ECF-200W-20-0015
Revision 0

Groundwater Elevation Mapping for 200 West Area - Quarter 4 Calendar Year 2019

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

Contractor for the U.S. Department of Energy
under Contract 89303320DEM000030

P.O. Box 1600
Richland, Washington 99352

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Date Published
February 2021

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CPCCo
Central Plateau
Cleanup Company
P.O. Box 1600
Richland, Washington 99352

APPROVED
By Lynn M Ayers at 1:51 pm, Feb 16, 2021

Release Approval Date

ENVIRONMENTAL CALCULATION COVER PAGE

SECTION 1 - Completed by the Responsible Manager

Project:
S&GRP Project Delivery

Date: 5/21/2020

Calculation Title and Description:
Groundwater Elevation Mapping for 200 West Area- Quarter 4 Calendar Year 2019

RELEASE / ISSUE

Qualifications Summary

Preparer(s):

Name: Kinsley Binard

Degree, Major, Institution, Year: MSE, Civil/Environmental Engineering, University of Michigan, Ann Arbor, 1994
BA, Physics, Denison University, 1991

Professional Licenses:

Brief Narrative of Experience: Ms. Binard provides engineering expertise in all phases of groundwater and soil-remediation projects and with a wide range of site contaminants and manages complex environmental remediation projects involving multiple responsible parties, coordination with ongoing industrial operations, and strict regulatory oversight. She has prepared design drawings, specifications, bid documents, and permit applications and has been responsible for materials procurement, construction supervision and management of system operations. Ms. Binard has experience in preparation of CERCLA and RCRA reports including feasibility studies, quality assurance project plans, field sampling plans and remedial action plans.

Checker(s):

Name: Toomas Parratt

Degree, Major, Institution, Year: MScF, Natural Resources Management, Lakehead University, Thunder Bay, Ontario, 2012
B. Eng, Civil Engineering, McMaster University, Hamilton, Ontario, 2007

Professional Licenses:

Brief Narrative of Experience: Mr. Parratt has extensive experience in surface-water and groundwater modeling of complex sites, including contaminated soils, earth filled embankments and forested landscapes. He has incorporated ecological principles, with physical-based water flow models, to assess aquifer impacts due to pumping, land-use, and climate change. He has multiple years of experience in assessing the risk and uncertainty associated with the parameterization of boundary conditions and the effect on hydraulic gradients.

ENVIRONMENTAL CALCULATION COVER PAGE (Continued)

Senior Reviewer(s):

Name: Mary Hartman

Degree, Major, Institution, Year: MS Hydrogeology, University of Idaho
BS Geology, University of Wisconsin

Professional Licenses:

Brief Narrative of Experience: Mary Hartman has over 30 years of experience in applied hydrogeology on the Hanford Site. Her responsibilities include interpreting hydraulic head and groundwater chemistry data to create conceptual site models for CERCLA investigations and environmental remediation; and designing and implementing groundwater monitoring programs for chemical and radioactive contaminants to meet requirements of CERCLA and RCRA.

SECTION 2 - Completed by Preparer

Calculation Number: ECF-200W-20-0015 | Revision Number: 0

Revision History

Revision No.	Description	Date	Affected Pages
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SECTION 3 - Completed by the Responsible Manager

Document Control:

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SECTION 4 - Document Review and Approval

Preparer(s):			
Kinsley Binard *Print First and Last Name*	Senior Engineer *Position*	 *Signature*	5/21/2020 *Date*
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Senior Reviewer(s):			
Mary Hartman *Print First and Last Name*	Senior Scientist *Position*	 *Signature*	5/21/2020 *Date*
Responsible Manager(s):			
William R. Faught *Print First and Last Name*	Manager *Position*	Faught, William R Digitally signed by Faught, William R Date: 2021.02.10 12:25:53 -08'00' *Signature*	*Date*

ENVIRONMENTAL CALCULATION COVER PAGE (Continued)

SECTION 5 - Applicable if Calculation is a Risk Assessment or Uses an Environmental Model

Prior to Initiating Modeling:

Required training for modelers completed:
Integration Lead:

Print First and Last Name	*Signature*	*Date*

Safety Software Approved:
Integration Lead:

Print First and Last Name	*Signature*	*Date*

Calculation Approved:
Risk/Modeling Integration Manager:

Print First and Last Name	*Signature*	*Date*

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Terms

ASCII	American Standard Code for Information Interchange
AWLN	automated water-level network
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
CPGWM	Central Plateau Groundwater Model
CY	calendar year
DWMU	dangerous waste management unit
ECF	environmental calculation file
HISI	Hanford Information Systems Inventory
MEUK	multi-event universal kriging
OU	operable unit
P&T	pump and treat
Rwie	Ringold Formation member of Wooded Island — unit E
SALDS	State Approved Land Disposal Site

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1 Purpose

This environmental calculation file (ECF) describes calculations made to generate water-level maps for the fourth quarter of calendar year (CY) 2019 in the 200 West Area at the Hanford Site Central Plateau (Figure 1). This ECF provides the conceptual and methodological basis for the calculations performed, details the specific methods and codes used to undertake the calculations, and presents results of calculations. These water-level maps are used in a variety of calculations and reports for the different *Resource Conservation and Recovery Act of 1976* dangerous waste management units (DWMUs) and *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) groundwater operable units (OUs) located within the 200 West Area. A separate ECF is being prepared to present calculations of groundwater hydraulic gradients and average linear velocities at the individual DWMUs.

2 Background

In the 200 West Area, groundwater pump and treat (P&T) technology is an element of the selected final CERCLA groundwater remedy for the 200-ZP-1 Groundwater OU and the interim groundwater remedy for the 200-UP-1 OU. Groundwater extracted from the 200-ZP-1 and 200-UP-1 P&T remedies is ultimately combined and treated at a single facility referred to hereinafter as the 200 West P&T facility. DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*, discusses the plan and schedule for the design, installation, and operation of the remedy set forth in the 200-ZP-1 OU record of decision (EPA et al., 2008, *Record of Decision, Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*). As part of the 200 West P&T system, as many as 30 injection wells and 26 extraction wells have operated at various times since June 2012.

Groundwater flow directions and rates in the 200 West Area are affected by groundwater extraction and injection from the P&T systems. The Central Plateau Groundwater Model (CPGWM) is the principal tool used to design, evaluate, and predict the performance of the 200 West P&T groundwater remedies. The CPGWM was developed primarily to support decisions made with regard to the 200-ZP-1 and adjacent 200-UP-1 groundwater remedies and is used to predict or assess the performance of the P&T remedies. The goal of this ECF, however, is to create water-level maps to independently interpret groundwater level and pumping information based on measurements made during the fourth quarter of CY 2019.

As described in ECF-200W-19-0082, *Groundwater Elevation Mapping for 200 West Area – Quarter 1 Calendar Year 2019*, a regression-based technique that incorporates underlying regression-based trend terms is used to interpret the measured water-level data and prepare depictions of hydraulic gradients and likely flow directions, and was used for the purposes of this analysis. The regression-based multi-event universal kriging (MEUK) technique (Tonkin et al., 2016, “Multi-Event Universal Kriging [MEUK]”) is used to obtain a piecewise, continuous grid and corresponding map of groundwater elevations. MEUK is an extension of the hybrid mapping technique that is implemented in the water-level kriging program KT3D-H2O that combines universal kriging with the analytic element method to interpret water-level data. The method incorporated in MEUK has been used along with the CPGWM for several years in the 200 West Area as a line of evidence to evaluate the 200 West P&T remedy performance, and for this reason is well suited to the purposes of the analysis detailed in this ECF.

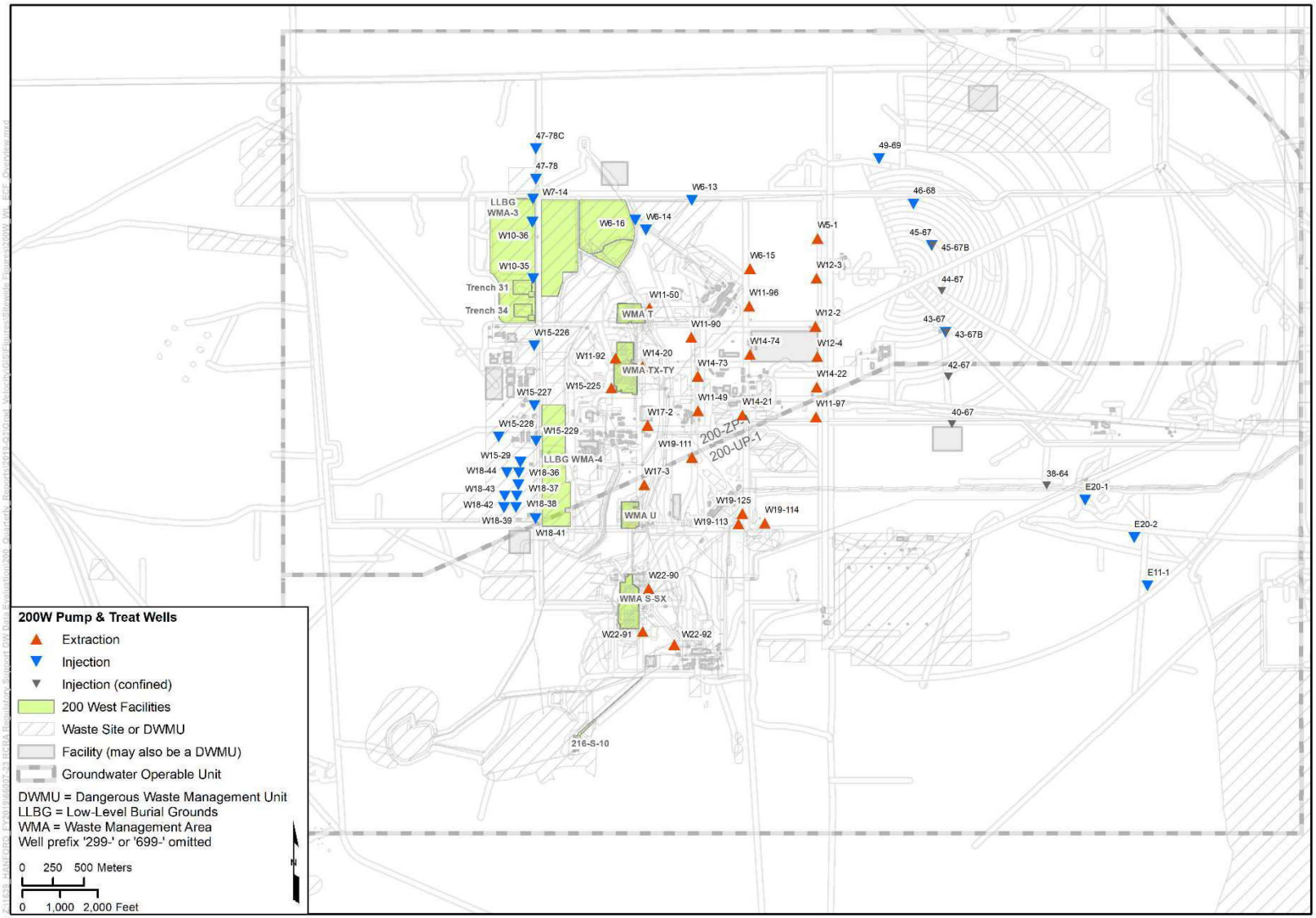

Figure 1. Hanford Site 200 West Area, Groundwater OUs, and Groundwater Extraction and Injection Wells

