SGW-59614
Revision 0

300-FF-5 Operable Unit Enhanced Attenuation Stage A Delivery Performance Report

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

P.O. Box 1600
Richland, Washington 99352

SGW-59614
Revision 0

300-FF-5 Operable Unit Enhanced Attenuation Stage A Delivery Performance Report

Date Published
December 2016

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

P.O. Box 1600
Richland, Washington 99352

APPROVED
By Julia Raymer at 2:40 pm, Dec 08, 2016

Release Approval Date

Executive Summary

This report presents the results and performance evaluation of the Stage A enhanced attenuation (EA) remedy implemented during November 2015 to sequester residual uranium that presents a continuing source of contamination to groundwater in the 300-FF-5 Operable Unit in the 300 Area of the Hanford Site. Past contaminant releases at waste disposal sites in the 300 Area Industrial Complex resulted in persistent uranium contamination within the underlying soil and groundwater.

Cleanup of the 300 Area is being accomplished under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[1] in accordance with the 300 Area Record of Decision (ROD).[2] Uranium is identified as a contaminant of concern in both soil and groundwater. Part of the selected remedy for uranium contamination in the 300 Area is EA of uranium using polyphosphate solutions to sequester the uranium and reduce its mobility in the vadose zone, periodically rewetted zone (PRZ), and top of the aquifer.

Enhanced attenuation of uranium is being implemented at a 1.2 ha (3 ac) area of high residual uranium contamination in the 300 Area Industrial Complex in accordance with the 300 Area ROD. Uranium sequestration will occur in two sequential stages (Stage A and Stage B), as described in the remedial design report/remedial action work plan addendum.[3]

Stage A was implemented from November 6 through 18, 2015 within an area of approximately 0.3 ha (0.75 ac). Polyphosphate solutions were applied to the vadose zone using a near-surface drip infiltration system, to the PRZ using subsurface injection, and to the top of aquifer using deeper subsurface injection. Soil samples were collected before and after treatment from three pairs of collocated boreholes to compare uranium concentrations and uranium leaching characteristics before and after the application of polyphosphate solutions. Groundwater samples and water levels were collected before,

---

[1] *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

[2] 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*, U.S. Environmental Protection Agency and U.S. Department of Energy, Richland, Washington, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087180.

[3] DOE/RL-2014-13-ADD2, 2015, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081151H.

during, and after application of polyphosphate solutions to evaluate the effectiveness of the treatment. Electrical resistivity tomography (ERT) was used to monitor the migration of polyphosphate solutions applied using infiltration.

The Stage A treatment performance was evaluated in accordance with the sampling and analysis plan,[4] based on the following aspects of the treatment:

- Monitoring of dissolved uranium concentrations in downgradient groundwater wells
- Post-treatment assessment of phosphate delivery and distribution within the subsurface
- Monitoring of groundwater to detect mobilization of uranium to groundwater
- Fate and transport modeling to predict downgradient uranium concentrations
- Assessment of the effect of polyphosphate solutions on aquifer properties

The data collected during and following the treatment indicate using injection wells to deliver high phosphate concentrations to the PRZ and to the top of aquifer was successful. The PRZ is the principal target zone of the remedy because it is deemed to be the primary contributor of uranium mass to the aquifer. Both the PRZ and aquifer injections were able to deliver high phosphate concentrations to the target depths containing residual uranium. The concentrations of phosphate in the groundwater continued to remain high following treatment, indicating further that delivery of phosphate was achieved within the PRZ and the aquifer.

The delivery of phosphate using infiltration to the lower vadose zone and PRZ was uneven because of the subsurface media heterogeneities that led to variable vertical flow velocities along the infiltrated depth. Due to varying travel times, the chemical reactions between infiltrating solutions and the soil column resulted in non-uniform precipitation of phosphate within the vadose zone, with some phosphate precipitating within shallow portions of the vadose zone above the target depth.

The column leach testing of soil samples collected from the PRZ, where high phosphate concentrations were delivered using injection, indicates residual uranium in the

---

[4] DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079669H.

post-treatment samples is less leachable than uranium in the pre-treatment samples. Results of the sequential extraction tests indicate the chemical interactions from addition of polyphosphate solutions to the vadose zone, PRZ, and aquifer led to some initial mobilization followed by reprecipitation of uranium. The chemical interactions have resulted in conditions favorable for formation of the amorphous calcium-phosphate phases that result in sequestration of uranium. A conceptual model of the chemical interactions resulting from polyphosphate solution application was developed based on the laboratory analyses and field observations. However, detailed laboratory testing has not been conducted to confirm the conceptual model or to evaluate potential secondary effects of adding high-concentration polyphosphate solutions to the 300 Area sediments.

Groundwater samples collected from the two closest wells downgradient of the Stage A area during the 6 months following the treatment show a significant decline in dissolved uranium concentrations, and concentrations have remained below the cleanup level (30 µg/L). Longer term groundwater monitoring is needed to confirm these trends.

A three-dimensional numerical model was used to simulate fate and transport of uranium in the vadose zone and unconfined aquifer in order to evaluate the effectiveness of the Stage A remedy. The modeling results predict reductions in groundwater uranium concentrations downgradient of the Stage A EA area in the near future and in the longer term as a result of the Stage A remedy. The model predicts that for the first year, due to treatment, the extent of the groundwater uranium plume will be considerably reduced in the Stage A area and will remain reduced, compared to the prediction for the no action case. The longer term simulated concentrations for the two closest downgradient wells that showed sharp declines in uranium concentrations following Stage A treatment indicate a gradual concentration increase but remain below the concentrations predicted for the no action case. The gradual rise reflects the combined effect of slow continued desorption of uranium into the aquifer from the Stage A area and contribution to the aquifer from areas outside of the Stage A area. The longer term predictive cases assume the post-treatment model parameters remain unchanged over the simulated time period. Due to these assumptions, the uncertainty in these longer term estimates is high and needs to be considered when making decisions.

Aquifer properties were evaluated to assess whether aquifer permeability was reduced due to the precipitation of phosphate minerals following infiltration and injection of polyphosphate solutions. Field testing methods, such as slug tests, were not conducted using the Stage A injection and monitoring wells. Instead, the effect of the polyphosphate applications was assessed by comparing aquifer hydraulic properties in the vicinity of the Stage A area before and after treatment. The evaluation indicated the polyphosphate injections and infiltration did not alter the hydraulic conductivity of the aquifer.

Based on the results of Stage A uranium sequestration, Stage B uranium sequestration operations will follow the same general design approach as used during Stage A treatment, with refinements made on how the polyphosphate solutions are delivered to the treatment zone. The 0.9 ha (2.25 ac) Stage B treatment area will consist of two depth intervals where polyphosphate solutions are injected into the lower vadose zone and PRZ. Polyphosphate solutions will be delivered to the lower vadose zone and PRZ through a network of up to 48 injection wells, each screened in the lower vadose zone and the PRZ. Up to 24 monitoring wells, an ERT network, pre-treatment and post-treatment soil sampling, and downgradient groundwater sampling are planned for evaluation of the Stage B treatment performance.

Contents

Appendices

Figures

Tables

Terms

AWLN	automated water level network
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
CSM	conceptual site model
DOE	U.S. Department of Energy
DOW	description of work
EA	enhanced attenuation
ERT	electrical resistivity tomography
ESD	explanation of significant differences
FS	feasibility study
IC	institutional control
MNA	monitored natural attenuation
OU	operable unit
PNNL	Pacific Northwest National Laboratory
PRZ	periodically rewetted zone
QC	quality control
RDR	request for data review
RDR/RAWP	remedial design report/remedial action work plan
RI	remedial investigation
Rlm	Ringold Formation lower mud unit
ROD	record of decision
ROI	radius of influence
SAP	sampling and analysis plan
SMR	Sample Management and Reporting
TPA	Tri-Party Agreement

This page intentionally left blank.

1 Introduction

This report presents the results and performance evaluation of the Stage A enhanced attenuation (EA) remedy implemented during November 2015 to sequester residual uranium that provides a continuing source of contamination to groundwater in the 300-FF-5 Operable Unit (OU) in the 300 Area of the Hanford Site.

The 300 Area encompasses approximately 105 km^2 (40 mi^2) adjacent to the Columbia River in the southern portion of the Hanford Site (Figure 1-1). The 300 Area includes a smaller operations area, called the 300 Area Industrial Complex, comprising several facilities and waste disposal sites that supported uranium fuel production and research and development activities. Past contaminant releases at waste disposal sites in the 300 Area Industrial Complex resulted in persistent uranium contamination within the underlying soil and groundwater.

Completion of the soil and groundwater cleanup is being accomplished under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) in accordance with 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,* hereinafter called the 300 Area Record of Decision (ROD). Uranium is identified as a contaminant of concern in both soil and groundwater. Part of the selected remedy for uranium contamination in the 300 Area Industrial Complex is EA of uranium using polyphosphate solutions to sequester the uranium and reduce the mass of mobile uranium migrating into the groundwater. The polyphosphate solutions interact with the sediment to form calcium-phosphate minerals that can bind residual uranium, thereby sequestering the uranium in situ.

Enhanced attenuation of uranium is being implemented at a 1.2 ha (3 ac) area of high residual uranium contamination in the 300 Area Industrial Complex in accordance with the 300 Area ROD (EPA and DOE, 2013). Uranium sequestration will occur in two sequential stages (Stage A and Stage B), as described in DOE/RL-2014-13-ADD2, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*.

Stage A was implemented from November 6 through 18, 2015, by infiltrating and injecting polyphosphate solutions at high concentrations into the vadose zone, periodically rewetted zone (PRZ), and top of the unconfined aquifer within an area of approximately 0.3 ha (0.75 ac) (Figure 1-2). The Stage A treatment performance is evaluated in this report in accordance with Appendix B of DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan* (hereinafter called the sampling and analysis plan [SAP]). The evaluation focuses on the following aspects of the treatment: (1) the change in uranium concentrations in groundwater downgradient from the Stage A area; (2) the delivery and distribution of phosphate to the lower vadose zone, PRZ, and top of the aquifer; (3) the mobilization of uranium to groundwater; (4) fate and transport modeling to predict the uranium concentrations in groundwater downgradient of the Stage A area; and (5) effect of the polyphosphate solutions on aquifer properties due to precipitation of phosphate minerals.

This report also identifies refinements needed for implementation of Stage B, based on the evaluation of the Stage A treatment performance. Stage B uranium sequestration will be performed in an adjacent area of approximately 0.9 ha (2.25 ac).

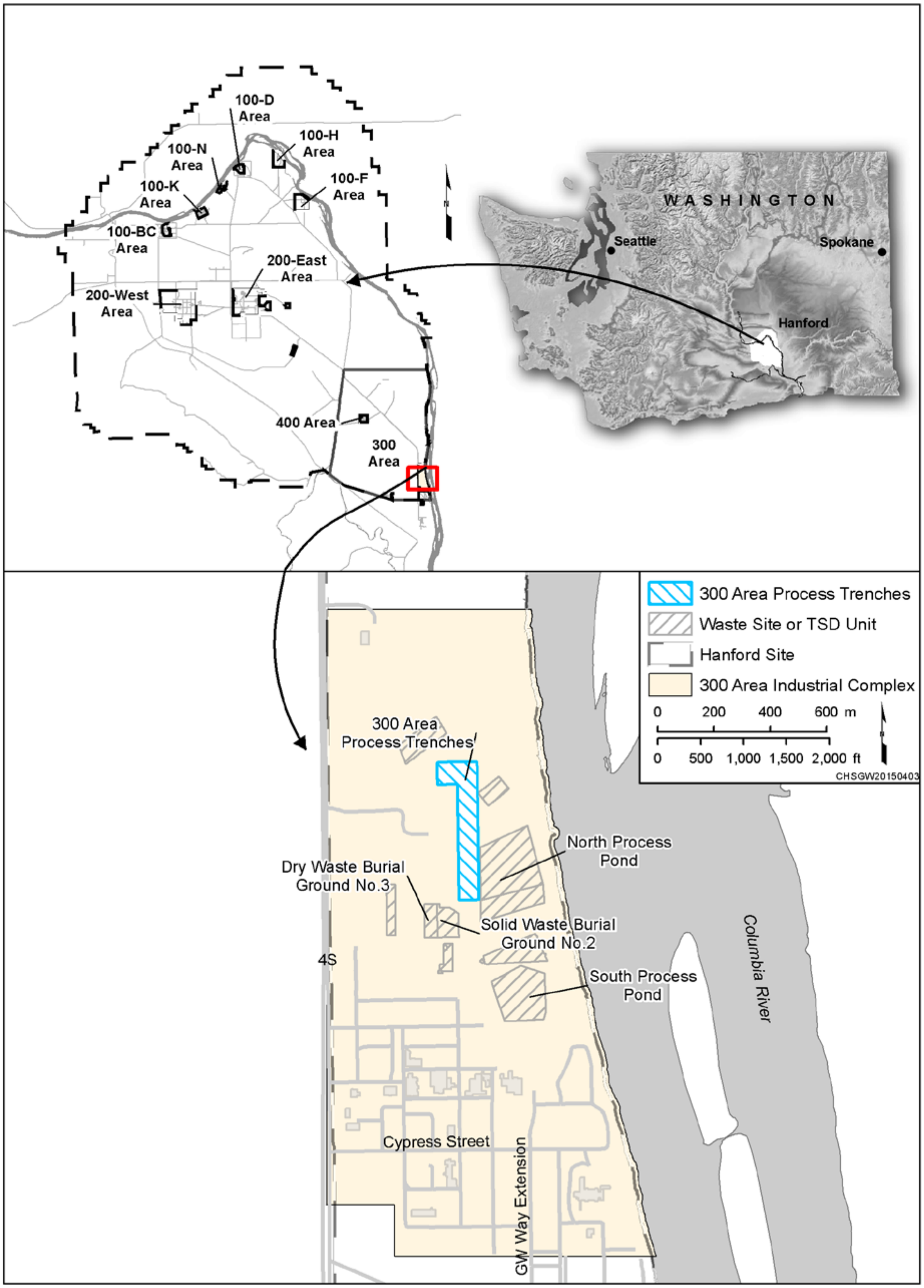


Figure 1-1. Map of the Hanford Site, 300 Area, and 300 Area Industrial Complex

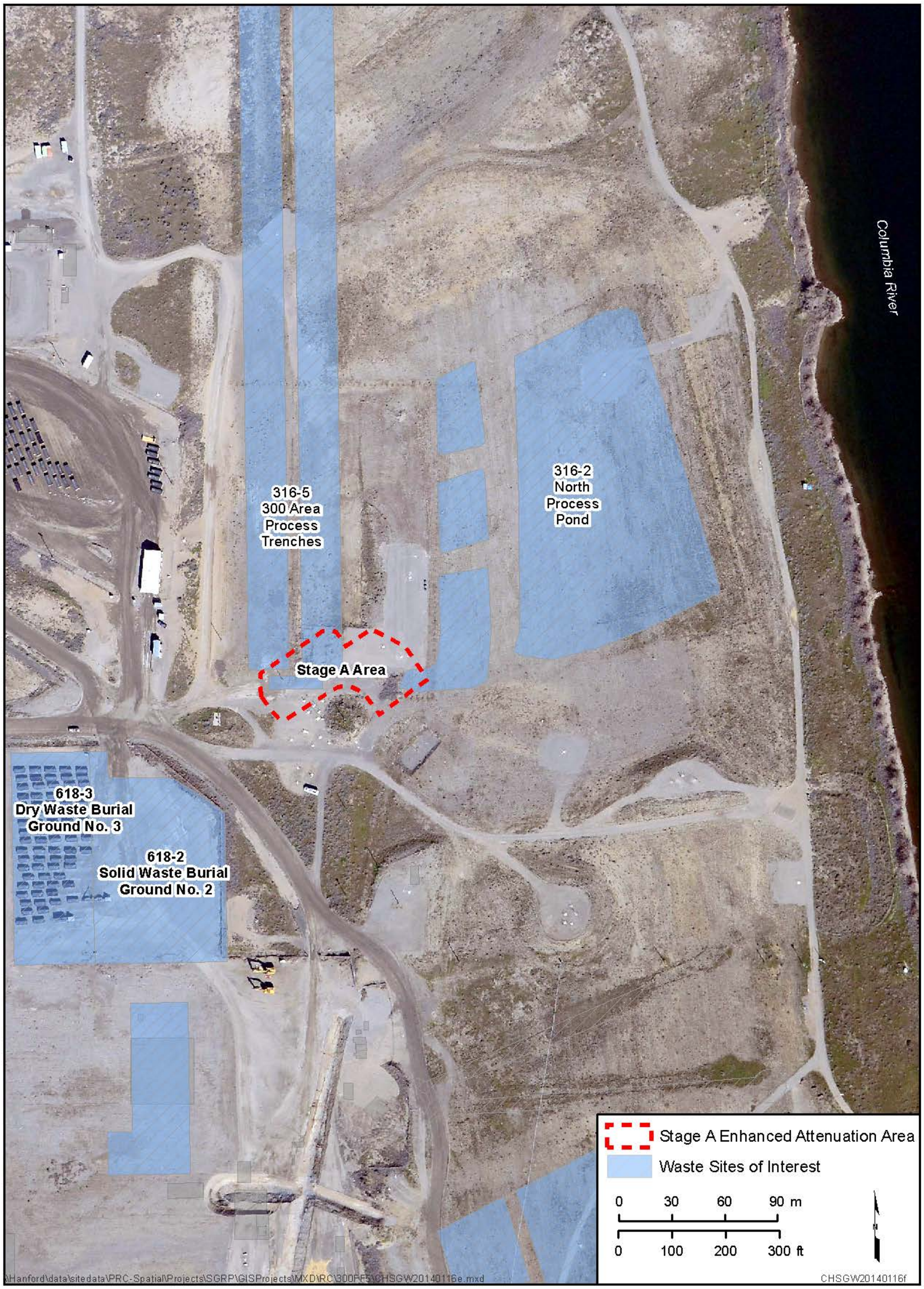


Figure 1-2. Aerial View of a Portion of the 300 Area Industrial Complex Showing the Stage A Enhanced Attenuation Area and Nearby Waste Sites

1.1 Purpose

The purpose of this report is to present the results and evaluate the performance of the Stage A uranium sequestration treatment. This report discusses the operational approach used for the Stage A polyphosphate applications and provides the operational and characterization data and observations collected before, during, and after the Stage A treatment.

Information on the final design and installation of the Stage A uranium sequestration system is documented in SGW-59455, *300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report*. Site layout plans and equipment design sheets are contained in ECR-15-000692, *300 Area Chemical Injection System* (Attachment A of SGW-59455).

1.2 Site Description

The 300 Area is located adjacent to the Columbia River in the southern portion of the Hanford Site (Figure 1-1). This section of the Columbia River is within the Hanford Reach, a nontidal, free flowing section of the Columbia River in Washington State. The Hanford Reach extends from the Priest Rapids Dam downstream to the slack water of Lake Wallula, which was created by McNary Dam.

1.2.1 Background

Operations in the 300 Area began in 1943. The 300 Area Industrial Complex included the buildings and facilities where the majority of uranium fuel production and research and development activities took place. Large volumes of liquid waste containing uranium were discharged to the soil column through waste disposal sites in the 300 Area Industrial Complex. Two former liquid waste disposal sites are located close to the Stage A EA area (Figure 1-2). The primary waste stream disposed to these two waste sites was process waste from nuclear fuel fabrication as described below.

- The 300 Area North Process Pond (Waste Site 316-2) was located to the northeast of the Stage A EA area. This waste site consisted of several separate sections separated by dikes. From 1948 to 1974, this site was used to dispose of cooling water and low-level liquid waste from the 300 Area fuel fabrication facilities. Lack of infiltration was a problem for the pond because it accumulated sludge containing large amounts of uranium and copper. The bottom of the pond was periodically dredged, and the sludge was deposited on the dikes. The site was remediated from May 1998 through January 1999 by excavating contaminated soil to a maximum depth of 7.5 m (25 ft) and backfilling the excavation.

- The 300 Area Process Trenches (Waste Site 316-5) were located north of the Stage A EA area. This site consisted of two trenches, each 468 m (1,535 ft) long, operated alternately. From 1975 to 1994, the trenches were used to dispose of cooling water and low-level liquid waste from the 300 Area fuel fabrication facilities. In 1991, the site was partially remediated through an expedited response action, which removed 0.3 to 0.9 m (1 to 3 ft) of contaminated soil and sludge from the bottom and sides of the trenches, respectively. The contaminated soil and sludge were stockpiled at the north end of the trenches. Final remediation, under CERCLA, was conducted from July 1997 through February 1998 by excavating contaminated soil to a maximum depth of about 5.5 m (18 ft) and backfilling the excavation.

Solid waste was disposed in burial grounds and shallow landfills from 1943 through the 1950s. Two former solid waste burial grounds are located near the Stage A EA area (Figure 1-2).

- The Solid Waste Burial Ground No. 2 (Waste Site 618-2) and Dry Waste Burial Ground No. 3 (Waste Site 618-3) were located to the southwest of the Stage A EA area. From 1951 through 1955, these waste sites were used to dispose of uranium-contaminated solid waste, including contaminated equipment and contaminated metal wastes, from 300 Area Industrial Complex facilities. Solid Waste Burial Ground No. 2 was remediated from August 1996 through November 2004 by excavating contaminated material to a depth of approximately 6 m (19.7 ft) and backfilling. One location was excavated to groundwater (between 11.5 and 15 m [37.7 and 49.2 ft] bgs). Dry Waste Burial Ground No. 3 was remediated from September 2004 through October 2004 by excavating contaminated material to a depth of approximately 5 m (16 ft).

Contaminant releases at waste sites resulted in uranium contamination in groundwater that exceeds the 30 µg/L cleanup level in the 300 Area ROD (EPA and DOE, 2013). In 2015, the area of the uranium plume in the 300 Area Industrial Complex was approximately 0.34 km^2 (0.13 mi^2) (DOE/RL-2016-09, *Hanford Site Groundwater Monitoring Report for 2015*).

1.2.2 Physical Setting

The following sections provide a summary of the site geology and hydrogeology for the 300 Area Industrial Complex and Stage A EA area. Detailed information on the geology and hydrogeology of the 300 Area is presented in Chapters 3 and 4 of the 300 Area remedial investigation (RI)/feasibility study (FS) report (DOE/RL-2010-99, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*). Detailed information on the geology and hydrogeology of the Stage A area is presented in the borehole summary report for the Stage A injection and monitoring wells installed in 2015 and 2016 (Chapter 3 of SGW-59465, *Borehole Summary Report for the Installation of Nine Injection Wells, Twenty-One Monitoring Wells, and Three Boreholes in the 300-FF-5 Operable Unit*).

1.2.2.1 Geology

The ground surface in the 300 Area Industrial Complex is relatively flat, except for the steep embankment that slopes to the Columbia River. The surface elevation for the 300 Area Industrial Complex is approximately 115 m (377 ft) (Section 3.1 of DOE/RL-2010-99).

The stratigraphic units that underlie the 300 Area Industrial Complex, from youngest to oldest, are the eolian surficial deposits, Hanford formation, and Ringold Formation. These sediments overlie the Columbia River Basalt Group (Figure 1-3):

- Eolian deposits (Holocene age): The most recently deposited sediment is a discontinuous veneer containing eolian (windblown) sand and/or sand and gravel backfill deposited within waste sites that were excavated during remediation. These deposits generally overlie the 300 Area Industrial Complex, with a typical thickness of approximately 1 to 6 m (3.3 to 19.7 ft).

- Hanford formation (Pleistocene age): The Hanford formation cataclysmic flood deposits generally comprise three subunits (silt-dominated, sand-dominated, and gravel-dominated), which grade into one another both vertically and laterally. In the 300 Area Industrial Complex, the Hanford formation is primarily composed of the gravel-dominated subunit with a typical range in thickness from 12 to 24 m (40 to 80 ft). The gravel-dominated sequence is coarse-grained, basalt-rich, clast-supported, open framework, sandy gravel with variable silt and clay content. As a result, the Hanford formation permeability is generally several orders of magnitude greater than that of the underlying Ringold Formation. The inferred contour map of the contact between the Hanford formation and Ringold Formation is shown in Figure 1-4.

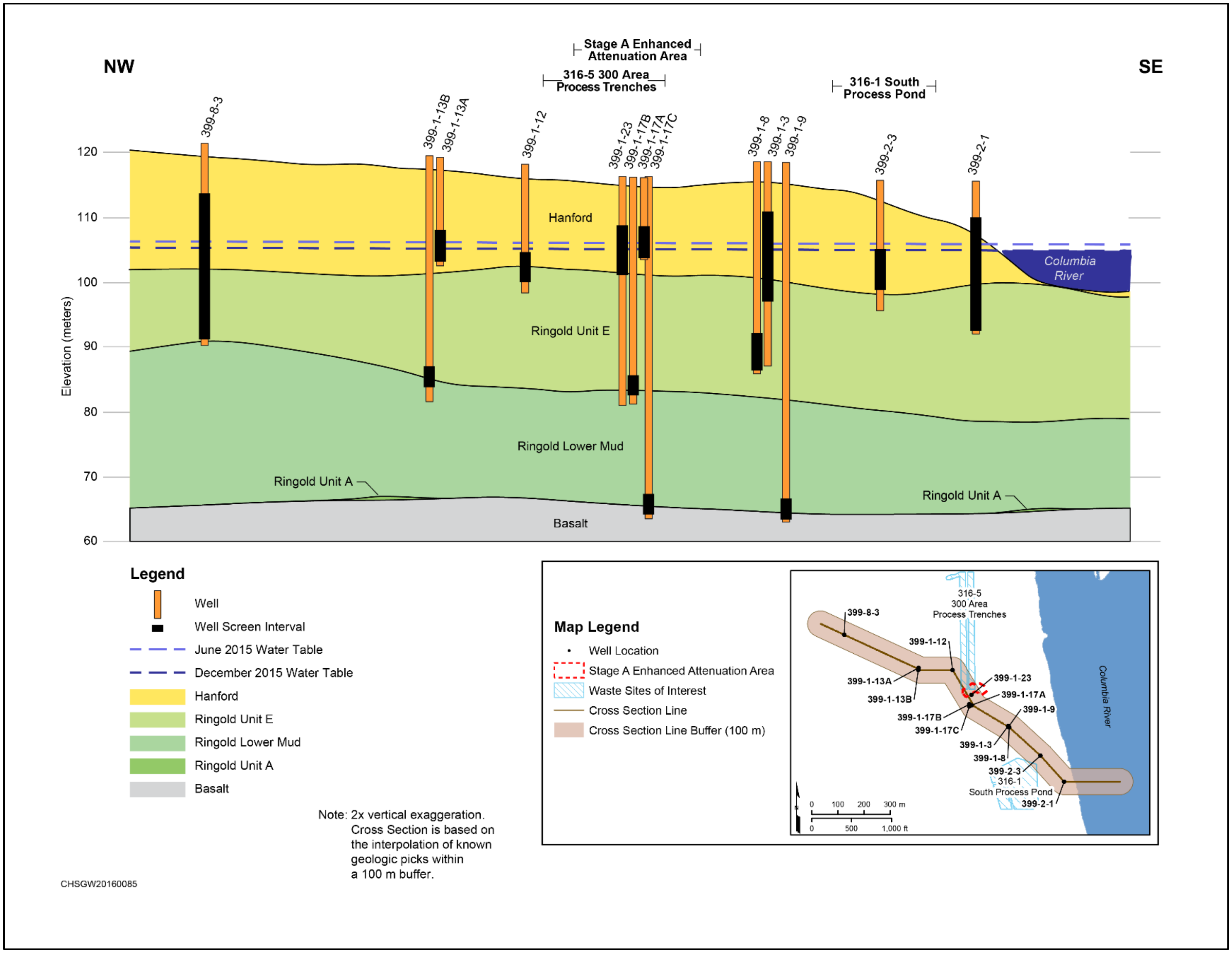


Figure 1-3. Cross Section of the General Geologic Features of the 300 Area Industrial Complex and Stage A Enhanced Attenuation Area

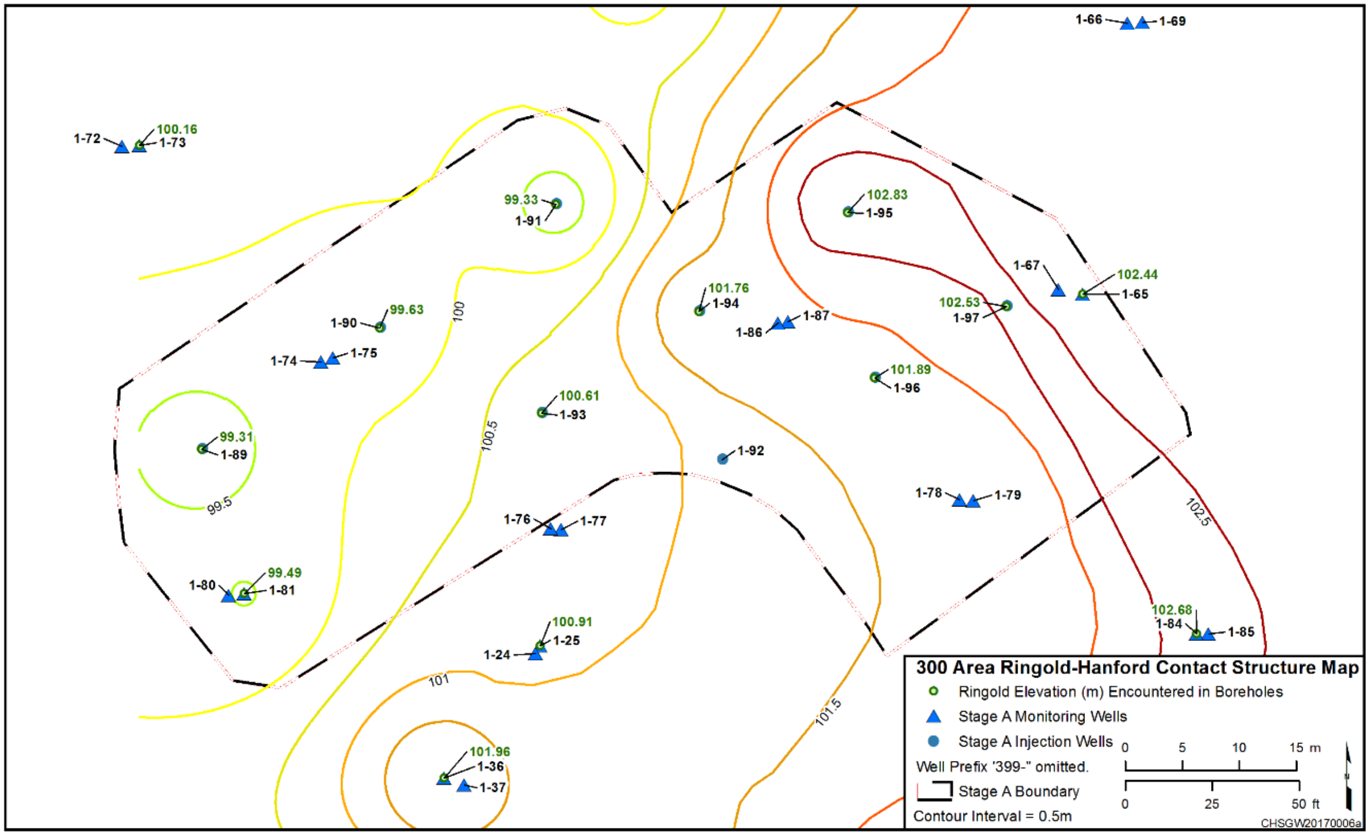


Figure 1-4. Inferred Contour Map of the Contact Between the Hanford Formation and Ringold Formation

- Ringold Formation (late Miocene to Pliocene age): The Ringold Formation is an unconsolidated to semiconsolidated sedimentary sequence deposited on the basalt by the ancestral Columbia River. The gravel-dominated Ringold Formation upper coarse unit (Unit E) is up to 24 m (80 ft) thick and is composed of pebble-cobble gravel compacted within a matrix of fine- to medium-grained sand with silt. A finer grained interval of silt and fine sand occurs at or near the top of the Ringold Formation Unit E over portions of the 300 Area Industrial Complex. The Ringold Formation Unit E overlies the Ringold Formation lower mud (Rlm) unit, a silt and clay-dominated layer, which ranges up to 24 m (80 ft) thick. These Rlm fine-grained, low-permeability sediments form an aquitard that significantly impedes the downward flow of groundwater. The Ringold Formation lower coarse unit (Unit A) is a silty, sandy gravel that occurs locally below the Rlm. The Rlm, or the Ringold Formation Unit A where present, forms the base of the unconfined aquifer system and overlies the basalt.

Injection and monitoring wells were installed to support implementation of the Stage A EA remedy for uranium (Figure 1-5). During drilling of the Stage A wells, only the gravel-dominated units of the Hanford formation and Ringold Formation Unit E were encountered (Chapter 3 of SGW-59465). The Ringold Formation Unit E was not fully penetrated.

Backfill placed into the remediated 316-2 North Process Pond and 316-5 300 Area Process Trenches is composed of Hanford formation sandy cobble gravel and clast-supported gravel. Large boulders are often present throughout the backfill material. Backfill in the 316-5 300 Area Process Trenches is present from ground surface to 4.9 to 5.5 m (16 to 18 ft) below ground surface (bgs). Backfill in the 316-2 North Process Pond extends from ground surface to no greater than 7.5 m (25 ft) bgs. Disturbed surface sediments surrounding the trenches and the pond extend from ground surface to approximately 0.6 m (2 ft) bgs.

The Hanford formation underlies the Stage A EA area between 0.6 and 15.4 m (2 ft and 50 ft) bgs (Figures 1-6 and 1-7). Rip-up clasts composed of silt and gravelly silt, present in abundance throughout the Hanford formation, are encountered sporadically throughout the Stage A area. Rip-up clasts are typically composed of nonindurated to very well indurated, massive to finely laminated silt, clayey silt, and gravelly silt. The rip-up clasts encountered throughout the Stage A area range in size from a few centimeters (inches) up to 1.2 m (4 ft).

The gravel-dominated Ringold Formation Unit E is present across the Stage A area between 11.4 and 15.5 m (37 and 50.5 ft) bgs (Figures 1-6 and 1-7).The silty sand to silt, fine-grained Ringold Formation subunit that locally overlies the gravel-dominated Ringold Formation Unit E in the vicinity of the 316-1 South Process Pond was not encountered during drilling in the Stage A area. However, stratigraphically equivalent, discontinuous sand lenses were encountered in the top meter (top few feet) of the Ringold Formation Unit E in some of the deep injection and monitoring wells.

1.2.2.2 Hydrogeology

The following information is obtained from Section 1.2 of the SAP (DOE/RL-2014-42).

The vadose zone in the 300 Area Industrial Complex consists primarily of backfill materials and unconsolidated gravels and sand of the Hanford formation. The average thickness of the vadose zone is 10 m (33 ft). However, the vadose zone thickness varies with the seasonal stages of the Columbia River and distance inland from the river. Rising groundwater elevations resulting from higher Columbia River stages seasonally saturate lower portions of the vadose zone, while lower river stages result in falling groundwater elevations that de-water these same lower portions of the vadose zone. These fluctuating groundwater elevations create the PRZ. Generally, wells adjacent to the river within the 300 Area Industrial Complex show larger variations in water level elevation in response to river stage changes than wells located at increasing distance from the shoreline.

