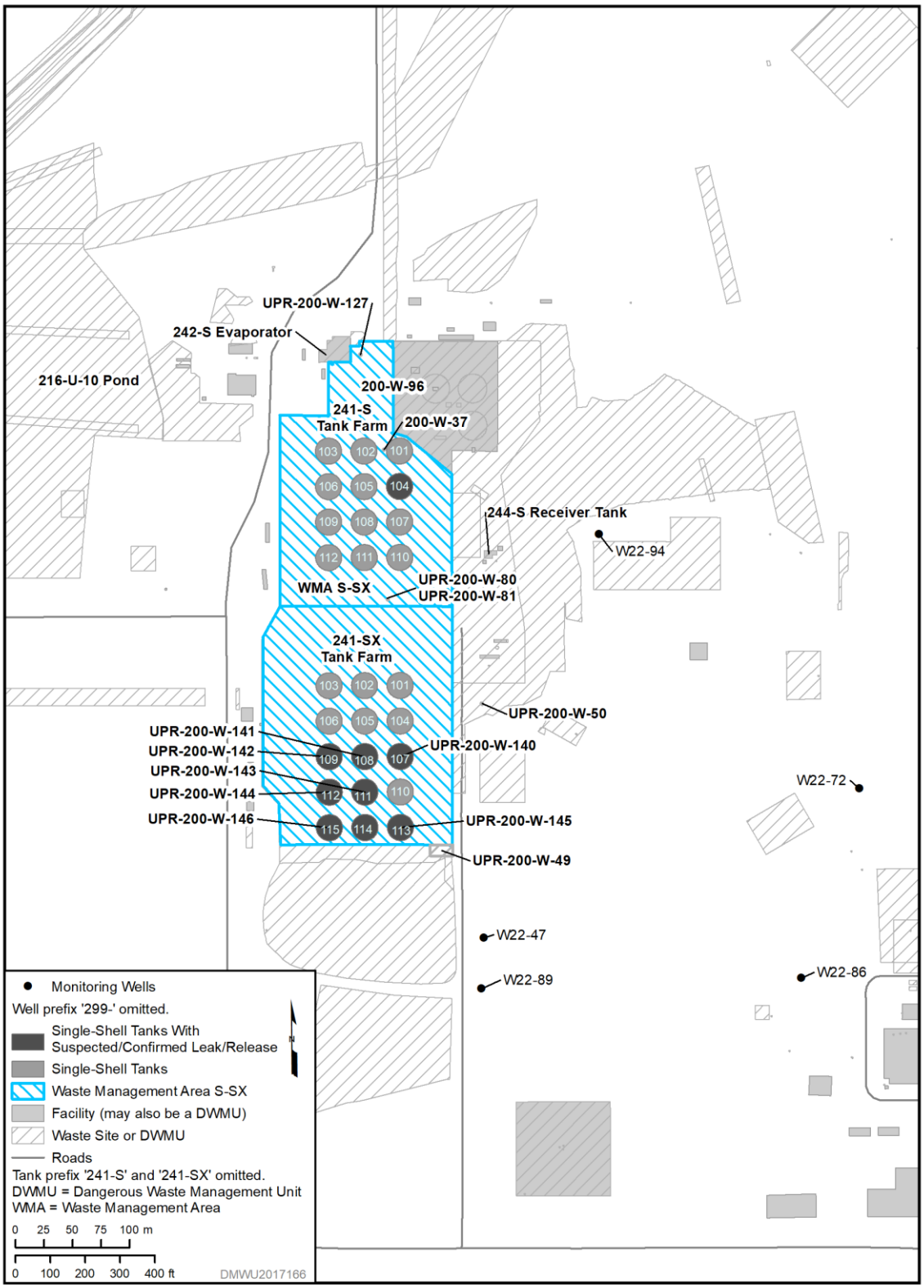


Figure 4-1. Wells Used during Interim Status Monitoring Including Vertical Contaminant Characterization Well Locations

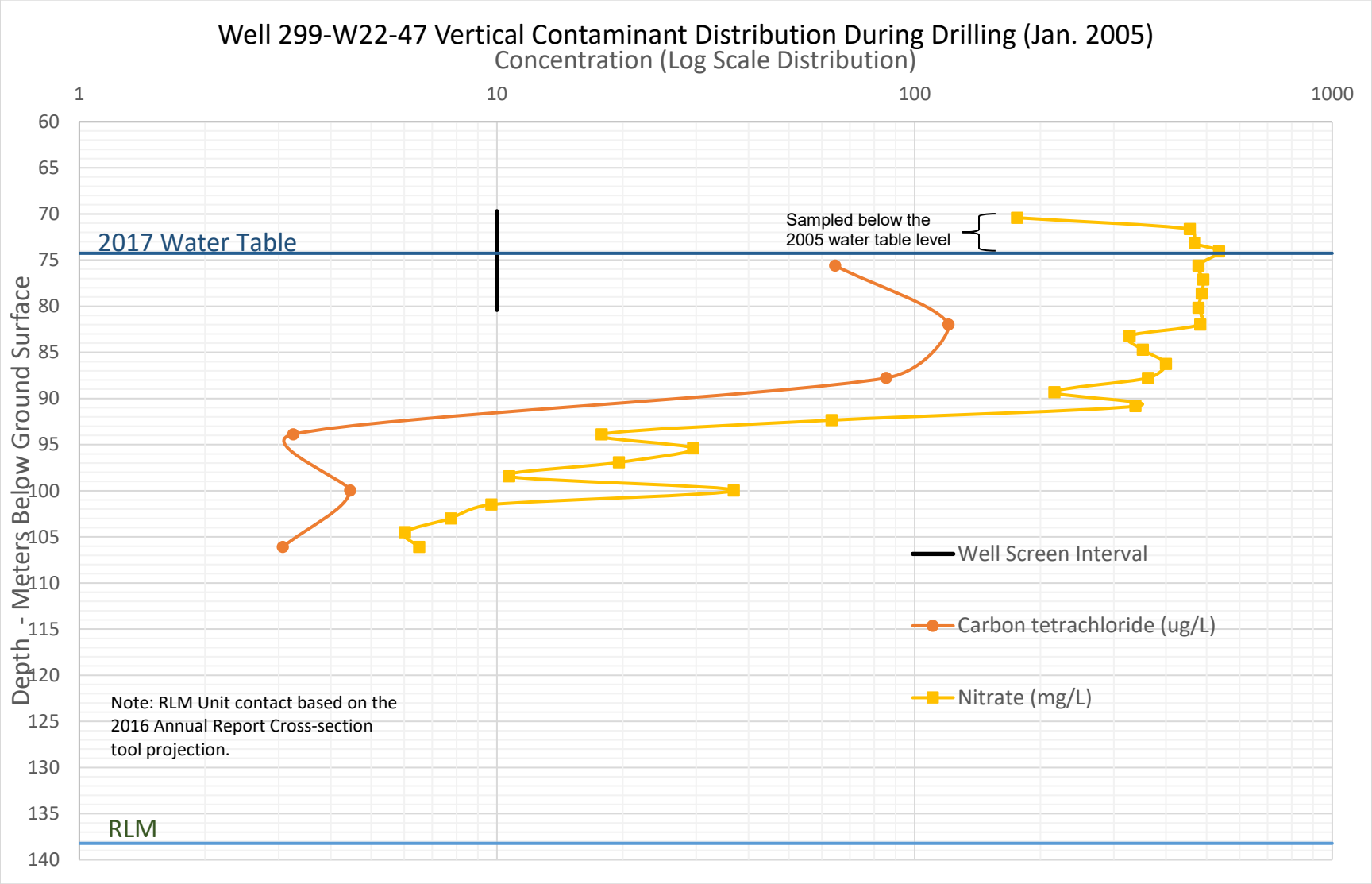


Figure 4-2. Vertical Contaminant Distribution Well 299-W22-47

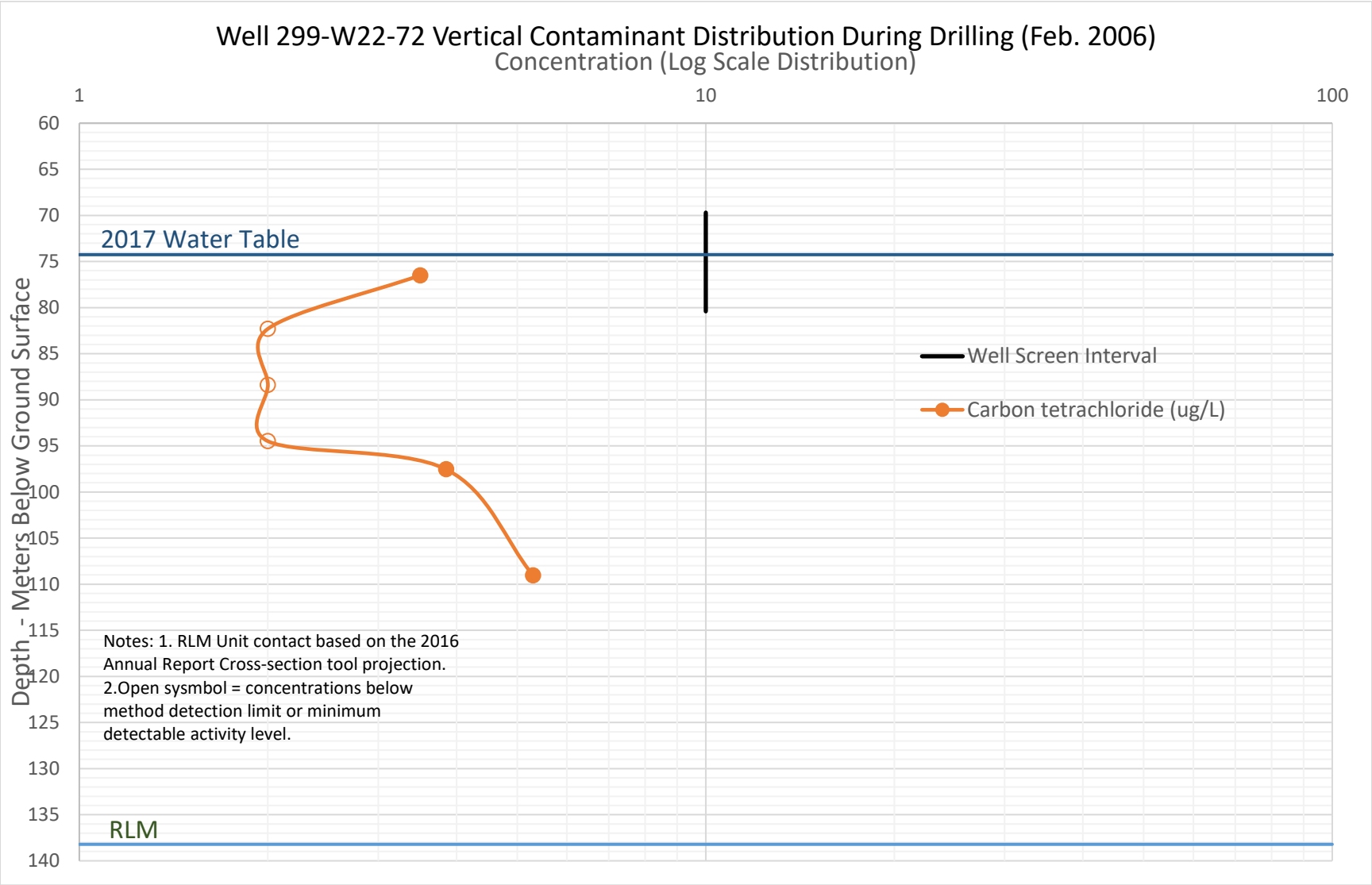


Figure 4-3. Vertical Contaminant Distribution Well 299-W22-72

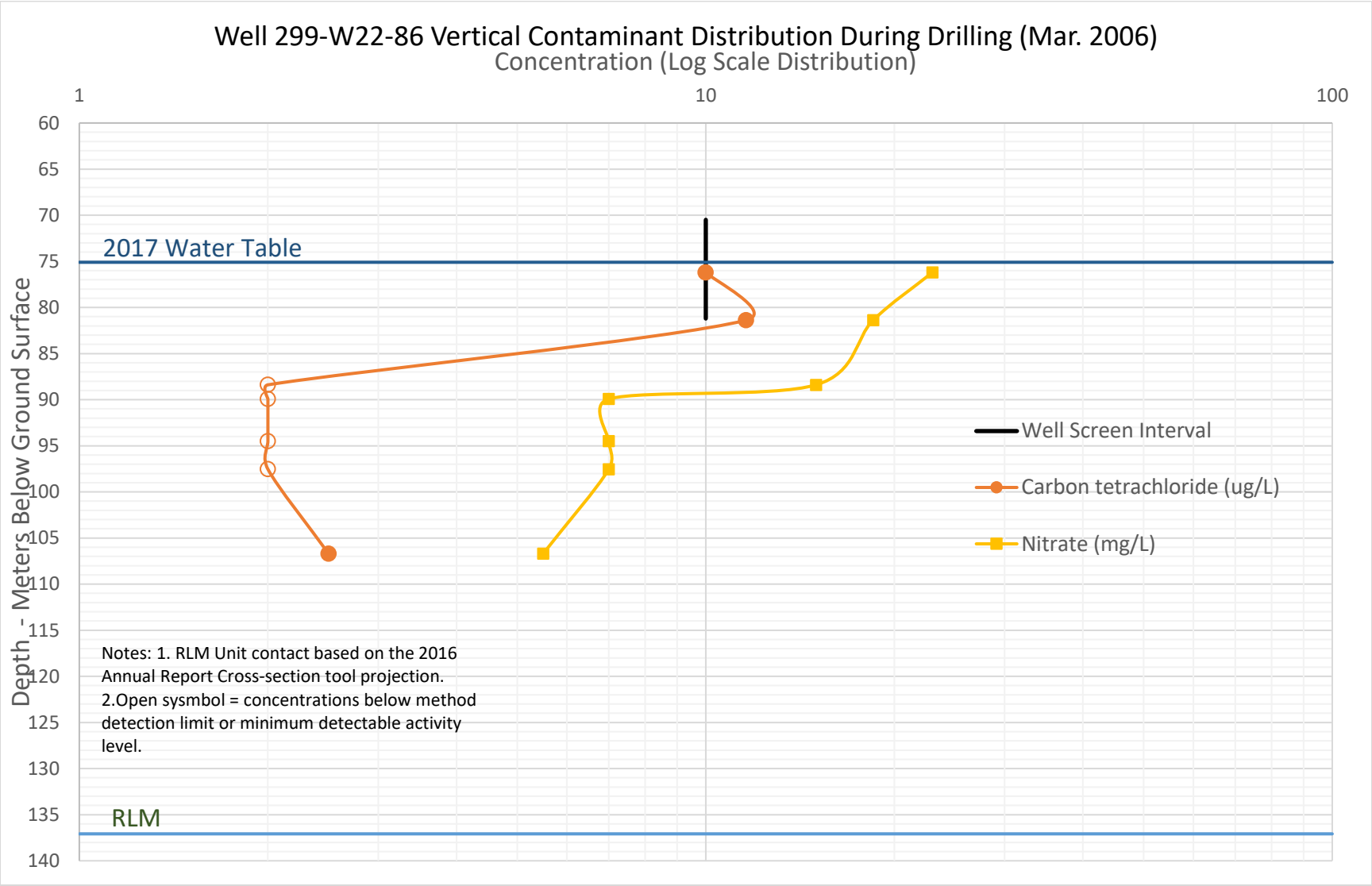


Figure 4-4. Vertical Contaminant Distribution Well 299-W22-86

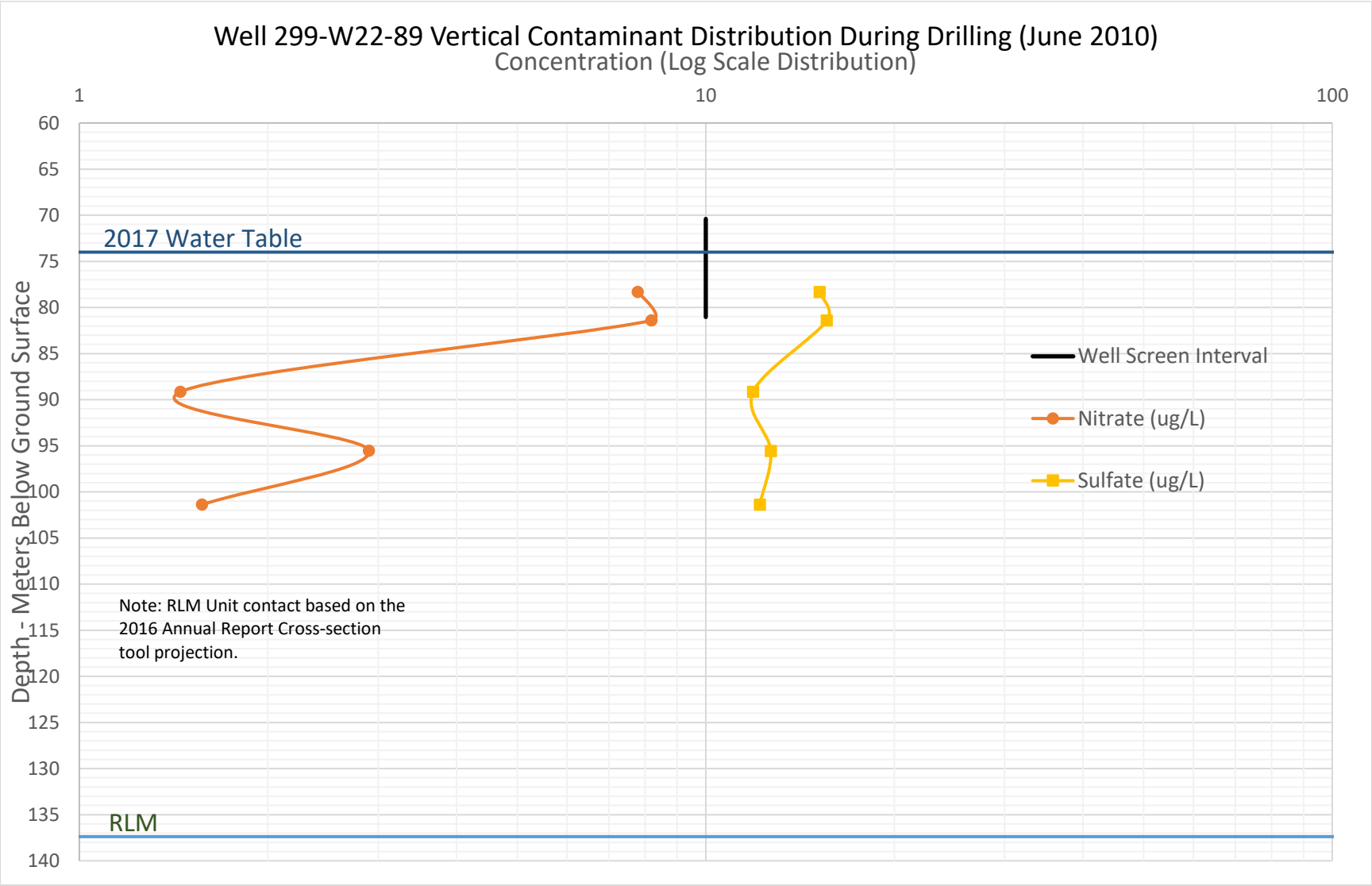


Figure 4-5. Vertical Contaminant Distribution Well 299-W22-89

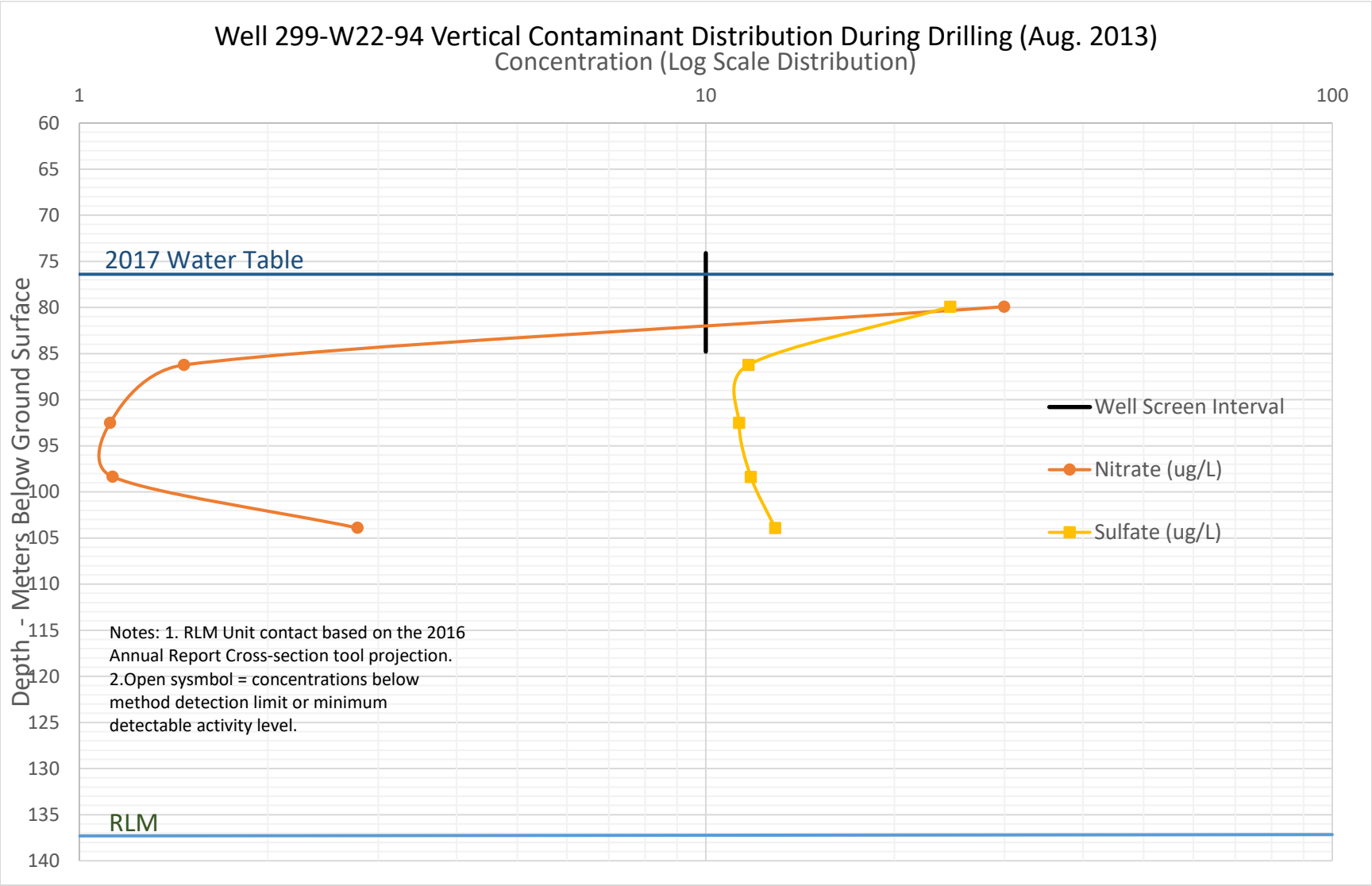


Figure 4-6. Vertical Contaminant Distribution Well 299-W22-94

In summary, WMA S-SX is located in the periphery of the regional 200 West Area plumes and within the local-scale plumes. It is additionally impacted by the current, local 200-UP-1 P&T and the 200 West P&T well network operations. Evaluated wells exhibit varying concentration trends with depth and number of analyzed data in wells near WMA S-SX. Based on the limited data available, the vertical distribution of plume concentrations do not appear to penetrate the entire depth of the aquifer. Available data for the wells are not sufficiently representative to evaluate vertical plume migration from a hypothetical release from WMA S-SX.

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5 Groundwater Flow Simulations

Groundwater flow simulations were conducted to evaluate the groundwater monitoring network for WMA S-SX (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 3-11 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 S-SX.

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).

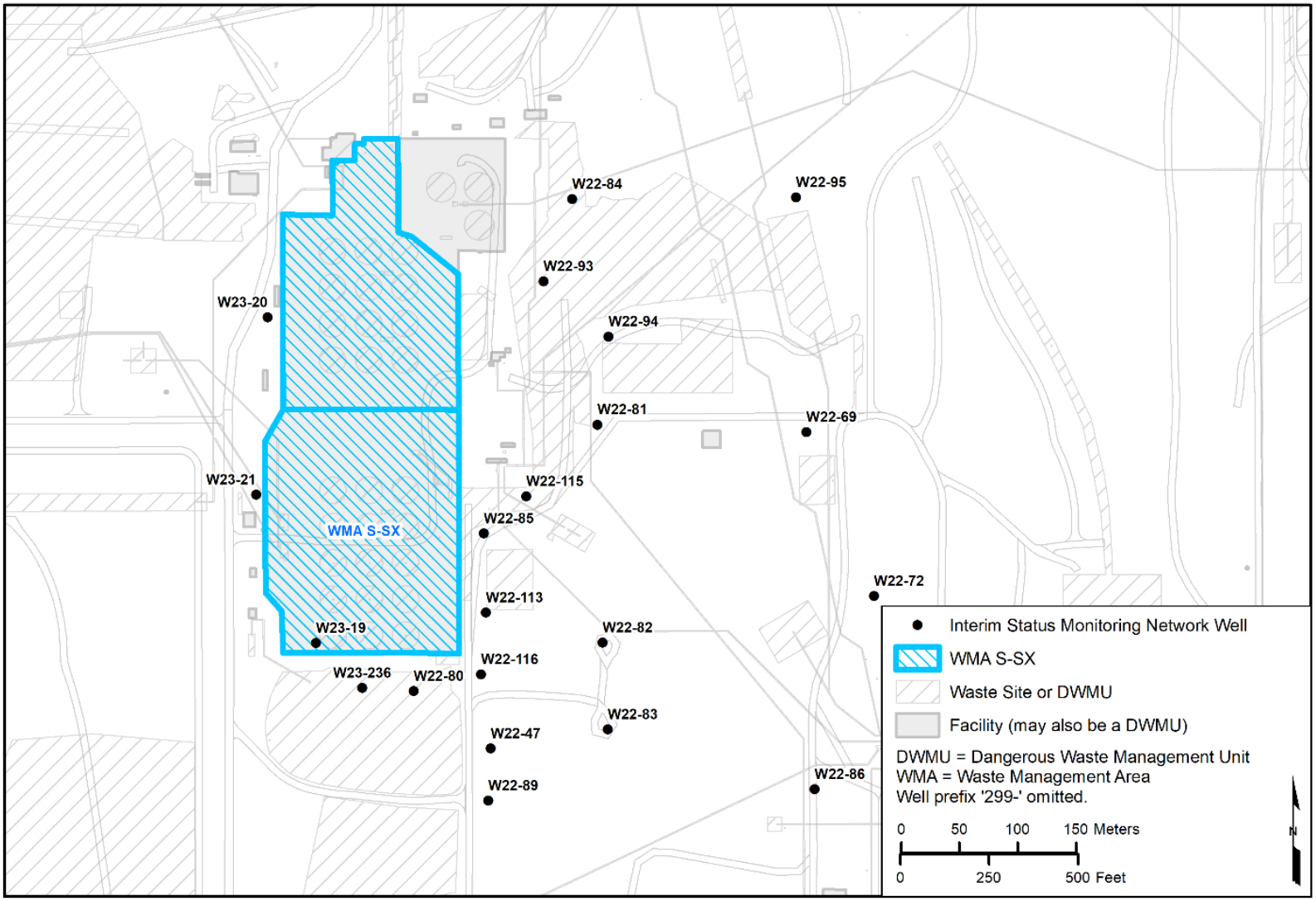
Contaminant transport is simulated using the Modular Three-Dimensional Multi-Species Transport Model (MT3DMS) code. MT3DMS was developed specifically for use with MODFLOW to simulate contaminant advection, dispersion, sources and sinks, and chemical reactions in groundwater systems.

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.



Source: Table 3-11 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*.

Figure 5-1. Interim Status Groundwater Monitoring Network

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

Table 5-1. Simulation Scenarios

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

Table 5-1. Simulation Scenarios

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

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

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

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

b. Current conditions as defined in Appendix G.

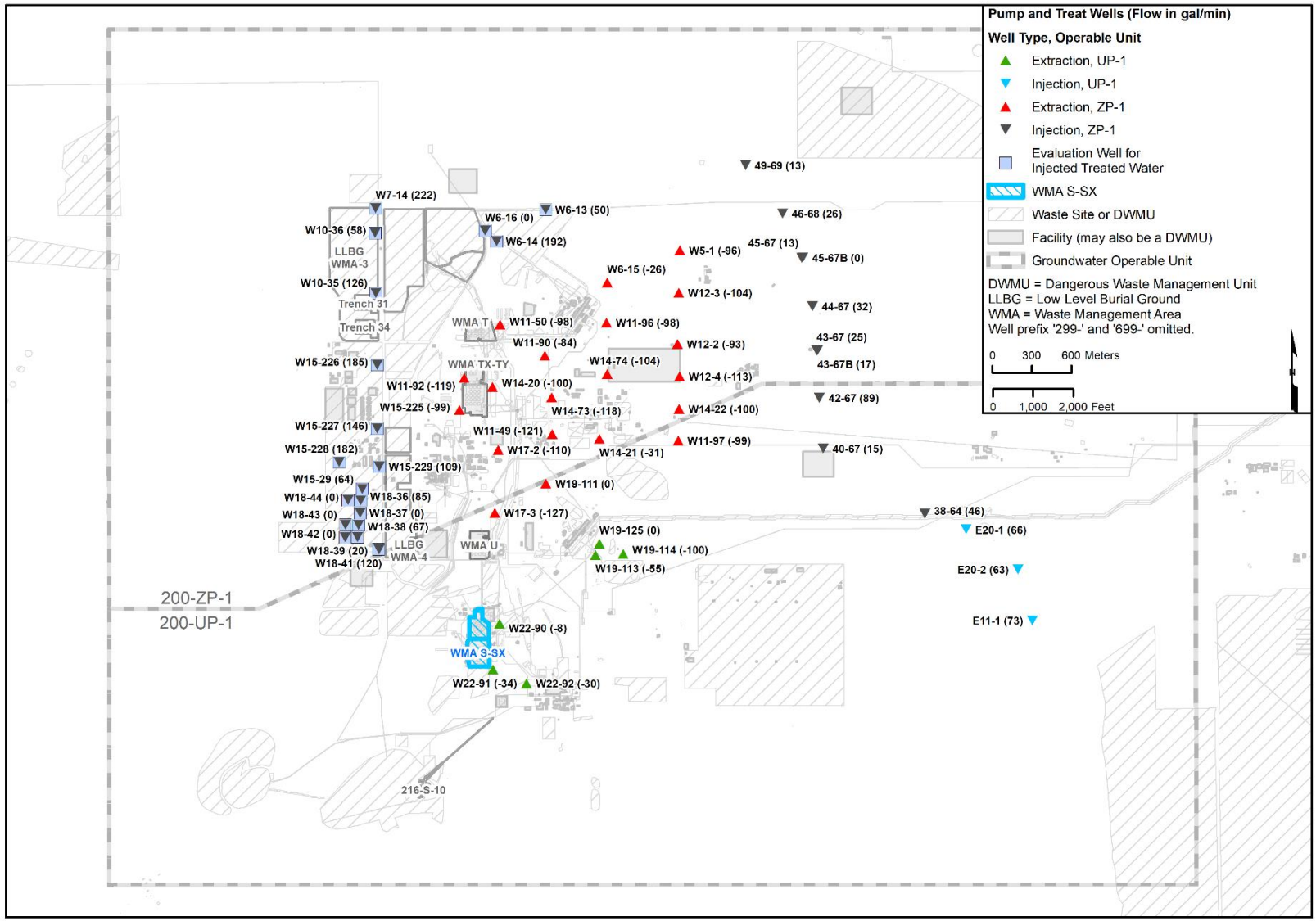


Figure 5-2. Locations and Average Pumping Rates (for December 2016) of 200 West P&T System Wells

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

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

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

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

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 S-SX. The simulations also account for the hydraulic influence of the 200 West P&T system extraction and injection wells. The simulations performed and output produced during the evaluation of the monitoring well network are described briefly in this chapter. Additional details about the modeling, including software used, inputs, and assumptions are described in Appendix F and in Appendix G.

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

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

Particle-tracking and transport modeling calculations and the output produced for WMA S-SX 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 S-SX 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 agrees with the conclusion of Hantush, 1964, “Hydraulics of Wells,” that the flows at locations that are a distance greater than approximately 1.5 to 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/d	Negligible term			

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

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

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

6.2 Particle Tracking

To evaluate the efficacy of the groundwater monitoring network to detect hypothetical increases in concentrations in groundwater due to releases from WMA S-SX, 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 27 SSTs located in WMA S-SX. 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 fiscal year (FY) 2037, which is when the 200-ZP-1 groundwater P&T remedy component is expected to cease operation in accordance with EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*. For scenario 3, which evaluates conditions after cessation of P&T system operations, the initial release to the water table is the end of FY 2037, and 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 S-SX 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 from WMA S-SX to the water table 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 groundwater flow rates and directions all explicitly include the effects of injection. Across scenarios modeled, the relative detectability calculation allows for the placement of wells in the most likely locations to detect a potential release. This calculation of "relative detectability" was performed on a finer spatial resolution than provided by the discretization of the CPGWM simulation grids. This refined calculation subgrid, shown in Figure 6-1, comprises 20 by 20 m (66 by 66 ft) cells, resulting in 25 calculation cells within each CPGWM simulation cell (100 by 100 m [328 by 328 ft], also shown in Figure 6-1). The relative detectability was calculated as follows:

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

The resulting maps of relative detectability for each scenario show the overall distribution for a release from WMA S-SX 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.

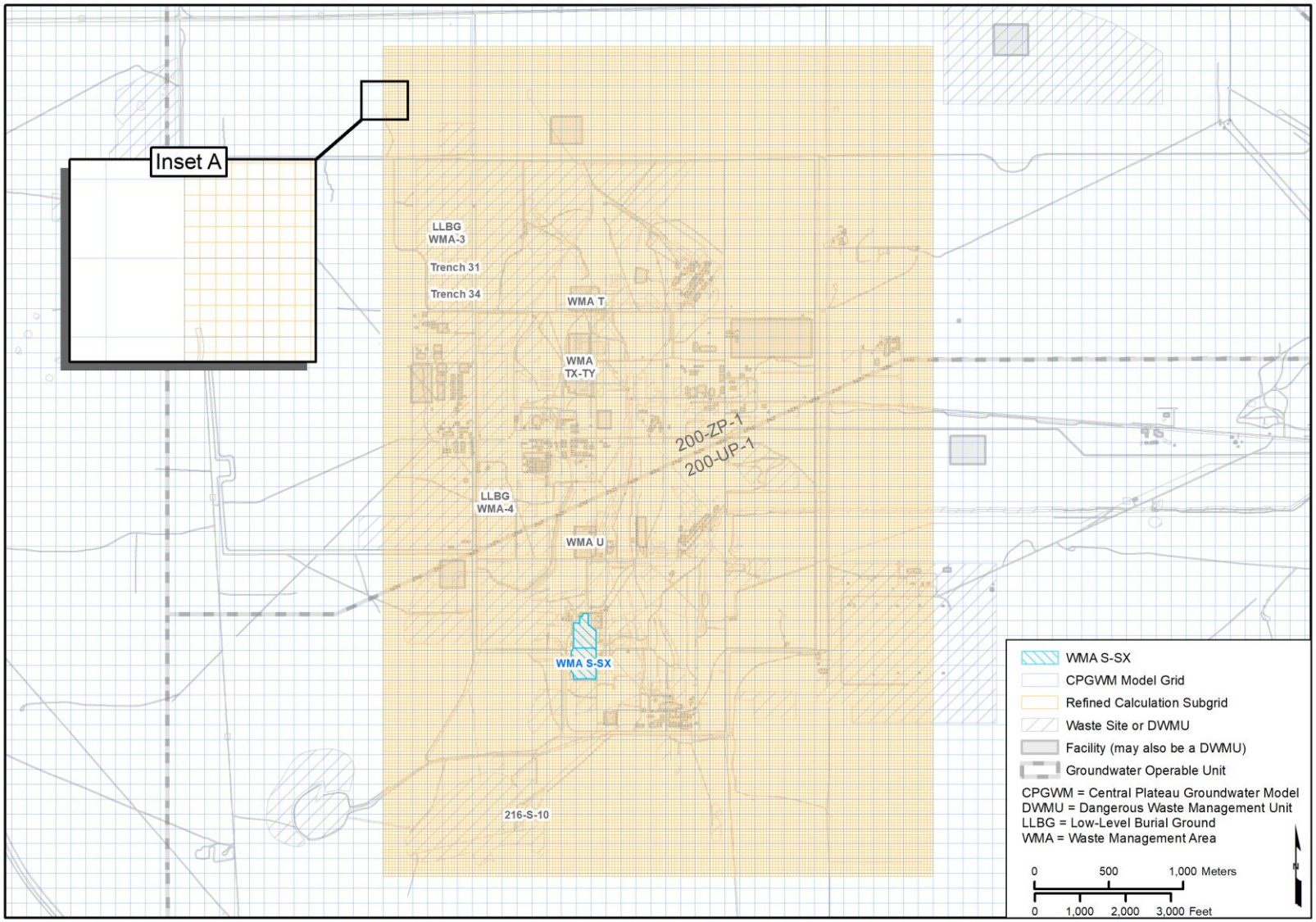


Figure 6-1. Location of Calculation Subgrid in Relation to 200 West Area Facilities Evaluated in Appendix F

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 S-SX 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 S-SX, unit concentrations representing the hypothetical contaminant were released at the water table in four model grid cells representing WMA S-SX (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 S-SX and to detect increases in contamination from known releases from the facility under various 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 7.3) derive from the calculations described in Chapter 6, which 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 each existing downgradient well location, breakthrough curves for injected treated water dilution and release concentrations can be compared to evaluate which well locations will likely have higher dilutions from injected treated water and which will likely 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 the 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 S-SX would most likely migrate and be detectable. The relative detectability maps are discussed in Section 7.2.

Section 7.3 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-W22-47, 299-W22-69, 299-W22-72, 299-W22-80, 299-W22-81, 299-W22-82, 299-W22-83, 299-W22-84, 299-W22-85, 299-W22-86, 299-W22-89, 299-W22-93, 299-W22-94, 299-W22-95, 299-W22-113, 299-W22-115, 299-W22-116, 299-W23-19, 299-W23-20, 299-W23-21, and 299-W23-236 (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 treated water injected 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 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 7-21 show the injected treated water dilution breakthrough curves for monitoring wells 299-W22-47, 299-W22-69, 299-W22-72, 299-W22-80, 299-W22-81, 299-W22-82, 299-W22-83, 299-W22-84, 299-W22-85, 299-W22-86, 299-W22-89, 299-W22-93, 299-W22-94, 299-W22-95, 299-W22-113, 299-W22-115, 299-W22-116, 299-W23-19, 299-W23-20, 299-W23-21, and 299-W23-236, 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 at most of the downgradient monitoring wells indicate that the injected treated water will not reach the wells during the modeled time frame or will just begin to reach the wells at the end of the modeled time. Wells that have any significant injected treated water breakthrough, including wells 299-W23-20, 299-W23-21, 299-W22-84, 299-W22-93, and 299-W22-94, show variability among the various sub-scenarios. The earliest breakthrough of injected treated water is in approximately 2025 at upgradient well 299-W23-20 (Figure 7-19). This result suggests that the variation in injection well operations influences the treated water observed at the WMA S-SX monitoring network wells. The results for downgradient wells are bounded on the high end (higher unit concentrations of injected treated water) with sub-scenario L and on the low end (lower unit concentrations) with sub-scenario R. The results for scenario 2 (included in Appendix G) were similar to those for scenario 1.