3 Calculation Methods

Calculations were completed to develop groundwater elevation maps for the 200 West Area. The calculation approach and tools developed for ECF-200W-19-0082 were used to meet the objectives of this ECF. The method detailed in ECF-200W-19-0082, MEUK, is designed to create a series of related groundwater elevation maps, each corresponding to a specific event, which can exhibit spatial relationships that persist over time. MEUK assumes that multi-event data can be described by a combination of trends that vary over time, trends that are invariant over time, and a stationary spatial correlation among residuals from the trend(s). In most applications, MEUK leads to improved water-level maps when the spatial distribution of monitoring locations varies from event to event and when there is an uncertain level of noise in the data.

Expressions that describe the groundwater level response to features or stresses are incorporated into MEUK using superposition of trend terms so that the complete form of the underlying trend is the summation of these terms. The MEUK technique includes the following two distinct processes:

1. Estimation: Use of generalized least squares regression to obtain trend term coefficients (“calibration”)
2. Prediction: Solution of the MEUK system of equations using the coefficients obtained through step 1 to predict water levels at intermediate locations or times, such as when producing a grid for contouring (“mapping”)

During step 1, the trend coefficients are estimated using generalized least squares, and during step 2, groundwater levels are calculated on a regular grid using the estimated trend coefficients. The resultant grid of water levels is then used to prepare contour maps for visualization. The process is iterative with the above steps repeated with alterations of the variogram parameters and evaluation and removal of outlier measurements to arrive at the final groundwater contours.

The water-level mapping analysis for the fourth quarter of CY 2019 used the following semivariogram parameters:

- Variogram model: Spherical
- Range: 2,600 m (8,530 ft)
- Sill: 8.6
- Nugget: 0.18

4 Assumptions and Inputs

Water-level contour maps were constructed using MEUK, which incorporates the effects of drawdown and mounding due to groundwater extraction and reinjection, respectively. While accounting for the values of water levels measured at each well, the resulting contour maps provide plausible interpretations of groundwater levels and hydraulic gradients between measured locations. In addition, the State Approved Land Disposal Site (SALDS) had measurable discharges in the fourth quarter of CY 2019 that were included in the analysis.

The assumptions that underlie the calculations are presented in ECF-200W-19-0082. The inputs used in the fourth quarter of CY 2019 calculations are presented in this chapter.

The general input requirements for the mapping calculations described in this ECF include the following:

- Groundwater elevations measured at monitoring wells within the kriging grid extents as listed in Table 1. Spatial coordinates are reported in the *North American Datum of 1983* State Plane, Washington South FIPS 4602 coordinate system.

Table 1. Kriging Grid Extents

	Minimum	Maximum
Easting (m)	563400	573400
Northing (m)	132300	140130

- Line drift inputs to represent the lateral transition of the water table from within the Ringold Formation member of Wooded Island — unit E (Rwie) in the west to within the Hanford formation and Cold Creek unit (CCU) gravel to the east.
- Extraction and injection rates at 200 West P&T wells and the SALDS discharge rates represented as point sink and source trend terms.

These input requirements are described in Sections 4.1 through 4.3.

4.1 Groundwater Elevations

Groundwater level data obtained during the fourth quarter of CY 2019 included manual measurements obtained before sampling, manual measurements not associated with sampling, and measurements that were obtained at various locations on a high frequency basis (i.e., hourly) from wells equipped with transducers and data loggers. The latter is collectively referred to as the Hanford Site automated water-level network (AWLN). Manual measurements are also obtained for some of the AWLN wells for validation purposes.

To generate the monthly water-level mapping datasets, water-level measurements within the kriging grid extents were averaged over the month for each well. Where manual measurements were available for AWLN wells, the manual measurement was generally used in the mapping dataset instead of the averaged AWLN measurement because the manual measurements are considered to be more reliable. Exceptions were made for manual measurements at AWLN wells that were determined to be outliers based on long-term water-level trends, in which case the averaged AWLN measurement was retained for the calculations.

Table 2 lists the average monthly water-level measurements that were used as input to generate water-level maps for the fourth quarter of CY 2019. Excluded water levels are indicated with a single asterisk. The full set of data used for the fourth quarter of CY 2019 is included in Appendix A with the exception of AWLN data. Since the AWLN data are collected hourly, they were excluded from Appendix A.

Table 2. Average Monthly Water-Level Measurements Used for Mapping

Well Name	Average Measured Water Levels (NAVD88 m)						2019 4th Quarter Average Measured Water Level (NAVD88 m)
	Oct-2019		Nov-2019		Dec-2019		
	Manual	AWLN	Manual	AWLN	Manual	AWLN	
299-E28-18	121.624	NM/NA	121.619	NM/NA	121.599	NM/NA	121.614
299-E32-5	121.608	NM/NA	121.615	NM/NA	121.597	NM/NA	121.607
299-E32-6	121.620	NM/NA	121.620	NM/NA	121.598	NM/NA	121.613
299-E32-8	121.624	NM/NA	121.622	NM/NA	121.607	NM/NA	121.618
299-E33-34	121.627	121.615*	121.618	121.608*	121.602	121.597*	121.616
299-W10-1	NM/NA	NM/NA	132.273	NM/NA	NM/NA	NM/NA	132.273
299-W10-24	NM/NA	NM/NA	130.670	NM/NA	NM/NA	NM/NA	130.670
299-W10-26	129.832	NM/NA	129.707	NM/NA	129.688	NM/NA	129.742
299-W10-27	NM/NA	NM/NA	129.800	NM/NA	NM/NA	NM/NA	129.800
299-W10-28	NM/NA	NM/NA	131.514	NM/NA	NM/NA	NM/NA	131.514
299-W10-29	136.306	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	136.306
299-W10-30	136.338	136.22*	136.166	136.296*	NM/NA	136.394	136.299
299-W10-31	135.677	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	135.677
299-W11-39	NM/NA	NM/NA	130.495	NM/NA	NM/NA	NM/NA	130.495
299-W11-40	NM/NA	NM/NA	130.330	NM/NA	NM/NA	NM/NA	130.330
299-W11-41	NM/NA	NM/NA	130.125	NM/NA	NM/NA	NM/NA	130.125
299-W11-42	NM/NA	NM/NA	130.476	NM/NA	NM/NA	NM/NA	130.476
299-W11-45	NM/NA	NM/NA	130.235	NM/NA	NM/NA	NM/NA	130.235
299-W11-47	NM/NA	NM/NA	130.135	NM/NA	NM/NA	NM/NA	130.135
299-W11-87	NM/NA	124.071	124.161	124.192*	NM/NA	123.855	124.029
299-W13-2P	NM/NA	NM/NA	126.643	NM/NA	NM/NA	NM/NA	126.643
299-W13-2Q	NM/NA	NM/NA	126.643	NM/NA	NM/NA	NM/NA	126.643
299-W14-11	NM/NA	NM/NA	127.444	NM/NA	NM/NA	NM/NA	127.444
299-W14-13	NM/NA	NM/NA	128.090	NM/NA	NM/NA	NM/NA	128.090
299-W14-14	NM/NA	129.193	129.392	129.292*	NM/NA	NM/NA	129.292
299-W14-15	NM/NA	NM/NA	129.009	NM/NA	NM/NA	NM/NA	129.009
299-W14-16	NM/NA	NM/NA	128.763	NM/NA	NM/NA	NM/NA	128.763
299-W14-18	129.110	NM/NA	128.849	NM/NA	128.964	NM/NA	128.974
299-W14-19	NM/NA	NM/NA	129.451	NM/NA	NM/NA	NM/NA	129.451
299-W14-72	NM/NA	125.859	NM/NA	125.810	NM/NA	125.572	125.747
299-W15-32	NM/NA	130.813	NM/NA	130.702	NM/NA	130.421	130.645
299-W15-33	NM/NA	NM/NA	NM/NA	NM/NA	134.042	NM/NA	134.042
299-W15-37	NM/NA	132.773	NM/NA	132.750	NM/NA	132.692	132.738
299-W15-44	NM/NA	131.163	131.384	131.341*	NM/NA	131.093	131.213