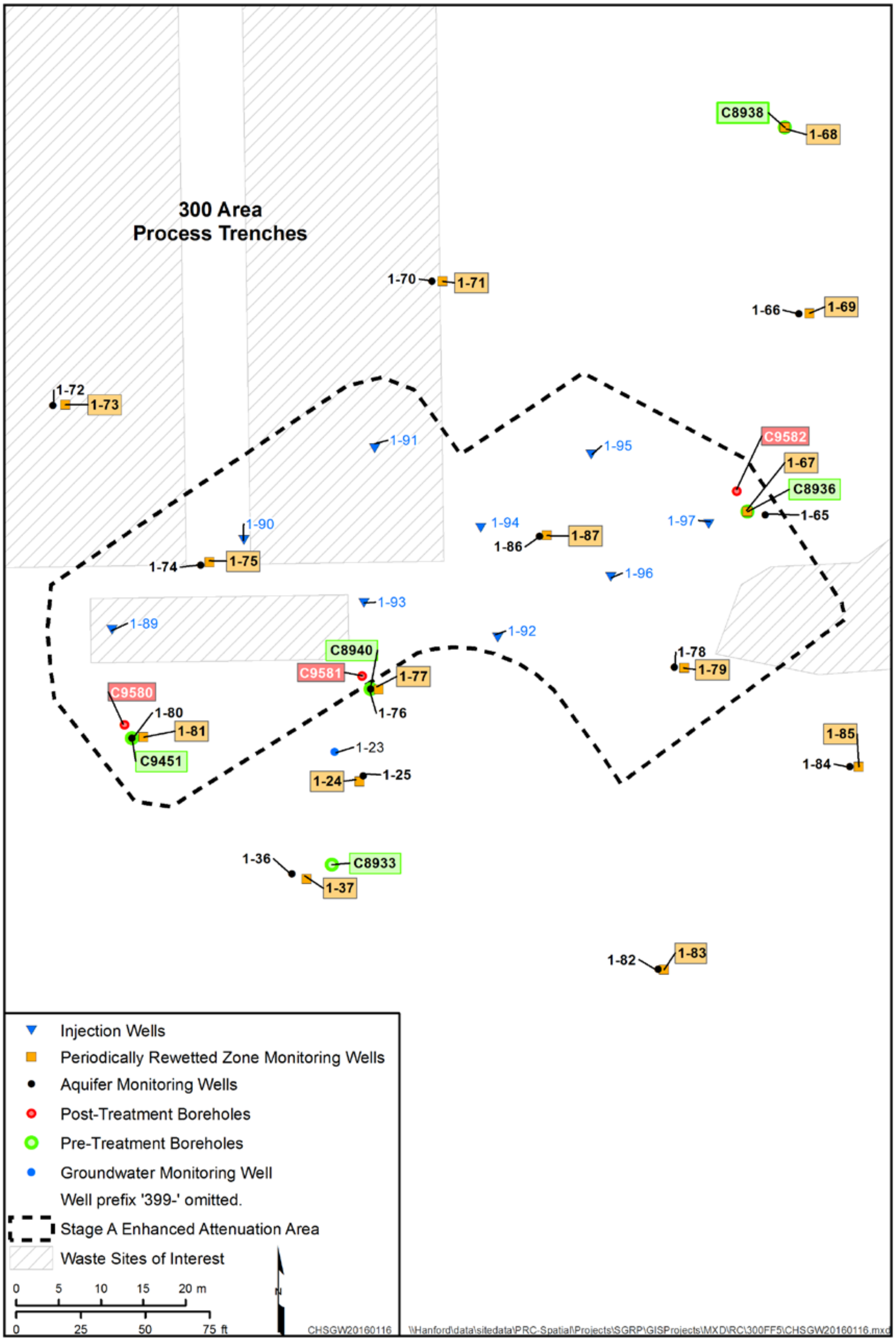


Figure 1-5. Stage A Enhanced Attenuation Area Well Field

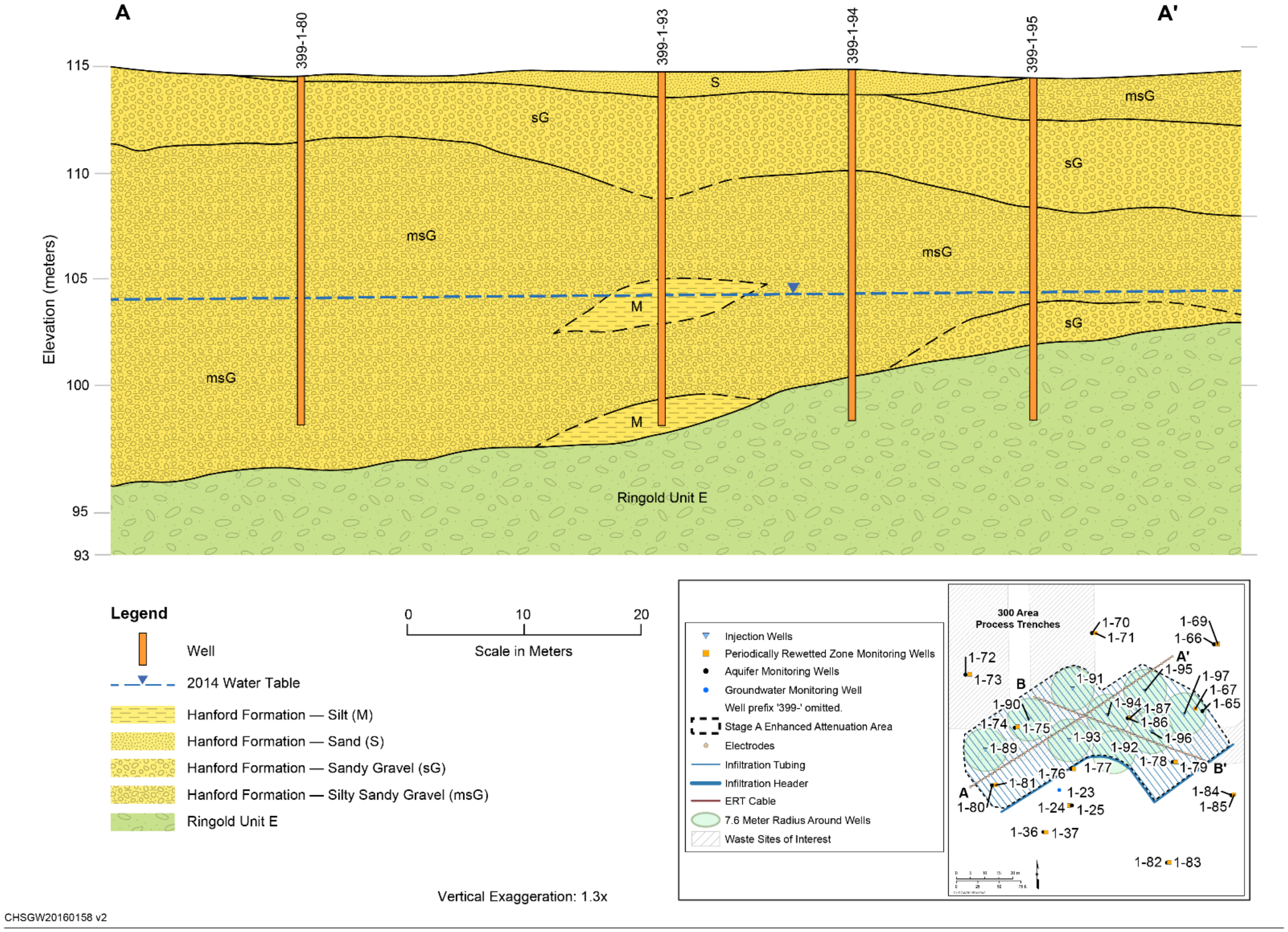


Figure 1-6. Southwest-Northeast Cross Section of Stage A Enhanced Attenuation Area

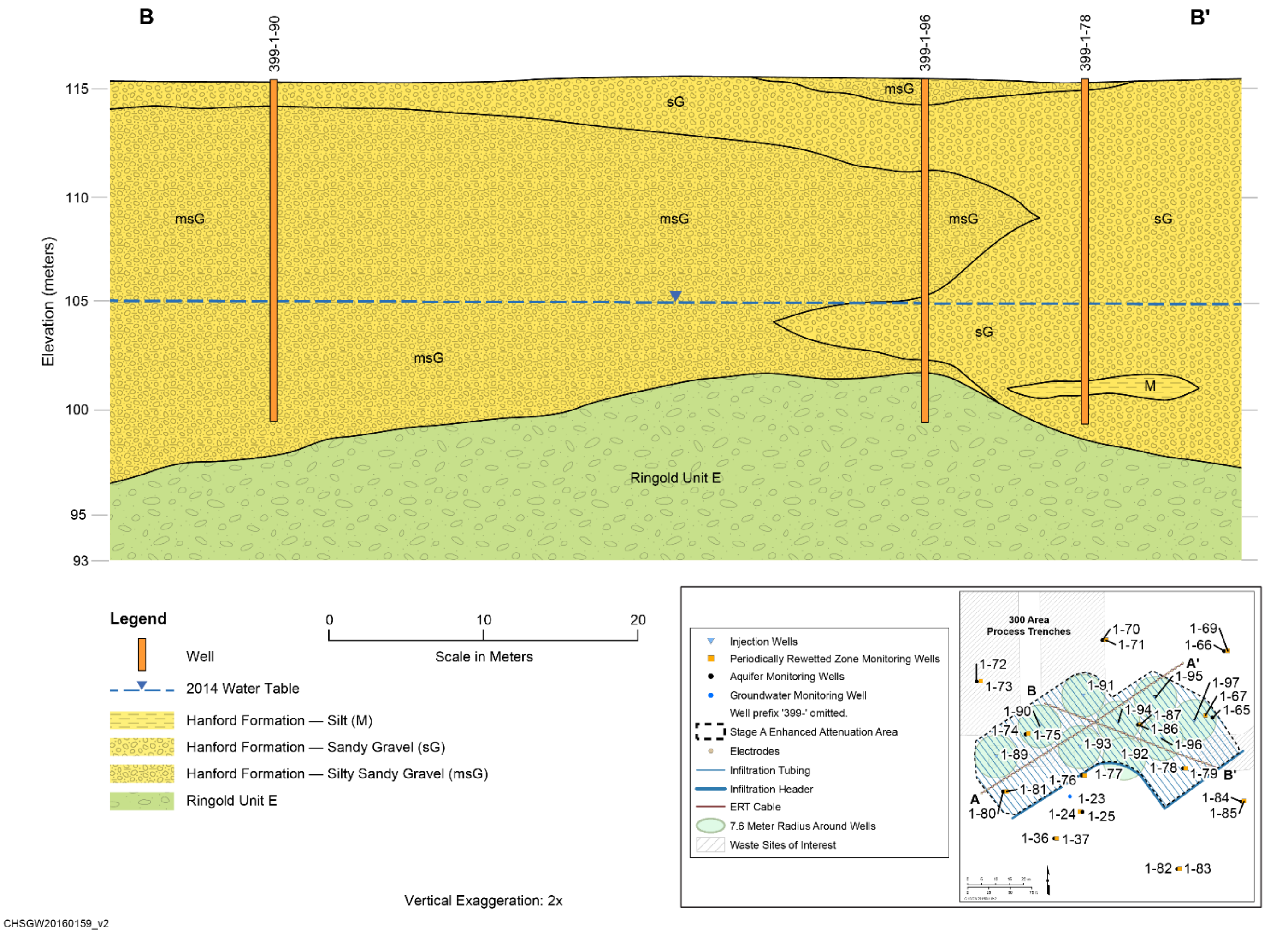


Figure 1-7. Northwest-Southeast Cross Section of Stage A Enhanced Attenuation Area

In the Stage A area, the PRZ is defined as the portion of the vadose zone from 105.0 to 107.0 m elevation that is contacted by typical seasonal increases in the groundwater elevation (Figure 1-8). The lower vadose zone, from 107.0 to 108.5 m elevation, represents the portion of the vadose contacted by increases in groundwater elevation in atypical high water years. The low elevation of the water table is 105.0 m.

The unconfined aquifer occurs in the highly permeable, gravel-dominated Hanford formation and in the underlying, less permeable gravel-dominated Ringold Formation Unit E.

Paleochannels carved into Ringold Formation Unit E sediments are filled with Hanford formation sand and gravel and act as preferential pathways for groundwater flow and for intrusion of river water during periods of high river stage. Paleochannels have not been identified in the Stage A area (Figure 1-4). The Ringold Formation lower mud unit is a confining layer (i.e., aquitard) that forms the base of the unconfined aquifer and is characterized by very low-permeability fine-grained sediment. This hydrologic unit prevents further downward movement of groundwater contamination to the deeper aquifers. The thickness of the unconfined aquifer along the Columbia River shoreline is about 25 m (80 ft).

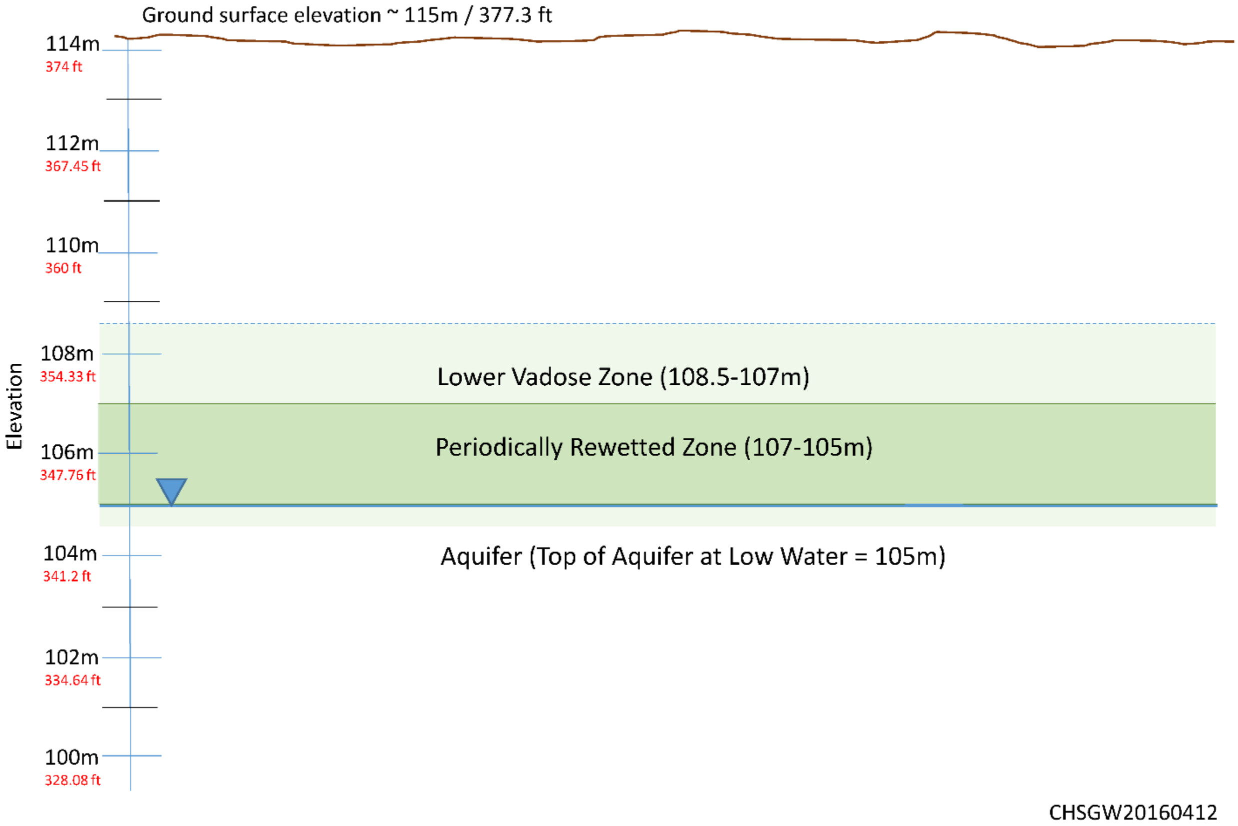


Figure 1-8. Elevations of the Periodically Rewetted Zone and Lower Vadose Zone in the Stage A Enhanced Attenuation Area

1.2.2.2.1 Groundwater Flow

Groundwater in the unconfined aquifer discharges to the Columbia River via upwelling through the riverbed and riverbank seeps. The flux from the unconfined aquifer is very low compared to the flow of the river. Because the river stage regularly fluctuates up and down, flow beneath the shoreline oscillates back and forth, with river water intruding into the unconfined aquifer and mixing with groundwater at times. When the river stage drops quickly to a low elevation, riverbank seeps appear.

Groundwater flow velocities beneath the 300 Area in the Hanford formation portion of the aquifer can be relatively rapid, with a velocity of 15.2 m/d (50 ft/d) estimated during a polyphosphate tracer test in December 2006 (PNNL-17708, *Three-Dimensional Groundwater Models of the 300 Area at the Hanford Site, Washington State*). However, the hydraulic gradients change direction in response to river stage, which fluctuates on seasonal and multiyear cycles. Consequently, groundwater flow is not always directed toward the river.

In general, regional groundwater flow converges on the 300 Area from the northwest, west, and southwest, inducing a southeast or east flow direction in the 300 Area (Section 3.6.1.3 of DOE/RL-2010-99). During periods of extended high river stage (typically March through June), water flows from the river into the aquifer.

The rise and fall of the river stage create a dynamic zone of interaction between groundwater and river water affecting groundwater flow patterns, contaminant transport rates (e.g., uranium in groundwater), groundwater geochemistry, contaminant concentrations, and contaminant attenuation rates.

1.2.2.2.2 Movement of Uranium Contamination

Uranium contamination remaining in the vadose zone resulted from active liquid waste discharge of uranium-bearing solutions during 300 Area operations. Uranium soil concentrations vary within the soil column, with higher concentrations associated typically with finer grained sediments. Uranium is mobilized during periodic rewetting of the lower portion of the vadose zone due to Columbia River stage fluctuations. The groundwater within the PRZ leaches residual uranium and drains under gravity, providing a pathway for dissolved uranium to reach the aquifer. Due to periodic river stage fluctuations and depending upon the inland distance from the river, the groundwater flow direction can change over a wide area and distribute the dissolved uranium within the aquifer. As a result of mixing of river water and groundwater, the alkalinity also varies spatially and temporally within the aquifer and can lead to variable speciation of uranium aqueous complexes. The amount of uranium leaching from the PRZ is affected by both the degree of saturation of the sediments and the alkalinity of the solution. The combination of uranium desorption and dilution in the river water/groundwater mixing zone results in a varying distribution of uranium concentrations in the aquifer.

1.2.3 Enhanced Attenuation Remedy Timeline

The 300 Area ROD (EPA and DOE, 2013) was issued in November 2013. Figure 1-9 shows the chronology of the significant activities, investigations, and decisions completed after issuance of the ROD that support implementation of uranium sequestration at the Stage A EA area. On the figure, key documents and decisions are shown above the timeline; investigations and actions are shown below the timeline. Chapter 7 of this document contains a bibliography that provides information on the documents shown on the timeline. Environmental investigations and remedial actions conducted in the 300 Area before the 300 Area ROD was issued are summarized in the 300 Area RI/FS report (Section 1.3 of DOE/RL-2010-99).

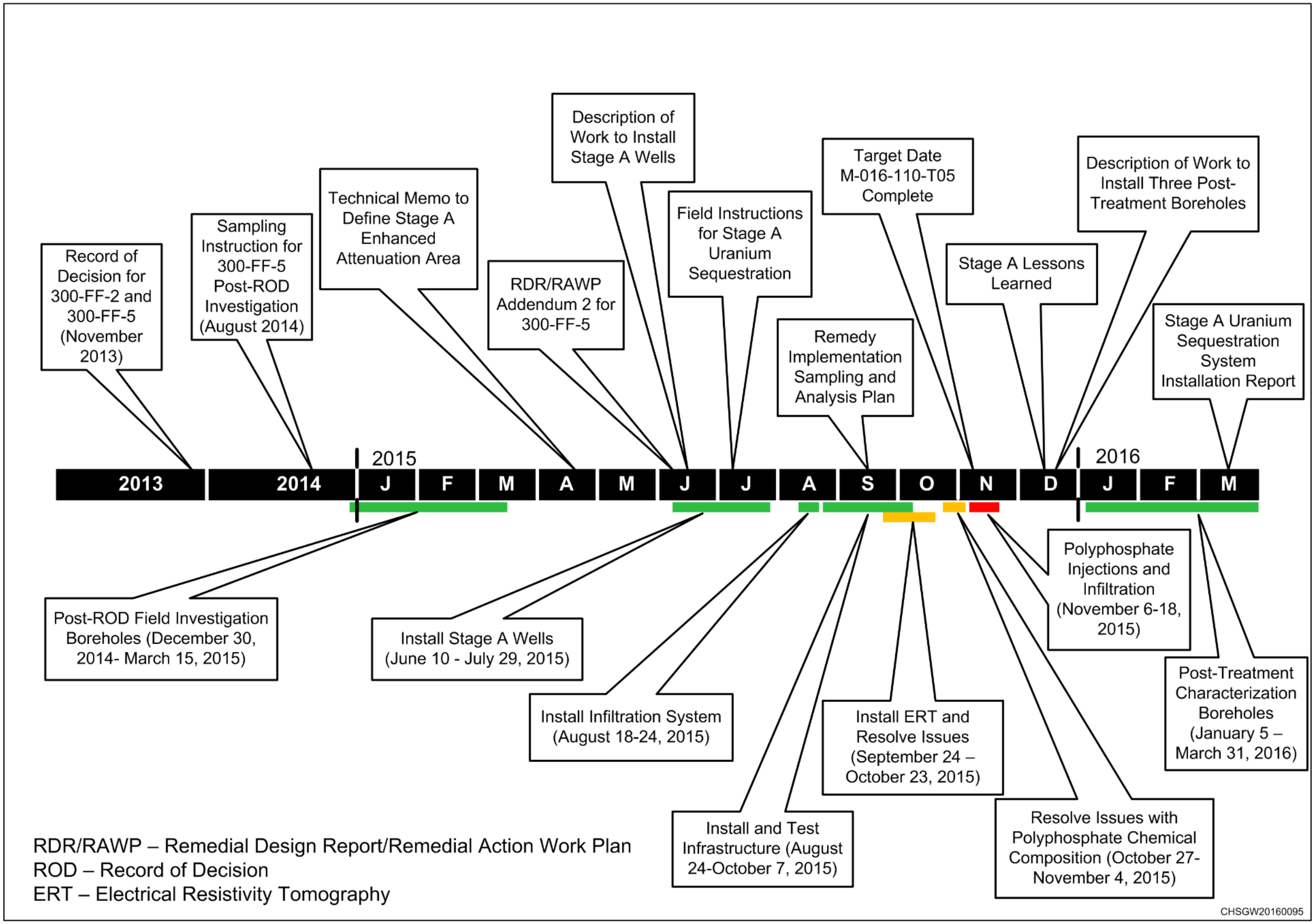


Figure 1-9. Timeline of Documents and Activities Supporting Uranium Sequestration at the Stage A Enhanced Attenuation Area

1.3 Uranium Sequestration Technology Description

The uranium sequestration technology was developed during treatability tests, and the technology was adapted for use as the EA remedy.

1.3.1 Treatability Tests

A treatability test was conducted at the 300 Area Industrial Complex to evaluate the use of polyphosphate as a remedial technology to sequester uranium (PNNL-18529, *300 Area Uranium Stabilization Through Polyphosphate Injection: Final Report*). The treatability test included both laboratory and field studies. The laboratory studies evaluated applying polyphosphate to vadose zone and PRZ sediments to immobilize uranium and prevent it from leaching to the aquifer. The field study evaluated direct sequestration of dissolved uranium in groundwater by injecting polyphosphate into the aquifer.

Laboratory tests demonstrated that when a soluble form of polyphosphate is injected into uranium-bearing saturated porous media, immobilization of uranium can occur due to formation of relatively insoluble uranyl-phosphate minerals, such as autunite ($Ca(UO_2)_2(PO_4)_2 \cdot nH_2O$).

Results of the field study demonstrated that, upon direct injection, the polyphosphate amendment could be effectively distributed over a relatively large lateral extent. Monitoring wells located at a radial distance of 23 m (75 ft) showed phosphate concentrations as high as 40 to 60 percent of the injection concentrations, which indicated that uranium sequestration could be effectively implemented on a full field scale.

Laboratory-scale column studies (PNNL-21733, *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment*) also were conducted to evaluate short- and long-term effects of polyphosphate treatment on uranium leaching from 300 Area PRZ sediments. Under idealized laboratory conditions, a wide range of polyphosphate treatments resulted in significant (average 54 percent) decreases in leached uranium mass in columns run for up to 1 year. Polyphosphate treatment decreased uranium leaching through the formation of nonuranium calcium-phosphate precipitates coating uranium surface phases, uranium adsorption to precipitates, or slow formation of uranium-phosphate precipitates. The simulated phosphate delivery strategy that resulted in the greatest decrease in uranium leaching involved maximizing stop-flow conditions to increase phosphate-sediment reaction time before groundwater advection, and the use of high-concentration (~50 mM) polyphosphate solutions.

1.3.2 Enhanced Attenuation Remedy

Based on the results of the treatability tests, uranium sequestration using polyphosphate solutions was adapted for use as a remedy for uranium in the 300 Area. During Stage A, two different polyphosphate solutions were blended and then infiltrated and injected into the vadose zone, PRZ, and top of the unconfined aquifer. The blend of orthophosphate[1] and pyrophosphate solutions was used to take advantage of the reaction kinetics of each compound. Orthophosphate combines with naturally occurring calcium in the vadose zone pore water for rapid formation of a monocalcium phosphate rind around sediment surfaces, some of which contain mobile uranium. Pyrophosphate hydrolyzes, or breaks down, slowly to orthophosphate over time, which allows for enhanced transport of phosphate to the lower vadose zone and PRZ and formation of the calcium phosphate rind.

The primary sequestration mechanism is the formation of an amorphous (unstructured) monocalcium phosphate rind that coats the sediments containing uranium and thereby reduces the dissolution of uranium-bearing mineral phases. Over months to years, this rind is expected to crystallize to form a stable calcium-phosphate mineral, hydroxyapatite ($Ca_{10}(PO_4)_6(OH_2)$), which has very low solubility. During crystallization, some incorporation of uranium into the hydroxyapatite structure is also expected.

---

[1] Orthophosphate refers to phosphate associated with monosodium (primarily) along with disodium species.

This page intentionally left blank.

2 Uranium Sequestration Implementation Approach

This chapter provides an overview of the approach used to implement uranium sequestration in the Stage A EA area. The sections summarize the objectives, design, and implementation of the Stage A polyphosphate infiltration and injection. The final section briefly discusses changes that were made from the original Stage A design when the Stage A system was completed and operated in the field.

2.1 Stage A Objectives

The objectives for the Stage A polyphosphate applications to sequester uranium include the following elements summarized from SGW-58976, *Field Instructions for Uranium Sequestration in the 300 Area*.

- Implement uranium sequestration on 0.3 ha (0.75 ac) using polyphosphate injection in nine wells spanning a length of 75 m (246 ft) and polyphosphate infiltration in the vadose zone from near-surface infiltration lines covering the area.
- Optimize the use of two injection skids to maximize the amount of polyphosphate solution in the vadose zone and PRZ through infiltration followed by well injections into the PRZ. Use two submersible river pumps to deliver makeup water to the mixing skids.
- Refine the use of the high-concentration formulations of orthophosphate and pyrophosphate solutions previously used in pilot test applications.
- Monitor delivery of polyphosphate solutions at selected monitoring wells using downhole instrumentation, electrical resistivity tomography (ERT), and groundwater monitoring in accordance with sampling and analysis protocols.
- Evaluate the treatment effectiveness of the Stage A polyphosphate application based on the phosphate distribution efficiency, overall decrease in uranium leachability in vadose zone and PRZ soil samples, decrease in uranium mobilization to groundwater, and changes to hydraulic conductivity of the aquifer due to precipitation of phosphate minerals.
- Apply experience and lessons learned from the Stage A application of polyphosphate solutions to a larger scale for Stage B.

The effectiveness of the Stage A phosphate applications in meeting these objectives is evaluated in this report. The proposed design of Stage B is discussed in Chapter 6.

2.2 Stage A Design

As specified in the 300 Area ROD (EPA and DOE, 2013), EA using uranium sequestration involves infiltrating and injecting polyphosphate solutions into the vadose zone, PRZ, and top of the aquifer to sequester, or bind, residual uranium by forming insoluble minerals. The target area for application of the polyphosphate solutions is a 1.2 ha (3 ac) area containing a persistent source of mobile uranium that contributes to contamination of the underlying groundwater. Uranium sequestration in the EA area is anticipated to reduce the mass of soluble uranium, thereby reducing the amount of uranium available to leach into the groundwater.

The conceptual design for implementing uranium sequestration in two stages is provided in DOE/RL-2014-13, *Integrated Remedial Design Report/Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units)*, hereinafter called the remedial design report/remedial action work plan (RDR/RAWP). The conceptual design for Stage A included the number and spacing of injection wells and infiltration lines, polyphosphate solution formulations, and injection and infiltration volumes and rates, based on chemical arrival responses observed during previous treatability tests in the 300 Area. The SAP (DOE/RL-2014-42) describes the monitoring required during injection and infiltration.

The Stage A polyphosphate applications were timed to coincide with the low river stage of the Columbia River to maximize the thickness of PRZ into which polyphosphate solutions could be injected (DOE/RL-2014-13-ADD2).

The following sections summarize the design of the Stage A uranium sequestration system as it was installed and implemented. Information on the Stage A uranium sequestration system is obtained from SGW-59455.

2.2.1 Stage A Enhanced Attenuation Area

In accordance with the RDR/RAWP, a supplemental post-ROD field investigation was conducted from December 30, 2014, through January 15, 2015, to collect uranium soil concentration data to refine the location of the Stage A EA area. Three boreholes were drilled within the EA area proposed in the 300 Area ROD (EPA and DOE, 2013). Samples were analyzed to provide uranium leachability data and to fill data gaps in the uranium conceptual site model (CSM). Results of the field investigation are provided in SGW-58830, *300-FF-5 Supplemental Post-ROD Field Investigation Summary*. Data collected during the supplemental field investigation were used to refine the uranium soil distribution within the region of the EA area. Based on the revision, the location and shape of the Stage A area were modified to coincide with the region of highest anticipated uranium concentrations in the PRZ.

Because two of the three post-ROD field investigation boreholes were not within the refined Stage A area, uranium soil concentrations were measured in samples collected from two wells drilled in the refined Stage A area during implementation of Stage A. Minor modifications to the shape of the Stage A EA area were made during site setup in the field to accommodate existing infrastructure and site topography. The final Stage A area is shown in Figure 1-5.

2.2.2 Stage A Injection Wells

The Stage A injection system included nine combination PRZ and aquifer injection wells (Figure 1-5). Each injection well was constructed with two screened intervals, with one screen in the PRZ and one screen in the upper part of the aquifer. The screens are separated by a grout seal at the interface of the bottom of the PRZ and top of aquifer to allow isolated injection (using inflatable packers) into either the PRZ or top of the aquifer.

The injection wells were drilled using a sonic drill rig between July 15 and July 28, 2015, in accordance with SGW-58553, *Description of Work for the Installation of Twenty Two Monitoring Wells and Nine Injection Wells in the 300-FF-5 Operable Unit, FY2015*. A summary of the drilling and well construction details are contained in SGW-59465. The injection wells were developed by overpumping in order to obtain maximum flow rates.

The wells are screened from elevations of approximately 108.9 to 105.9 m (depths of 6.1 m [20 ft] to 9.1 m [30 ft] bgs) through the PRZ and from elevations of approximately 104.3 to 101.3 m (depths of 10.7 m [35 ft] to 13.7 m [45 ft] bgs) in the aquifer, based on the seasonal low water table elevation. Figure 2-1 shows the construction of a typical injection well, PRZ monitoring well, and aquifer monitoring well. The seasonal low water table in this region is estimated to be at an elevation of 105.0 m (depth of approximately 10 m [33 ft] bgs), and the seasonal high water table in this region is estimated to be at an elevation of 107.0 m (depth of approximately 8 m [26 ft] bgs). Therefore, the seasonal PRZ is approximately 2 m (6.6 ft) thick in this region (Figure 1-8). In atypical high water conditions, the elevation of the high water table is estimated to be 108.5 m (depth of approximately 6.5 m [21 ft] bgs), making the lower vadose zone approximately 1.5 m (4.9 ft) thick in this region. Figure 2-2 shows each of the injection wells and the elevations of the well screens and total depth.

2.2.3 Stage A Monitoring Wells

The Stage A monitoring system included 26 individual monitoring wells, consisting of 13 collocated well pairs (including 2 existing well pairs and 1 well from the post-ROD investigation). For each well pair, one well is partially screened in the PRZ, and one well is screened in the aquifer to enable monitoring of these two zones. The monitoring well system includes three monitoring well pairs upgradient of the Stage A treatment area, 6 monitoring well pairs within the Stage A treatment area, and four monitoring well pairs downgradient of the Stage A treatment area (Figure 1-5).

The PRZ and aquifer monitoring wells were drilled using a sonic drill rig between June 9 and July 13, 2015, in accordance with SGW-58553. A summary of the drilling and well construction details are contained in SGW-59465. All of the monitoring wells were developed with a submersible pump using a pumping rate of approximately 4 L/min (1 gal/min).

The 13 PRZ monitoring wells are screened from elevations of approximately 105.9 to 104.3 m (depths of 9.1 m [30 ft] to 10.7 m [35 ft] bgs) (Figure 2-1). The PRZ wells were screened across the lower portion of the PRZ and top of the aquifer to ensure the presence of groundwater for sampling the uppermost portion of the aquifer during low water conditions. With the exception of well 399-1-84, the aquifer monitoring wells are screened from elevations of approximately 102.8 to 101.3 m (depths of 12.2 m [40 ft] to 13.7 m [45 ft] bgs). Well 399-1-84 is screened from elevations of approximately 100.2 to 98.6 m (depths of 14.8 m [48 ft] to 16.3 m [53 ft] bgs) because of a deep silt layer that would have encompassed the planned screened depth. Figure 2-3 shows each of the monitoring wells and the elevations of the well screens and total depth.

2.2.4 Stage A Infiltration System

A polyphosphate solution infiltration system was installed within the Stage A area in accordance with SGW-58976. The infiltration network consisted of high-density polyethylene liquid distribution lines installed approximately 1.8 m (6 ft) bgs to prevent accumulation and wicking of sodium and phosphate up into the surficial soil, which would inhibit the establishment and growth of vegetation. The drip lines were spaced approximately 2 m (6.5 ft) apart, resulting in a total of 44 lines aligned southeast to northwest (Figure 2-4).

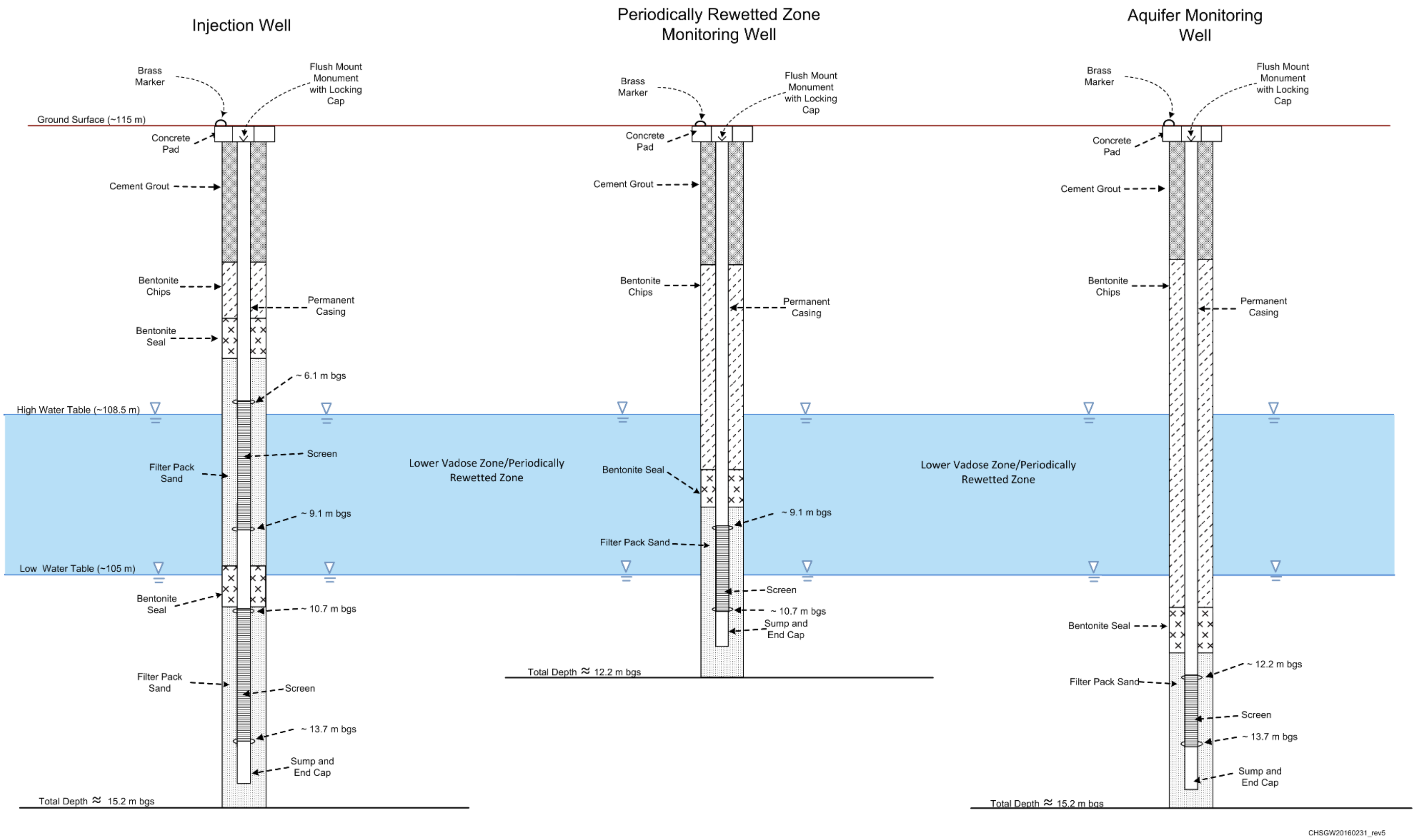
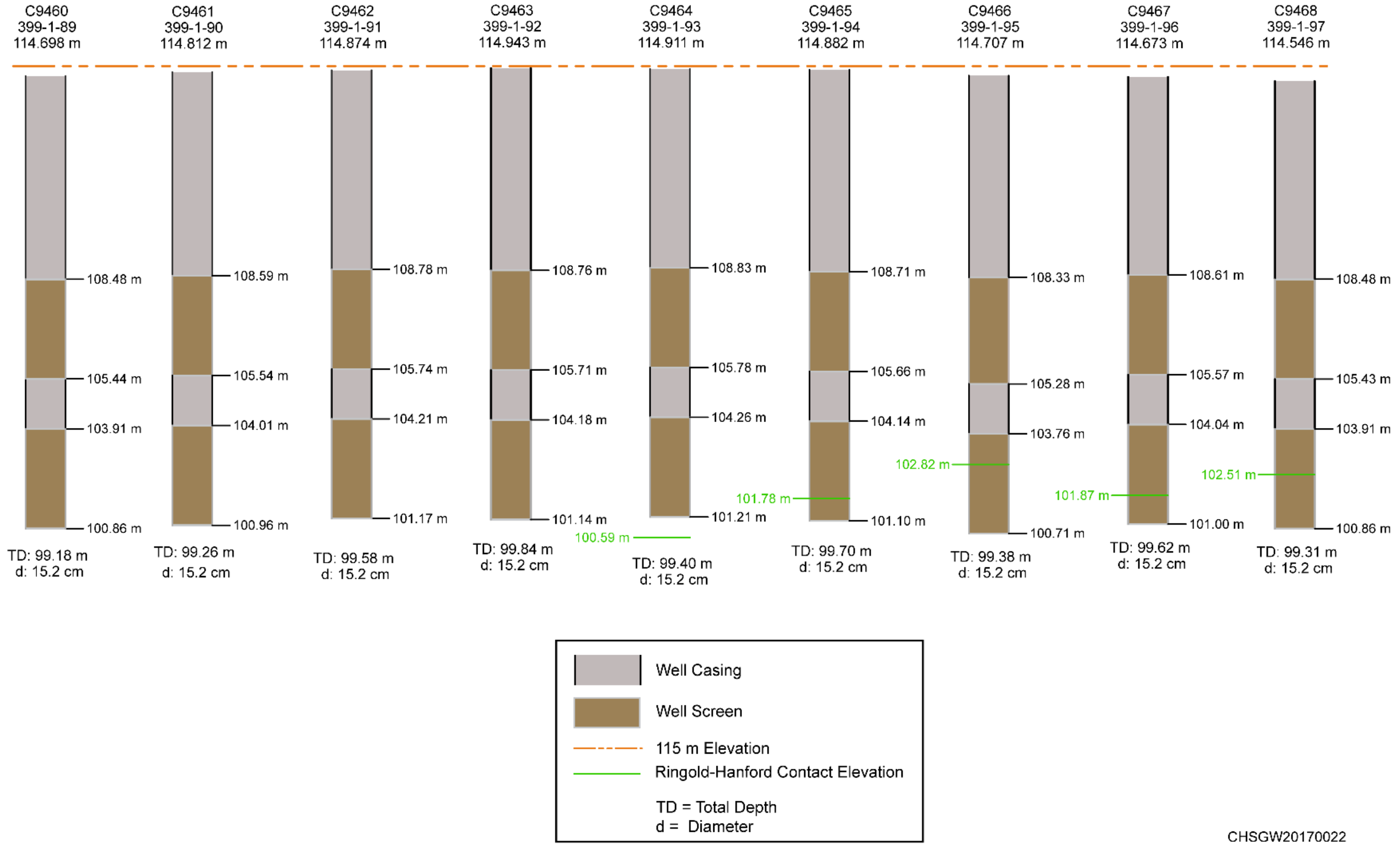


Figure 2-1. Construction Diagrams of Typical Injection, Periodically Rewetted Zone Monitoring, and Aquifer Monitoring Wells for Stage A



CHSGW20170022

Figure 2-2. Injection Well Features and Elevations

This page intentionally left blank.