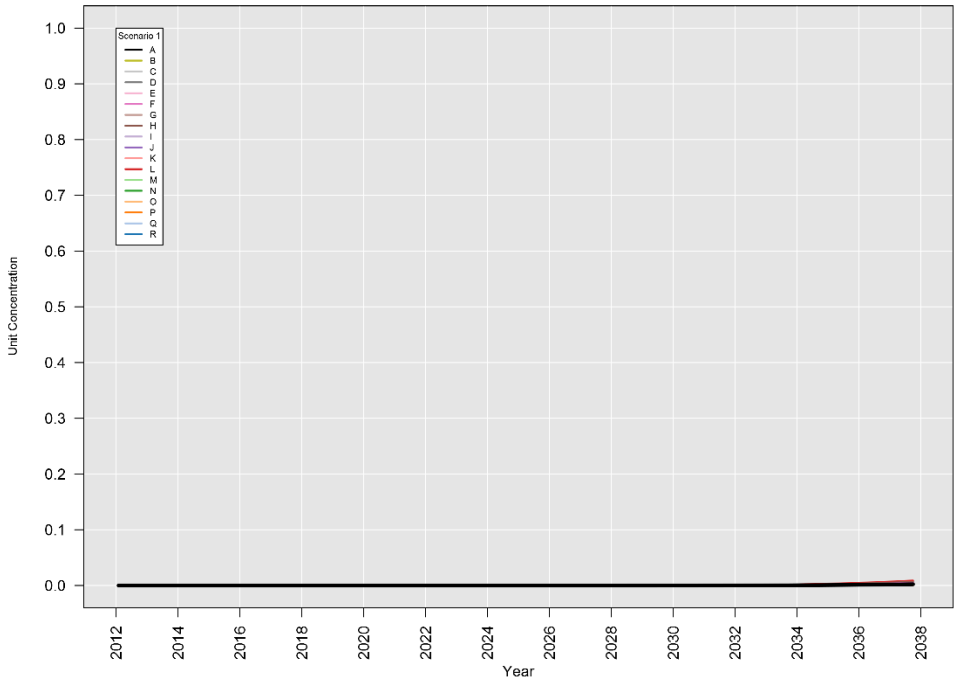


Figure 7-1. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-47

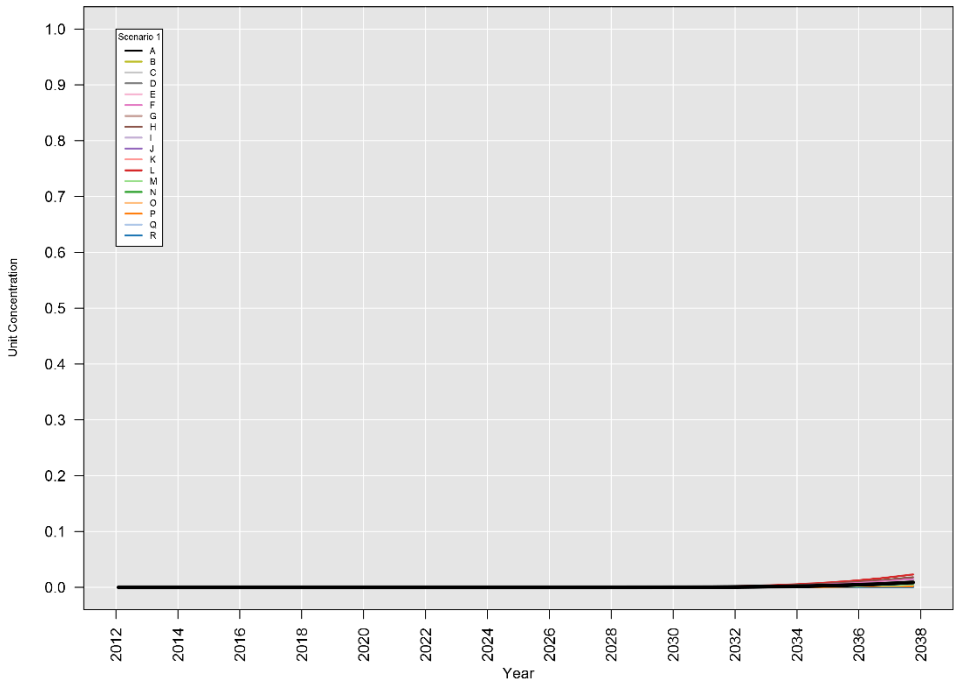


Figure 7-2. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-69

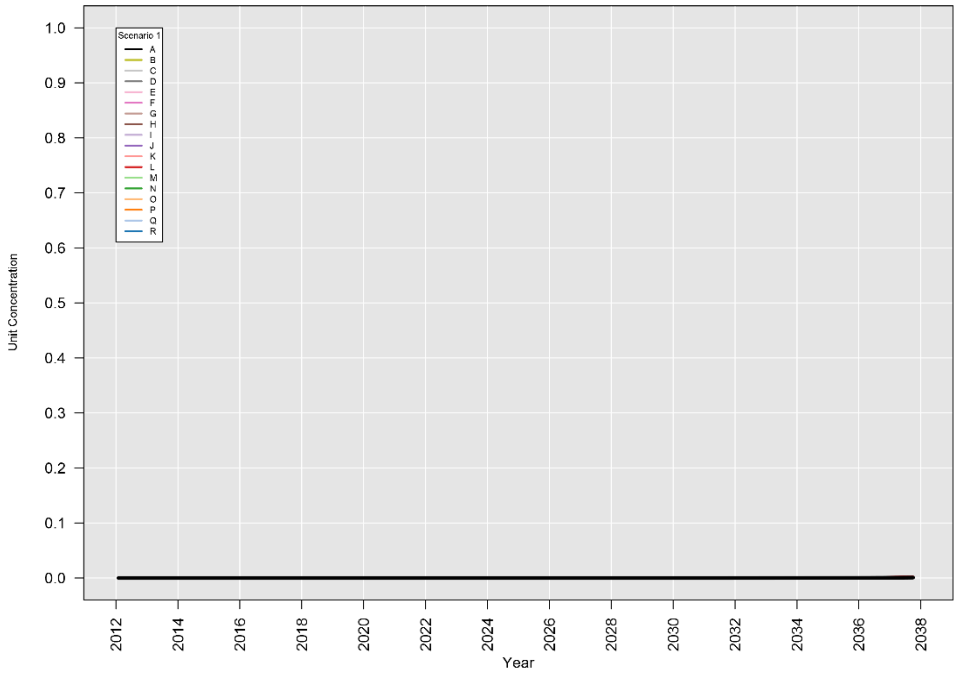


Figure 7-3. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-72

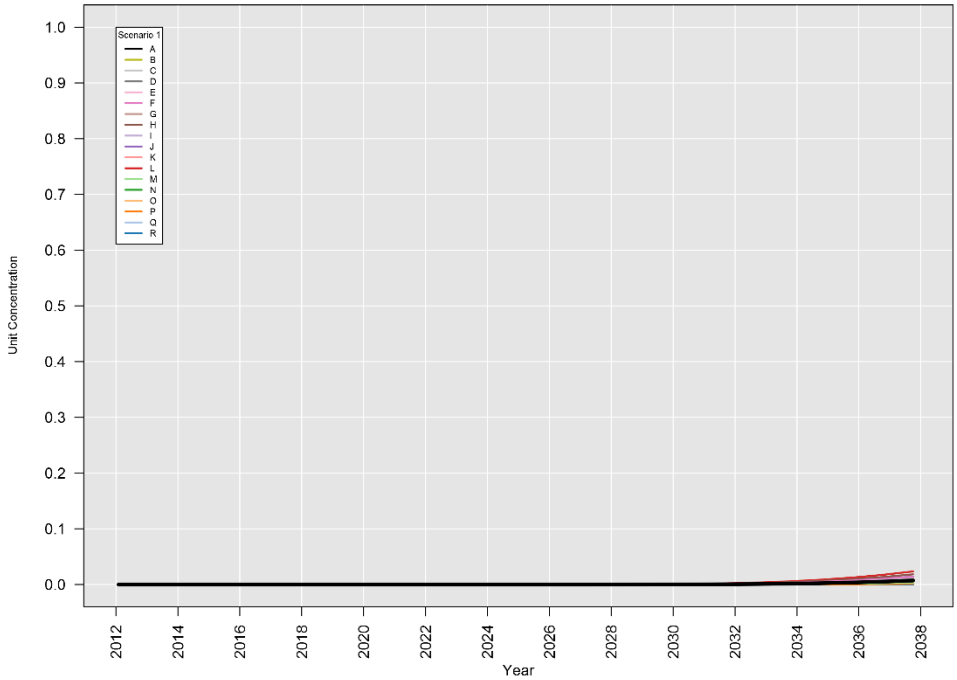


Figure 7-4. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-80

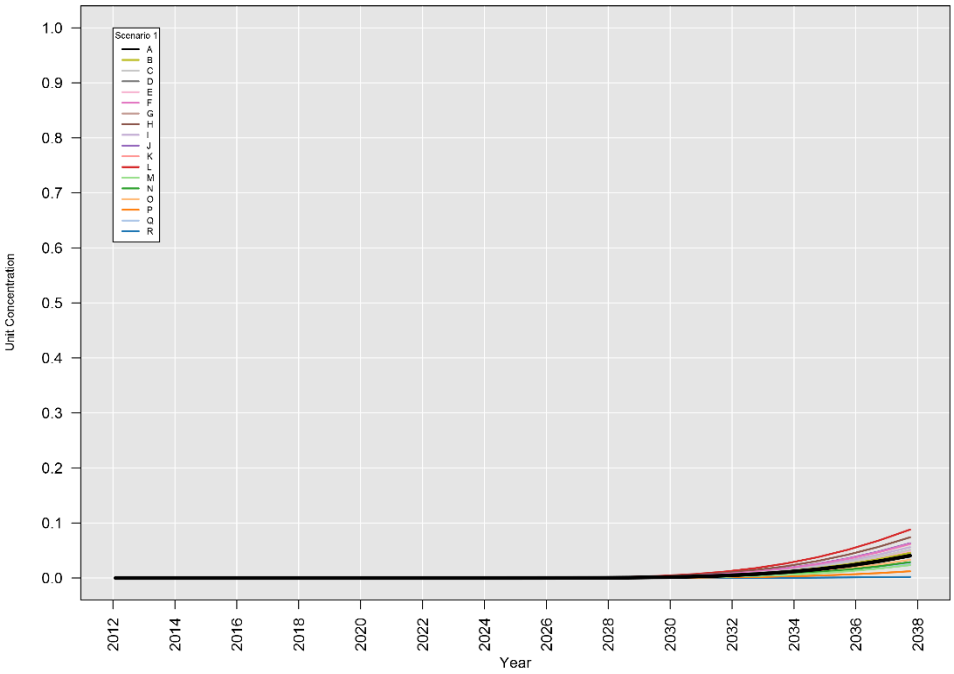


Figure 7-5. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-81

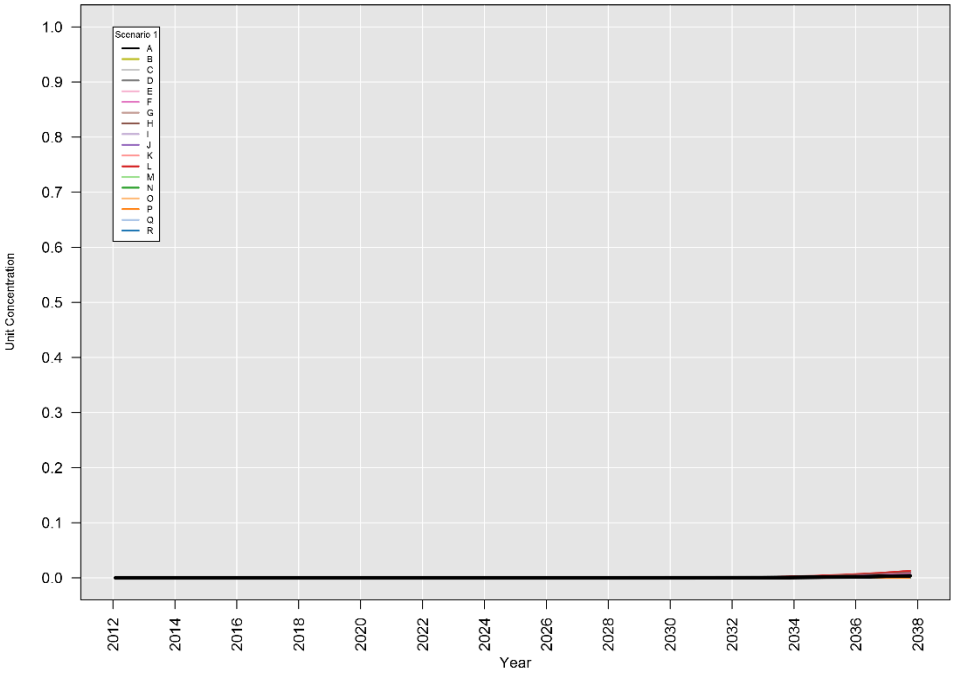


Figure 7-6. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-82

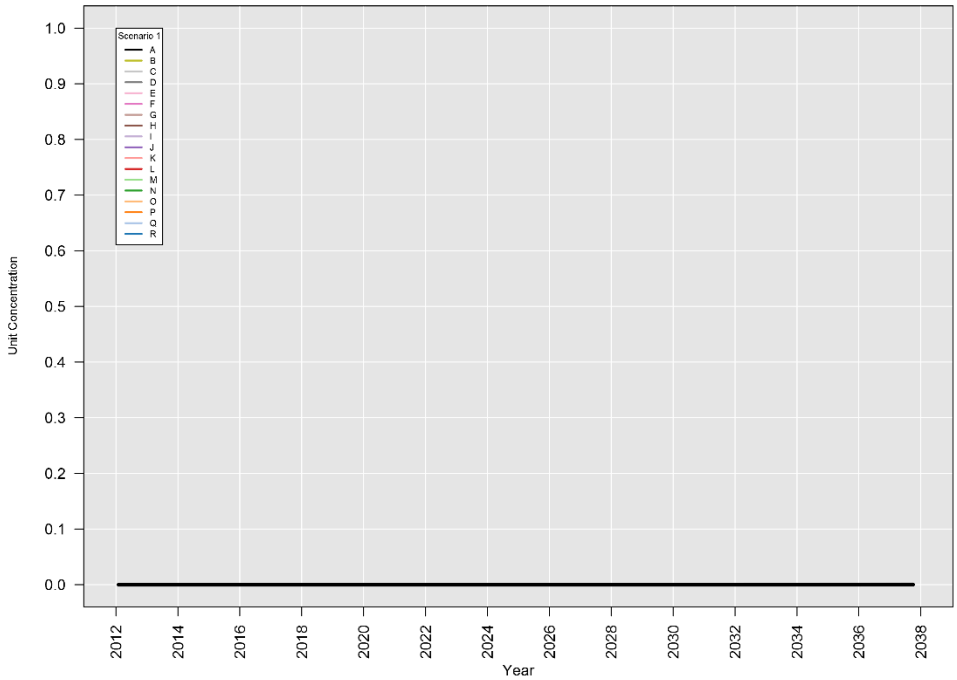


Figure 7-7. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-83

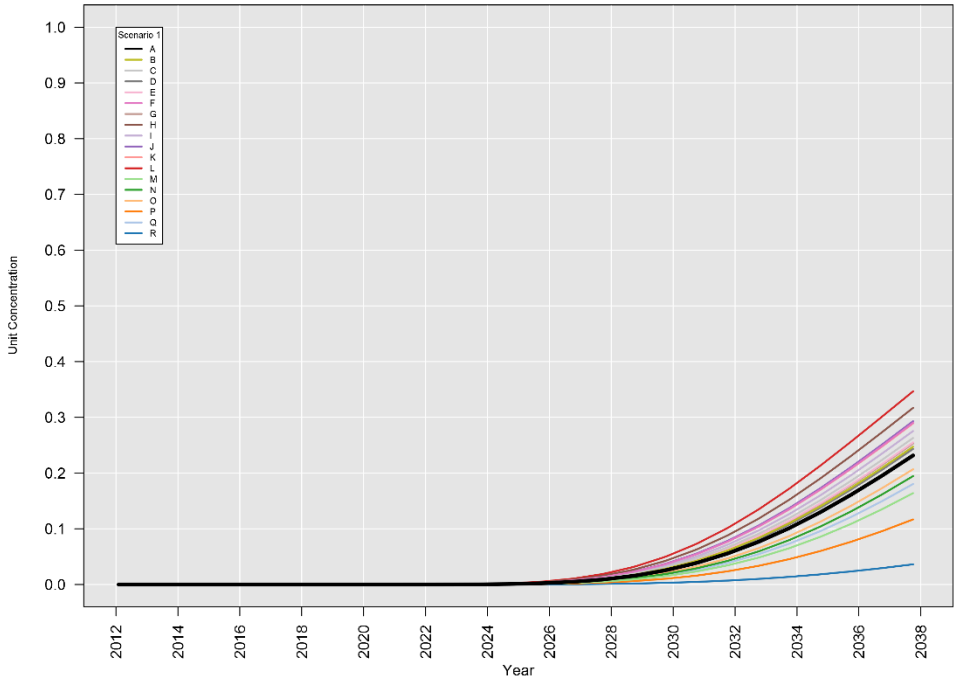


Figure 7-8. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-84

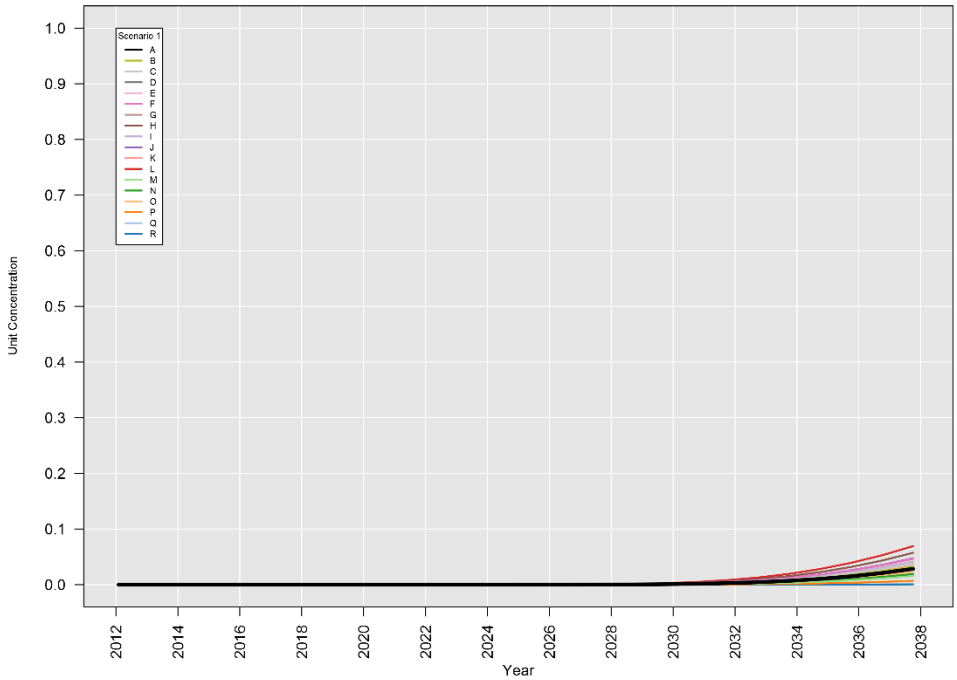


Figure 7-9. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-85

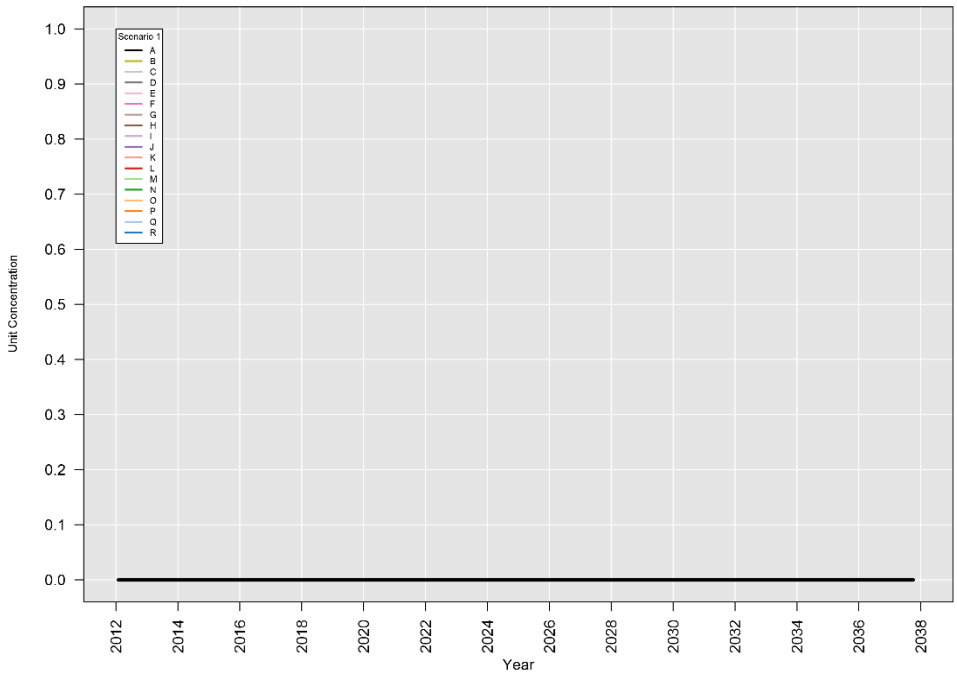


Figure 7-10. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-86

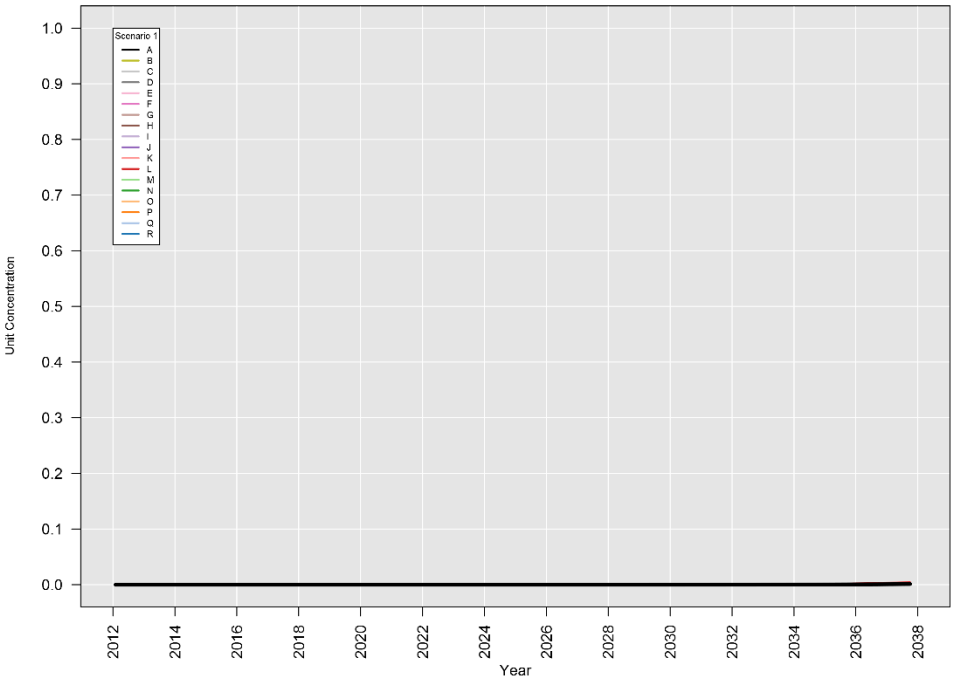


Figure 7-11. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-89

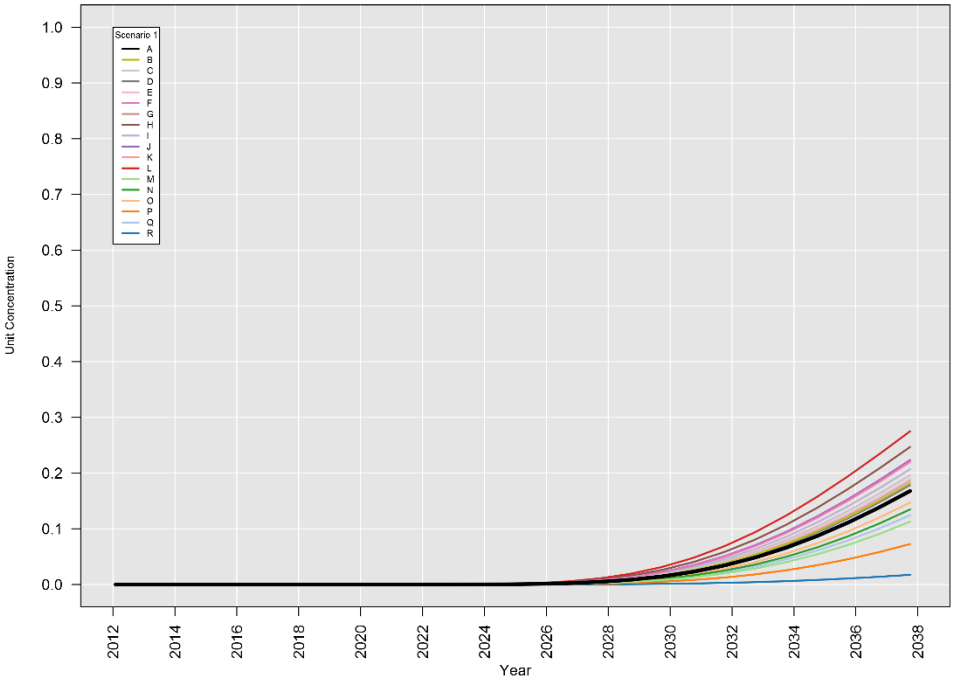


Figure 7-12. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-93

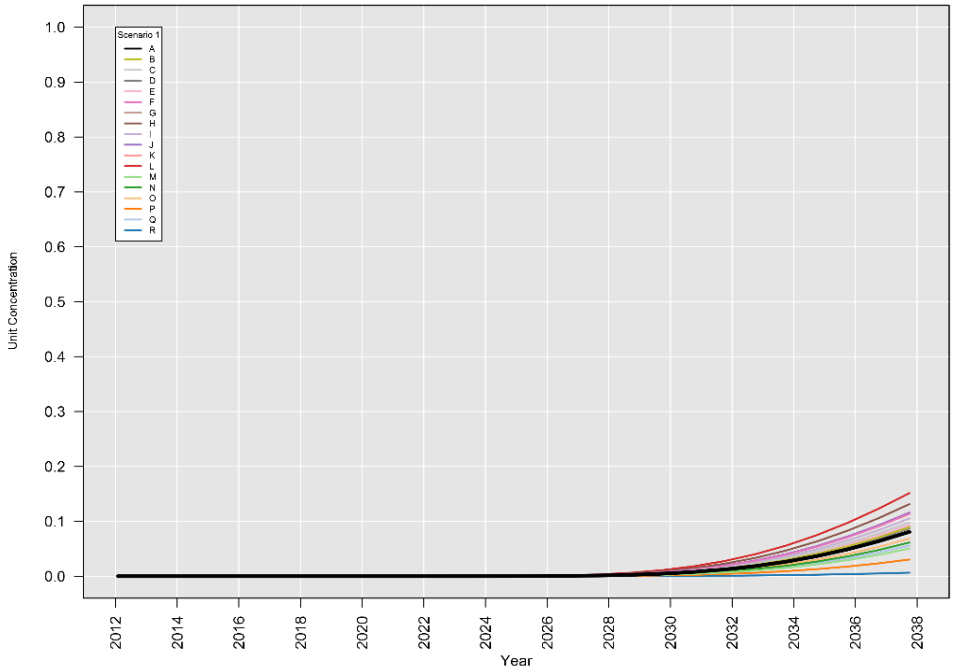


Figure 7-13. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-94

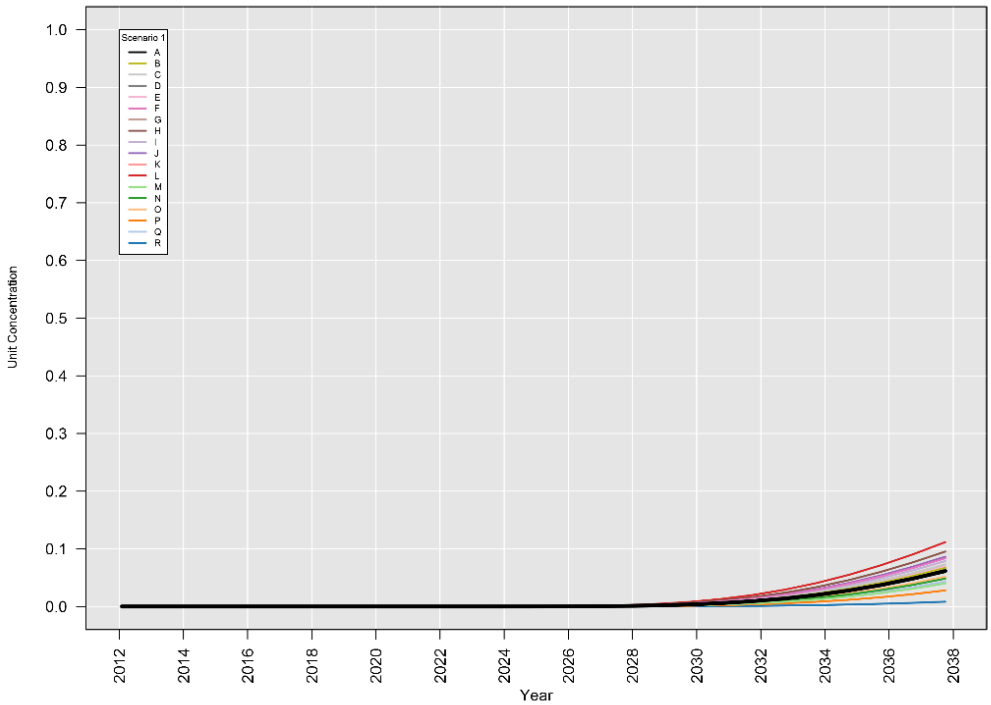


Figure 7-14. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-95

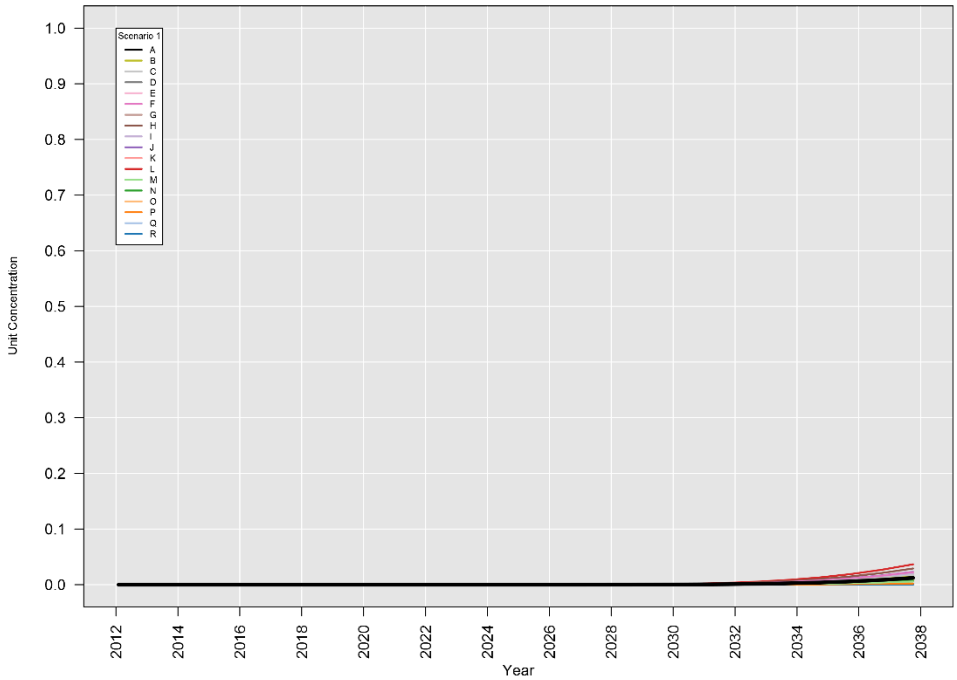


Figure 7-15. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-113

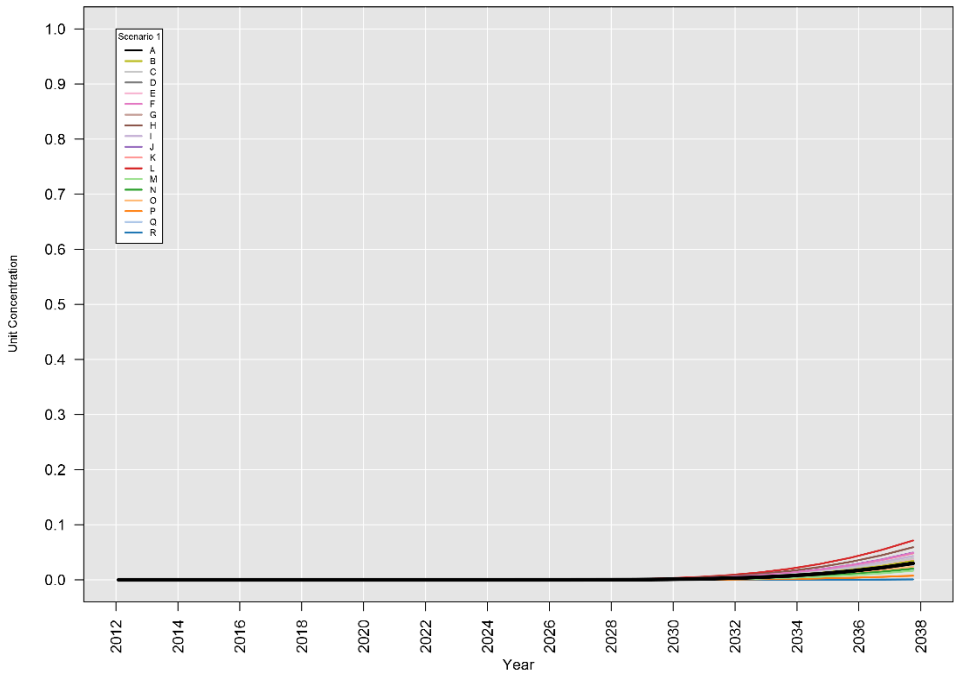


Figure 7-16. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-115

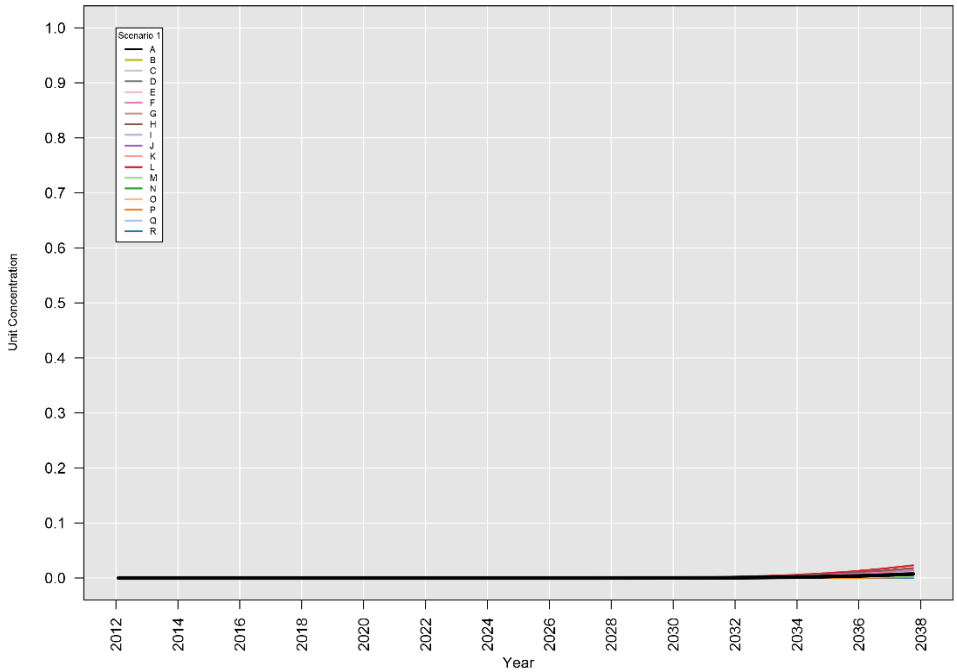


Figure 7-17. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-116

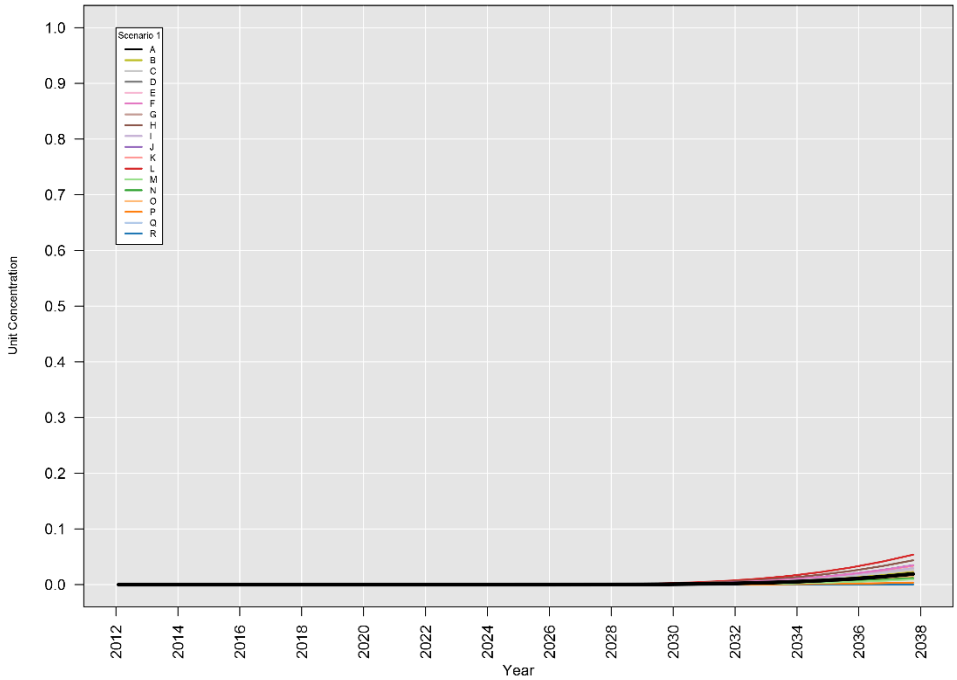


Figure 7-18. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-19

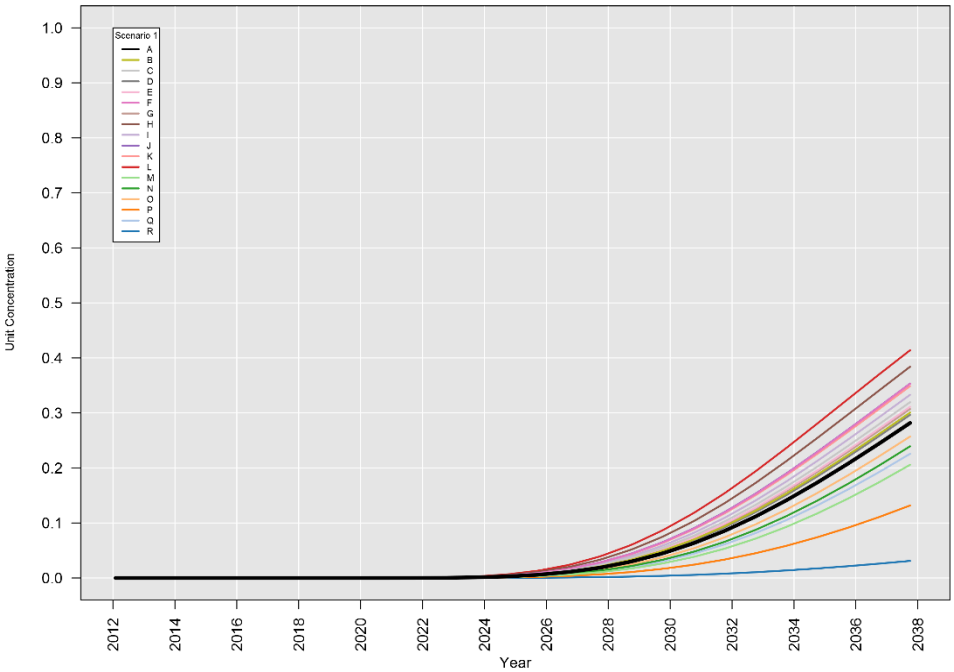


Figure 7-19. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-20

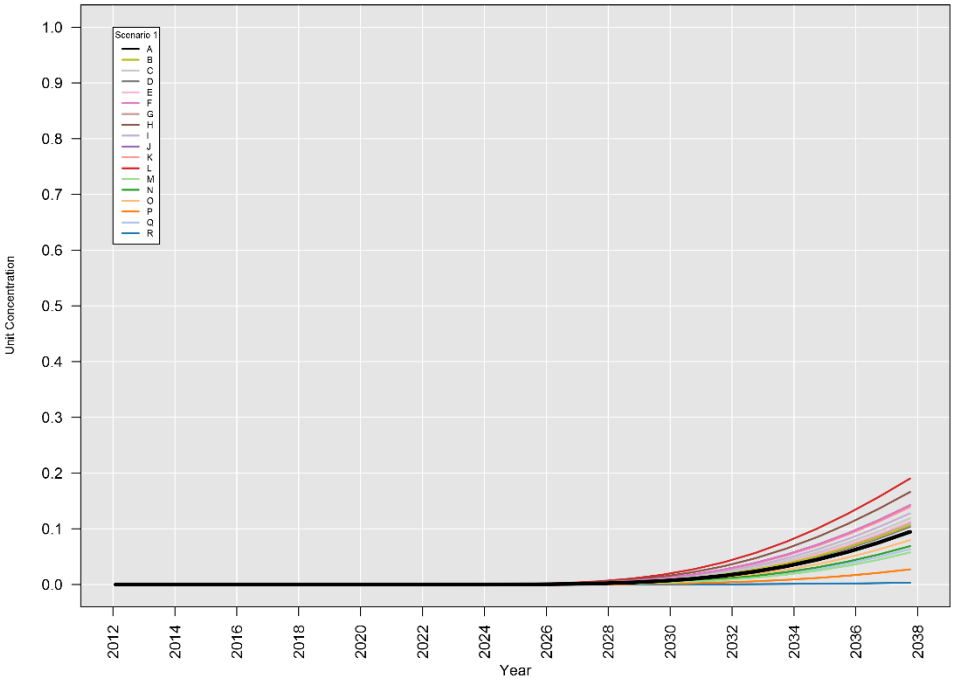


Figure 7-20. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-21

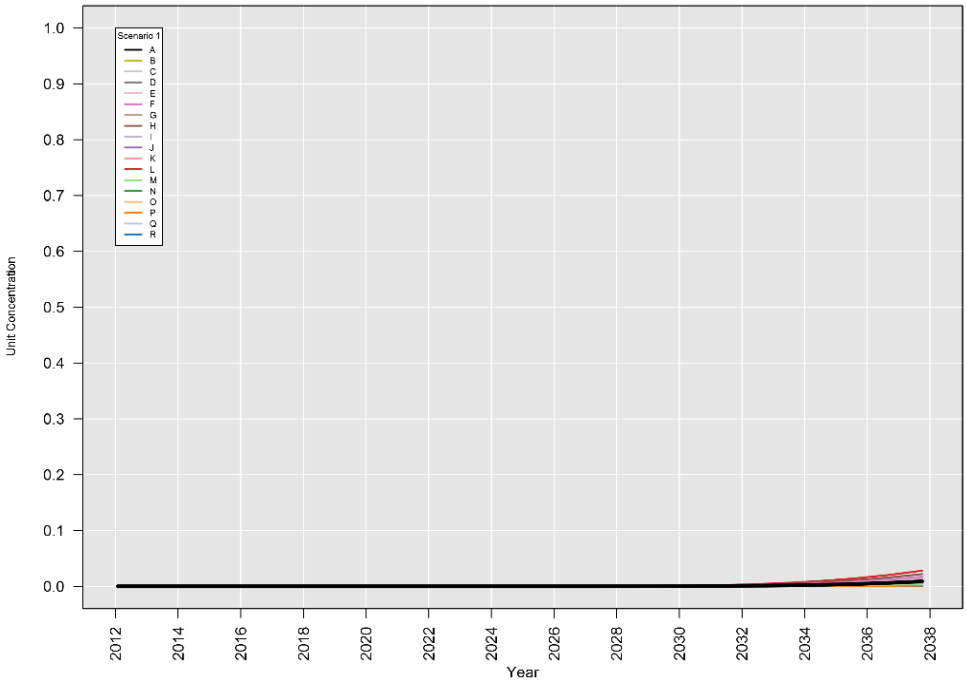


Figure 7-21. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-236

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-W22-113	1	0.000	0.037	0.013
	2	0.000	0.055	0.020
299-W22-115	1	0.001	0.071	0.031
	2	0.001	0.102	0.046
299-W22-116	1	0.000	0.023	0.008
	2	0.000	0.035	0.012
299-W22-69	1	0.000	0.023	0.009
	2	0.000	0.035	0.014
299-W22-72	1	0.000	0.003	0.001
	2	0.000	0.005	0.002
299-W22-80	1	0.000	0.023	0.008
	2	0.000	0.036	0.012
299-W22-81	1	0.002	0.088	0.041
	2	0.002	0.121	0.059

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-W22-82	1	0.000	0.013	0.004
	2	0.000	0.020	0.007
299-W22-83	1	0.000	0.001	0.000
	2	0.000	0.002	0.000
299-W22-84	1	0.036	0.347	0.230
	2	0.036	0.406	0.280
299-W22-85	1	0.001	0.069	0.029
	2	0.001	0.098	0.044
299-W22-86	1	0.000	0.000	0.000
	2	0.000	0.000	0.000
299-W22-89	1	0.000	0.004	0.001
	2	0.000	0.007	0.002
299-W22-93	1	0.017	0.275	0.168
	2	0.017	0.333	0.211
299-W22-94	1	0.006	0.151	0.082
	2	0.006	0.195	0.109
299-W22-95	1	0.008	0.112	0.062
	2	0.008	0.145	0.082
299-W23-15	1	0.000	0.028	0.009
	2	0.000	0.043	0.015
299-W23-19	1	0.000	0.054	0.020
	2	0.000	0.078	0.031
299-W23-20	1	0.031	0.414	0.280
	2	0.031	0.478	0.338
299-W23-21	1	0.003	0.190	0.096
	2	0.003	0.246	0.131
299-W23-236	1	0.000	0.028	0.009
	2	0.000	0.043	0.015

The release concentration breakthrough curves for monitoring wells 299-W22-47, 299-W22-69, 299-W22-72, 299-W22-80, 299-W22-81, 299-W22-82, 299-W22-83, 299-W22-84, 299-W22-85, 299-W22-86, 299-W22-89, 299-W22-93, 299-W22-94, 299-W22-95, 299-W22-113, 299-W22-115, 299-W22-116, 299-W23-19, 299-W23-20, 299-W23-21, and 299-W23-236 for all sub-scenarios of scenario 1 are shown in Figures 7-22 through 7-42, respectively. These figures, which depict the simulated breakthrough of a unit-source release to the groundwater table from WMA S-SX, provide for a relative comparison of the monitoring well locations. The plotted unit concentrations are the ratios of the simulated concentration that would be observed at a downgradient monitoring well location to the original concentration of the release. A unit concentration of 1 represents the original concentration of the release reaching the monitoring well. The breakthrough curves show the relative time of arrival of the release concentration at the monitoring well in terms of years after release to groundwater beneath the facility. The release time (represented on the figures as arrival time year 0) corresponds to October 1, 2017. The unit concentrations and arrival times consider advection and dispersion but do not include chemical-specific, predictive calculations for more complex, constituent-dependent processes such as sorption and degradation (decay) that would decrease the concentration or delay arrival time at the wells.

