SGW-64538
Revision 0

Data Usability Assessment for 300-FF-5 Stage B Soils

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

Approved for Public Release;
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Terms

CHPRC	CH2M HILL Plateau Remediation Company
COC	contaminant of concern
DQI	data quality indicator
DQO	data quality objective
DUA	data usability assessment
DUP	field duplicate
EA	enhanced attenuation
EB	equipment blank
EPA	U.S. Environmental Protection Agency
ERT	electrical resistivity tomography
FTB	full trip blank
FXR	field transfer blank
HEIS	Hanford Environmental Information System
ID	identification
LCS	laboratory control sample
LVZ	lower vadose zone
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
OU	operable unit
PQL	practical quantitation limit (synonymous with EQL)
PRZ	periodically rewetted zone
PSQ	principal study question
QA	quality assurance
QC	quality control
RPD	relative percent difference
SAP	sampling and analysis plan
SDG	sample delivery group
SMR	Sample Management and Reporting (group)

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1 Introduction

This data usability assessment (DUA) report evaluates laboratory data produced from soil samples collected as part of well installations for the implementation and performance monitoring of the enhanced attenuation remedy for the 300-FF-5 Operable Unit (OU). The data quality indicators (DQIs) assessment included in this DUA are used for samples collected under DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan* (hereinafter referred to as the 300-FF-5 OU sampling and analysis plan [SAP]) (as modified by TPA-CN-0762, TPA-CN-0820, TPA-CN-0827, and TPA-CN-0867) and its associated addendum DOE/RL-2014-42-ADD1, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan Addendum for Stage B Uranium Sequestration* (hereinafter referred to as ADD1) (as modified by TPA-CN-0828, TPA-CN-0835, and TPA-CN-0868) because a judgmental sampling design was used. This DUA completes the U.S. Environmental Protection Agency (EPA) data quality life cycle (planning, implementation, and assessment).

When judgmental (focused) sampling designs are implemented in the field, the DQIs precision, accuracy/bias, representativeness, comparability, completeness, and sensitivity for the specific data sets are evaluated according to EPA/240/R-02/004, *Guidance on Environmental Data Verification and Data Validation*. Data verification and validation are integral to the DQI evaluation process. CH2M HILL Plateau Remediation Company (CHPRC) used results of the DQI evaluation process to interpret the data and determine whether the data quality objectives (DQOs) for this activity have been met.

This report documents components of the DUA, including data verification (Chapter 2), data validation (Chapter 3), data quality indicators evaluation (Chapter 4), and conclusions (Chapter 5).

1.1 Purpose

The purpose of this DUA is to determine whether the data collected under the 300-FF-5 OU SAP (DOE/RL-2014-42) and ADD1 (DOE/RL-2014-42-ADD1) are the right type and of sufficient quality and quantity to support groundwater monitoring and remediation decisions. The DUA process is not intended to be a definitive analysis of a project or problem. Rather, the method provides an initial assessment of the reasonableness of the generated data based solely on the associated quality control (QC) information and not on the technical interpretations of the data values.

The information contained in this report follows guidelines for DUAs established by the CHPRC Soil and Groundwater Remediation Project based on EPA/240/R-02/004.

1.2 Scope

This DUA focuses on the chemical characterization data collected by sampling soil for Stage B of the 300-FF-5 OU uranium sequestration enhanced attenuation by polyphosphate injection project. The data are evaluated to determine whether they meet the analytical criteria outlined in the 300-FF-5 OU SAP (DOE/RL-2014-42) and ADD1 (DOE/RL-2014-42-ADD1) and are adequate to support decisionmaking. The 300-FF-5 OU SAP specifies the QC requirements that are to be followed in both the field and analytical laboratory to ensure that reliable data are obtained. The ADD1 specifies the number and type (matrix) of samples that are required to be collected during the installation of the monitoring wells, injection wells, and characterization boreholes during Stage B of the project. These quality control requirements and the completeness of the soil sample collection are evaluated in this DUA report.

Other data collected for the project that were not within the scope of the 300-FF-5 OU SAP (DOE/RL-2014-42) and ADD1 (DOE/RL-2014-42-ADD1) are not discussed in this report.

1.3 Project Background

This section describes the sampling design and associated project objectives, including implementation of the sampling design.

The 300-FF-5 OU comprises groundwater contaminated by releases from facilities and waste sites associated with past operation of uranium fuel production and research and development in the 300 Area Industrial Complex. EPA and DOE, 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*, identifies uranium, gross alpha, nitrate, tritium, trichloroethene (TCE), and *cis*-1,2-dichloroethene (*cis*-1,2-DCE) as the groundwater contaminants of concern (COCs).

The Stage B enhanced attenuation remedy was designed to deliver three pore volumes of polyphosphate solution uniformly to the lower vadose zone (LVZ) and periodically rewetted zone (PRZ) within the enhanced attenuation (EA) area to sequester uranium. Pore volume is the total volume of void space between sediment particles.

1.3.1 Sampling Design

EA using uranium sequestration was implemented in a 1.2 ha (3 ac) area in two stages, A and B. Stage B treatment area consisted of two spatially distinct segments where injections were required. The Stage B area was equipped with 48 injection wells, up to 24 monitoring wells, and an electrical resistivity tomography (ERT) network. Concentrated phosphate solutions were stored in aboveground chemical tanks mixed with river water and injected into the LVZ and PRZ within the Stage B EA area. Figure 1 shows the general layout and the Stage B injection wells.

1.3.2 Project Objectives

Uranium sequestration involved injecting phosphate solutions to the LVZ and PRZ to sequester or bind residual mobile uranium to form insoluble minerals. The target area for application of the phosphate solutions was a 1 ha (3 ac) area that contained a persistent source of uranium contamination to groundwater. Uranium sequestration in the LVZ and PRZ is anticipated to reduce the mass of soluble uranium entering the groundwater in this area and thereby reduce the restoration timeframe for uranium in the groundwater.

The intent of the Stage B EA was to deliver three pore volumes of phosphate solution uniformly to the LVZ and the PRZ to sequester uranium.

During borehole installation of the injection and monitoring wells for Stage B, baseline sampling of soils was conducted to measure pre-treatment uranium concentrations and leachability. Six months after EA treatment, post-treatment soil samples were collected from nine new post-treatment boreholes for comparison with the pre-treatment samples to determine the effectiveness of the EA treatment.

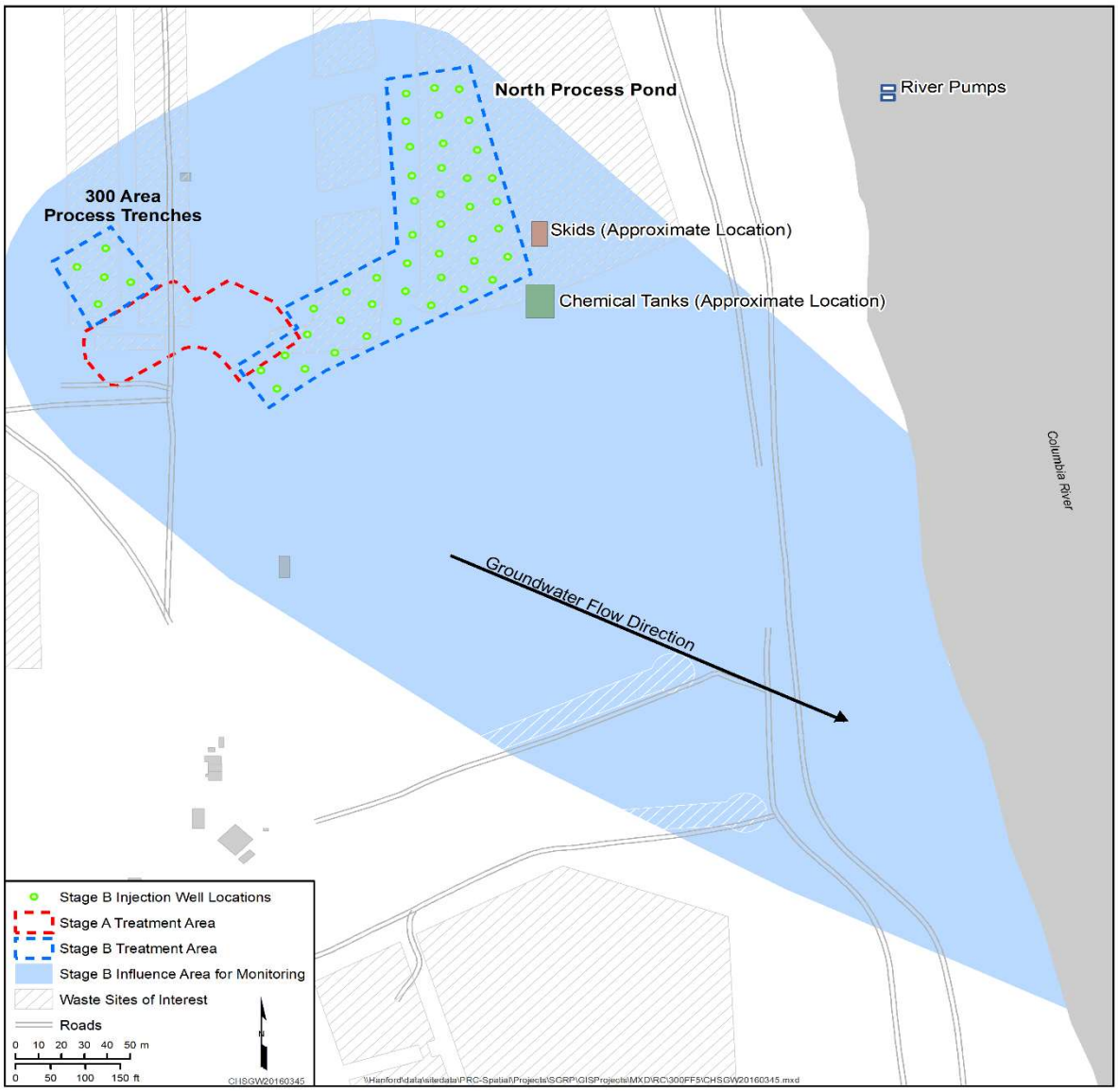

Figure 1. Stage B Injection General Site Layout

1.3.3 Design Objectives

The EPA seven-step DQO process (EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process*) was used to guide development of remedy implementation for the 300-FF-5 OU. The following principal study question (PSQ) was developed for the Stage B design objectives:

- Will the operation of Stage B meet the design objectives:
  - Achieve treatment solution concentrations; achieve injection flowrate and volume
  - Evaluate the distribution of phosphate over time in the LVZ, PRZ, and top of the aquifer
  - Determine the short-term impact (<1 year) to local uranium groundwater concentrations and chemistry
  - Determine the change, if any, observed in the leachability of uranium after treatment

Table 1 lists the specific design objectives for soil sampling.