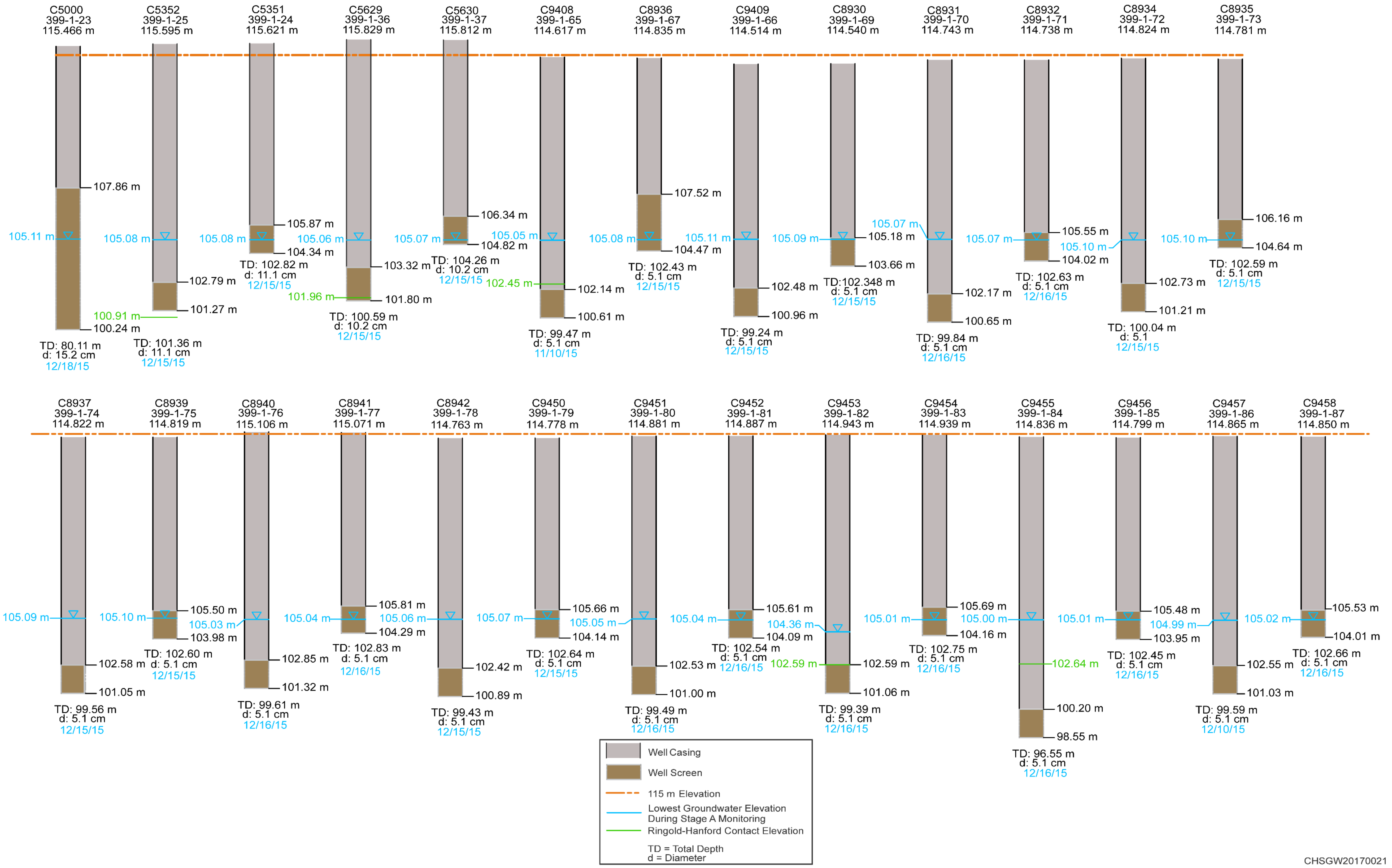


Figure 2-3. Monitoring Well Features and Elevations

This page intentionally left blank.

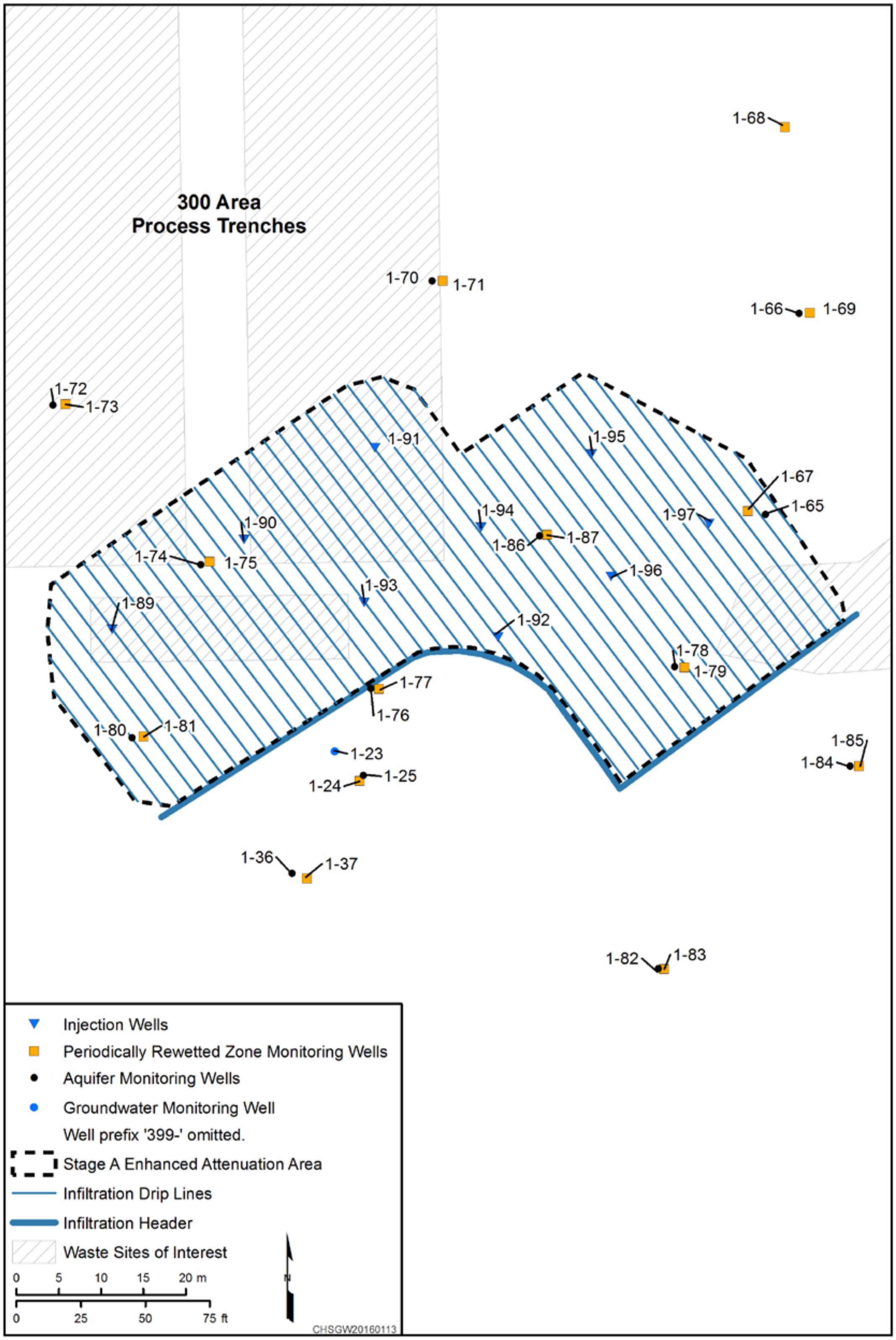


Figure 2-4. Infiltration System in the Stage A Enhanced Attenuation Area

Each drip line was designed to infiltrate polyphosphate solutions at a rate of 8 L/hr (2 gal/hr) from each of the emitters spaced 0.36 m (14 in.) apart along the drip lines. Each drip line was installed with a pressure regulator set at 103.4 kPa (15 lb/in^2) and was connected to a flexible header hose through which the polyphosphate solution was delivered. The specification of liquid distribution lines was selected to achieve a liquid application rate of at least 511 L/min (135 gal/min) over the 0.3 ha (0.75 ac) Stage A treatment area. Details of the infiltration system installation are provided in SGW-59455.

2.2.5 Stage A Chemical Mixing Skids and Site Infrastructure

Two chemical mixing skids were used during Stage A in accordance with SGW-58976. Each skid was capable of delivering polyphosphate solution at a flow rate of up to 1,136 L/min (300 gal/min). Skid 1 delivered polyphosphate solution to six injection wells at a time; the target design rate was 189 L/min (50 gal/min) per well. Skid 2 delivered polyphosphate solution to the infiltration network; the target design rate was 511 L/min (135 gal/min). Flowmeters and sample ports were provided on each skid to monitor and collect samples of the polyphosphate solution.

Feed water for the polyphosphate solutions was obtained using two separate submersible pumps, each capable of supplying up to 1,136 L/min (300 gal/min). The pumps were set in the Columbia River approximately 9.1 m (30 ft) apart and approximately 30.5 m (100 ft) from shore. Feed water was piped from the Columbia River to the chemical mixing skids, where it was filtered and then blended with the phosphate chemicals in an inline mixing chamber. Following mixing, a manifold routed the polyphosphate solutions to transfer hoses for distribution to the injection wells and infiltration lines. Flowmeters and pressure gauges were installed on each manifold to monitor the polyphosphate solution flow rates.

Phosphate chemicals were delivered to the site in tanker trucks in concentrated liquid form and stored in eight 30,283 L (8,000 gal) tanks. The tank configuration included two tanks containing pyrophosphate solution and six tanks containing orthophosphate solution. Two separate chemical distribution lines routed the phosphate chemicals to the chemical mixing skids. The chemical feed pumps were set to mix the phosphate chemicals and feed water automatically at the specified ratios. Details of the chemical tank and mixing skid installation are provided in SGW-59455.

2.2.6 Stage A Electrical Resistivity Tomography Network

Infiltration of polyphosphate solutions into the vadose zone and PRZ increased the electrical conductivity of the vadose zone by increasing both liquid saturation and pore fluid specific conductance. These changes enabled use of time-lapse ERT for remotely monitoring the advancement of the wetting front of the polyphosphate solution through the vadose zone and PRZ.

An ERT network was installed in the Stage A area (Figure 2-5). The longer ERT array (Line A-A’), oriented east-west through the Stage A area, was monitored using 60 electrodes at 1.5 m (5 ft) spacing. The shorter array (Line B-B’), oriented north-south through the Stage A area, was monitored using 47 electrodes at 1.5 m (5 ft) spacing. Details of the ERT network installation are provided in SGW-59455.

2.2.7 Stage A Enhanced Attenuation System Configuration

Figure 2-6 is an aerial view of the Stage A uranium sequestration system showing the location of the river pumps, chemical mixing skids, chemical storage tanks, and general location of the Stage A treatment area. The injection wells and ERT network can be seen within the Stage A EA area.

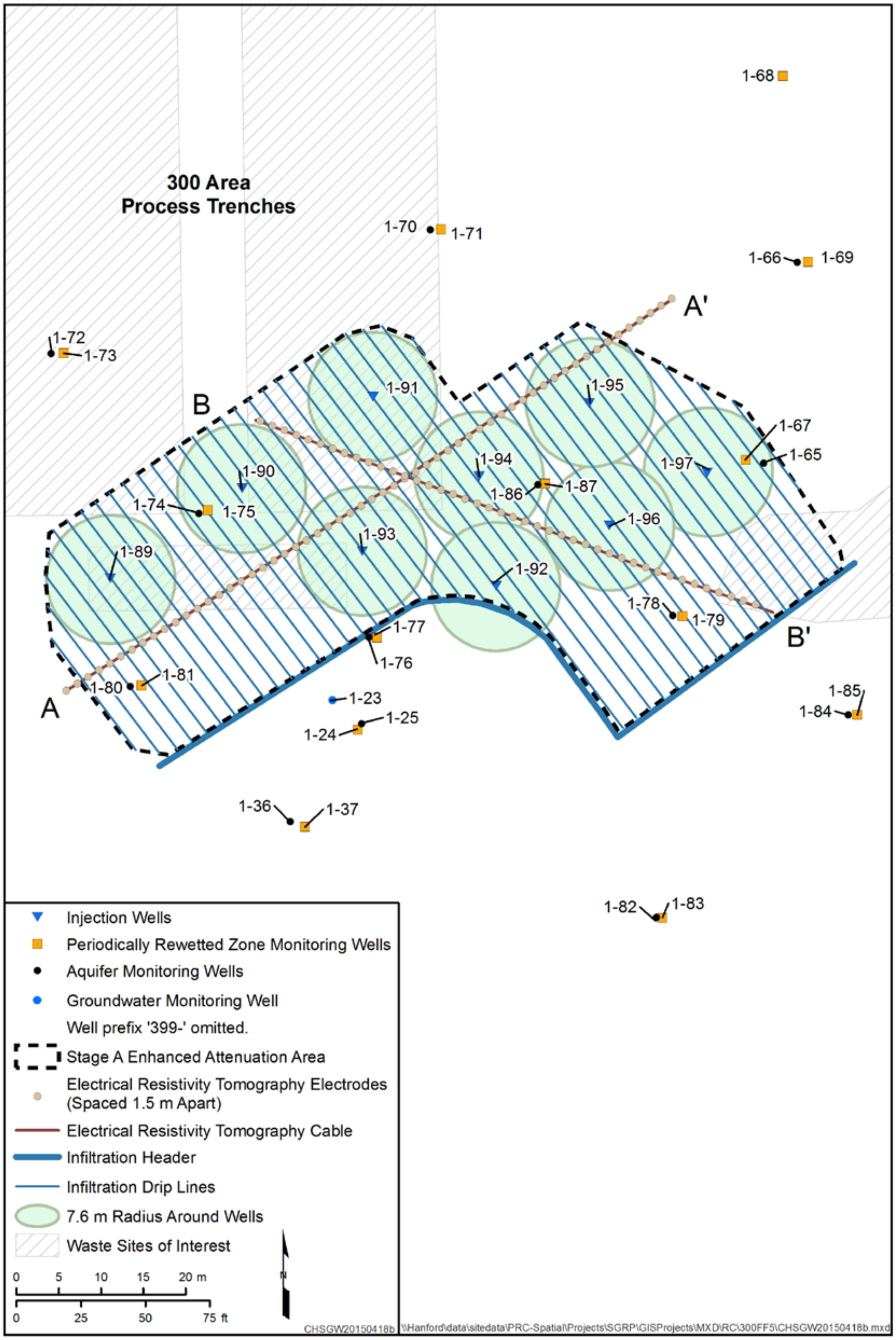


Figure 2-5. Electrical Resistivity Tomography Arrays for the Stage A Enhanced Attenuation Area

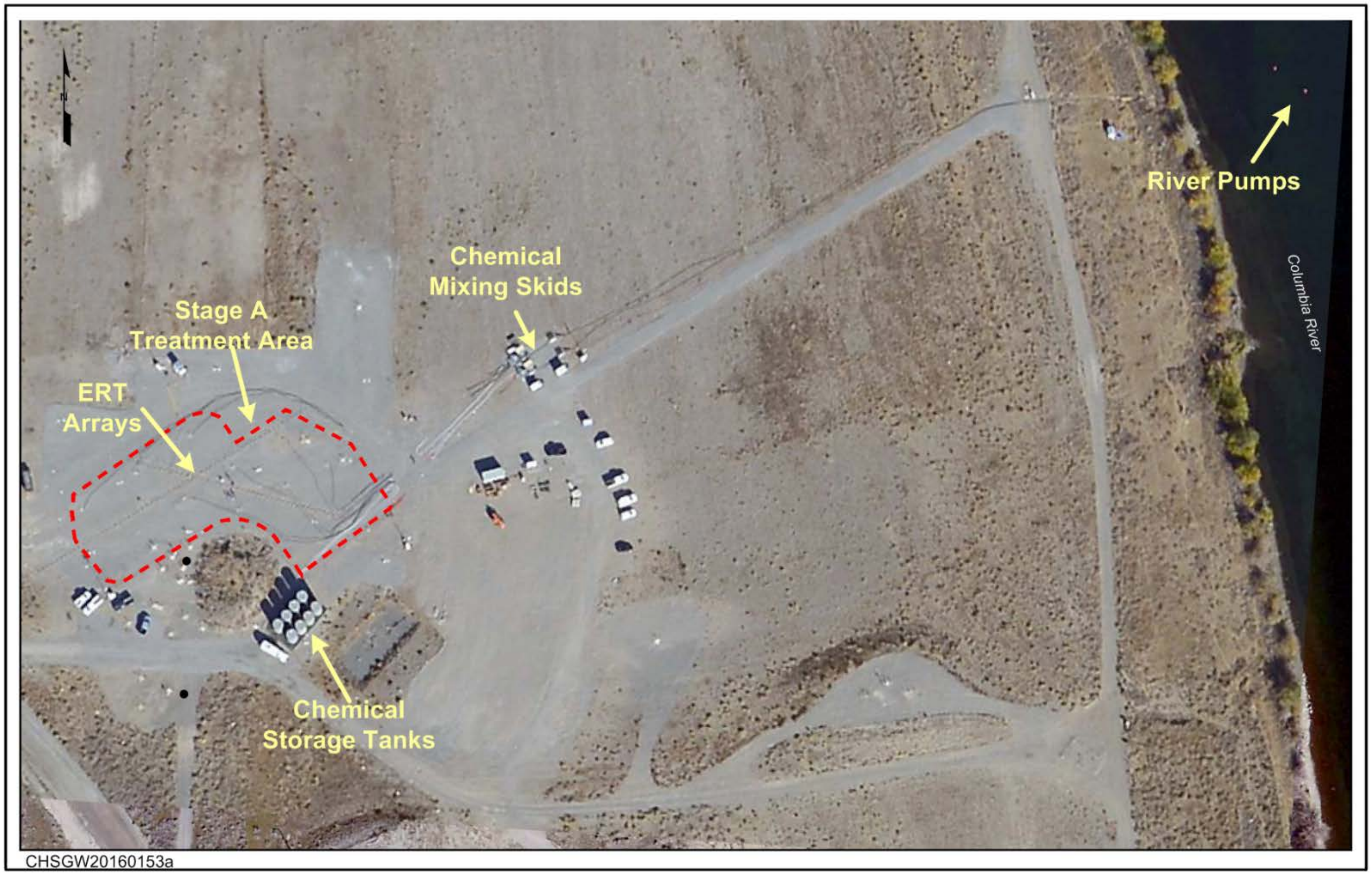


Figure 2-6. Aerial View of the Stage A Uranium Sequestration System

2.3 Stage A Timing and Order of Treatment

Design of the Stage A EA treatment system specified application of polyphosphate solutions using near-surface infiltration into the vadose zone, direct injection into the PRZ, and direct injection into the top of the aquifer. Stage A treatment of the EA area occurred over 13 days from November 6 through November 18, 2015.

Polyphosphate solution was injected through nine injection wells into the unconfined aquifer on November 6, 9, and 16 (days 1, 4, and 11). On each day, a different combination of six injection wells was used for approximately 8 hours (Table 2-1). The design sequence of the Stage A aquifer injections was to inject polyphosphate solution into the aquifer at least 1 day before, during, and after the polyphosphate infiltration period to establish a layer of phosphate in groundwater below the infiltration area in order to remediate uranium that might be flushed to groundwater during infiltration operations. The design sequence also called for conducting injections into at least six wells at a time, during daytime hours while varying the locations of the six wells being injected over the 3 days in order to maximize the distribution of phosphate in groundwater below the infiltration area.

Infiltration of polyphosphate solution was continuous (24 hr/d operation) for 217 hours, starting November 7 and concluding November 16 (days 2 through 11) (Table 2-1). Polyphosphate solution was delivered to all 44 infiltration lines simultaneously. Infiltration was continued after ERT imaging and sustained increases in groundwater specific conductivity confirmed that the infiltration solution had reached the PRZ and aquifer in order to deliver the required amount of chemical to the vadose zone and to ensure the PRZ moisture content was maximized prior to injection into the PRZ.

Polyphosphate solution was injected into the PRZ on November 16, 17, and 18 (days 11, 12, and 13). Each day, a different combination of six injection wells was used for approximately 8 hours (Table 2-1).

The volumes and rates of polyphosphate solution injected and infiltrated during Stage A are provided in Section 4.3 of this report.

Table 2-1. Summary of Stage A Uranium Sequestration Operations

Operation Day (Date)	**Aquifer Injection Wells**[a]	**PRZ Injection Wells**[a]	**Average Infiltration Rate Achieved (L/min [gal/min])**	**Total Injection Rate Achieved (L/min [gal/min])**	**Duration of Operations**	
					Start	**Stop**
1 (Nov. 6)	1-89, 1-90, 1-91, 1-92, 1-93, 1-94	--	--	1,136 (300)	0854	1646
2 (Nov. 7)	--	--	212 (56)	--	0716	[b]
3 (Nov. 8)	--	--	198 (52)	--	[b]	[b]
4 (Nov. 9)	1-92, 1-93, 1-94, 1-95, 1-96, 1-97	--	197 (52)	1,136 (300)	0935	1600
5 (Nov. 10)	--	--	202 (53)	--	[b]	[b]
6 (Nov. 11)	--	--	254 (67)	--	[b]	[b]
7 (Nov. 12)	--	--	316 (84)	--	[b]	[b]
8 (Nov. 13)	--	--	311 (82)	--	[b]	[b]

Table 2-1. Summary of Stage A Uranium Sequestration Operations

Operation Day (Date)	Aquifer Injection Wells[a]	PRZ Injection Wells[a]	Average Infiltration Rate Achieved (L/min [gal/min])	Total Injection Rate Achieved (L/min [gal/min])	Duration of Operations	
					Start	Stop
9 (Nov. 14)	--	--	303 (80)	--	[b]	[b]
10 (Nov. 15)	--	--	298 (79)	--	[b]	[b]
11 (Nov. 16)	--	--	303 (80)	--	[b]	0800
	1-95, 1-96, 1-97, 1-89, 1-90, 1-91	--	--	1,136 (300)	0930	1600
	--	1-89, 1-90, 1-91, 1-92, 1-93, 1-94	--	1,136 (300)	1855	0300
12 (Nov. 17)	--	1-92, 1-93, 1-94, 1-95, 1-96, 1-97	--	1,136 (300)	0404	1200
13 (Nov. 18)	--	1-95, 1-96, 1-97, 1-89, 1-90, 1-91	--	1,136 (300)	0700	1300

a. All well names begin with 399-.

b. 24 hr/d infiltration began on November 7 and concluded on November 16, 2015.

Monitoring during Stage A polyphosphate infiltration and injection included (1) pre-treatment (baseline) groundwater and soil sampling; (2) monitoring of skid system parameters and chemical concentrations, ERT, and groundwater during treatment; and (3) post-treatment groundwater and soil sampling. Sampling and analysis requirements are described in Chapter 6 of SGW-58976 and Chapter 3 of the SAP (DOE/RL-2014-42). Sampling and monitoring methodology is described in Chapter 3 of this report.

2.4 Deviations from Design

The following bullets summarize instances where implementation and operation of the Stage A treatment and monitoring differed from the design presented in DOE/RL-2014-13-ADD2 and the SAP (DOE/RL-2014-42). The potential impact of the deviations is also discussed.

- DOE/RL-2014-42 states “Infiltration and injection will be performed in September through October, the time of year when the river stage is low and groundwater flow direction at the EA area will be to the southeast.” The Stage A application of polyphosphate solution (infiltration and injection) was conducted in November 2015. Groundwater levels in the treatment area began to climb during the period in early November when operations were conducted. Although not conducted during the optimal low river stage season (September and October), the groundwater levels were low (within 0.3 m [1 ft] of September and October water levels) and the flow direction was to the southeast during this time, based on increased phosphate concentrations detected in this direction. The difference in groundwater levels represents less than about 10 percent of the 3 m (10 ft) long PRZ injection screen interval, so the impact to treatment effectiveness is not considered significant.
- Aquifer monitoring well 399-1-84 was screened from 14.6 m (48 ft) to 16.2 m (53 ft) bgs, due to a deep silt layer that would have encompassed the planned screened depth. All other aquifer monitoring

wells were screened from approximately 12.2 m (40 ft) to 13.7 m (45 ft) bgs in accordance with the design. Aquifer monitoring well 399-1-84 was used for sampling, although it was screened in a deeper part of the aquifer. The data are considered adequate for the purpose of monitoring the constituents of concern in the aquifer.

- The infiltration system was not operated at 511 L/min (135 gal/min). The initial flow rates ranged from 197 to 212 L/min (52 to 56 gal/min). After modification of pressure regulators, flow rates ranged from 298 to 316 L/min (79 to 84 gal/min). Also, the infiltration system was operated for a longer period of time in order to achieve application of the design volume. Nonuniform flow rates or lower flow rates throughout the infiltration emitter network could have affected vertical fluid velocity, which potentially negatively impacted phosphate distribution in the vadose zone.
- Daily sampling of all 26 monitoring wells during the treatment application was not feasible with available resources. Seven wells within the Stage A EA area were sampled daily. This limited number of daily sampling locations presented challenges in thoroughly evaluating Stage A performance because daily samples were not available to monitor changes at the other 19 locations during treatment.
- Water levels and field parameters (specific conductivity, temperature, pH, and oxidation-reduction potential) were monitored every 30 minutes using downhole instruments in 6 monitoring wells rather than in all 26 monitoring wells. Additional wells could not be configured with instrumentation because of lack of equipment, and manual monitoring of this number of wells at 4-hour intervals was not feasible with available resources. This limited number of continuous sampling locations presented challenges in thoroughly evaluating Stage A performance because continuous samples were not available to monitor changes at the other 20 locations during treatment.

This page intentionally left blank.

3 Sampling and Monitoring Methods

This chapter describes the methods used for sampling, analysis, and monitoring of soil, groundwater, polyphosphate solutions, and electrical resistivity before, during, and after completion of treatment activities to determine the initial site conditions and changes during and following implementation of the Stage A EA remedy.

3.1 Soil Sampling and Analysis

Soil samples were collected during borehole drilling before and after application of polyphosphate solutions. The soil samples were analyzed for uranium concentrations and used for uranium leachability analyses. The leachability data were collected by Pacific Northwest National Laboratory (PNNL) during four different laboratory tests (Section 1.0 of PNNL-25420, *Analytical Data Report for Sediment Samples Collected from 300-FF-5: Boreholes C9580, C9581, and C9582*, included in Appendix A of this report):

- Sequential uranium extraction tests – These tests quantify how uranium in sediment samples is distributed among surface phases that require different strengths of extraction solutions to remove the uranium from the sediment. Uranium phases that require stronger solutions have slower leaching characteristics under normal field conditions.
- Labile uranium leach tests – These tests evaluate the quantity of uranium that is readily solubilized into the aqueous phase, helping define the most mobile portion of uranium in a sediment sample. The test simulated field conditions expected during groundwater-soil interactions in the PRZ (Section 4.2 of PNNL-25420, included in Appendix A of this report).
- Flow-through column tests on both intact soil samples and fine-grained (<2-mm size fraction) repacked columns – These tests provide information about the rate of uranium released into groundwater.
- Identification of uranium mineral phase(s) and surface coating(s) – Identification of mineral phases can be used to interpret uranium leaching behavior based on the types of surface phases present.

Comparison of data from the pre-treatment and post-treatment boreholes is used to evaluate the distribution of the uranium and phosphate and the sequestration of uranium.

Analytical results for the soil samples are summarized in Section 4.1. The data are provided in Appendix A.

3.1.1 Pre-Treatment Sampling and Analysis

Soil samples were collected from three boreholes drilled in accordance with SGW-58261, *Description of Work for Borehole Drilling, Sampling, and Construction of Monitoring Wells in Support of the 300-FF-5 OU Supplemental Post ROD Field Investigation*. Boreholes C8933, C8936, and C8938 were drilled from December 30, 2014 to January 15, 2015 (Figure 3-1). The borehole locations were selected based on elevated uranium groundwater concentrations observed at wells 399-1-17A and 399-1-55. Boreholes C8936 and C8938 were completed as monitoring wells (399-1-67 and 399-1-68, respectively). Borehole C8933 was decommissioned. Well 399-1-67 was used as part of the monitoring well network for the Stage A EA area. The data from the boreholes drilled in December 2014 through January 2015 were used to select the location for the refined Stage A EA area.

Because boreholes C8933 and C8938 were outside of the refined Stage A EA area, two additional boreholes inside the EA area were sampled to characterize pre-treatment uranium concentrations. Boreholes C8940 and C9451 were drilled from July 7 to July 14, 2015, and completed as monitoring wells (399-1-76 and 399-1-80, respectively) (Figure 3-1). Soil samples were collected from boreholes C8940 and C9451 in accordance with SGW-58553.

Continuous split-spoon samples were collected from these five boreholes from approximately 3.1 m (10 ft) bgs to 11.4 m (37 ft) bgs and analyzed for total uranium concentrations in accordance with SGW-56993, *Sampling Instruction for the 300-FF-5 Operable Unit Supplemental Post ROD Field Investigation*. The samples were not analyzed for phosphate concentrations. The total uranium results were used to select discrete samples for leachability characteristic tests, uranium-bearing mineral-phase analyses, and flow-through column tests. The uranium leachability characteristic data were used to document the pre-treatment leachability of uranium in the vadose zone and PRZ at these locations and refine the CSM.

3.1.2 Post-Treatment Sampling and Analysis

Soil samples were collected from three boreholes drilled after the Stage A polyphosphate application in accordance with SGW-59369, *Description of Work for the Installation of Three Boreholes in the 300-FF-5 Groundwater Operable Unit, FY2016*. Boreholes C9580, C9581, and C9582 were drilled from January 5 to January 11, 2016 for post-treatment characterization of the Stage A EA area. Each post-treatment borehole was drilled at a location adjacent to one of the three pre-treatment boreholes within the Stage A EA area (Figure 3-1).

Continuous split-spoon samples were collected and analyzed for total uranium and uranium leachability in accordance with SGW-56993 to determine the post-treatment uranium leaching characteristics in soil. The samples for uranium leachability characteristic tests, uranium-bearing mineral-phase analyses, and flow-through column tests were collected at the same depth intervals that were selected for the pre-treatment soil samples. The uranium leachability characteristic data were used to characterize the post-treatment leachability of uranium in the vadose zone and PRZ at these locations and to refine the CSM.

The following two methods were used to analyze for phosphorus in the post-treatment soil samples. Water-based sample extractions were analyzed using ion chromatography, which measures the phosphorus present as the phosphate ion. The results represent phosphate in the soil that is soluble in water. Acid-based sample extractions were analyzed using inductively coupled plasma-optical emission spectroscopy, which measures the phosphorus present as elemental phosphorus. The results are closer to an approximation of total phosphorus in the soil samples. Although most of the elemental phosphorus may be present as phosphate, results of the two methods are not directly comparable. In this report, the total phosphorus is assumed to represent phosphate because the treatment solutions contained significant quantities of phosphate.

3.2 Groundwater Sampling and Monitoring

Groundwater sampling and monitoring was conducted prior to, during, and following the Stage A uranium sequestration treatment.

3.2.1 Manual Monitoring

Groundwater was sampled from all 26 Stage A PRZ and aquifer monitoring wells (Figure 1-5) to evaluate the distribution and concentration of uranium and phosphate in the PRZ and aquifer. Samples were collected before, during, and after treatment. A portable pump was operated at a nominal flow rate of 3.8 L/min to 7.6 L/min (1 gal/min to 2 gal/min). Typically, three well volumes were purged, and the sample was collected after field parameters (pH, specific conductivity, dissolved oxygen, oxidation-reduction potential, and temperature) had stabilized.

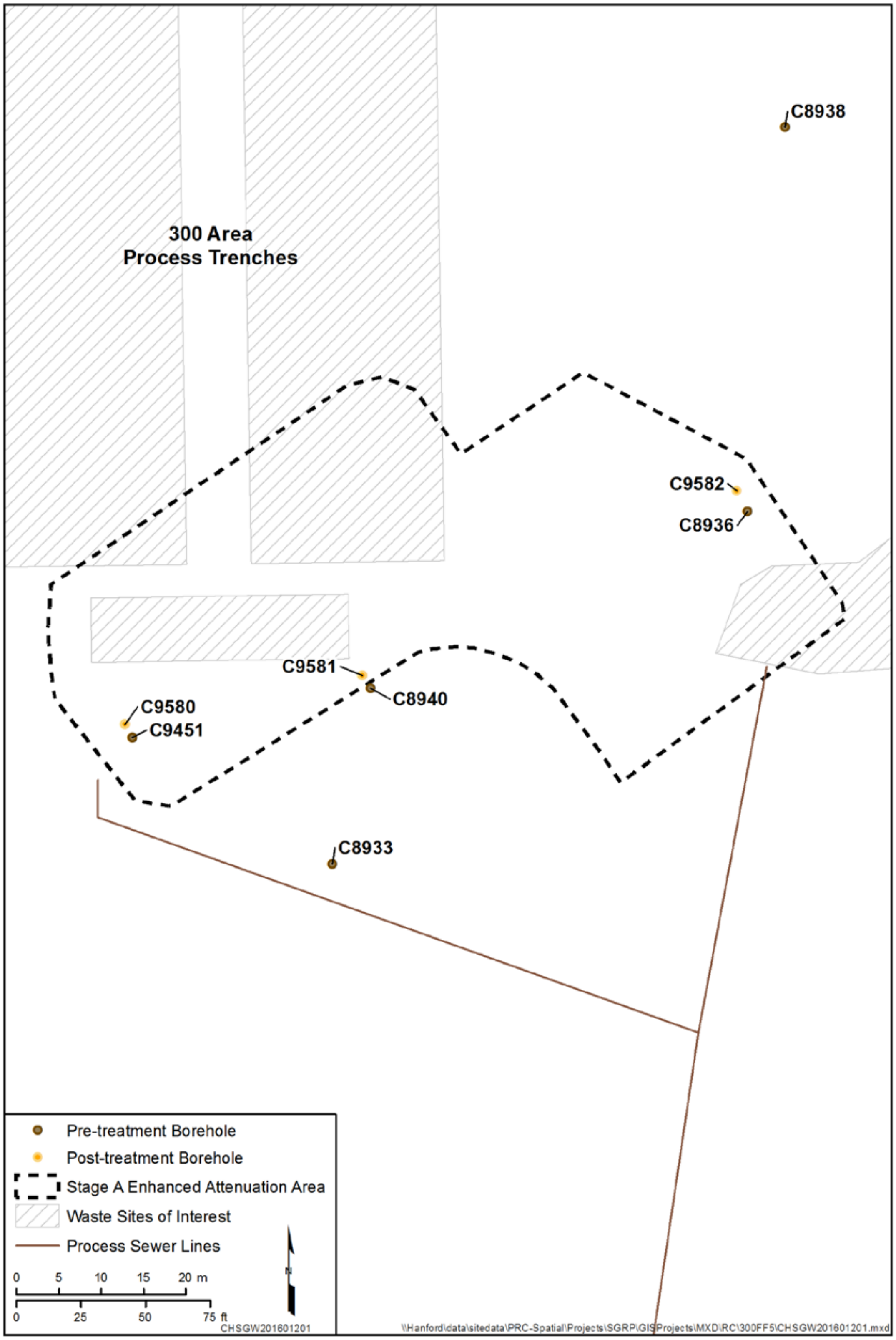


Figure 3-1. Location of Characterization Boreholes in the Stage A EA Area

The new PRZ and aquifer monitoring wells installed for Stage A were developed in June and July 2015 using a submersible pump. The pre-treatment well development data are provided in Appendix B.

Prior to treatment (August 28 through September 2015), 1 round of samples was collected from all 26 wells to determine baseline (pre-treatment) conditions.

During treatment and the day after treatment (November 6 through November 19, 2015), groundwater samples were collected daily from a subset of five PRZ wells (399-1-67, 399-1-75, 399-1-77, 399-1-81, and 399-1-87) and two aquifer wells (399-1-65 and 399-1-74) (Figure 3-2). These samples were collected to determine the influence of the polyphosphate solution infiltration and injection in the PRZ and aquifer and the impact to uranium.

For the month following treatment (November 20 through December 16, 2015), groundwater samples were collected weekly from all 26 monitoring wells.