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

Figures 7-22 through 7-42 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 will vary but is not very sensitive to changes in the 200 West P&T system operating conditions during the modeled time frame. The curves for wells 299-W22-47, 299-W22-83, 299-W22-86, and 299-W22-89, located south and southeast of the other monitoring well locations, indicates significant dilution (less of the original release concentration). Therefore, those well locations are less likely to detect releases for all the operating scenarios relative to other monitoring well locations. Release concentration breakthrough curves for several monitoring wells (299-W2-69, 299-W22-81, 299-W22-85, 299-W22-93, 299-W22-94, 299-W22-113, and 299-W22-115) show medium to high unit concentrations, which indicate the monitoring network wells are located in areas having high potential for detecting releases from WMA S-SX. The results for scenario 2 (included in Appendix G) are similar to those for scenario 1. Table 7-2 shows the range of release concentration breakthrough curves for the monitoring wells for scenarios 1, 2, and 3.

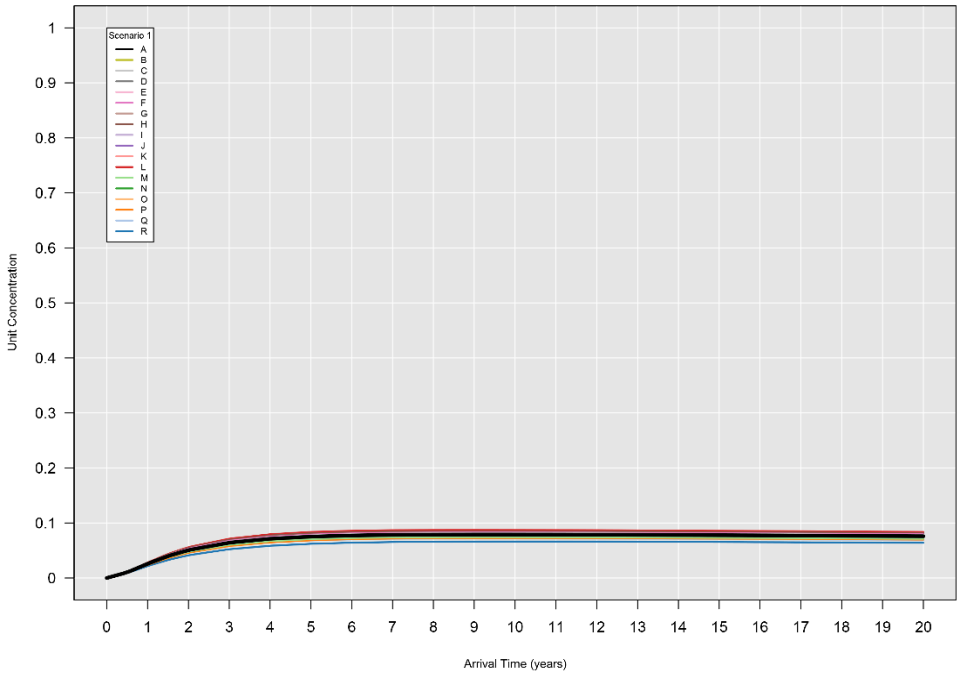


Figure 7-22. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-47

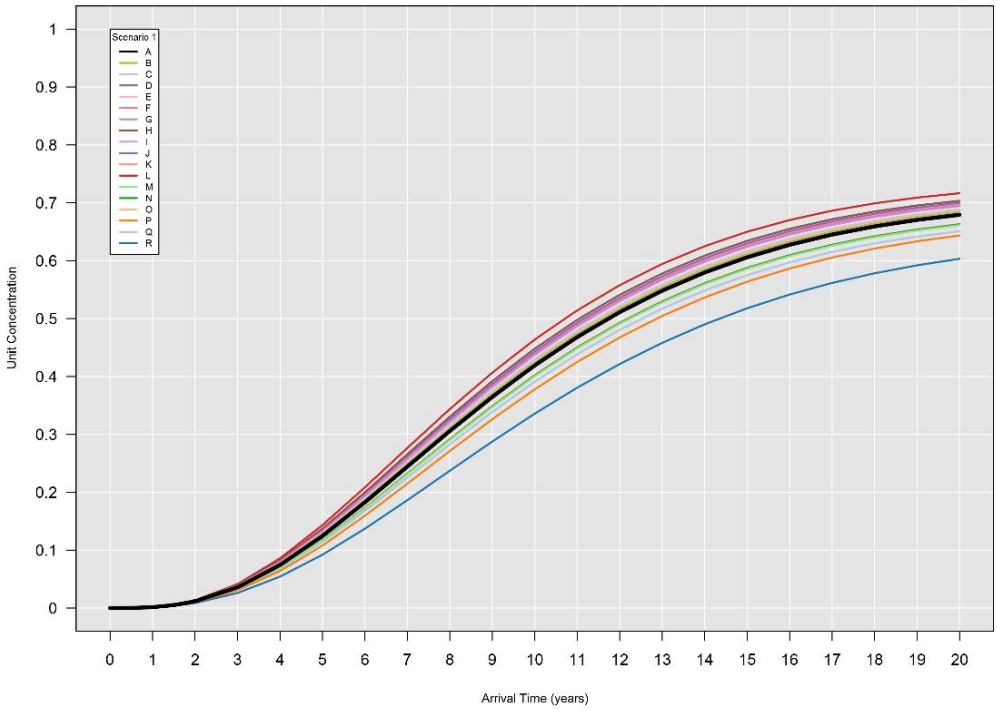


Figure 7-23. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-69

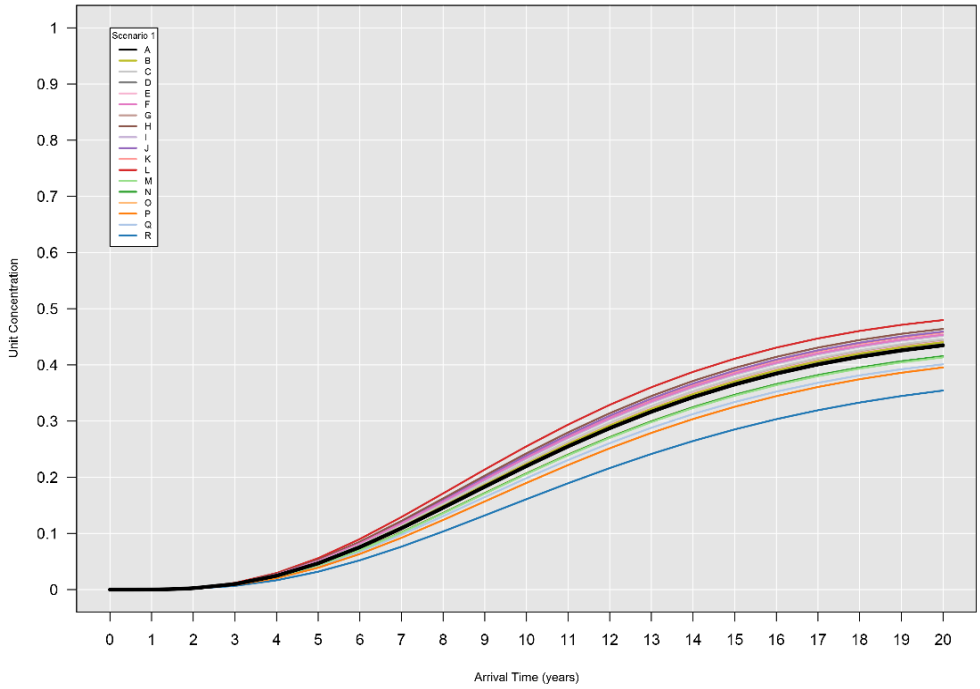


Figure 7-24. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-72

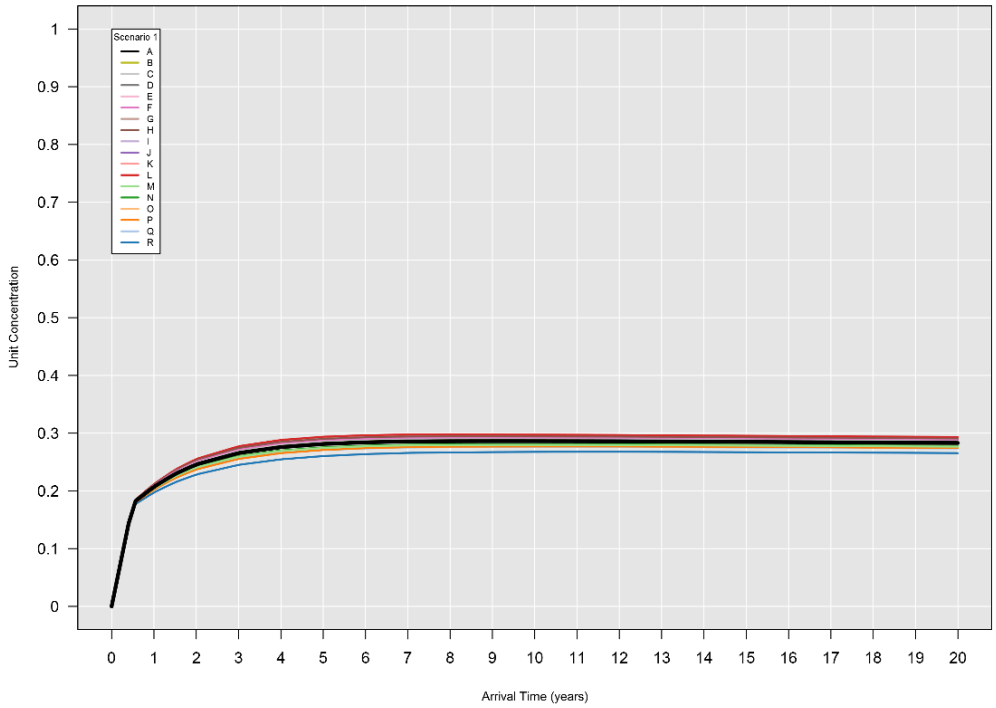


Figure 7-25. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-80

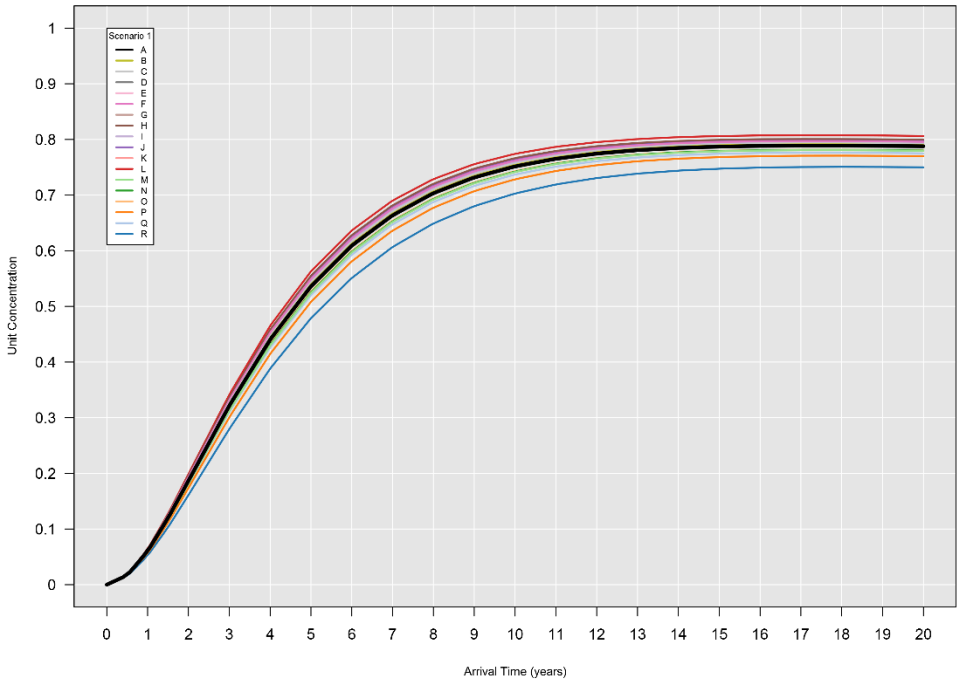


Figure 7-26. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-81

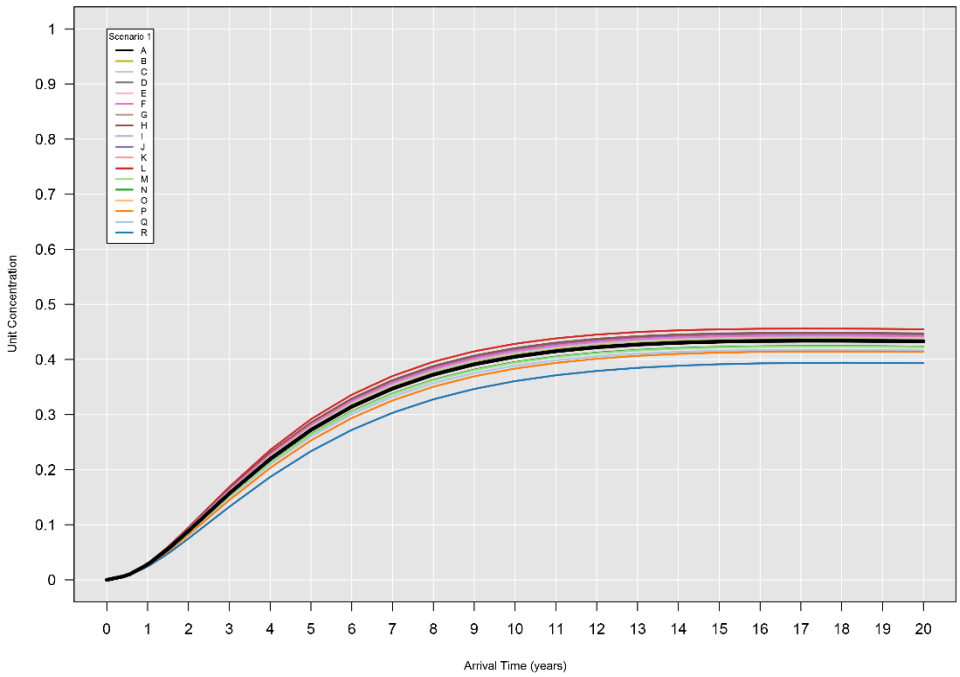


Figure 7-27. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-82

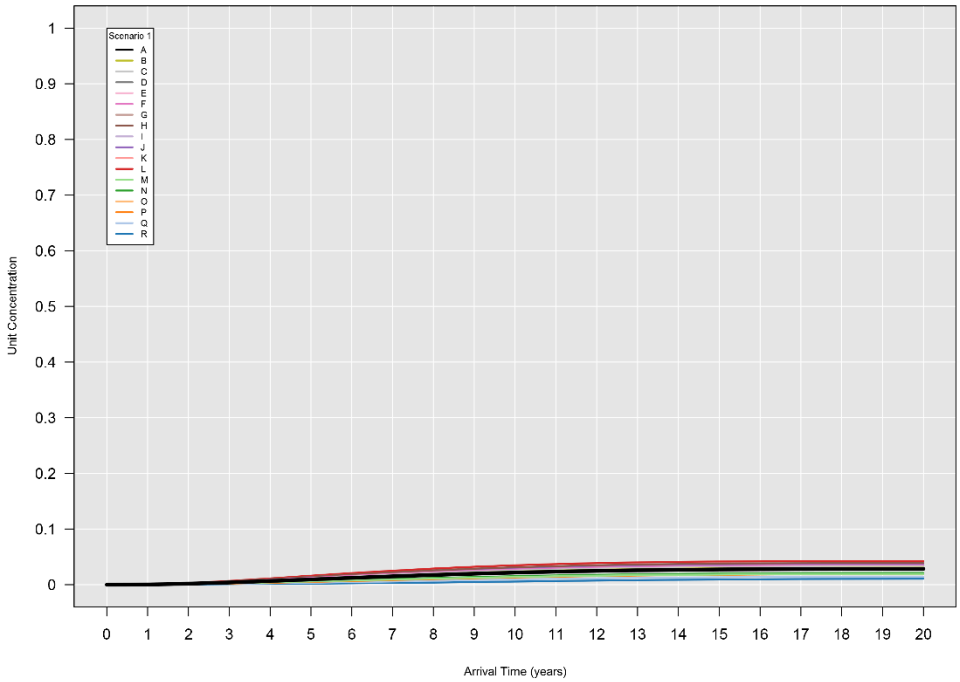


Figure 7-28. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-83

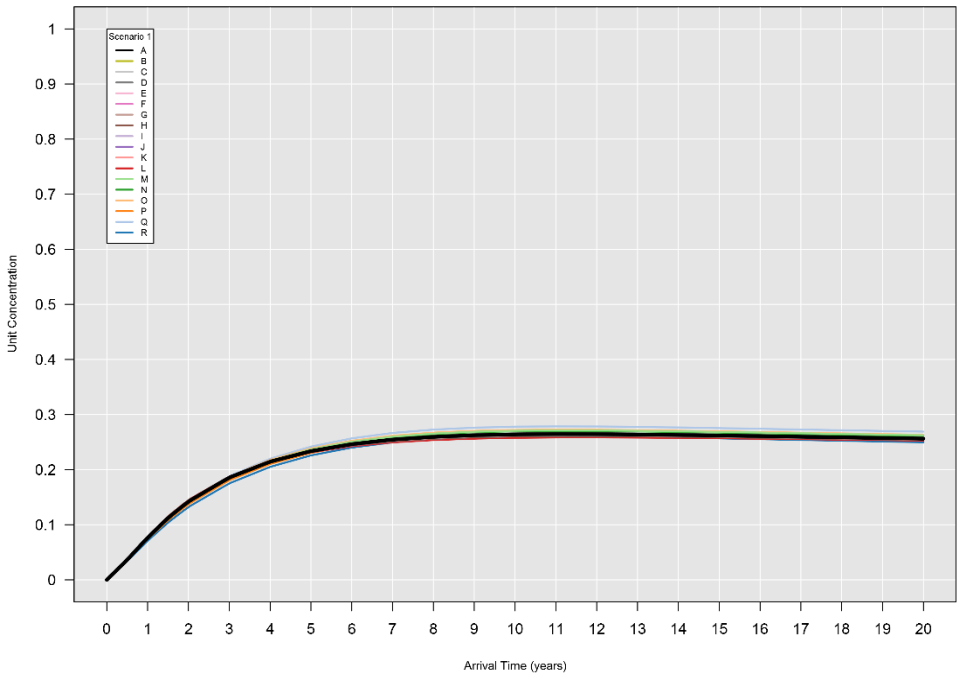


Figure 7-29. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-84

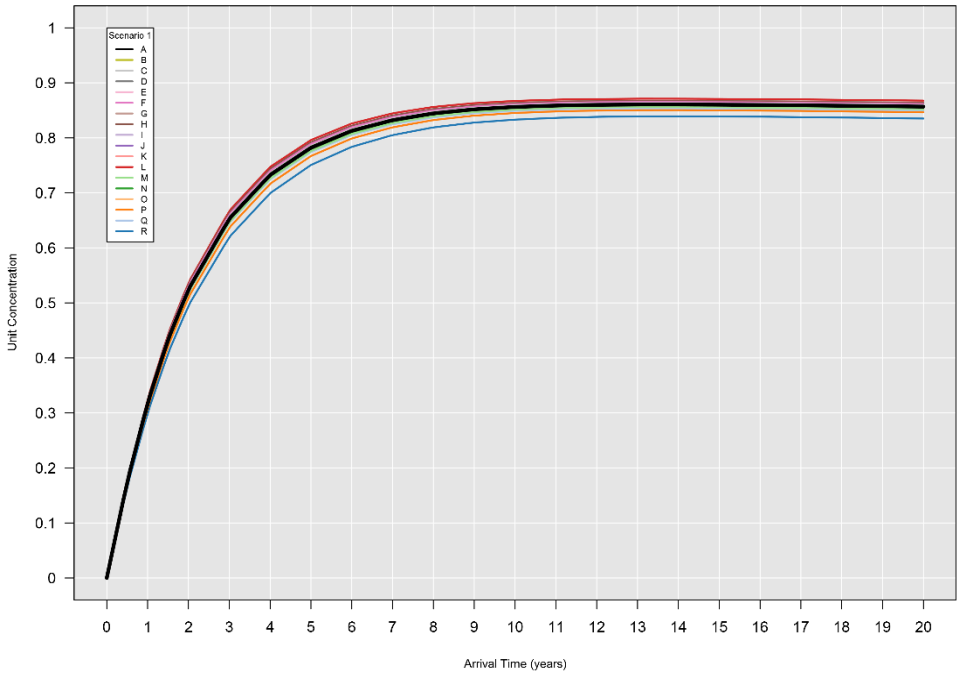


Figure 7-30. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-85

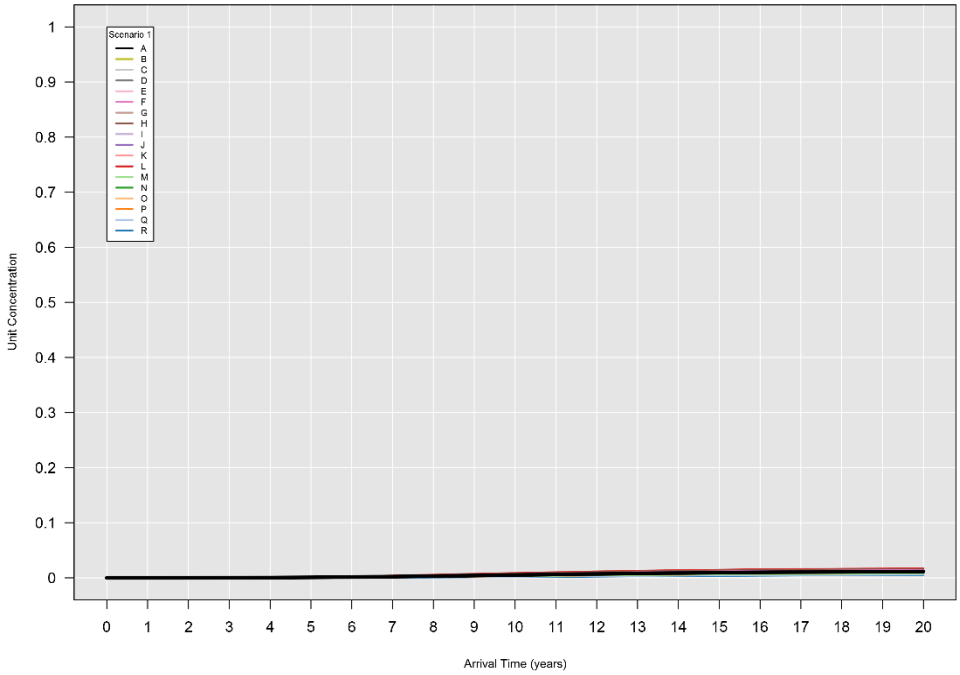


Figure 7-31. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-86

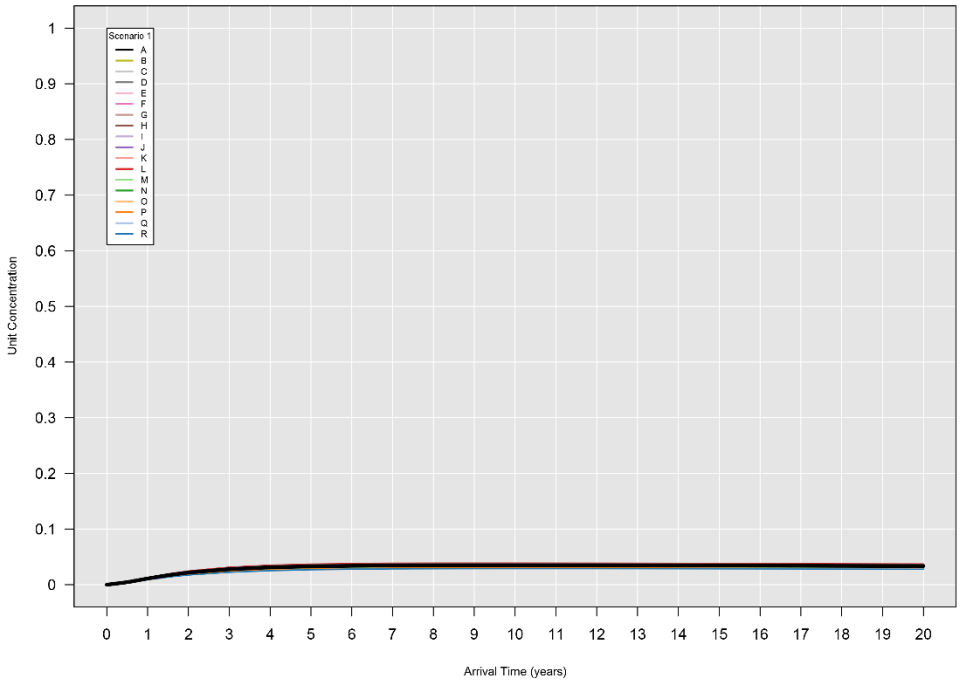


Figure 7-32. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-89

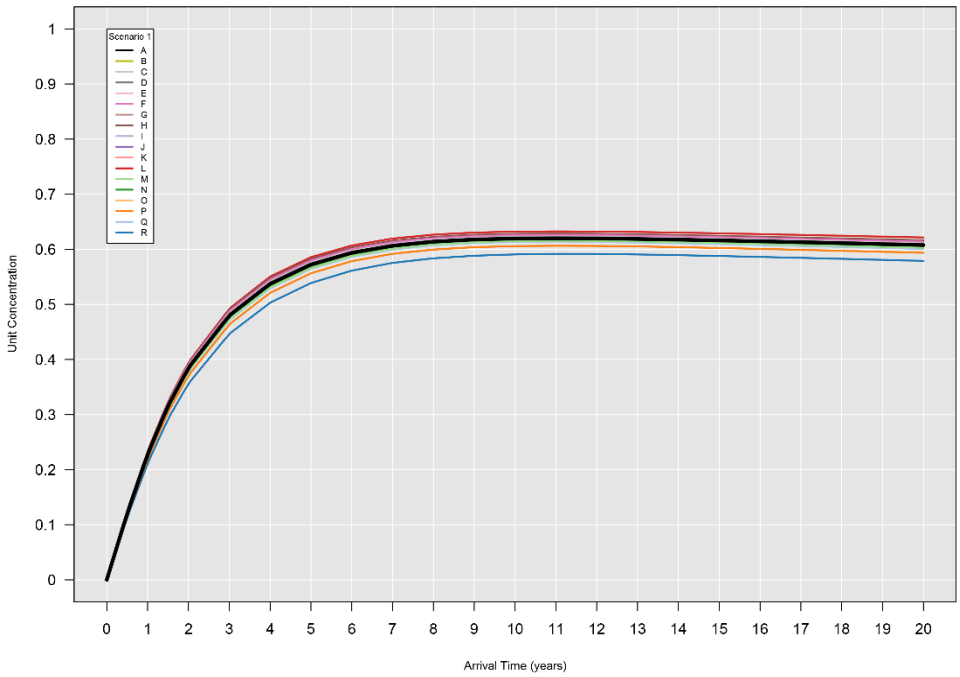


Figure 7-33. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-93

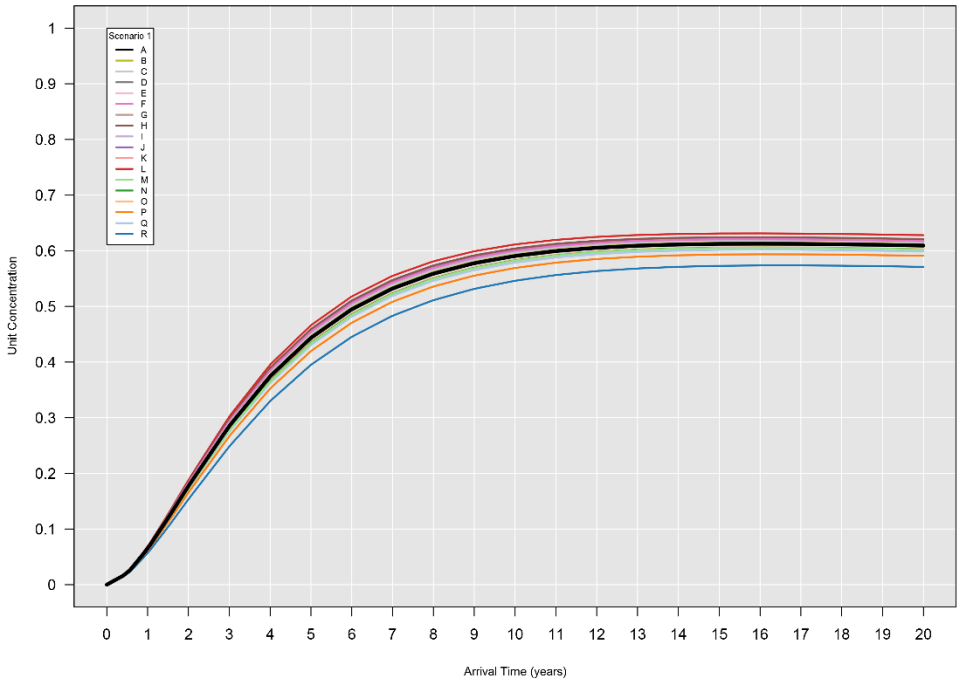


Figure 7-34. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-94

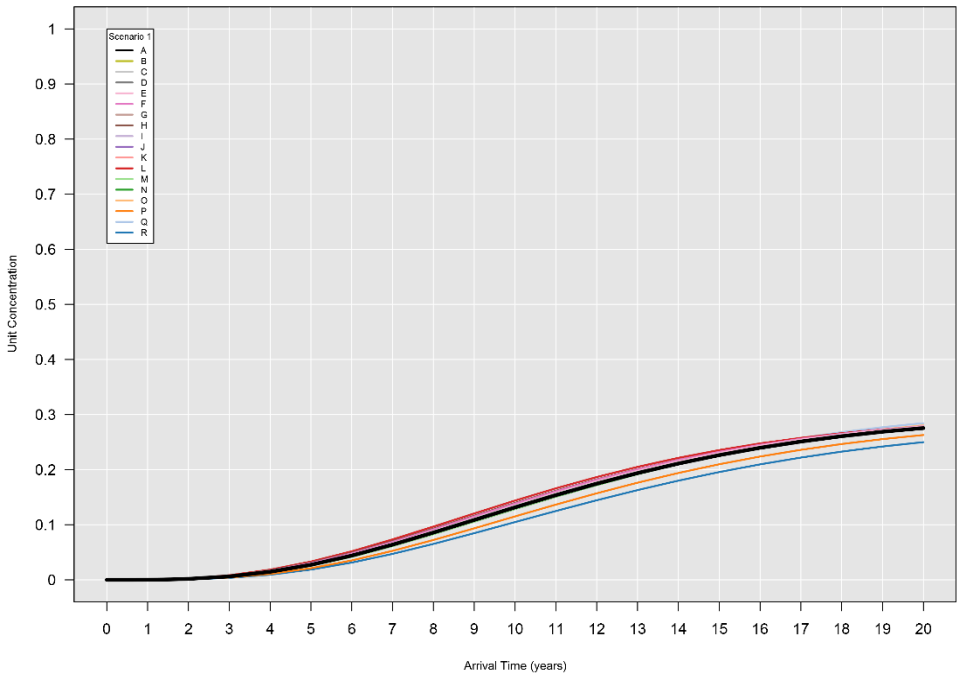


Figure 7-35. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-95

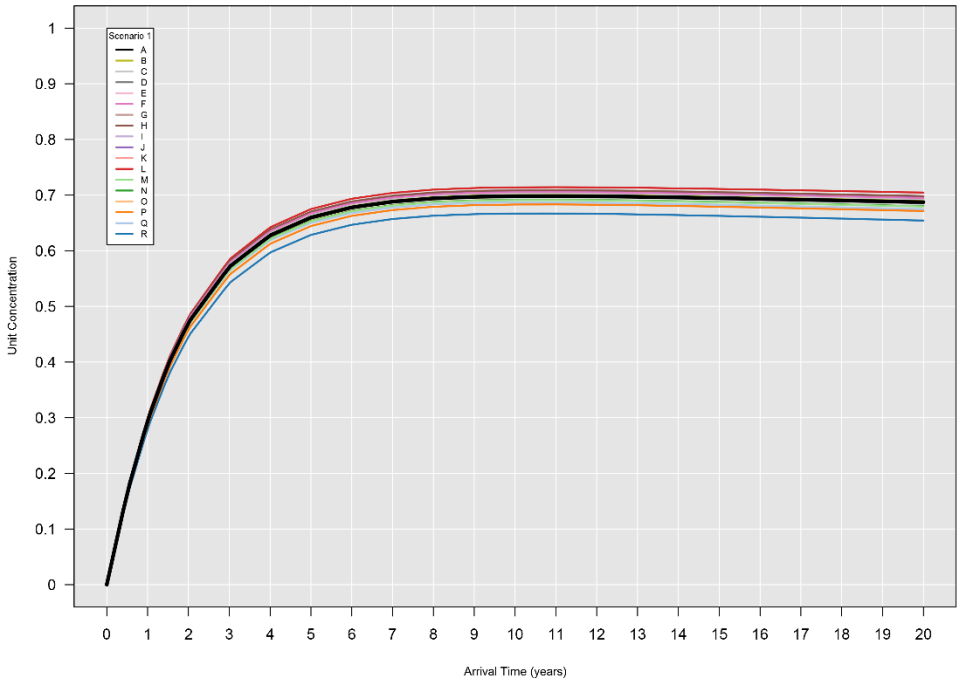


Figure 7-36. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-113

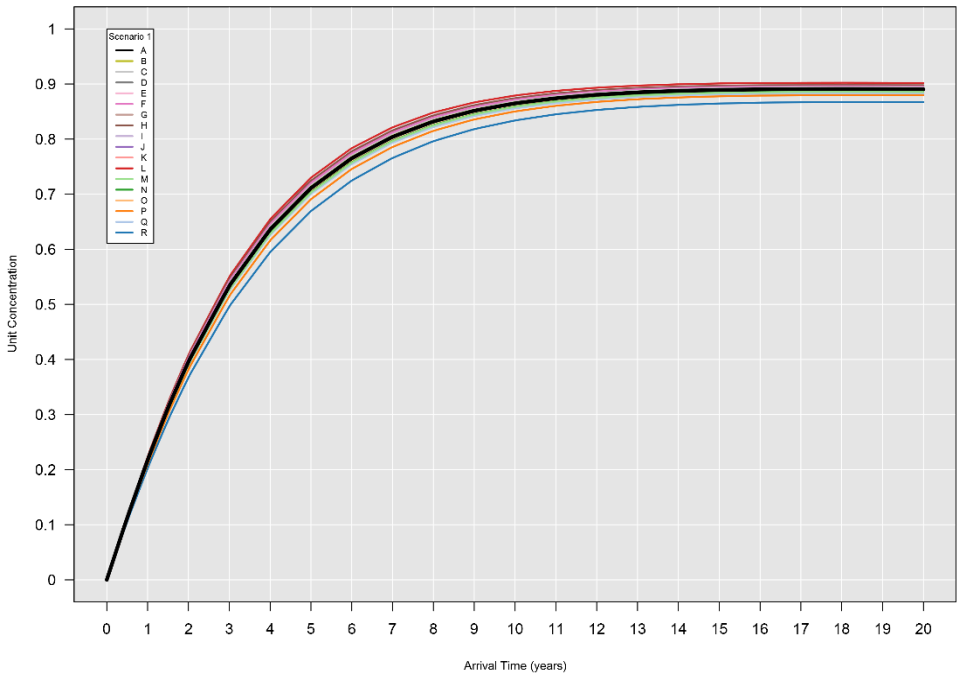


Figure 7-37. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-115

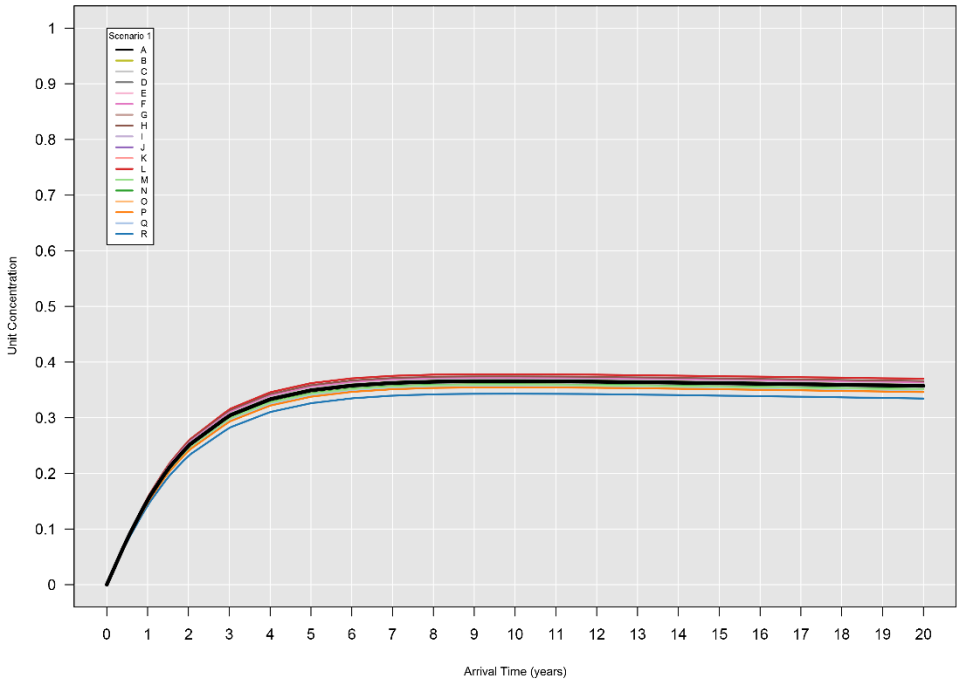


Figure 7-38. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W22-116

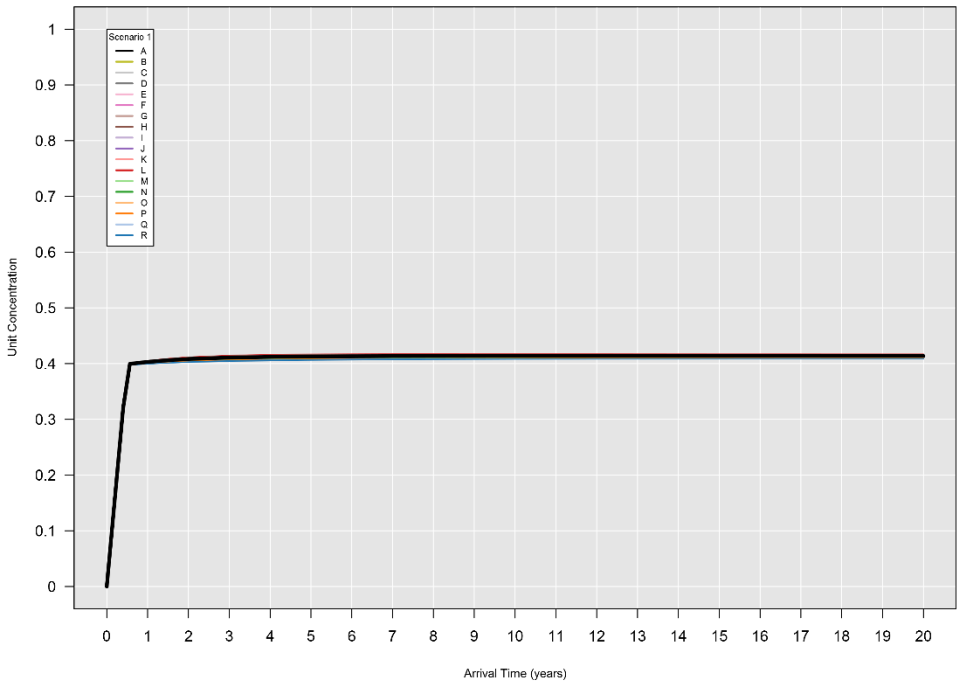


Figure 7-39. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-19

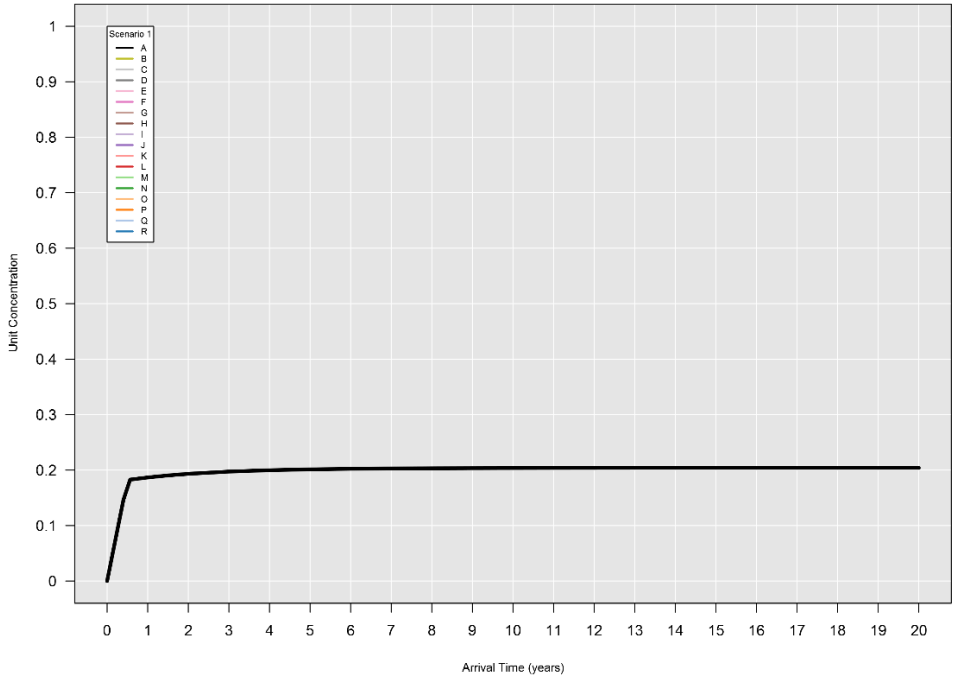


Figure 7-40. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-20

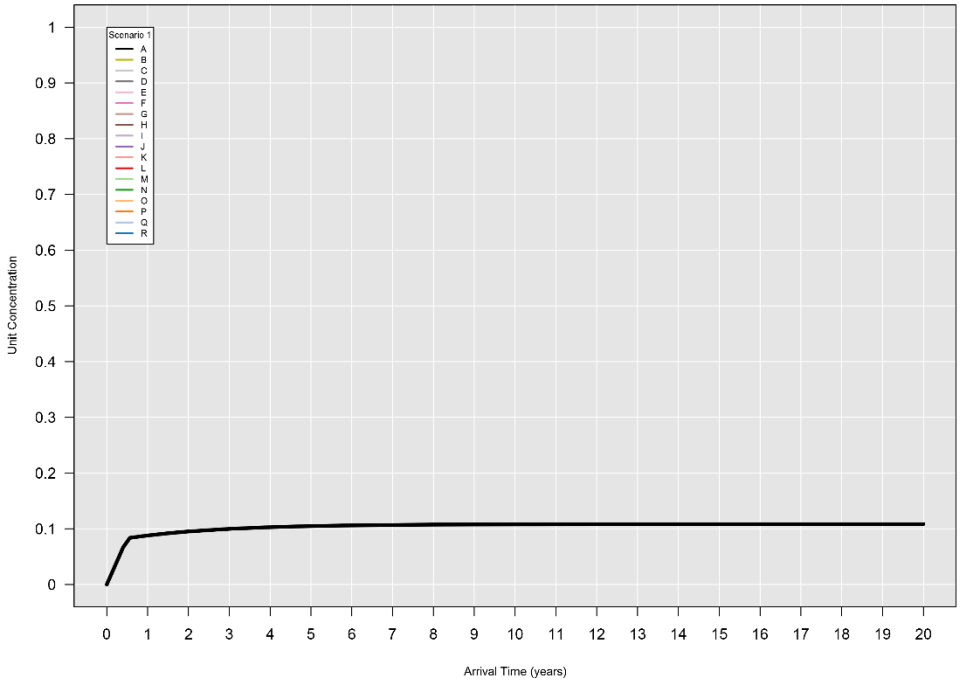


Figure 7-41. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-21

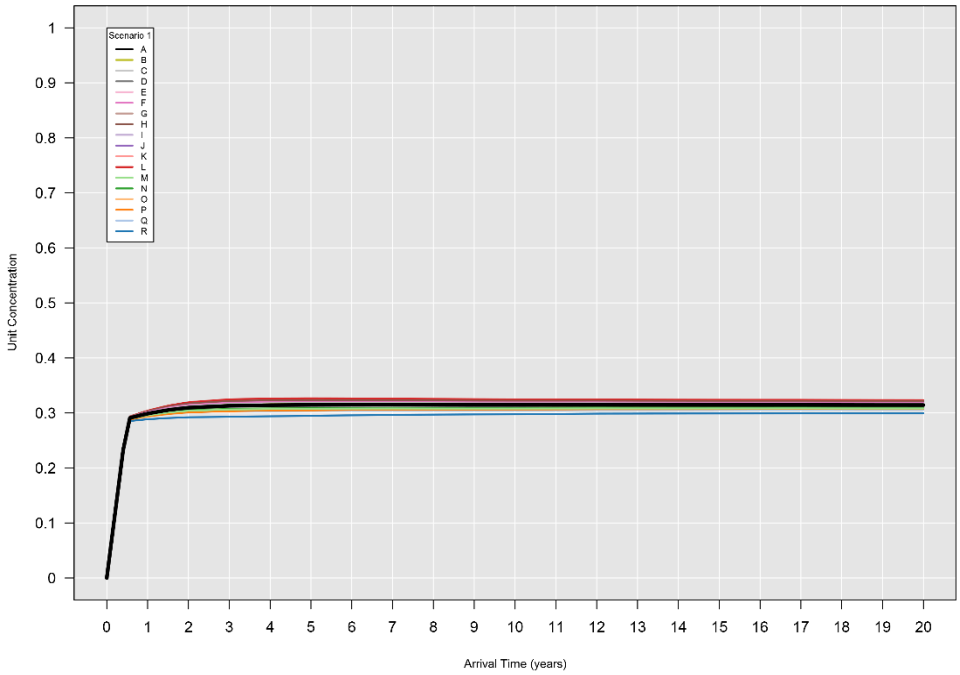


Figure 7-42. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W23-236

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-W22-113	1	0.654	0.705	0.687	0.818
	2	0.654	0.711	0.692	
299-W22-115	1	0.867	0.902	0.890	0.910
	2	0.867	0.907	0.895	
299-W22-116	1	0.335	0.370	0.357	0.361
	2	0.335	0.372	0.358	
299-W22-69	1	0.603	0.717	0.678	0.450
	2	0.603	0.731	0.692	
299-W22-72	1	0.354	0.480	0.434	0.624
	2	0.354	0.491	0.444	
299-W22-80	1	0.266	0.293	0.283	0.251
	2	0.266	0.293	0.281	
299-W22-81	1	0.750	0.806	0.787	0.883
	2	0.750	0.816	0.796	
299-W22-82	1	0.393	0.455	0.432	0.533
	2	0.393	0.460	0.436	
299-W22-83	1	0.011	0.042	0.028	0.015

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
	2	0.006	0.035	0.020	
299-W22-84	1	0.250	0.269	0.257	0.538
	2	0.250	0.283	0.271	
299-W22-85	1	0.835	0.868	0.857	0.915
	2	0.835	0.873	0.861	
299-W22-86	1	0.005	0.017	0.011	0.009
	2	0.003	0.013	0.007	
299-W22-89	1	0.028	0.037	0.033	0.004
	2	0.028	0.036	0.033	
299-W22-93	1	0.579	0.622	0.607	0.907
	2	0.579	0.632	0.617	
299-W22-94	1	0.571	0.628	0.609	0.478
	2	0.571	0.641	0.621	
299-W22-95	1	0.250	0.284	0.275	0.502
	2	0.250	0.312	0.303	
299-W23-15	1	0.277	0.300	0.292	0.129
	2	0.277	0.298	0.289	
299-W23-19	1	0.409	0.416	0.414	0.196
	2	0.409	0.416	0.413	
299-W23-20	1	0.204	0.204	0.204	0.104
	2	0.204	0.204	0.204	
299-W23-21	1	0.108	0.108	0.108	0.108
	2	0.108	0.108	0.108	
299-W23-236	1	0.299	0.323	0.314	0.141
	2	0.299	0.321	0.311	