Table 1. Specific Design Objectives

Design Objective*	Scope of Work
Determine distribution of PO4 in vadose zone, PRZ, and groundwater	A total of 5 to 6 soil samples to be collected at each of 20 pre-treatment wells and up to 9 post-treatment wells. Total phosphorus, grab samples from drive barrel every 0.75 m (2.5 ft) starting at approximately 108.5 to 104.5 m amsl (20 ft bgs and ending at 33 ft bgs) vertical profile (roughly 5 or 6 samples).
Determine change, if any, in leachability of uranium after treatment	A total of 5 to 6 soil samples to be collected at each of 20 pre-treatment wells and up to 9 post-treatment wells. Total uranium, grab samples from drive barrel every 0.75 m (2.5 ft) starting at 108.5 to 104.5 m amsl (20 ft bgs and ending at 33 ft bgs) vertical profile (roughly 5 or 6 samples).

*Principal study question objective and data needs are defined in Section 1.2 of DOE/RL-2014-42-ADD1, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan Addendum for Stage B Uranium Sequestration*.

amsl = above mean sea level
bgs = below ground surface
PRZ = periodically rewetted zone

1.3.3.1 Implementation of the Sample Design

In accordance with ADD1 (DOE/RL-2014-42-ADD1), drilling and construction of 67 wells for the pre-treatment phase of Stage B operations occurred from January 24, 2017, through June 1, 2017 (SGW-61092, *Borehole Summary Report for the Installation of Forty Eight Injection [W]ells and Nineteen Monitoring Wells at the 300-FF-5 Operable Unit, FY 2017*). This new well construction included 48 injection wells and 19 monitoring wells.

Also in accordance with ADD1 (DOE/RL-2014-42-ADD1), at least seven soil (grab) samples were collected from 19 of the pre-treatment injection wells and one of the pre-treatment monitoring wells for laboratory analysis for the COCs uranium, phosphorus, and pH. Per ADD1, the soil samples were collected continuously in 2.5 ft intervals from 20 to 32.5 ft below ground surface. A total of 280 samples were collected during drilling, of which 165 were selected for laboratory analysis for the COCs uranium, phosphorus, and pH. The 165 soil samples also include field QC samples such as equipment blanks (EBs) in agreement with the number of samples estimated to be required for laboratory analysis in ADD1. Figure 2 shows the locations of the 67 new wells installed in the 300-FF-5 OU for Stage B operations. Table 2 lists the well identifications (IDs), sample depths, and Hanford Environmental Information System (HEIS) numbers of those 167 soil samples collected during the drilling of these pre-treatment wells and selected for laboratory analysis for the COCs uranium, phosphorus, pH, and other analyses.

Six months after the polyphosphate solution injections were performed, another nine characterization boreholes were drilled for post-treatment monitoring, with 112 soil samples collected for laboratory analysis for the COCs uranium, phosphorus, and pH. These efforts are in agreement with the number of samples estimated in ADD1 (DOE/RL-2014-42-ADD1) to be selected for laboratory analysis from the post-treatment boreholes. Figure 3 shows the locations of the nine post-EA treatment boreholes. Table 3 lists the well IDs, intervals, and HEIS numbers of the post-EA treatment injection soil samples.

Soil samples selected for laboratory analysis were collected and analyzed for constituents identified in Table 6 of ADD1 (DOE/RL-2014-42-ADD1) and Table 4-3 of the 300-FF-5 OU SAP (DOE/RL-2014-42).

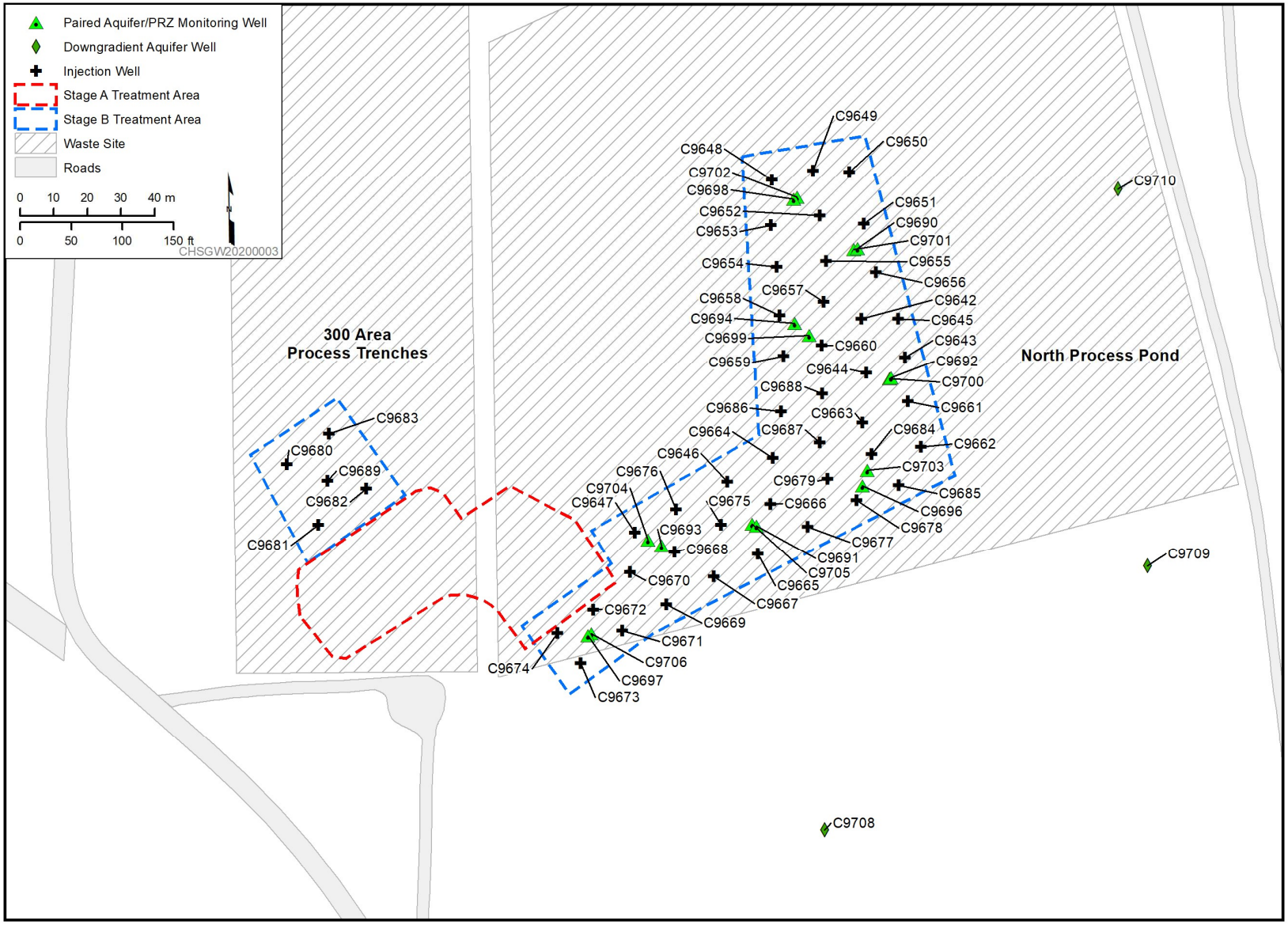

Figure 2. Location of Stage B Boreholes (Pre-Treatment)

Table 2. Stage B Soil Sample Collection (Pre-Treatment)

Borehole ID Well Name (Well Type)	Sample Depth (ft bgs)	HEIS Number (Sample ID)	SDG
C9642 399-1-98 (injection)	EB	B389X7	GEL417869
	20.0–22.5	B389W5	
	22.5–25.0	B389W8, B389X1	
	25.0–27.5	B389X4	
	27.5–30.0	B389Y0	
	30.0–32.5	B389Y3	
C9643 399-1-99 (injection)	EB	B38B20	GEL419430
	15.0–18.0	No samples collected	
	20.0–22.5	B38B05, B38B08	
	22.5–25.0	B38B11	
	25.0–27.5	B38B14	
	27.5–30.0	B38B17	
	30.0–32.5	B38B23	
C9644 (injection)	--	No samples collected	--
C9645 (injection)	--	No samples collected	--
C9646 399-1-102 (injection)	EB	B38B54	GEL421477
	20.0–22.5	B38B36	
	22.5–25.0	B38B39	
	25.0–27.5	B38B42, B38B45	
	27.5–30.0	B38B48	
	30.0–32.5	B38B51	
C9647 399-1-103 (injection)	EB	B38B69	GEL423563
	20.0–22.5	B38B66	
	22.5–25.0	B38B72	
	25.0–27.5	B38B75	
	27.5–30.0	B38B78, B38B81	
	30.0–32.5	B38B84	
C9648 (injection)	--	No samples collected	--