The pre-treatment and post-treatment samples were analyzed for the constituents listed in Table 3-1. The samples collected during treatment were analyzed for the characteristics listed in Table 3-1 plus selected metals (calcium, sodium, and uranium) and anions (phosphate).

PNNL collected groundwater samples from seven downgradient wells (399-1-23, 399-1-16A, 399-1-17A, 399-2-1, 399-2-2, 399-2-3, and 399-1-7) before, during, and following application of polyphosphate solutions at the Stage A EA area (Figure 3-3). The samples were analyzed for groundwater characteristics (dissolved oxygen, specific conductance, pH, and temperature), water level, metals (calcium, iron, magnesium, manganese, potassium, sodium, and uranium), and anions (chloride, fluoride, nitrite, nitrate, phosphate, and sulfate).

Analytical results for the groundwater samples are summarized in Section 4.2. The data are provided in Appendix C.

3.2.2 Automated Monitoring

Automated groundwater measurements were obtained from monitoring wells before, during, and following Stage A uranium sequestration treatment.

3.2.2.1 In Situ Measurements

Data logging downhole instruments were deployed in six Stage A aquifer monitoring wells for continuous monitoring of water levels and field parameters (specific conductivity, temperature, pH, and oxidation-reduction potential). One well (399-1-70) was upgradient of the Stage A treatment area, two wells (399-1-82 and 399-1-84) were downgradient of the Stage A treatment area, and three wells (399-1-76, 399-1-80, and 399-1-86) were within the Stage A treatment area (Figure 3-4). Water levels and field parameters were measured in situ every 30 minutes from September 11 to December 28, 2015. The data were stored on data loggers, which were manually downloaded at the conclusion of the monitoring period. This information was used to evaluate the distribution and migration of the polyphosphate solution in the aquifer.

Analytical results for the automated groundwater measurements are discussed in Section 4.2.2. The data are provided in Appendix D.

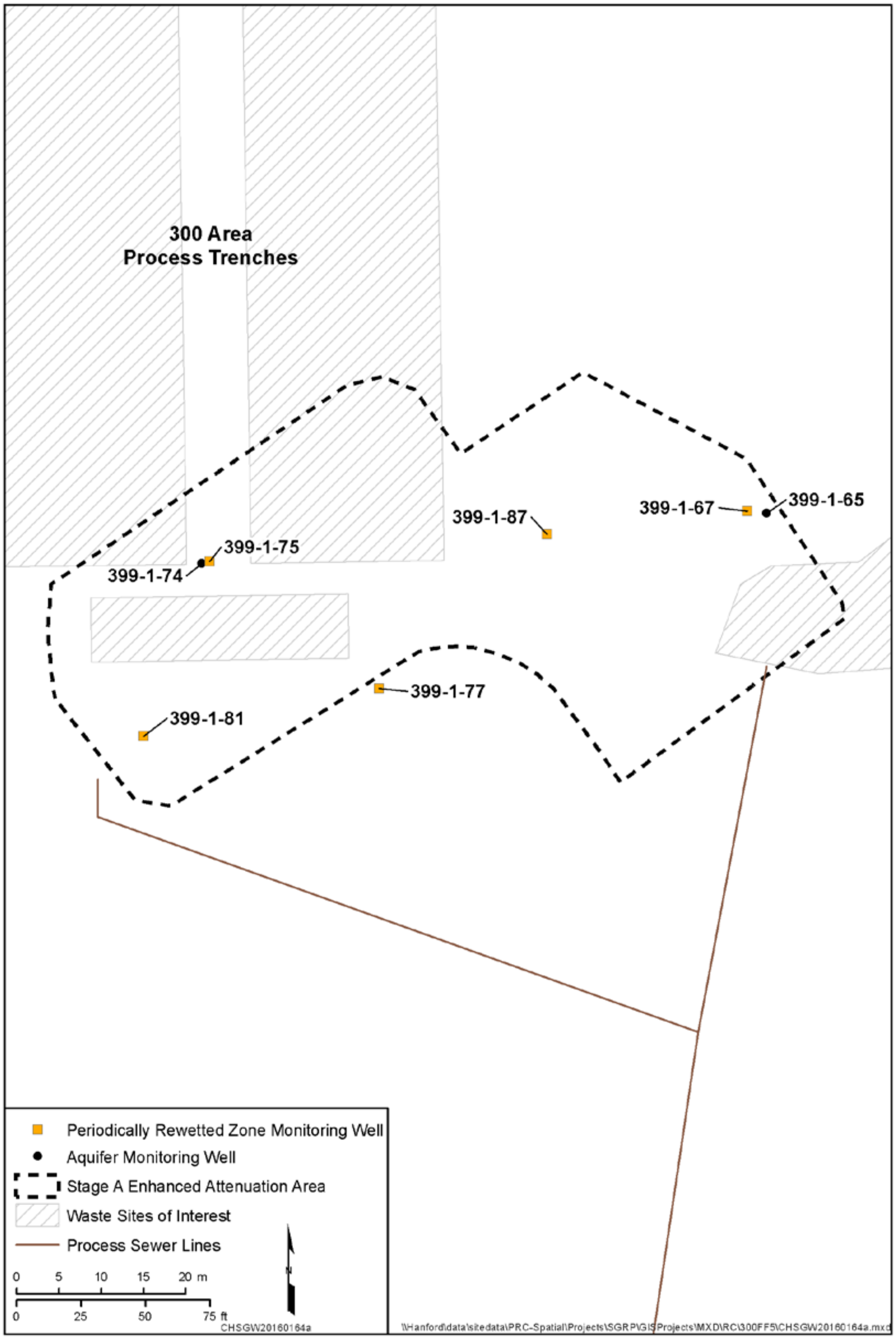


Figure 3-2. Stage A Monitoring Wells Sampled Daily During Treatment

Table 3-1. Constituents Monitored in Groundwater Samples

Characteristics	Metals	Anions
Bicarbonate alkalinity	Calcium	Chloride
Carbonate alkalinity	Magnesium	Phosphate
pH	Potassium	Sulfate
Specific conductivity	Sodium	▨
Oxidation-reduction potential	Uranium	
Dissolved oxygen	▨	
Temperature		

3.2.2.2 Water Level Monitoring

Six groundwater wells (399-1-12A, 399-1-16A, 399-1-23, 399-1-7, 399-2-2, and 399-8-1) in the vicinity of the Stage A EA area and the 300 Area river gauge (station SWS-1) were monitored as part of the local automated water level network (AWLN) (Figure 3-5). Water levels and, in some wells, temperature and specific conductivity, were logged at 15-minute intervals during 2014, 2015, and 2016 and stored on dataloggers or data collection telemetry units. The data were used to monitor the extent of migration of the polyphosphate solution and to evaluate the impact of the injections on nearby water levels. The data also were used to assess whether aquifer permeability was reduced due to the precipitation of phosphate minerals by comparing aquifer hydraulic properties in the vicinity of the EA area before and after polyphosphate application (Section 5.2.2). Results for the automated groundwater measurements are discussed in Section 4.2.2. The data are provided in Appendix D.

3.3 Operations Monitoring

Field measurements and samples for laboratory analysis were collected to monitor the infiltration and injection system operations. Results for the operations monitoring are discussed in Section 4.3.

Flow rates for the pyrophosphate chemical, orthophosphate chemical, and filtered river water entering the infiltration and injection mixing skids were displayed continuously on control panels and inline flowmeters that were mounted on the mixing skid piping at various locations. Flow rates were monitored at the control panel and inline flowmeters and recorded hourly by operations personnel. Injection wellhead pressure readings and flow rates were measured and recorded hourly for each injection well during injection operations.

Grab samples of the polyphosphate treatment solutions were collected at the start of infiltration or injection and then every 4 hours throughout the duration of the operation. Field measurements of pH, temperature, specific conductivity, oxidation-reduction potential, and dissolved oxygen of the polyphosphate treatment solution grab samples were recorded by operations personnel.

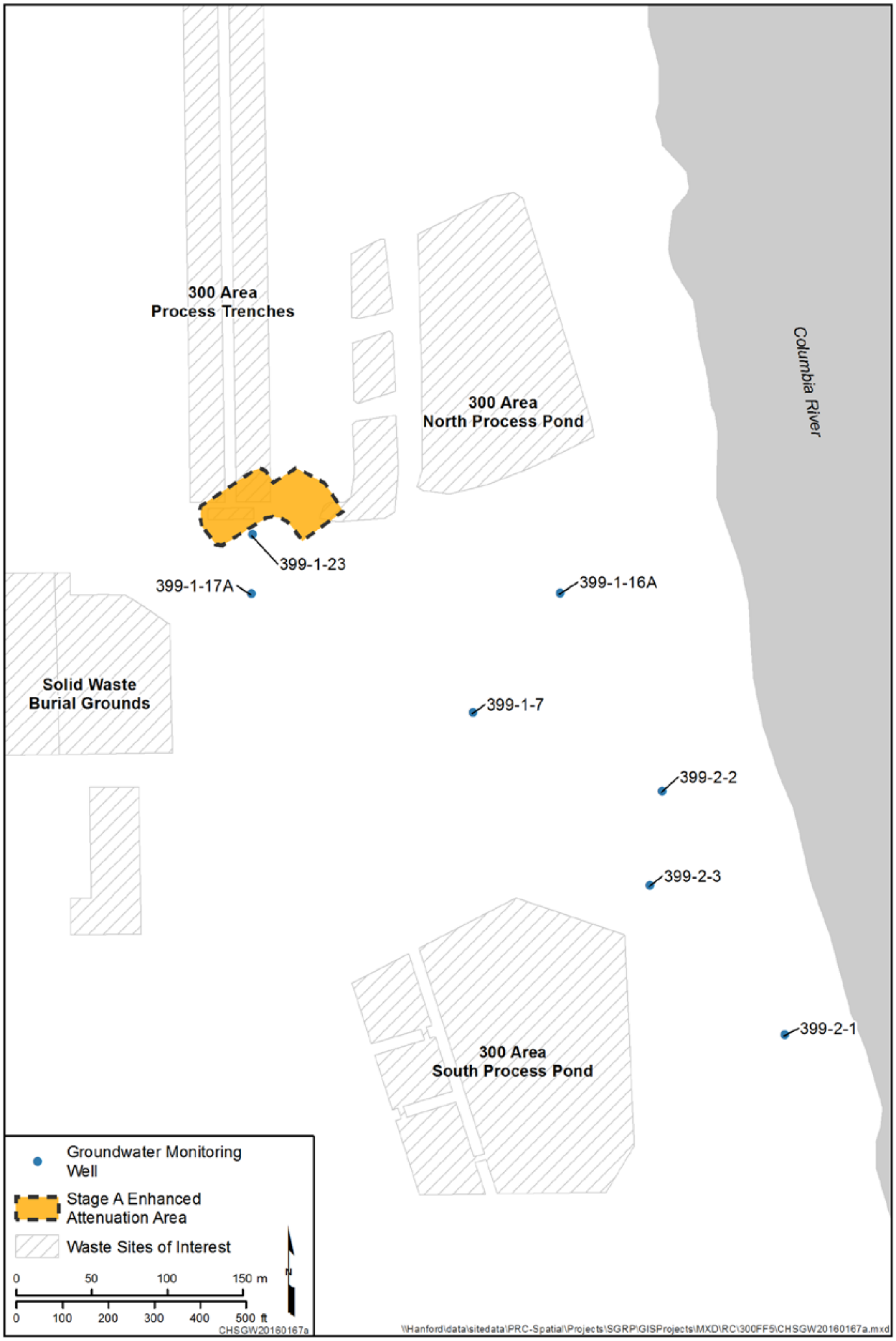


Figure 3-3. Groundwater Wells Sampled by PNNL During and Following Stage A Treatment

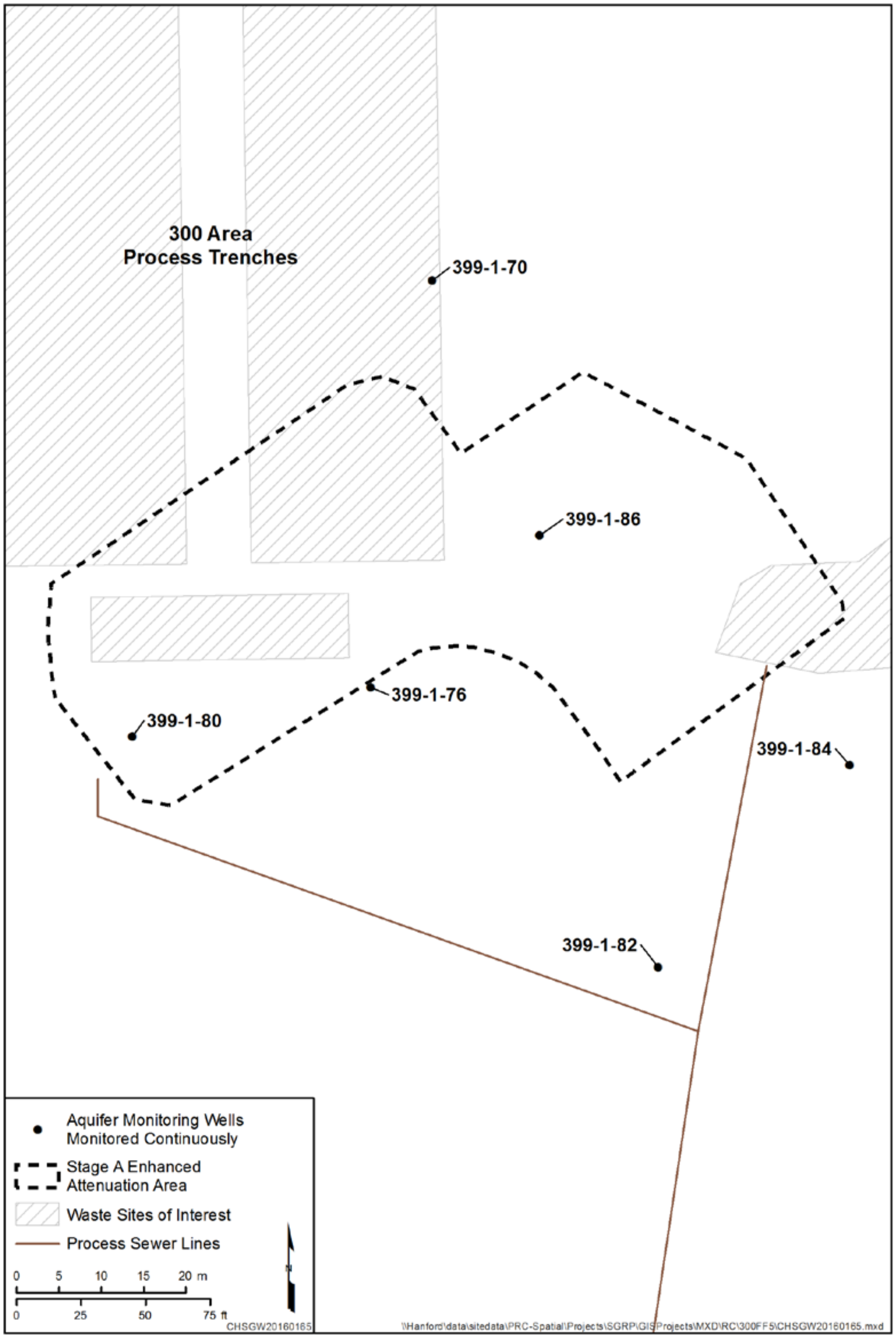


Figure 3-4. Stage A Aquifer Monitoring Wells Used for Continuous In Situ Measurements Recorded on Data Loggers

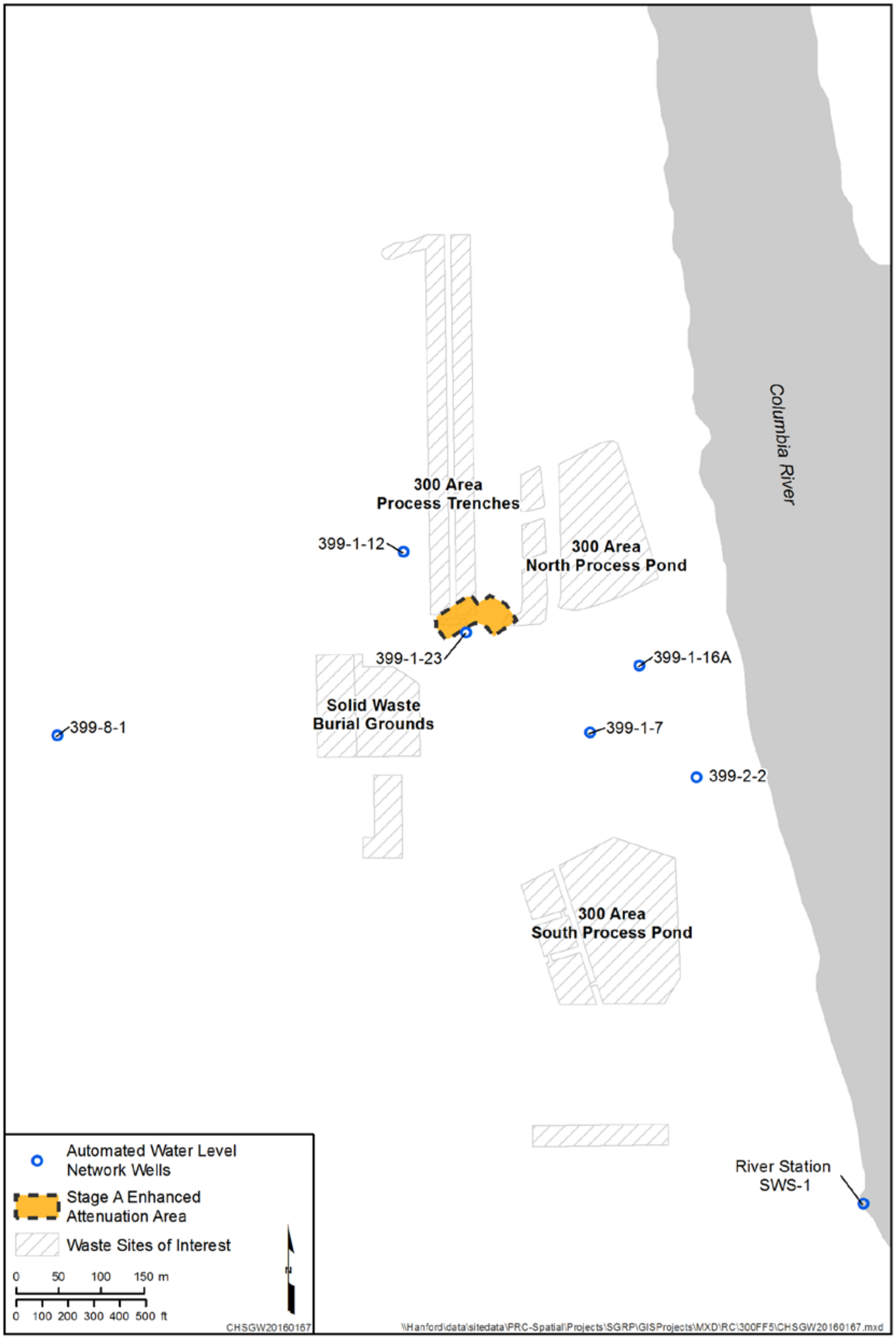


Figure 3-5. AWLN Wells in the Vicinity of the Stage A Enhanced Attenuation Area

The primary design parameter for successful completion of the infiltration and injection treatment was to deliver polyphosphate solutions to the vadose zone, PRZ, and top of the aquifer that contained specific concentrations of orthophosphate and pyrophosphate. The orthophosphate and pyrophosphate concentrations were monitored using samples of the polyphosphate treatment solution collected daily from the discharge end of the infiltration and injection skids. One sample of river water was collected for each skid prior to mixing with the chemicals. The samples were analyzed at an offsite laboratory for the constituents listed in Table 3-2. The analytical results associated with these samples are provided in Appendix E.

Table 3-2. Constituents Monitored Daily in Polyphosphate Solutions

Characteristics	Metals	Anions
Bicarbonate alkalinity	Calcium	Chloride
Carbonate alkalinity	Magnesium	Phosphate
	Potassium	Sulfate
	Sodium	

3.4 Electrical Resistivity Tomography

Real-time ERT was conducted by PNNL in the Stage A EA area to monitor the spatial and temporal change in electrical conductivity corresponding to the advancement of the polyphosphate infiltration solution through the vadose zone. Baseline ERT surveys were collected prior to polyphosphate infiltration in order to image pre-infiltration subsurface structure and establish baseline conditions. Infiltration of the polyphosphate solution increased electrical conductivity in the vadose zone and PRZ by increasing both the degree of saturation and the specific conductance of the pore fluid. These changes enabled use of time-lapse ERT for remote monitoring of the advancement of the wetting front of the polyphosphate solution. ERT imaging surveys were conducted at 12-minute intervals and reported on a dedicated website. The turnaround time from the beginning of a survey until time-lapse images were available on the website was approximately 30 minutes.

The ERT electrodes were deployed along two transects bisecting the length and width of the infiltration area (Figure 2-5). Line A-A’ consisted of 60 electrodes and extended a total length of 89.9 m (295 ft). Line B-B’ consisted of 47 electrodes and extended a total length of 70.1 m (230 ft). Each electrode consisted of a 1.88 cm (0.75 in.) diameter carbon steel rod, approximately 40.6 cm (16 in.) long. Each ERT measurement required applying a voltage across a pair of electrodes to induce current flow within the subsurface.

ERT data were recorded from November 2 through December 16, 2015, with the exception of three short periods caused by site power supply interruptions. For time-lapse imaging, surveys were continuously collected and processed to provide a chronological sequence of image frames that illustrate the change in bulk conductivity with time. Subtracting the baseline image (i.e., the pre-treatment image) from the time-lapse images reveals the change in bulk conductivity caused by the polyphosphate solution, thereby providing the distribution of solution in space and time. The time-lapse images were then analyzed to investigate solution delivery performance and timing. Results for the ERT monitoring are discussed in Section 4.4. A detailed description of the ERT operations and imaging interpretation is provided in PNNL-SA-25232, *Electrical Resistivity Tomography Report*, which is included as Appendix F of this report.

3.5 Numerical Modeling of Uranium Fate and Transport

A numerical model was developed to evaluate the fate and transport of uranium in the vadose zone and unconfined aquifer following the injection and infiltration of polyphosphate solutions within the Stage A EA area. Two environmental calculation files were prepared to document development of the model and are provided in Appendix G of this report: ECF-300FF5-16-0087, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit*, *Hanford Washington*, and ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit*.

3.6 Long-Term Groundwater Monitoring

Semiannual long-term groundwater samples were collected from four downgradient wells (399-1-17A, 399-1-7, 399-2-1, and 399-2-2) in December 2015 and June 2016 in accordance with the SAP (DOE/RL-2014-42). The samples were analyzed for groundwater characteristics (specific conductance, pH, temperature, and turbidity), water level, uranium, and gross alpha. Analytical results for the groundwater samples are summarized in Section 4.2. The data are provided in Appendix H.

3.7 Data Management

A data review and usability determination was conducted in accordance with Section 4.4 of the SAP (DOE/RL-2014-42). The CH2M HILL Plateau Remediation Company (CHPRC) Sample Management and Reporting (SMR) organization, in coordination with the 300-FF-5 OU Project Manager, was responsible for ensuring analytical data were appropriately reviewed, managed, and stored in accordance with the applicable programmatic requirements governing data management methods. All samples submitted to analytical laboratories were accompanied by appropriately filled out chain-of-custody forms.

All operational monitoring, field measurements, and quality control (QC) data were recorded on data sheets by operations in accordance with SGW-58976. The original data sheets were reviewed by operations and transferred to the 300 Area field lead following completion of injections. The 300 Area field lead provided the data sheets to SMR for archiving. The data sheets are included in Appendix I.

Data review and verification were performed to confirm sampling and chain-of-custody documentation was complete. This review included linking sample numbers to specific sampling locations, reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times were met, and reviewing QC data to determine whether analyses met the data quality requirements specified in the SAP (DOE/RL-2014-42).

Data validation of laboratory samples was completed. No major deficiencies were found. There were no minor deficiencies leading to qualification of sample results as estimates. The data validation report is provided in Appendix J.

3.8 Lessons Learned from Stage A Operations

Post-job review meetings covering the Stage A uranium sequestration activities were held on December 9 and 10, 2015. Representatives of the groups and disciplines that supported and executed installation and operation of the Stage A system participated in the meetings. These lessons learned have been considered during planning of the Stage B uranium sequestration activities. The report on the lessons learned review of Stage A implementation is provided in Appendix K.

This page intentionally left blank.

4 Sampling and Monitoring Results

This chapter provides the results for sampling and monitoring of soil, groundwater, polyphosphate solutions, and electrical resistivity before, during, and after the completion of treatment activities to determine initial site conditions and changes resulting from implementation of the Stage A EA remedy.

4.1 Soil Sampling and Leachability Characteristics

Soil sampling and analysis was conducted before and after application of polyphosphate treatment solutions. Samples were analyzed for uranium and tested for leachability characteristics.

4.1.1 Pre-Treatment Sampling and Analysis

Five boreholes were drilled and sampled to determine pre-treatment characteristics of the vadose zone, PRZ, and top of the aquifer (Section 3.1.1). The locations of the pre-treatment boreholes are shown in Figure 3-1.

Soil samples collected from the pre-treatment boreholes were analyzed for total uranium concentrations. The total uranium results were used to select discrete sample intervals for comprehensive tests on uranium leachability, mineral phase association, and soil characteristics.

4.1.1.1 Total Uranium and Phosphate Results

Samples collected in boreholes C8933, C8936 (well 399-1-67), and C8938 (well 399-1-68) during January 2015 and boreholes C8940 (well 399-1-76) and C8951 (well 399-1-80) during July 2015 were analyzed for total uranium concentrations. A summary of total uranium results is provided in Appendix A.

Concentrations of total uranium ranged from 0.141 to 41.4 µg/g. Background uranium levels in 300 Area soil have been previously calculated as 3.21 µg/g (Section 3.1 of SGW-58830). Pre-treatment samples showed elevated uranium above background levels at all five borehole locations.

Among the three boreholes sampled in January 2015, the highest concentrations of uranium were found in borehole C8936 (Figure 4-1). The location of the refined Stage A area was selected to include borehole C8936. Based on the relatively low uranium concentrations in boreholes C8933 and C8938, the refined Stage A area did not include these locations (Section 2.2.1 and Figure 3-1). Samples from boreholes C8940 and C9451, which were drilled within the refined Stage A area in July 2015, had slightly higher uranium concentrations in the lower vadose zone and PRZ than boreholes C8933 and C8938.

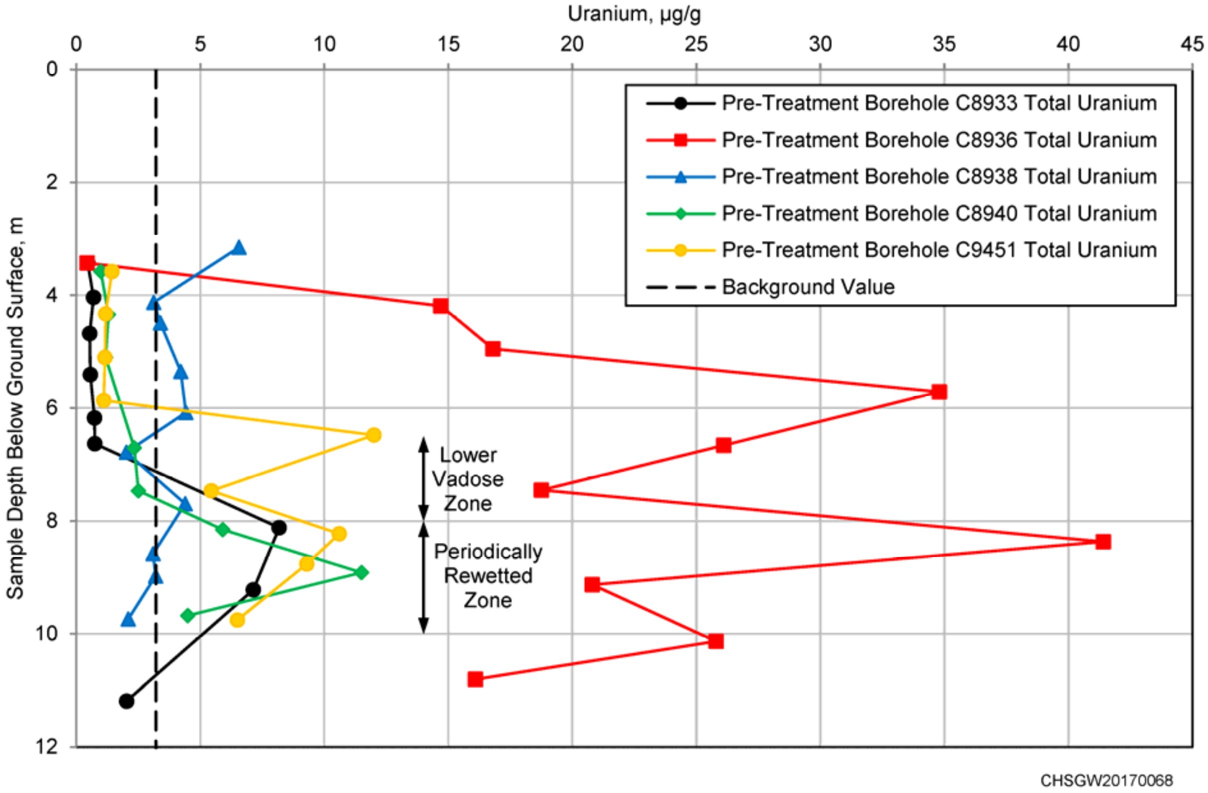
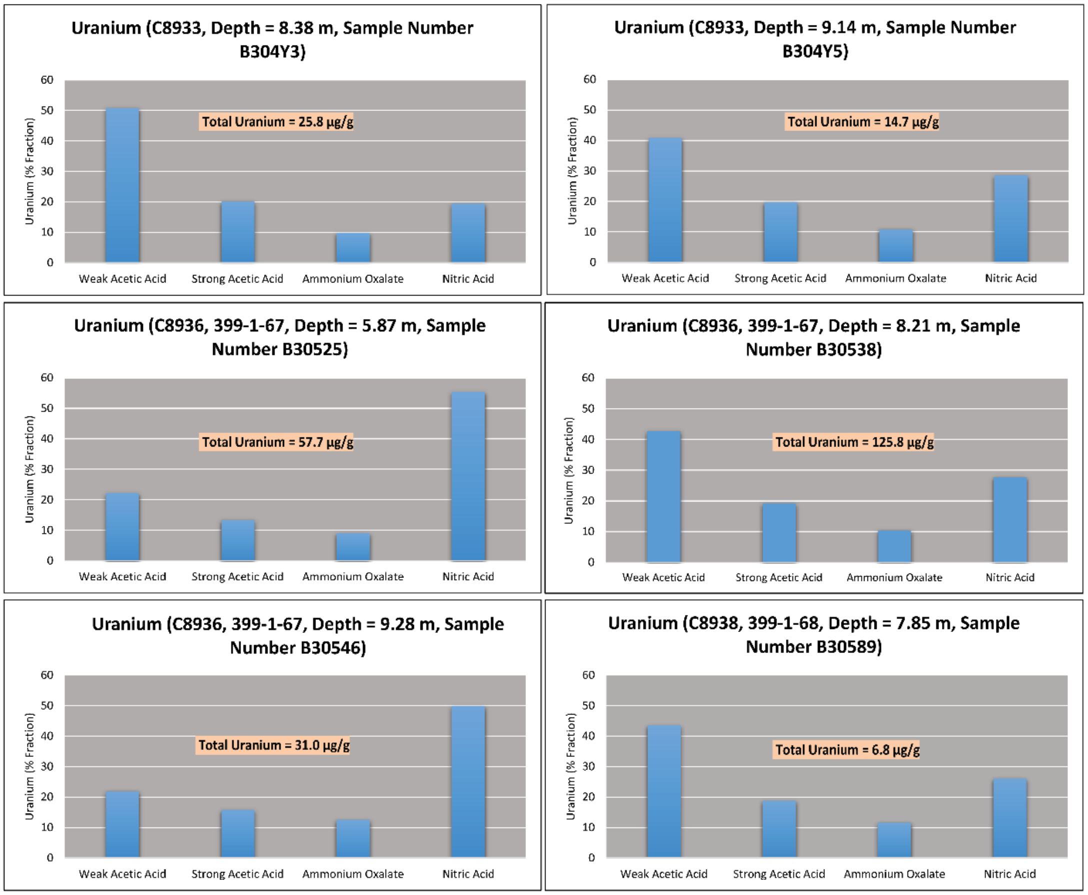


Figure 4-1. Total Uranium Concentrations in Pre-Treatment Boreholes C8933, C8936, C8938, C8940, and C9451.

Phosphate extraction using nitric acid was conducted on selected pre-treatment samples from boreholes C8940 and C9451 (PNNL-25420, included in Appendix A of this report). Results from the pre-treatment samples provide an average phosphate concentration of 1,750 mg/kg, indicating that residual phosphate exists in this area from past liquid discharges (Section 6.3 of ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit*, included in Appendix G of this report).

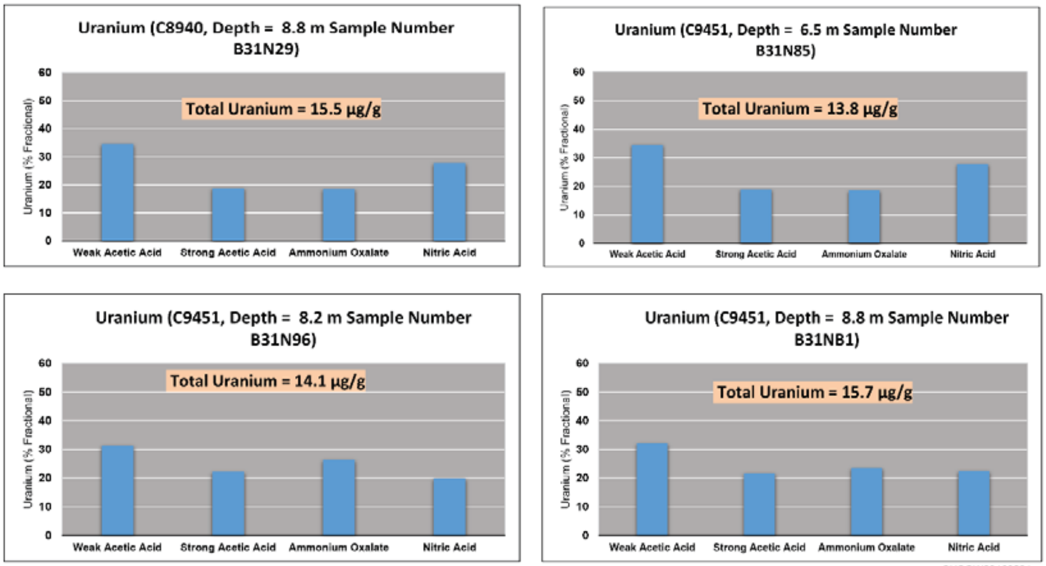
4.1.1.2 Uranium Leachability Characteristics Test Results

Semi-selective chemical extractions were conducted on 10 pre-treatment soil samples. The semi-selective extractions were performed sequentially in the following order: weak acetic acid, strong acetic acid, ammonium oxalate, and nitric acid. The results are presented in Figures 4-2 and 4-3 as the percent of uranium extracted during each extraction along with the total extracted uranium concentration. The total extracted uranium concentrations ranged from about 7 to 126 µg/g, with the highest concentration observed in a sample from borehole C8936. In almost all samples, the weak acetic acid and nitric acid extracted the highest uranium concentrations. The weak acetic acid extractions target the weakly adsorbed and readily leachable uranium-bearing carbonate mineral phases, while the nitric acid extraction targets the nonleachable (strongly bound) uranium associated with crystalline oxides, hydroxides, and clays that remain after all other extractions have occurred. The strong acetic acid and ammonium oxalate extractions target the strongly bound (surface complexed) uranium and uranium associated with amorphous oxides of iron, manganese, aluminum, and silica.



CHSHW20160280

Figure 4-2. Results from the Semi-Selective Sequential Extraction Experiments on Pre-Treatment Samples from Boreholes C8933, C8936, and C8938



CHSGW20160291

Figure 4-3. Results from the Semi-Selective Sequential Extraction Experiments on Pre-Treatment Samples from Boreholes C8940 and C9451

The relatively large fraction of uranium associated with the carbonate mineral phases, based on the weak acetic acid extractions, indicates that the labile and readily leachable uranium fraction varies from 20 to 50 percent of the total uranium. In the sample from a depth of 8.2 m (27 ft) bgs in borehole C8936 with the highest extracted total uranium concentration of approximately 126 µg/g, the labile uranium fraction is around 43 percent. Because this sample is located near the PRZ, it is likely that the relative mobility of the labile uranium contributes to contamination of the groundwater (Section 4.5.2 of SGW-58830).

The leachable (labile) uranium concentrations determined using the sodium bicarbonate (and sodium carbonate) extraction method are compared with the weak acetic acid extraction method in Figures 4-4 and 4-5. Samples showing higher uranium concentrations from sodium bicarbonate/carbonate extraction also tend to indicate higher concentrations from weak acetic acid extraction; however, the latter extraction leads to larger uranium concentrations. This implies that most of the uranium that is potentially labile is associated with soluble carbonate mineral phases with a relatively smaller amount weakly complexed at the surface sites (Section 4.5.2 of SGW-58830).