The release concentration breakthrough curves for scenario 3 (Figure 7-43) indicate that wells 299-W22-81, 299-W22-85,299-W22-93, and 299-W22-115 will show minimal dilution (unit concentrations near 0.9). The unit concentrations for wells 299-W22-47, 299-W22-83, 299-W22-86, and 299-W22-89 are at or near zero for scenario 3. The release time for scenario 3 (represented on the figure as arrival time year 0) corresponds to October 1, 2037.

Figures 7-44 through 7-46 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 7-44 and 7-45 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.

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 S-SX, upgradient wells 299-W23-20 and 299-W23-21 are shown on the edge of where the release unit concentration is greater than zero (Figures 7-44 through 7-46). The outer fringe of the release unit plume is a result of the size of the grid cells representing the facility and the spatial interpolation between the nodes of the grid cell representing the facility (in which the unit concentration of 1 was released) and the upgradient grid cells containing the upgradient wells, which have simulated unit concentrations near zero. The particle-tracking results, which are discussed in Section 7.2, indicate that those wells remain upgradient of potential releases in the scenarios evaluated.

Figures 7-44 through 7-46 show that downgradient wells 299-W23-19, 299-W22-72, 299-W22-80, 299-W22-82, 299-W22-84, 299-W22-95, 299-W22-116, and 299-W23-236 are generally within the unit plume but in areas of low unit concentrations, whereas downgradient wells 299-W22-47, 299-W22-83, 299-W22-86, and 299-W22-89 are located outside of the release unit plume. These conclusions are consistent with the conclusions based on the breakthrough curves.

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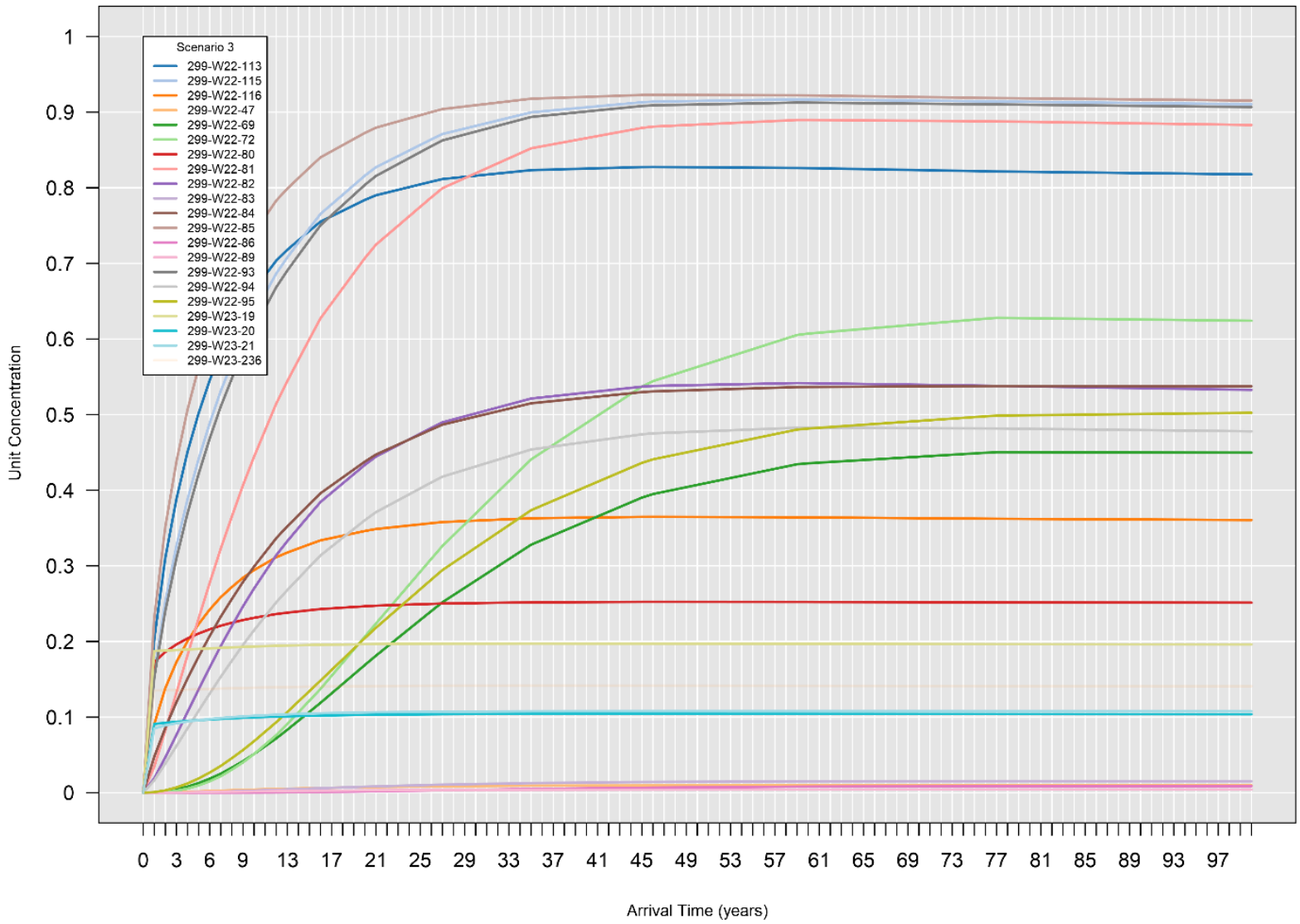

Figure 7-43. Release Concentration Breakthrough Curves at Monitoring Wells, Scenario 3

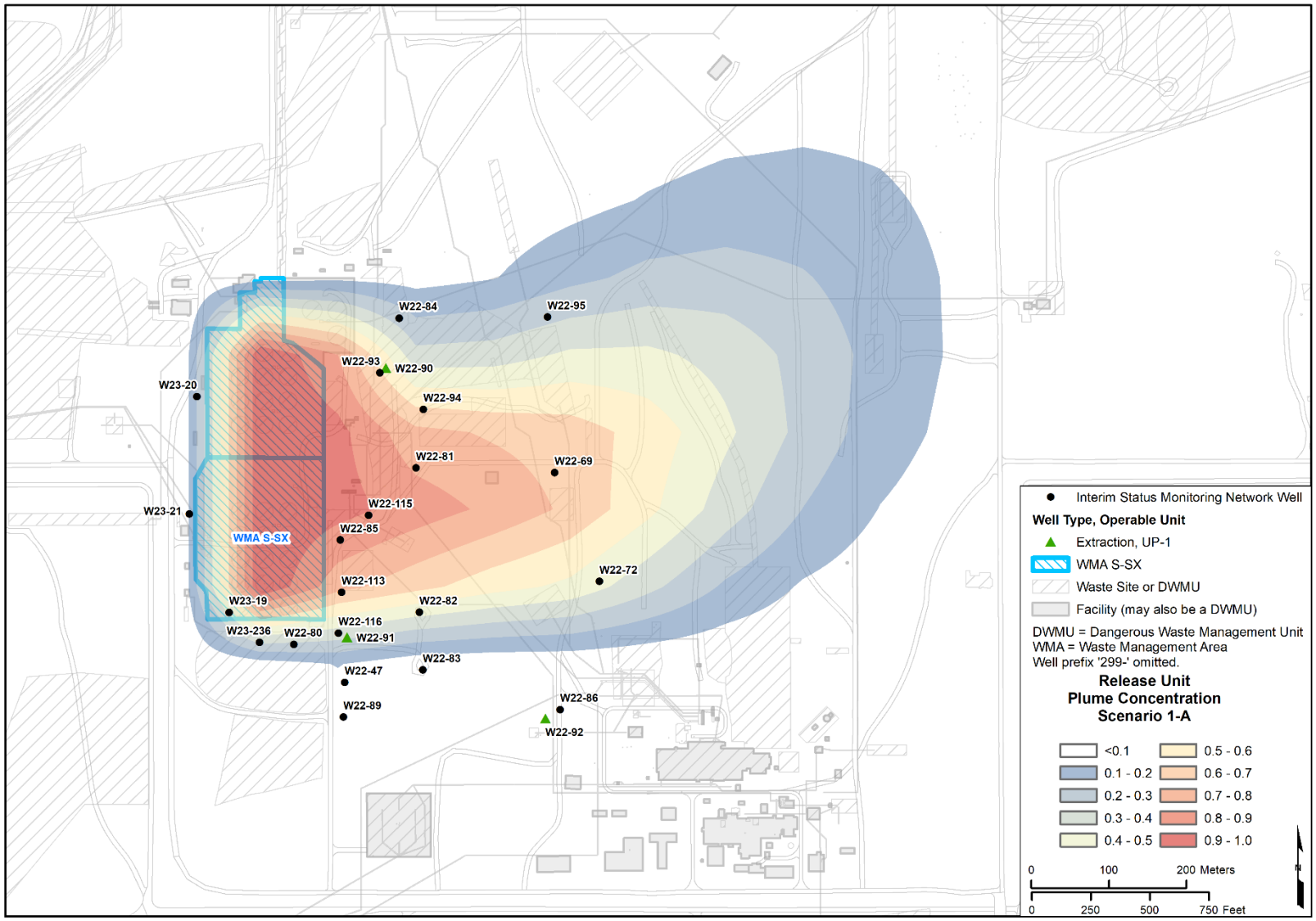

Figure 7-44. Release Unit Plume Map, Scenario 1, Sub-Scenario A

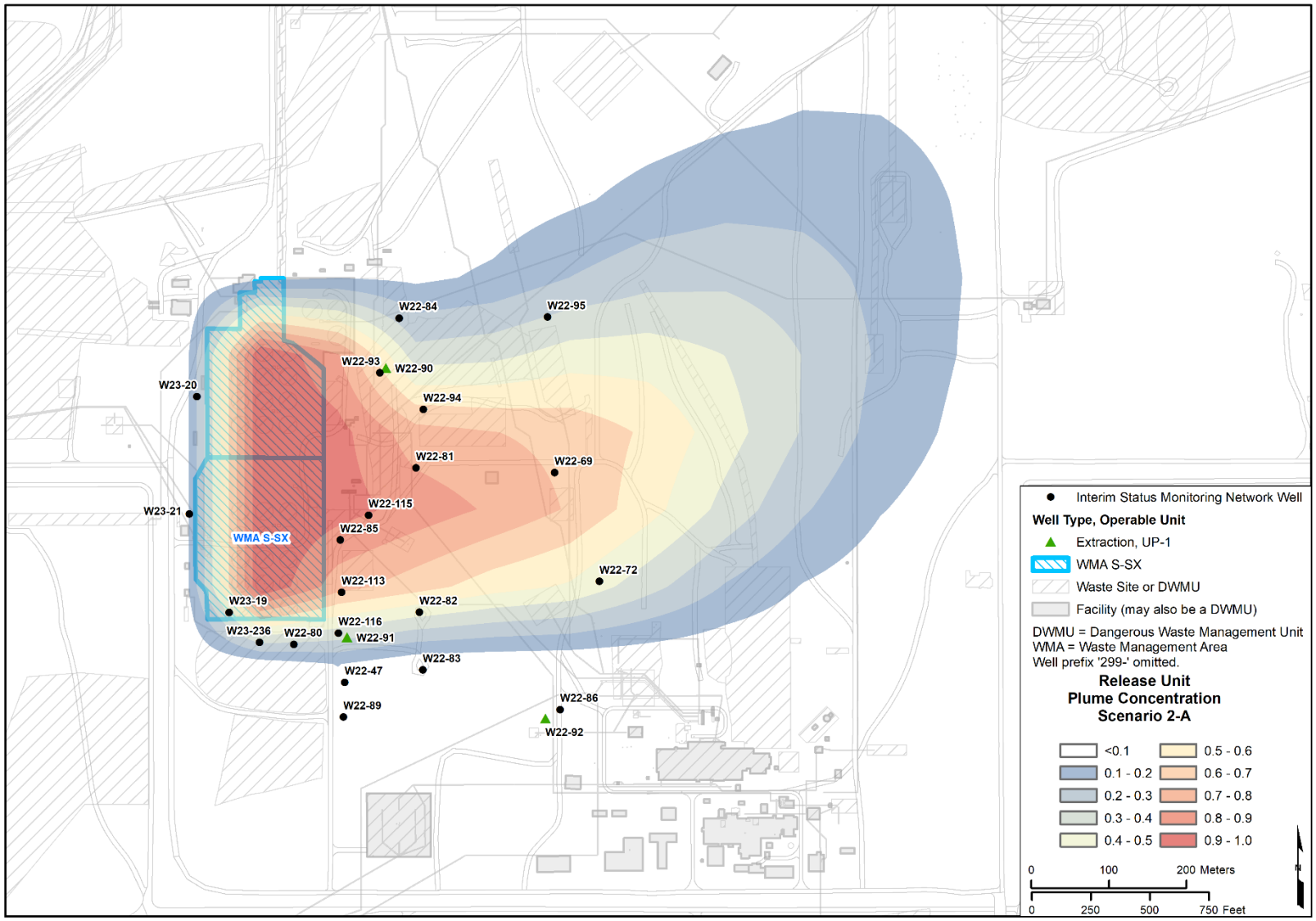

Figure 7-45. Release Unit Plume Map, Scenario 2, Sub-Scenario A

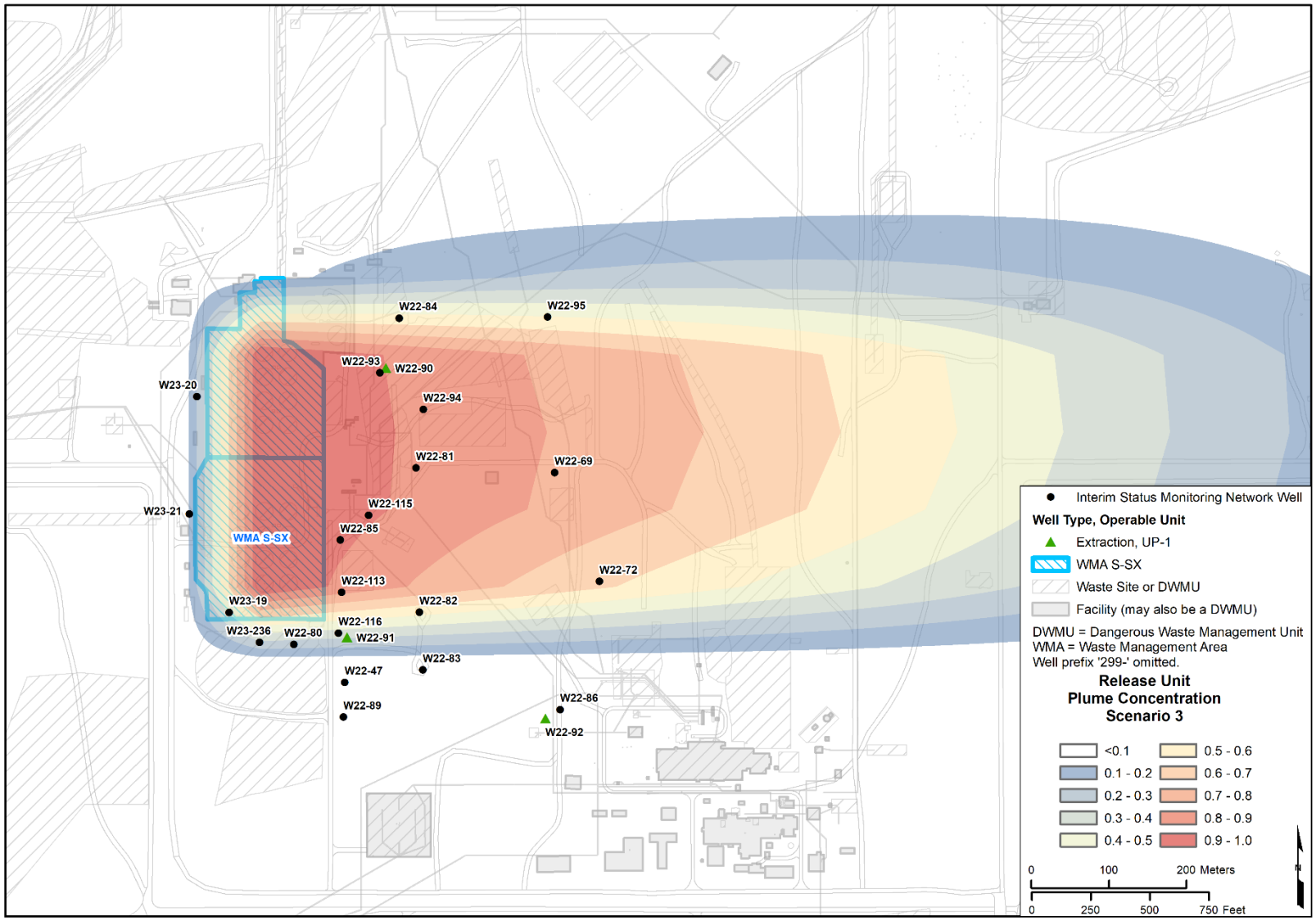

Figure 7-46. Release Unit Plume Map, Scenario 3

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 S-SX. 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 injection wells and nearby extraction wells.

Figures 7-47 and 7-48 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 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 7-49) represents conditions after cessation of the 200 West P&T system operations and therefore has no injected treated water component.

The particle tracking indicates that the downgradient monitoring wells generally are well located for detecting releases from the facility for all the scenarios with the exception of wells 299-W22-47, 299-W22-80, 299-W22-83, 299-W22-86, 299-W22-89, and 299-W23-236, which are located cross gradient to the south of the release particle pathlines.

Maps of relative detectability identify areas of the aquifer where a hypothetical release that impacts the water table beneath WMA S-SX 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.

As described in Section 6.2.2, the relative detectability was determined by first calculating, for each sub-scenario, the number of released particles that traversed each calculation subgrid cell. Particle count maps generated for each sub-scenario are included as Appendix A in Appendix G. Using the particle counts, relative detectability for each scenario was determined by computing a weighted sum of the particle counts for each individual cell for all sub-scenarios within the scenario using the weights shown in Table 5-1 to account for the estimated relative probability of each sub-scenario.

Figures 7-50 through 7-52 depict the relative detectability distribution for releases to the water table beneath the facility for scenarios 1, 2, and 3, respectively. The release distribution is color-coded to reflect the results of the weighted percent distribution of particle counts throughout the release pathline. Where the weighted percent distribution of particle counts is higher, the probability of release detection is also higher.

The relative detectability maps for scenarios 1 and 2 show that the downgradient groundwater monitoring wells generally are located in areas of high relative detectability for particle releases from WMA S-SX. Monitoring wells 299-W22-47, 299-W22-83, 299-W22-86, 299-W22-89, 299-W22-95, and 299-W23-236 are located outside of the relative detectability area. After the cessation of 200 West P&T system operations, however, the shift in the groundwater flow from a northeastern to an eastern direction results in wells 299-W22-47, 299-W22-80, 299-W22-83, 299-W22-86, 299-W22-89, and 299-W23-236 being outside the relative detectability area for scenario 3.

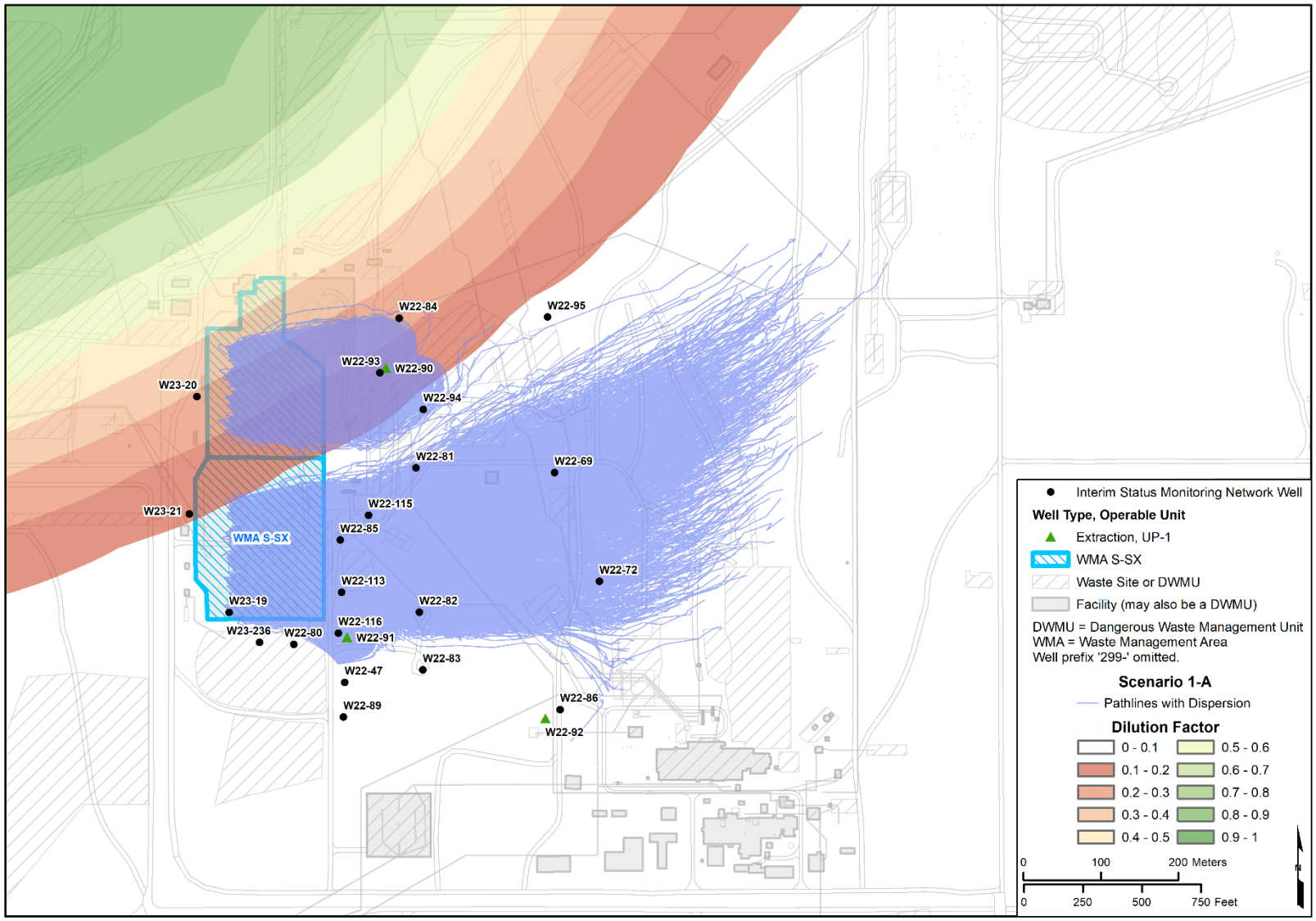

Figure 7-47. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 1, Sub-Scenario A

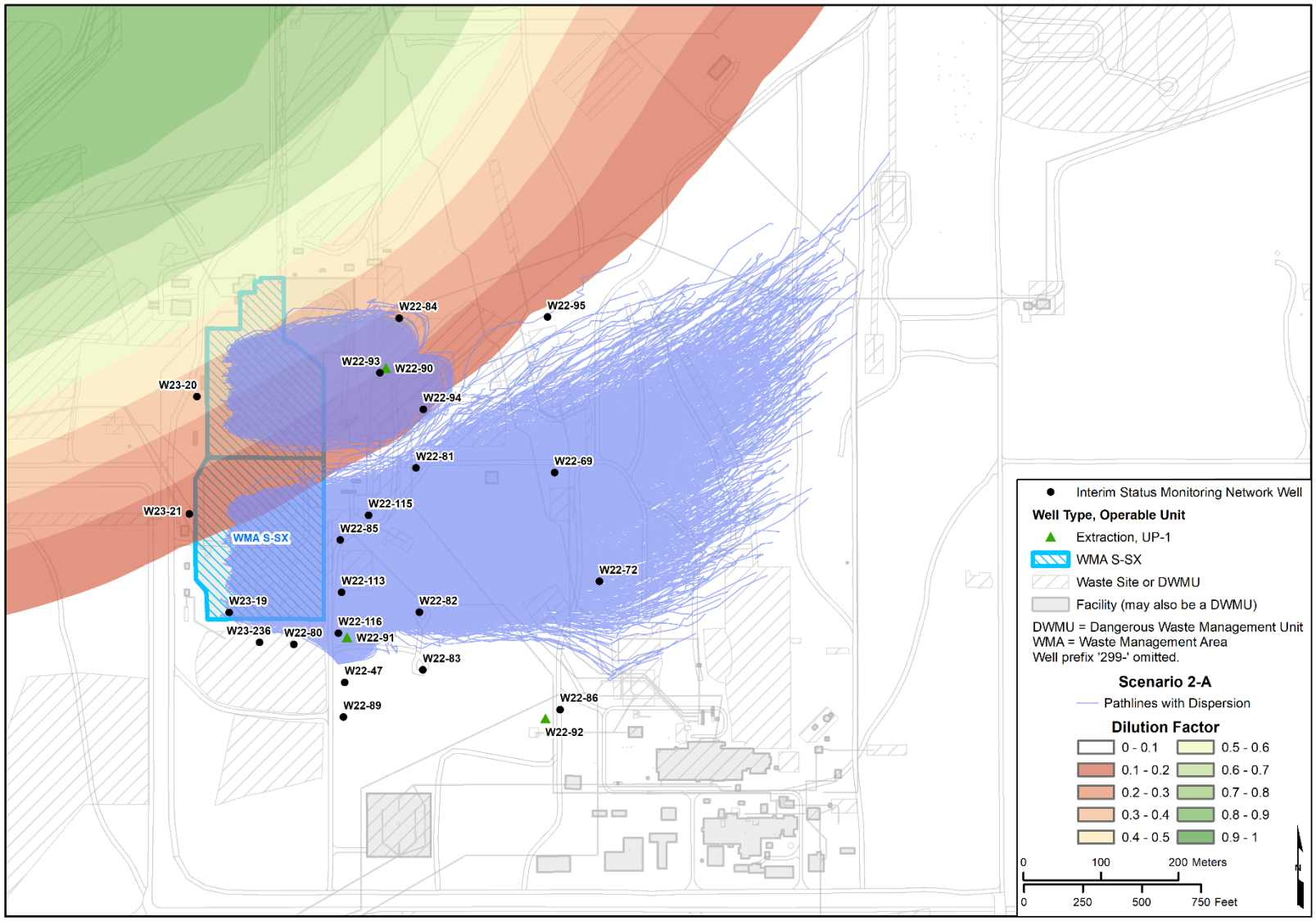

Figure 7-48. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 2, Sub-Scenario A