Table 2. Stage B Soil Sample Collection (Pre-Treatment)

Borehole ID Well Name (Well Type)	Sample Depth (ft bgs)	HEIS Number (Sample ID)	SDG
C9649 399-1-105 (injection)	EB	B38BB2	GEL415914
	20.5–23.0	B38B96	
	23.0–25.5	B38B99	
	25.5–28.0	B38BB5	
	28.0–30.5	B38BB8	
	31.0–33.5	B38BC1, B38BC4	
C9650 399-1-106 (injection)	19.0	B38T63	GEL416674
C9651 399-1-107 (injection)	EB	B38BF8	GEL417074
	19.0–20.0	B38BH7	
	20.0–22.5	B38BD6	
	22.5–25.0	B38BD9, B38BF2	
	25.0–27.5	B38BF5	
	27.5–30.0	B38BH1	
	30.0–32.5	B38BH4	
C9652 (injection)	--	No samples collected	--
C9653 399-1-109 (injection)	EB	B38BL1	GEL416674, GEL417074
	19.0–20.0	B38BL7	
	20.0–22.5	B38BJ6, B38BJ9	
	22.5–25.0	B38BK2	
	25.0–27.5	B38BK5	
	27.5–30.0	B38BK8	
	30.0–32.5	B38BL4	
C9654 (injection)	--	No samples collected	--
C9655 399-1-111 (injection)	EB	B38BP4	GEL417289
	20.0–22.5	B38BM6	
	22.5–25.0	B38BM9	
	25.0–27.5	B38BN2, B38BN5	
	27.5–30.0	B38BN8	
	30.0–32.5	B38BP1	
C9656 399-1-112 (injection)	16.5–17.5	B38T69	GEL417869
	21.0	B38T66	

Table 2. Stage B Soil Sample Collection (Pre-Treatment)

Borehole ID Well Name (Well Type)	Sample Depth (ft bgs)	HEIS Number (Sample ID)	SDG
C9657 399-1-113 (injection)	18.0	B38T78, B399F3	GEL418733
C9658 399-1-114 (injection)	18.5	B399F4, B38T81	GEL418733
C9659 399-1-115 (injection)	13.0	B38T72	GEL419226
	14.0	B38T75	
	20.0	B38T84	
C9660 399-1-116 (injection)	15.0	No samples collected	GEL419226
	19.0–20.0	B38T90	
	41.5–44.5	B38T87	
C9661 399-1-117 (injection)	20.0–21.5	B38TB2	GEL419726
	10.0–20.0	No samples collected	
	30.0	No samples collected	
C9662 399-1-118 (injection)	EB	B38BR9	GEL419530
	18.0–19.0	B38BV7	
	10–20	No samples collected	
	20.0–22.5	B38BR6	
	22.5–25.0	B38BT2	
	25.0–27.5	B38BT5	
	27.5–30.0	B38BT8, B38BV1	
	30.0–32.5	B38BV4	
C9663 399-1-119 (injection)	EB	B38BX2	GEL420103
	10.0–20.0	No samples collected	
	20.0–22.5	B38BW6	
	22.5–25.0	B38BW9	
	25.0–27.5	B38BX5	
	27.5–30.0	B38BX8	
	30.0–32.5	B38BY1, B38BY4	
C9664 399-1-120 (injection)	19.0–20.0	B38TD0, B39W86	GEL423023
C9665 (injection)	--	No samples collected	--

Table 2. Stage B Soil Sample Collection (Pre-Treatment)

Borehole ID Well Name (Well Type)	Sample Depth (ft bgs)	HEIS Number (Sample ID)	SDG
C9666 (injection)	15.0–20.0	No samples collected	--
	20.0–21.0	No samples collected	
	32.0	No samples collected	
C9667 399-1-123 (injection)	EB	B388N4	GEL420546, GEL420693
	20.0–22.0	B388M2	
	22.0–25.0	B388M5, B388M8	
	25.0–27.5	B388N1	
	27.5–30.0	B388N7	
	30.0–32.5	B388P0	
	15.0	No samples collected	
C9668 (injection)	10.0–20.0	No samples collected	--
C9669 (injection)	10.0–20.0	No samples collected	--
C9670 399-1-126 (injection)	27.5	B38TB8	GEL421221
	30.0	B38TC1	
	35.0	B38TC4	
	40.0	B38TC7	
C9671 (injection)	14.0	No samples collected	--
C9672 399-1-128 (injection)	EB	B388T7	GEL419841
	20.0–22.5	B388R2, B388R5	
	22.5–25.0	B388R8	
	25.0–27.5	B388T1	
	27.5–30.0	B388T4	
	30.0–32.5	B388V0	
C9673 399-1-129 (injection)	EB	B388Y0	GEL419226
	20.0–22.5	B388W2	
	22.5–25.0	B388W5	
	25.0–27.5	B388W8, B388X1	
	27.5–30.0	B388X4	
	30.0–32.5	B388X7	
C9674 (injection)	--	No samples collected	--
C9675 (injection)	20.0–30.0	No samples collected	--

Table 2. Stage B Soil Sample Collection (Pre-Treatment)

Borehole ID Well Name (Well Type)	Sample Depth (ft bgs)	HEIS Number (Sample ID)	SDG
C9676 (injection)	15.0–17.0	No samples collected	--
C9677 399-1-133 (injection)	EB	B38905	GEL421074
	14.0	No samples collected	
	20.0–22.5	B38902	
	22.5–25.0	B38908	
	25.0–27.5	B38911	
	27.5–30.0	B38914, B38917	
	30.0–32.5	B38920	
C9678 (injection)	12.5	No samples collected	--
C9679 399-1-135 (injection)	EB	B38938	GEL420693
	20.0–22.5	B38932	
	22.5–25.0	B38935	
	25.0–27.5	B38941	
	27.5–30.0	B38944	
	30.0-32.5	B38947, B38950	
C9680 399-1-136 (injection)	16.0–20.0	B39W88, B39JV2	GEL423426
C9681 399-1-137 (injection)	EB	B38974	GEL423299
	20.0–22.5	B38962	
	22.5–25.0	B38965, B38968	
	25.0–27.5	B38971	
	27.5–30.0	B38977	
	30.0–32.5	B38980	
C9682 399-1-138 (injection)	EB	B389B7	GEL423426
	15.0–20.0	No samples collected	
	20.0–22.5	B38992, B38995	
	22.5–25.0	B38998	
	25.0–27.5	B389B1	
	27.5–30.0	B389B4	
	30.0–32.5	B389C0	

Table 2. Stage B Soil Sample Collection (Pre-Treatment)

Borehole ID Well Name (Well Type)	Sample Depth (ft bgs)	HEIS Number (Sample ID)	SDG
C9683 399-1-139 (injection)	EB	B389L3	GEL423299
	7.5–9.0	No samples collected	
	15.0	No samples collected	
	18.0–20.0	No samples collected	
	20.0–22.5	B389J5	
	22.5–25.0	B389J8	
	25.0–27.5	B389K1, B389K4	
	27.5–30.0	B389K7	
	30.0–32.5	B389L0	
C9684 (injection)	--	No samples collected	--
C9685 399-1-141 (injection)	22.0–23.0	B38TB5	GEL420546
C9686 399-1-142 (injection)	EB	B389M8	GEL419726
	20.0–22.5	B389M5	
	22.5–25.0	B389N1	
	25.0–27.5	B389N4	
	27.5–30.0	B389N7, B389PO	
	30.0–32.5	B389P3	
C9687 (injection)	10.0–20.0	No samples collected	--
	20.0–30.0	No samples collected	
C9688 (injection)	--	No samples collected	--
C9689 (injection)	15.0	No samples collected	--
	20.0	No samples collected	
	20.0–22.0	No samples collected	
	24.0–25.0	No samples collected	
	25.0–26.0	No samples collected	
	30.0	No samples collected	
C9690 (monitoring)	--	No samples collected	--
C9691 (monitoring)	--	No samples collected	--
C9692 (monitoring)	10.0–20.0	No samples collected	--

Table 2. Stage B Soil Sample Collection (Pre-Treatment)

Borehole ID Well Name (Well Type)	Sample Depth (ft bgs)	HEIS Number (Sample ID)	SDG
C9693 (monitoring)	10.0–20.0	No samples collected	--
C9694 399-1-150 (monitoring)	EB	B389T1	GEL418855
	10.0–12.5	B389V6	
	10.0–20.0	No samples collected	
	20.0–22.5	B389R5	
	22.5–25.0	B389R8	
	25.0–27.5	B389T4, B389V3	
	27.5–30.0	B389T7	
	30.0–32.5	B389V0	
C9697 (monitoring)	30.0	No samples collected	--
C9700 (monitoring)	17.0	No samples collected	--
C9705 399-1-161 (monitoring)	16.5–17.5	B39W84	GEL421378
C9706 399-1-162 (monitoring)	20.0	B38T93	GEL419430
	40.0	B38T96	
	43.0	B38T99	

-- = no data or not applicable
bgs = below ground surface
EB = equipment blank
HEIS = Hanford Environmental Information System
ID = identification
SDG = sample delivery group