4.1.2 Post-Treatment Sampling and Analysis

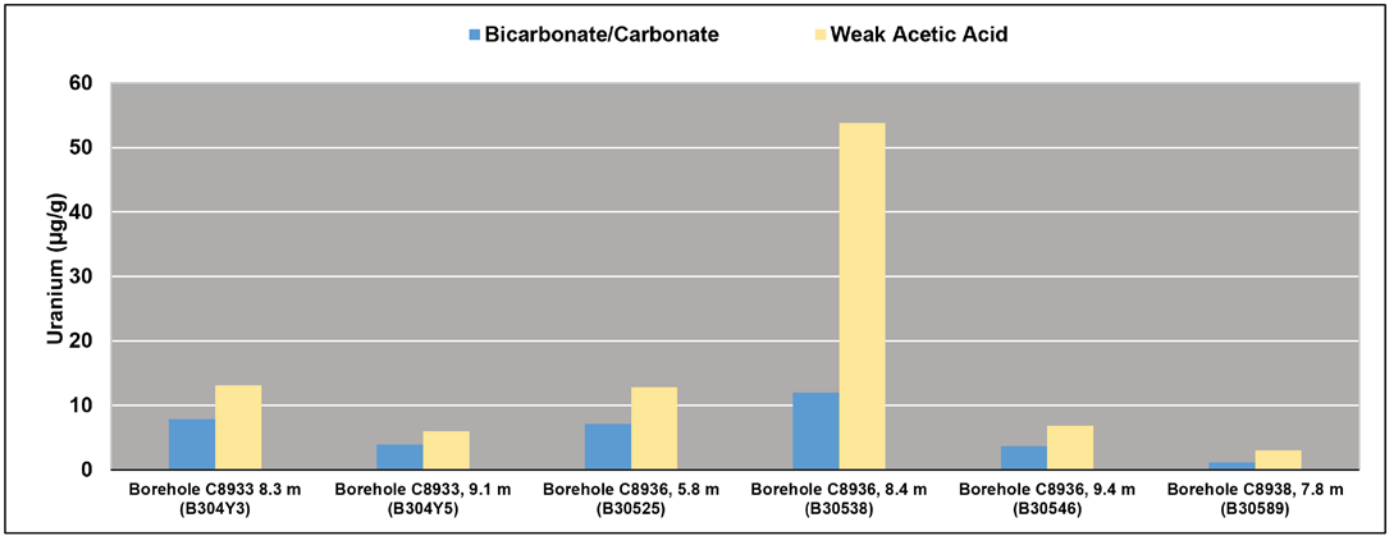
Three boreholes were drilled and sampled in January 2016 to determine post-treatment characteristics of the Stage A EA area (Section 3.1.2). The three boreholes were drilled adjacent to three pre-treatment boreholes, resulting in the following corresponding collocated borehole pairs: C9451 and C9580; C8940 and C9581; and C8936 and C9582 (Figure 3-1).

4.1.2.1 Total Uranium and Phosphate Results

Sampling performed in boreholes C9580, C9581, and C9582 was used to obtain post-treatment total uranium and phosphate concentrations in the vadose zone, PRZ, and top of the aquifer. A summary of the results for total uranium and other selected metals (calcium and phosphorus) and anions (chloride, fluoride, nitrate, nitrite, phosphate, and sulfate) from the post-treatment boreholes is provided in Appendix A. The samples also were used to test for leachability characteristics, including total uranium extracted by sequential extraction (Section 4.1.2.2). The pre-treatment and post-treatment total uranium concentrations and total extracted uranium concentrations are shown on Figures 4-6 through 4-8.

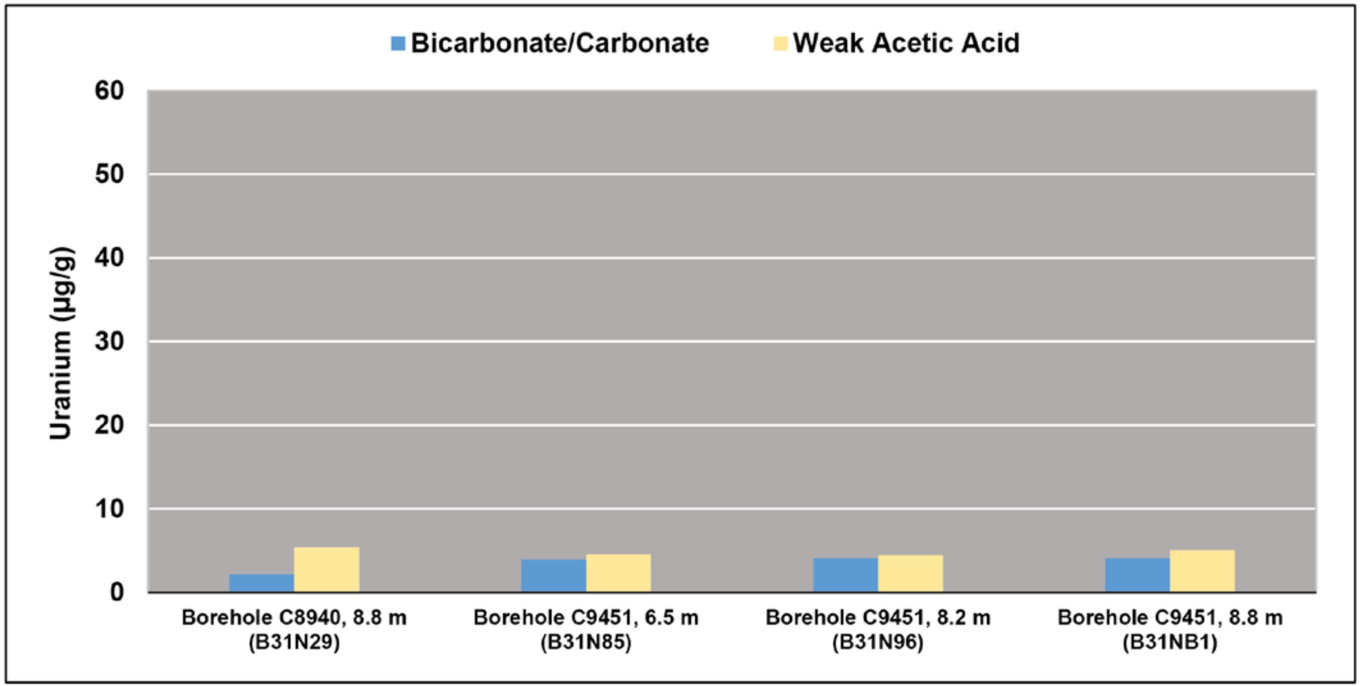
Post-treatment borehole C9580 shows total uranium values near or below the background value (3.21 µg/g) with the exception of the sample collected from the PRZ (9.1 to 9.2 m [29.5 to 30 ft] bgs) (Figure 4-6). Total uranium concentrations in the collocated pre-treatment borehole C9451 are highest in the lower vadose zone and PRZ. At this location, the maximum concentrations in pre- and post-treatment samples are 12 µg/g and 7.6 µg/g, respectively. The maximum total extracted uranium concentrations based on sequential extraction in pre- and post-treatment samples are 15.7 µg/g and 13.6 µg/g, respectively.

Post-treatment borehole C9581 samples from just above and within the PRZ (7.8 to 8.8 m [25.5 to 28.5 ft] bgs) contained total uranium concentrations that slightly exceeded the background value (Figure 4-7). Total uranium results from the adjacent pre-treatment borehole C8940 also exceeded the background value in the PRZ. At this location, the maximum concentrations in pre- and post-treatment samples are 11.5 µg/g and 5.3 µg/g, respectively. The maximum total extracted uranium concentrations based on sequential extraction in pre- and post-treatment samples are 15.5 µg/g and 5.9 µg/g, respectively.



CHSGW20160302

Figure 4-4. Uranium Concentration from Sodium Bicarbonate/Carbonate Extraction Compared with the Uranium Concentration from Weak Acetic Acid Extraction for Pre-Treatment Samples from Boreholes C8933, C8936, and C8938



CHSGW20160303

Figure 4-5. Uranium Concentration from Sodium Bicarbonate/Carbonate Extraction Compared with the Uranium Concentration from Weak Acetic Acid Extraction for the Pre-Treatment Samples from Boreholes C8940 and C9451

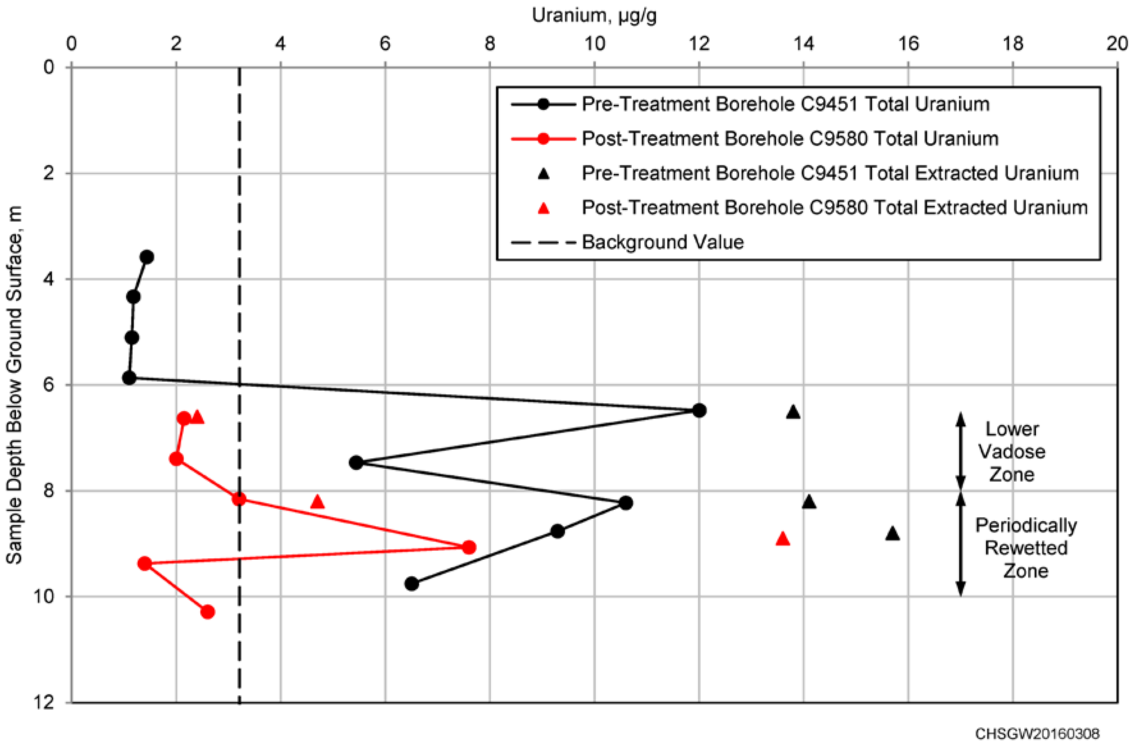


Figure 4-6. Total Uranium Concentrations and Total Extracted Uranium in Pre-Treatment Borehole C9451 and Post-Treatment Borehole C9580

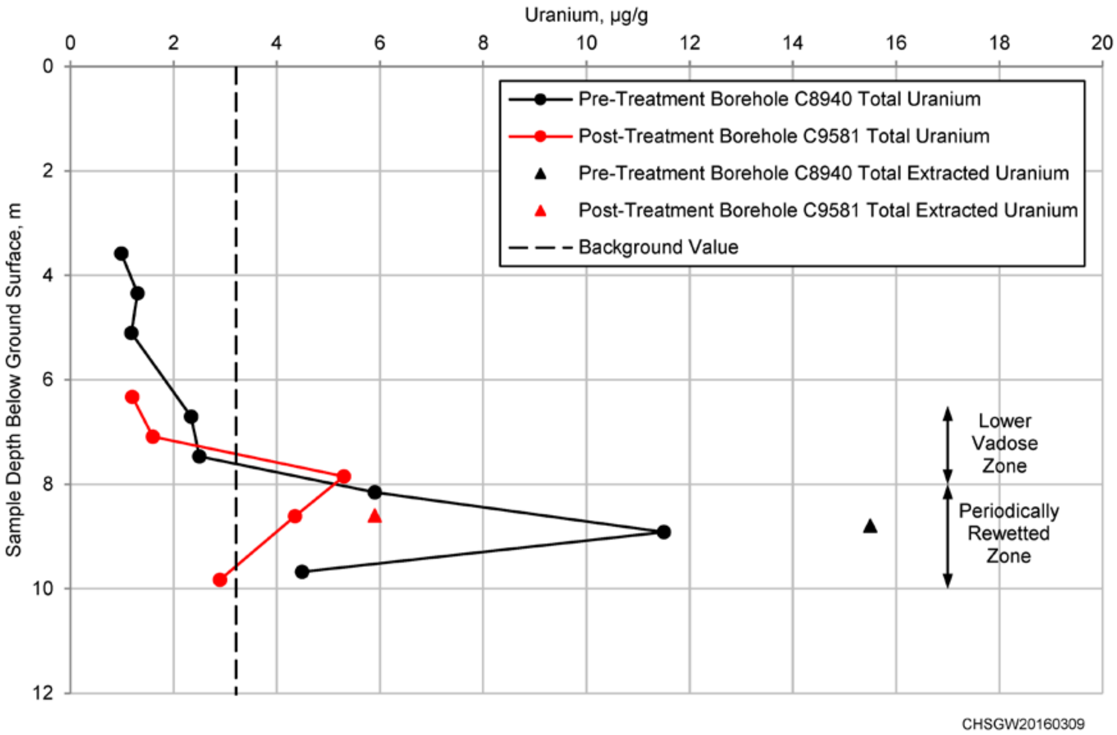


Figure 4-7. Total Uranium Concentrations and Total Extracted Uranium in Pre-Treatment Borehole C8940 and Post-Treatment Borehole C9581

Total uranium concentrations in samples from post-treatment borehole C9582 exceed the background value at all depths sampled; concentrations were highest in the lower vadose zone (Figure 4-8). Uranium concentrations in the collocated pre-treatment borehole C8936 exceeded background in all but the shallowest sample. At this location, the maximum concentrations in pre- and post-treatment samples are 41 µg/g and 100 µg/g, respectively. The maximum total extracted uranium concentrations based on sequential extraction in pre- and post-treatment samples are 125.8 µg/g and 105.3 µg/g, respectively.

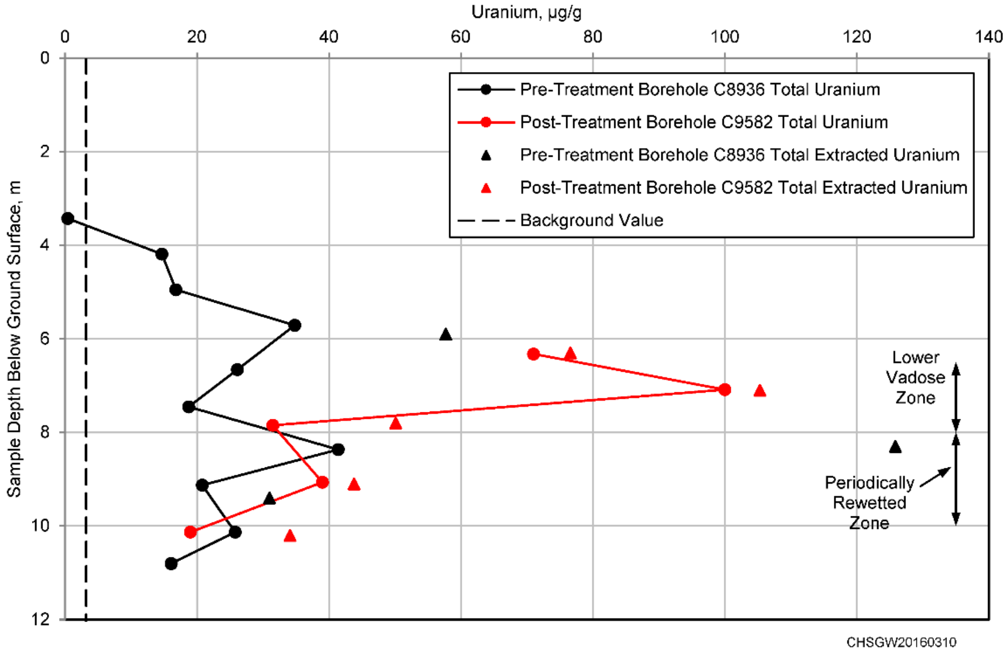


Figure 4-8. Total Uranium Concentrations and Total Extracted Uranium in Pre-Treatment Borehole C8936 and Post-Treatment Borehole C9582

Comparing total uranium concentrations and total extracted uranium based on sequential extraction in collocated pre- and post-treatment borehole samples indicates the uranium concentrations remained largely unchanged in the soil following treatment. Some difference in vertical concentration profiles is expected based on natural variability in the soil column. However, uranium concentrations in the pre-treatment and post-treatment pairs are of the same order of magnitude. This shows that most of the uranium present in the soil remained in place, and only a limited amount was displaced during infiltration and injection (Section 6.3 of ECF-300FF5-16-0091, included in Appendix G of this report).

The vertical profiles of phosphate concentrations detected in the post-treatment boreholes can be used to indicate the distribution of the phosphate delivered by the polyphosphate solutions. Phosphate concentrations obtained by performing water extraction (analyzed using ion chromatography) are shown in Figure 4-9; phosphate concentrations obtained by performing acid extraction (analyzed using inductively coupled plasma-optical emission spectroscopy) are shown in Figure 4-10. The highest concentrations in boreholes C9580 and C9581 occur at approximately 5 m (16.4 ft) and 2 to 3 m (6.6 to 9.8 ft) bgs, respectively, suggesting that more phosphate in the infiltration solutions precipitated in upper vadose zone. (The high concentration at 5 m [16.4 ft] bgs in borehole C9580 corresponds to the presence of a thin silt zone.) However, the phosphate concentrations are relatively higher throughout the vadose zone in borehole C9580. Phosphate concentrations in borehole C9582 are relatively low throughout the vadose zone. All three boreholes show increased phosphate concentrations in the PRZ, reflecting the direct injection of phosphate solution at that depth.

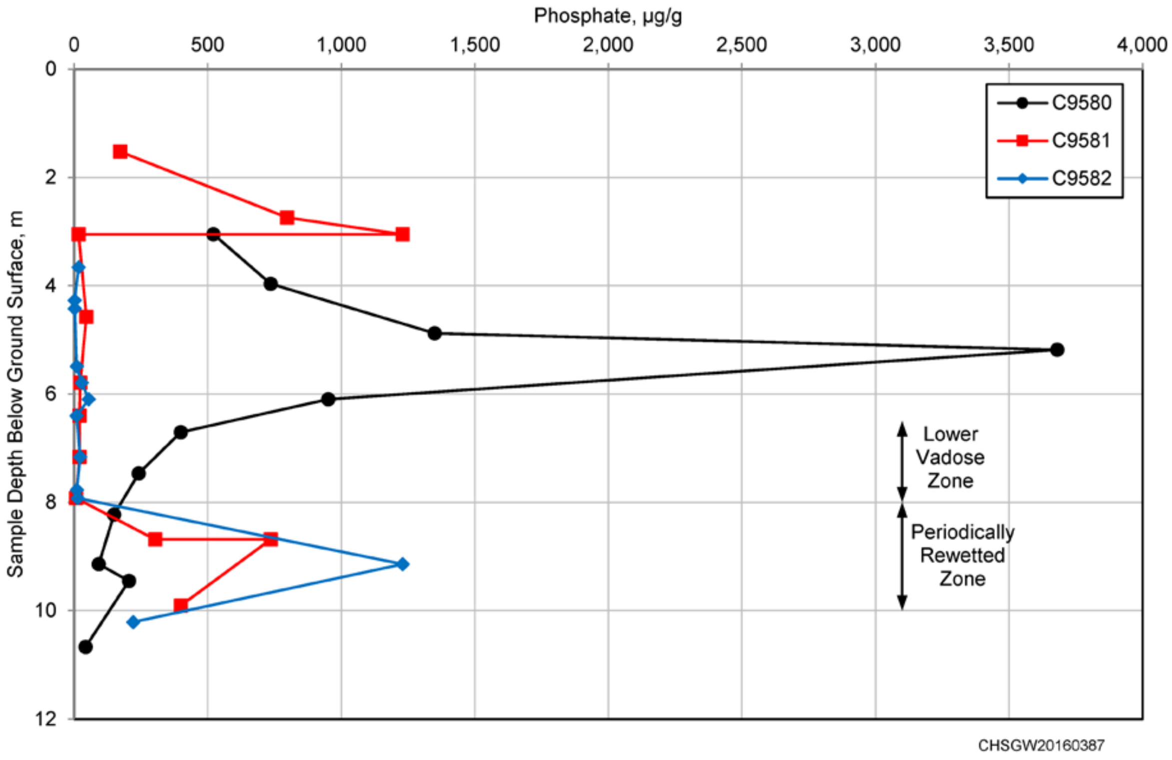


Figure 4-9. Phosphate Concentrations based on Water Extraction in Samples from the Post-Treatment Boreholes

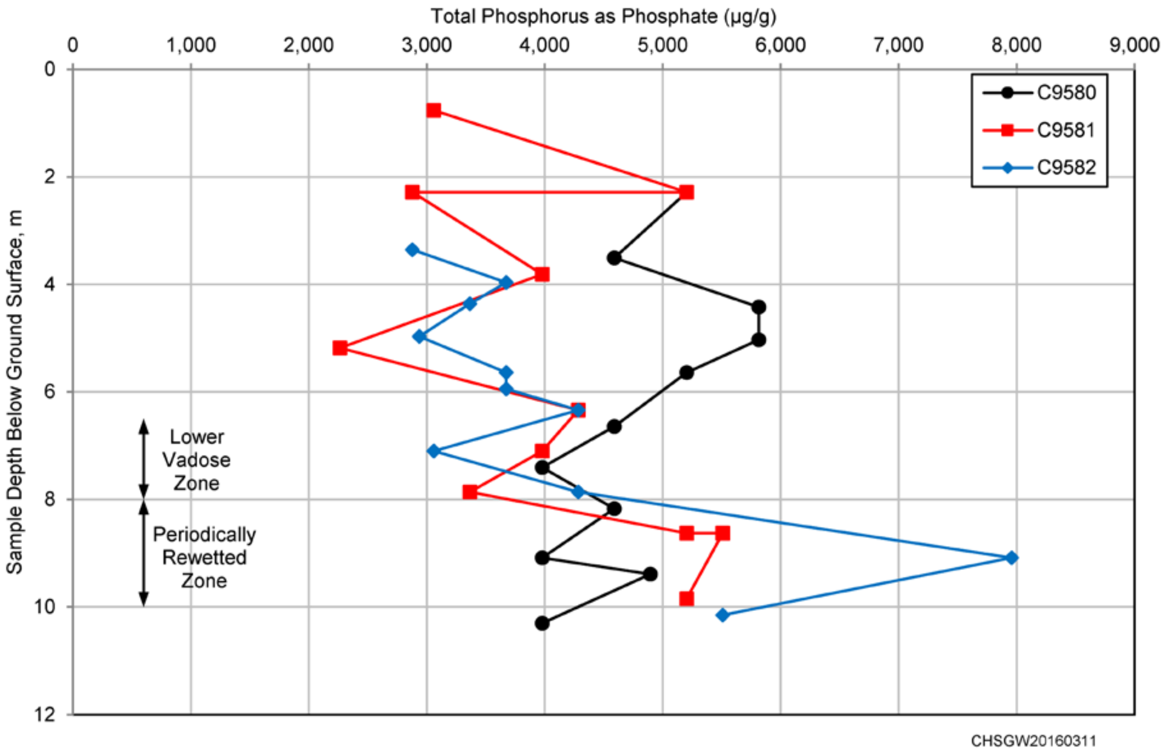
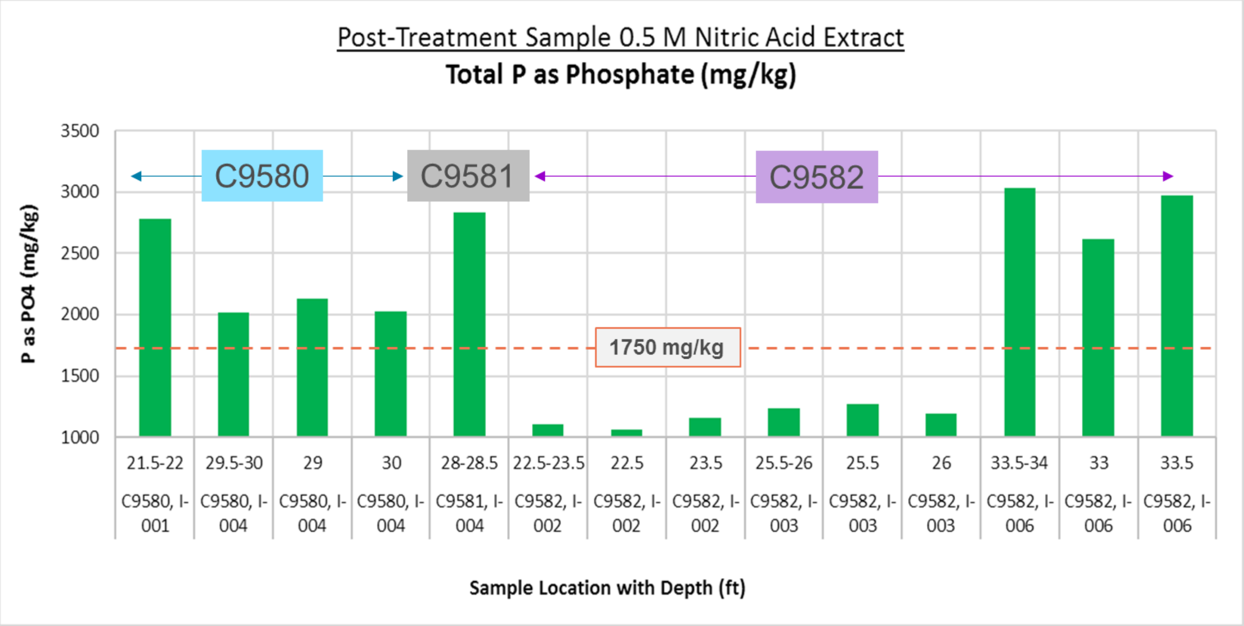


Figure 4-10. Phosphate (Total Phosphorus as Phosphate) Concentrations based on Acid Extraction in Samples from the Post-Treatment Boreholes

Phosphate extraction using nitric acid was conducted on selected post-treatment samples from boreholes C9580, C9581, and C9582 (PNNL-25420, included in Appendix A of this report). Phosphate concentrations are typically higher than 2,000 mg/kg (i.e., higher than the pre-treatment average concentration) for samples from borehole C9580 and for deeper samples from borehole C9582 (Figure 4-11). These elevated concentrations are consistent with contact by phosphate-bearing solutions resulting from Stage A treatment. Borehole C9580 has high phosphate concentrations throughout its depth profile, consistent with the ERT data. The ERT data show that infiltrating solutions migrated to about 6 m (19.7 ft) bgs (i.e., above the lower vadose zone) in most of the Stage A area but were able to reach the water table in the western region where infiltration was more rapid and where borehole C9580 is located (Section 4.4). Higher phosphate concentrations observed in deeper samples from borehole C9582 appear to be a result of polyphosphate injections into the PRZ. The higher phosphate concentration for the deeper sample from borehole C9581 also is consistent with injections delivering high concentrations of phosphate (Section 6.3 of ECF-300FF5-16-0091, included in Appendix G of this report).

The relative vertical distribution of phosphate in post-treatment boreholes based on nitric acid extraction (Figure 4-11) is consistent with laboratory analyses of phosphate concentrations in sediment samples collected from the post-treatment boreholes (Figures 4-9 and 4-10). The magnitude of phosphate concentrations derived from acid extraction (Figure 4-10) is similar to the phosphate concentrations based on nitric acid extraction (Figure 4-11). Concentrations derived by water extraction are lower (Figure 4-9).



Reference: Figure 6-16 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 4-11. Concentration of Phosphate (Total Phosphorus as Phosphate) Based on 0.5 M Nitric Acid Extraction on Post-Treatment Samples

Based on the vertical profile of phosphate concentrations, direct injection of polyphosphate solutions into the PRZ is a more effective method than infiltration for delivery of phosphate to the PRZ.

4.1.2.2 Uranium Leachability Characteristics Test Results

Semi-selective chemical extractions were conducted on nine soil samples collected from the three post-treatment boreholes. The sample intervals were selected to correspond with those tested in the pre-treatment boreholes. Semi-selective extraction was performed on the post-treatment samples using the same sequence as used for the pre-treatment samples: weak acetic acid, strong acetic acid, ammonium oxalate, and nitric acid. Results are presented in Figures 4-12 and 4-13 as the percent of uranium extracted during each extraction along with the total extracted uranium concentration.

The total extracted uranium ranged from 2.4 to 105 µg/g. Consistent with the total uranium results, the highest uranium concentrations were extracted from the five samples collected from borehole C9582. Borehole C9582 is collocated with borehole C8936, which contained the highest concentrations of total uranium among the pre-treatment boreholes (Figure 4-1).

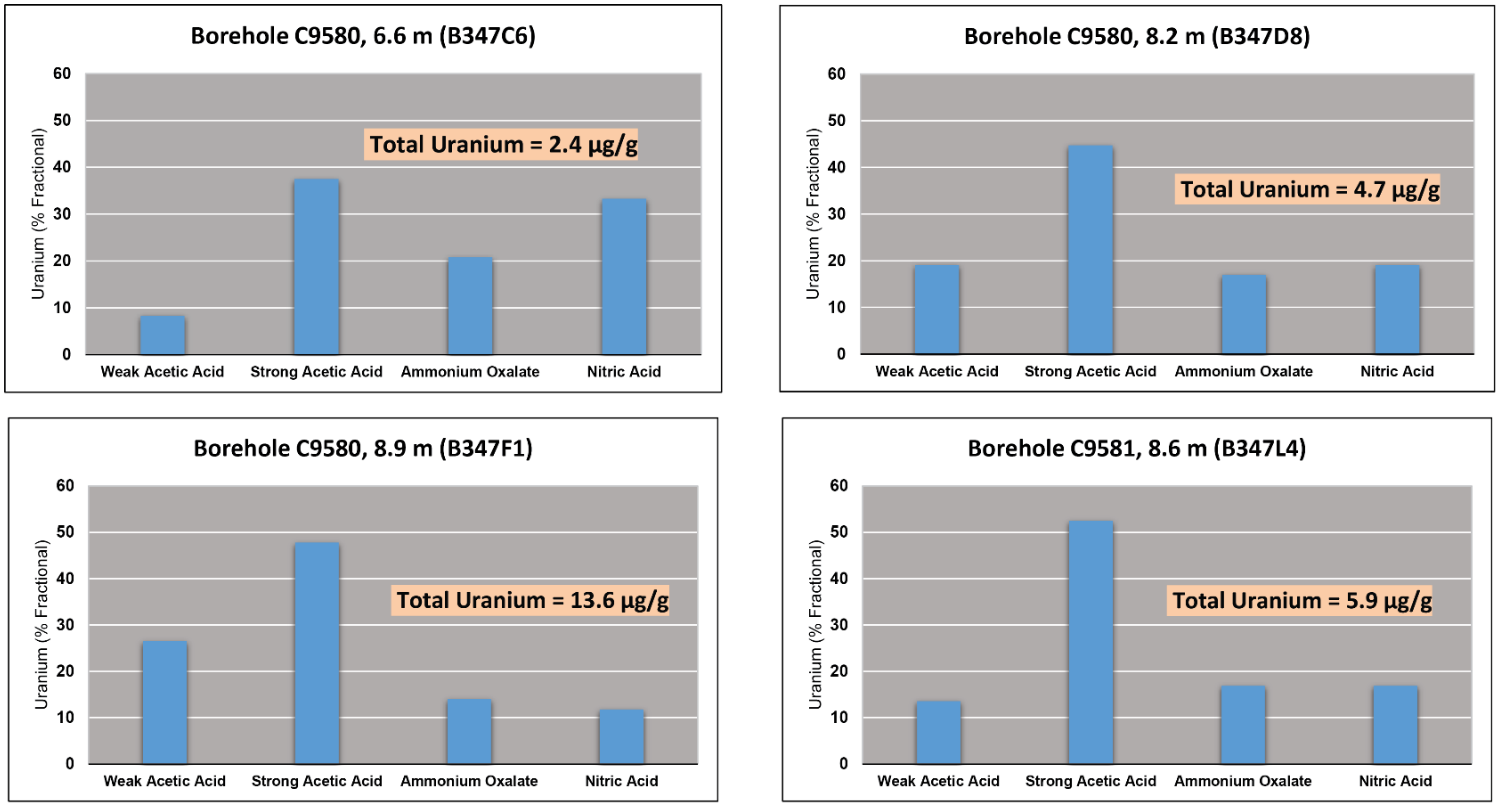
In all of the post-treatment samples, strong acetic acid extracted the highest concentrations of uranium, ranging from 37.5 to 56.8 percent of the total extracted uranium concentration. The strong acetic acid extractions selectively target the (strongly bound) uranium surface complexed with carbonate minerals.

The relative contribution of uranium from each semi-selective extraction is compared for samples from similar depths in the pre-treatment borehole C9451 (Figure 4-14, shown on the left) and the collocated post-treatment borehole C9580 (Figure 4-14, shown on the right). In each of the sample pairs, the relative contribution of uranium from the strong acetic acid extraction is higher in the post-treatment sample, indicating more uranium is strongly bound by surface complexation. Most of the post-treatment samples also show a decrease in the relative contribution from the weak acetic acid and nitric acid extractions, indicating that less of the uranium is readily soluble or nonleachable.

Figure 4-15 shows the relative contribution of uranium from each semi-selective extraction for samples from comparable depths in pre-treatment borehole C8940 and the collocated post-treatment borehole C9581. Figure 4-16 shows the relative contribution of uranium from each semi-selective extraction for samples from comparable depths in pre-treatment borehole C8936 and the collocated post-treatment borehole C9582. The sample pairs show a similar change in the relative contribution of uranium in the extractions between pre-treatment and post-treatment conditions.

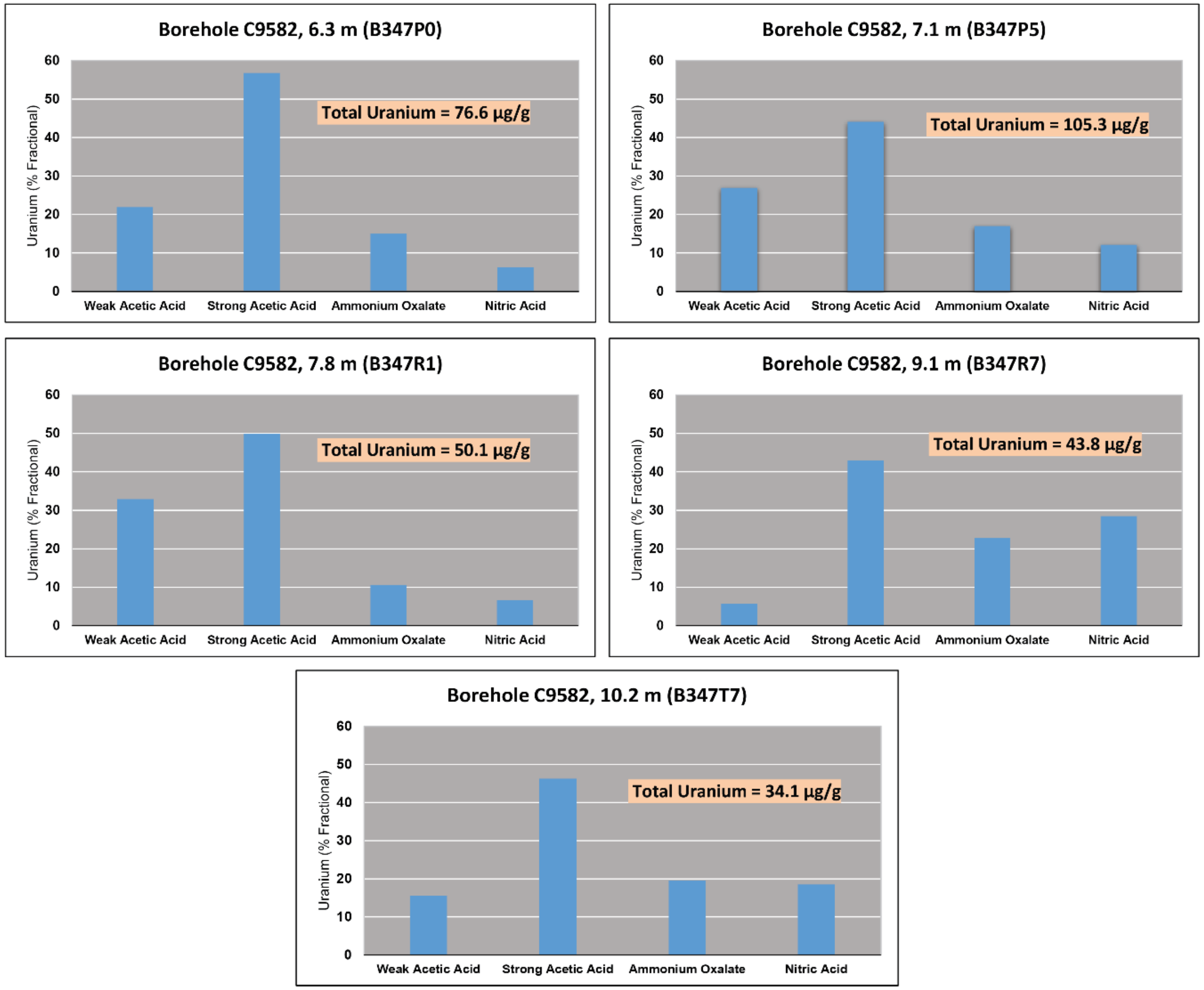
Each extractant solution was also analyzed for phosphorus, calcium, aluminum, iron, and manganese. Results for these analyses are discussed in Section 6.3.1 in ECF-300FF5-16-0091 (included in Appendix G of this report). The results are used in Section 5.2 of this report to develop the conceptual model of geochemical reactions resulting from application of polyphosphate solutions.

The readily leachable (labile) uranium concentrations determined using the sodium bicarbonate and sodium carbonate extraction method are presented in Figure 4-17. The amounts of uranium that are weakly surface complexed and readily leachable from weak acetic acid extraction also are presented for comparison. The three shallower samples from borehole C9582 (samples B347P0, B347P5, and B347R1 from the lower vadose zone) have higher uranium concentrations from sodium bicarbonate/carbonate extraction and from weak acetic acid extraction. These results imply most of the uranium that is potentially labile in these samples is associated with soluble carbonate mineral phases. Similar results were obtained for the pre-treatment samples, suggesting phosphate from infiltration did not reach the lower vadose zone at this location.