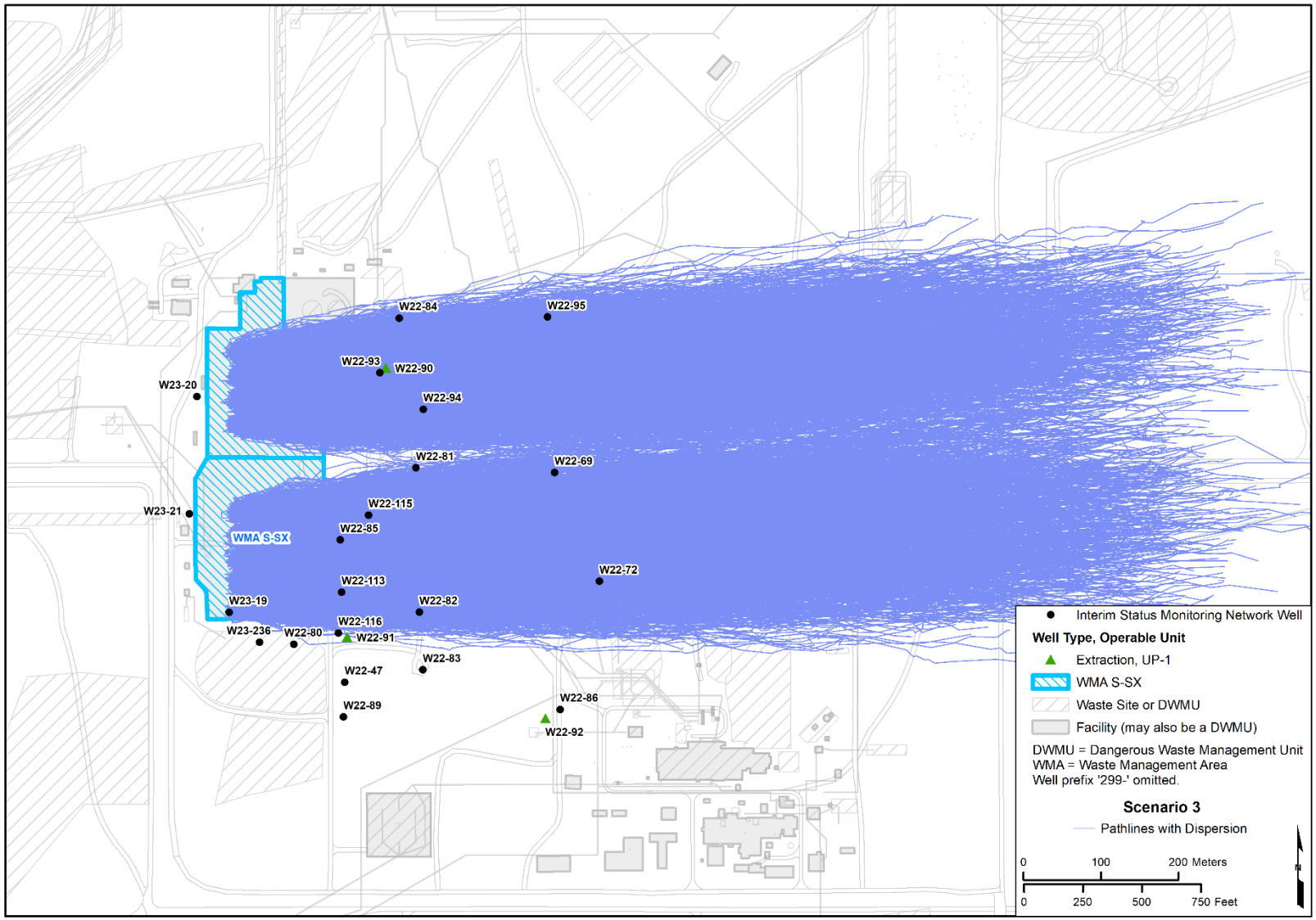

Figure 7-49. Particle Pathlines, Scenario 3

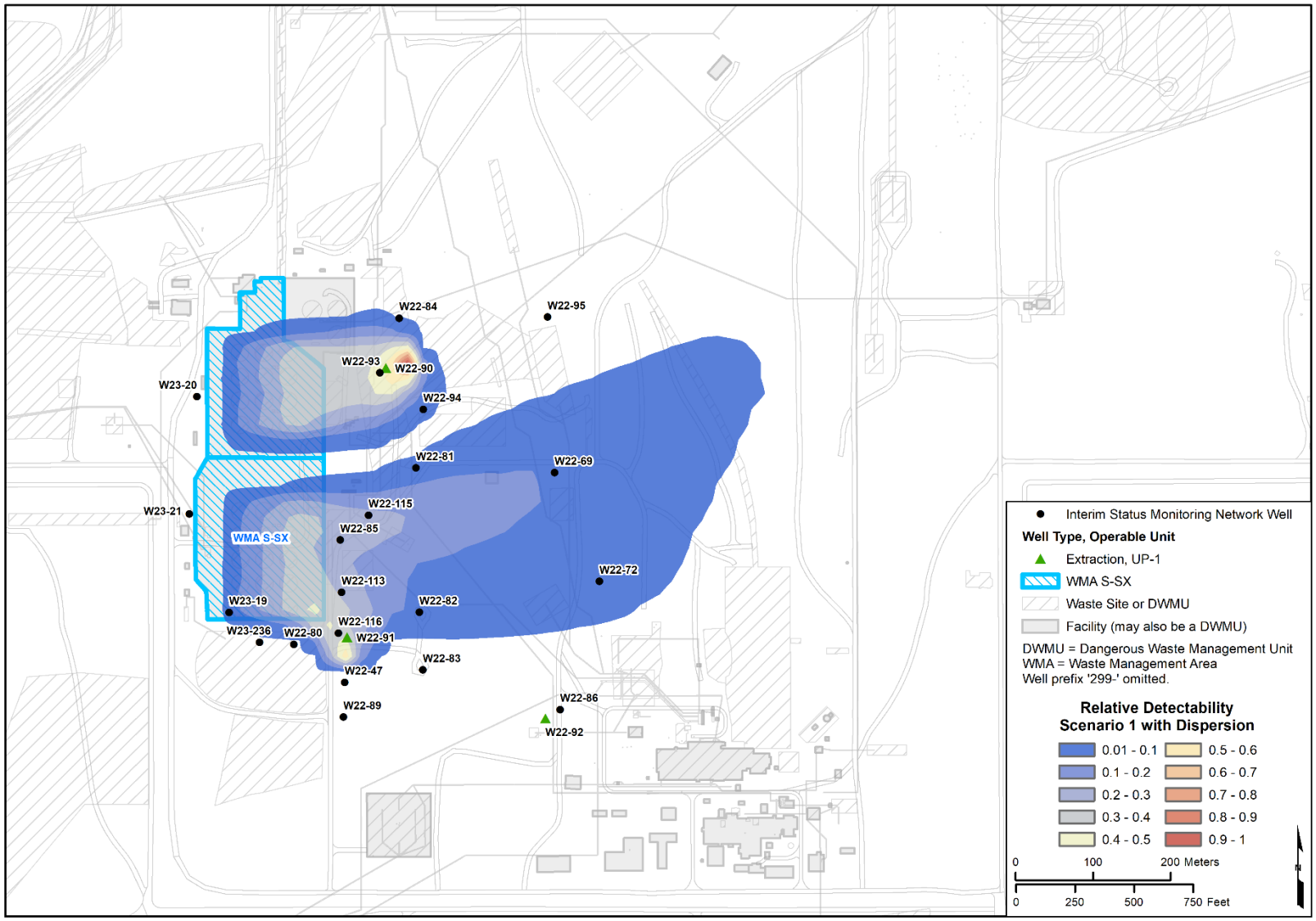

Figure 7-50. Relative Detectability of Release, Scenario 1

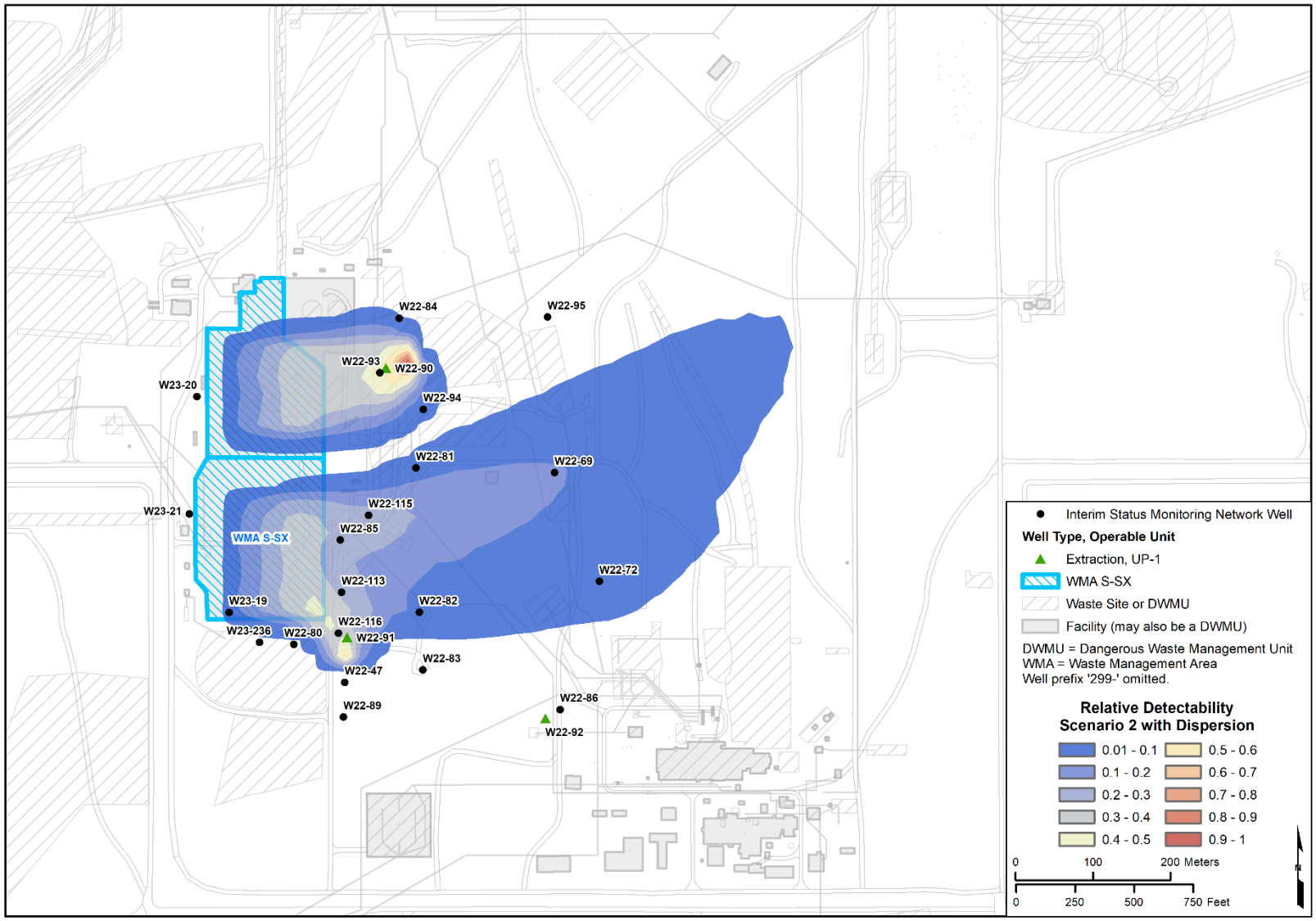

Figure 7-51. Relative Detectability of Release, Scenario 2

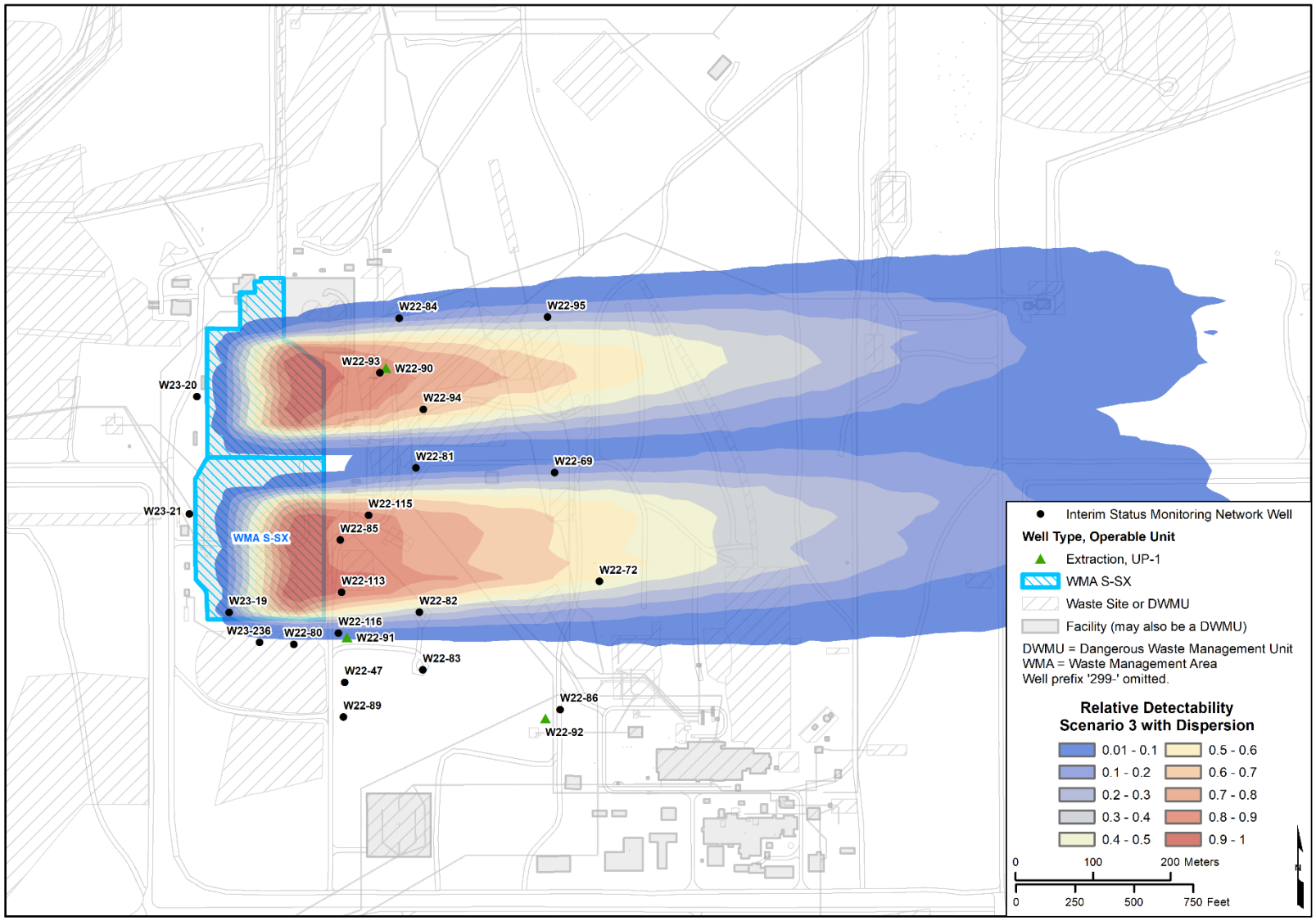

Figure 7-52. Relative Detectability of Release, Scenario 3

7.3 Modeling Conclusions

The proposed final status groundwater monitoring network for WMA S-SX includes retaining existing upgradient wells 299-W23-20 and 299-W23-21 and existing downgradient wells 299-W22-80, 299-W22-81, 299-W22-84, 299-W22-85, 299-W22-93, 299-W22-94, 299-W22-113, 299-W22-115, 299-W22-116, and 299-W23-19. Wells not included in the final status monitoring network are downgradient wells 299-W22-47, 299-W22-69, 299-W22-72, 299-W22-82, 299-W22-83, 299-W22-86, 299-W22-89, 299-W22-95, and 299-W23-236. Those wells are removed because they are located either outside the flow paths or too far downgradient. Other network wells retained in the monitoring system are located in the flow path closer to the point of compliance. The proposed final status monitoring network is based on the results of the simulation scenarios presented in Appendix G and summarized herein.

Figure 7-53 shows the final status monitoring network wells compared to the combined extents of the relative detectability greater than 0.01 for scenarios 1, 2, and 3 from particle tracking and the combined extents of release unit plumes greater than 0.1 for sub-scenario A of scenarios 1 and 2, and scenario 3 from transport modeling.

The simulations indicate that, under the scenarios evaluated, upgradient monitoring wells 299-23-20 and 299-W23-21, along with the 10 downgradient groundwater monitoring wells of the interim status groundwater monitoring network (299-W22-80, 299-W22-81, 299-W22-84, 299-W22-85, 299-W22-93, 299-W22-94, 299-W22-113, 299-W22-115, 299-W22-116, and 299-W23-19) are well placed for detecting increases in concentrations of contaminants due to a release to the water table from WMA S-SX.

The release concentration breakthrough curves for the recommended downgradient monitoring network wells indicate a range of dilution of approximately 10%[1] to 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 9% to approximately 80%[3]. Additional discussion regarding each well is provided in Section 9.3.

[1] 10% dilution corresponds to a release unit concentration of approximately 0.90 for sub-scenario L of scenario 1 at monitoring well 299-W22-115 (Figure 7-37).

[2] More than 75% dilution corresponds to a release unit concentration of 0.25 for sub-scenario R of scenario 1 at monitoring well 299-W22-84 (Figure 7-29).

[3] 9%-80% dilution for scenario 3 corresponds to a release unit concentration of more than 0.91 and approximately 0.20 for wells 299-W22-85 and 299-W23-19, respectively (Figure 7-43).

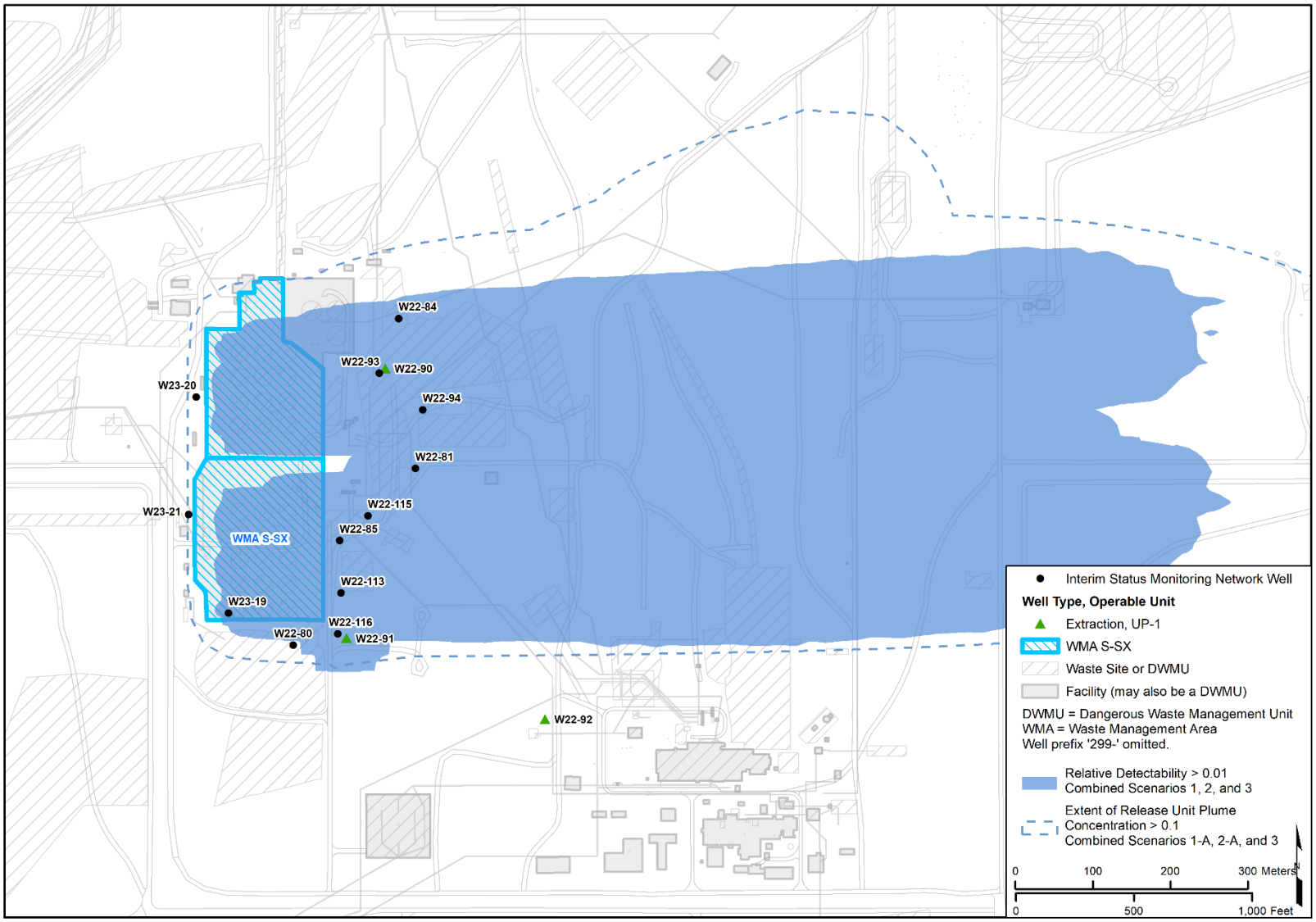

Figure 7-53. Proposed Final Status Groundwater Monitoring Network with Combined Relative Detectability and Release Unit Plume Results

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8 Identification of Site-Specific Monitoring Constituents

An evaluation of the waste constituents associated with WMA S-SX, 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 S-SX were evaluated and screened in accordance with the summary descriptions provided in Subsections 8.1.1 through 8.1.3. 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 S-SX during interim status monitoring comprise the data sets used to identify potential monitoring constituents. The use of the Part A Permit Application information and groundwater sample data are discussed in the following subsections.

8.1.1 Hanford Facility RCRA Permit Part A Form Dangerous Wastes

The Hanford Facility RCRA Permit Part A Form for the SST System identifies the dangerous wastes codes associated with the TSD unit, which includes the WMA S-SX SSTs. A list of dangerous wastes and their corresponding Chemical Abstracts Service 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 2-1.

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 S-SX, 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 database and presented in separate Microsoft® Excel® workbooks.

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

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

measurements, and non analyte-specific measures (e.g., total organic carbon and total organic halides) 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 identified potential monitoring constituents to be included as proposed monitoring constituents to detect and monitor wastes from WMA S-SX 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 S-SX (Section 9.4), these constituents were identified as proposed monitoring constituents.

The remaining potential monitoring constituents were evaluated in two groups:

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

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

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

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

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

8.2 Results of Selection of Groundwater Monitoring Constituents

Based on the evaluation of the dangerous wastes identified from the SST System Part A Permit Application and groundwater data collected for WMA S-SX under interim status monitoring plans, 68 waste constituents are identified as proposed monitoring constituents to detect and monitor any groundwater impacts from dangerous waste releases at WMA S-SX (Table 8-1). Of the 68 waste constituents, 5 are nondangerous waste constituents that were quantified in groundwater above the applicable action level and were identified in the waste profile for the WMA S-SX 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 S-SX

Waste Constituent	CAS Number
Dangerous Waste Constituents	
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
1,1,2-Trichloroethane	79-00-5
1,1-Dichloroethylene	75-35-4
1,2-Dichloroethane	107-06-2
1,4-Dichlorobenzene	106-46-7
2,4-Dinitrotoluene	121-14-2
2-Nitropropane	79-46-9
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
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

Table 8-1. Proposed Groundwater Monitoring Constituents for WMA S-SX

Waste Constituent	CAS Number
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroform	67-66-3
Chloromethane	74-87-3
Chromium	7440-47-3
cis-1,2-Dichloroethylene	156-59-2
Cobalt	7440-48-4
Copper	7440-50-8
Cresols	1319-77-3
Cyclohexanone	108-94-1
Diethylphthalate	84-66-2
Ethyl acetate	141-78-6
Ethyl ether	60-29-7
Ethylbenzene	100-41-4
Hexavalent chromium	18540-29-9
Isobutanol	78-83-1
Lead	7439-92-1
Mercury	7439-97-6
Methanol	67-56-1
Methyl ethyl ketone (2-Butanone)	78-93-3
Methyl isobutyl ketone (4-methyl-2-pentanone)	108-10-1
Methylene chloride	75-09-2
n-Butyl alcohol (1-Butanol)	71-36-3
n-Nitrosodimethylamine	10595-95-6
n-Nitrosomorpholine	59-89-2
Nitrobenzene	98-95-3
Nickel	7440-02-0

Table 8-1. Proposed Groundwater Monitoring Constituents for WMA S-SX

Waste Constituent	CAS Number
Ortho-dichlorobenzene (1,2-dichlorobenzene)	95-50-1
Pyridine	110-86-1
Selenium	7782-49-2
Silver	7440-22-4
Sulfide	18496-25-8
Tetrachloroethene	127-18-4
Tin	7440-31-5
Toluene	108-88-3
Tributyl phosphate	126-73-8
Trichloroethylene	79-01-6
Trichlorofluoromethane	75-69-4
Vanadium	7440-62-2
Vinyl chloride (chloroethene)	75-01-4
Xylenes (total)	1330-20-7
Zinc	7440-66-6
Nondangerous Waste Constituents	
Aluminum	7429-90-5
Iron	7439-89-6
Manganese	7439-96-5
Nitrate	14797-55-8
Nitrite	14797-65-0

CAS = Chemical Abstracts Service

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9 Groundwater Monitoring

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

9.1 Final Status Groundwater Monitoring Program Determination

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

To date, a release to the environment (statistically significant evidence of contamination at the point of compliance) of chromium and nitrate has been observed at WMA S-SX. Therefore, WMA S-SX will be in compliance monitoring under WAC 173-303-645(10) when WMA S-SX 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 10 downgradient wells proposed for the monitoring well network (299-W22-80, 299-W22-81, 299-W22-84, 299-W22-85, 299-W22-93, 299-W22-94, 299-W22-113, 299-W22-115, 299-W22-116, and 299-W23-19]) span the range of particle distribution as released from WMA S-SX. The well placement is suitable for detecting releases to the water table from WMA S-SX under the evaluated range of conditions. The proposed well locations comply with the intent of WAC 173-303-645(6), which is 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 Monitoring Well Network

The proposed groundwater monitoring network for WMA S-SX consists of two background (upgradient) and 10 point of compliance (downgradient) wells to monitor for releases to the water table and detection of increases of contamination from WMA S-SX (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 constructed according to WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." Each well is screened in the upper unconfined aquifer in order to yield sufficient groundwater for representative sampling. Sections 9.3.1 through 9.3.12 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 S-SX 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), two background (upgradient) wells have been selected that would be representative of ambient conditions during operation of the 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 S-SX is discussed in Section 9.7.

Based on current groundwater flow direction to the east and predictions of future groundwater flow in the same direction over time (see Sections 7.2 and 7.3), 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, which are screened in the top of the uppermost unconfined aquifer, are suitable for monitoring (Section 7.5 of Appendix G) and determination of compliance with groundwater protection standards (WAC 173-303-645(10)(a)).

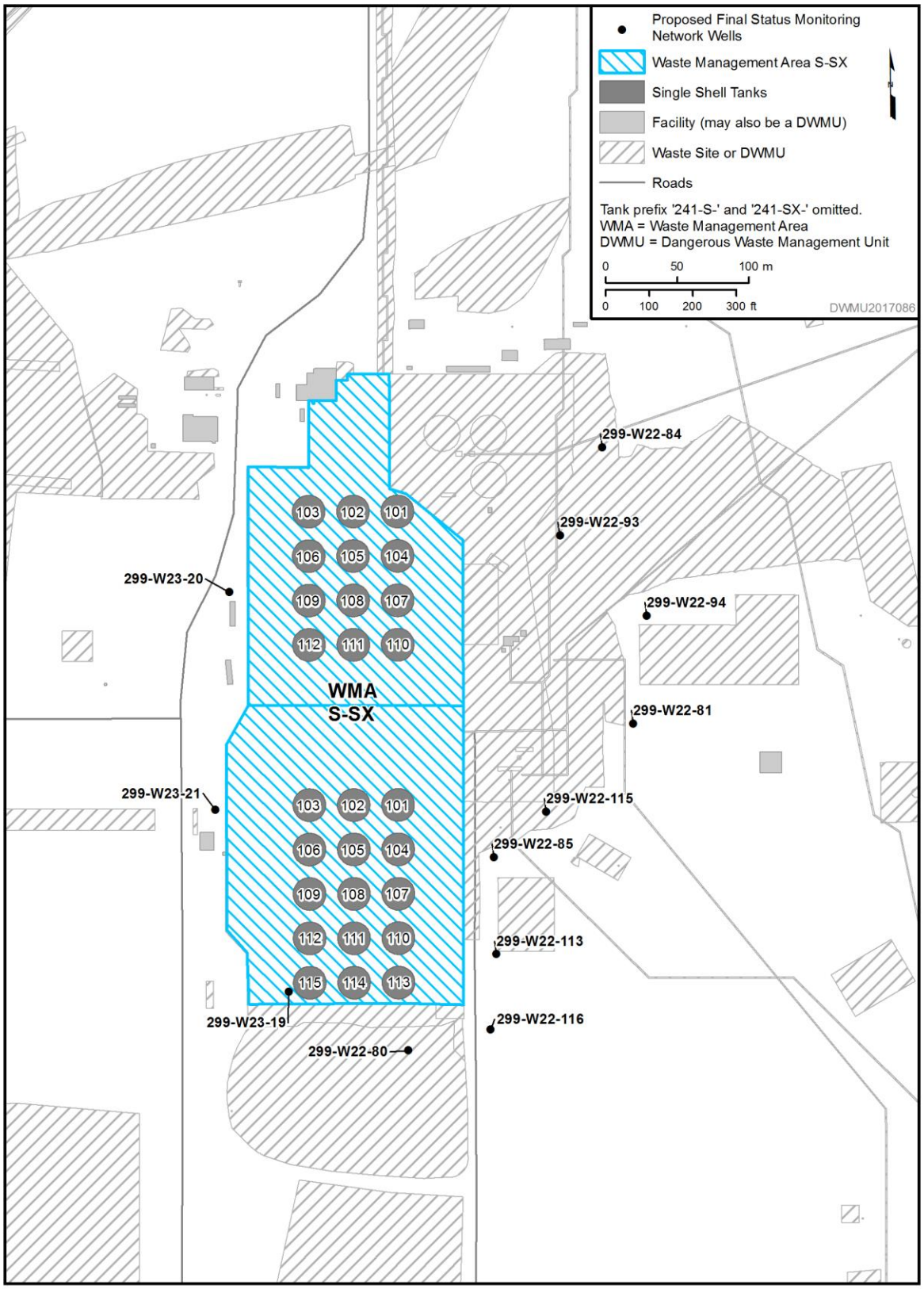

Figure 9-1. Proposed Final Status Groundwater Monitoring Network for WMA S-SX

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

Well Name	Completion Date	Easting[a] (m)	Northing[a] (m)	Top of Casing Elevation (m [ft]) (NAVD88)	Water Table Elevation (m [ft]) (amsl)	Water Depth (m [ft] bgs)	Depth of Water in Screen (m [ft])	Water-Level Date
299-W22-80	9/11/2000	566842.85	134125.65	200.86 (658.98)	132.46 (434.59)	68.4 (224.39)	5.67 (18.61)	8/28/2017
299-W22-81	1/31/2001	567000.26	134354.19	206.64 (677.97)	131.96 (432.94)	74.69 (245.03)	5.82 (19.09)	8/28/2017
299-W22-84	11/1/2001	566978.76	134547.62	208.51 (684.09)	131.98 (432.99)	76.54 (251.1)	5.57 (18.26)	8/28/2017
299-W22-85	10/26/2001	566902.90	134260.58	204.41 (670.63)	132.35 (434.23)	72.06 (236.4)	5.48 (17.99)	8/28/2017
299-W22-93	5/14/2015	566949.07	134485.98	207.63 (681.2)	131.79 (432.38)	75.84 (248.82)	10.16 (33.33)	8/28/2017
299-W22-94	9/30/2013	567009.82	134429.75	208.04 (682.54)	131.87 (432.65)	76.17 (249.89)	9.37 (30.74)	8/28/2017
299-W22-113	10/8/2014	566904.52	134192.75	204.76 (671.77)	132.29 (434.01)	72.47 (237.76)	8.72 (28.6)	8/28/2017
299-W22-115	6/4/2015	566939.39	134292.43	204.37 (670.49)	132.2 (433.74)	72.16 (236.75)	9.64 (31.64)	8/28/2017
299-W22-116	4/22/2015	566900.50	134139.92	204.91 (672.27)	132.3 (434.05)	72.61 (238.23)	10.43 (34.21)	8/28/2017
299-W23-19	11/17/1999	566759.12	134166.65	202.49 (664.34)	132.95 (436.19)[b]	69.54 (228.15)[b]	4.01 (13.16)[b]	7/15/2016[b]
299-W23-20	8/21/2000	566717.67	134446.19	203.81 (668.65)	132.89 (436)	70.91 (232.65)	6.14 (20.15)	8/28/2017
299-W23-21	11/7/2000	566707.74	134293.99	203.36 (667.19)	133.02 (436.43)	70.34 (230.77)	6.54 (21.47)	8/28/2017

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

amsl = above mean sea level

bgs = below ground surface

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

b. Water-level measurements are not possible from 299-W23-19 because it is located within the tank farm fence line and sampled remotely from outside the fence. The water level was estimated by trend surface analysis of the July 15, 2016 measurement of nearby well 299-W23-236 and from the March 2016 site-wide groundwater gradient map.

9.3.1 Groundwater Monitoring Well 299-W23-20

Groundwater monitoring well 299-W23-20 is proposed as a background well. It was constructed in 2000 to the standards of WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA S-SX. The well is upgradient and screened from elevation 138.33 m (453.85 ft) to elevation 126.75 m (415.85 ft) (Appendix E). Based on 2017 water elevation data, well 299-W23-2 is screened across the upper 6.14 m (20.15 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction at well 299-W23-2 is predominantly to the east (Figure 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release. The results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that this well will remain upgradient of WMA S-SX 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 28% for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.28 shown on the injection injected treated water dilution breakthrough curve in Figure 7-19).

9.3.2 Groundwater Monitoring Well 299-W23-21

Groundwater monitoring well 299-W23-21 is proposed as a background well. It was constructed in 2000 to the standards of WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA S-SX. The well is upgradient and screened from elevation 137.78 m (452.05 ft) to elevation 126.48 m (414.95 ft) (Appendix E). Based on 2017 water elevation data, well 299-W23-21 is screened across the upper 6.54 m (21.47 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction at well 299-W23-21 is predominantly to the east (Figure 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release. The results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that this well will remain upgradient of WMA S-SX 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 10% for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.10 shown on the injection injected treated water dilution breakthrough curve in Figure 7-20).

9.3.3 Groundwater Monitoring Well 299-W22-80

Groundwater monitoring well 299-W22-80 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 S-SX. The well is downgradient of WMA S-SX and is screened from elevation 137.49 m (451.08 ft) to elevation 126.79 m (415.98 ft) (Appendix E). Based on 2017 water elevation data, well 299-W22-80 is screened across the upper 5.67 m (18.61 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 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) indicate that this well is located within the southern extent of the estimated area of detectability for scenarios 1 and 2 and south of the detectable area for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well (Figures 7-25 and 7-43) 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 approximately 72% (corresponding to a release unit concentration of approximately 0.28 shown in Figure 7-25) 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 1% 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 0.01 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 1%, 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 S-SX under the range of operating conditions evaluated.

9.3.4 Groundwater Monitoring Well 299-W22-81

Groundwater monitoring well 299-W22-81 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 S-SX. The well is downgradient of WMA S-SX and is screened from elevation 136.78 m (448.75 ft) to elevation 126.14 m (413.85 ft) (Appendix E). Based on 2017 water elevation data, well 299-W22-81 is screened across the upper 5.82 m (19.09 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 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) indicate that this well is located within the northern extent of the detectable area extending from the 241-SX Tank Farm for scenarios 1 and 2 and centrally located within the detectable area for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well (Figures 7-26 and 7-43) 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 approximately 21% (corresponding to a release unit concentration of approximately 0.79 shown in Figure 7-26) 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 4% 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 0.04 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 4%, 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 S-SX under the range of operating conditions evaluated.

9.3.5 Groundwater Monitoring Well 299-W22-84

Groundwater monitoring well 299-W22-84 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 S-SX. The well is downgradient of WMA S-SX and is screened from elevation 137.08 m (449.74 ft) to elevation 126.41 m (414.74 ft) (Appendix E). Based on 2017 water elevation data, well 299-W22-84 is screened across the upper 5.57 m (18.26 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 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) indicate that this well is located within the northern extent of the detectable area for scenarios 1, 2, and 3. The release concentration breakthrough curves for this well (Figures 7-29 and 7-43) 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 approximately 74% (corresponding to a release unit concentration of approximately 0.26 shown in Figure 7-29) 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 23% 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 0.23 shown on the injection injected treated water dilution breakthrough curve in Figure 7-8). This could result in further dilution of the release concentration by some amount up to but likely less than 23%, 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 S-SX under the range of operating conditions evaluated.

9.3.6 Groundwater Monitoring Well 299-W22-85

Groundwater monitoring well 299-W22-85 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 S-SX. The well is downgradient of WMA S-SX and is screened from elevation 137.51 m (451.15 ft) to elevation 126.87 m (416.25 ft) (Appendix E). Based on 2017 water elevation data, well 299-W22-85 is screened across the upper 5.48 m (17.99 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 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) indicate that this well is centrally located in the estimated area of detectability for scenarios 1, 2, and 3. The release concentration breakthrough curves for this well (Figures 7-30 and 7-43) 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 approximately 14% (corresponding to a release unit concentration of approximately 0.86 shown in Figure 7-30) 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 3% 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 0.03 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 3%, 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 S-SX under the range of operating conditions evaluated.

9.3.7 Groundwater Monitoring Well 299-W22-93

Groundwater monitoring well 299-W22-93 is proposed as a point of compliance well. It was constructed in 2015 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA S-SX. The well is downgradient of WMA S-SX] and is screened from elevation 132.30 m (434.06 ft) to elevation 121.63 m (399.06 ft) (Appendix E). Based on 2017 water elevation data, well 299-W22-93 is screened across the upper 10.16 m (33.33 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 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) indicate that this well is centrally located in the estimated area of detectability for scenarios 1, 2, and 3. The release concentration breakthrough curves for this well (Figures 7-33 and 7-43) 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 approximately 39% (corresponding to a release unit concentration of approximately 0.61 shown in Figure 7-33) 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 17% 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 0.17 shown on the injection injected treated water dilution breakthrough curve in Figure 7-12). This could result in further dilution of the release concentration by some amount up to but likely less than 17%, 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 S-SX under the range of operating conditions evaluated.

9.3.8 Groundwater Monitoring Well 299-W22-94

Groundwater monitoring well 299-W22-94 is proposed as a point of compliance well. It was constructed in 2013 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA S-SX. The well is downgradient of WMA S-SX and is screened from elevation 133.16 m (436.89 ft) to elevation 122.50 m (401.89 ft) (Appendix E). Based on 2017 water elevation data, well 299-W22-94 is screened across the upper 9.37 m (30.74 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 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) indicate that this well is located within the southern extent of the estimated area of detectability for scenarios 1 and 2 and centrally located within 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 7-34 and 7-43) 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 approximately 39% (corresponding to a release unit concentration of approximately 0.61 shown in Figure 7-34) through the processes of advection, dispersion, and recharge by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 8% 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 0.08 shown on the injection injected treated water dilution breakthrough curve in Figure 7-13). This could result in further dilution of the release concentration by some amount up to but likely less than 8%, 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 S-SX under the range of operating conditions evaluated.

9.3.9 Groundwater Monitoring Well 299-W22-113

Groundwater monitoring well 299-W22-113 is proposed as a point of compliance well. It was constructed in 2014 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA S-SX. The well is downgradient of WMA S-SX and is screened from elevation 132.75 m (435.53 ft) to elevation 123.57 m (405.43 ft) (Appendix E). Based on 2017 water elevation data, well 299-W22-113 is screened across the upper 8.72 m (28.6 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the east at this well (Figure 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) indicate that this well is centrally located in the estimated area of detectability for scenarios 1, 2, and 3. The release concentration breakthrough curves for this well (Figures 7-36 and 7-43) 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 approximately 31% (corresponding to a release unit concentration of approximately 0.69 shown in Figure 7-36) through the processes of advection, dispersion, and recharge by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 1% 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 0.01 shown on the injection injected treated water dilution breakthrough curve in Figure 7-15). This could result in further

dilution of the release concentration by some amount up to but likely less than 1%, 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 S-SX under the range of operating conditions evaluated.

9.3.10 Groundwater Monitoring Well 299-W22-115

Groundwater monitoring well 299-W22-115 is proposed as a point of compliance well. It was constructed in 2015 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA S-SX. The well is downgradient of WMA S-SX and is screened from elevation 133.26 m (437.2 ft) to elevation 122.56 m (402.10 ft) (Appendix E). Based on 2017 water elevation data, well 299-W22-115 is screened across the upper 9.64 m (31.64 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 east-northeast at this well (Figure 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) indicate that this well is centrally located in the estimated area of detectability for scenarios 1, 2, and 3. The release concentration breakthrough curves for this well (Figures 7-37 and 7-43) 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 approximately 11% (corresponding to a release unit concentration of approximately 0.89 shown in Figure 7-37) 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 3% 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 0.03 shown on the injection injected treated water dilution breakthrough curve in Figure 7-16). This could result in further dilution of the release concentration by some amount up to but likely less than 3%, 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 S-SX under the range of operating conditions evaluated.

9.3.11 Groundwater Monitoring Well 299-W22-116

Groundwater monitoring well 299-W22-116 is proposed as a point of compliance well. It was constructed in 2015 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA S-SX. The well is downgradient of WMA S-SX and is screened from elevation 132.54 m (434.85 ft) to elevation 121.87 m (399.85 ft) (Appendix E). Based on 2017 water elevation data, well 299-W22-116 is screened across the upper 10.43 m (34.21 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 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) indicate that this well is centrally located within the estimated area of detectability leading toward extraction well 29-W22-91 for scenarios 1 and 2 and on the southern edge 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 7-38 and 7-43) 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 approximately 64% (corresponding to a release unit concentration of approximately 0.36 shown in Figure 7-38) 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 1% 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 0.01 shown on the injection injected treated water dilution breakthrough curve in Figure 7-17). This could result in further dilution of the release concentration by some amount up to but likely less than 1%, 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 S-SX under the range of operating conditions evaluated.

9.3.12 Groundwater Monitoring Well 299-W23-19

Groundwater monitoring well 299-W23-19 is proposed as a point of compliance well. It was constructed in 1999 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for WMA S-SX. The well is downgradient of WMA S-SX and is screened from elevation 138.27 m (453.64 ft) to elevation 128.94 m (423.04 ft ft) (Appendix E). Based on 2017 water elevation data, well 299-W23-19 is screened across the upper 4.01 m (13.16 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 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of transport calculations (Figures 7-44 through 7-46) and the results of particle-tracking calculations (Figures 7-47 through 7-49) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-50 through 7-52) 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 7-39 and 7-43) 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 approximately 59% (corresponding to a release unit concentration of approximately 0.41 shown in Figure 7-39) 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 2% 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 0.02 shown on the injection injected treated water dilution breakthrough curve in Figure 7-18). This could result in further dilution of the release concentration by some amount up to but likely less than 2%, 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 S-SX under the range of operating conditions evaluated.

9.4 Constituent List and Frequency

The proposed WMA S-SX final status groundwater monitoring network detailed in this report consists of 2 upgradient wells (299-W23-20 and 299-W23-21) and 10 downgradient wells (299-W22-80, 299-W22-81, 299-W22-84, 299-W22-85, 299-W22-93, 299-W22-94, 299-W22-113, 299-W22-115, 299-W22-116, and 299-W23-19). Each of these wells are part of the WMA S-SX interim status groundwater monitoring network (Table 3-2 in DOE/RL-2009-73) 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, 56 waste constituents were selected to detect and monitor groundwater impacts from dangerous waste releases at WMA S-SX.

Table 9-2 identifies the proposed monitoring network and sampling frequency for WMA S-SX. 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 semiannually. Field measurements (pH, specific conductance, dissolved oxygen, 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 S-SX.

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 9-2. Monitoring Wells and Sample Schedule for WMA S-SX

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	Hexavalent Chromium	Sulfide	Methanol	Metals[c]	Anions[d]	Volatile Organic Compounds[e]	Semivolatile Organic Compounds[f]	Table 9-4	
299-W23-20	Upgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W23-21	Upgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W22-80	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W22-81	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W22-84	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W22-85	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W22-93	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W22-94	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W22-113	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W22-115	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W22-116	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/A	Q/S
299-W23-19	Downgradient	Y	E	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, "Groundwater Monitoring Requirements for 200 West Area Single-Shell Tank (SST) Farms Final Status Groundwater Monitoring Plan," and to support collection of sufficient samples to perform statistical testing (e.g., 8 samples), quarterly sampling

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

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

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, selenium, silver, tin, vanadium, and zinc.

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

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

f. Semivolatile organic compounds are provided in Table 9-3 and include 1,2-dichlorobenzene (o-dichlorobenzene); 1,4-dichlorobenzene; 2,4-dinitrotoluene; 2,4,5-trichlorophenol; 2,4,6-trichlorophenol; bis(2-ethylhexyl) phthalate; cresols; diethylphthalate; nitrobenzene; n-nitrosodimethylamine; n-nitrosomorpholine; pyridine; and tributyl phosphate.

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
Q = quarterly
S = semiannually
WAC = *Washington Administrative Code*
Y = well is, or will be, constructed as a resource protection well (WAC 173-160, “Minimum Standard for Construction and Maintenance of Wells”)

Table 9-3. Proposed Groundwater Monitoring Constituents for WMA S-SX

Waste Constituent	CAS Number
Inorganics	
Ammonia	7664-41-7
Hexavalent Chromium	18540-29-9
Sulfide	18496-25-8
Metals	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Copper	7440-50-8
Lead	7439-92-1
Mercury	7439-97-6
Nickel	7440-02-0
Selenium	7782-49-2
Silver	7440-22-4
Tin	7440-31-5
Vanadium	7440-62-2
Zinc	7440-66-6
Volatile Organic Compounds	
1-Butanol (n-Butyl alcohol)	71-36-3
1,1-Dichloroethylene	75-35-4
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
1,1,2-Trichloroethane	79-00-5
1,2-Dichloroethane	107-06-2
2-Butanone (Methyl ethyl ketone)	78-93-3
2-Nitropropane	79-46-9

Table 9-3. Proposed Groundwater Monitoring Constituents for WMA S-SX

Waste Constituent	CAS Number
2-Propanone (Acetone)	67-64-1
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1
Acetonitrile	75-05-8
Benzene	71-43-2
Bromodichloromethane	75-27-4
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroform	67-66-3
Chloromethane	74-87-3
cis-1,2-Dichloroethylene	156-59-2
Cyclohexanone	108-94-1
Ethyl acetate	141-78-6
Ethyl ether	60-29-7
Ethylbenzene	100-41-4
Isobutanol (Isobutyl alcohol)	78-83-1
Methylene chloride	75-09-2
Tetrachloroethene	127-18-4
Toluene	108-88-3
Trichloroethylene (TCE)	79-01-6
Trichlorofluoromethane	75-69-4
Vinyl chloride (Chloroethene)	75-01-4
Xylene (total)	1330-20-7
Semivolatile Organic Compounds	
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1
1,4-Dichlorobenzene	106-46-7
2,4-Dinitrotoluene	121-14-2
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2

Table 9-3. Proposed Groundwater Monitoring Constituents for WMA S-SX

Waste Constituent	CAS Number
Bis(2-ethylhexyl) phthalate	117-81-7
Cresols	1319-77-3
Diethylphthalate	84-66-2
Nitrobenzene	98-95-3
n-Nitrosodimethylamine	10595-95-6
n-Nitrosomorpholine	59-89-2
Pyridine	110-86-1
Tributyl phosphate	126-73-8
Alcohols/Ketones	
Methanol	67-56-1
Nondangerous Waste Constituents	
Anions	
Nitrate	14797-55-8
Nitrite	14797-65-0
Metals	
Aluminum	7429-90-5
Iron	7439-89-6
Manganese	7439-96-5

CAS = Chemical Abstracts Service

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

Constituent	CAS Number	Constituent	CAS Number
Inorganic Constituents			
Antimony	7440-36-0	Mercury	7439-97-6
Arsenic	7440-38-2	Nickel	7440-02-0
Barium	7440-39-3	Selenium	7782-49-2
Beryllium	7440-41-7	Silver	7440-22-4
Cadmium	7440-43-9	Sulfide	18496-25-8
Chromium	7440-47-3	Thallium	7440-28-0

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

Constituent	CAS Number	Constituent	CAS Number
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
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

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

Constituent	CAS Number	Constituent	CAS Number
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
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	59-50-7	p-Nitrophenol (4-Nitrophenol)	100-02-7

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

Constituent	CAS Number	Constituent	CAS Number
(p-Chloro-m-cresol)			
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
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

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

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

9.7 Statistical Method

Under the most recent (2011) interim status monitoring plan (DOE/RL-2009-73), samples for site-specific constituents that are identified as proposed monitoring constituents (i.e., chromium and nitrate) were collected at varying frequencies at WMA S-SX. Chromium was collected annually at upgradient wells and at frequencies that varied from quarterly to annually at other network wells. Other supporting parameters (including metals) were collected annually at upgradient wells and at frequencies that varied from quarterly to annually at other network wells. EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, requires a minimum of eight samples to be able to define background. While the minimum number of samples are available, the 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 baseline conditions given the fluctuating groundwater beneath WMA S-SX 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, 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 periodically reassessed.