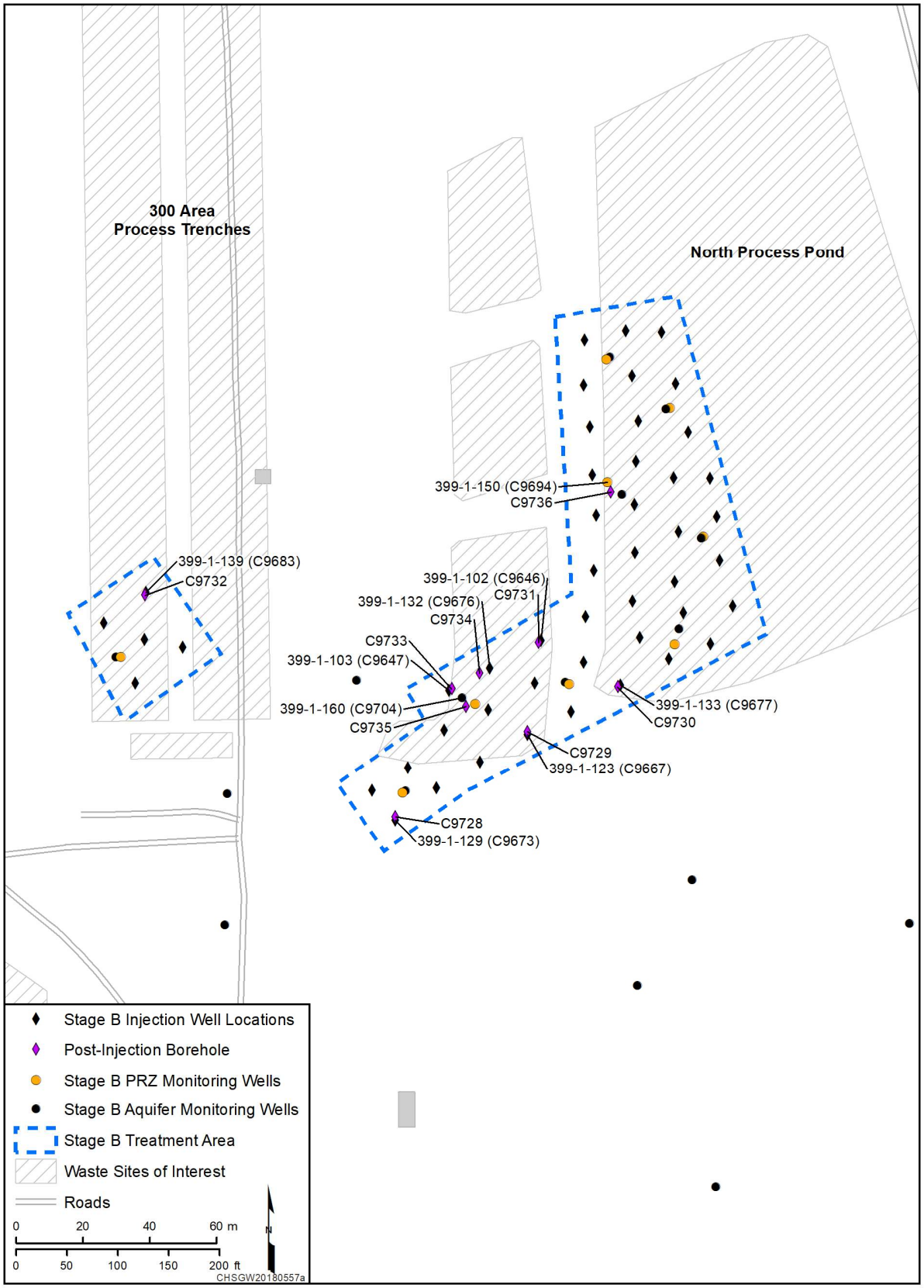

Figure 3. Location of Stage B Boreholes (Post-Treatment)

Table 3. Stage B Soil Sample Collection (Post-Treatment)

Borehole ID	Actual Depth (ft bgs)	HEIS Number (Sample ID)	SDG
C9728 (borehole)	20	B3P2J5, B3P2J6, B3P2J7, B3P3F1	GEL474580, GEL474581, GEL474750, GEL474756, GEL474757, GEL474772, SL33449-1, SL33471-1, SL33472-1
	22.5	B3P2J9, B3P2K0, B3P2K1, B3P3F2	
	25	B3P2K3, B3P2K4, B3P2K5, B3P3F3	
	27.5	B3P2K7, B3P2K8, B3P2K9, B3P3F4	
	30	B3P2L1, B3P2L2, B3P2L3, B3P3F5, B3P425, B3P426, B3P427, B3P429	
C9729 (borehole)	10	B3P4F6, B3P4F7	GEL474750, GEL474756, GEL474757, GEL474772, GEL475409, GEL475432, SL33471-1, SL33472-1
	20	B3P2L5, B3P2L6, B3P2L7, B3P3F6	
	22.5	B3P2L9, B3P2M0, B3P2M1, B3P3F7	
	25	B3P2M3,, B3P2M4, B3P2M5, B3P3F8	
	27.5	B3P2M7, B3P2M8, B3P2M9, B3P3F9	
	30	B3P2N1, B3P2N2, B3P2N3, B3P3H0, B3P431, B3P432, B3P433, B3P435	
C9730 (borehole)	20	B3P2N5, B3P2N6, B3P3H1	GEL474580, GEL474581, GEL474750, GEL474756, GEL474757, GEL474772, SL33449-1, SL33471-1, SL33472-1
	22.5	B3P2N9, B3P2P0, B3P2P1, B3P3H2	
	25	B3P2P3, B3P2P4, B3P2P5, B3P3H3	
	27.5	B3P2P7, B3P2P8, B3P2P9, B3P3H4	
	30	B3P2R1, B3P2R2, B3P2R3, B3P3H5, B3P437, B3P438, B3P439, B3P441	
C9731 (borehole)	21	B3P2R5, B3P2R6, B3P2R7, B3P3H6	GEL474750, GEL474756, GEL474757, GEL474772, GEL476738, SL33471-1
	24	B3P2R9, B3P2T0, B3P2T1, B3P3H7	
	25	B3P2T3	
	27.5	B3P2T7, B3P2T8, B3P2T9, B3P3H9	
	30	B3P2V1, B3P2V2, B3P2V3, B3P3J0, B3P443, B3P444, B3P445, B3P447	
C9732 (borehole)	20	B3P2V5, B3P2V6, B3P2V7, B3P3J1	GEL474750, GEL474756, GEL474757, GEL474772, GEL474854, GEL474887, SL33471-1, SL33488-1
	22.5	B3P2V9, B3P2W0, B3P2W1, B3P3J2	
	25	B3P2W3, B3P2W4, B3P2W5, B3P3J3	
	27.5	B3P2W7, B3P2W8, B3P2W9, B3P3J4	
	30	B3P2X1, B3P2X2, B3P2X3, B3P3J5, B3P449, B3P450, B3P451, B3P453	
C9733 (borehole)	20	B3P2X5, B3P2X6, B3P2X7, B3P3J6	GEL474300, GEL474313, GEL474750, GEL474756, GEL474757, SL33391-1, SL33471-1, SL33472-1
	22.5	B3P2X9, B3P2Y0, B3P2Y1, B3P3J7	
	25	B3P2Y3, B3P2Y4, B3P2Y5, B3P3J8	
	27.5	B3P2Y7, B3P2Y8, B3P2Y9, B3P3J9	
	30	B3P301, B3P302, B3P303, B3P3K0, B3P455, B3P456, B3P459	

Table 3. Stage B Soil Sample Collection (Post-Treatment)

Borehole ID	Actual Depth (ft bgs)	HEIS Number (Sample ID)	SDG
C9734 (borehole)	20	B3P305, B3P306, B3P307, B3P3K1	GEL474756, GEL474772, SL33471-1, SL33472-1
	22.5	B3P309, B3P310, B3P311, B3P3K2	
	25	B3P313, B3P314, B3P315, B3P3K3	
	27.6	B3P317, B3P318, B3P319, B3P3K4	
	30.1	B3P321, B3P322, B3P323, B3P3K5, B3P461, B3P462, B3P463, B3P465	
C9735 (borehole)	15	B3P4K1, B3P4K2	GEL474854, GEL474887, GEL475409, GEL475432, SL33488-1
	20	B3P325, B3P326, B3P327, B3P3K6	
	22.5	B3P329, B3P330, B3P331, B3P3K7	
	25	B3P333, B3P334, B3P335, B3P3K8	
	27.5	B3P337, B3P338, B3P339, B3P3K9	
	30	B3P341, B3P342, B3P343, B3P3L0, B3P467, B3P468, B3P469, B3P471	
C9736 (borehole)	20	B3P345, B3P346, B3P347, B3P3L1	GEL474412, GEL474413, GEL474756, GEL474772, SL33412-1, SL33471-1
	22.5	B3P349, B3P350, B3P351, B3P3L2	
	25	B3P353, B3P354, B3P355, B3P3L3	
	27.5	B3P357, B3P358, B3P359, B3P3L4	
	30	B3P361, B3P362, B3P363, B3P3L5, B3P473, B3P474, B3P477	

bgs = below ground surface
HEIS = Hanford Environmental Information System
ID = identification
SDG = sample delivery group

1.4 Quality Assurance and Quality Control Requirements

This section describes the analytical and laboratory quality assurance (QA) and QC requirements identified in Table 4-5 of the 300-FF-5 OU SAP (DOE/RL-2014-42).