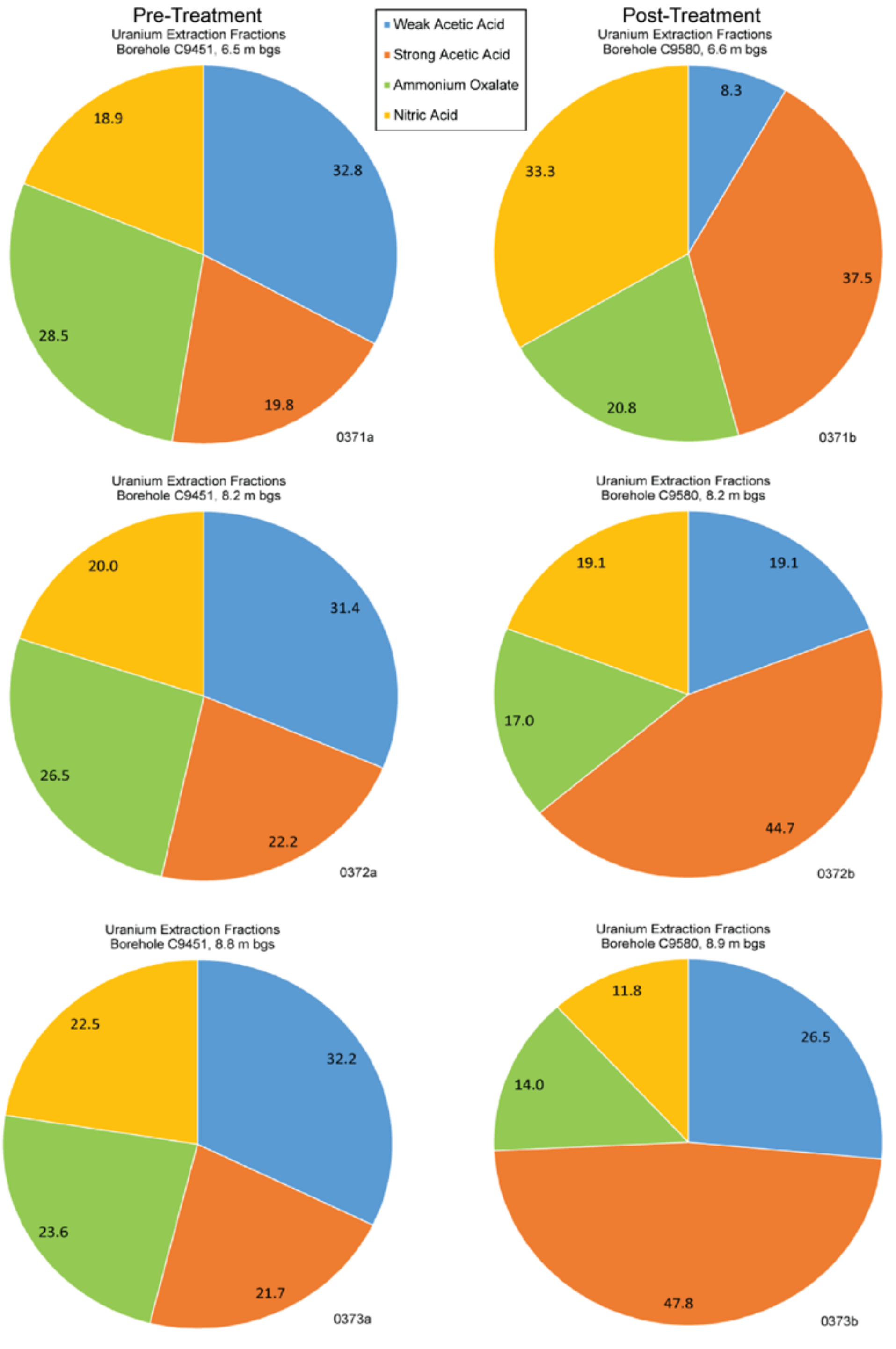
CHSGW20160300

Figure 4-12. Results from Semi-Selective Sequential Extraction Experiments on Samples from Post-Treatment Boreholes C9580 and C9581



CHSGW20160301

Figure 4-13. Results from Semi-Selective Sequential Extraction Experiments on Samples from Post-Treatment Borehole C9582



CHSGW20160371

Figure 4-14. Relative Uranium Extraction Contribution in Borehole Pair C9451-C9580

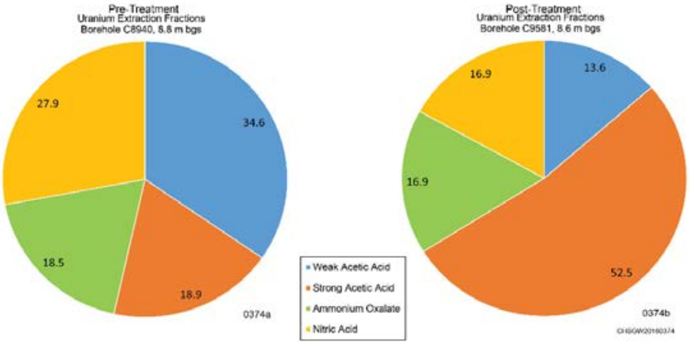


Figure 4-15. Relative Uranium Extraction Contribution in Borehole Pair C8940-C9581

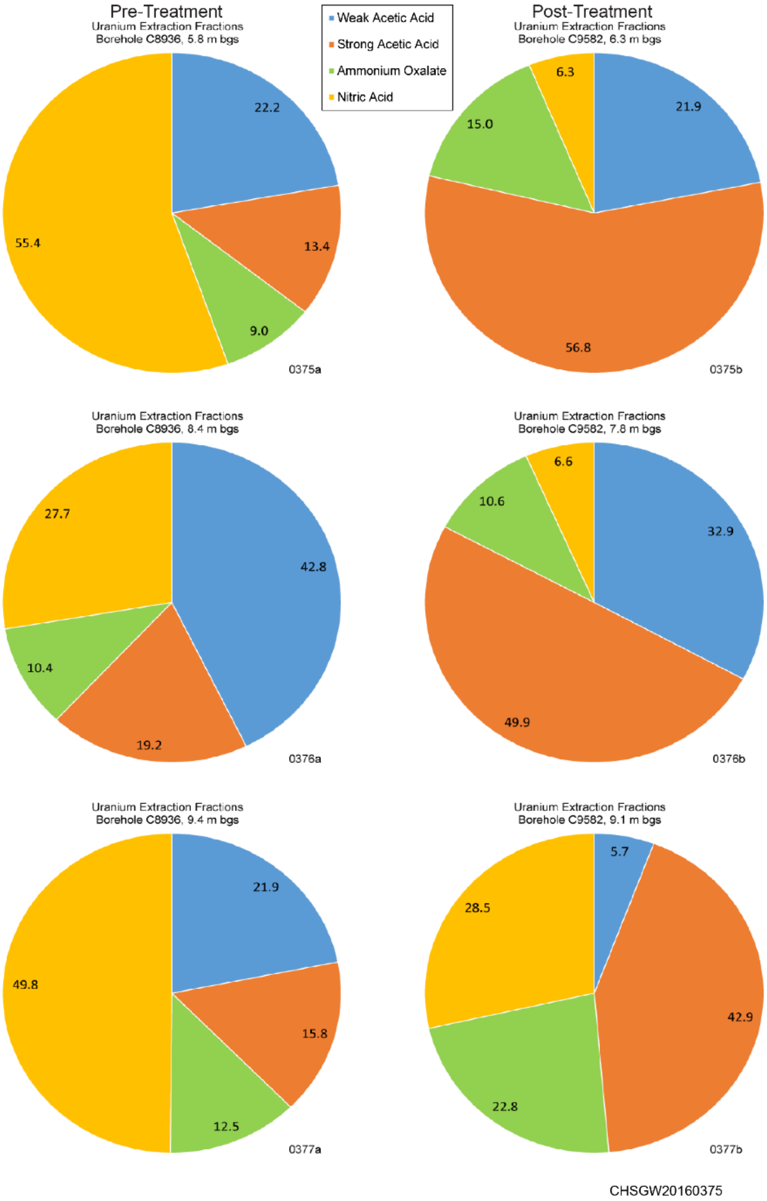
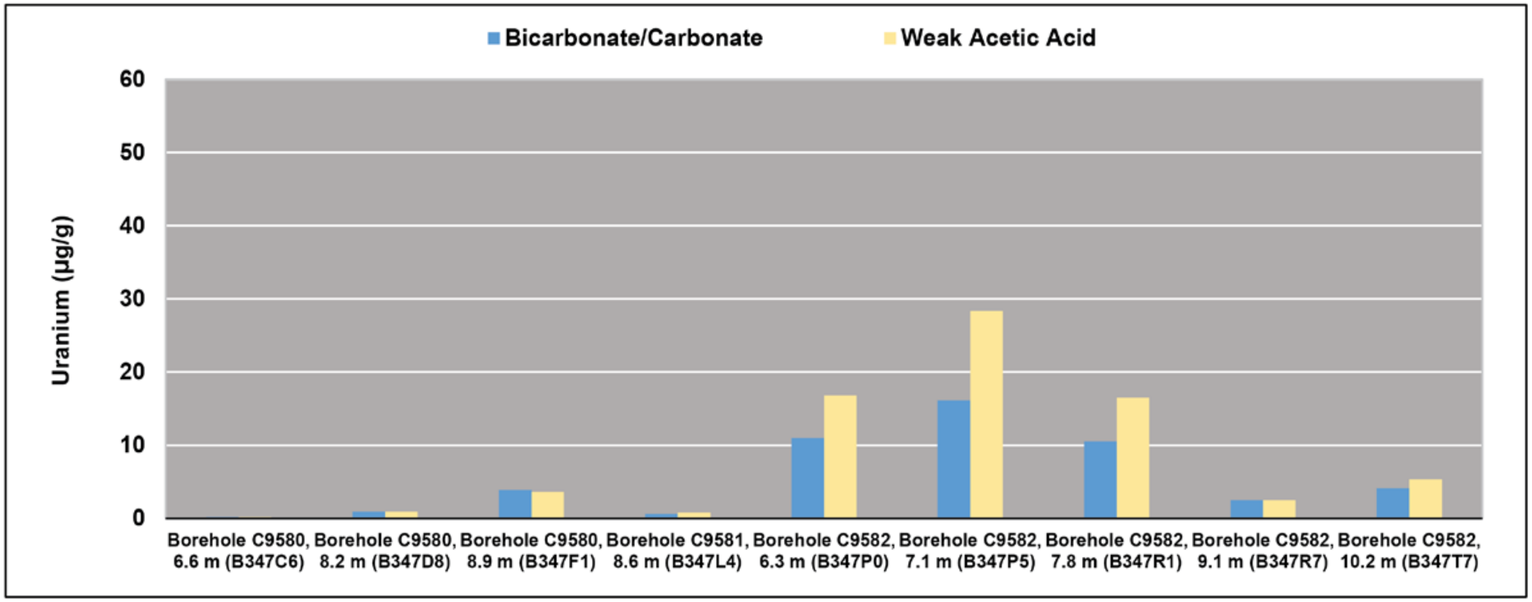


Figure 4-16. Relative Uranium Extraction Contribution in Borehole Pair C8936-C9582



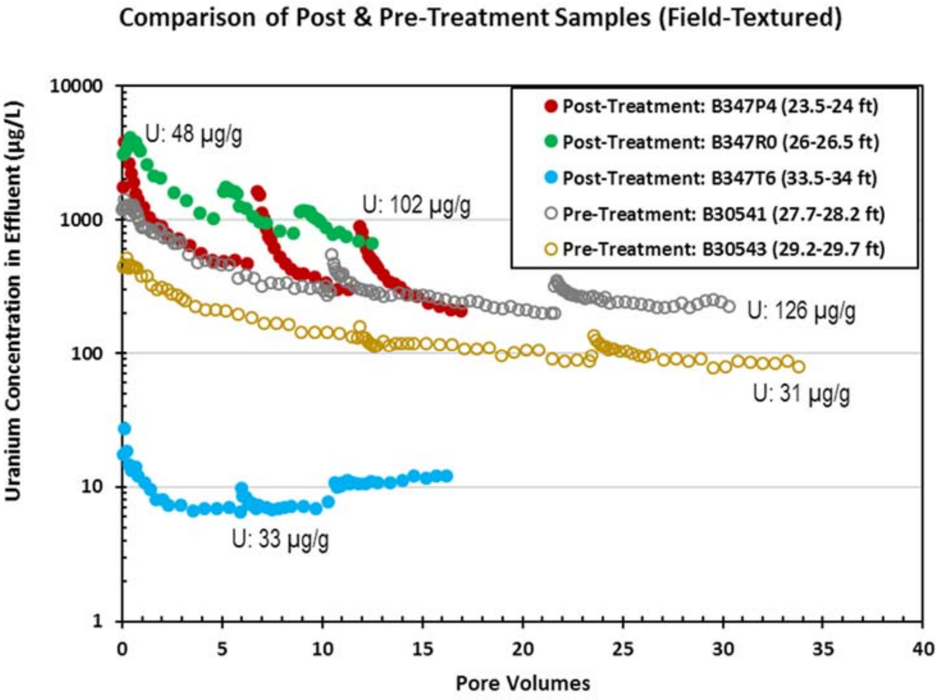
CHSGW20160304

Figure 4-17. Uranium Concentration from Sodium Bicarbonate/Carbonate Extraction Compared with the Uranium Concentration from Weak Acetic Acid Extraction for Post-Treatment Borehole Samples

The distribution of phosphate and uranium is not uniform among the three post-treatment boreholes. Uranium concentrations in boreholes C9580 and C9581 are at or below the background concentration at depths above the PRZ. Uranium concentrations in borehole C9582 exceed the background concentration throughout the vadose zone and PRZ. The vertical distribution of uranium is similar in the collocated pre-treatment samples. Phosphate concentrations in boreholes C9581 and C9582 are relatively low in the vadose zone. Phosphate concentrations in borehole C9580 are higher. As a result, only overall trends can be compared.

Flow-through column leach tests were conducted on three intact samples and four repacked columns containing less than 2 mm size fraction material from post-treatment boreholes (Table 6-4 in ECF-300FF5-16-0091, included in Appendix G of this report). The depth intervals were selected based on the distribution of uranium concentrations in the soil and the depth of the pre-treatment samples.

Results from flow-through column leach tests performed on two intact lower vadose zone samples from pre-treatment borehole C8936 are compared to intact lower vadose zone and PRZ samples from collocated post-treatment borehole C9582 in Figure 4-18. The total uranium soil concentrations based on sequential leach tests are shown next to the column test results. Initial high uranium concentrations decline over the first few pore volumes, after which the rate of decline is slower. The intermittent increase in concentrations and gradual decline results from resumption of flow following the stop-flow events. The total uranium soil concentration in all five samples is high (ranging from 31 to 126 µg/g), and the effluent concentrations are sustained, indicating uranium mass has not been depleted. Results for repacked columns containing less than 2 mm size fraction material correspond to the results for the intact samples from the same depths (Section 6.3 of ECF-300FF5-16-0091, included in Appendix G of this report).



Reference: Figure 6-28 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 4-18. Comparison of Effluent Uranium Concentrations from Column Leach Tests Performed on Intact (Field-Textured) Samples from Post-Treatment and Pre-Treatment Boreholes

The flow-through column leaching behavior of the pre-treatment samples from the lower vadose zone (B30541 and B30543) is similar to the leaching behavior observed for the two post-treatment samples from the lower vadose zone (B347P4 and B347R0). High phosphate concentrations were not available in the pre-treatment samples, and they were not delivered to the post-treatment lower vadose zone samples by infiltration. The results for the post-treatment sample from the PRZ (B347T6) show that initial concentrations are lower and remain low throughout the duration of the experiment. The low effluent concentrations indicate the post-treatment sample from the PRZ most likely was impacted by phosphate injection into the PRZ and that the injected phosphate appears to have sequestered uranium. Because all three post-treatment boreholes show similar high phosphate concentrations at depth (Figure 6-17 in ECF-300FF5-16-0091, included in Appendix G of this report), similar leaching behavior of uranium is likely in all three locations.

Labile uranium leach testing was conducted on aliquots of the less than 2 mm size fraction samples from the three post-treatment boreholes. The results indicate uranium-containing carbonates are present in the soil in sufficient amounts to continue to dissolve and release uranium even after 66 days of continuous testing. This type of nonequilibrium, kinetically controlled leaching in contact with a bicarbonate aqueous solution could be expected to continue under field conditions. However, the amount of uranium leached is relatively low for three samples from borehole C9580, one PRZ sample from borehole C9581, and two PRZ samples from borehole C9582 (Figure 5-6 in PNNL-25420, included in Appendix A of this report). The amount of uranium leached is relatively high for four samples above the PRZ from borehole C9582. These results suggest that the labile uranium concentration remains relatively low in samples where the phosphate concentration is above background due to possible reactions of the uranium with calcium phosphate (Section 6.3.3 of ECF-300FF5-16-0091, included in Appendix G of this report).

4.2 Groundwater Sampling and Monitoring

The following subsections provide results of groundwater sampling and monitoring conducted before, during, and after application of polyphosphate treatment solutions to the vadose zone, PRZ, and top of the aquifer. The purpose of the sampling was to monitor the effects of the polyphosphate solutions on the groundwater and evaluate performance of the remedy.

4.2.1 Manual Monitoring

Manual groundwater monitoring is described in Section 3.2.1. Analytical results for the samples collected as part of operational monitoring are provided in Appendix C of this report, and analytical results for the samples collected as part of long-term monitoring are provided in Appendix H.

Phosphate concentrations were minimal in the three pairs of monitoring wells (399-1-72/73, 399-1-70/71, and 399-1-66/69) upgradient from the treatment area (Figure 1-5). These wells were located outside the radius of influence (ROI) of the polyphosphate injections, and the phosphate data suggest that groundwater was not flowing toward the northeast during and after treatment.

Figure 4-19 shows trend plots of phosphate concentration at the 10 pairs of Stage A monitoring wells located inside and downgradient of the EA area and at groundwater well 399-1-23 located downgradient of the EA area. In the two aquifer monitoring wells sampled daily (399-1-65 and 399-1-74) (Figure 3-2), the trend plots show no significant increase in phosphate following aquifer injections despite their close proximity to the injection wells. In four of the five PRZ monitoring wells located in the EA area and sampled daily (399-1-75, 399-1-87, 399-1-67, and 399-1-77), a significant increase in phosphate concentrations (to approximately 4,000 to 8,000 mg/L) immediately following PRZ injections was followed by a decrease, which suggests that PRZ injections were effective at delivering a high concentration of phosphate to the PRZ for a short duration. However, the plot of the fifth PRZ monitoring well sampled daily (399-1-81) showed no significant increase in phosphate following PRZ injections, most likely because it was not within the ROI of the injections or in the flow path of groundwater.

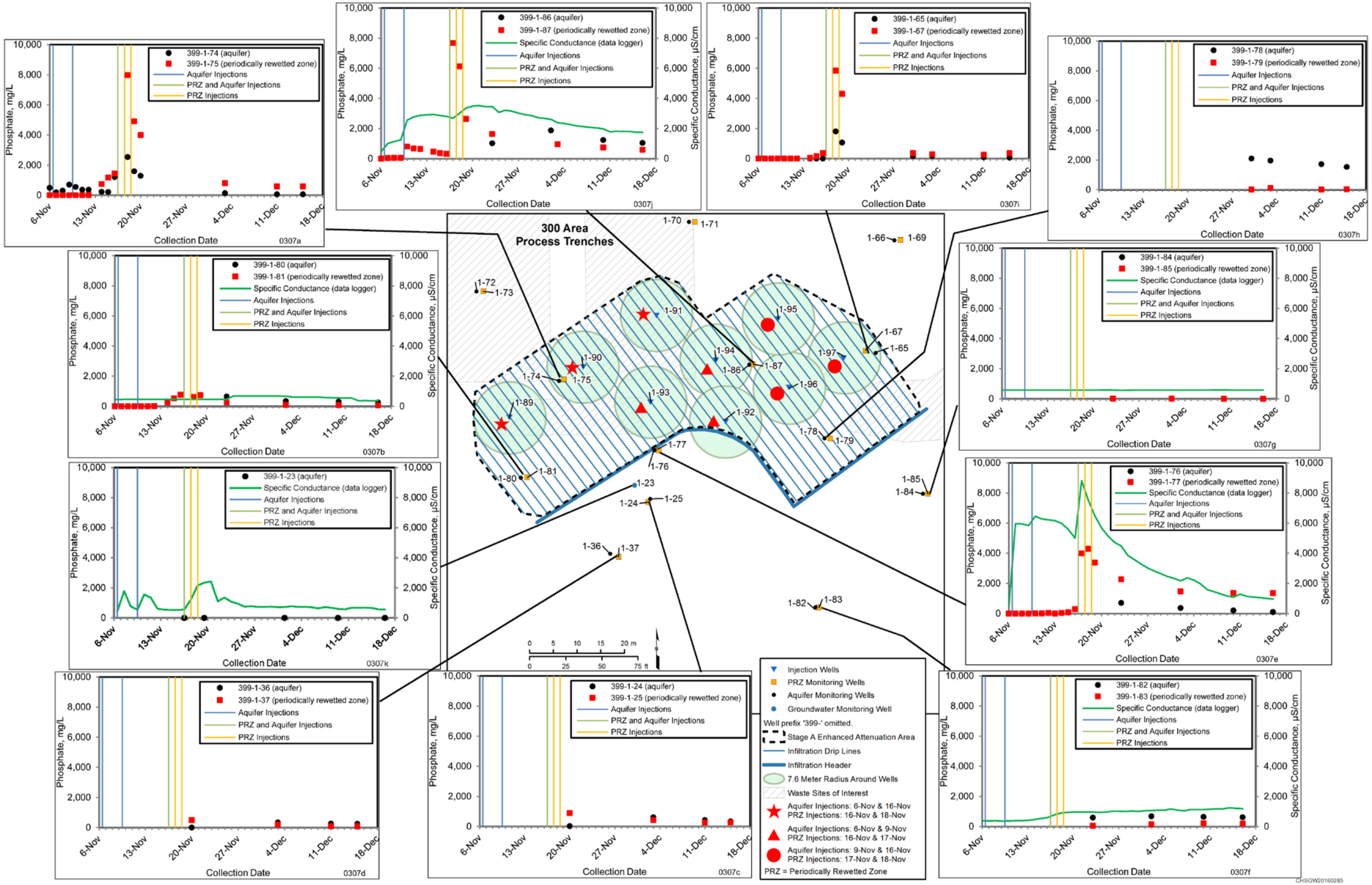


Figure 4-19. Phosphate Concentration and Specific Conductance Trends in Stage A Monitoring Wells

This page intentionally left blank.

In the weekly samples taken after polyphosphate treatment, data showed that phosphate concentrations in the PRZ and aquifer were much lower (approximately <2,000 mg/L) than concentrations immediately following injections. This suggests that phosphate reached the PRZ and aquifer in the EA area during treatment, but concentrations reduced as the phosphate was diluted and migrated in the groundwater.

The distribution of phosphate in the PRZ on November 20, 2015, 2 days after PRZ injections were completed, is shown in Figure 4-20. The distribution of phosphate in the aquifer on November 20 and December 3, 2015, is shown in Figures 4-21 and 4-22, respectively. The two figures for November 20, 2015, show relatively high concentrations in the PRZ, but not in the aquifer, following PRZ injections. The figure for December 3, 2015, indicates that the phosphate is draining from the PRZ to the aquifer. The western Stage A area drained faster than the eastern Stage A area, consistent with ERT data for infiltration rates (Section 4.4).

Figures 4-23 and 4-24 show trend plots of uranium concentrations in the PRZ and aquifer in the 26 monitoring wells. In the monitoring wells sampled daily during treatment, a pulse of uranium was observed shortly after infiltration began. Application of the polyphosphate solutions with higher ionic strength would be expected to temporarily mobilize uranium. There were minimal changes in uranium concentration in the monitoring wells upgradient from the EA area or outside the downgradient flow path of the groundwater.

Trend plots of uranium, phosphate, and specific conductance through June 2016 (7 months after the completion of polyphosphate injection and infiltration) are shown for downgradient wells 399-1-23, 399-1-17A, 399-1-7, and 399-2-2 in Figures 4-25 through 4-28. The locations of the wells are shown on Figure 3-3. All of the data for these wells and for wells 399-1-16A, 399-2-1, and 399-2-3 collected by PNNL between September 2015 and June 2016 are provided in Appendix C; the data collected by CHPRC in December 2015 and June 2016 are provided in Appendix H.

- Well 399-1-23 (~5 m [16 ft] downgradient of the Stage A area) and well 399-1-17A (38.1 m [125 ft] downgradient of the Stage A area) show steep increases in specific conductance and phosphate concentrations approximately 1 week after the start of polyphosphate application. Concentrations slowly declined but remained slightly elevated above pre-treatment concentrations as of June 2016. During this same timeframe, uranium concentrations decreased below pre-treatment concentrations and the cleanup level (30 µg/L).
- Well 399-1-7 (157.0 m [515 ft] downgradient of the Stage A area) shows a gradual increase in specific conductance and phosphate concentrations approximately 1 month after the start of polyphosphate application. Concentrations had not started to decline as of June 2016. During this same timeframe, uranium concentrations decreased and remained below pre-treatment concentrations and the cleanup level.
- Well 399-2-2 (280.4 m [920 ft] downgradient of the Stage A area) shows no significant increases in specific conductance or phosphate. Uranium concentrations in this well have fluctuated and were typically lower in June (high river stage) than in December (low river stage). The low concentrations near the cleanup level in June 2016 may reflect this seasonal variation.

The data collected from wells farther downgradient of the Stage A EA area corroborate the observations made at monitoring wells within and near the EA area, which show that any temporary spikes of uranium in the aquifer due to polyphosphate application have not impacted groundwater quality. Conversely, uranium concentrations downgradient of the Stage A EA area have decreased due to the Stage A phosphate application.