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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.

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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Appendix A

Interim Status Data Summary

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A1 Introduction

Section 2.4 of the main document summarizes the groundwater monitoring history at Waste Management Area (WMA) S-SX. 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 1996 when WMA S-SX was placed into a groundwater quality assessment monitoring program in accordance with 40 CFR 265.93(d), "Preparation, Evaluation, and Response." WMA S-SX has been monitored under a groundwater quality assessment program since 1996.

The interim status groundwater monitoring history of WMA S-SX through 2016 was compiled. Information from annual reporting documents and groundwater monitoring plans was utilized to compile a summary of wells in the WMA S-SX 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 are presented in separate Microsoft Excel workbooks. Sample data for each well were retrieved from the Hanford Environmental Information System database. The workbooks are contained in electronic files to accompany this report.

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Appendix B

Identification of Site-Specific Monitoring Constituents for Waste Management Area S-SX - ECF-200UP1-17-0221

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The calculation ECF-200UP1-17-0221, *Identification of Site-Specific Monitoring Constituents for Waste Management Area S-SX,* was performed evaluate the waste constituents associated with Waste Management Area S-SX 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=0065253H.

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Appendix C

Topographic Map

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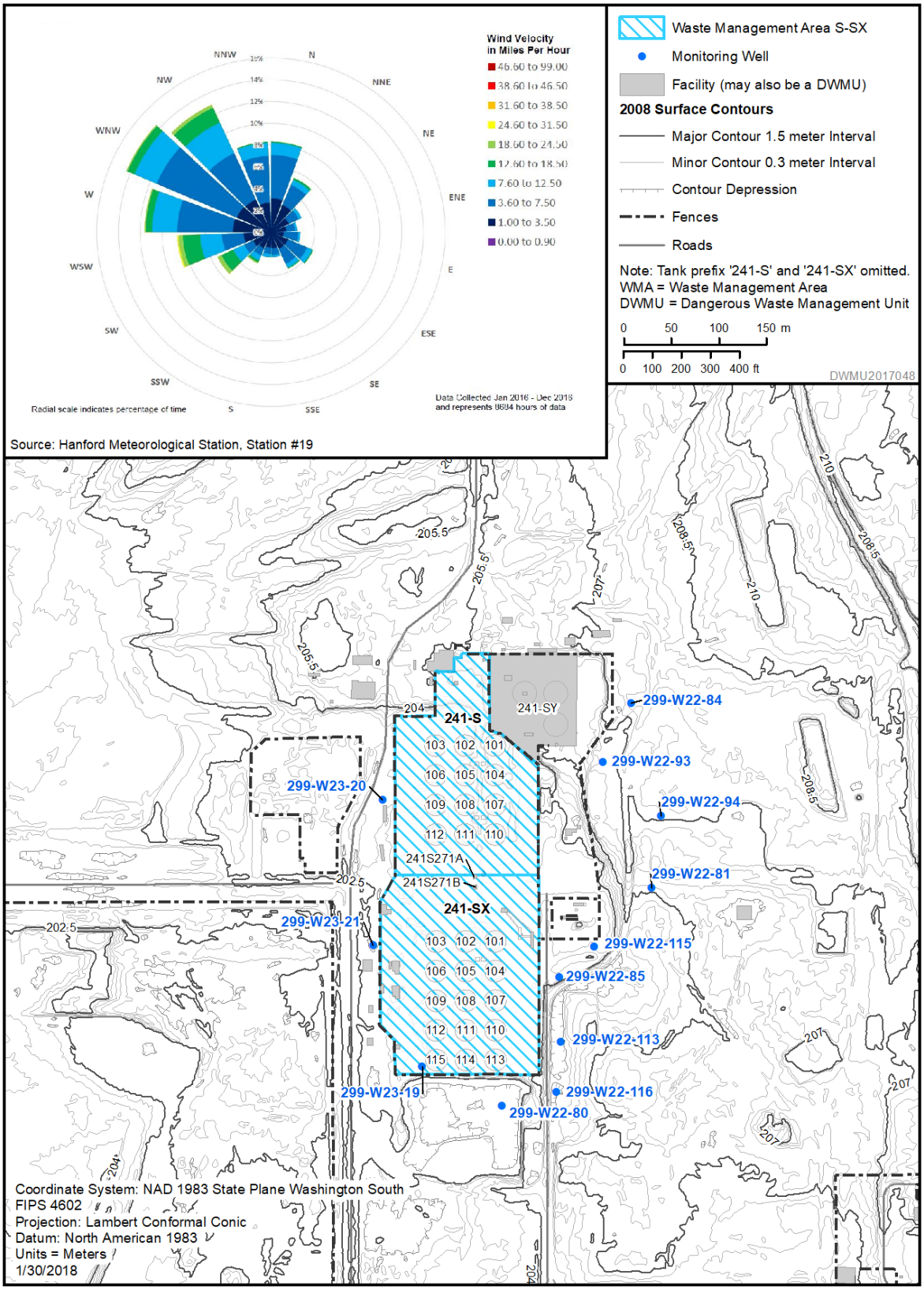

Figure C-1. Topographic Map

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Appendix D

Plume Maps

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This appendix presents regional plume maps in the vicinity of Waste Management Area (WMA) S-SX (Figures D-1 through D-3). These plumes do not originate solely from WMA S-SX, but rather WMA S-SX 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 S-SX monitoring well network (Table 3-11 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*) are presented (Figures D-4 through D-6) WAC 173-303-806(4)(a)(xx)(D)(II) defines the constituents to be those listed in Appendix "Ground-Water Monitoring List" in *Chemical Testing Methods for Designating Dangerous Waste*, which is incorporated at WAC 173-303-110(3)(c) and (7), and any other constituents not listed there which have caused a managed waste to be regulated. WAC 173-303-110(3)(c) references Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, and WAC 173-303-110(7) references Appendix 5 of Ecology Publication No. 97-407. Accordingly, the constituents identified in Appendix 5 of Ecology Publication No. 97-407 were evaluated for inclusion in these figures. Additionally, other chemical constituents that are not included in Appendix 5 of Ecology Publication No. 97-407, but were detected in 2016 samples from network wells, were evaluated for inclusion.

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

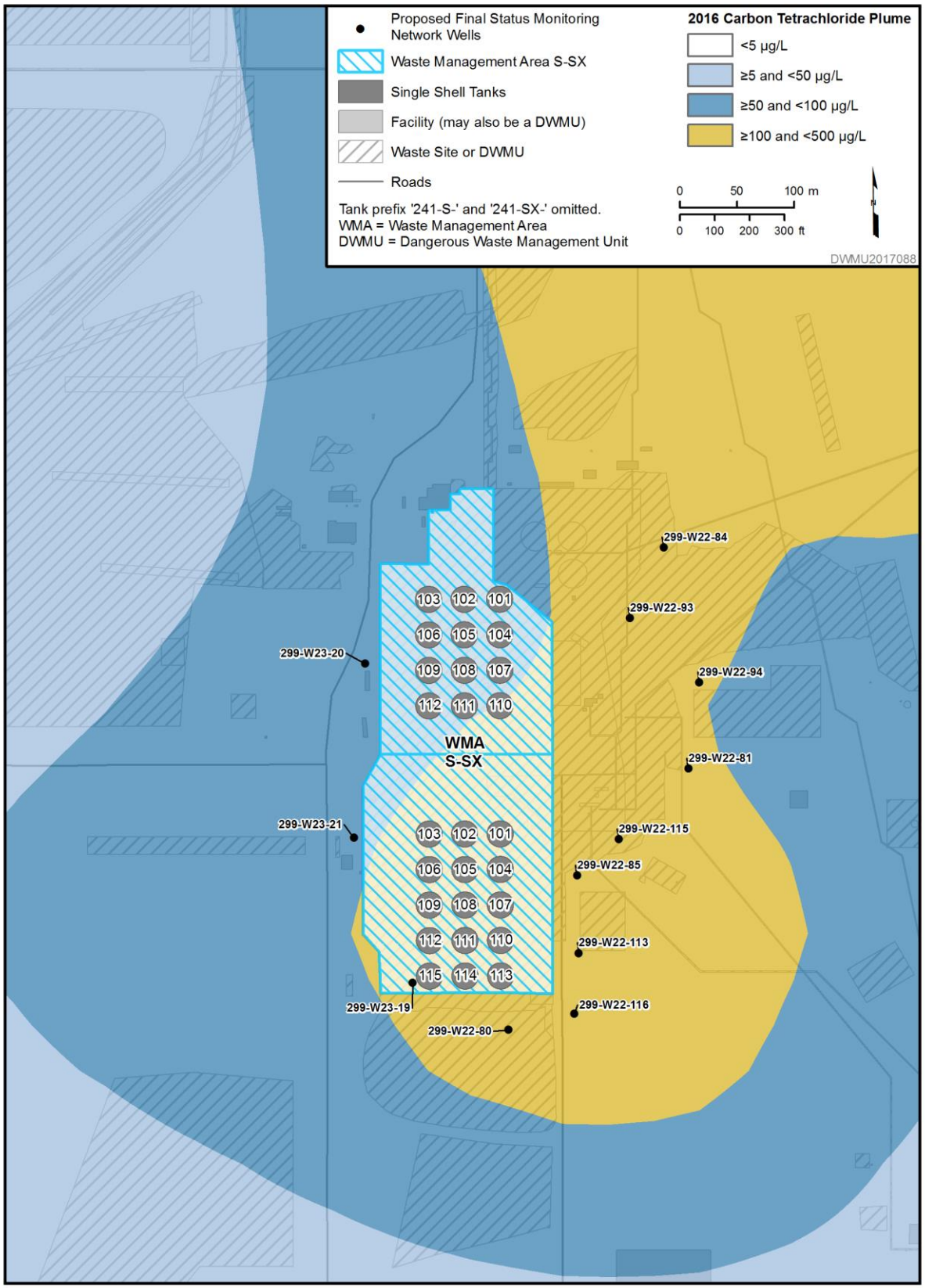

Figure D-1 Regional Carbon Tetrachloride Plume at WMA S-SX

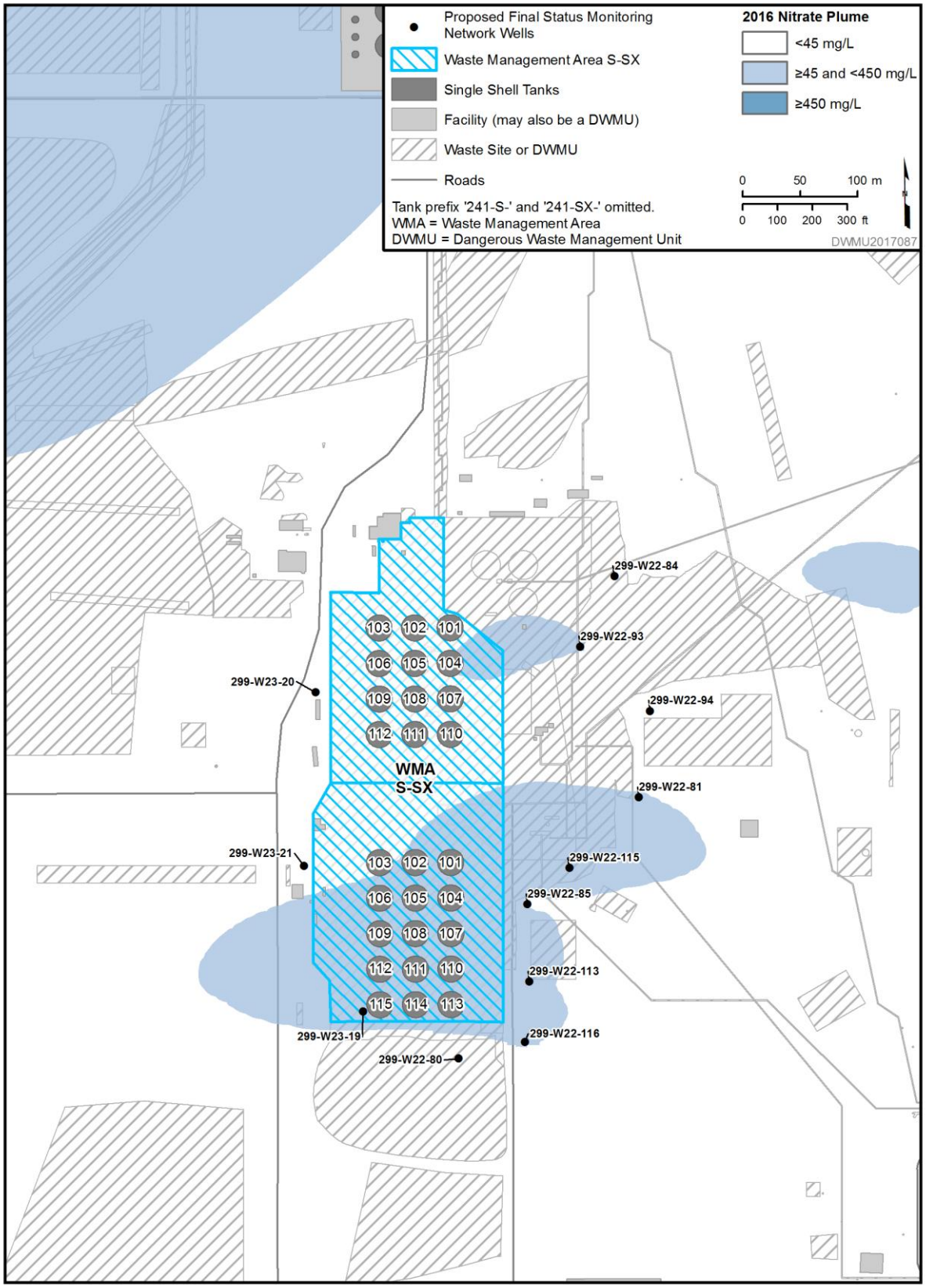

Figure D-2. Regional Nitrate Plume at WMA S-SX

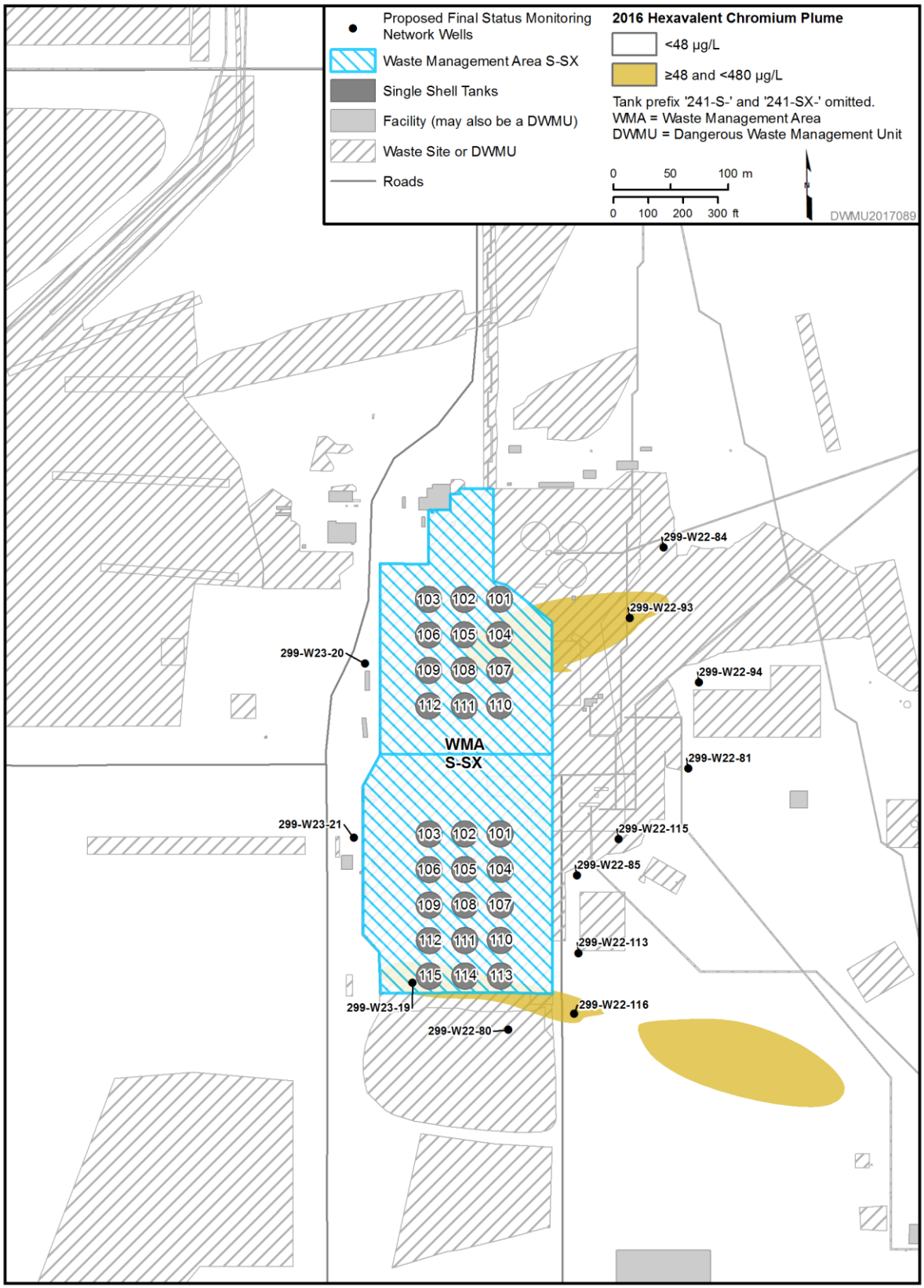

Figure D-3. Regional Hexavalent Chromium Plume at WMA S-SX

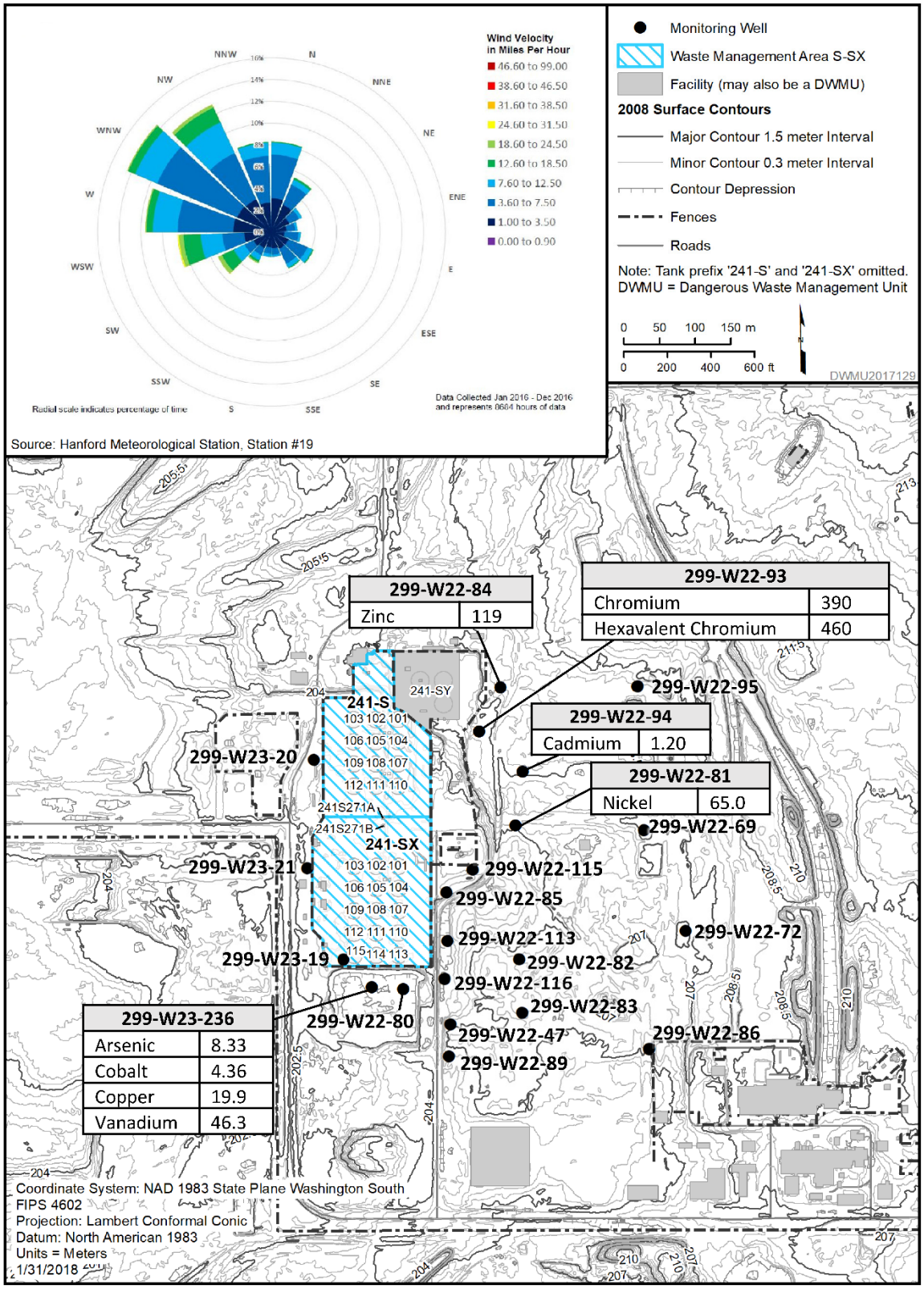

Figure D-4. 2016 Maximum Detected Groundwater Results of Metals and Inorganics in WMA S-SX Network Wells (µg/L)

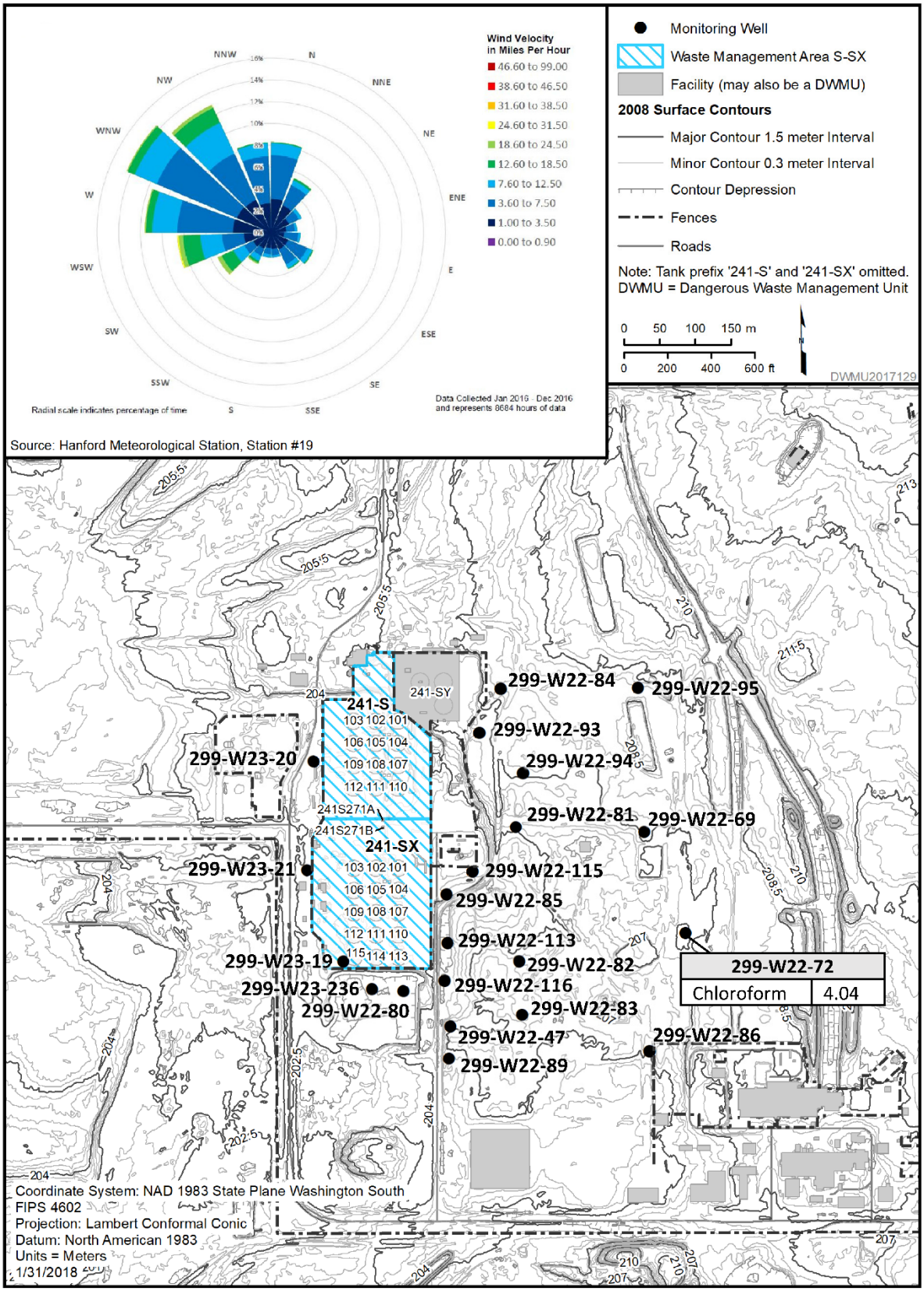

Figure D-5. 2016 Maximum Detected Groundwater Results of Organics in WMA S-SX Network Wells (µg/L)

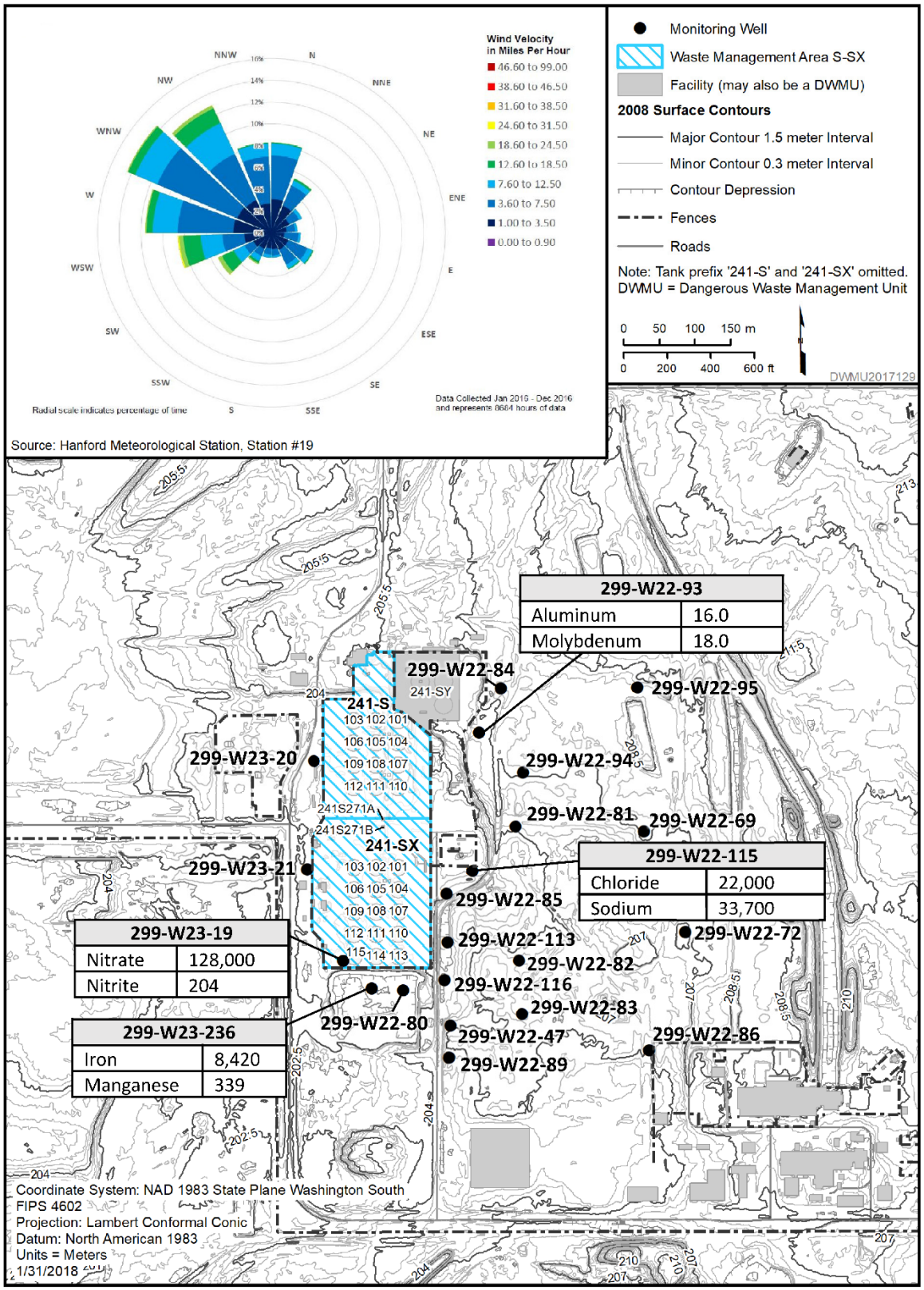

Figure D-6. 2016 Maximum Detected Groundwater Results of Nondangerous Constituents in WMA S-SX Network Wells (µg/L)

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Appendix E

Well As-Built Diagrams

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Contents

E1 Introduction E-1

E2 Reference E-31

Figures

Figure E-1. Well 299-W22-80 Construction and Completion Summary E-3
Figure E-2. Well 299-W22-81 Construction and Completion Summary E-5
Figure E-3. Well 299-W22-84 Construction and Completion Summary E-6
Figure E-4. Well 299-W22-85 Construction and Completion Summary E-8
Figure E-5. Well 299-W22-93 Construction and Completion Summary E-10
Figure E-6. Well 299-W22-94 Construction and Completion Summary E-14
Figure E-7. Well 299-W22-113 Construction and Completion Summary E-17
Figure E-8. Well 299-W22-115 Construction and Completion Summary E-19
Figure E-9. Well 299-W22-116 Construction and Completion Summary E-23
Figure E-10. Well 299-W23-19 Construction and Completion Summary E-27
Figure E-11. Well 299-W23-20 Construction and Completion Summary E-28
Figure E-12. Well 299-W23-21 Construction and Completion Summary E-30

Tables

Table E-1. Hydrogeologic Monitoring Unit Classification Scheme E-1
Table E-2. Sampling Interval Information for Wells within the WMA S-SX Network E-1

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E1 Introduction

This appendix provides the following information for the existing Waste Management Area (WMA) S-SX 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

Figures E-1 through E-12 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 S-SX 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-W22-80	TU	137.49 (451.08)	126.79 (415.98)	10.7 (35.1)	Air Rotary
299-W22-81	TU	136.78 (448.75)	126.14 (413.85)	10.64 (34.91)	Cable Tool
299-W22-84	TU	137.08 (449.74)	126.41 (414.73)	10.67 (35.01)	Cable Tool
299-W22-85	TU	137.51 (451.15)	126.87 (416.24)	10.64 (34.91)	Cable Tool
299-W22-93	TU	132.3 (434.06)	121.63 (399.05)	10.67 (35.01)	Becker Hammer
299-W22-94	TU	133.16 (436.88)	122.5 (401.9)	10.66 (34.97)	Cable Tool/Air Rotary
299-W22-113	TU	132.75 (435.53)	123.57 (405.41)	9.18 (30.12)	Auger/Cable Tool
299-W22-115	TU	133.26 (437.2)	122.56 (402.1)	10.7 (35.1)	Auger
299-W22-116	TU	132.54 (434.84)	121.87 (399.84)	10.67 (35.01)	Auger
299-W23-19	TU	138.27 (453.64)	128.94 (423.03)	9.33 (30.61)	Air Rotary with Sonic
299-W23-20	TU	138.33 (453.84)	126.75 (415.85)	11.58 (37.99)	Air Rotary
299-W23-21	TU	137.78 (452.03)	126.48 (414.96)	11.3 (37.07)	Cable Tool

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

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

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

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

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary Csg. Hamme	Sample Method:	Grab/Split Spoon
Drilling Fluid Used:	Air	Additives Used:	None
Driller's Name:	M. Wraspir	WA State Lic Nr:	1909
Drilling Company:	RSI	Company Location:	Woodland, Ca.
Date Started:	01Sep00	Date Completed:	11Sep00

WELL NUMBER:	299-W22-80	C3115	TEMPORARY WELL NO: Not Allowed
Coordinates: N	Not documented		
Coordinates: E	Not documented		
Start Card #:	R043398		
Elevation Ground Surface:			

Depth to Water: 205.29 ft. ft 11Sep00
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.2 ft.

Type of Surface Seal: 4x4 Concrete Pad

0 - 12 ft : Slightly Silty SAND

12 - 55 ft : Silty SAND

55 - 72 ft : SAND

72 - 133 ft : Silty SAND

133 - 138 ft : Silty Sandy GRAVEL

138 - 158 ft : SAND

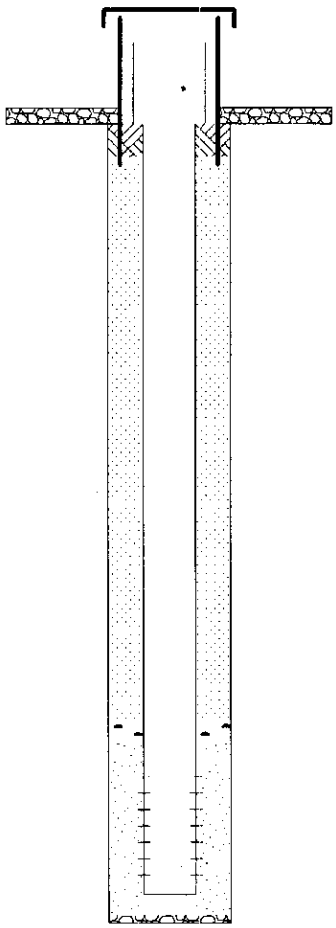
158 - 177 ft : Sandy GRAVEL

177 - 185 ft : Gravelly SAND

185 - 212 ft : Sandy GRAVEL

212 - 237 ft : Silty Sandy GRAVEL

237 - 251 ft : Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 10.2 ft : 9-inch hole Cement Surface Seal	0 - 205.03 ft : 4 inch 4" 304 SS Sch 5 csg	
10.2 - 187.1 ft : 9-inch hole Granular Bentonite		
187.1 - 194.8 ft : 9-inch hole 3/8" Bentonite Pellets		205.03 - 240.05 ft : 4 inch 4" SS Wire Wrap .020 Slot Scm.
194.8 - 248.4 ft : 9-inch hole 10/20 Silica Sand		
248.4 - 251 ft : 9-inch hole Slough	240.05 - 242.05 ft : 4 inch 4" 304 SS Sump	

251 ft : Borehole drilled depth

0 - 251 ft : 9-in. 8-5/8" CS Temp. Csg. set w/Air Rotary Casing Hammmer

Drawing By:	JEA
Reference:	Hanford Wells
Revision:	0
Revision Date:	25Sep00
Print Date:	25Sep00

Report Form: WELLS Project File: WELLS.GPJ

Figure E-1. Well 299-W22-80 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W22-80

WELL DESIGNATION	:	**299-W22-80**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**251.0 ft**
MEASURED DEPTH (GS)	:	**242.05 11Sep00**
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	:	**Air Rortary Casing Hammer 8-5/8" CS csg to 251'**
TV SCAN COMMENTS	:	

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **25Sep00**
Print Date: **25Sep00**

Report Form: WELLS Project File: WELLS.GPJ

Figure E-1. Well 299-W22-80 Construction and Completion Summary (continued)

0532885

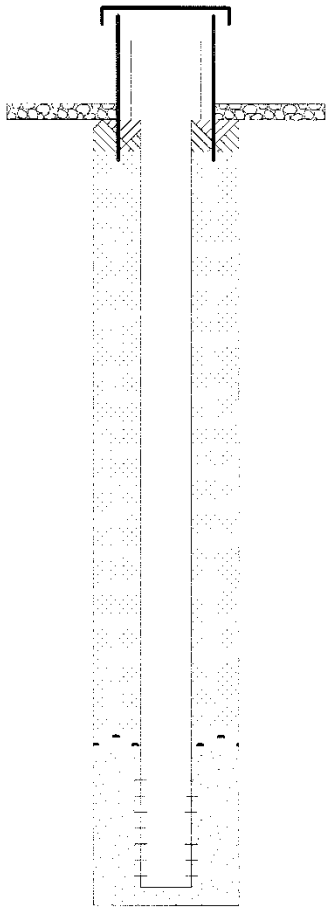
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W22-81 C3123
Drilling Fluid Used:	none	Additives Used:	water	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	Gary Howell	WA State Lic Nr:	Not Available	Coordinates: N	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	09Jan01	Date Completed:	31Jan01	Start Card #:	Not Available
				Elevation Ground Surface:	

Depth to Water: **225.9 ft. ft 26Mar01**
(Ground surface)

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 9.5 ft : Silty Sandy GRAVEL
9.5 - 19 ft : Slightly Silty SAND
19 - 34 ft : SAND
34 - 40 ft : Slightly Silty SAND
40 - 45 ft : Slightly Silt Gravelly SAND
45 - 48 ft : Silty Sandy GRAVEL
48 - 70 ft : Slightly Silty SAND
70 - 140 ft : SAND
140 - 163 ft : Silty SAND
163 - 174 ft : Silty Sandy GRAVELravel
174 - 178 ft : Silty SAND
178 - 259 ft : Silty Sandy GRAVEL
259 - 270 ft : Sandy GRAVEL



Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **11 ft.**

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

Fill	*Casing*	*Screen*
0 - 11 ft : 11-inch hole Cement Surface Seal	0 - 226.75 ft : 4 inch 4" 304L SS sch 5 csg.	
11 - 209.9 ft : 11-inch hole Granular Bentonite		
209.9 - 216.7 ft : 11-inch hole 3/8" Bentonite Pellets		226.75 - 261.72 ft : 4 inch 4" 304 SS .020 Slot Scrn.
216.7 - 263.72 ft : 11-inch hole 10/20 Silica Sand		
263.72 - 270 ft : 11-inch hole 10/20 Silica Sand	261.72 - 263.72 ft : 4 inch 4" 304L SS sump	

270 ft : Borehole drilled depth

0 - 270 ft : 11-in. 10-3/4" CS Temporary csg.