1.4.1 Laboratory Information

The laboratory sample results discussed in this DUA were downloaded from the HEIS database on April 1, 2020. For this set of data, a total of 277 soil samples were submitted for laboratory analysis, yielding 831 analytical laboratory results. The soil samples were analyzed for all COCs requested in the 300-FF-5 OU SAP (DOE/RL-2014-42) and ADD1 (DOE/RL-2014-42-ADD1) at GEL Laboratories, LLC in Charleston, South Carolina, which generated 100% of the analytical laboratory results discussed in this assessment.

1.4.2 Analytical Methods

Samples were analyzed for the COCs using methods listed in Table 4. Both multi- and single-component method-based analyses were used. Multi-component method-based analyses are those typically based on EPA methods, as applicable, that yield concentration data for multiple analytes in a single analysis. The analytes may include both target and non-target analytes. Single-component method-based analyses are those based on EPA methods, as applicable, that yield concentration data for a single-target analyte in a single analysis.

Table 4. Analytical Methods in Soil

Parameter	Analytical Method
Uranium	EPA 6020
Phosphorus	EPA 6010
pH	EPA 9045

Note: For four-digit EPA methods, see the SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium*.
EPA = U.S. Environmental Protection Agency

1.4.3 Analytical Requirements

Analytical performance requirements for soil/aquifer sediment samples are defined in the 300-FF-5 OU SAP (DOE/RL-2014-42). Table 5 summarize the analytical performance requirements for laboratory analysis of soil samples.

Table 5. Analytical Performance Requirements for Soil Samples

CAS	Analyte	PQL (µg/kg)	Analytical Method[a]	Precision (RPD)[b]	Accuracy (Recovery)[c]
7440-61-1	Uranium	150	SW-846 6020	≤30%	70–130%
7723-14-0	Phosphorus	--	SW-846 6010	≤30%	70–130%
--	pH	--	SW-846 9045	≤20%	90-110%

Source: Table 4-3 in DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*.
a. The analytical methods listed in this table are spelled using the syntax in the HEIS database.
b. Precision criteria based on laboratory control sample duplicate, matrix spike duplicate, or laboratory duplicate RPDs.
c. Accuracy criteria based on laboratory control sample or matrix spike percent recoveries (%R).

-- = no data or not applicable
CAS = Chemical Abstracts Service
HEIS = Hanford Environmental Information System
PQL = practical quantitation limit
RPD = relative percent difference

1.4.4 Laboratory Quality Assurance and Quality Control Requirements

The QA/QC requirements govern nearly all aspects of analytical laboratory operation, including instrument procurement, maintenance, calibration, and operation. Laboratory requirements for internal QC checks are performed as appropriate for the analytical method at a rate of one QC check sample per sample batch or 1 in 20 (5%), whichever is more frequent. Laboratory internal QC checks include the following:

- **Laboratory Contamination**. Each analytical batch contains a laboratory method blank (material of composition similar to that of the samples with known or minimal contamination of the analytes of interest) carried through the complete analytical process. The method blank is used to evaluate false positive results in samples caused by contamination during handling at the laboratory.
- **Analytical Accuracy**. For most analyses, a known quantity of representative analytes of interest (matrix spike [MS]) is added to a separate aliquot of a sample from the analytical batch. The known amount added is then compared to the actual measured amount to calculate the percent recovery. The recovery percentage of the added MS is used to evaluate analytical accuracy.

- **Analytical Precision**. Separate aliquots removed from the sample containers (duplicate samples) are analyzed for each analytical batch for metals. The duplicate sample results are compared to the original sample results, which are evaluated as relative percent differences (RPDs) and are used to assess analytical precision. Alternately, a matrix spike duplicate (MSD) may be used for assessing precision of metals parameters. For a MSD, a separate aliquot is removed from the same sample container and spiked in the same manner as the MS. The results, not recoveries, from the MS/MSD are also used to calculate RPDs to assess precision.
- **Laboratory Control Samples or QC Reference Samples (Analytical Accuracy)**. A laboratory control sample (LCS) may be prepared from an independent standard or from the same standard used for instrument calibration at a concentration within the calibration range. The LCS is taken through all the preparation and analysis steps used in the method. The LCS or QC reference sample measures the accuracy of the analytical process. Depending on how it is introduced into the analysis, the LCS is sometimes referred to as a blank spike sample.

Laboratories are also subject to periodic audits of laboratory performance, systems, and overall program. No audits were performed specific to the data analyses performed as part of this project.

1.4.4.1 Qualification Flags

During the generation of environmental analytical data, any of several qualification flags may be assigned to an individual result. The HEIS database carries qualification flags applied by three sources: the laboratory, third-party data validator, or a data user or reviewer. The tables of data within this report show all of these applied qualification flags. Potential flags and their meaning are provided in Table 6.

Table 6. Qualification Flags

Flag	Definition
Laboratory-Applied Flags	
>	Wetchem* – Result greater than quantifiable range or greater than upper limit of the analysis range.
*	Inorganics – Duplicate analysis not within control limits.
+	INORGANICS – Correlation coefficient for MSA is < 0.995.
A	ORGANICS – Valid for TICs only: The TIC is a suspected aldol-condensation product.
B	(Inorganics and Wetchem) – The analyte was detected at a value less than the PQL but greater than or equal to the MDL. The data should be considered usable for decisionmaking purposes. (Organics) – The analyte was detected in both the associated QC blank and in the sample. (Radionuclides) – The associated QC sample blank has a result ≥2× the MDA and, after corrections, result is ≥MDA for this sample.
C	(Inorganics and Wetchem) – The analyte was detected in both the sample and the associated QC blank, and the sample concentration was less than or equal to five times the blank concentration. The data should be considered unusable for decisionmaking purposes.
D	All – Analyte was reported at a secondary dilution factor, typically DF>1 (i.e., the primary preparation required dilution to either bring the analyte within the calibration range or to minimize interference). Required for Organics/Wetchem if the sample was diluted.
E	Inorganics – Reported value is estimated because of interference. See comment on cover page, hardcopy case narrative or specific inorganic hardcopy data sheet.
J	Organics – Estimated value constituent detected at a level <PQL and ≥MDL and estimated concentration of TICs.
M	INORGANICS – Duplicate precision criteria not met.

Table 6. Qualification Flags

Flag	Definition
N	All (except GC/MS based analysis) – Spike and/or spike duplicate sample recovery is outside control limits.
o	All – The laboratory control sample recovery is outside control limits.
P	ORGANICS (PCB only) – Aroclor target analyte with greater than 25% difference between column analyses.
Q	ORGANICS (Dioxins & PCB-congeners only) – Estimated maximum concentration. Used if one of the qualitative identification criteria is not met (e.g., chlorine isotopic ratios outside theoretical range).
S	INORGANICS – Reported value determined by the MSA.
T	ORGANICS (GC/MS only) – Spike and/or spike duplicate sample recovery is outside control limits.
U	(All) – The constituent was analyzed for and was not detected. The data should be considered usable for decisionmaking purposes.
X, Y	(All) – The result-specific translation of this qualifier code is provided in the data report and/or case narrative.
Z	Same as X and Y if more than two flags are required.
Third Party-Validation Applied Flags	
U	The constituent was analyzed for but was not detected above the MDL. The data should be considered usable for decisionmaking purposes.
UJ	The constituent was analyzed for and was not detected. Because of a quality control deficiency identified during data validation, the value reported may not accurately reflect the RL. The data should be considered usable for decisionmaking purposes.
J	Indicates the constituent was analyzed for and detected. The associated value is estimated because of a quality control deficiency identified during data validation. The data should be considered usable for decisionmaking purposes.
J+	Indicates the constituent was analyzed for and detected. The result is an estimated quantity, but the result may be biased high. The data should be considered usable for decisionmaking purposes.
J-	Indicates the constituent was analyzed for and detected. The associated value is estimated with a suspected negative bias due to quality control deficiency identified during data validation. The data should be considered usable for decisionmaking purposes.
NJ	The analysis indicates the presence of an analyte that has been tentatively identified and the associated numerical value represents its approximate concentration.
C	The target pesticide or Aroclor analyte identification has been confirmed by GC/MS.
X	The target pesticide or Aroclor analyte identification was not confirmed when GC/MS analysis was performed. The data should be considered unusable for decisionmaking purposes.
UR	Indicates the constituent was analyzed for and not detected. However, due to an identified quality control deficiency, the data should be considered unusable for decisionmaking purposes.
R	Rejected value: The value may not reflect true concentrations. The ability to establish detection/non-detection may be questionable. Validation activities identified major quality control deficiency/s or sample matrix interferences. The data should be considered unusable for most purposes. Any use of this data should be undertaken with great care. The data should not be used for certain regulatory decisionmaking purposes.
Data User-Applied Flags	
A	Indicates an issue with the chain of custody that could affect data usability.
F	Result is undergoing further review. (This review qualifier is assigned when a RDR is first processed).
G	Record has been reviewed and determined to be correct, or the record has been corrected with laboratory confirmation or other supporting information.

Table 6. Qualification Flags

Flag	Definition
H	Laboratory holding time exceeded before the sample was analyzed.
Y	Result is suspect. Review had insufficient evidence to show result valid or invalid.
Z	Miscellaneous circumstance exists. Additional information may be found in the result comment field (in the HEIS result table) for this record and/or in the sample comment field in the HEIS sample table.

*Wetchem is a group of analytical methods that are associated with "wet" chemical reactions.