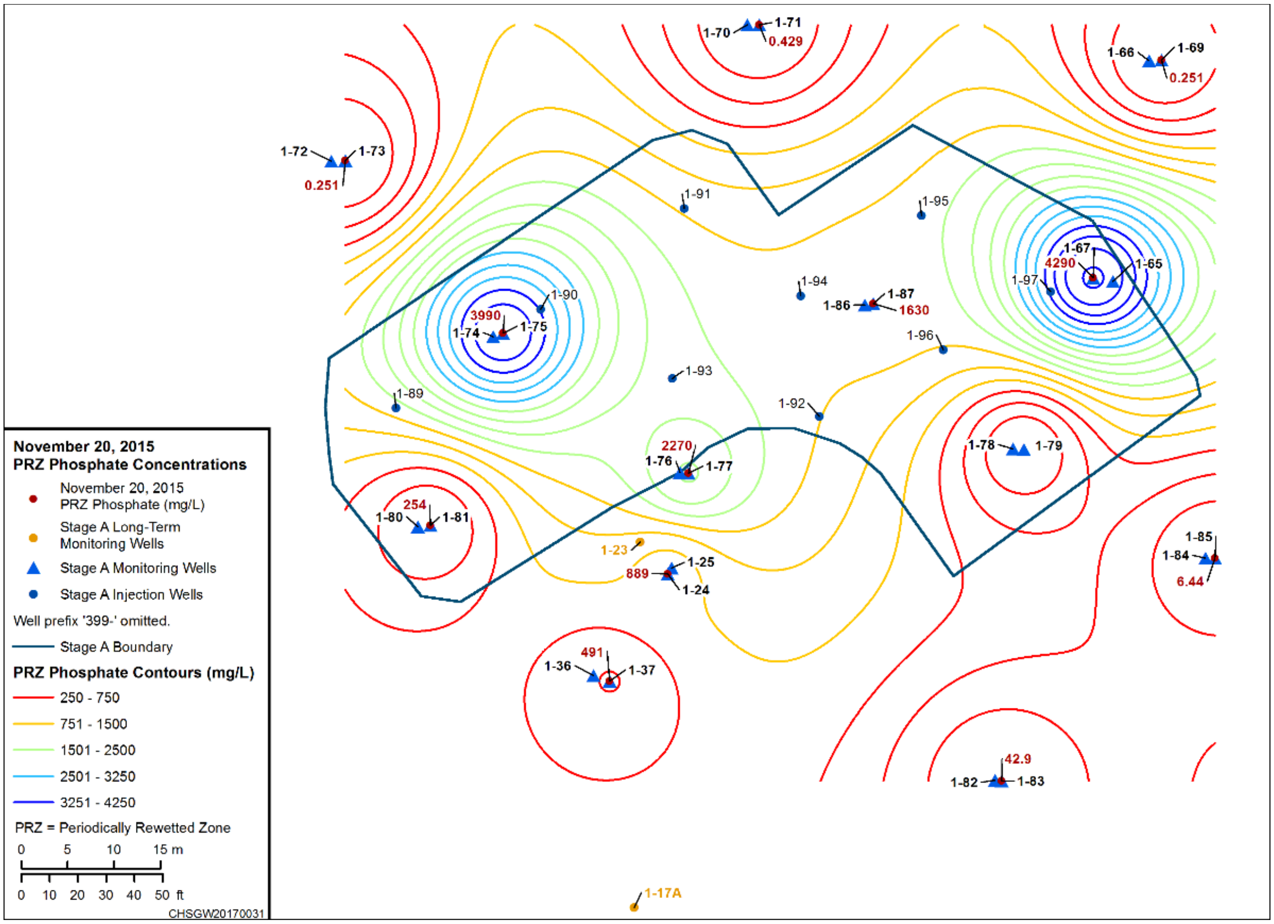


Figure 4-20. Distribution of Phosphate in the PRZ on November 20, 2015

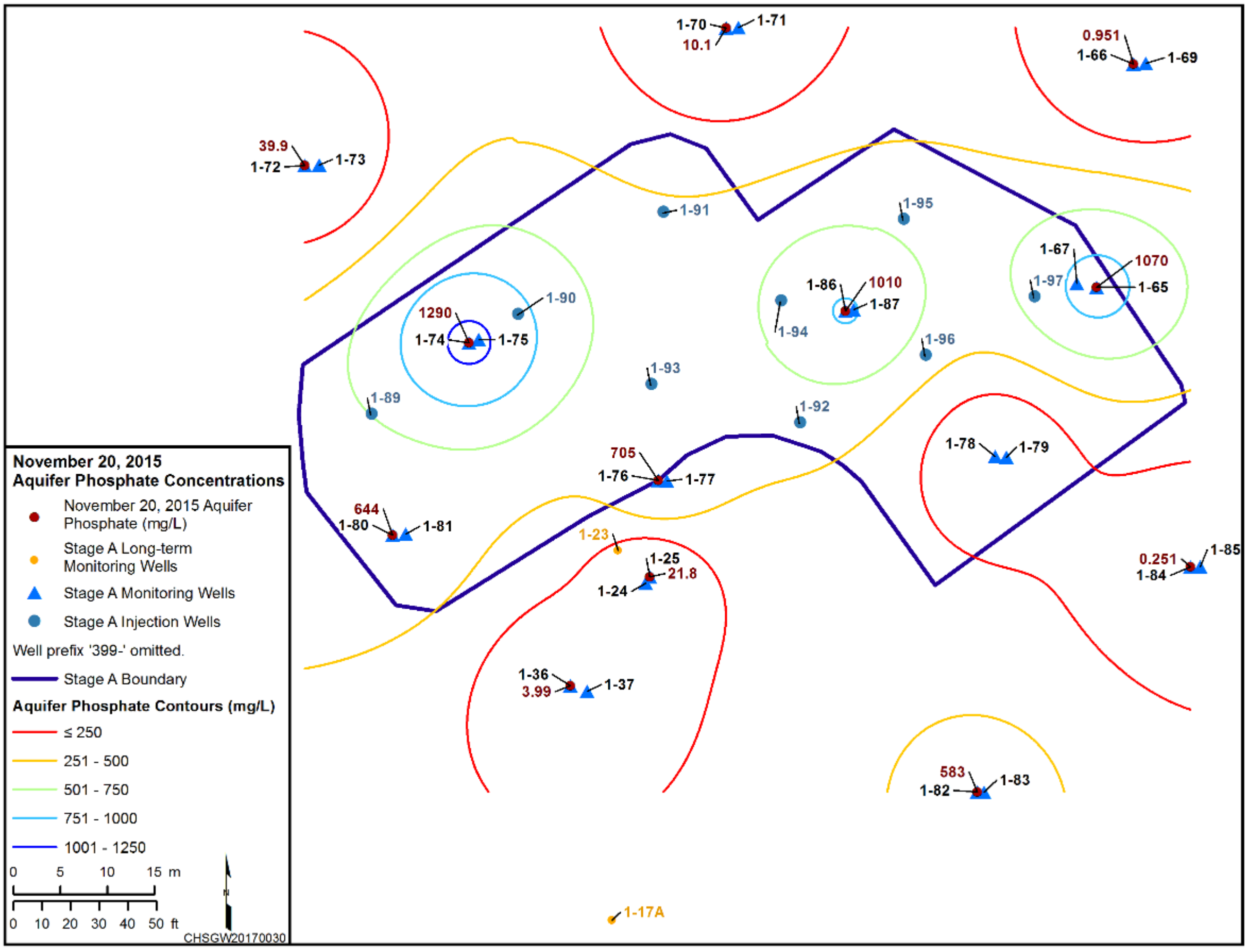


Figure 4-21. Distribution of Phosphate in the Aquifer on November 20, 2015

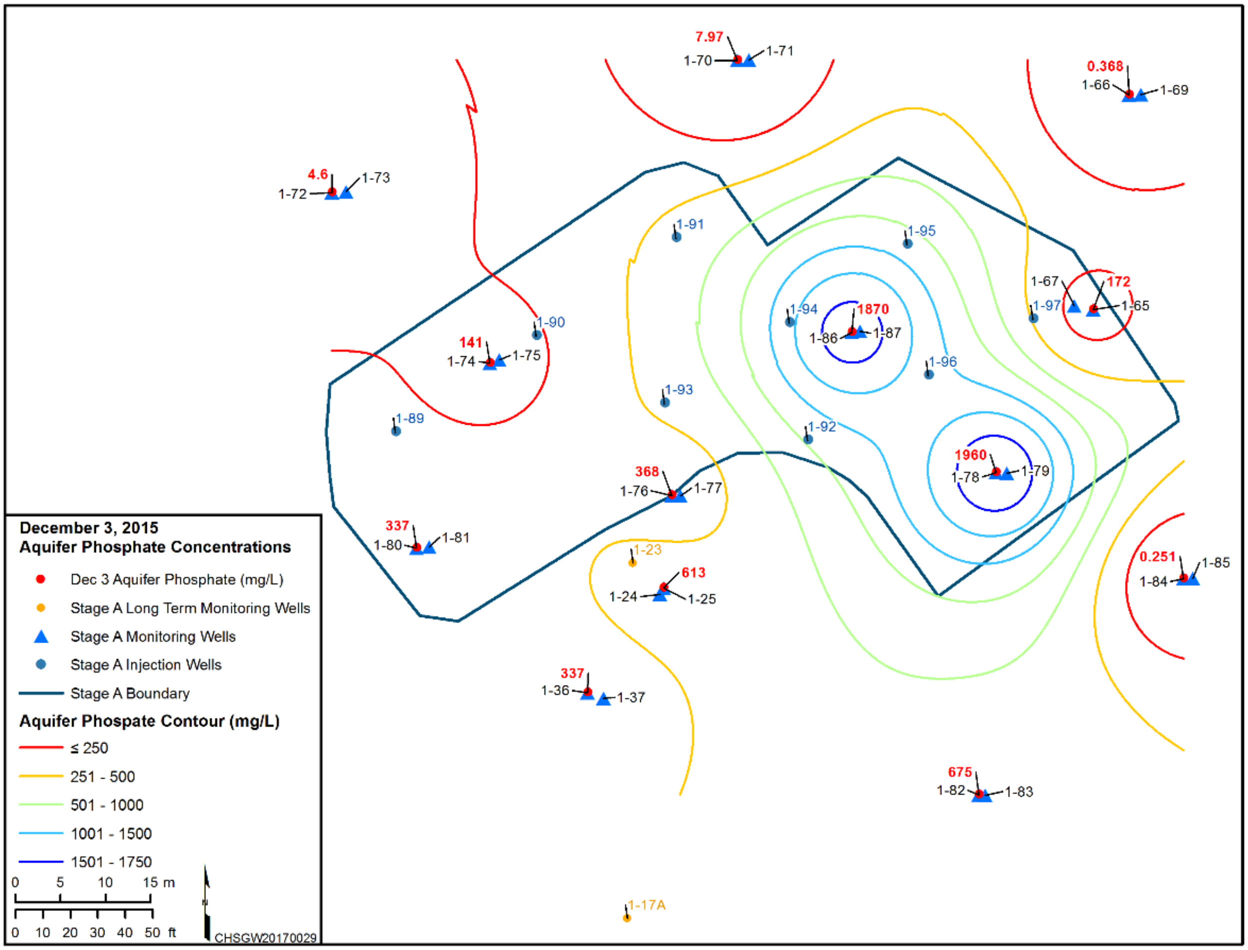


Figure 4-22. Distribution of Phosphate in the Aquifer on December 3, 2015

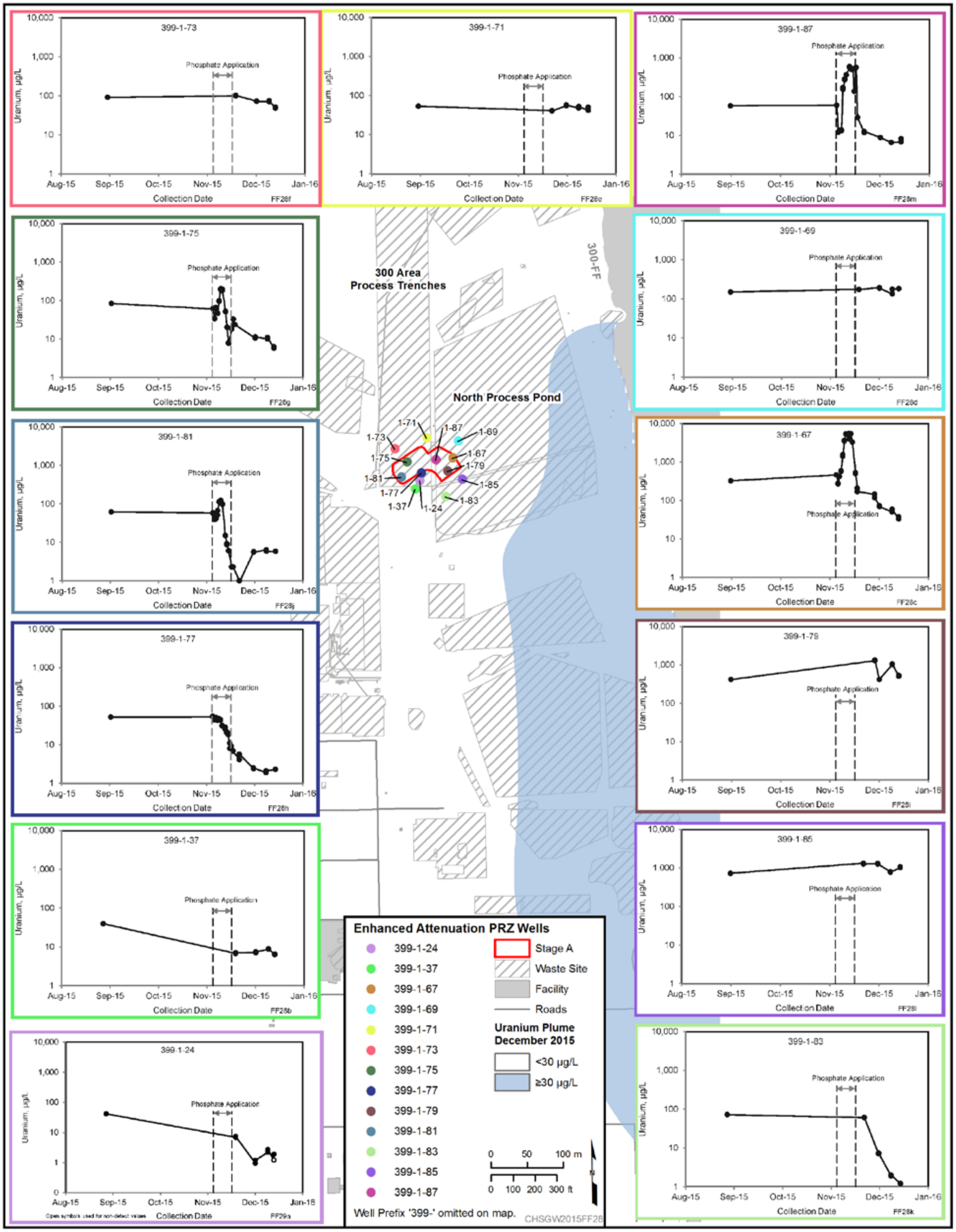


Figure 4-23. Uranium Concentration Trends in Stage A PRZ Monitoring Wells

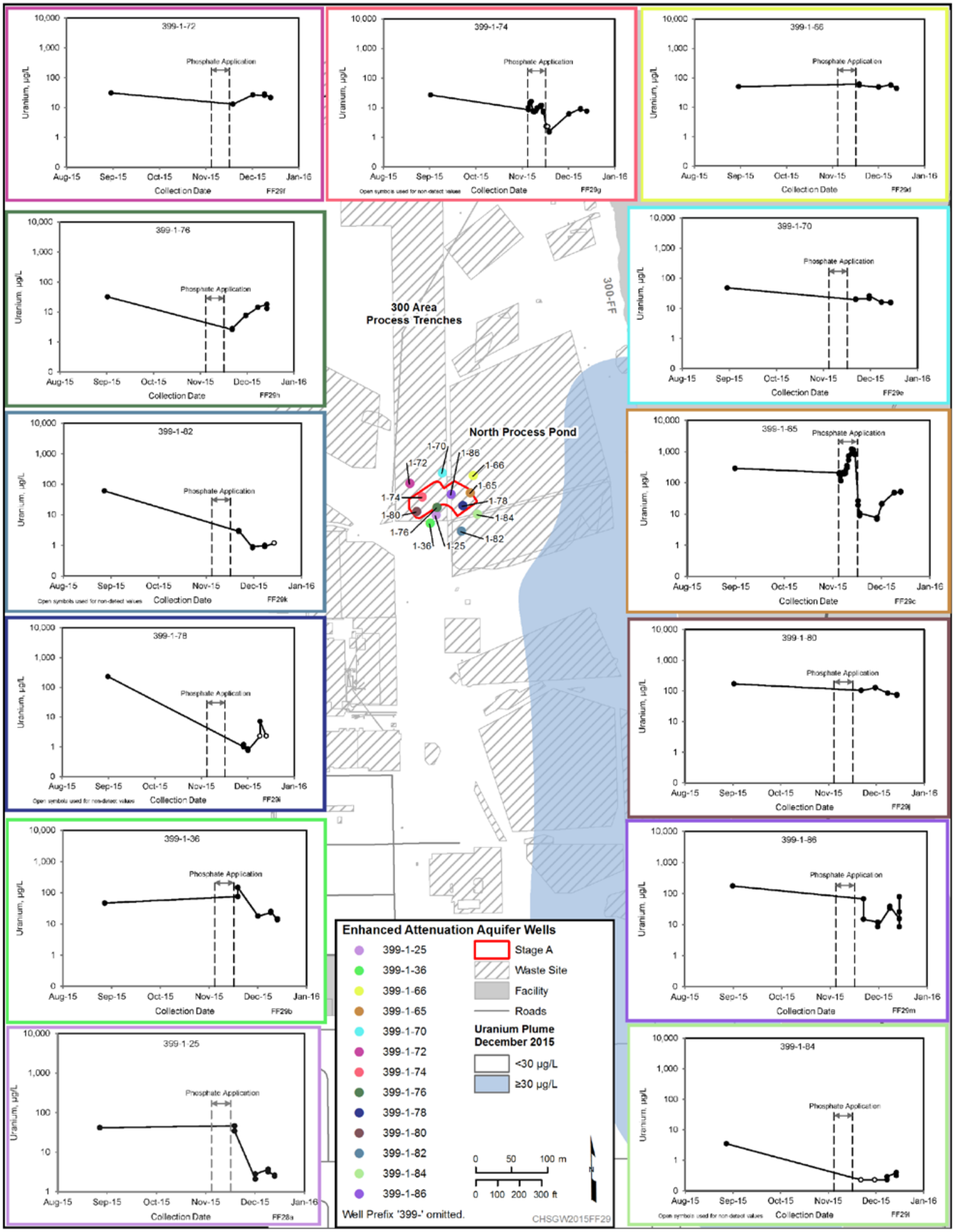


Figure 4-24. Uranium Concentration Trends in Stage A Aquifer Monitoring Wells

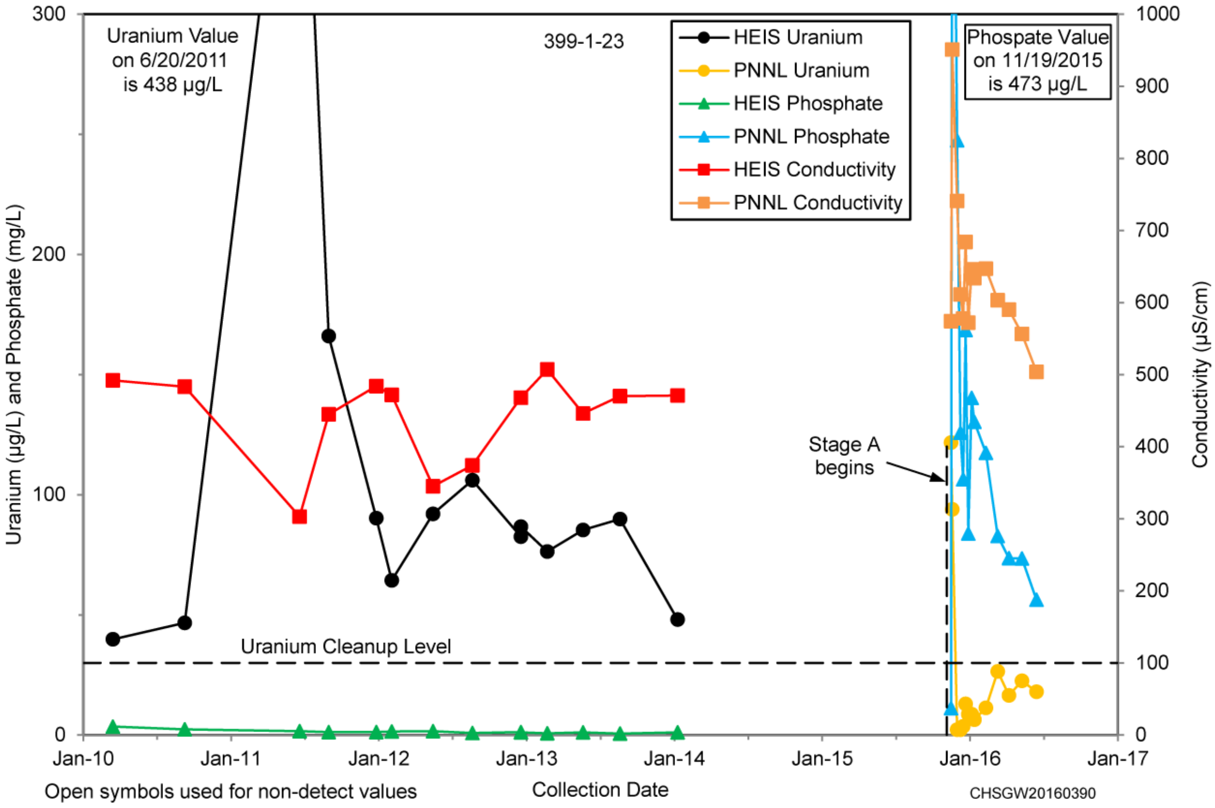


Figure 4-25. Groundwater Specific Conductance, Uranium, and Phosphate Concentrations in Well 399-1-23

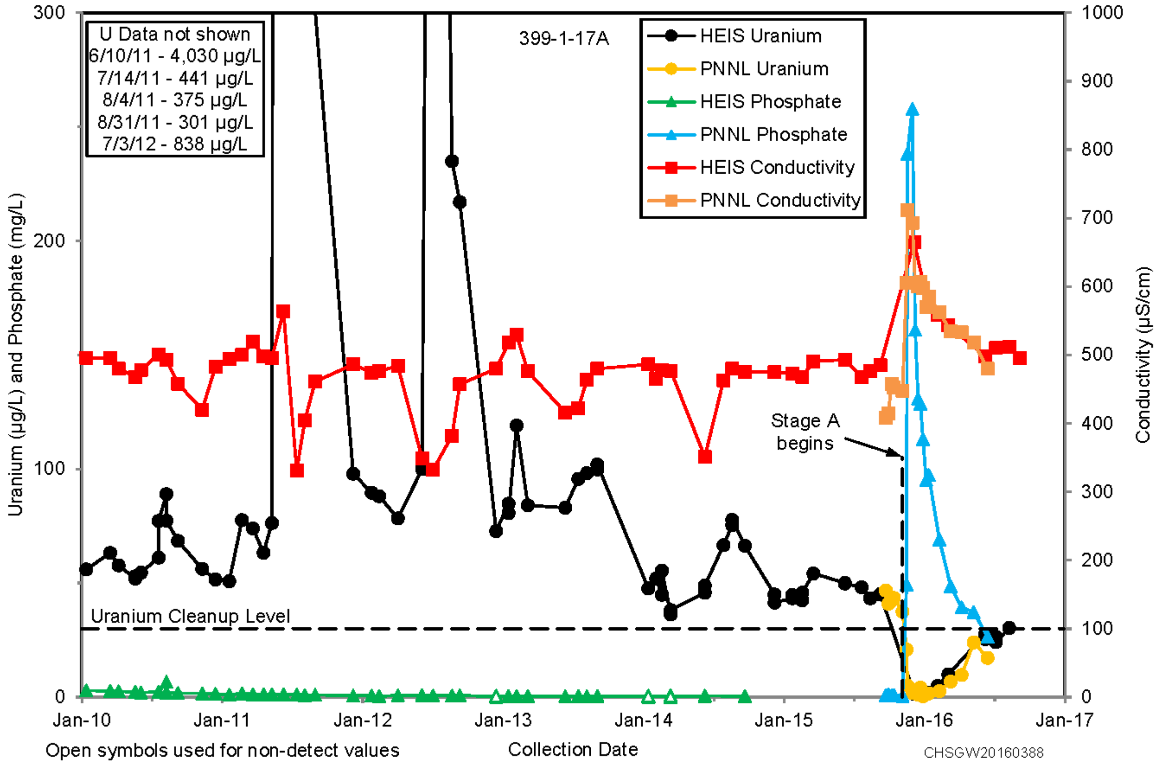


Figure 4-26. Groundwater Specific Conductance, Uranium, and Phosphate Concentrations in Well 399-1-17A

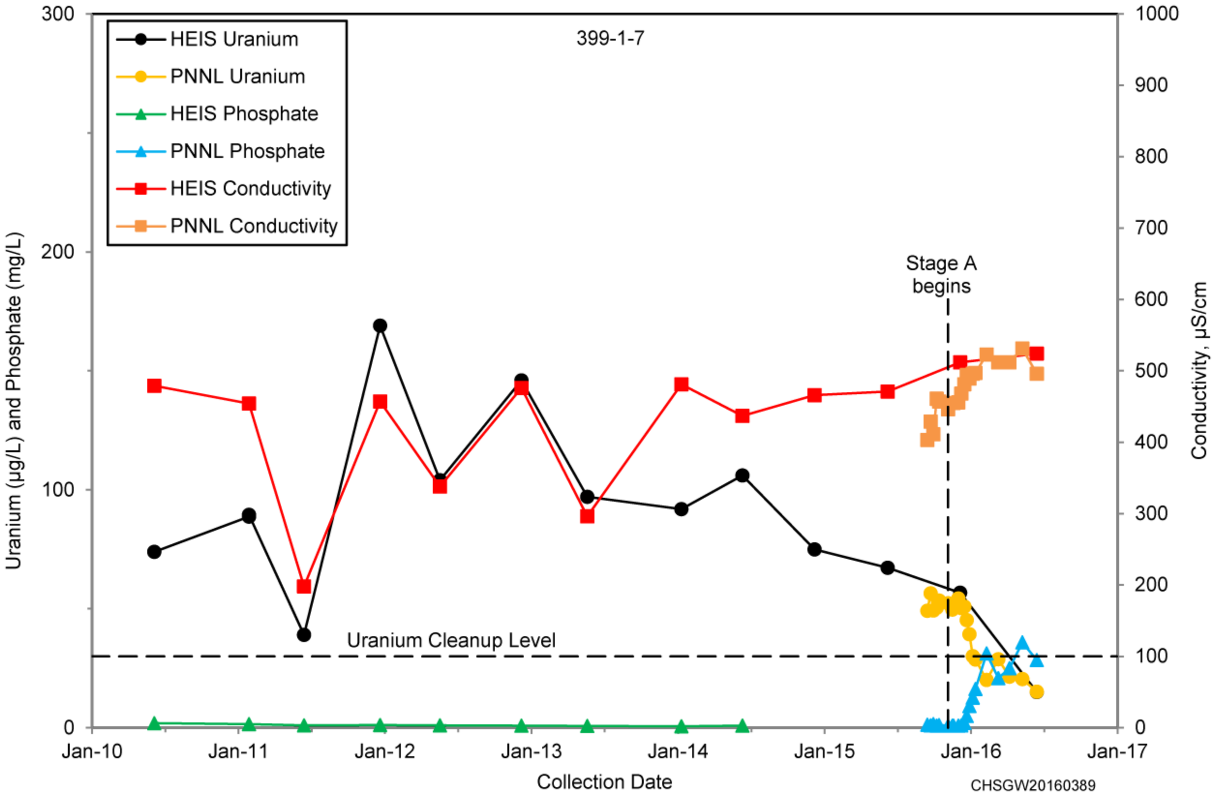


Figure 4-27. Groundwater Specific Conductance, Uranium, and Phosphate Concentrations in Well 399-1-7

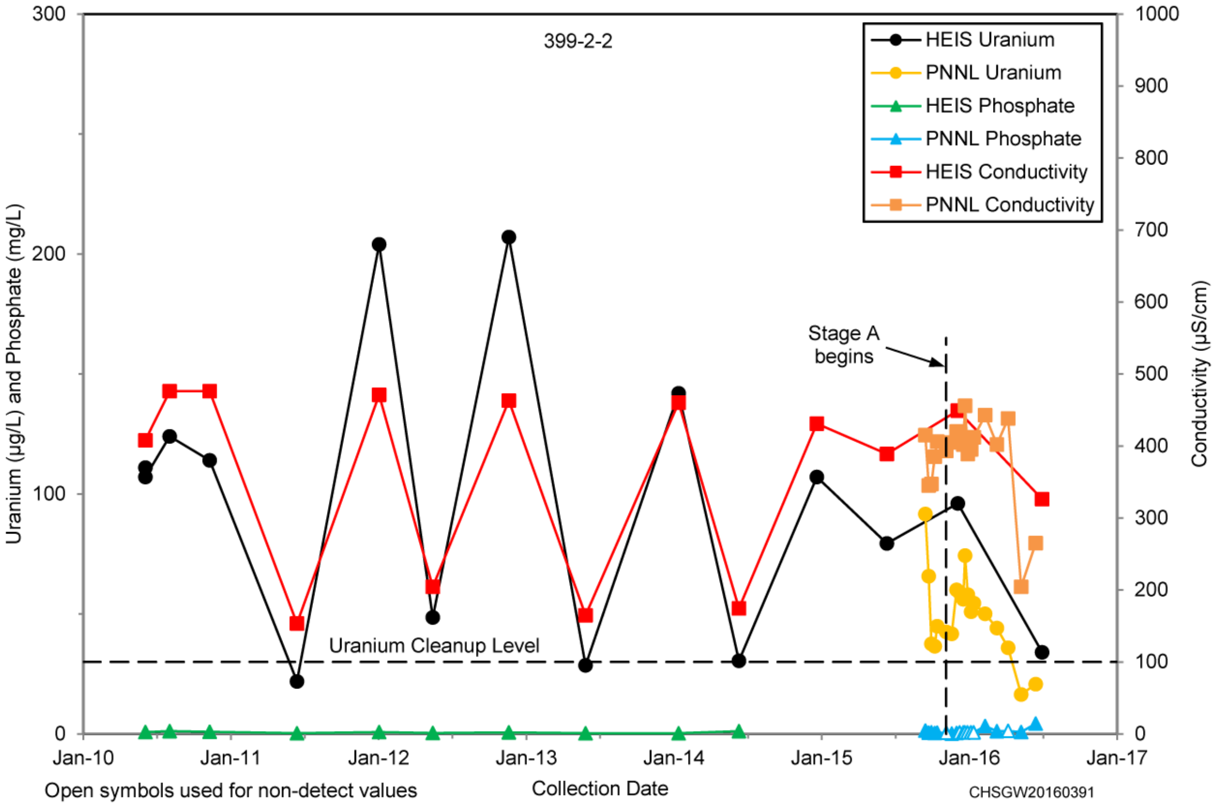


Figure 4-28. Groundwater Specific Conductance, Uranium, and Phosphate Concentrations in Well 399-2-2

Groundwater monitoring results for well 399-1-17A show temporary increases in trace metals such as arsenic and vanadium following application of the polyphosphate solutions (Figure 4-29). Both arsenic and vanadium are likely naturally occurring and possibly being mobilized from dissolution of iron oxides and clay minerals from interaction with phosphate-bearing solutions. Vanadium could also be made available from dissolution of a uranium-bearing mineral, such as carnotite.

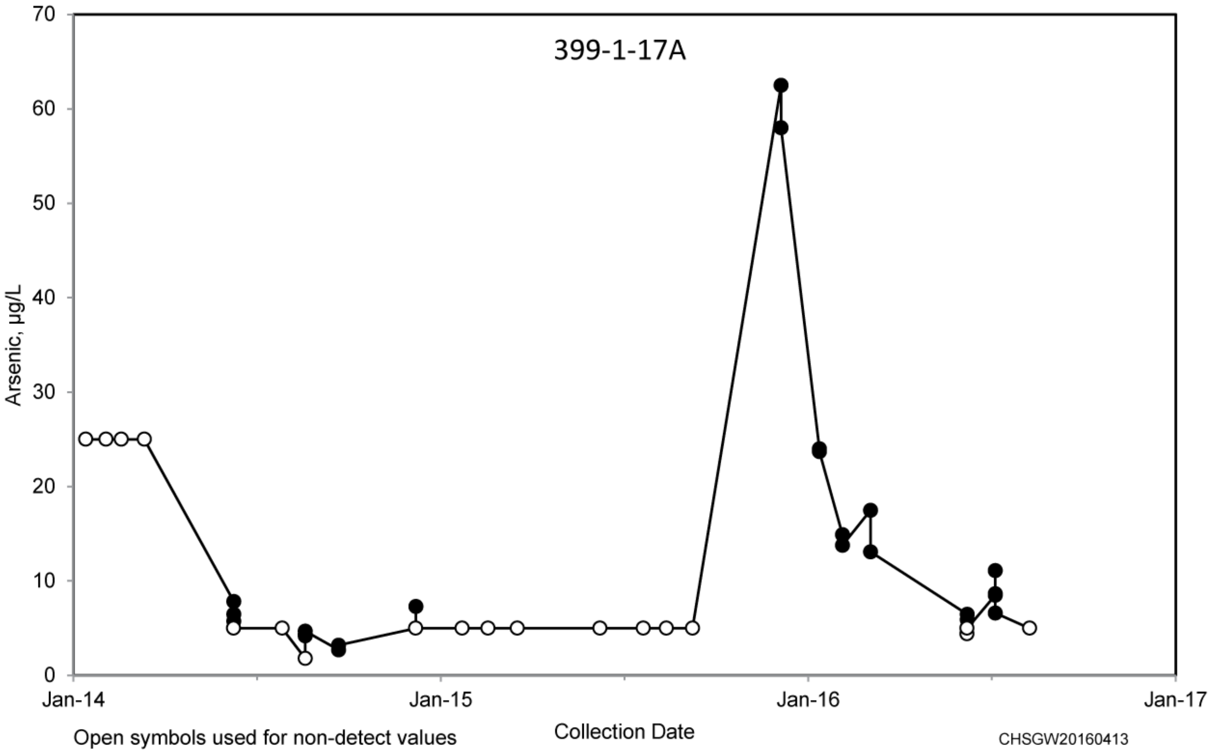


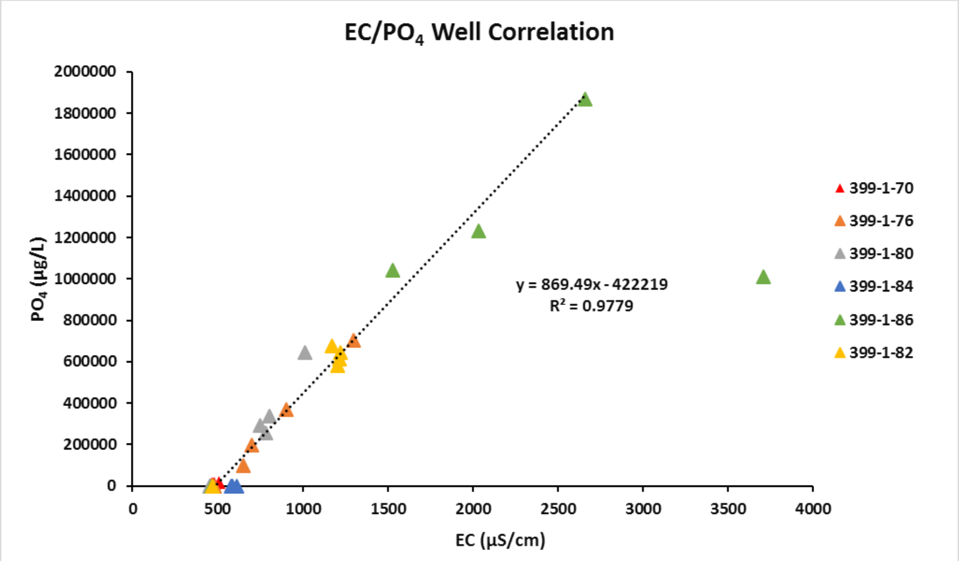
Figure 4-29. Temporary Increase in Arsenic Concentration in Well 399-1-17A following Polyphosphate Treatment

4.2.2 Automated Monitoring

Automated groundwater monitoring is described in Section 3.2.2. Analytical results for the automated groundwater measurements are summarized in Appendix D of this report.

4.2.2.1 In Situ Monitoring

Data loggers were installed in six aquifer monitoring wells inside and outside of the Stage A EA area (Figure 3-4). Specific conductance measurements recorded using the dataloggers indicate the extent of the polyphosphate solution migration. Figure 4-30 shows the correlation between the specific conductance measured using the data loggers and the phosphate concentration analyzed in groundwater samples from five of the six monitoring wells that were in or downgradient from the EA area. The sixth data logger was in a monitoring well (399-1-70) upgradient from the EA area that did not receive a significant amount of phosphate. Specific conductance at monitoring wells 399-1-80, 399-1-82, and 399-1-84 did not change (Figure 4-19). This is consistent with groundwater samples from the wells, which contained low concentrations of phosphate. Specific conductance measured at monitoring wells 399-1-76 and 399-1-86 increased after each aquifer injection (Figure 4-19). Phosphate was not measured daily in these two wells; however, the specific conductance/phosphate correlation (Figure 4-30) indicates phosphate was present in the aquifer.



Reference: Figure 6-7 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Note: Regression excludes outlier.

Figure 4-30. Electrical Conductivity and Phosphate Correlation

4.2.2.2 Water Level Monitoring

Six groundwater wells in the vicinity of the Stage A treatment area and the 300 Area river gauge (station SWS-1) were continuously monitored as part of the local AWLN (Figure 3-5). The water levels and river stage measured before, during, and after the injections were used in the numerical fate and transport modeling described in Chapter 5 of this report and in ECF-300FF5-16-0091 (included in Appendix G of this report). The water levels and specific conductivity measurements were used in the evaluation of the impact of phosphate injections on aquifer properties described in Chapter 5 of this report.

4.3 Operations Monitoring

The following subsections describe the results of operations monitoring of the Stage A infiltration and injection systems. The data are provided in Appendix E of this report.

4.3.1 Infiltration System

Infiltration was initiated on November 7, 2015. One mixing skid was used to mix concentrated orthophosphate and pyrophosphate chemicals with filtered Columbia River water and deliver the polyphosphate solution to the infiltration system distribution header. From the distribution header, the polyphosphate solution was delivered to infiltration drip lines (Figure 2-4). The configuration of the infiltration system is described in Section 2.2.4.

The infiltration system was operated 24 hr/d for 271 hours, ending on November 16, 2015. During the first 4 days of infiltration, the polyphosphate solution infiltrated at average flow rates ranging between 197 and 212 L/min (52 and 56 gal/min) (Table 2-1). This flow rate was less than half of the design flow rate of 511 L/min (135 gal/min). On November 11, 2015, the 103 kPa (15 lb/in^2) pressure regulators connecting each drip line to the header were replaced with 138 kPa (20 lb/in^2) pressure regulators. The average flow rate increased, ranging between 254 and 318 L/min (67 and 84 gal/min), for the remaining 5 days of infiltration. Figure 4-31 shows the average daily infiltration flow rates for the 10 days of infiltration.

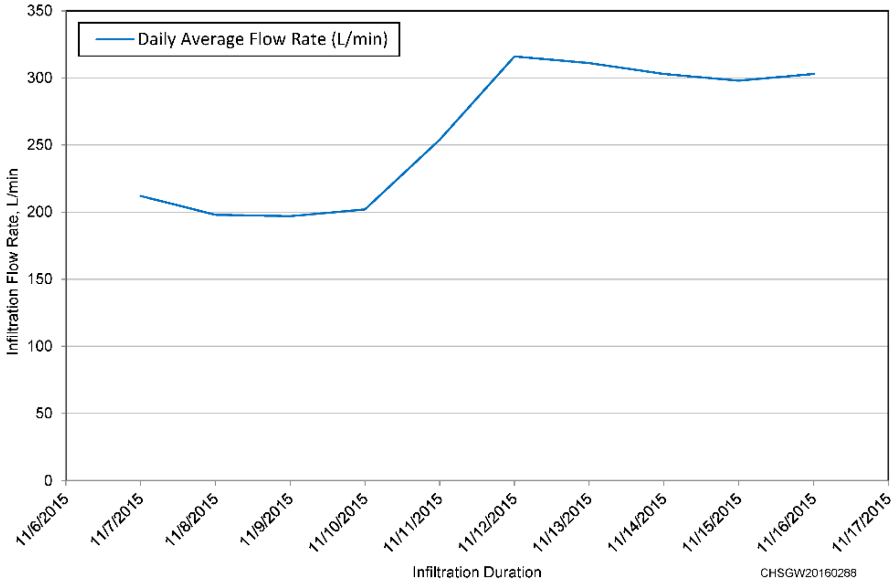


Figure 4-31. Stage A Daily Average Infiltration Flow Rates

Conductivity levels on the first day of infiltration were higher than anticipated in the treatment solution discharging from the mixing skid to the infiltration lines. This indicated the solution may have contained a higher phosphate concentration than intended. Operations personnel continued to collect field measurements every 4 hours to monitor conductivity. These data continued to show elevated conductivity levels and confirmed the phosphate concentrations were higher than desired. The issue was traced to inaccurate flow rates displayed on the skid control panel. Using the more accurate flow rates displayed on the in-line flowmeters, operators were able to adjust the mixing parameters and bring the phosphate concentrations into the desired range. The success of the adjustment was confirmed by the field measurements.

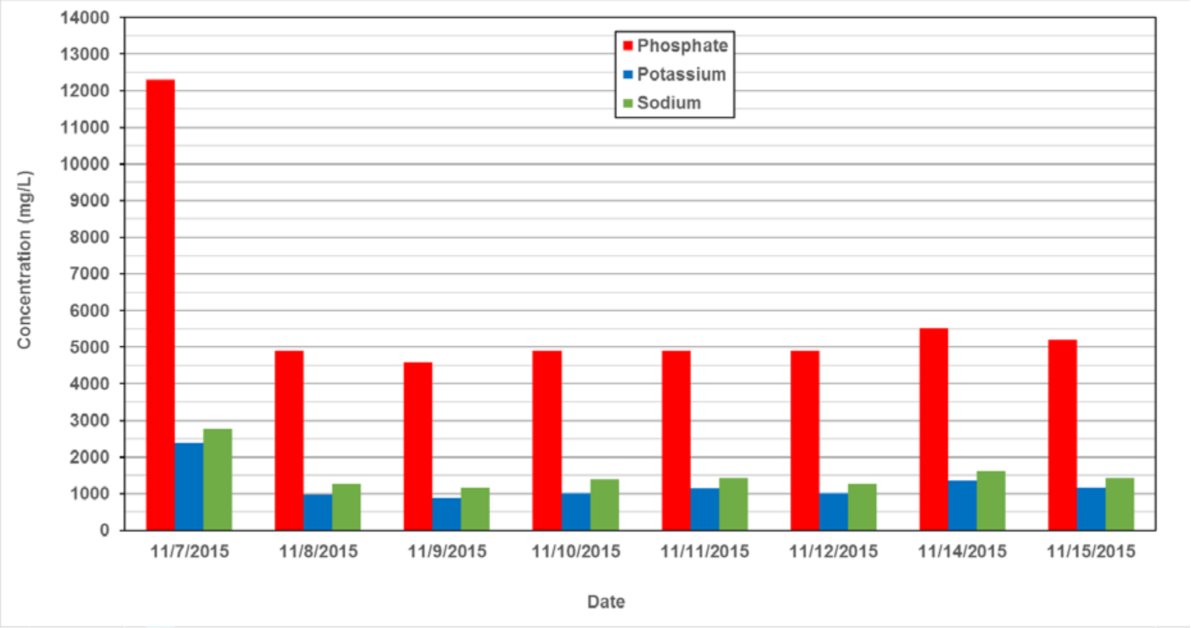
Totalizer volumes recorded on the inline flowmeters at the conclusion of the infiltration operations on November 16, 2015, indicated 3,342,889 L (883,194 gal) of polyphosphate solution was delivered to the vadose zone during Stage A. The actual volume was less than the design volume of 3,679,420 L (972,000 gal) by 10.1 percent.

The polyphosphate solution used for infiltration was composed of a mixture of 90 percent orthophosphate and 10 percent pyrophosphate, by weight as phosphate. The target infiltration concentrations are provided in Table 4-1. The composition of the infiltrated solution for the three primary components (sodium, potassium, and phosphate) is shown in Figure 4-32, based on daily samples collected from the infiltration skid. During infiltration, phosphate concentrations were generally maintained around 5,000 mg/L (50 mM) except for the first day of infiltration when the concentrations were around 12,000 mg/L due to operational issues related to mixing with river water. Sodium and potassium concentrations varied in proportion to the phosphate concentrations, with the sodium concentrations being slightly greater than potassium concentrations.

Table 4-1. Target Concentrations for Vadose Zone Infiltration

Infiltration Solution Component	Target Infiltration Concentration (mM)	Approximate Target Infiltration Concentration of Phosphate (mg/L)
Orthophosphate*	47.5	4,520
Pyrophosphate ($Na_4P_2O_7$)	2.5	480
Total approximate phosphate (PO_4) concentration	50	5,000

* Mixture of NaH_2PO_4-Na_2HPO_4-KH_2PO_4-K_2HPO_4.



Source: Figure 6-3b in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Note: No sample taken on November 13, 2015.

Figure 4-32. Stage A Infiltration Solution Daily Sample Concentrations at the Mixing Skid

4.3.2 Injection System

Injections into the top of the aquifer were conducted on November 6, 9, and 16, 2015 (Table 2-1). Injections into the PRZ were conducted between November 16, 17, and 18, 2015 (Table 2-1). The duration of each round of injections was 8 continuous hours; starting and ending times for the injections are provided in Table 2-1. During injections, the polyphosphate solution was delivered simultaneously to six of the nine injection wells at a combined target flow rate of 1,136 L/min (300 gal/min). Instruments on the injection mixing skid were monitored to ensure that appropriate flow rates and system parameters were maintained.

Totalizer volumes recorded on the inline flowmeters at the conclusion of the final aquifer injection on November 16, 2015, indicated 1,697,722 L (448,492 gal) of polyphosphate solution was delivered to the top of the aquifer during Stage A. The actual volume exceeded the intended design volume of 1,635,298 L (432,000 gal) by 3.7 percent.

Total volumes of polyphosphate solution delivered to each well during aquifer injections is shown in Figure 4-33. The volume injected into seven of the nine wells exceeded the target volume of 181,699 L (48,000 gal) of polyphosphate solution per well. Wells 399-1-95 and 399-1-97 accepted solution at rates less than the target operational parameter of 189 L/min (50 gal/min). This deficiency was anticipated due to very low pumping rates experienced when the wells were developed during construction (Appendix B). The low injection rates and pumping rates in these two wells are consistent with the presence of the less permeable Ringold Formation in the lower portion of the screened intervals in the aquifer (Figure 2-2). In an effort to mitigate the lower flow rates for wells 399-1-95 and 399-1-97, flow rates (and subsequent volumes) were increased to the adjacent wells (399-1-91, 399-1-94, and 399-1-96).

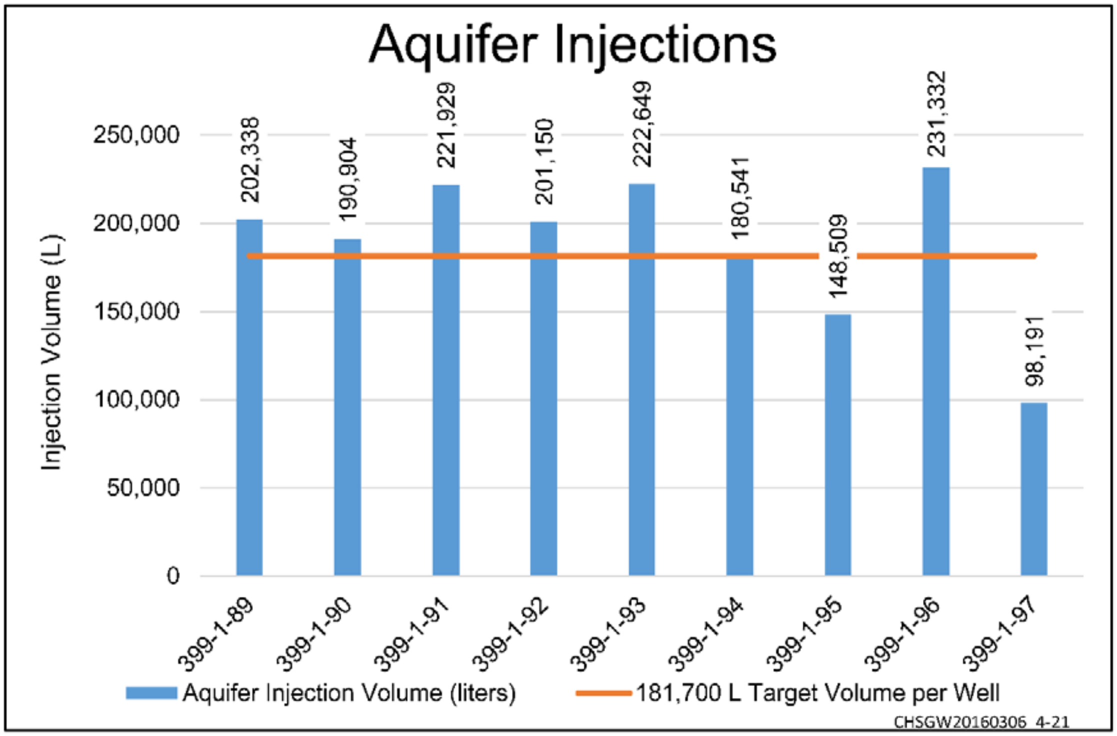


Figure 4-33. Stage A Aquifer Injection Volume Per Well

Totalizer volumes recorded on the inline flowmeters at the conclusion of the final PRZ injections on November 18, 2015, indicated 1,809,474 L (478,014 gal) of polyphosphate solution was delivered to the PRZ during Stage A. The actual volume exceeded the design volume of 1,635,298 L (432,000 gal) by 10.7 percent.