Table 2. Average Monthly Water-Level Measurements Used for Mapping

Well Name	Average Measured Water Levels (NAVD88 m)						2019 4th Quarter Average Measured Water Level (NAVD88 m)
	Oct-2019		Nov-2019		Dec-2019		
	Manual	AWLN	Manual	AWLN	Manual	AWLN	
299-W15-49	NM/NA	132.281*	NM/NA	132.337*	135.426*	132.407*	NU
299-W15-763	NM/NA	NM/NA	130.676	NM/NA	NM/NA	NM/NA	130.676
299-W15-765	NM/NA	NM/NA	129.971	NM/NA	NM/NA	NM/NA	129.971
299-W18-15	NM/NA	NM/NA	NM/NA	NM/NA	134.426	NM/NA	134.426
299-W18-21	NM/NA	NM/NA	NM/NA	NM/NA	137.295	NM/NA	137.295
299-W18-260	131.731	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	131.731
299-W18-40	132.844	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	132.844
299-W19-101	NM/NA	127.403*	127.495*	127.416*	127.402*	127.342*	NU
299-W19-105	NM/NA	NM/NA	NM/NA	NM/NA	129.608	NM/NA	129.608
299-W19-107	NM/NA	127.301	127.274	127.294*	NM/NA	127.246	127.274
299-W19-115	NM/NA	129.958	129.876	129.928*	129.863	129.865*	129.899
299-W19-116	NM/NA	NM/NA	128.469	NM/NA	128.471	NM/NA	128.470
299-W19-12	131.715	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	131.715
299-W19-123	NM/NA	NM/NA	128.986	NM/NA	NM/NA	NM/NA	128.986
299-W19-131	128.233	128.32*	128.251	128.323*	128.223	128.266*	128.236
299-W19-36	NM/NA	128.546	NM/NA	128.513	128.447	128.489*	128.502
299-W19-39	NM/NA	NM/NA	NM/NA	NM/NA	128.592	NM/NA	128.592
299-W19-41	131.803	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	131.803
299-W19-42	131.769	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	131.769
299-W19-43	NM/NA	NM/NA	NM/NA	NM/NA	127.099	NM/NA	127.099
299-W19-44	131.726	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	131.726
299-W19-45	131.737	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	131.737
299-W19-46	NM/NA	NM/NA	NM/NA	NM/NA	129.059	NM/NA	129.059
299-W19-47	131.753	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	131.753
299-W19-48	NM/NA	128.608	128.588	128.599*	128.546	128.551*	128.581
299-W19-49	NM/NA	NM/NA	NM/NA	NM/NA	129.239	NM/NA	129.239
299-W21-3	NM/NA	NM/NA	NM/NA	NM/NA	129.735	NM/NA	129.735
299-W22-113	NM/NA	NM/NA	NM/NA	NM/NA	131.898	NM/NA	131.898
299-W22-115	NM/NA	NM/NA	NM/NA	NM/NA	131.829	NM/NA	131.829
299-W22-116	NM/NA	131.892*	NM/NA	131.878*	131.861*	131.83*	NU
299-W22-47	NM/NA	NM/NA	NM/NA	NM/NA	131.857	NM/NA	131.857
299-W22-69	NM/NA	NM/NA	NM/NA	NM/NA	130.997	NM/NA	130.997
299-W22-72	NM/NA	NM/NA	NM/NA	NM/NA	130.990	NM/NA	130.990
299-W22-79	NM/NA	NM/NA	NM/NA	NM/NA	129.615	NM/NA	129.615

Table 2. Average Monthly Water-Level Measurements Used for Mapping

Well Name	Average Measured Water Levels (NAVD88 m)						2019 4th Quarter Average Measured Water Level (NAVD88 m)
	Oct-2019		Nov-2019		Dec-2019		
	Manual	AWLN	Manual	AWLN	Manual	AWLN	
299-W22-80	NM/NA	NM/NA	NM/NA	NM/NA	132.120	NM/NA	132.120
299-W22-81	NM/NA	NM/NA	NM/NA	NM/NA	131.539	NM/NA	131.539
299-W22-82	131.584	NM/NA	NM/NA	NM/NA	131.625	NM/NA	131.605
299-W22-83	NM/NA	131.574	131.550	131.567*	131.549	131.512*	131.557
299-W22-84	NM/NA	131.583	NM/NA	131.558	131.466	131.512*	131.535
299-W22-85	NM/NA	131.989	NM/NA	131.979	131.996	131.935*	131.988
299-W22-86	NM/NA	131.034	131.016	131.032*	131.034	130.974*	131.028
299-W22-87	NM/NA	NM/NA	NM/NA	NM/NA	129.869	NM/NA	129.869
299-W22-88	NM/NA	129.791	129.760	129.797*	NM/NA	NM/NA	129.776
299-W22-89	NM/NA	NM/NA	NM/NA	NM/NA	131.893	NM/NA	131.893
299-W22-93	NM/NA	NM/NA	NM/NA	NM/NA	131.218	NM/NA	131.218
299-W22-94	NM/NA	131.430	131.249	131.413*	131.423	131.366*	131.367
299-W22-95	NM/NA	NM/NA	NM/NA	NM/NA	130.729	NM/NA	130.729
299-W22-96	NM/NA	NM/NA	NM/NA	NM/NA	130.812	NM/NA	130.812
299-W23-20	NM/NA	NM/NA	NM/NA	NM/NA	132.680	NM/NA	132.680
299-W23-21	NM/NA	NM/NA	NM/NA	NM/NA	132.835	NM/NA	132.835
299-W23-236	NM/NA	NM/NA	NM/NA	NM/NA	132.441	NM/NA	132.441
299-W23-4	133.280	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	133.280
299-W26-13	NM/NA	NM/NA	133.317	NM/NA	NM/NA	NM/NA	133.317
299-W26-14	NM/NA	NM/NA	132.629	NM/NA	NM/NA	NM/NA	132.629
299-W5-2P	NM/NA	NM/NA	127.461	NM/NA	NM/NA	NM/NA	127.461
299-W5-2Q	NM/NA	NM/NA	127.461	NM/NA	NM/NA	NM/NA	127.461
299-W6-17	NM/NA	128.742	NM/NA	128.770	NM/NA	128.727	128.746
299-W6-3	NM/NA	NM/NA	NM/NA	NM/NA	131.122	NM/NA	131.122
299-W9-2	136.687	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	136.687
699-29-66	129.051	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	129.051
699-30-57	123.945	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	123.945
699-30-63	128.289	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	128.289
699-30-66	NM/NA	NM/NA	129.189	NM/NA	NM/NA	NM/NA	129.189
699-30-70	130.267	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	130.267
699-30-73	130.642	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	130.642
699-31-68	NM/NA	NM/NA	NM/NA	NM/NA	129.303	NM/NA	129.303
699-32-59	124.274	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	124.274
699-32-64	128.266	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	128.266

Table 2. Average Monthly Water-Level Measurements Used for Mapping

Well Name	Average Measured Water Levels (NAVD88 m)						2019 4th Quarter Average Measured Water Level (NAVD88 m)
	Oct-2019		Nov-2019		Dec-2019		
	Manual	AWLN	Manual	AWLN	Manual	AWLN	
699-32-76	NM/NA	NM/NA	132.332	NM/NA	NM/NA	NM/NA	132.332
699-33-75	NM/NA	NM/NA	132.049	NM/NA	132.044	NM/NA	132.047
699-33-76	NM/NA	NM/NA	132.939	NM/NA	NM/NA	NM/NA	132.939
699-34-61	125.755	NM/NA	125.855	NM/NA	125.858	NM/NA	125.823
699-34-72	NM/NA	NM/NA	NM/NA	NM/NA	130.249	NM/NA	130.249
699-35-66A	128.755	NM/NA	128.833	NM/NA	128.943	NM/NA	128.844
699-35-78A	NM/NA	134.988	134.931	134.962*	NM/NA	134.968	134.962
699-36-61A	123.897	123.991*	124.016	123.997*	124.018	123.99*	123.977
699-36-63B	127.435*	NM/NA	127.446*	NM/NA	NM/NA	NM/NA	NU
699-36-66B	128.789	NM/NA	128.889	NM/NA	128.981	NM/NA	128.886
699-36-70A	129.537	NM/NA	NM/NA	NM/NA	NM/NA	NM/NA	129.537
699-36-70B	NM/NA	NM/NA	NM/NA	NM/NA	129.219	NM/NA	129.219
699-37-66	128.470	NM/NA	128.575	NM/NA	128.651	NM/NA	128.565
699-38-61	123.680	123.742*	123.723	123.733*	123.722	123.721*	123.708
699-38-64B	128.715*	NM/NA	128.732*	NM/NA	NM/NA	NM/NA	NU
699-38-65	128.468	128.717*	127.751*	128.685*	NM/NA	128.697*	128.468
699-39-79	NM/NA	139.054	138.437	138.904*	139.297	139.276*	138.929
699-40-62	122.557	NM/NA	122.555	NM/NA	122.551	NM/NA	122.554
699-40-65	126.530	126.618*	126.601	126.612*	126.592	126.601*	126.574
699-44-64	NM/NA	NM/NA	NM/NA	NM/NA	123.059	NM/NA	123.059
699-44-70B	NM/NA	125.874	125.797	125.95*	NM/NA	125.788	125.820
699-46-61	NM/NA	121.999	NM/NA	121.995	NM/NA	121.988	121.994
699-48-71	NM/NA	128.631	128.641	128.515*	NM/NA	128.293	128.522
699-48-77D	133.871	NM/NA	133.883	NM/NA	133.940	NM/NA	133.898
699-49-55A	121.621	NM/NA	121.632	NM/NA	121.638	NM/NA	121.630
699-49-57A	121.605	NM/NA	121.606	NM/NA	121.611	NM/NA	121.607
699-50-56	121.633	NM/NA	121.628	NM/NA	121.615	NM/NA	121.625
699-51-63	122.431	NM/NA	122.438	NM/NA	122.625	NM/NA	122.498
699-52-55	121.688	NM/NA	121.689	NM/NA	121.700	NM/NA	121.692

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

*Excluded water-level measurement.

AWLN = automated water-level network
NAVD = *North American Vertical Datum of 1988*
NM/NA = not measured/not available at time of data pull
NU = not usable

In addition, some wells were screened in deeper aquifers with different flow conditions. These monitoring wells, listed below, were removed from the kriging dataset altogether on account of their well screen configuration not representing the water table (i.e., not screened at or near the water table). As such, the following wells are not listed in Table A-2 of Appendix A:

- 299-W5-2Q
- 299-W11-13
- 299-W11-43
- 299-W11-48
- 299-W11-88
- 299-W13-2Q
- 299-W14-71
- 299-W18-22
- 299-W19-34A
- 299-W19-34B
- 699-43-69
- 699-45-69C
- 699-48-77C

4.2 Line Drift Input

Location of line drift points are depicted in Figure 2. The line drift values are presented in Table B-1in Appendix B of ECF-200W-19-0082.

4.3 Extraction and Injection Rates at Wells

Monthly average groundwater extraction and injection flow rates for the 200 West P&T wells and the SALDS discharge rates for the fourth quarter of CY 2019 were used as inputs for the water-level mapping and are provided in Tables B-1 and B-2 in Appendix B, respectively. Injection wells screened in the confined aquifer were excluded from the analysis.