DF = dilution factor
GC/MS = gas chromatograph/mass spectrometer
HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
MDL = method detection limit
MSA = method of standard additions
PQL = practical quantitation limit
QC = quality control
RDR = request for data review
RL = reporting limit
TIC = tentatively identified compounds

1.4.5 Field Quality Control Sampling Requirements

The 300-FF-5 OU SAP (DOE/RL-2014-42) required collection of full trip blank (FTB) samples, field transfer blank (FXR) samples, EB samples, field duplicate samples (DUP), and split samples. Table 7 summarizes the required frequency for each field QC sample type.

Table 7. Project Field Quality Control Checks

QC Sample Type	Purpose	Frequency
Full trip blank	Assess contamination from containers or transportation	One per 20 samples, *well trip*
Equipment rinsate blank	Verify adequacy of sampling equipment decontamination	As needed. If only disposable equipment is used, or equipment is dedicated to a particular well, then an EB is not required. Otherwise, 1 for every 20 samples for each media, or 1 for every borehole for soil samples.[a,b]
Field duplicates	Estimate precision, including sampling and analytical variability	One field duplicate will be collected at each borehole.
Split sample	Estimate precision, including sampling, analytical, and inter-laboratory variability.	As needed. When needed, the minimum is one for every analytical method, for analyses performed where detection limit and precision and accuracy criteria have been defined in the analytical performance requirements table.

a. Whenever a new type of non-dedicated equipment is used, an equipment rinsate blank will be collected every time sampling occurs until it can be shown that less frequent collection of equipment rinsate blanks is adequate to monitor the decontamination procedure for the non-dedicated equipment.

b. Vendor-provided borehole equipment is considered dedicated equipment, and EBs are not typically performed.

EB = equipment blank
QC = quality control

1.4.5.1 Field Blank Requirements

FTBs are samples prepared by the sampling team before traveling to the sampling site. The preserved bottle set is identical to the set collected in the field, but it is filled with reagent water or silica sand, as appropriate, for the primary sample media. The unopened bottles are sealed and transported to the field in the same storage container used for samples collected the same day. FTBs are typically analyzed for the same constituents as the samples from the associated sampling event.

EB samples are collected for non-dedicated sampling devices to assess the adequacy of the decontamination process. EBs will consist of silica sand or reagent water poured over the decontaminated sampling equipment and placed in containers as identified on the project sampling authorization form. If disposable (i.e., single-use) equipment is used, EBs are not required.

Field blank (i.e., FTB, FXR, and EB) results greater than two times the method detection limit (MDL) are identified as suspected contamination.

1.4.5.2 Field Duplicate Requirements

Field duplicate samples are used to evaluate sample consistency and the precision of field sampling methods. Field duplicates are independent samples collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed as independent samples at a single laboratory.

The duplicate should be collected generally from an area expected to have some contamination so that valid comparisons between the samples can be made (e.g., at least some of the constituents will be greater than the detection limit). Typically, soil/aquifer sediment is composited in a stainless steel mixing bowl, and the soil/aquifer sediment and duplicate samples are then collected from this composited material.

Evaluation of the results can provide an indication of intra-laboratory variability. Only those field duplicate result pairs with at least one result greater than five times the MDL or MDC are evaluated. Field duplicate sample results must agree within 30% as measured by the RPD to be acceptable. Large RPDs can be an indication of laboratory performance problems and should be investigated.

Footnote “e” on page 4-17 of the 300-FF-5 OU SAP (DOE/RL-2014-42) indicates that using RPDs of soil sample duplicates as a measure of precision in sample analysis is not recommended due to inherent sample inhomogeneity characteristics of soil samples.

1.4.5.3 Split Sample Requirements

Field split samples are duplicate samples from a sampling event sent to two different laboratories for analysis. Evaluation of the results can provide an indication of inter-laboratory variability.

1.4.6 Laboratory Quality Control Requirements

In addition to the evaluation performed on field QC data (as described in Section 1.4.5), a broad review of the laboratory QC results was also conducted for this report (Chapter 4). Laboratory QC results are stored electronically in HEIS and were evaluated using various database queries against the acceptance criteria. Table 8 provides a summary of the laboratory QC acceptance criteria used.

Table 8. Laboratory QC Acceptance Criteria

QC Element	Acceptance Criteria; Corrective Action
Laboratory duplicate samples (DUP)	Alkalinity: <35% RPD; data reviewed Anions by IC: <35% RPD; data reviewed Uranium (metals) by ICP: <35% RPD; flagged with “N” Gross alpha, tritium: 30% RPD; data reviewed
Laboratory blank samples (MB)	Alkalinity: <MDL, <5% sample concentration; flagged with “C” Anions by IC: <MDL, <5% sample concentration; flagged with “C” Uranium (metals): <RDL, <5% sample concentration; flagged with “C” TCE, *cis*-1,2-DCE by GC/MS: <MDL, <5% sample concentration; flagged with “B” Gross alpha, tritium: <MDC, <5% sample concentration; flagged with “B”

Table 8. Laboratory QC Acceptance Criteria

QC Element	Acceptance Criteria; Corrective Action
Laboratory control samples (LCS)	Alkalinity: 80–120% recovery; data reviewed Anions by IC: 80–120% recovery; data reviewed Uranium (metals) by ICP: 80–120% recovery; data reviewed TCE, *cis*-1,2-DCE by GC/MS: statistically derived; data reviewed Gross alpha, tritium: 70–130% recovery; data reviewed
Matrix spikes/Matrix spike duplicates (MS/MSD)	Anions by IC, MS: 75–125% recovery; flagged with "N" Anions by IC, MS/MSD: <35% RPD; data reviewed Uranium (metals) by ICP, MSD: <35% RPD; flagged with "N" TCE, *cis*-1,2-DCE by GC/MS, MS: % recovery statistically derived* TCE, *cis*-1,2-DCE by GC/MS, MSD: RPD statistically derived; data reviewed Gross alpha, tritium: 60–140% recovery; flagged with "N"

Source: Table 4-5 in DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*.

*Corrective action: Flagged with "T" if analyzed by GC/MS; otherwise, "N" based on FEAD.

DUP	=	field duplicate	MDC	=	minimum detectable concentration
FEAD	=	format for electronic analytical data	MDL	=	method detection limit
GC/MS	=	gas chromatograph/mass spectrometer	MS	=	matrix spike
IC	=	ion chromatography	MSD	=	matrix spike duplicate
ICP	=	inductively coupled plasma	QC	=	quality control
LCS	=	laboratory control sample	RDL	=	required detection limit
MB	=	method blank	RPD	=	relative percent difference

2 Data Verification

Data verification is the process of evaluating the completeness, correctness, conformance, and compliance of a specific data set against the method, procedural, or contractual requirements. The process includes confirmation that the specified sampling and analytical requirements have been completed (i.e., verification that the number, type, and location of all samples identified in the 300-FF-5 OU SAP [DOE/RL-2014-42] and ADD1 [DOE/RL-2014-42-ADD1] have been collected and that all required measurements and analyses were performed). This evaluation is documented in the completeness section (Section 4.1.5), which evaluates the sampling design versus field implementation. In addition, verification is performed for field QC and laboratory QC samples and is documented in the field QC and laboratory QC sections (Sections 2.2 and 2.3, respectively).

2.1 Data Verification Results

Data verification requires the evaluation of collected documentation to verify that key information for subsequent validation and data indicator evaluations are present.

The 300-FF-5 OU SAP (DOE/RL-2014-42) does not provide a numerical (percentage) requirement for data verifications. However, data verification is performed in accordance with internal procedures, which requires verification of a minimum of 25% of all final analytical data packages. This verification procedure requirement is all-inclusive and based on a random selection of the total final analytical data packages, not on individual projects. For the 300-FF-5 OU soils, final analytical data package verification was performed on 19 data deliverables out of 44, which is 43% of the relevant data packages from both the pre-treatment and post-treatment soil sampling events.

The following sections evaluate and describe the sampling design versus field implementation. All discrepancies between the sampling and analysis requirements outlined in the 300-FF-5 OU SAP (DOE/RL-2014-42) and ADD1 (DOE/RL-2014-42-ADD1) and what was actually performed are identified. Data verification is performed for field QC and laboratory QC samples.

2.2 Field Quality Control

The results of the field blanks, field duplicates, and field splits are discussed below.

2.2.1 Field Blanks

FTBs samples are analyzed to determine if positive results may be attributed to contaminants introduced as a result of field conditions. Any analyte measured above the laboratory detection limits is evaluated for potential impacts to associated sample results. EBs provide a measure of sample cross contamination.

No soil sample FTBs were collected during the pre- or post-treatment phases of the Stage B efforts.

During borehole drilling activities for the pre-treatment phase 20 soil samples representing EBs were prepared and submitted for laboratory analysis for the COCs uranium, phosphorus, and pH. The number of EBs collected met the requirements of the 300-FF-5 OU SAP (DOE/RL-2014-42) for the number of EBs to be collected for the pre-treatment phase of Stage B. No EBs were collected during borehole installation activities associated with the post-treatment boreholes. Listed here is a summary of the observations regarding the results of laboratory analysis of the EBs for the COCs.

Total uranium was detected in all of the EBs. However, in all boreholes that included an EB, the concentration of total uranium found in the soil samples was significantly greater than the concentration of total uranium found in the EBs. Thus, the detection of uranium in the EBs does not significantly impact the determination of total uranium in the soil samples or any QC measurements discussed in this assessment. (Note: Ottawa Sand [used to prepare EBs] contains traces of uranium and other metals.) Table 9 lists the concentration of uranium detected in the EBs.