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-W22-81 Construction and Completion Summary

0540440

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W22-84 C3398
Drilling Fluid Used:	None	Additives Used:	none	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	Gary Howell	WA State Lic Nr:	1930	Coordinates: N	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	01Oct01	Date Completed:	01Nov01	Start Card #:	R037815
				Elevation Ground Surface:	

Depth to Water: 232.36 ft 02Nov01
(Ground surface)

Elevation of Reference Point: m

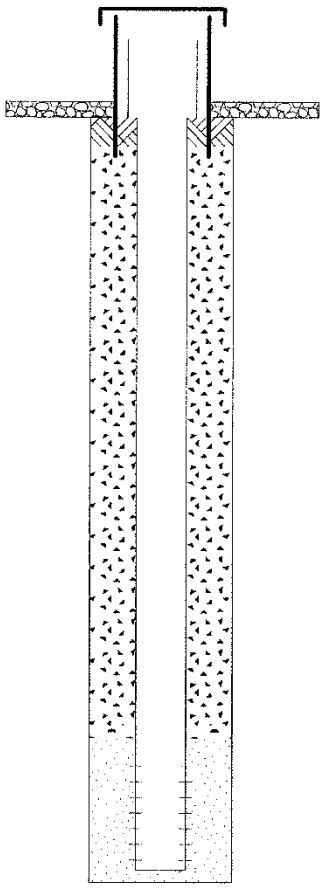
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.3 ft

Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 10 ft : Fill Material
10 - 25.3 ft : Gravelly Sand
25.3 - 39 ft : Sand
39 - 54.8 ft : Gravelly Sand
54.8 - 60 ft : Sand
60 - 70 ft : Slightly Silty Gravelly Sand
70 - 130 ft : Silty Sand w/clay lens 94 to 94.5 ft
130 - 148 ft : Sand
148 - 156 ft : Silt w/trace of sand
156 - 157 ft : Gravelly Sandy Silt
157 - 158 ft : Silty Sand
158 - 161 ft : Sand
161 - 180 ft : Silty Sand
180 - 250 ft : Silty Sandy Gravel
250 - 255 ft : Sandy Silt
255 - 265 ft : Silty Gravelly Sand
265 - 273.5 ft : Sandy Gravel



Fill	Casing	Screen
0 - 10.3 ft : 11-inch hole Cement Surface Seal	0 - 232 ft : 4 inch 304/304L SS sch 5 csg	
10.3 - 217.4 ft : 11-inch hole Bentonite Crumbles		
217.4 - 222 ft : 11-inch hole 1/4" Bentonite Pellets		232 - 267 ft : 4 inch 304/304L SS Wire Wrap .020 slot scrn
222 - 269.1 ft : 11-inch hole 10/20 Silica Sand		
269.1 - 273.5 ft : 11-inch hole 10/20 Silica Sand	267 - 269.1 ft : 4 inch 304/304L SS Sump	

273.5 ft : Borehole drilled depth

0 - 273.5 ft : 11-in. Cable Tool 10-3/4" CS Temp csg to 273.5 ft

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

Report Form: WELLS Project File: WELLS.GPJ

Figure E-3. Well 299-W22-84 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W22-84

WELL DESIGNATION	:	**299-W22-84**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**273.5 ft**
MEASURED DEPTH (GS)	:	**269.1 02Nov01**
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 273.5 ft**
TV SCAN COMMENTS	:	

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

Report Form: WELLS Project File: WELLS.GPJ

Figure E-3. Well 299-W22-84 Construction and Completion Summary (continued)

0540438

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	2399-W22-85
Drilling Fluid Used:	None	Additives Used:	None Documented	Coordinates: N	Not documented
Driller's Name:	K. Olson	WA State Lic Nr:	1217	Coordinates: E	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Start Card #:	R037815
Date Started:	21Sep01	Date Completed:	26Oct01	Elevation Ground Surface:	

TEMPORARY WELL NO: C3399 Not Allowed

Depth to Water: 218.42 ft ft 26Oct01
(Ground surface)

Elevation of Reference Point: m

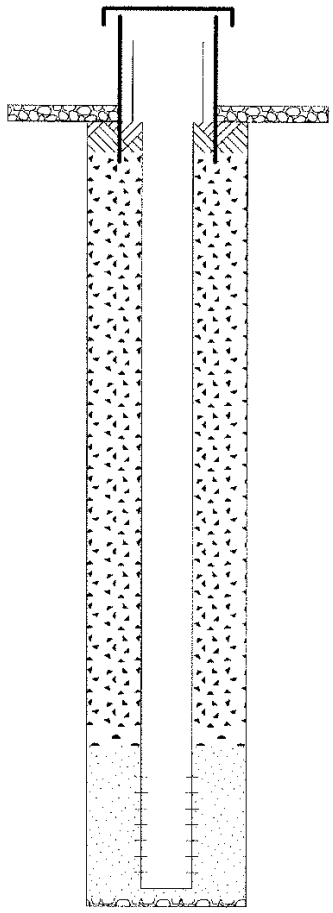
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.1 ft

Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 5 ft : Backfill material
5 - 17 ft : Sand (silt lens @16 ft)
17 - 25 ft : Sandy Silt
25 - 32 ft : Sand
32 - 45 ft : Silty Sand w/silt lens @ 35 ft
45 - 47 ft : Sandy Gravel
47 - 54 ft : Silty Sandy Grvel
54 - 57 ft : Sand
57 - 65 ft : Silty Sand w/silt lens @ 60 ft
65 - 70 ft : Sand w/silt lens @ 66 ft.
70 - 100 ft : Silty Sand w/silt lenses @ 85 and 86 ft.
100 - 104 ft : Sand
104 - 130 ft : Silty Sand
130 - 140 ft : Silt
140 - 143 ft : Sandy Silt
143 - 149 ft : Silt
149 - 151 ft : Sandy Silt
151 - 153 ft : Silt
153 - 155 ft : Caliche
155 - 162 ft : Silty Sandy Gravel
162 - 168 ft : Silty Gravelly Sand
168 - 174 ft : Sand
174 - 180 ft : Sandy Gravel
180 - 235 ft : Silty Sandy Gravel
235 - 255 ft : Gravelly Silty Sand
255 - 260.1 ft : Silty Sandy Gravel



260.1 ft : Borehole drilled depth

0 - 260.1 ft : 12-in. Cable Tool 11-3/4" CS Temp csg

Fill	*Casing*	*Screen*
0 - 10.1 ft : 12-inch hole Cement Surface Seal	0 - 217.12 ft : 4 inch 304L SS sch 5 csg	
10.1 - 202.1 ft : 12-inch hole Bentonite crumbles		
202.1 - 206.8 ft : 12-inch hole 1/4" Bentonite Pellets		217.12 - 252.03 ft : 4 inch 304L SS Wire Wrap .020 slot scrn
206.8 - 254.13 ft : 12-inch hole 10/20 Silica Sand		
254.13 - 257.5 ft : 12-inch hole 10/20 Silica Sand	252.03 - 254.13 ft : 4 inch 304L SS Sump	
257.5 - 260.1 ft : 12-inch hole Slough		

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

Report Form: WELLS Project File: WELLS.GPJ

Figure E-4. Well 299-W22-85 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 2399-W22-85

WELL DESIGNATION	:	**2399-W22-85**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**260.1 ft**
MEASURED DEPTH (GS)	:	**254.13 26Oct01**
AVAILABLE LOGS	:	**Geologist & Geophysical**
DATE EVALUATED	:	**Data not available**
EVAL RECOMMENDATION	:	**Data not available**
LISTED USE	:	**RCRA Monitoring**
CURRENT USER	:	**RCRA & Operations**
PUMP TYPE	:	**Not Documented**
MAINTENANCE	:	**Data not available**
COMMENTS	:	**Cable Tool 11-3/4" CS Temp csg to 260.1 ft.**
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

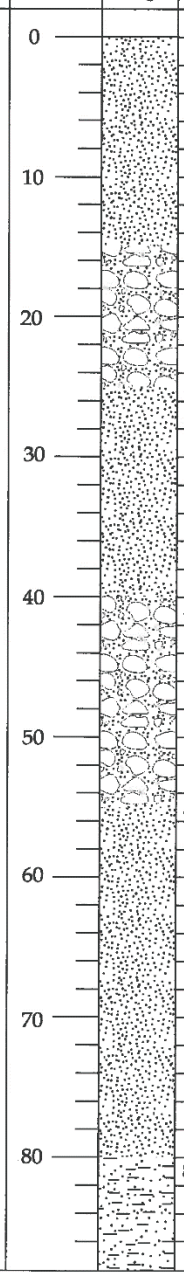
Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **08Nov01**
Print Date: **08Nov01**

Figure E-4. Well 299-W22-85 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 5/06/2015 Finish Date: ~~5/13/2015~~ 5/18/15 AJG 7/16/15	Page 1 of 4
Well ID: C8202		Well Name: 299-W22-93	
Location: 10 m E of 241 S		Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody	Date: 5/27/15	Reviewed By: MEHRER	Date: 7-22-
Signature:		Signature:	

CONSTRUCTION DATA

Description	Diagram
Concrete Pad: 0.5 ft above ground surface (ags)	
6-in Protective Casing: 2.94 ft ags - 2.06 ft below ground surface (bgs)	
Type I/II Portland Cement Grout: 0 - 10.0 ft bgs	
3/8 in Cetco Medium Bentonite Chips: 10.0 - 240.8 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.05 ft ags - 244.7 ft bgs	
Depths are in ft below ground surface. Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 288.1 ft bgs. All temporary drill casing was removed from the ground.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
0		0 - 15 Sand (S)
10		
		15 - 25 Sandy Gravel (sG)
20		
		25 - 40 Sand (S)
30		
40		40 - 55 Sandy Gravel (sG)
50		
		55 - 80 Sand (S)
60		
70		
80		80 - 100 Silty Sand (mS)

A-6003-643 (REV 1)

Figure E-5. Well 299-W22-93 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 5/06/2015 Finish Date: ~~5/13/2015~~ 5/18/15 ASG 7/16/15	Page 2 of 4
Well ID: C8202		Well Name: 299-W22-93	
Location: 10 m E of 241 S		Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody	Date: 5/27/15	Reviewed By: D. MEHRER	Date: 7-22-1
Signature:		Signature:	

CONSTRUCTION DATA

Description

3/8 in Cetco Medium Bentonite Chips: 10.0 - 240.8 ft bgs

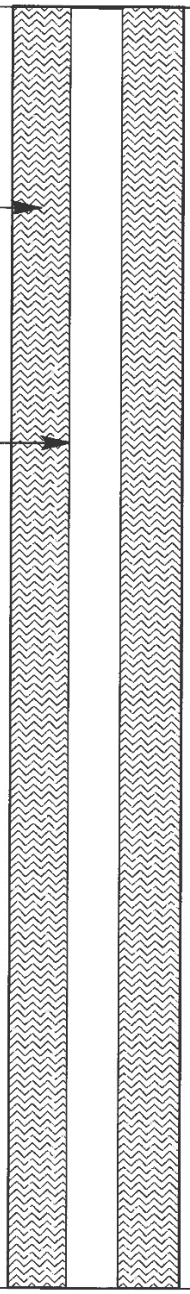
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.05 ft ags - 244.7 ft bgs

Depths are in ft below ground surface.

Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 288.1 ft bgs

All temporary drill casing was removed from the ground.

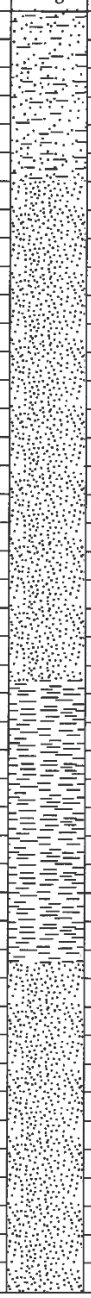
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 90, 100, 110, 120, 130, 140, 150, 160, 170

Graphic Log



Lithologic Description (ft bgs)

80 - 100 Silty Sand (mS)

100 - 135 Sand (S)

135 - 155 Silt (M)

155 - 180 Sand (S)

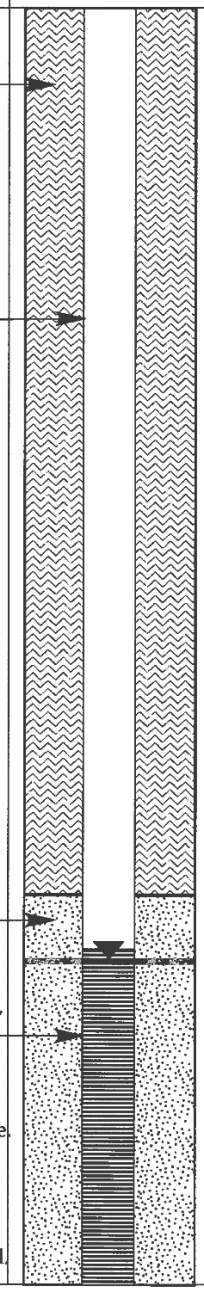
A-6003-643 (REV 1)

Figure E-5. Well 299-W22-93 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 5/06/2015 Finish Date: ~~5/13/2015~~	Page 3 of 4
Well ID: C8202	Well Name: 299-W22-93 5/18/15 RJG 7/10/15	
Location: 10 m E of 241 S	Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody Date: 5/27/15	Reviewed By: J.D. MEHRER	Date: 7-22-15
Signature:	Signature:	

CONSTRUCTION DATA

Description	Diagram
3/8 in Cetco Medium Bentonite Chips: 10.0 - 240.8 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.05 ft ags - 244.7 ft bgs	
10-20 mesh Premier Colorado Silica Filter Pack Sand: 240.8 - 288.1 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, 20-slot (0.020 in.) Stainless Steel Screen: 244.7 - 279.7 ft bgs	
Depths are in ft below ground surface.	
Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 288.1 ft bgs	
All temporary drill casing was removed from the ground.	



GEOLOGIC/HYDROLOGIC DATA

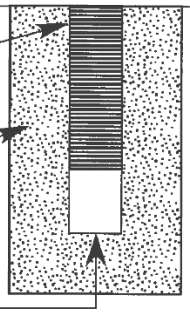
Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
180		155 - 180 Sand (S)
		180 - 190 Gravelly Sand (gS)
190		190 - 195 Silty Sandy Gravel (msG)
		195 - 200 Sandy Gravel (sG)
200		200 - 210 Gravel (G)
210		210 - 215 Sand (S)
		215 - 230 Sandy Gravel (sG)
220		
230		230 - 250 Gravel (G)
240		
		Static Water Level: 244.6 ft bgs (05/11/15)
250		250 - 255 Silty Sandy Gravel (msG)
		255 - 260 Sand (S)
260		260 - 265 Sandy Gravel (sG)
		265 - 288.1 Silty Sandy Gravel (msG)

A-6003-643 (REV 1)

Figure E-5 Well 299-W22-93 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 5/06/2015 Finish Date: ~~5/13/2015~~	Page 4 of 4
Well ID: C8202	Well Name: 299-W22-93 5/18/15 RSG 7/16/15	
Location: 10 m E of 241 S	Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody — Date: 5/27/15	Reviewed By: J.D. MEHRER — Date: 7-22-1	
Signature:	Signature:	

CONSTRUCTION DATA

Description	Diagram
4-in I.D. Schedule 10, Type 304/304L, 20-slot (0.020 in.) Stainless Steel Screen: 244.7 - 279.7 ft bgs 10-20 mesh Premier Colorado Silica Filter Pack Sand: 240.8 - 288.1 ft bgs 4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 279.7 - 284.7 ft bgs	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
270		265 - 288.1 Silty Sandy Gravel (msG)
280		
290		
		Total Depth: 288.1 ft bgs (5/6/2015)
		Straightness Test: 5/11/2015, Pass
300		
310		
320		
330		
340		
350		

Depths are in ft below ground surface.

Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 288.1 ft bgs

All temporary drill casing was removed from the ground.

A-6003-643 (REV 1)

Figure E-5 Well 299-W22-93 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 7/24/2013 Finish Date: 9/30/2013	Page 1 of 3
Well ID: C8203		Well Name: 299-W22-94	
Location: 200W Area, East of S-Tank Farm		Project: M-24 RCRA Compliance Wells	
Prepared by: Tessa Clark	Date: 11-1-13	Reviewed by: L. Craig Swanson	Date: 10/31/13
Signature:		Signature:	

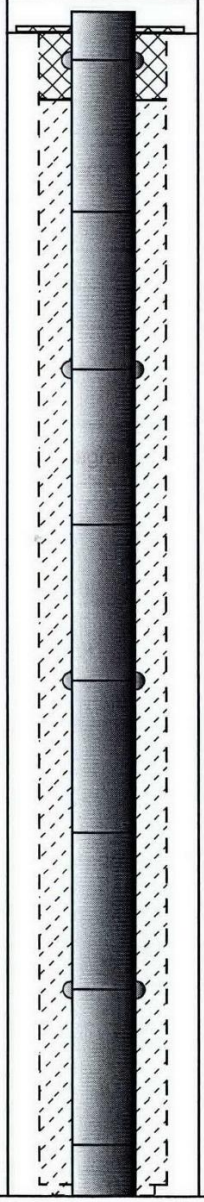
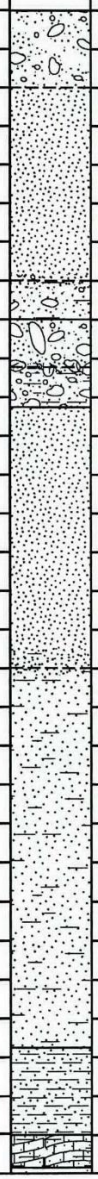
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
Surface Completion: 4'x4'x6" Concrete Pad w/brass survey marker and 6" protective monument (3 ft ags).		0		0 - 10: Gravelly Sand, gS
Concrete Surface Seal: Type I/II Portland Cement 0.0' bgs - 8.7' bgs.				10 - 35: Sand, S
Permanent Well: 4 1/2" OD Stainless Steel Blank 1.88' ags - 243.15' bgs		25		35 - 40: Gravelly Silty Sand, gmS
4 1/2" OD Stainless Steel 0.030 slot Screen 243.15' bgs - 278.18' bgs				40 - 46: Sandy Gravel, sG
				46 - 51.5: Silty Sandy Gravel, msG
4 1/2" Stainless Steel Sump w/end cap 278.18' bgs - 283.52' bgs		50		51.5 - 85: Sand, S
3/8" Granular Bentonite Chips: 8.7' bgs - 233.9' bgs		75		
3/8" Coated Bentonite Pellets: 233.9' bgs - 238.2' bgs				85 - 133.5: Slightly Silty Sand, (m)S
10-20 Colorado Silica Sand Pack: 238.2' bgs - 284.4' bgs				
Natural Backfill: 284.4' bgs - 287.1' bgs		100		
10-20 Colorado Silica Sand Pack: 287.1' bgs - 288.3' bgs				
3/8" Granular Bentonite Chips: 288.3' bgs - 341.2' bgs		125		
Natural Backfill: 341.2' bgs - 342.8' bgs				
bgs = below ground surface ags = above ground surface				133.5 - 145: Sandy Silt, sM
				145 - 149: Silty Sand, mS

Figure E-6. Well 299-W22-94 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 7/24/2013 Finish Date: 9/30/2013	Page 2 of 3
Well ID: C8203		Well Name: 299-W22-94	
Location: 200W Area, East of S-Tank Farm		Project: M-24 RCRA Compliance Wells	
Prepared by: Tessa Clark	Date: 11-1-13	Reviewed by: L. Craig Swanson	Date: 10/31/13
Signature:		Signature:	

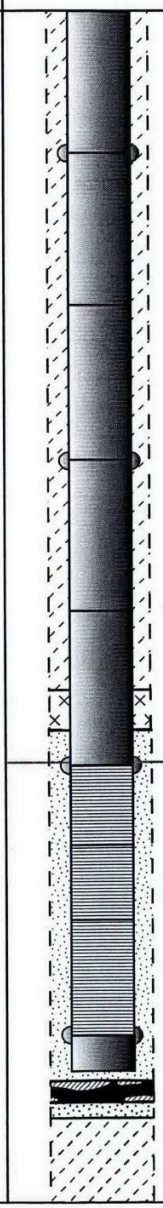
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
bgs = below ground surface ags = above ground surface		150 175 200 225 250 275		145 - 149: Silty Sand, mS 149 - 162.5: Silty Sand, mS 162.5 - 180: Sand, S 180 - 191.5: Silty Sand, mS 191.5 - 265: Silty Sandy Gravel, msG DTW = 243.1bgs (8/22/2013) 265 - 268: Gravelly Sand, gS 268 - 275: Silty Sandy Gravel, msG 275 - 285: Sand, S 285 - 288: Sandy Gravel, sG 288 - 320: Silty Sandy Gravel, msG

Figure E-6. Well 299-W22-94 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 7/24/2013 Finish Date: 9/30/2013	Page 3 of 3
Well ID: C8203		Well Name: 299-W22-94	
Location: 200W Area, East of S-Tank Farm		Project: M-24 RCRA Compliance Wells	
Prepared by: Tessa Clark	Date: 11-1-13	Reviewed by: L. Craig Swanson	Date: 10/31/13
Signature:		Signature: Hydrogeologist	

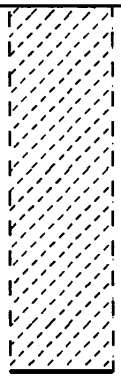
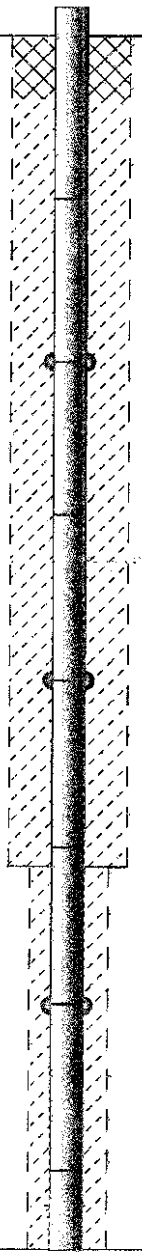
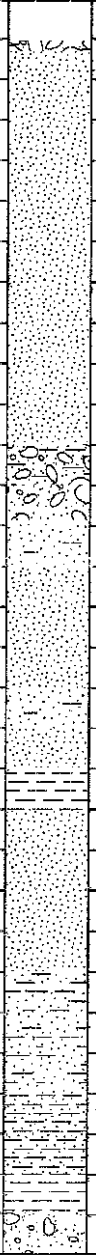
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
All temporary 8 5/8" OD casing completely removed from ground (9/27/2013). All temporary 10 3/4" OD casing completely removed from ground (9/27/2013). bgs = below ground surface ags = above ground surface		300 325 350 375 400 425		288 - 320: Silty Sandy Gravel, msG 320 - 342.8: Silty Sandy Gravel, msG TD = 342.8' bgs (9/18/2013)

Figure E-6. Well 299-W22-94 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 7-23-2014 Finish Date: 10-8-2014	Page 1 of 2
Well ID: C8943	Well Name: 299-W22-113	
Location: SE corner of WMA SX	Project: TPA M-24 Monitoring Wells	
Prepared by: Abby Wicks — Date: 10-22-14	Reviewed by: J.D. MEHRER — Date: 1-21-15	
Signature: Abby A. Wicks	Signature:	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
Temporary Casing Materials 12" Carbon Steel (11 3/4" OD, 11 5/16" ID) 0.0 ft -105 ft bgs 8" Carbon Steel (8 11/16" OD, 8 3/4" ID) 105 ft- 271ft bgs		0 25		0-1": Gravel Pad 1"-50': Sand [S]
Permanent Casing Materials 4" Type 316 L sch 10s Riser 2.00 ft ags- 233.9 ft bgs 4" Type 316 L sch10s Continuous wire wrap screen 40-slot. 233.9 ft bgs- 264.0 ft bgs 4" Type 316 L sch 10s sump 264.0 ft-267.0 ft bgs		50		50'-55': Silty Sandy Gravel [msG] 55'-60': Sandy Gravel [sG] 60'-65: Slt. Silty Sandy Gravel [(m)S] 65'-80': Sand [S]
Construction Materials Type I/II Portland Cement 0.0 ft bgs - 11.1ft bgs Medium Bentonite Chips 11.1 ft bgs- 104.2 ft bgs #8 Granular Bentonite 104.2 ft bgs- 227 ft bgs 3/8" Bentonite Pellets 227.1 ft bgs- 230.0 ft bgs Colorado Silica Sand 230.0 ft bgs -269.1 ft bgs		75 100		80'-85' Slt. Silty Sand [(m)S] 85'-90' Sand [S] 90'-95' Silt [M] 95'-115' Sand [S] 115'-130' Silty Sand [mS]
Note: All temporary casing has been removed from the ground. All depths are reported in feet below ground surface (ft bgs) unless otherwise noted.		125		130'-140' Sandy Silt [sM] 140'-145' Silt [M] 145'-155' Gravelly Sand [gS]

A-6003-643 (03/03)

Figure E-7. Well 299-W22-113 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 7-23-2014 Finish Date:10-8-2014	Page 2 of 2
Well ID: C8943		Well Name: 299-W22-113	
Location: SE corner of WMA SX		Project: TPA M-24 Monitoring Wells	
Prepared by: Abby Wicks	Date: 10-22-14	Reviewed by: J.D. MEHRER	Date: 1-21-15
Signature: Abby A. Wicks		Signature:	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
		150		145'-155' Gravelly Sand [gS]
				155'-160' Sand [S]
				160'-165' Slt. Silty Grvly Sand [(m)gS]
				165'-170' Slt. Silty Sand [(m)S]
		175		170'-172' Sand [S]
				172'-177' Gravelly Sand [gS]
				177'-200 Sandy Gravel [sG]
		200		200'-205' Slt. Silty Sand [(m)S]
				205'-238' Sandy Gravel [sG]
		225		
				238'-240' Gravelly Sand [gS]
				240'-271' Sandy Gravel [sG]
		250		
		275		TD= 271.3 ft bgs
				DTW=232.5 ft bgs 10/8/2014

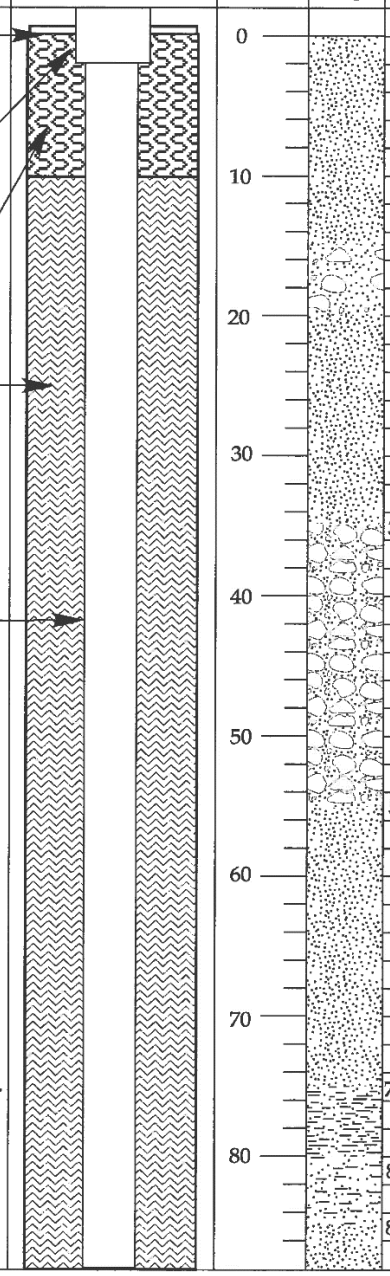
A-6003-643 (03/03)

Figure E-7. Well 299-W22-113 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 5/15/2015 Finish Date: 6/5/2015	Page 1 of 4
Well ID: C9430		Well Name: 299-W22-115	
Location: 50 m E of 241-SX		Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody	Date: 5/27/15	Reviewed By: D. MEHRER	Date: 7-27
Signature:		Signature:	

CONSTRUCTION DATA

Description	Diagram
Concrete Pad: 0.5 ft above ground surface (ags)	
6-in Protective Casing: 3.19 ft ags - 1.81 ft below ground surface (bgs)	
Type I/II Portland Cement Grout: 0 - 10.1 ft bgs	
8-20 mesh Bentonite Crumbles: 10.1 - 226.7 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.08 ft ags - 230.82 ft bgs	
Depths are in ft below ground surface. Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 271.0 ft bgs. All temporary drill casing was removed from the ground.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
0		0 - 15 Sand (S)
10		
		15 - 20 Gravelly Sand (gS)
20		20 - 35 Sand (S)
30		
		35 - 55 Sandy Gravel (sG)
40		
50		
		55 - 75 Sand (S)
60		
70		
		75 - 80 Sandy Silt (sM)
80		80 - 85 Silty Sand (mS)
		85 - 120 Sand (S)

A-6003-643 (REV 1)

Figure E-8. Well 299-W22-115 Construction and Completion Summary

WELL SUMMARY SHEET	Start Date: 5/15/2015 Finish Date: 6/5/2015	Page 2 of 4
Well ID: C9430	Well Name: 299-W22-115	
Location: 50 m E of 241-SX	Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody — Date: 5/27/15	Reviewed By: J.D. MEHRER — Date: 7-22	
Signature:	Signature:	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
8-20 mesh Bentonite Crumbles: 10.1 - 226.7 ft bgs		90		85 - 120 Sand (S)
		100		
		110		
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.08 ft ags - 230.82 ft bgs		120		120 - 125 Sandy Silt (sM)
				125 - 150 Silt (M)
		130		
		140		
		150		150 - 155 Sandy Gravel (sG)
				155 - 170 Sand (S)
		160		
Depths are in ft below ground surface.				
Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 271.0 ft bgs		170		170 - 175 Gravelly Sand (gS)
All temporary drill casing was removed from the ground.				175 - 185 Silty Sandy Gravel (msG)

A-6003-643 (REV 1)

Figure E-8. Well 299-W22-115 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 5/15/2015 Finish Date: 6/5/2015	Page 3 of 4
Well ID: C9430	Well Name: 299-W22-115	
Location: 50 m E of 241-SX	Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody	Date: 5/27/15	Reviewed By: D. MEHRER	Date: 7-22-
Signature:	Signature:	

CONSTRUCTION DATA

Description

8-20 mesh Bentonite Crumbles: 10.1 - 226.7 ft bgs

4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.08 ft ags - 230.82 ft bgs

Depths are in ft below ground surface.

Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 271.0 ft bgs

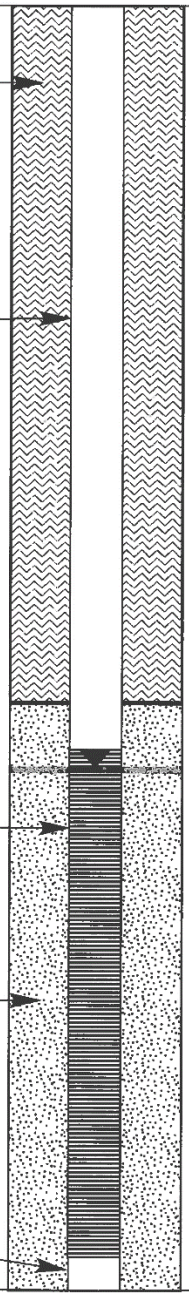
All temporary drill casing was removed from the ground.

4-in I.D. Schedule 10, Type 304/304L, 20-slot (0.020 in.) Stainless Steel Screen: 230.82 - 265.85 ft bgs

10-20 mesh Premier Colorado Silica Filter Pack Sand: 226.7 - 272.3 ft bgs

4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 265.85 - 270.86 ft bgs

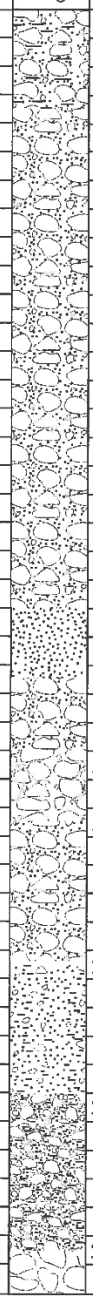
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 180, 190, 200, 210, 220, 230, 240, 250, 260

Graphic Log



Lithologic Description (ft bgs)

175 - 185 Silty Sandy Gravel (msG)

185 - 220 Sandy Gravel (sG)

220 - 225 Sand (S)

225 - 230 Sandy Gravel (sG)

230 - 235 Gravel (G)

Static Water Level: 231.2 ft bgs (5/18/15)

235 - 245 Sandy Gravel (sG)

245 - 255 Slightly Silty Gravelly Sand ((m)gS)

255 - 265 Silty Sandy Gravel (msG)

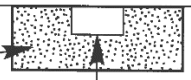
265 - 272.3 Gravel (G)

A-6003-643 (REV 1)

Figure E-8. Well 299-W22-115 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 5/15/2015 Finish Date: 6/5/2015	Page 4 of 4
Well ID: C9430		Well Name: 299-W22-115	
Location: 50 m E of 241-SX		Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody	Date: 5/27/15	Reviewed By: D. MEHRER	Date: 7-2-15
Signature:		Signature:	

CONSTRUCTION DATA

Description	Diagram
10-20 mesh Premier Colorado Silica Filter Pack Sand: 226.7 - 272.3 ft bgs 4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 265.85 - 270.86 ft bgs	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
270		265 - 272.3 Gravel (G)
		Static Water Level: 321.2 ft bgs (05/18/15)
		Total Depth: 272.3 ft bgs (05/18/15)
280		
290		
300		
310		
320		
330		
340		
350		

Depths are in ft below ground surface.
Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 271.0 ft bgs
All temporary drill casing was removed from the ground.

A-6003-643 (REV 1)

Figure E-8. Well 299-W22-115 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: ~~4/07/2015~~ 4/8/15 AJG 7/16/15	Page 1 of 4
	Finish Date: ~~5/12/2015~~ 5/11/15	

Well ID: C9431		Well Name: 299-W22-116	
Location: 25 m SE of 241 SX		Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody	Date: 5/26/15	Reviewed By: D. MEHRER	Date: 7-23-15
Signature:		Signature:	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
Concrete Pad: 0.5 ft above ground surface (ags)		0		0 - 55 Sand (S)
6-in Protective Casing: 2.92 ft ags - 2.08 ft below ground surface (bgs)		10		
Type I/II Portland Cement Grout: 0 - 10.5 ft bgs		20		
Cetco Bentonite Crumbles: 10.5 - 230.6 ft bgs		30		
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.99 ft ags - 234.99 ft bgs		40		
		50		55 - 70 Gravelly Sand (gS)
		60		
		70		70 - 120 Sand (S)
Depths are in ft below ground surface. Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 272.4 ft bgs. All temporary drill casing was removed from the ground.		80		

A-6003-643 (REV 1)

Figure E-9. Well 299-W22-116 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: ~~4/07/2015~~ 4/8/15 ~~5/11/15~~ 7/16/15 Finish Date: ~~5/12/2015~~ 5/14/15	Page 2 of 4
Well ID: C9431		Well Name: 299-W22-116	
Location: 25 m SE of 241 SX		Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody	Date: 5/26/15	Reviewed By: D. MEHRER	Date: 7-23-15
Signature:		Signature:	

CONSTRUCTION DATA

Description	Diagram
Cetco Bentonite Crumbles: 10.5 - 230.6 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.99 ft ags - 234.99 ft bgs	
Depths are in ft below ground surface.	
Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 272.4 ft bgs	
All temporary drill casing was removed from the ground.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
90		70 - 140 Sand (S)
100		
110		
120		
130		
140		140 - 145 Sandy Silt (sM)
		145 - 150 Silty Sandy Gravel (msG)
150		150 - 160 Gravelly Sand (gS)
160		160 - 165 Sand (S)
		165 - 175 Gravelly Sand (gS)
170		
		175 - 185 Sandy Gravel (sG)

A-6003-643 (REV 1)

Figure E-9. Well 299-W22-116 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: ~~4/07/2015~~ 4/8/15 ~~5/11/15~~	Page 3 of 4
	Finish Date: ~~5/12/2015~~ 5/11/15	

Well ID: C9431		Well Name: 299-W22-116	
Location: 25 m SE of 241 SX		Project: 8 M24 TPA GW Monitoring Wells FY2015	
Prepared By: Jessa Szecsody	Date: 5/26/15	Reviewed By: [illegible]	Date: 7-23-15
Signature:		Signature:	

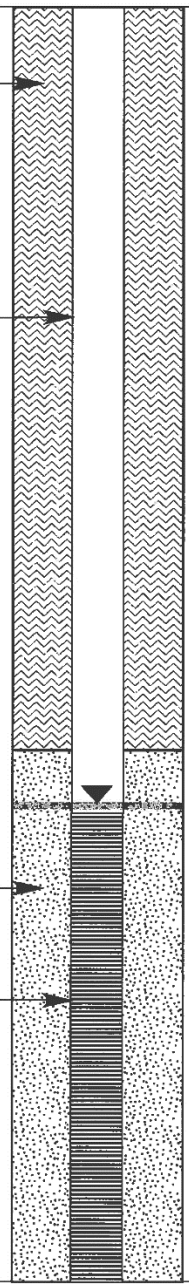
CONSTRUCTION DATA

Description	Diagram
Cetco Bentonite Crumbles: 10.5 - 230.6 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.99 ft ags - 234.99 ft bgs	
10-20 mesh Premier Colorado Silica Filter Pack Sand: 230.6 - 275.3 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, 20-slot (0.020 in.) Stainless Steel Screen: 234.99 - 270.01 ft bgs	

Depths are in ft below ground surface.

Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 272.4 ft bgs

All temporary drill casing was removed from the ground.



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
180		175 - 185 Sandy Gravel (sG)
		185 - 190 Sand (S)
190		190 - 230 Sandy Gravel (sG)
200		
210		
220		
230		230 - 275.3 Gravel (G)
		Static Water Level: 234.6 ft bgs (04/20/15)
240		
250		
260		

A-6003-643 (REV 1)

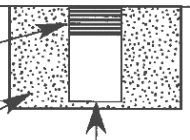
Figure E-9. Well 299-W22-116 Construction and Completion Summary (continued)

4/8/15 AJG 7/16/15

WELL SUMMARY SHEET	Start Date: ~~4/07/2015~~ 5/11/15 Finish Date: ~~5/12/2015~~	Page 4 of 4

Well ID: C9431	Well Name: 299-W22-116
Location: 25 m SE of 241 SX	Project: 8 M24 TPA GW Monitoring Wells FY2015
Prepared By: Jessa Szecsody — Date: 5/26/15	Reviewed By: D. DIEHLER — Date: 7-23-15
Signature:	Signature:

CONSTRUCTION DATA

Description	Diagram
4-in I.D. Schedule 10, Type 304/304L, 20-slot (0.020 in.) Stainless Steel Screen: 234.99 - 270.01 ft bgs 10-20 mesh Premier Colorado Silica Filter Pack Sand: 230.6 - 275.3 ft bgs 4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 270.01 - 275.01 ft bgs	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
270		230 - 275.3 Gravel (G)
280		
290		Straightness Test: 04/20/2015, Pass Total Depth: 275.3 ft bgs (4/9/2015)
300		
310		
320		
330		
340		
350		

Depths are in ft below ground surface.

Borehole drilled with 8 7/8-in O.D. casing from 0.0 - 272.4 ft bgs

All temporary drill casing was removed from the ground.

A-6003-643 (REV 1)

Figure E-9. Well 299-W22-116 Construction and Completion Summary (continued)

0527804

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary and Sonic	Sample Method:	Split Spoon	WELL NUMBER:	299-W23-19 B8809
Drilling Fluid Used:	N/A	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	Wesley Worth	WA State Lic Nr:	2273	Coordinates: N	Not documented
Drilling Company:	Resonant Sonic Intl.	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	02Aug99	Date Completed:	17Nov99	Start Card #:	R42661
				Elevation Ground Surface:	Brass Marker

Depth to Water: 211.8 ft. 28Sep99
(Ground surface) 211.6 ft 04Nov99

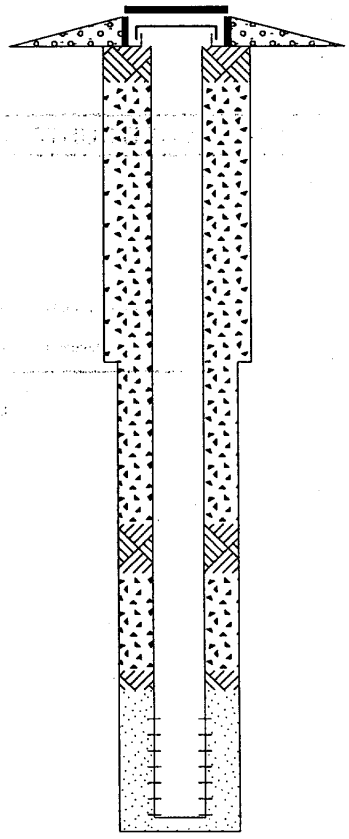
GENERALIZED STRATIGRAPHY Geologist's Log

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 11.19 ft.

Type of Surface Seal: Subsurface Completion



Fill	*Casing*	*Screen*
0 - 11.19 ft : 11-inch hole Cement Surface Seal	0.6 - 211.6 ft : 4 inch 4" SS Sch. 40 Csg.	
11.19 - 99.04 ft : 11-inch hole Bentonite Crumbles		
99.04 - 149.73 ft : 9-inch hole Bentonite Crumbles		
149.73 - 165.08 ft : 9-inch hole Cement Grout Seal		
165.08 - 195.58 ft : 9-inch hole Bentonite Crumbles		210.66 - 241.3 ft : 4 inch 4" SS .020 Slot Wire Wrap Screen
195.48 - 201.48 ft : 9-inch hole Cement Grout Seal		
201.48 - 244.26 ft : 9-inch hole 10/20 Silica Sand	241.3 - 241.6 ft : 4 inch 4" SS End Cap	
244.26 - 246 ft : 9-inch hole 10/20 Silica Sand		

246 ft : Borehole drilled depth

0 - 99.04 ft : 10.75-in. 10-3/4" CS Temp. Csg. set at 99.04
99.04 - 246 ft : 8.62-in. 8-5/8" CS. Temp. Csg. set 243.86 ft.

Drawing By: JEA
Reference: Hanford Wells
Revision: B
Revision Date: 14Oct99
Print Date: 06Dec99

Report Form: WELLS Project File: WELLS.GPJ

Figure E-10. Well 299-W23-19 Construction and Completion Summary

0526561

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary Csg. Hamme	Sample Method:	Grab/Split Spoon
Drilling Fluid Used:	Air	Additives Used:	None
Driller's Name:	M. Wraspir	WA State Lic Nr:	1909
Drilling Company:	RSI	Company Location:	Woodland, Ca.
Date Started:	27Jul00	Date Completed:	21Aug00

WELL NUMBER:	299-W23-20	C3112	TEMPORARY WELL NO: Not Allowed
Coordinates: N	Not documented		
Coordinates: E	Not documented		
Start Card #:	R043398		
Elevation Ground Surface:			

Depth to Water: **214.29 ft ft 15Aug00**
(Ground surface)

Elevation of Reference Point: m

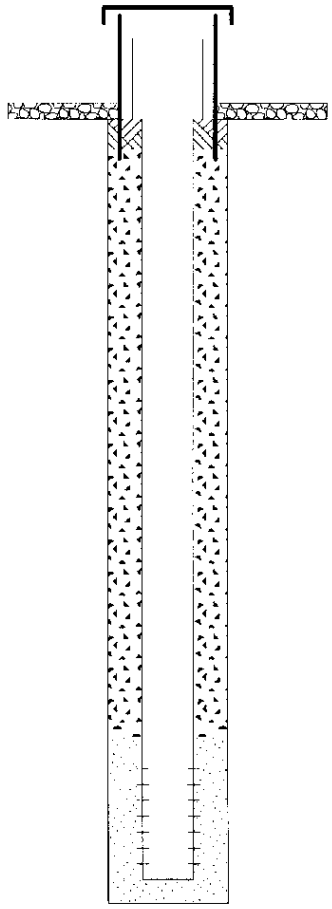
Height of Reference Point Above Ground Surface:

Depth of Surface Seal:

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

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 6 ft : Silty Sandy GRAVEL
6 - 19 ft : Sandy GRAVEL
19 - 34 ft : Gravvelly SAND
34 - 36 ft : Sandy GRAVEL
36 - 55 ft : SAND
55 - 83 ft : SAND
83 - 87 ft : Gravelly SAND
87 - 94 ft : SAND
94 - 102 ft : Gravelly SAND
102 - 117 ft : SAND
117 - 139 ft : Slightly Silty SAND
139 - 148 ft : No Returns
148 - 153 ft : Silty SAND
153 - 157 ft : Silty Sandy GRAVEL (w/caliche)
157 - 169 ft : No Returns
169 - 184 ft : Silty Sandy GRAVEL
184 - 220 ft : Sandy GRAVEL
220 - 260.5 ft : Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 10 ft : 9-inch hole Cement Surface Seal	0 - 215.5 ft : 4 inch 4" 304L SS Sch 5 csg.	
10 - 200.1 ft : 9-inch hole Bentonite Crumbles		
200.1 - 205 ft : 9-inch hole Bentonite Pellets		215.5 - 250.5 ft : 4 inch 4" SS Wire Wrap .020 slot scrn.
205 - 252.5 ft : 9-inch hole 10/20 Silica Sand		
252.5 - 260.5 ft : 9-inch hole 10/20 Silica Sand	250.5 - 252.5 ft : 4 inch 4" SS Sump	

260 ft : Borehole drilled depth

0 - 206.5 ft : 9-in. 8-5/8" CS csg. set with Air Rotary csg hammer

Report Form: WELLS Project File: WELLS.GPJ

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

Figure E-11. Well 299-W23-20 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W23-20

WELL DESIGNATION	:	**299-W23-20**
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	**260.0 ft**
MEASURED DEPTH (GS)	:	**260.5 15Aug00**
AVAILABLE LOGS	:	**Geologist**
DATE EVALUATED	:	**Data not available**
EVAL RECOMMENDATION	:	**Data not available**
LISTED USE	:	**RCRA monitoring/sampling**
CURRENT USER	:	**RCRA & Operations**
PUMP TYPE	:	**Hydrostar**
MAINTENANCE	:	**Data not available**
COMMENTS	:	**8-5/8" CS Temp. csg set w/Air Rotary Csg. Hammer**
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-11. Well 299-W23-20 Construction and Completion Summary (continued)

0532877

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W23-21 C3113
Drilling Fluid Used:	none	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	M. Wraspir	WA State Lic Nr:	1909	Coordinates: N	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	26Sep00	Date Completed:	07Nov00	Start Card #:	Not Available
				Elevation Ground Surface:	

Depth to Water: 212.88 ft 03Nov00
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 0.5 ft : Gravel
0.5 - 8.5 ft : Sand
8.5 - 20 ft : Sand to Slightly Silty Sand
20 - 36.8 ft : Sandy GRAVEL

36.8 - 38.5 ft : Silty SAND
38.5 - 40 ft : Slightly Gravelly SAND
40 - 80 ft : SAND

80 - 83 ft : Gravelly SAND
83 - 88 ft : Silty SAND
88 - 99 ft : Gravelly SAND
99 - 120.5 ft : SAND

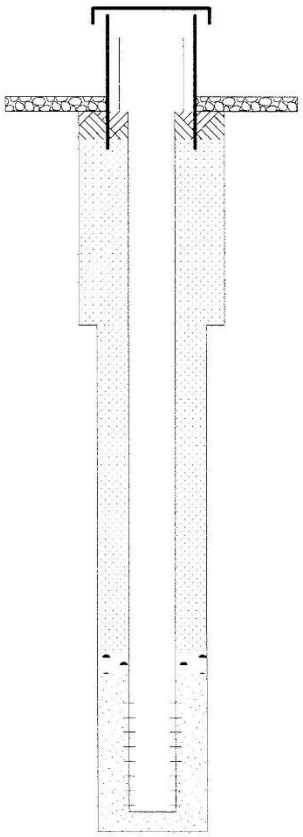
120.5 - 130.5 ft : Silty SAND

130.5 - 131.5 ft : Sandy SILT
131.5 - 139 ft : Silty SAND
139 - 141.5 ft : Slightly Silty SAND
141.5 - 143.5 ft : Silty SAND
143.5 - 147 ft : Slightly Silty SAND
147 - 153 ft : Sandy Silt
153 - 158 ft : Slightly Silty Gravelly SAND
158 - 168 ft : SAND
168 - 189 ft : Sandy GRAVEL

189 - 193 ft : Slightly Silty Gravelly SAND
193 - 197.5 ft : Gravelly Silty SAND
197.5 - 204 ft : Gravelly Sandy SILT
204 - 214 ft : Silty Sandy GRAVEL
214 - 219 ft : Gravelly Sandy SILT
219 - 240 ft : Silty Sandy GRAVEL

240 - 255 ft : Sandy GRAVEL

255 - 259 ft : Gravelly Silty SAND



259 ft : Borehole drilled depth

0 - 76.41 ft : 12-in. 11-3/4" CS Temp csg set w/Cable Tool
76.41 - 2529 ft : 9-in. 8-5/8" CS Temp csg set w/Cable Tool

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.1 ft.