To improve the representation of the hydraulic response to injection and the resulting mapped water levels in the vicinity of the 200-UP-1 iodine injection wells, injection rates used as input to MEUK for wells 299-E20-1, 299-E20-2, and 299-E11-1, for purposes of water-level mapping, were set equal to the reported rates multiplied by four. The underlying rationale for this is presented in ECF-200W-19-0082.

The following coordinates were used as input for the location of the SALDS infiltration: 566395.40 m easting and 137979.33 m northing (in NAD83 State Plane, Washington South 4602) (NAD83, *North American Datum of 1983*). The analysis from which these coordinates were obtained are also discussed in ECF-200W-19-0082.

Figure 2 depicts locations for the 200 West P&T treatment system wells and the SALDS.

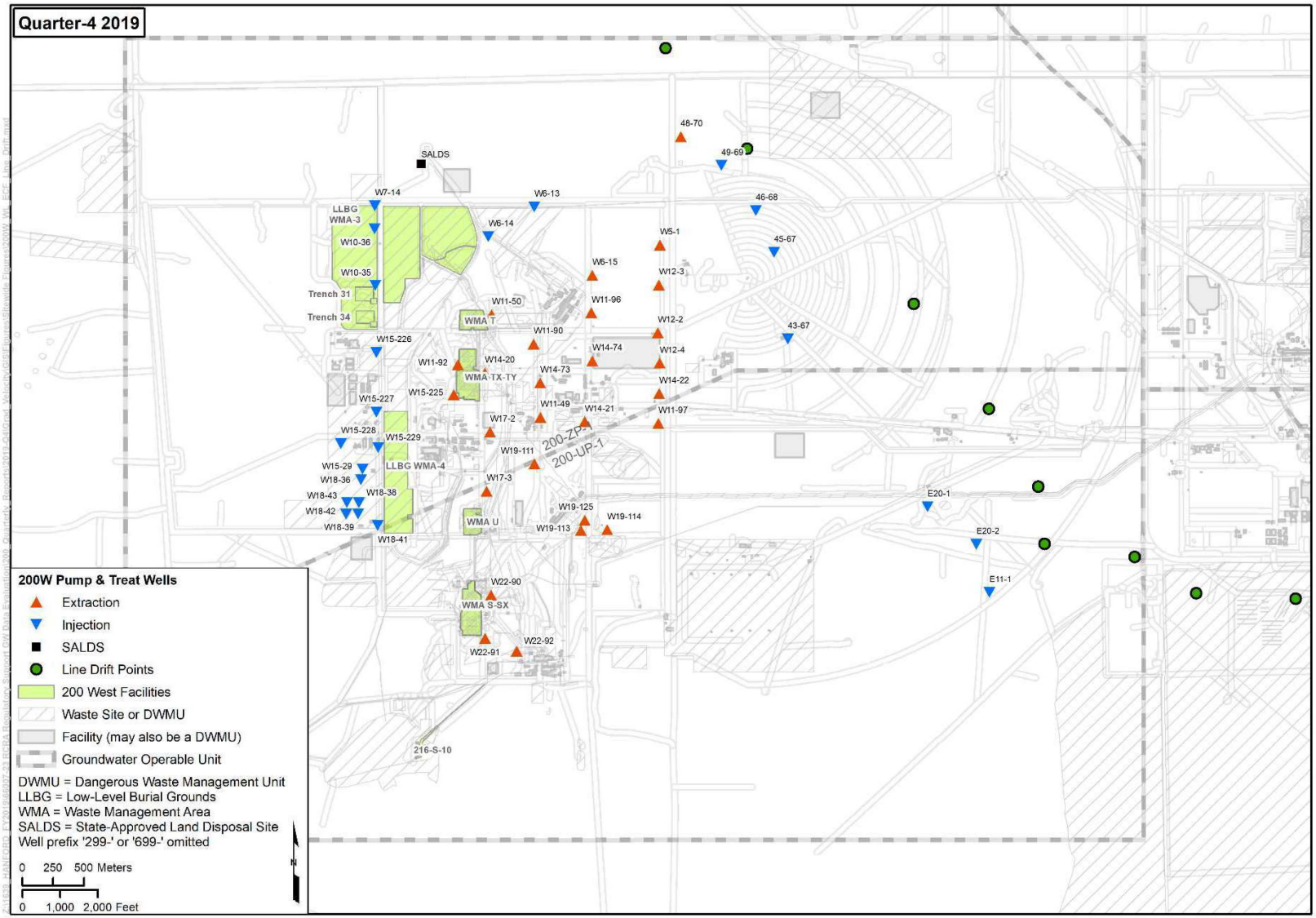

Figure 2. Location of the 200 West P&T Extraction and Injection Wells in the Unconfined Aquifer and Line Drift Points for Fourth Quarter of CY 2019

5 Software Applications, Descriptions, Installation and Checkout, and Statements of Validity

Software used to perform the calculations for this ECF was in accordance with PRC-PRO-IRM-309, *Controlled Software Management*.

5.1 Approved Software

The software used for this ECF was approved and complies with PRC-PRO-IRM-309. The following software is managed consistent with PRC-PRO-IRM-309 based on:

- CHPRC-02839, *KT3D_H2O and MEUK Integrated Software Management Plan: KT3D_H2O Version 3.5.1 and MEUK Version 0.2.2*

PRC-PRO-IRM-309 distinguishes between safety software and support software based on whether the software calculates reportable results or provides run support, visualization, or similar functions. Brief descriptions of the software are provided in Section 5.2.

5.2 Software Description

MEUK was used to perform groundwater elevation mapping using measured groundwater levels. MEUK is part of the KT3D_H2O software, which is classified as safety software and graded level C based on responses to the Software Grading Checklist in PRC-PRO-IRM-309. Use of this software at the Hanford Site is managed under the integrated software management plan (CHPRC-02839) as follows:

- Software title: MEUK (S.S. Papadopulos and Associates, Inc., 2016, Version 0.2.6)
- Software version: CH2M HILL Plateau Remediation Company (CHPRC) Build 2 (Version 0.2.2)
- Hanford Information Systems Inventory (HISI) identification number: 2832 (safety software, graded level C)
- Workstation type and property number (from which software is run): SSPA, 616

MEUK is programmed in the R language (R Development Core Team, 2013, *R: A Language and Environment for Statistical Computing*) and uses the gstat package (Pebesma, 2004, "Multivariable Geostatistics in S: the gstat Package"). MEUK can be supplemented or validated using KT3D_H2O (Karanovic et al., 2009, "KT3D_H20: A Program for Kriging Water Level Data Using Hydrologic Drift Terms").

5.3 Support Software

The following software programs are classified as support software:

- ArcGIS®: Visualization and post-processing tool for assessing simulated plume distributions, identifying extraction/injection well coordinates, and mapping auxiliary data (Mitchell, 1999, *The ESRI Guide to GIS Analysis, Volume 1: Geographic Patterns & Relationships*).
- R**:** The R programming environment for statistical computing and graphics (R Development Core Team, 2013; Ihaka and Gentleman, 1996, "R: A Language for Data Analysis and Graphics"), was

® ArcGIS is a registered trademark of the Environmental Systems Research Institute, Inc., Redlands, California.

used to perform a variety of data processing, including post-processing calculation results and generating plots of aggregate data time series. The following R packages were also used:

  - Package gstat provided the kriging engine for water levels.
  - Package SSPAMEUK2 provided functions for the generation of water-level kriging drifts.
  - Package raster was used to generate water-level American Standard Code for Information Interchange (ASCII) grids and raster calculations.

- Surfer®: Data interpolation for visualization, model implementation, and quality assurance purposes.

5.4 Software Installation and Checkout

Safety software is checked out in accordance with procedures specified PRC-PRO-IRM-309. Executables are obtained from the CHPRC software owner (who maintains the configuration-managed copies in MKS Integrity®). Installation tests identified in CHPRC-02839 are performed on the software and successful installation confirmed. Software installation and checkout forms are required and must be approved for installations used to perform model runs. Approved users are registered in HISI for safety software.

5.4.1 Statement of Valid Software Application

The software identified above was used consistent with intended uses, as identified in CHPRC-02839, and is a valid use of this software for this application. The software was used within its limitations, as identified in CHPRC-02839.

6 Calculations

This chapter describes the calculations and steps performed to develop the necessary input files, perform the calculations, and post-process the outputs to develop the groundwater-level maps using MEUK through the R environment.

The following steps were taken to produce the groundwater elevation maps presented in this ECF:

1. Input data were compiled from retrieved database sources. Measured groundwater elevations were obtained for each month in the fourth quarter of CY 2019. Water levels for which there were multiple measurements (such as for the AWLN wells) were averaged so that one value was assigned to each monitoring well for each month.

   To do this, the AWLN data were compared to manual measurements to test the reliability of the transducer measurements. During this inspection, it was noted that some AWLN wells exhibit relatively constant discrepancies between transducer data and manual measurements. This is defined as a ‘shift.’

   For wells with shifts, a constant adjustment was applied to the transducer data such that it matched the manual measurements as illustrated in Figure 3, with well 299-W15-44 for the period of CY 2017 to 2019. Measured water levels shown in the figure are based on the *North American Vertical Datum of 1988*.

® Surfer is a registered trademark of Golden Software, LLC, Golden, Colorado.
® MKS Integrity is a registered trademark of MKS, Inc., Needham, Massachusetts.