Table 9. Total Uranium Detection in Equipment Blanks

Well Name	Sample ID	Total Uranium (µg/kg)
399-1-98	B389X7	46
399-1-99	B38B20	41
399-1-102	B38B54	66
399-1-103	B38B69	63
399-1-105	B38BB2	48
399-1-107	B38BF8	71
399-1-109	B38BL1	123
399-1-111	B38BP4	48
399-1-118	B38BR9	49
399-1-119	B38BX2	70
399-1-123	B388N4	99
399-1-128	B388T7	70
399-1-129	B388Y0	122
399-1-133	B38905	29
399-1-135	B38938	69

Table 9. Total Uranium Detection in Equipment Blanks

Well Name	Sample ID	Total Uranium (µg/kg)
399-1-137	B38974	72
399-1-138	B389B7	75
399-1-139	B389L3	76
399-1-142	B389M8	118
399-1-150	B389T1	95

ID = identification

2.2.2 Field Duplicates

Field duplicate soil samples were collected from all 19 pre-treatment injection wells and the single monitoring well, thus satisfying field duplicate requirements of 300-FF-5 OU SAP (DOE/RL-2014-42). Field duplicate soil samples were collected from all nine of the post-treatment boreholes, thus satisfying the field duplicate requirements of the 300-FF-5 OU SAP. According to footnote "e" in Table 4.5 of the 300-FF-5 OU SAP, however, field duplicate results of soil samples as RPD should not be considered as a measuring element for data acceptance criteria due to inherent sample inhomogeneity; thus, the 300-FF-5 OU SAP provides no criteria for field duplicate RPDs.

2.2.3 Field Splits

No field splits were collected during the pre-treatment soil sampling phase nor the post-treatment soil sampling phase of the Stage B operations. Neither the 300-FF-5 OU SAP (DOE/RL-2014-42) nor ADD1 (DOE/RL-2014-42-ADD1) includes criteria for the number or frequency that field splits should be acquired.

2.3 Laboratory Quality Control

Laboratory contamination, precision, and accuracy are discussed below.

2.3.1 Laboratory Contamination

CHPRC laboratory contracts require that laboratory method blanks be analyzed with each batch of up to 20 samples.

A total of 57 laboratory blank samples were analyzed for the COCs (listed in Table 4) and represent the soil samples collected during both the pre- and post-treatment sampling phases of Stage B. Of the 57 laboratory blank sample results reported, two were B-flagged (uranium, phosphorus), indicating that the analyte was detected at a value that was greater than or equal to the MDL but less than the contract required detection limit. However, concentrations of uranium and phosphorus detected in the laboratory blank did not exceed 5% of the analyte concentrations in any samples in the analytical batch. Therefore, these values represent a QC acceptance rate of 100% for laboratory contamination.

2.3.2 Laboratory Precision

Laboratory precision is determined by the difference between duplicate sample pair results or between MS/MSD sample results. Normally, spike duplicates are used for metals.

For soil samples, a total of 91 duplicate pairs were evaluated for the COCs (listed in Table 4) and represent the soil samples collected during both the pre- and post-treatment sampling phases of Stage B. Of the 91 duplicate pairs, 11 sample duplicates (4 phosphorus, 7 uranium) showed RPD values greater than 30% and were flagged with an "*" laboratory qualifier. The overall QC acceptance rate for precision

was determined to be 88%. Sample inhomogeneity is thought to be the reason for the low QC acceptance rate for precision and not a result of poor performance in laboratory analysis. The low QC acceptance rate demonstrated by the laboratory duplicate analyses supports the argument that duplicate soil samples may show high RPD and should not be used as an indicator for field sampling performance.

2.3.3 Laboratory Accuracy

Two types of QC are used to assess accuracy. The LCS is used to assess the accuracy of the laboratory preparation and analysis processes. The MS samples are used to assess the accuracy of the published method on the sample matrix and evaluate matrix effects that may bias the data. Laboratory surrogate recoveries are used to assess overall method performance for organic methods.

2.3.3.1 Laboratory Control Samples

A total of 86 LCS results were evaluated for the COCs (listed in Table 4) and represent the soil samples collected during both the pre- and post-treatment sampling phases of Stage B. All LCS recoveries satisfied the evaluation criteria.

2.3.3.2 Matrix Spike Recovery

Matrix spike recovery is also used as a measure of analytical accuracy. There were a total of 59 matrix spike sample results reported that represent the COCs (listed in Table 4) and represent the soil samples collected during both the pre-treatment and post-treatment sampling phases of Stage B. Of the 59 matrix spike samples analyzed, a total of 7 (all uranium) showed percent recovery values outside of the laboratory's control limits of 75% to 125% for MS recovery and were flagged with an "N" laboratory qualifier. The overall QC acceptance rate for precision was determined to be 88%. The spike recovery excursions are likely due to homogeneity issues with the soil samples (as seen with the sample duplicates above) and not a result of poor performance in laboratory analysis.

3 Data Validation

Data validation is an analyte- and sample-specific process that extends the evaluation of data beyond method or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set, typically data in single analytical batches. Data validation is an independent assessment to ensure that the reliability of data is known by the user. Analytical data validation provides a level of assurance based on technical evaluation that an analyte is either present or absent. Validation may also include verification of the minimum detection limits, evaluation of analytical results based on method blanks, recovery of various internal standards, and the effect of quality deficiencies on the analytical sample data. Third-party validation was performed on a minimum of 5% of all project data, and the results of those validations are described in this chapter.

3.1 Data Validation Reports

Data validation was performed by Analytical Quality Associates of Albuquerque, New Mexico.
All validation qualifiers resulting from data validation were entered into the HEIS database.

3.2 Data Validation Results

The 300-FF-5 OU SAP (DOE/RL-2014-42) specifies that data validation activities will be performed at the discretion of the OU Project Manager and under the direction of the Sample Management and Reporting group (SMR). Level C data validation of at least 5% of the project data was performed and includes the evaluation and qualification of sample results based on the following:

- Matrix spike, laboratory control sample, laboratory duplicate, and chemical and surrogate recovery criteria (as appropriate to the method).

- Field trip blanks, field duplicates, and field splits (if information is provided) are examined. Full trip blank samples were not included in the sample count to determine percent validated.
- No other validation or calculation checks are performed.

Tables 10 and 11 summarize the samples and laboratory methods that were independently validated for both pre- and post-treatment soil samples. As shown in Tables 10 and 11, the analyses were reviewed with a validation percentage of at least 5% where validations were performed.

Table 10. Validated Sample Summary (Pre-Treatment Phase) from VSR19-026

Analytical Method*	Total Number of Samples Analyzed	Total Number of Samples Validated	Percent Validated
Phosphorus, EPA 6010	165	10	6%
Uranium, EPA 6020	165	10	6%
pH, EPA 9045	164	9	5%

*For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium.*
EPA = U.S. Environmental Protection Agency

Table 11. Validated Sample Summary (Post-Treatment Phase) from VSR19-024

Analytical Method*	Total Number of Samples Analyzed	Total Number of Samples Validated	Percent Validated
Phosphorus, EPA 6010	56	6	11%
Uranium, EPA 6020	56	4	7%
pH, EPA 9045	54	4	7%

*For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium*.
EPA = U.S. Environmental Protection Agency

3.2.1 Major Deficiencies

A major deficiency results in qualification of sample data as unusable for decisionmaking purposes.

3.2.1.1 Pre-Treatment Soil Samples

No major deficiencies found in the pre-treatment soil sample analyses.

3.2.1.2 Post-Treatment Soil Samples

No major deficiencies found in the post-treatment soil sample analyses.

3.2.2 Minor Deficiencies

A minor deficiency results in qualification of sample data as nondetect or an estimate; however, data are considered usable for decisionmaking purposes.

3.2.2.1 Pre-Treatment Soil Samples

Minor deficiencies leading to qualification of sample results as estimates were due to these variables:

- Lack of matrix spike accuracy data
- Laboratory blank contamination, matrix spike exceedances, and duplicate exceedances
- Holding time exceedances (for pH results)

3.2.2.2 Post-Treatment Soil Samples

Minor deficiencies leading to qualification of sample results as estimates were due to these variables:

- Matrix spike and duplicate exceedances
- Holding time exceedances and low matrix spike recoveries (for pH results)

3.2.3 Qualification Flags Applied to the Data Set

Tables 12 and 13 list qualification flags applied to the data set as a result of the data validation process.

Table 12. Summary of Data Validation Qualification Flags for Pre-Treatment Soil Samples

Method/Analyte(s)[a]	Qualifier[b]	Affected Samples	Reason
Data Validation Report VSR19-026: Inorganics (EPA 6020-ICP/MS) Metals Analysis Qualification Summary			
Uranium, EPA 6020	J	B38T78, B38T81	Low matrix spike recovery and poor duplicate precision
Uranium, EPA 6020	J	B38992, B38995, B38998, B389B1, B389B4, B389B7, B389C0, B39JV2	Poor duplicate precision
General Chemistry Qualification Summary (VSR19-026)			
pH, EPA 9045	J	B38T78, B38992, B38995, B38998, B389B1, B389B4, B389B7, B389C0, B39JV2	Analyzed beyond recommended holding time[c]

a. For the four digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium*.
b. Qualifiers are defined in Section 1.4.4.1.
c. Holding time for pH determination (for soil samples) compliant with SAP.
EPA = U.S. Environmental Protection Agency
ICP/MS = inductively coupled plasma/mass spectrometry
SAP = sampling and analysis plan

Table 13. Summary of Data Validation Qualification Flags for Post-Treatment Soil Samples

Method/Analyte(s)[a]	Qualifier[b]	Affected Samples	Reason
Data Validation Report VSR19-024: Inorganics (6020-ICP/MS) Metals Analysis Qualification Summary			
U, EPA 6020	J	B3P353, B3P357, B3P361, B3P473	High matrix spike recovery
General Chemistry Qualification Summary (VSR19-024)			
pH, EPA 9045	J	B3P354, B3P358, B3P362, B3P474	Analysis beyond the holding time[c]

a. For the four digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium*.
b. Qualifiers are defined in Section 1.4.4.1.
c. Holding time for pH determination (for soil samples) compliant with SAP.
EPA = U.S. Environmental Protection Agency
ICP/MS = inductively coupled plasma/mass spectrometry
SAP = sampling and analysis plan

3.2.3.1 Holding Times and Sample Preservation

Holding times are defined as the period from sample collection to sample analysis or extraction, and the period of time from sample extraction to sample analysis. Holding times are calculated from the date of sample collection as recorded on the chain-of-custody form to the date and time of laboratory sample preparation or analysis to determine the validity of the results.