Type of Surface Seal: 4x4 Concrete Pad

Fill	*Casing*	*Screen*
0 - 10.1 ft : 12-inch hole Cement Surface Seal	0 - 212.58 ft : 4 inch 4" 304L SS csg	
10.1 - 76.41 ft : 12-inch hole Granular Bentonite		
76.41 - 193.7 ft : 9-inch hole Granular Bentonite		
193.7 - 202 ft : 9-inch hole Bentonite pellets		212.58 - 249.69 ft : 4 inch 4" 304 SS Wire Wrap .020 slot scrn.
202 - 251.87 ft : 9-inch hole 10/20 Silica Sand		
251.87 - 259 ft : 9-inch hole 10/20 Silica Sand	249.69 - 251.87 ft : 4 inch 4" SS Sump	

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

Report Form: WELLS Project File: WELLS.GPJ

Figure E-12. Well 299-W23-21 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/.

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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 S-SX Monitoring Network – ECF-200W-17-0076

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The calculation ECF-200W-17-0076, *Groundwater Flow and Migration Calculations to Support Assessment of the WMA S-SX Monitoring Network,* was performed to evaluate monitoring well locations for the Waste Management Area S-SX groundwater monitoring network. The calculation is available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065254H.

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Appendix H

Statistical Method Determination

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Contents

H1 Introduction H-1

H2 Reference H-10

Figures

Figure H-1. Data Evaluation H-2
Figure H-2. Outlier Test Evaluation H-3
Figure H-3. Intrawell/Interwell Assessment H-4
Figure H-4. Spatial Variance Evaluation H-5
Figure H-5. Data Distribution Evaluation H-6
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.

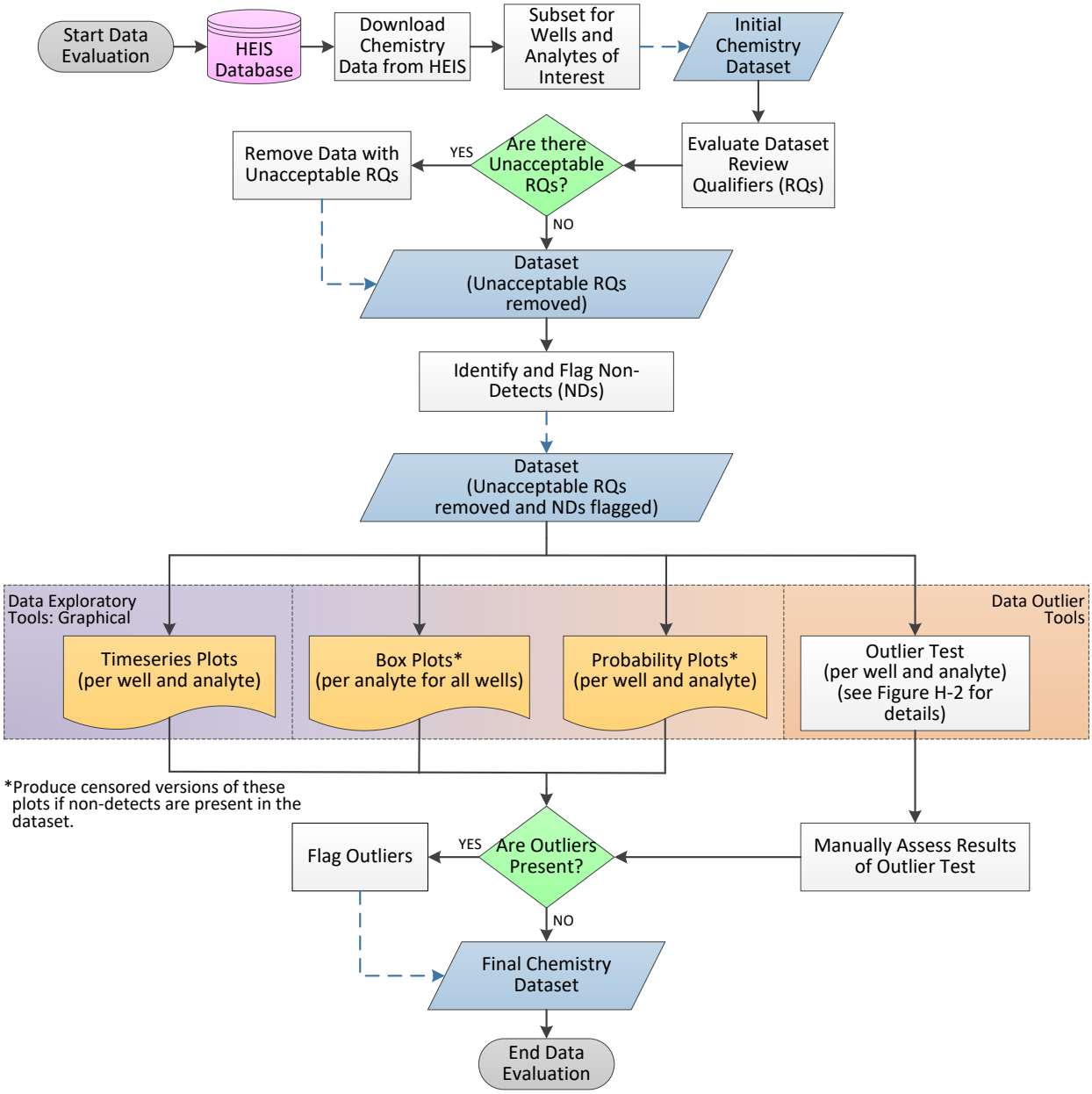

Figure H-1. Data Evaluation

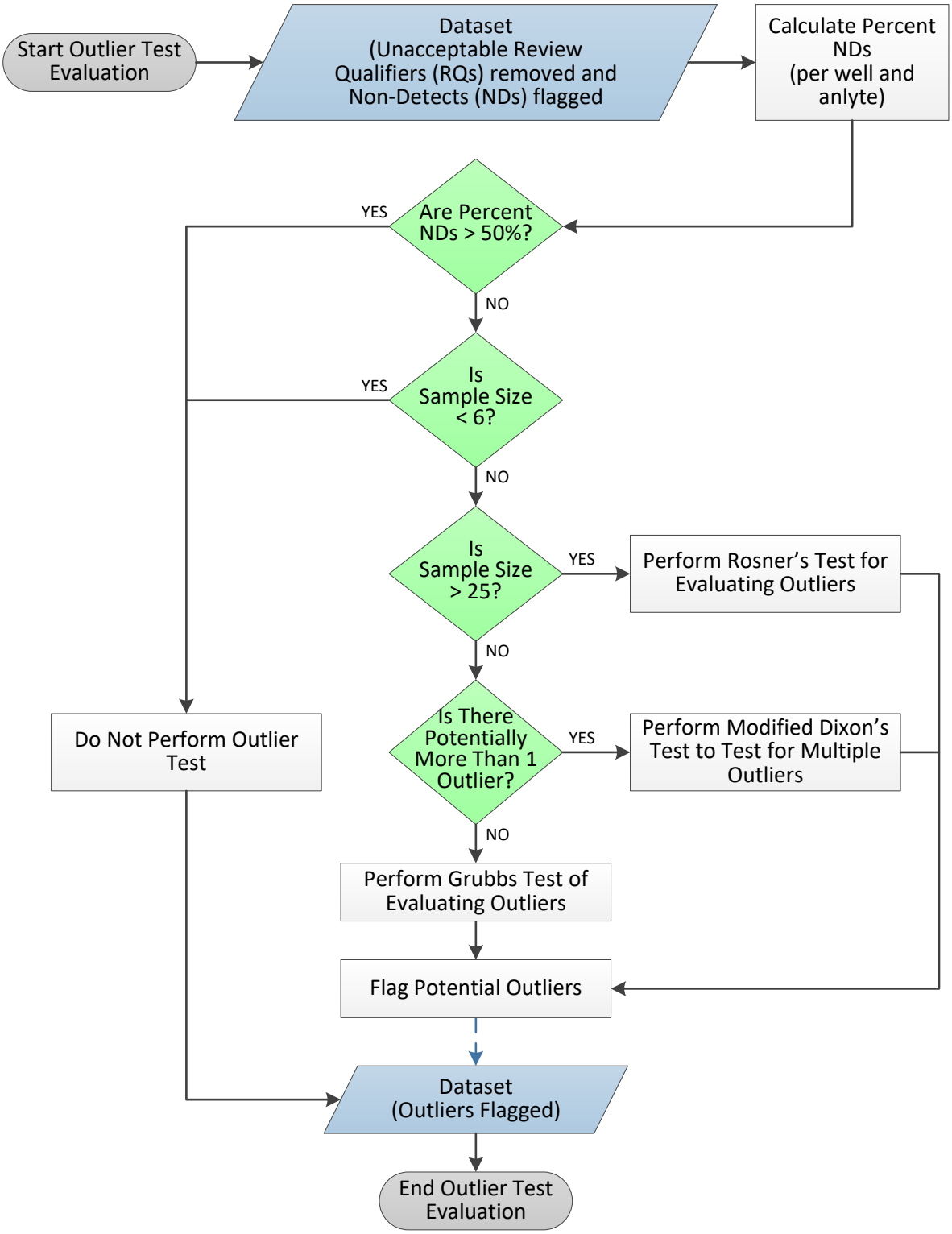

Figure H-2. Outlier Test Evaluation

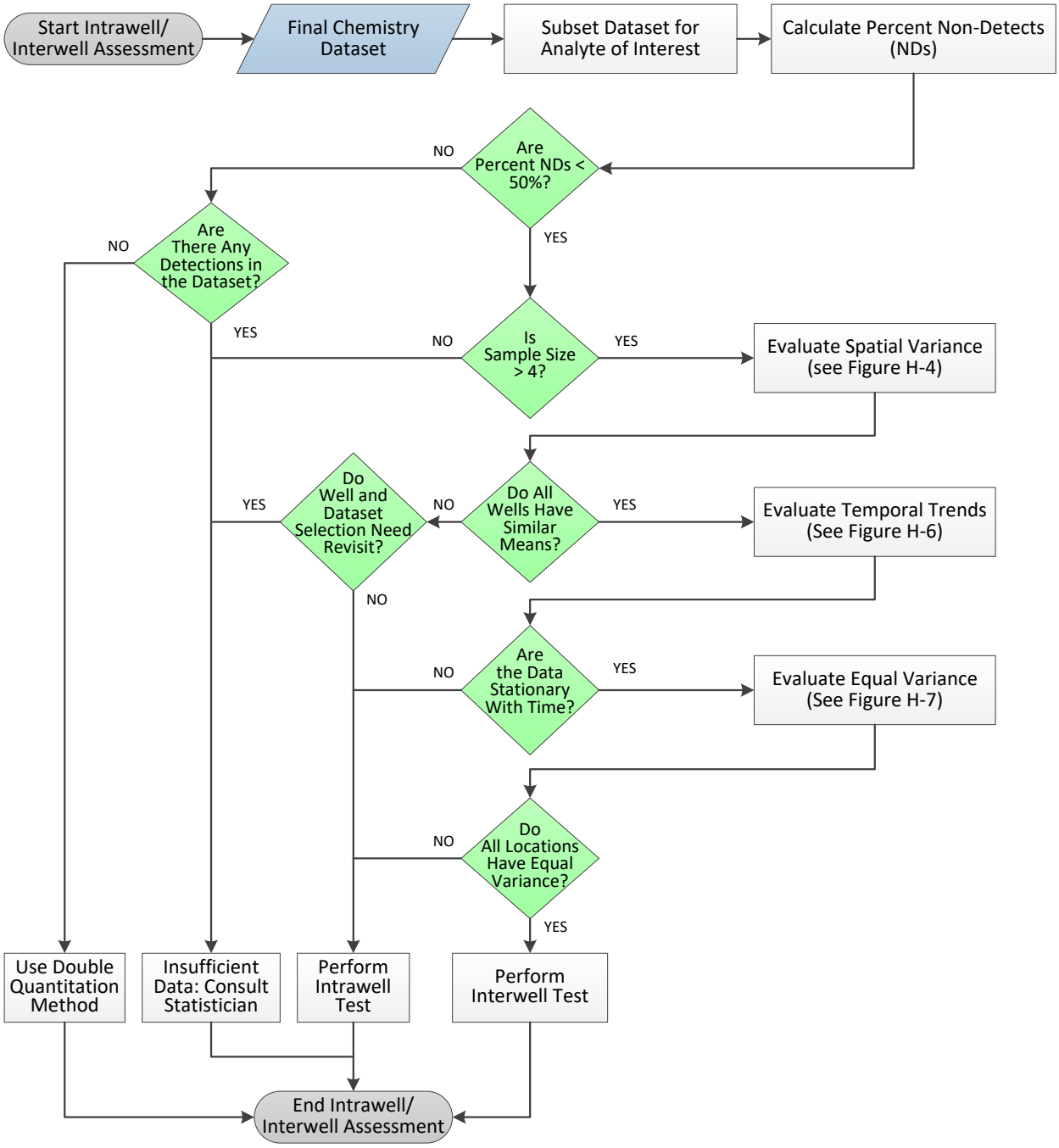

Figure H-3. Intrawell/Interwell Assessment

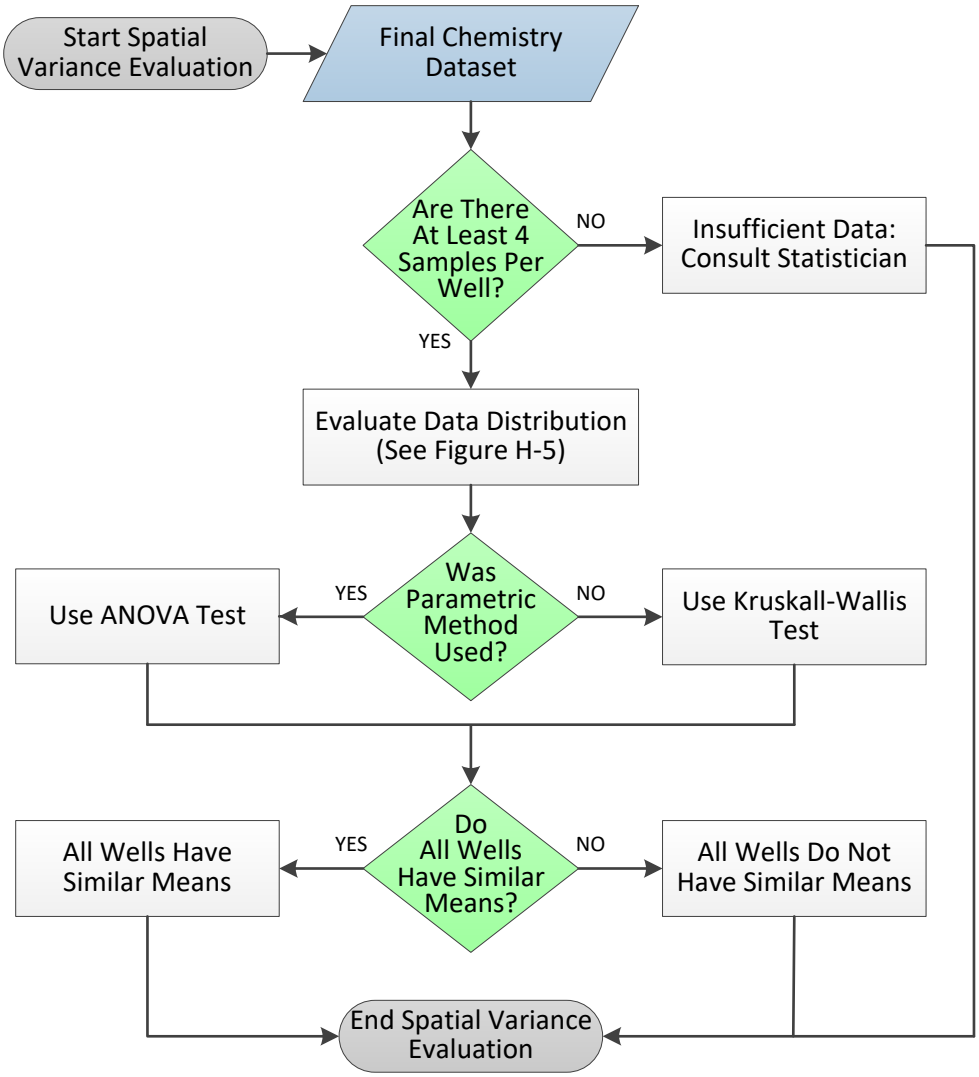

Figure H-4. Spatial Variance Evaluation

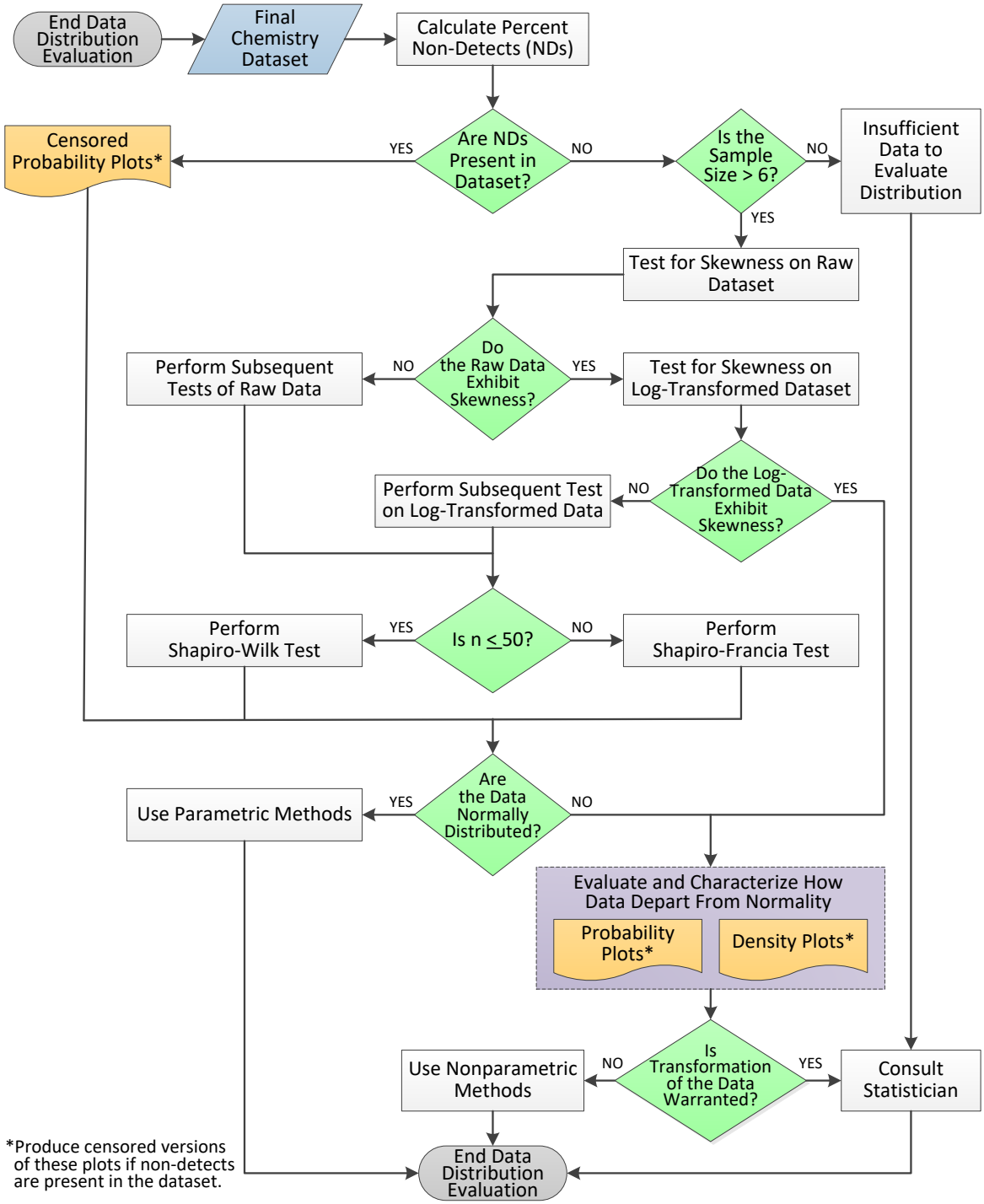

Figure H-5. Data Distribution Evaluation

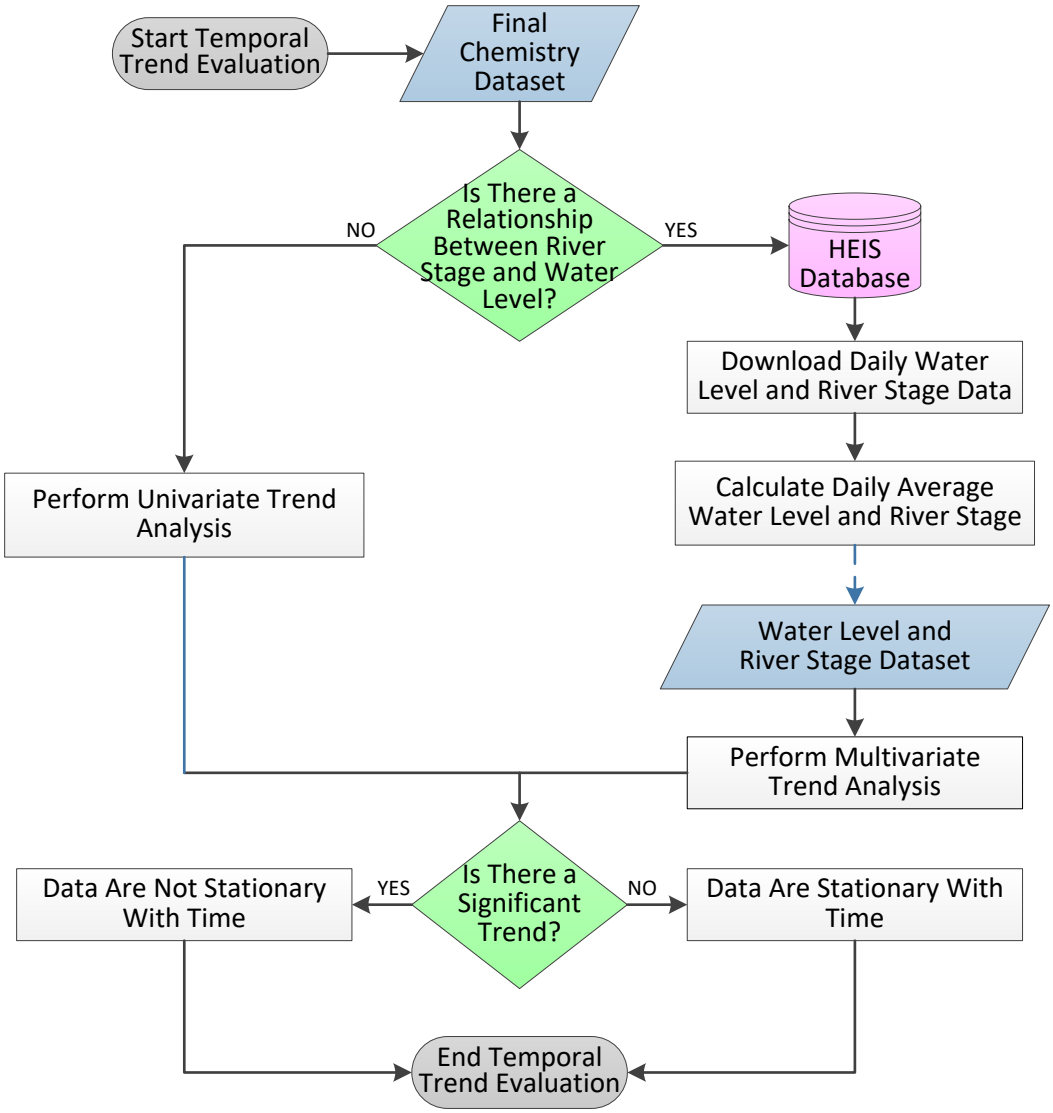

Figure H-6. Temporal Trend Analysis

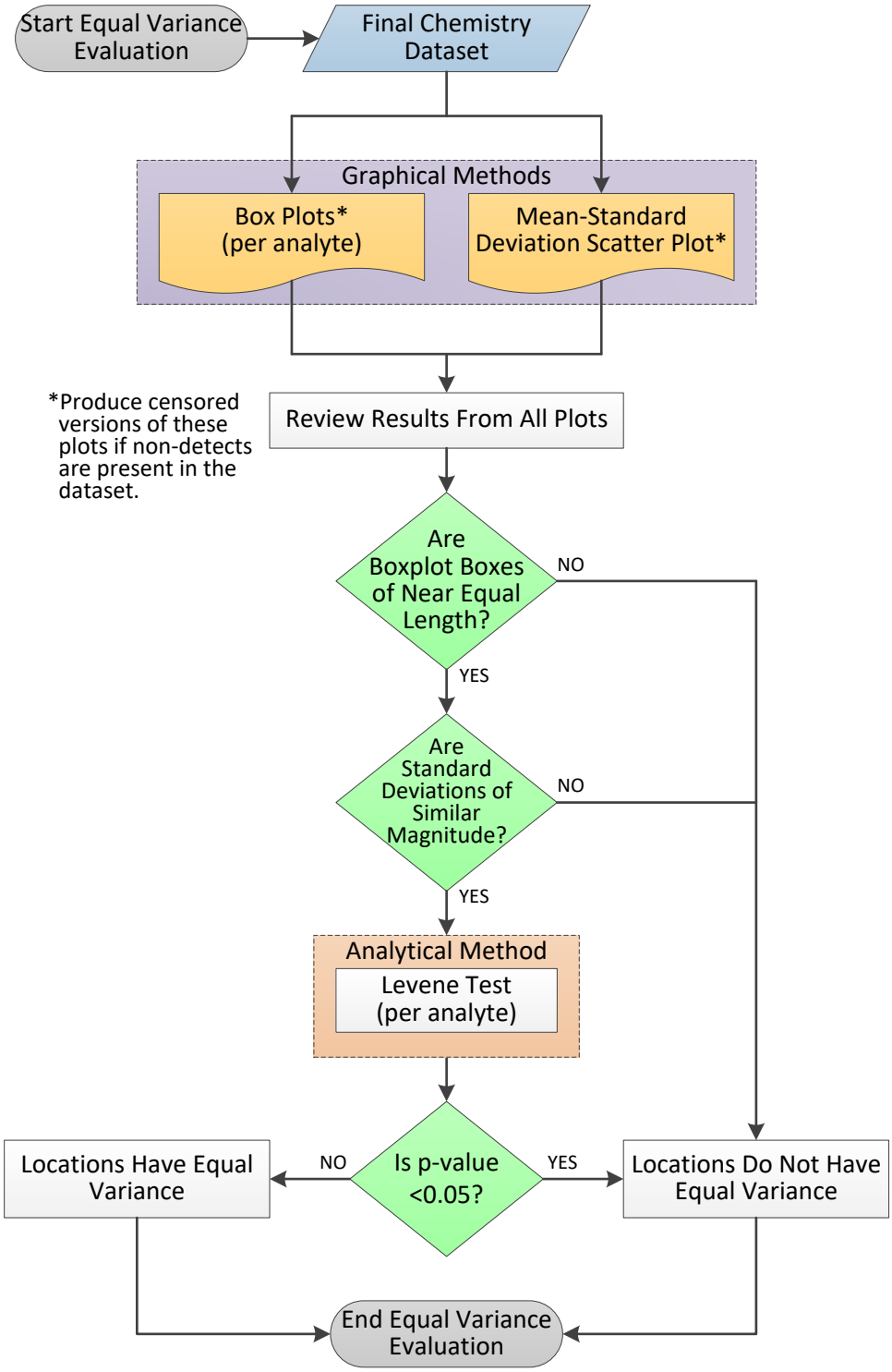

Figure H-7. Equal Variance Evaluation

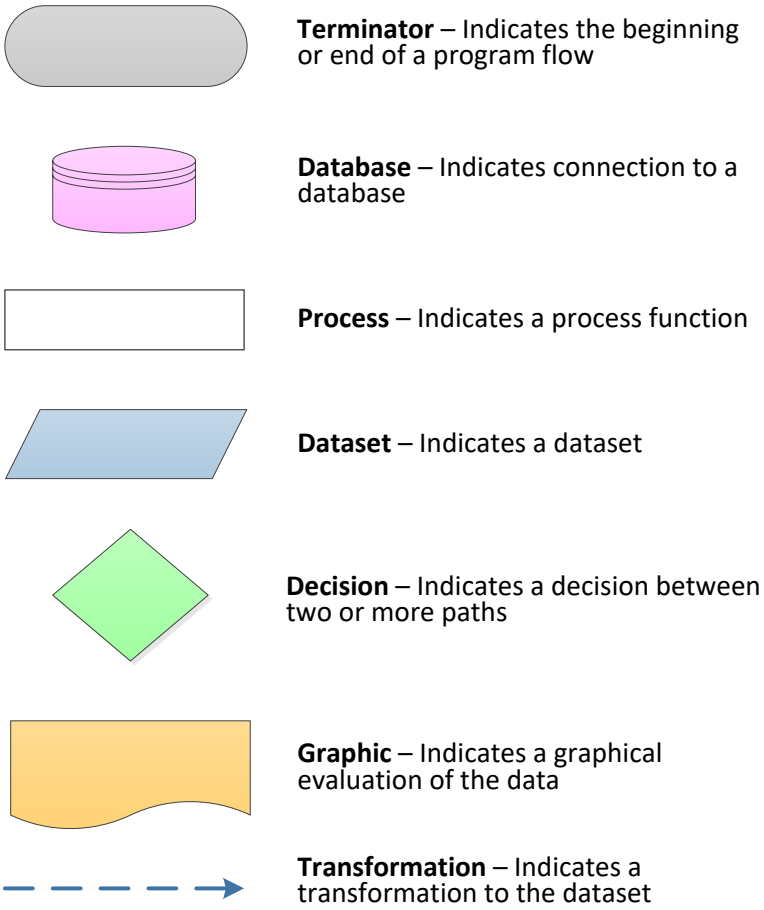

Figure H-8. Chart Legend

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: January 17, 2018 Dispositioned: February 2, 2018 and March 8, 2018 RCR Closed: March 8, 2018 Page 1 of 5

Document Title(s)/Number(s): Engineering Evaluation Report for Single-Shell Tank Waste Management Area S-SX Groundwater Monitoring/SGW-60577

Document Lead/Phone #/email: Dwayne Crumpler/509-372-7925/dcru461@ecy.wa.gov | **Project Manager/Phone #/email:** Jeff Lyon/509-372-7114/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, T and TX-TY EERs. Basis/Justification: Previous relevant comments need to be incorporated into this document.		Accept. Modifications made.	Accept.	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.	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." Same as Item 31 WMA T	Accept.	C 2/2/2018 Redline reviewed.	ALL
Item 3 P: 2-15 L: 1-2	Comment: This identifies well 299-W23-3 as both an upgradient and downgradient well. The Table 3-6 in WHC-SD-EN-AP-012, Rev. 0 identifies 299-W23-4 as an upgradient well. Basis/Justification:		Accept. Change upgradient 299-W23-3 to 299-W23-4 as shown. Text change: "…three upgradient wells (299-W23-~~43~~, 299-W23-8, and 299-W23-13) and nine downgradient wells…"	Accept.	C 2/2/2018 Redline reviewed.	SPL
Item 4 P: 4-3 L: 24-28	Comment: This does not state anything regarding the lateral extent of the chromium plume. This is important because chromium is the major dangerous constituent that this plan will address. Basis/Justification:		No change to text, see also Item 10. Some far-field wells are monitored annually for Cr and Cr-6 as part of the 200-UP-1 CERCLA remedy (DOE/RL-2015-14, R0). Data from the CERCLA program are integrated in plume mapping activities. The proposed RCRA monitoring network is set up to monitor at the point of compliance. Discussion in 2/2/2018 meeting on how to approach this topic. AEA/RCRA integration through the CERCLA remedial action and alternative requirements.	Accept.	C 2/2/2018 No change.	SPL
Item 5 P: 4-3	Comment: This states depth-discrete sampling while drilling 299-W22-47 indicated that chromium was present		Accept with modification.	Accept.	C	SPL

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NOTE: Text changes shown in DOE Responses may be modified slightly in the final document due to production editing.
EERs = Engineering Evaluation Reports

Review Comment Record	Washington State Department of Ecology Nuclear Waste Program Cleanup Section/ER Project	Received: January 17, 2018 Dispositioned: February 2, 2018 and March 8, 2018 RCR Closed: March 8, 2018 Page 2 of 5

Document Title(s)/Number(s): Engineering Evaluation Report for Single-Shell Tank Waste Management Area S-SX Groundwater Monitoring/SGW-60577

Document Lead/Phone #/email: Dwayne Crumpler/509-372-7925/dcru461@ecy.wa.gov | **Project Manager/Phone #/email:** Jeff Lyon/509-372-7114/jeff.lyon@ecy.wa.gov

Item # Page # Section # Line #s	Comment and Basis/Justification	Modification Needed	DOE Response	Ecology Response	O/C	Reviewer (Initials)
L: 28-30	within the upper 20 m (65 ft) of the aquifer (Section 3.4 in DOE/RL-2016-66, Rev. 0). The engineering report does not provide any other information regarding the vertical extent of contamination. General comment regarding the approach. The simulations are performed under the assumption that all releases are in the future. I don't see how compliance monitoring of existing contaminant plumes is addressed by the simulations or the conclusions. Basis/Justification:		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." Additional text added in Section 4.5 addressing vertical data, including chromium. Same as Item 31 WMA T		3/8/2018 Redline reviewed.	
Item 6 P: 7-26 L: 1st paragraph and Figures 7-44 and 7-45	Comment: The release unit plume maps for scenario 1 and scenario 2 don't show influence of the extraction wells, whereas the relative detectability maps on Figure 7-50 and 7-51 do show the influence of the extraction wells. Does the modeling that produces the release unit plume maps (Figures 7-44 and 7-45) not include the influence of extraction wells? I don't believe the differences are due to the interpolation process described in the 2nd paragraph. Basis/Justification:		No change to text. With the grid size used in the unit release calculations, the pumping rate in this area does not have a strong enough effect over the area of the grid cell. The model grid size is 100 and the particle tracking uses a grid size of 20.	Discussed, no changes needed.	C 2/2/2018 No change.	SPL
Item 7 P: 7-30 L: 8	Comment: This sentence makes reference to nearby injection and extraction wells. Injection wells are over 1 kilometer to the northwest. Reconsider the descriptor "nearby" in reference to the injection wells. Basis/Justification:		Accept. Changed text to read, "…the operation of injection wells and nearby extraction ~~and injection~~ wells."	Accept.	C 2/2/2018 Redline reviewed.	SPL
Item 8 P: 7-34 L: 9-11	~~Comment: This states that after the cessation of 200 West P&T system operations there is a shift in the groundwater flow from a northeastern to an eastern direction. It is important also to note that the simulation indicates pathlines do not extend much beyond the extraction well on the north end of the WMA.~~		No response required.	Comment retracted.	C 2/2/2018 No change.	SPL

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Item # Page # Section # Line #s	Comment and Basis/Justification	Modification Needed	DOE Response	Ecology Response	O/C	Reviewer (Initials)
	~~Basis/Justification:~~					
Item 9 P: 7-34 L: 14-22	Comment: Final Status Network. It may not be too important to consider the scenario 3 relative detectability in the network at this time, other than stating that will be evaluated much later, close to the completion of the pump and treat activities (Section 10?). However, if an extraction well (e.g., 299-W22-91) is shut down, the flow will change and impact the monitoring network, likely more than the scenarios based on varying injection well rates. This must be considered in some way in this report. This area is in a complex setting, as evidenced by the extreme effect extraction well W22-90 has on the flow system. Uncertainties in the model framework and the simulations may not be adequately considered or addressed. DOE cannot rely entirely on the simulations to locate wells. Current contaminant levels in groundwater must also be taken into account. Basis/Justification:		<u>No change to text.</u> Extraction rates are not varied. Section 5.2 states, "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." Evaluation of the monitoring well network on an annual basis is addressed in Chapter 10. Current contaminant levels were considered in developing the proposed monitoring well network. This was discussed in a meeting on 2/2/2018.	Discussed, no change needed.	C 2/2/2018 No change.	SPL
Item 10 P: 7-34 and elsewhere L: 17-19	Comment: The report identifies wells that will not be included. I question removing 299-W22-83 and 299-W22-95, because chromium exceeds 48 µg/L and <u>these two wells</u> are necessary to monitor plumes for compliance monitoring (whether regulated units are in compliance with the groundwater protection standard). Well 299-W22-83 exceeded 48 µg/L in 2016 and is in the center of the southern plume, and should continue to be monitored to evaluate concentrations within that plume (it also has a long history). Well 299-W22-95 chromium concentration was 55.5 µg/L in December 2016, bounds the eastern lateral extent of the north plume, and has more than doubled since 2014 and continues increasing. I don't see any other wells located downgradient that have monitored this portion of the plume. That well should continue to be evaluated.		<u>Accept.</u> Far field wells 299-W22-83 and 299-W22-95 are both monitored annually for Cr and Cr-6 as part of the 200-UP-1 CERCLA remedy (DOE/RL-2015-14, R0). Data from the CERCLA program are integrated in plume mapping activities. The proposed RCRA monitoring network is set up to monitor at the point of compliance. Discussion in 2/2/2018 meeting on how to approach this topic. AEA/RCRA integration through the CERCLA remedial action and alternative requirements.	Accept.	C 2/2/2018 No change.	SPL

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Item # Page # Section # Line #s	Comment and Basis/Justification	Modification Needed	DOE Response	Ecology Response	O/C	Reviewer (Initials)
	Basis/Justification:					
Item 11 P: G-13 S: G1.1	Comment: States in 1st paragraph, "The monitoring network is designed to detect significant increases in groundwater contamination that would result from hypothetical releases from single-shell tanks within the regulated unit." Comment: The site will be in compliance; therefore the network is designed to evaluate whether the groundwater protection standard is exceeded. Basis/Justification:		<u>No change to text.</u> Acknowledged with no change to text.	Accept.	C 2/2/2018 No change.	SPL
Item 12 P: G-13 S: 1-1	Comment: States in 1st paragraph, "The calculations evaluate the suitability of the current WMA S-SX interim status groundwater monitoring network (Figure 1-1) for detecting releases from single-shell tanks and liquid handling structures within WMA S-SX and determine if additional monitoring locations are required for detecting releases." Comment – should the calculations evaluate whether the network is suitable to evaluate whether the groundwater protection standard is exceeded? Basis/Justification:		<u>No change to text.</u> Discussed in 2/2/2018 meeting.	Discussed, no change needed.	C 2/2/2018 No change.	SPL
Item 13 P: G3-4 S: 3.2 L: 8-9	Comment: The simulated scenarios identify various conditions for the injection rates, but nothing is discussed or considered for various extraction rates. Consideration must be given to the simulations given varying extraction rates, especially given that the extraction wells are very near the S-SX monitoring system relative to the injection wells. Basis/Justification:		<u>No change to text.</u> Extraction rates are not varied. Section 5.2 states, "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." Evaluation of the monitoring well network on an annual basis is addressed in Chapter 10. Current contaminant levels were considered in developing the proposed monitoring well network. This was discussed in a meeting on 2/2/2018.	Discussed, no change needed.	C 2/2/2018 No change.	SPL

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