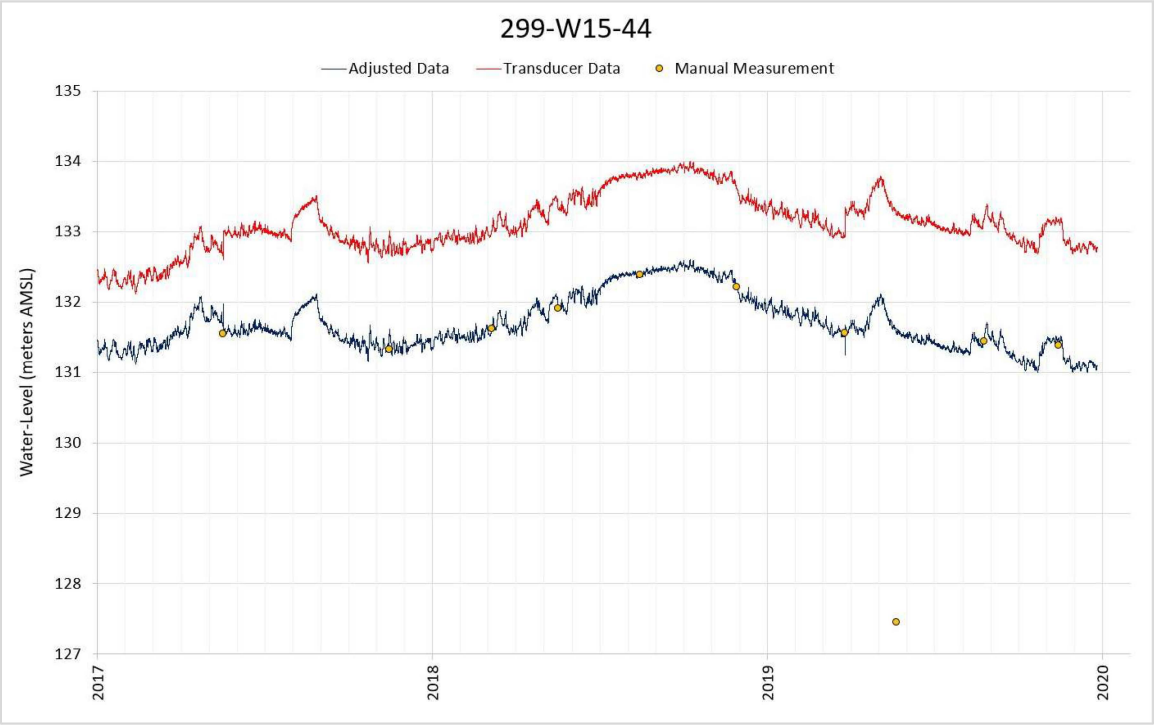

Figure 3. Example of AWLN Data Adjustment for Wells with Constant Shifts

Table 3 lists the AWLN wells that required transducer data adjustments for the fourth quarter of CY 2019 and the corresponding adjustments.

Table 3. AWLN Transducer Data Shift Adjustments for Fourth Quarter of CY 2019

Well Name	Adjustment
299-E33-34	-2.62E-02
299-W10-30	-1.25E-01
299-W11-13	5.00E-02
299-W11-43	-1.04E-01
299-W11-87	-1.00E-01
299-W15-37	2.99E-01
299-W15-44	-1.68E+00
299-W19-107	-1.26E-01
299-W19-48	1.17E-01
299-W22-116	5.63E-01
299-W22-94	1.81E-01
699-36-61A	-2.00E-01
699-38-65	-2.02E+00

At the conclusion of the AWLN adjustments, monthly averaged data were compiled into tables suitable for mapping.

Cross-validation analyses were then performed to find the wells with the highest residual values. The water levels at these wells with the highest residuals were considered suspect and subject to systematic error, which may be attributable to the wells deviating from vertical or to error in manual and/or transducer measurements. Based on the results from the cross-validation analysis, measurements for the following wells were excluded from the mapping process for producing high kriging residuals:

- 299-W15-49
- 299-W19-101
- 299-W22-116
- 699-36-63B
- 699-38-64B

The excluded water levels are indicated with an asterisk in Table A-1 in Appendix A.

1. To represent large-scale transitions in aquifer properties between the Rwie on the west and the Hanford formation and CCU on the east, line drift points were created approximately along the line where the water table crosses the top of the Rwie. Line drift points, included in Table B-1 in Appendix B of ECF-200W-19-0082, were set constant for all events (i.e., specified as global trend terms).
2. Pumping data for the fourth quarter of CY 2019, which includes extraction and injection rates for 200-ZP-1 P&T remedies, 200-UP-1 P&T remedies, and the SALDS, were assembled as monthly average rates as listed in Table B-1 in Appendix B.
3. MEUK was executed and kriging results were saved in ArcGIS ASCII (*.asc) grid format.
4. Water-level ASCII (*.asc) grid files were imported into Surfer, then water-level contours were exported in ArcGIS shapefile format.

7 Results

This chapter presents outputs from the described calculations. Figures 4 through 6 depict the water-level maps for each month of the fourth quarter of CY 2019 and were created using MEUK. Figure 7 depicts the average groundwater elevation contours for the fourth quarter of CY 2019 throughout the 200 West Area. The figures depict the locations of the monitoring wells with the average monthly water-level measurements reported in Table 2 and the general patterns of groundwater elevations and hydraulic gradients for conditions representative of the fourth quarter of CY 2019.