Inorganics. The holding time requirements for inductively coupled plasma and inductively coupled plasma-mass spectrometry metals are analysis within 180 days of sample collection for soil samples.

For both pre- and post-treatment, the soil samples were analyzed within the prescribed holding time and properly preserved.

General Chemistry. The 300-FF-5 OU SAP (DOE/RL-2014-42) calls out 6 months for the holding time for pH determination of soil samples. However, the validation procedure and SMR's sample data system indicates as soon as possible for pH determination; thus, there is a conflict when comparing the results of the validation and the 300-FF-5 OU SAP.

For the pre-treatment soil samples, the samples were analyzed within the prescribed holding times and properly preserved with the following exceptions:

- For sample delivery group (SDG) GEL418733, sample B37T78 was analyzed for pH 12 days after sample collection. Based on professional judgment, the pH result should be qualified as an estimate and flagged "J."
- For SDG GEL423426, all samples except for sample B39JV2 were analyzed for pH 7 days after sample collection and sample B39JV2 was analyzed 9 days after sample collection. Based on professional judgment, the pH results should be qualified as estimates and flagged "J."

For the post-treatment soil samples, the samples were analyzed within the prescribed holding times and properly preserved with the following exception:

- For SDG GEL474413, all samples were analyzed for pH 12 days after sample collection. Based on professional judgment, the pH results should be qualified as estimates and flagged "J."

3.2.3.2 Review of Laboratory QC Information

Laboratory data package case narratives were reviewed to identify potential QC issues that would affect the usability of these data. Overall, no issues were identified that would have led to the rejection of any reported results.

4 Data Quality Indicator Evaluation

The DQI evaluation process is used to assess data usability for non-statistical (judgmental) sampling designs. Data verification and data validation reports were reviewed to determine the usability of the data set as a whole and the quality of individual results as appropriate in terms of the following DQIs:

- **Precision** – Describes the repeatability of field duplicate data and laboratory QC duplicates (e.g., RPDs of laboratory sample duplicates, laboratory control sample duplicates, and matrix spike/matrix spike duplicates).
- **Accuracy/Bias** – Discusses evidence of field contamination, and laboratory QC (e.g., percent recoveries of laboratory control samples, matrix spikes, and surrogates).
- **Representativeness** – Discusses the extent to which the sampling design was accomplished and the representativeness of the samples and the design as a whole. Identify any specific measurements not representative of the target condition, explain why they are non-representative, and discuss the impact to the data set.
- **Comparability** – If multiple laboratories were used or if this data set is intended to be combined with others, discuss the nature of differences that may limit the comparability. For example, note that samples were analyzed using recognized standard methods. If multiple laboratories analyzed field QC split samples, discuss how closely the results agreed between the two laboratories.

- **Completeness** – Discuss the accomplishment of all data generating activities required by the 300-FF-5 OU SAP (DOE/RL-2014-42). Include a comparison of samples actually collected versus those identified in the original sampling design. Include required field QC blanks, duplicates, and splits in the comparison. Also, compare the analyses performed to the analyses identified in the 300-FF-5 OU SAP. Comment on the impact to data set usability of any planned samples that were not taken or analyses not performed.
- **Sensitivity** – Discuss any laboratory data that do not meet the reporting limits required by the 30-FF-5 OU SAP (DOE/RL-2014-42) and other decision thresholds as described in the DQOs.

4.1 Data Quality Indicator Evaluation Results

The DQI evaluation step involves assessing whether the samples collected and the resulting analytical data meet project quality objectives in terms of the DQIs described above. The data verification acceptance rates discussed below are based on the evaluation of QC performance compared to the 300-FF-5 OU SAP (DOE/RL-2014-42) requirements for the entire data set. Validation acceptance rates are based on the data determined to be legitimate (i.e., not rejected) in the verifiable data set.

4.1.1 Precision

Laboratory precision is determined by the RPD between duplicate sample pair results including sample duplicate results, LCS/LCS-duplicate pair duplicate results, and MS/MSD pair duplicate results.

For all soil samples collected in both the pre- and post-treatment phases, data verification results showed an overall precision QC acceptance rate of 84% for uranium and phosphorus based on precision. Data validation resulted in the qualification of 16 results (10 uranium, 6 phosphorus) based on poor duplicate precision. Data validation results show an overall QC acceptance rate of 100% for precision.

4.1.2 Accuracy/Bias

Laboratory accuracy is determined by the percent recovery (%R) of the LCS and MS results. These QC types are also used to evaluate matrix effects that may bias the data.

For soils, data verification results showed an overall accuracy QC acceptance rate of 100% for the MS recovery. All LCS recoveries satisfied the QC criteria. Data validation resulted in the qualification of three total uranium results due to low MS recovery and four total uranium results due to high MS recovery. Data validation results show an overall QC acceptance rate of 100% for accuracy and also 100% for analytical bias, as the MS recoveries and laboratory blank results did not indicate any systemic bias.

4.1.3 Representativeness

The estimates that five to six soil samples per borehole should be collected for analysis requires that soil samples be collected from at least 19 injection wells. This effort would include one monitoring from the pre-treatment boreholes and nine of the post-treatment boreholes, thus estimating that at least 145 to 174 soil samples should be collected and analyzed for Stage B. In fact, 230 soil samples were collected; thus, the requirements of the 300-FF-5 OU SAP (DOE/RL-2014-42) and ADD1 (DOE/RL-2014-42-ADD1) for soil sampling were accomplished. Qualification of analysis of the soil samples for the COCs are summarized below, with the results indicating potential inhomogeneity in the soil samples.

- Precision:
  - Six duplicate pairs out of 28 tests failed for phosphorus; acceptance rate: 79%
  - Ten duplicate pairs out of 24 tests failed for uranium; acceptance rate: 58%

- Accuracy:
  - Zero matrix spikes out of 57 tests failed for phosphorus; acceptance rate: 100%
  - Seven matrix spikes out of 59 tests failed for uranium; acceptance rate: 88%

4.1.4 Comparability

To generate comparable data, sampling was accomplished using the same procedures uniformly for field sampling. Laboratory analyses were performed using industry-recognized standard procedures (Table 4) and produced comparable results. All COCs analyses were performed by the same laboratory.

4.1.5 Completeness

All soil samples estimated for collection and all data generating activities required by the 300-FF-5 OU SAP (DOE/RL-2014-42) were achieved with 100% completeness.

4.1.6 Sensitivity

For soil samples, the 300-FF-5 OU SAP (DOE/RL-2014-42) identified only one analyte, uranium, with an analytical practical quantitation limit (PQL) of 150 µg/kg. The analytical laboratory's actual PQLs are about 40 µg/kg for uranium in soil; thus, the laboratory analysis satisfied the 300-FF-5 OU SAP requirement for sensitivity.

For all soil samples analyzed, no results for uranium (EPA Method 6020; SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium*) were "U" qualified; thus, all samples showed some measurable amount of uranium. The equipment blanks (20 total) showed results that were about 220 times smaller than the average amount of uranium in the soil samples. The standard material (Ottawa Sand) used for the equipment blanks, therefore, is adequate for its intended purpose as an equipment blank. Because the average value of the 20 equipment blank results is less than half of the PQL value for uranium at 72 µg/kg, the laboratory's sensitivity is wholly adequate for the determination of uranium in the soil samples.

5 Conclusions

Based on the results of this DUA, the sample set is sufficiently complete, as there is a low overall degree qualified data points. Given the high degree of acceptable data, the analytical results are considered useable for their intended purposes as indicated in Chapter 4. Samples were collected and analyzed as specified in the 300-FF-5 OU SAP (DOE/RL-2014-42) and ADD1 (DOE/RL-2014-42-ADD1). Sample results accurately indicate the presence or absence of target analyte contamination at sample locations.

Laboratory and matrix accuracy and precision were in control overall, and no systematic or general discrepancies were obvious. Sample results appear to be representative of site conditions at the time of collection. Results obtained are comparable to industry standards in that collection and analytical techniques followed approved documented procedures (except as noted in this report and reflected in qualified data points). All results are reported in industry standard units.

Detection limits, precision, accuracy, and data completeness were evaluated to determine whether any analytical data should be rejected as a result of QA/QC deficiencies. The conclusions of this DUA are that the data that have been collected are of the right type, quality, and quantity for evaluating the polyphosphate injection data.

Lastly, the 5% 300-FF-5 OU SAP (DOE/RL-2014-42) requirement for data validation was satisfied for all matrices and analyte groups, and the 25% requirement by SMR for data package verification of the relevant soil sample data packages was also satisfied.

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