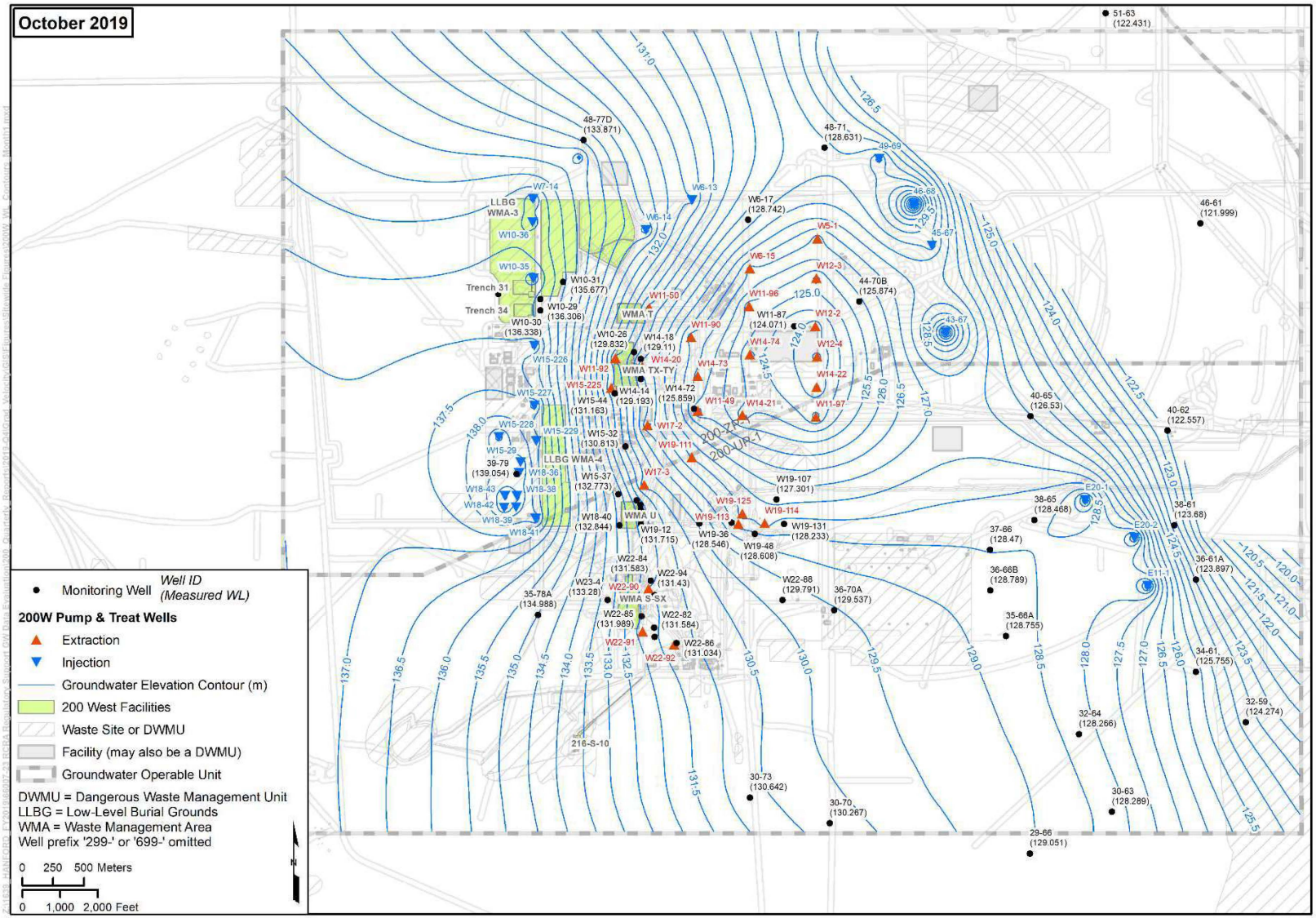

Figure 4. Mapped Groundwater Elevations – October 2019

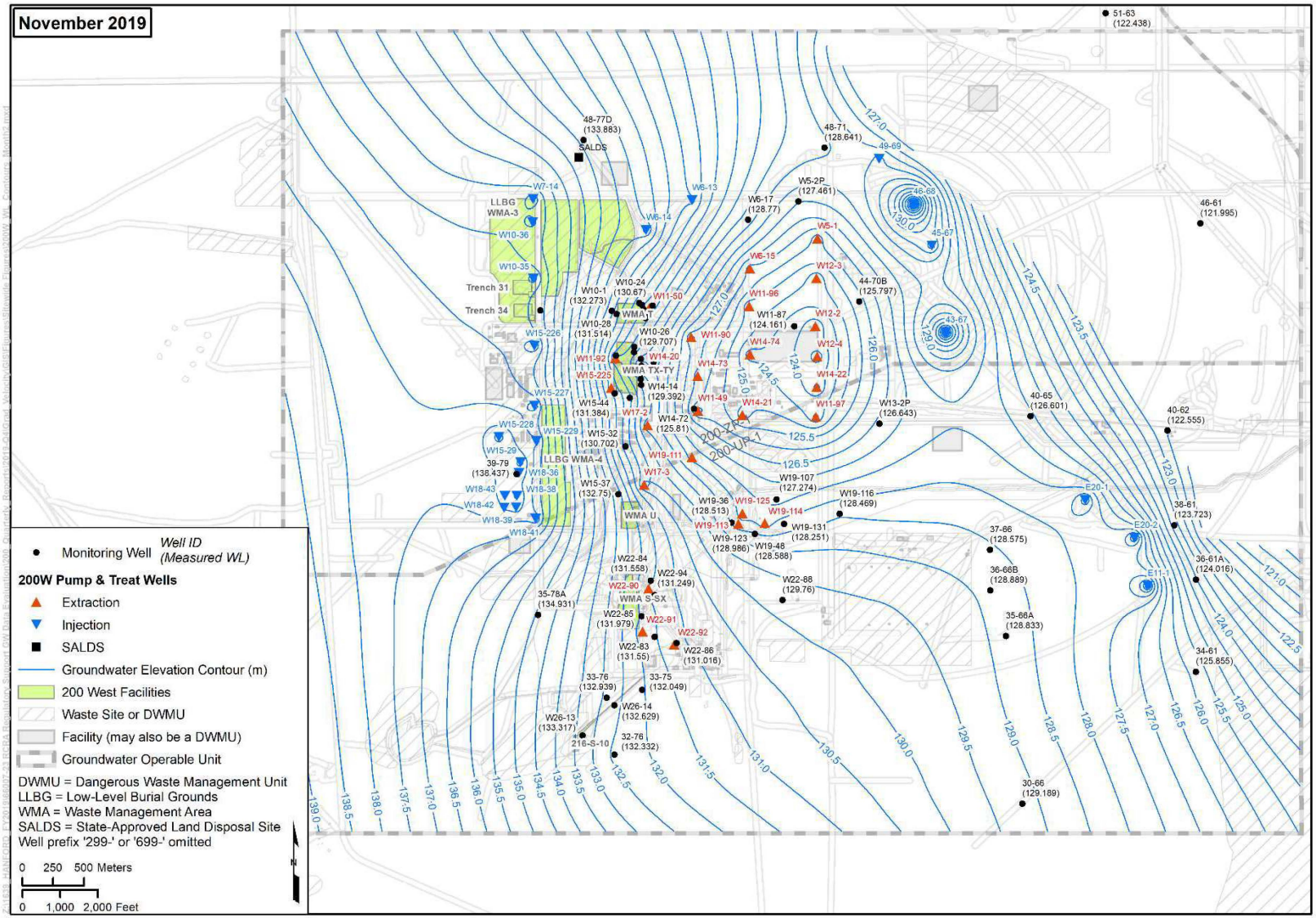

Figure 5. Mapped Groundwater Elevations – November 2019

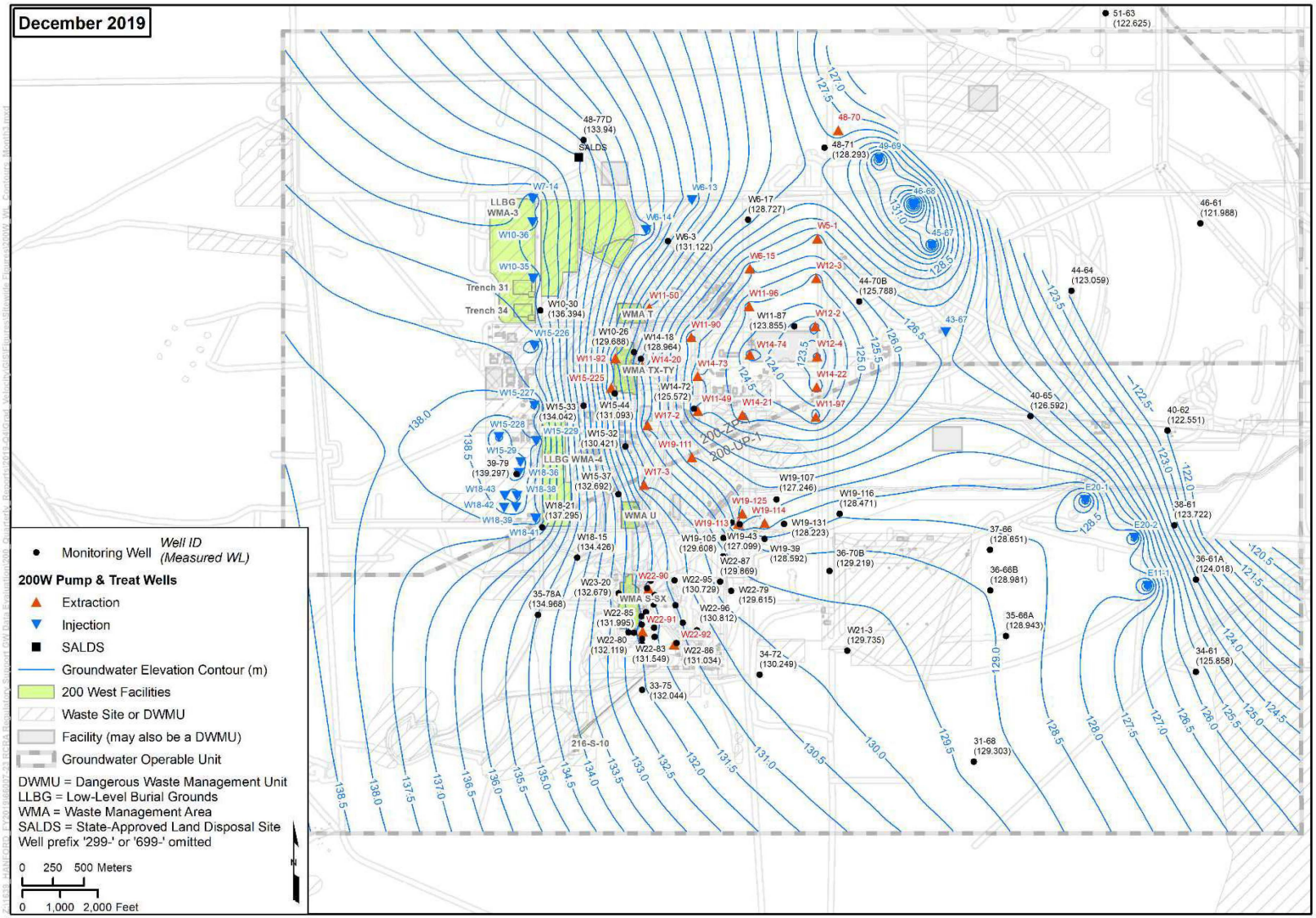

Figure 6. Mapped Groundwater Elevations – December 2019

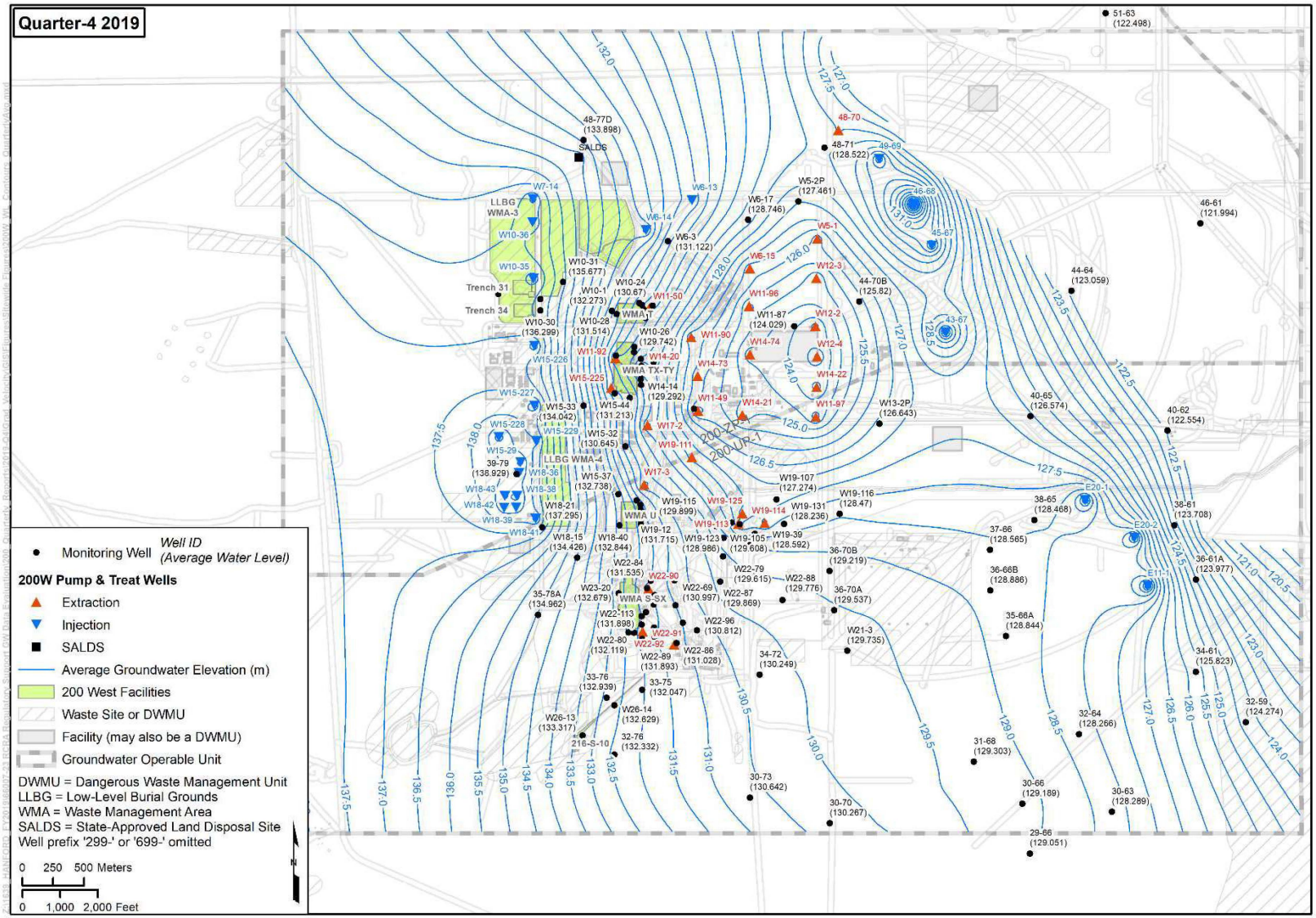

Figure 7. Mapped Groundwater Elevations – Average for October Through December 2019

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Appendix A

Groundwater Elevations in Monitoring Wells

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Contents

Tables

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A1 Introduction

Tables A-1 through A-3 present the data used in the calculations. The data were retrieved from the Hanford Environmental Information System database on February 4, 2020.

Measured water-levels presented in this appendix are based on the *North American Vertical Datum of 1988*. Spatial coordinates of well locations are presented in the *North America Datum of 1983* State Plane, Washington South FIPS 4602 coordinate system.

Water levels from wells marked with an asterisk (*) are clear outliers or consistently produced high kriging residuals, which were manifested as unrealistic artifacts in the water-level maps. As such, water-level measurements for these wells were considered unreliable and removed from the kriging dataset.

The following data are excluded altogether from this appendix:

- Data obtained for wells outside of the kriging grid extents as presented in Table A-1.
- Data obtained as part of the Hanford Site automated water-level network (AWLN) since measurements are collected on an hourly basis. The monthly averaged AWLN data used as input for the water-level mapping are provided in Table A-2.
- Data obtained for wells with screen configurations not representing the water table (i.e., not screened at or near the water table). These wells are listed in Section 4.1 and listed again as follows for reference:
  - 299-W5-2Q
  - 299-W11-13
  - 299-W11-43
  - 299-W11-48
  - 299-W11-88
  - 299-W13-2Q
  - 299-W14-71
  - 299-W18-22
  - 299-W19-34A
  - 299-W19-34B
  - 699-43-69
  - 699-45-69C
  - 699-48-77C

Table A-1. Measured Groundwater Elevations Used for Water-Level Mapping: October 2019

Well Name	Easting (NAD83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
299-E28-18	573104	136768	10/25/2019	121.624
299-E32-5	572600	137285	10/25/2019	121.608
299-E32-6	572600	137515	10/25/2019	121.620
299-E32-8	572663	137741	10/25/2019	121.624
299-E33-34	573104	137740	10/25/2019	121.627
299-W10-26	566843	136401	10/24/2019	129.832
299-W10-29	566083	136829	10/16/2019	136.306
299-W10-30	566083	136739	10/16/2019	136.338
299-W10-31	566266	136968	10/16/2019	135.677
299-W14-18	566897	136344	10/24/2019	129.110
299-W18-260	566863	135197	10/10/2019	131.731
299-W18-40	566723	134996	10/10/2019	132.844
299-W19-12	566897	135059	10/9/2019	131.715
299-W19-131	568060	135008	10/10/2019	128.233
299-W19-41	566897	135005	10/9/2019	131.803
299-W19-42	566897	135123	10/9/2019	131.769
299-W19-44	566897	135042	10/9/2019	131.726
299-W19-45	566898	135088	10/9/2019	131.737
299-W19-47	566895	135162	10/10/2019	131.753
299-W22-82	567005	134167	10/23/2019	131.584
299-W23-4	566628	134392	10/10/2019	133.280
299-W9-2	565742	136873	10/16/2019	136.687
699-29-66	570054	132337	10/9/2019	129.051
699-30-63	570717	132675	10/11/2019	128.289
699-30-70	568429	132582	10/11/2019	130.267
699-30-73	567782	132790	10/11/2019	130.642
699-32-59	571800	133400	10/17/2019	124.274
699-32-64	570451	133304	10/11/2019	128.266

Table A-1. Measured Groundwater Elevations Used for Water-Level Mapping: October 2019

Well Name	Easting (NAD83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
699-34-61	571396	133810	10/23/2019	125.755
699-35-66A	569858	134099	10/23/2019	128.755
699-36-61A	571395	134557	10/23/2019	123.897
699-36-63B	570684	134229	10/23/2019	127.435*
699-36-66B	569731	134469	10/23/2019	128.789
699-36-70A	568467	134309	10/9/2019	129.537
699-37-66	569730	134797	10/23/2019	128.470
699-38-61	571219	134997	10/23/2019	123.680
699-38-64B	569900	135320	10/23/2019	128.715*
699-38-65	570090	135040	10/23/2019	128.468
699-40-62	571164	135764	10/23/2019	122.557
699-40-65	570057	135881	10/23/2019	126.530
699-48-77D	566433	138119	10/23/2019	133.871
699-49-55A	573146	138352	10/23/2019	121.621
699-49-57A	572544	138389	10/23/2019	121.605
699-50-56	572748	138842	10/23/2019	121.633
699-51-63	570664	139148	10/18/2019	122.431
699-52-55	573102	139443	10/18/2019	121.688

References: NAVD88, *North American Vertical Datum of 1988*.
NAV83, *North America Datum of 1983*.

Table A-2. Measured Groundwater Elevations Used for Water-Level Mapping: November 2019

Well Name	Easting (NAD83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
299-E28-18	573104	136768	11/15/2019	121.619
299-E32-5	572600	137285	11/15/2019	121.615
299-E32-6	572600	137515	11/15/2019	121.620
299-E32-8	572663	137741	11/15/2019	121.622

Table A-2. Measured Groundwater Elevations Used for Water-Level Mapping: November 2019

Well Name	Easting (NAD83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
299-E33-34	573104	137740	11/15/2019	121.618
299-W10-1	566663	136735	11/7/2019	132.273
299-W10-24	566885	136799	11/6/2019	130.670
299-W10-26	566843	136401	11/15/2019	129.707
299-W10-27	566844	136442	11/15/2019	129.800
299-W10-28	566702	136710	11/5/2019	131.514
299-W10-30	566083	136739	11/1/2019	136.166
299-W11-39	566908	136780	11/6/2019	130.495
299-W11-40	566927	136710	11/7/2019	130.330
299-W11-41	566936	136678	11/6/2019	130.125
299-W11-42	566920	136746	11/6/2019	130.476
299-W11-45	566993	136776	11/11/2019	130.235
299-W11-47	566934	136681	11/7/2019	130.135
299-W11-87	568141	136609	11/1/2019	124.161
299-W13-2P	568833	135819	11/19/2019	126.643
299-W14-11	566902	136288	11/13/2019	127.444
299-W14-13	566902	136282	11/13/2019	128.090
299-W14-14	566898	136181	11/14/2019	129.392
299-W14-15	566900	136231	11/18/2019	129.009
299-W14-16	567001	136318	11/17/2019	128.763
299-W14-18	566897	136344	11/14/2019	128.849
299-W14-19	566899	136135	11/18/2019	129.451
299-W15-44	566685	136066	11/15/2019	131.384
299-W15-763	566809	136029	11/15/2019	130.676
299-W15-765	566697	136373	11/15/2019	129.971
299-W19-101	567939	135014	11/1/2019	127.495*
299-W19-107	567998	135206	11/1/2019	127.274
299-W19-115	567372	135012	11/1/2019	129.862

Table A-2. Measured Groundwater Elevations Used for Water-Level Mapping: November 2019

Well Name	Easting (NAD83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
299-W19-115	567372	135012	11/11/2019	129.876
299-W19-116	568510	135090	11/11/2019	128.469
299-W19-123	567512	134988	11/11/2019	128.986
299-W19-131	568060	135008	11/1/2019	128.251
299-W19-48	567823	134926	11/1/2019	128.588
299-W22-83	567009	134093	11/1/2019	131.550
299-W22-86	567187	134041	11/1/2019	131.016
299-W22-88	568046	134391	11/1/2019	129.760
299-W22-94	567010	134430	11/1/2019	131.249
299-W26-13	566424	133294	11/8/2019	133.317
299-W26-14	566683	133539	11/8/2019	132.629
299-W5-2P	568175	137621	11/18/2019	127.461
699-30-66	569991	132739	11/12/2019	129.189
699-32-76	566684	133138	11/8/2019	132.332
699-33-75	566908	133662	11/8/2019	132.049
699-33-76	566621	133600	11/8/2019	132.939
699-34-61	571396	133810	11/8/2019	125.855
699-35-66A	569858	134099	11/20/2019	128.833
699-35-78A	566064	134271	11/1/2019	134.931
699-36-61A	571395	134557	11/1/2019	123.942
699-36-61A	571395	134557	11/8/2019	124.016
699-36-63B	570684	134229	11/8/2019	127.446*
699-36-66B	569731	134469	11/20/2019	128.889
699-37-66	569730	134797	11/20/2019	128.575
699-38-61	571219	134997	11/1/2019	123.694
699-38-61	571219	134997	11/8/2019	123.723
699-38-64B	569900	135320	11/8/2019	128.732*
699-38-65	570090	135040	11/1/2019	127.751*

Table A-2. Measured Groundwater Elevations Used for Water-Level Mapping: November 2019

Well Name	Easting (NAD83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
699-39-79	565891	135412	11/1/2019	138.437
699-40-62	571164	135764	11/8/2019	122.555
699-40-65	570057	135881	11/1/2019	126.518
699-40-65	570057	135881	11/8/2019	126.601
699-44-70B	568670	136810	11/1/2019	125.797
699-48-71	568388	138057	11/1/2019	128.641
699-48-77D	566433	138119	11/8/2019	133.883
699-49-55A	573146	138352	11/20/2019	121.632
699-49-57A	572544	138389	11/20/2019	121.606
699-50-56	572748	138842	11/20/2019	121.628
699-51-63	570664	139148	11/8/2019	122.438
699-52-55	573102	139443	11/8/2019	121.689

References: NAVD88, *North American Vertical Datum of 1988*.
NAV83, *North America Datum of 1983*.

Table A-3. Measured Groundwater Elevations Used for Water-Level Mapping: December 2019

Well Name	Easting (NAND83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
299-E28-18	573104	136768	12/19/2019	121.599
299-E32-5	572600	137285	12/19/2019	121.597
299-E32-6	572600	137515	12/19/2019	121.598
299-E32-8	572663	137741	12/19/2019	121.607
299-E33-34	573104	137740	12/19/2019	121.602
299-W10-26	566843	136401	12/19/2019	129.688
299-W14-18	566897	136344	12/19/2019	128.964
299-W15-33	566433	135967	12/19/2019	134.042
299-W15-49	566307	135973	12/19/2019	135.426*
299-W18-15	566380	134733	12/6/2019	134.426

Table A-3. Measured Groundwater Elevations Used for Water-Level Mapping: December 2019

Well Name	Easting (NAND83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
299-W18-21	566098	134979	12/18/2019	137.295
299-W19-101	567939	135014	12/6/2019	127.402
299-W19-105	567565	134745	12/6/2019	129.608
299-W19-115	567372	135012	12/6/2019	129.863
299-W19-116	568510	135090	12/6/2019	128.471
299-W19-131	568060	135008	12/2/2019	128.223
299-W19-36	567635	135017	12/6/2019	128.447
299-W19-39	567902	134887	12/6/2019	128.592
299-W19-43	567699	135004	12/6/2019	127.099
299-W19-46	567783	134842	12/6/2019	129.059
299-W19-48	567823	134926	12/6/2019	128.546
299-W19-49	567568	134894	12/6/2019	129.239
299-W21-3	568571	133980	12/2/2019	129.735
299-W22-113	566905	134193	12/5/2019	131.853
299-W22-113	566905	134193	12/31/2019	131.942
299-W22-115	566939	134292	12/5/2019	131.783
299-W22-115	566939	134292	12/31/2019	131.874
299-W22-116	566901	134140	12/6/2019	131.850*
299-W22-116	566901	134140	12/31/2019	131.871*
299-W22-47	566909	134076	12/6/2019	131.857
299-W22-69	567180	134348	12/6/2019	130.997
299-W22-72	567237	134207	12/6/2019	130.990
299-W22-79	567630	134465	12/2/2019	129.615
299-W22-80	566843	134126	12/5/2019	132.082
299-W22-80	566843	134126	12/31/2019	132.157
299-W22-81	567000	134354	12/4/2019	131.551
299-W22-81	567000	134354	12/6/2019	131.527
299-W22-82	567005	134167	12/6/2019	131.625

Table A-3. Measured Groundwater Elevations Used for Water-Level Mapping: December 2019

Well Name	Easting (NAND83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
299-W22-83	567009	134093	12/2/2019	131.549
299-W22-84	566979	134548	12/4/2019	131.419
299-W22-84	566979	134548	12/31/2019	131.512
299-W22-85	566903	134261	12/5/2019	131.960
299-W22-85	566903	134261	12/31/2019	132.031
299-W22-86	567187	134041	12/6/2019	131.034
299-W22-87	567542	134540	12/2/2019	129.844
299-W22-87	567542	134540	12/6/2019	129.894
299-W22-89	566907	134032	12/6/2019	131.893
299-W22-93	566949	134486	12/4/2019	131.218
299-W22-93	566949	134486	12/4/2019	131.218
299-W22-94	567010	134430	12/4/2019	131.438
299-W22-94	567010	134430	12/6/2019	131.407
299-W22-95	567171	134549	12/6/2019	130.729
299-W22-96	567352	134146	12/6/2019	130.812
299-W23-20	566718	134446	12/4/2019	132.670
299-W23-20	566718	134446	12/31/2019	132.689
299-W23-21	566708	134294	12/6/2019	132.789
299-W23-21	566708	134294	12/31/2019	132.881
299-W23-236	566799	134128	12/31/2019	132.441
299-W6-3	567118	137299	12/18/2019	131.122
699-31-68	569598	133081	12/2/2019	129.303
699-33-75	566908	133662	12/6/2019	132.044
699-34-61	571396	133810	12/6/2019	125.858
699-34-72	567860	133785	12/6/2019	130.249
699-35-66A	569858	134099	12/31/2019	128.943
699-36-61A	571395	134557	12/6/2019	124.018
699-36-66B	569731	134469	12/31/2019	128.981

Table A-3. Measured Groundwater Elevations Used for Water-Level Mapping: December 2019

Well Name	Easting (NAND83 m)	Northing (NAD83 m)	Date	Measured Water Level (NAV88 m)
699-36-70B	568428	134626	12/6/2019	129.219
s699-37-66	569730	134797	12/31/2019	128.651
699-38-61	571219	134997	12/6/2019	123.722
699-39-79	565891	135412	12/6/2019	139.297
699-40-62	571164	135764	12/6/2019	122.551
699-40-65	570057	135881	12/6/2019	126.592
699-44-64	570391	136897	12/18/2019	123.059
699-48-77D	566433	138119	12/4/2019	133.940
699-49-55A	573146	138352	12/19/2019	121.638
699-49-57A	572544	138389	12/19/2019	121.611
699-50-56	572748	138842	12/19/2019	121.615
699-51-63	570664	139148	12/4/2019	122.625
699-52-55	573102	139443	12/4/2019	121.700

References: NAVD88, 1988, *North American Vertical Datum of 1988*.
NAV83, 1991, *North America Datum of 1983*.

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Appendix B

200 West Area Water-Level Mapping Drift Input Data for Fourth Quarter of Calendar Year 2019

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Table B-1. Average Monthly Pumping Rates (gal/min) for 200-ZP-1 and 200-UP-1 Pump and Treat Remedies During the Fourth Quarter of Calendar Year 2019

Well Name	Plant ID	Easting (NAD83 m)	Northing (NAD83 m)	Drift Term	Oct	Nov	Dec	4th Quarter
299-E11-1	YJ-28	571003	134505	29	70.97	84.00	84.72	78.99
299-E20-1	YJ-26	570503	135200	29	64.47	49.49	79.39	63.92
299-E20-2	YJ-27	570898	134896	29	67.43	71.27	71.28	69.23
299-W10-35	YJ-04	566025	136995	29	112.28	125.90	88.33	107.48
299-W10-36	YJ-03	566019	137452	29	53.79	58.70	63.51	58.03
299-W11-49	YE-12	567362	135925	30	132.66	137.38	128.99	131.53
299-W11-50	YE-06	566966	136757	30	58.89	17.85	58.49	44.89
299-W11-90	YE-07	567307	136520	30	83.40	110.05	111.69	100.53
299-W11-92	YE-16	566693	136352	30	107.44	124.56	102.31	110.10
299-W11-96	YE-08	567775	136772	30	75.81	81.13	93.37	82.56
299-W11-97	YE-13	568318	135876	30	124.22	129.10	125.11	124.75
299-W12-2	YE-05	568313	136610	30	87.59	104.21	105.31	97.92
299-W12-3	YE-18	568322	136998	30	86.76	100.30	104.30	96.04
299-W12-4	YE-19	568327	136364	30	97.09	117.73	128.34	113.12
299-W14-20	YE-02	566909	136284	30	103.47	112.31	67.56	93.24
299-W14-21	YE-15	567722	135890	30	95.39	98.47	95.52	95.40
299-W14-22	YE-20	568325	136117	30	90.61	107.25	110.62	101.67
299-W14-73	YE-03	567359	136205	30	20.95	31.20	67.67	39.61
299-W14-74	YE-04	567781	136381	30	66.96	96.62	105.00	88.49
299-W15-225	YE-01	566657	136109	30	80.78	46.53	96.28	74.03
299-W15-226	YJ-05	566033	136450	29	120.21	146.81	158.76	140.34
299-W15-227	YJ-06	566034	135967	29	130.80	143.61	154.66	141.48
299-W15-228	YJ-07	565745	135711	29	109.05	120.21	132.66	119.35
299-W15-229	YJ-24	566049	135679	29	53.94	84.28	107.77	81.09
299-W15-29	YJ-18	565921	135506	29	59.07	98.40	102.24	85.51
299-W17-2	YE-10	566952	135806	30	99.22	103.38	98.32	99.19
299-W17-3	YE-09	566926	135325	30	108.47	117.57	118.03	113.43
299-W18-36	YJ-19	565909	135419	29	78.85	84.72	88.58	83.14
299-W18-38	YJ-21	565892	135233	29	53.02	85.65	78.36	71.42
299-W18-39	YJ-22	565886	135141	29	4.82	56.00	46.19	35.07
299-W18-41	YJ-08	566045	135049	29	123.88	137.18	146.37	134.33

Table B-1. Average Monthly Pumping Rates (gal/min) for 200-ZP-1 and 200-UP-1 Pump and Treat Remedies During the Fourth Quarter of Calendar Year 2019

Well Name	Plant ID	Easting (NAD83 m)	Northing (NAD83 m)	Drift Term	Oct	Nov	Dec	4th Quarter
299-W18-42	YJ-32	565788	135139	29	118.23	19.44	29.05	55.37
299-W18-43	YJ-31	565794	135234	29	75.36	19.42	28.99	41.05
299-W19-111	YE-11	567313	135547	30	17.63	30.05	29.14	25.28
299-W19-113	YE-25	567690	135008	30	42.18	44.58	39.63	41.65
299-W19-114	YE-26	567902	135013	30	71.95	74.28	72.11	71.98
299-W19-125	YE-24	567720	135091	30	47.11	49.63	48.23	47.79
299-W22-90	YE-21	566961	134483	33	23.50	24.88	24.08	23.89
299-W22-91	YE-22	566912	134135	33	28.27	29.77	28.94	28.67
299-W22-92	YE-23	567168	134030	33	23.63	23.80	24.24	23.63
299-W5-1	YE-17	568330	137321	30	81.72	94.61	97.40	90.23
299-W6-13	YJ-01	567313	137631	29	58.53	65.02	70.81	64.09
299-W6-14	YJ-02	566940	137389	29	126.28	137.31	146.35	135.17
299-W6-15	YE-14	567782	137076	30	74.31	76.39	85.10	77.78
299-W7-14	YJ-25	566022	137639	29	119.13	122.80	123.45	120.47
699-43-67	YJ-13	569370	136560	32	40.47	41.94	3.17	28.08
699-45-67	YJ-11	569257	137263	32	8.22	12.87	38.82	19.83
699-46-68	YJ-23	569110	137601	32	51.95	52.62	61.96	54.94
699-48-70	YE-33	568500	138200	30	0.00	0.00	69.96	23.32
699-49-69	YJ-09	568830	137967	32	14.96	5.90	38.82	19.83

Reference: NAV83, *North America Datum of 1983*.

Note: Spatial coordinates are reported in the *North American Datum of 1983* (NAD83) State Plane, Washington South 4602 coordinate system.

*Rates of 200-UP-1 iodine injection wells were multiplied by four to adjust for lower transmissivity.

ID = identification

Table B-2. Average Monthly Discharge Rates (gal/min) for the State Approved Land Disposal Site During the Fourth Quarter of Calendar Year 2019

ID	Easting (NAV83 m)	Northing (NAV83 m)	Drift Term	Oct	Nov	Dec	4th Quarter
SALDS	566395	137979	32	65.5	0.0	22.9	29.5

Reference: NAV83, *North America Datum of 1983*.

SALDS = State Approved Land Disposal Site

ID = identification