Total volumes of polyphosphate solution discharged to each of the nine wells during PRZ injections are shown in Figure 4-34. The volume injected into all of the wells exceeded the polyphosphate treatment solution target volume of 181,699 L (48,000 gal).

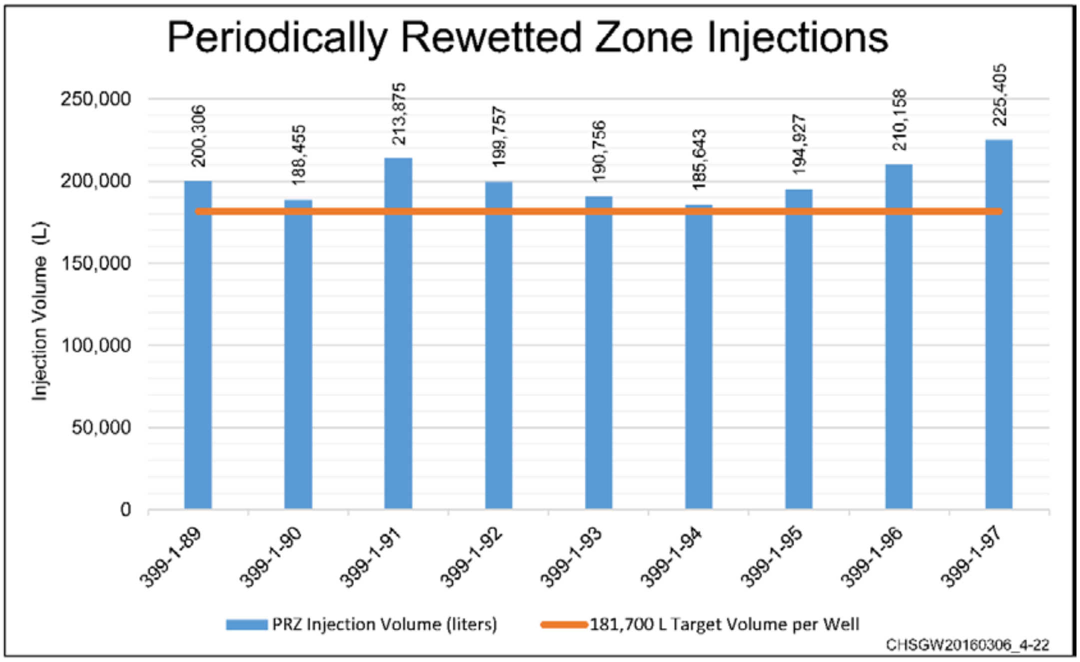


Figure 4-34. Stage A PRZ Injection Volume Per Well

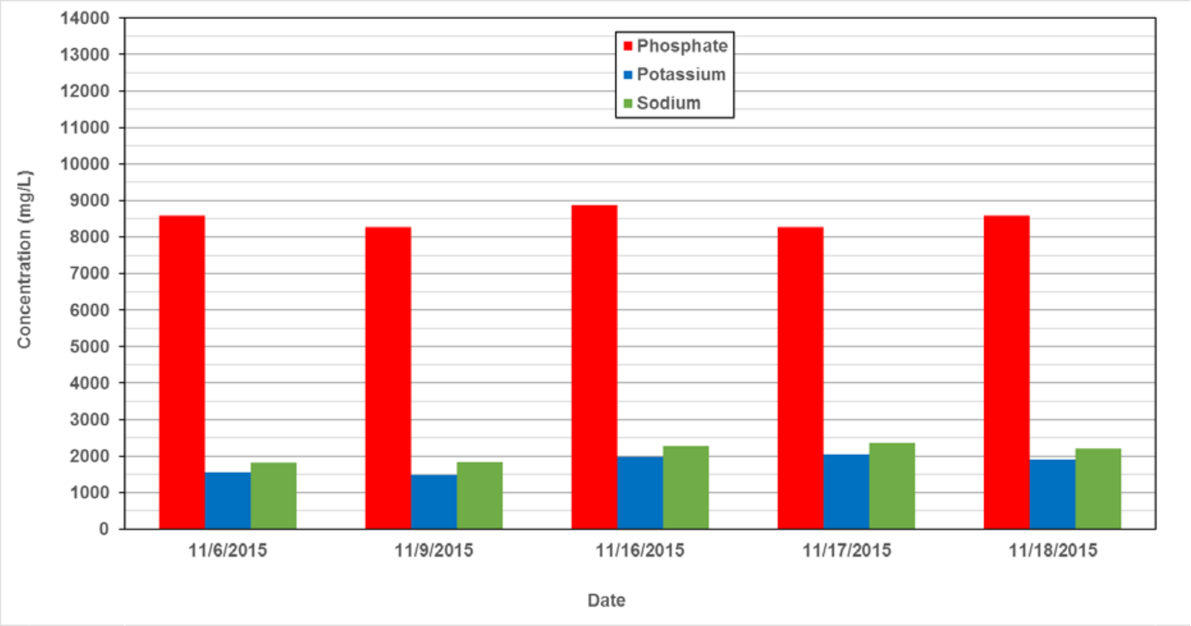
The polyphosphate solution used for aquifer and PRZ injections was composed of a mixture of 90 percent orthophosphate and 10 percent pyrophosphate, by weight as phosphate. The target infiltration concentrations are provided in Table 4-2. The composition of the injected solution for the three primary components (sodium, potassium, and phosphate [PO4]) is shown in Figure 4-35, based on daily samples collected from the injection skid. Concentrations were higher on the days when solutions were being injected (Figure 4-35), and lower on days when they were infiltrated (Figure 4-32), per the design objectives. During injection, phosphate concentrations varied from around 8,000 mg/L to 9,000 mg/L (84 to 95 mM), reflecting variability in the manufacturing of the concentrated solution and mixing with the river water in the mixing skids. Sodium and potassium concentrations varied in proportion to the phosphate concentrations, with the sodium concentrations being slightly greater than potassium concentrations.

The sample collected on November 16 represents both the aquifer injection and PRZ injection solution on that day of the operation. On November 16, a decision was made to continue 8-hour PRZ injections through the night rather than shut down in the afternoon and restart the following morning. Therefore, a second sample of the phosphate treatment solution was not collected when injections were transitioned from the top of the aquifer to the PRZ on November 16.

Table 4-2. Target Concentrations for Aquifer and PRZ Injections

Injection Solution Component	Target Injection Concentration (mM)	Approximate Target Injection Concentration of Phosphate (mg/L)
Orthophosphate*	78.4	7,450
Pyrophosphate ($Na_4P_2O_7$)	4.1	790
Total approximate phosphate (PO_4) concentration	82.5	8,240

* Mixture of NaH_2PO_4-Na_2HPO_4-KH_2PO_4-K_2HPO_4.



Source: Figure 6-3a in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 4-35. Stage A Injection Solution Daily Sample Concentrations at the Mixing Skid

Application of polyphosphate solution through injection met the design parameters.

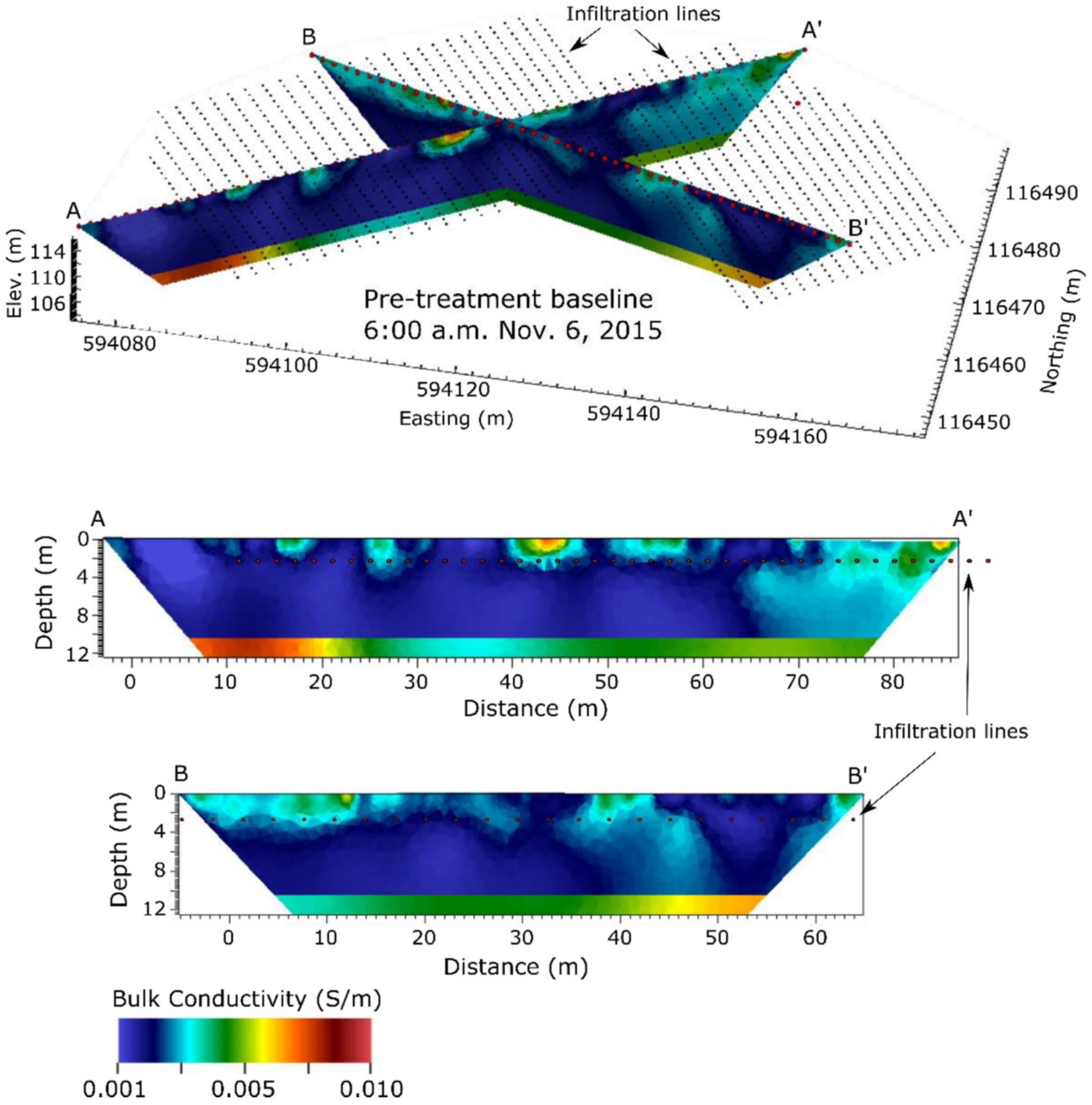
4.4 Electrical Resistivity Tomography

Real-time ERT was used to image the spatial and temporal change in electrical conductivity corresponding to migration of the polyphosphate infiltration solution through the vadose zone. The ERT network is described in Section 2.2.6, and ERT data collection is described in Section 3.4. The ERT report (PNNL-SA-25232) is provided in Appendix F.

4.4.1 Pre-Treatment Monitoring

The baseline (pre-treatment) ERT image represents the bulk conductivity distribution prior to infiltration of polyphosphate solution. The baseline image is critical because it is subtracted from every time-lapse image to reveal the change in bulk conductivity with time. During Stage A infiltration operations, the change in bulk conductivity is caused by the increase in saturation and pore fluid conductivity.
The baseline image can also be used to infer geologic structure or other properties related to spatial variations in porosity, saturation, pore fluid conductivity, texture, and mineralogy.

The baseline image for the time-lapse imaging was collected at 6:00 a.m. on November 6, 2015, just prior to the onset of polyphosphate solution injection into the saturated zone (Figure 4-36). The image shows background levels of low conductivity as expected for this region and conditions. However, some localized regions of elevated conductivity are evident. Prior to the acquisition of the baseline image, the performance of the polyphosphate solution infiltration system was tested by injecting river water into the infiltration lines. Areas of elevated bulk conductivity likely resulted from the infiltration performance test.



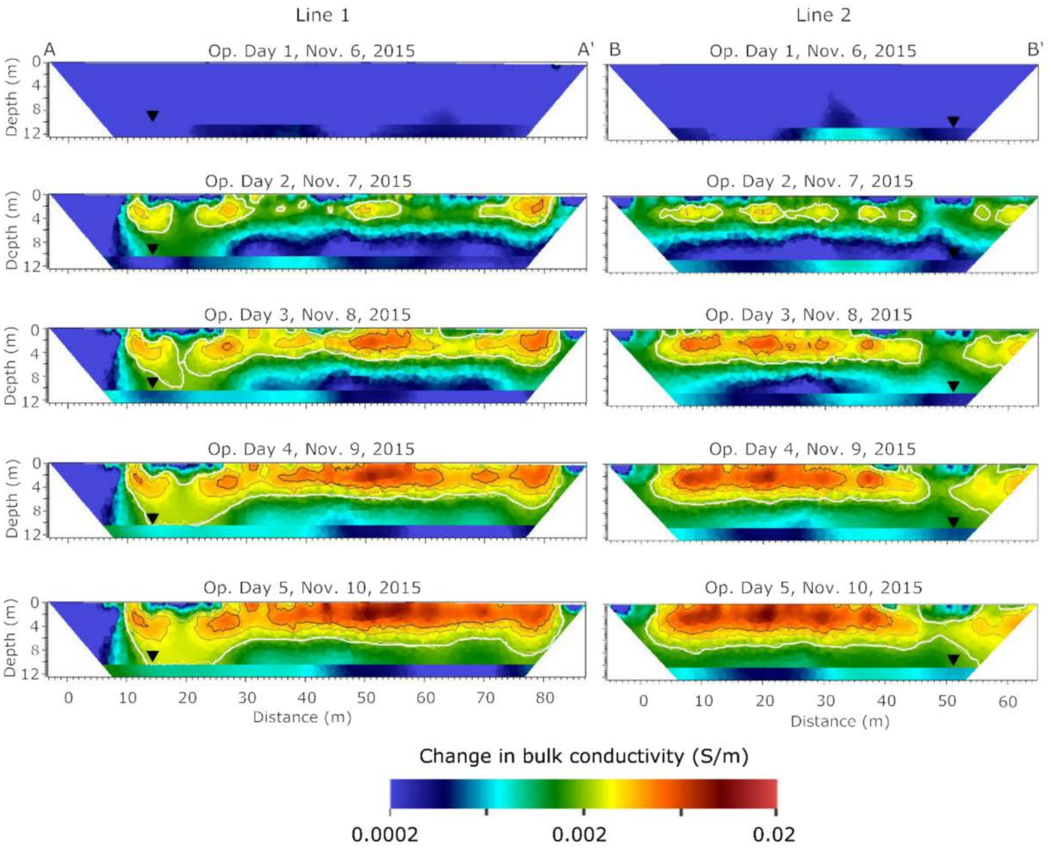
Reference: Figure 4.1 from PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography* (included in Appendix F of this report).

Figure 4-36. Baseline ERT Images for the Stage A EA Area

Due to the increase in saturation and likely change in pore water specific conductance, the baseline image does not represent absolute native conditions. However, the conditions shown are well within the range caused by natural precipitation events for this period (SGW-59455).

4.4.2 Monitoring During Treatment

Figure 4-37 shows ERT images for operating days 1 through 5 (November 6 through November 10, 2015). The column of images on the left depicts the bulk conductivity measurements for line A-A’ (line A). The column of images on the right depicts the bulk conductivity measurements for line B-B’ (line B).



Reference: Figure 4.3 from PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography* (included in Appendix F of this report).

Note: The white, gray, and black contour lines represent increases in bulk conductivity of 0.002, 0.003, and 0.004 S/m, respectively.

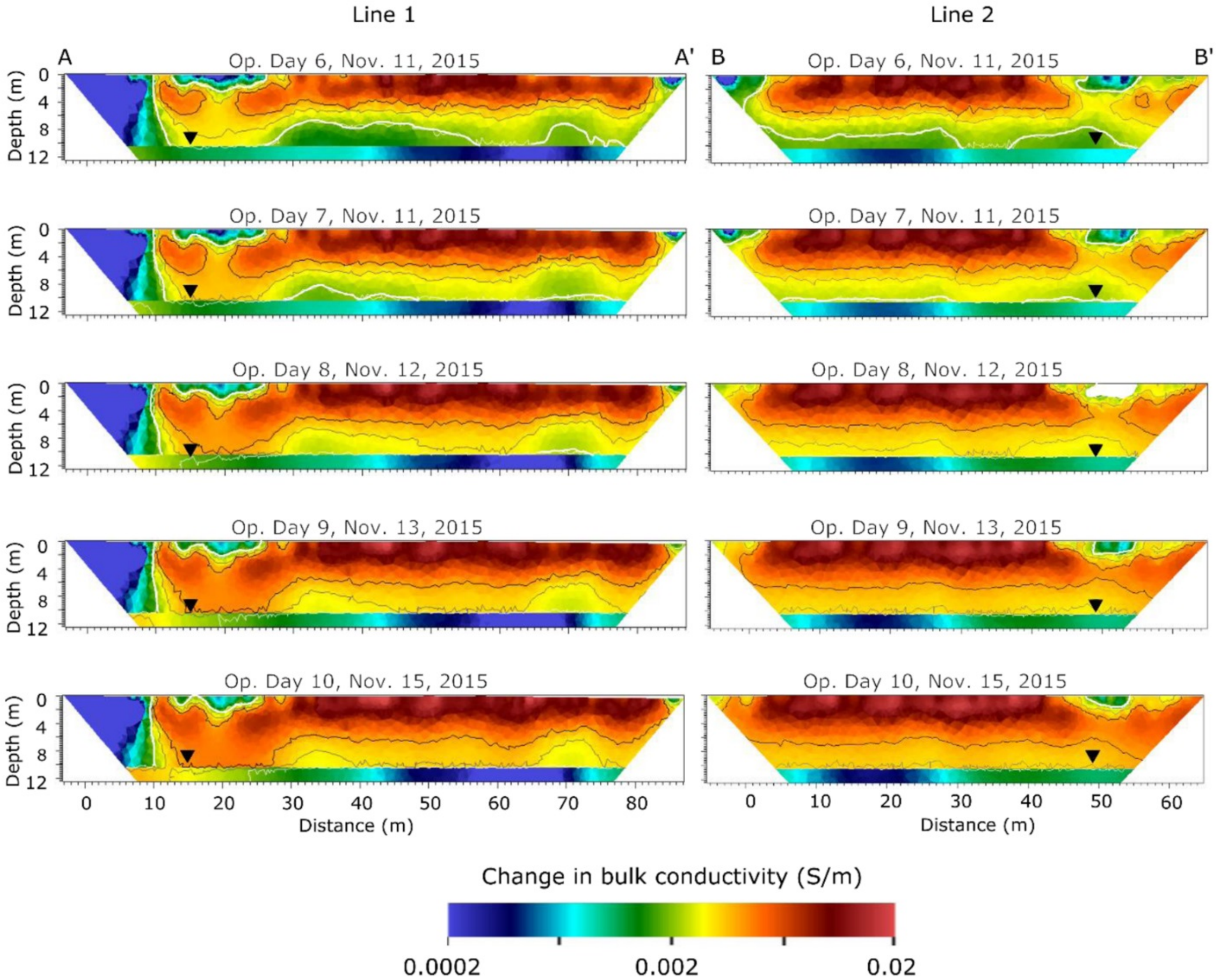
Figure 4-37. Change in Bulk Conductivity from Baseline Conditions on Operational Days 1 through 5

On day 1 (November 6, 2015), polyphosphate solution was injected into the aquifer wells. Increases in conductivity are evident below the water table beneath both ERT lines. There also appears to be a slight increase in vadose zone conductivity during day 1, which may be an artifact of limited imaging resolution.

Polyphosphate solution infiltration began on day 2 (November 7, 2015) and ended on the morning of day 11 (November 16, 2015). Figures 4-37 and 4-38 show marked increases in bulk conductivity as the solution wetting front moves toward the water table from day 2 to day 10. On day 10, ERT images display increases in bulk conductivity throughout the unsaturated zone beneath each line, suggesting the presence of polyphosphate solution throughout, with the caveat that resolution limitations disable the capability to resolve small (less than approximately 1 m^3 [35 ft^3]) regions that may have been left untreated. With the exception of one region on the western end of line A and one on the southern end of line B, the polyphosphate solution wetting front appears to have advanced relatively uniformly beneath both lines. There is no evidence of untreated regions beneath either line (Section 4.2 of PNNL-SA-25232, included in Appendix F of this report).

Figure 4-37 shows that the polyphosphate solution reached the water table relatively quickly within the region below the western end of line A, from approximately 15 to 22 m east of the westernmost end of the line. The relatively low increase in conductivity suggests lower saturation compared to the upper mid- and eastern sections of line A from days 2 through 5. Conductivity below the western end of line A steadily increased from days 6 through 10 (Figure 4-38). All of these observations are consistent with relatively coarse-grained, higher porosity materials at the western end of line A (Section 4.2 of PNNL-SA-25232).

The southern end of line B, from approximately 48 to 50 m south of the northernmost end of the line, exhibits relatively low increases in conductivity during infiltration (Figures 4-37 and 4-38). However, the southern end of line B shows a significant increase in conductivity down to the water table on day 10. The time-lapse images suggest significant lateral flow of polyphosphate solution above an elevation of approximately 110 m (5 m [16.4 ft] bgs). Lateral flow from adjacent infiltration lines delivered polyphosphate solution deeper below the southern end of line B. These observations suggest that vertical flow may have been relatively low beneath the southern end of line B because of relatively low solution application rates rather than geologic heterogeneities (Sections 4.2 and 5.1 of PNNL-SA-25232).



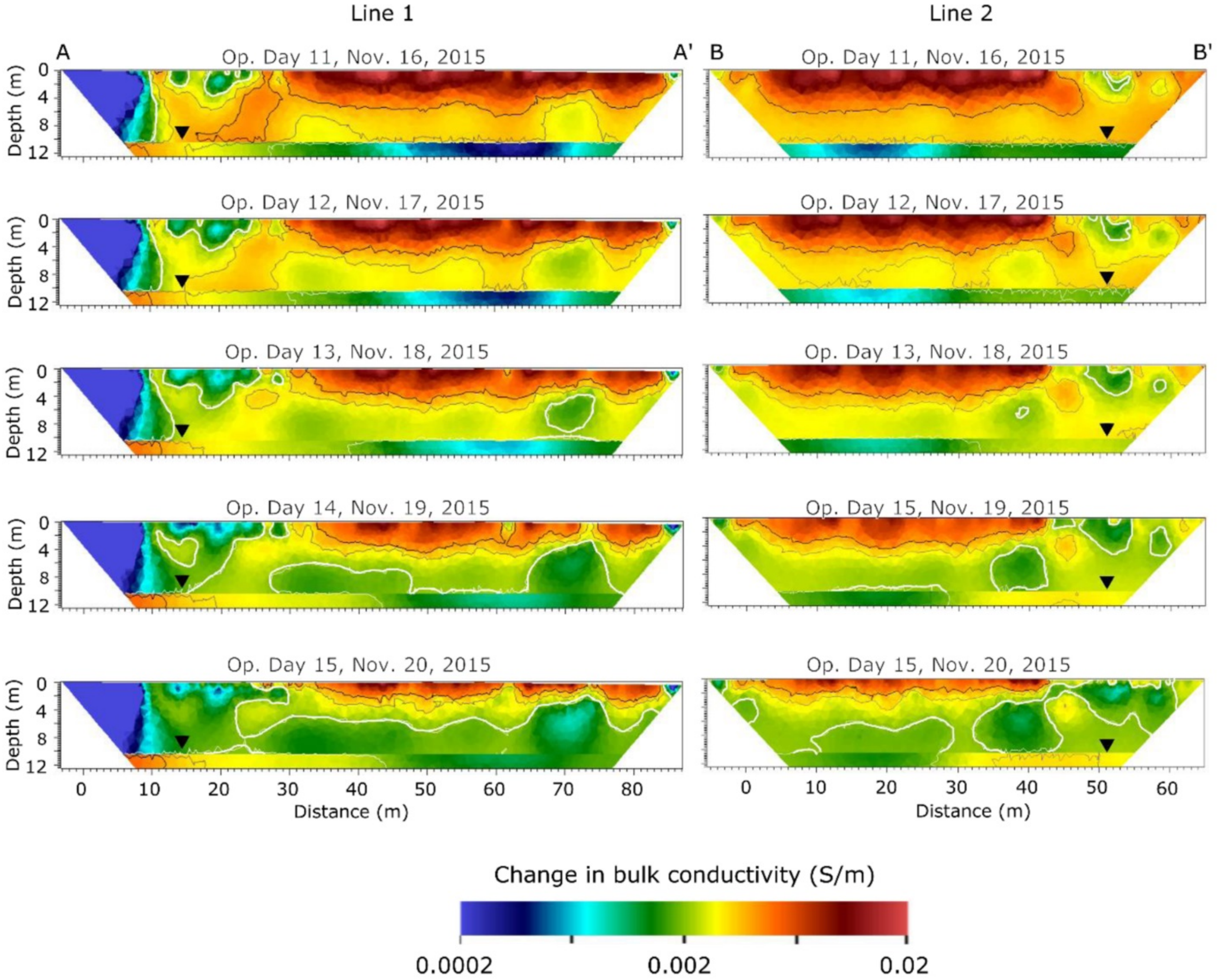
Reference: Figure 4.4 from PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography* (included in Appendix F of this report).

Note: The white, gray, and black contour lines represent increases in bulk conductivity of 0.002, 0.003, and 0.004 S/m, respectively.

Figure 4-38. Change in Bulk Conductivity from Baseline Conditions on Operational Days 6 through 10

4.4.3 Post-Treatment Monitoring

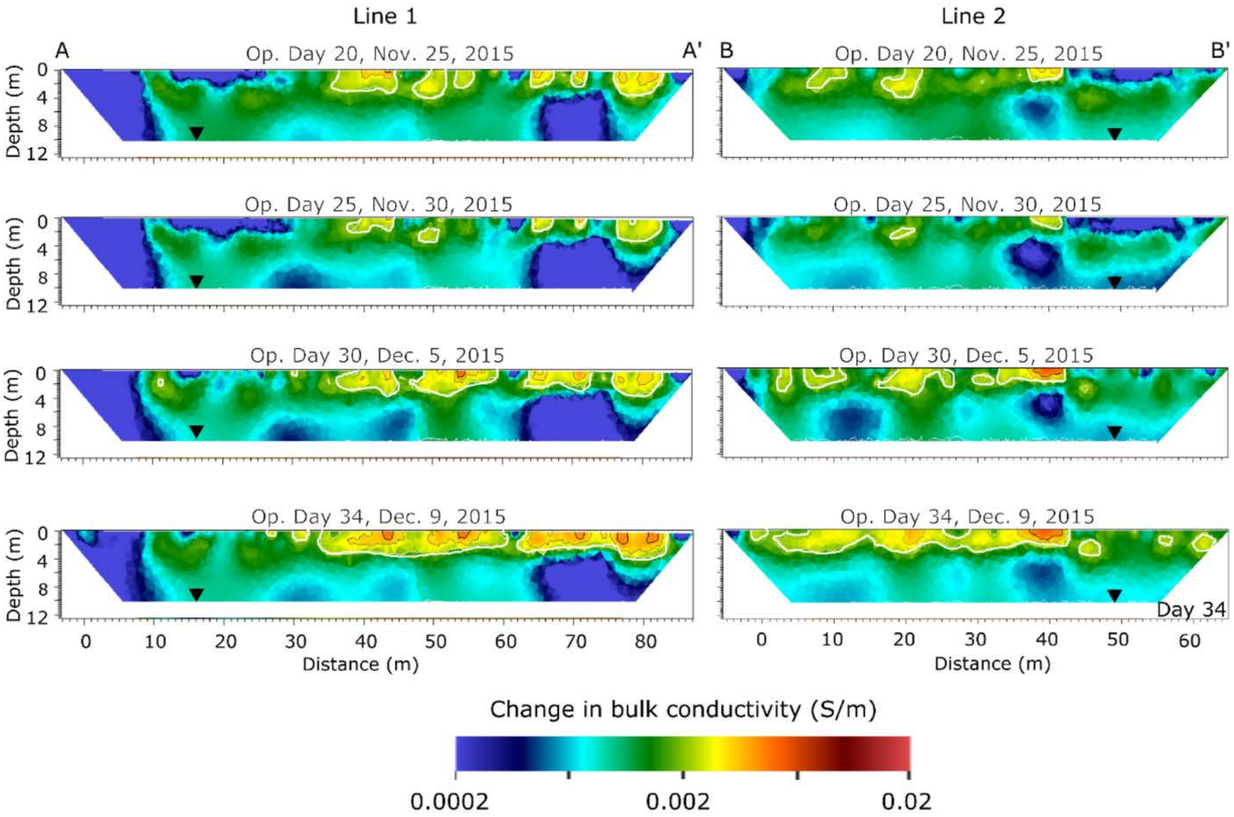
Figures 4-39 and 4-40 show ERT images collected after completion of polyphosphate solution application through the infiltration system. These images show bulk conductivity decreasing with time as polyphosphate solution drains from the unsaturated zone, starting at the water table and progressing upward. By day 25, the unsaturated zone appears to have reached a relatively steady-state condition of elevated conductivity, suggesting the presence of polyphosphate solution in the residual pore water. Increases in conductivity after day 25, particularly near the surface, are likely associated with significant precipitation events that occurred during that period (Section 4.2 of PNNL-SA-25232, included in Appendix F of this report).



Reference: Figure 4.5 from PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography* (included in Appendix F of this report).

Note: The white, gray, and black contour lines represent increases in bulk conductivity of 0.002, 0.003, and 0.004 S/m, respectively.

Figure 4-39. Change in Bulk Conductivity from Baseline Conditions on Operational Days 11 through 15



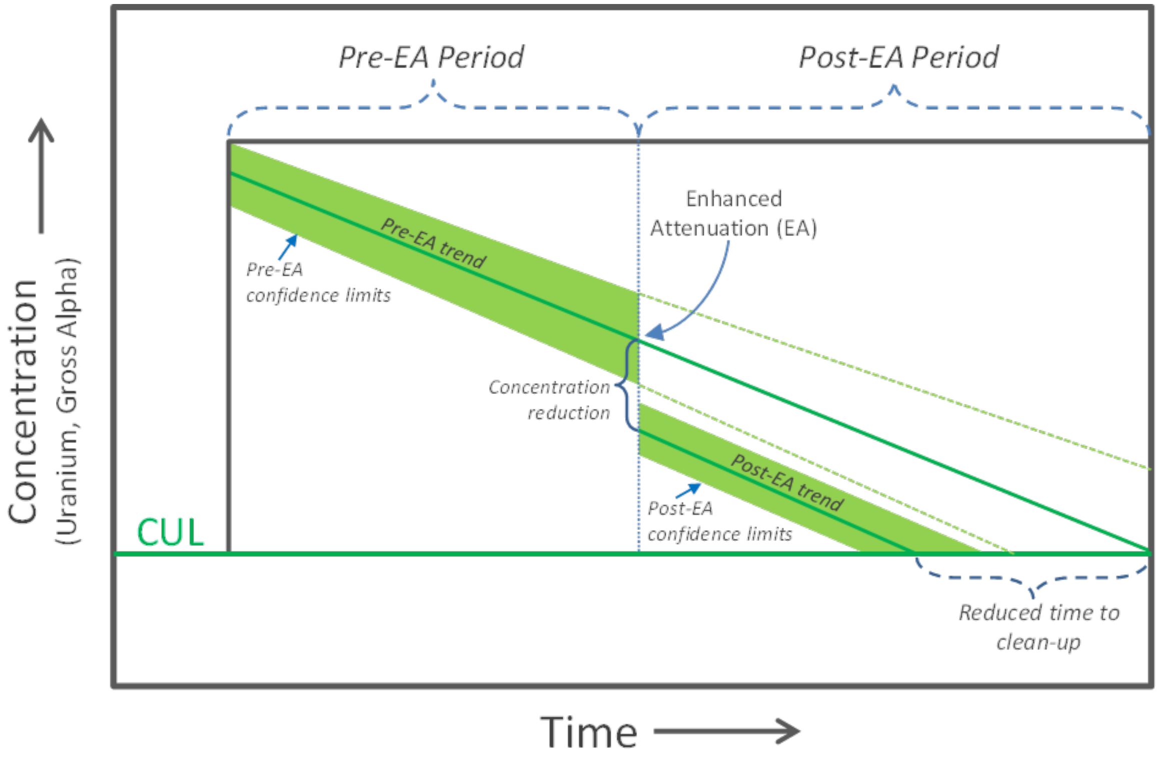
Reference: Figure 4.6 from PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography* (included in Appendix F of this report).

Note: The white, gray, and black contour lines represent increases in bulk conductivity of 0.002, 0.003, and 0.004 S/m, respectively.

Figure 4-40. Change in Bulk Conductivity from Baseline Conditions on Operational Days 20, 25, 30, and 34

5 Stage A Enhanced Attenuation Performance Evaluation

The expected outcome of the Stage A EA using polyphosphate solution application is uranium concentrations in groundwater downgradient of the EA treatment area will be lower than before the treatment (Appendix B of DOE/RL-2014-42). Furthermore, mobilization of uranium resulting from seasonal fluctuations in groundwater elevations is expected to be diminished because the uranium will be sequestered “in situ” within the vadose zone and PRZ. This may be expected to result in less seasonal variation in uranium concentrations in the underlying groundwater. The conceptual pattern of one possible groundwater response to the EA is depicted in Figure 5-1.



Source: Figure B-1 in DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan.*

Figure 5-1. Schematic of Projected Concentrations and Trends from EA

Figure 5-1 is simplified to show a linear change in concentrations following treatment, but in reality concentrations are expected to change in a more complicated manner varying spatially and temporally within the aquifer. It may take more than one cycle (e.g., 1 year) of seasonal fluctuations in groundwater elevation to evaluate the change in uranium groundwater concentrations affected by polyphosphate solution application.

Five performance measures for Stage A treatment are evaluated in this chapter:

- Phosphate delivery and distribution
- Effect of polyphosphate applications on geochemical processes and aquifer properties
- Mobilization of uranium to groundwater
- Downgradient uranium groundwater concentrations
- Uranium fate and transport modeling

The Stage A EA treatment performance is evaluated using the following lines of evidence in accordance with DOE/RL-2014-42:

- Groundwater data from samples collected before, during, and after polyphosphate solution application
- Uranium leachability data collected before and after Stage A polyphosphate solution application
- Fate and transport modeling before and after Stage A polyphosphate solution application
- Real-time monitoring of the polyphosphate solution movement in the vadose zone, PRZ, and aquifer
- Aquifer properties before and after the polyphosphate solution treatment

Treatment effectiveness also is evaluated based on the polyphosphate solution distribution resulting from infiltration and injection operations.

5.1 Polyphosphate Delivery and Distribution

This discussion is supported by the real-time monitoring of phosphate line of evidence and the analysis of soil samples needed for the leachability data line of evidence. Real-time ERT was used to evaluate polyphosphate solution infiltration by imaging the changes in spatial and temporal distribution of electrical conductivity in the vadose zone and PRZ. A complete discussion of the ERT imaging implementation and data interpretation is presented in PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography* (included in Appendix F in this report).

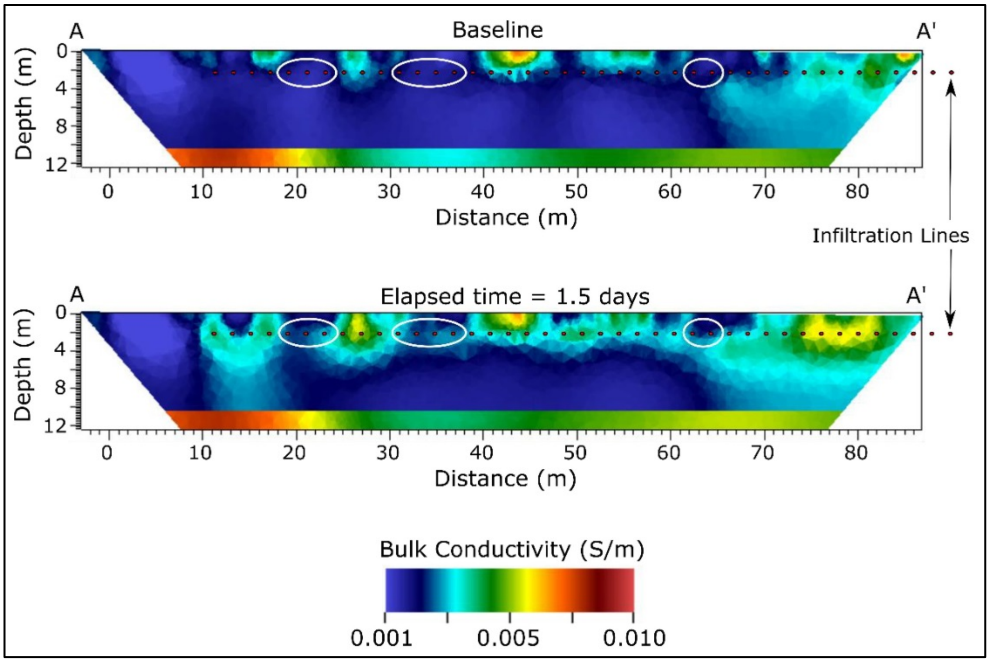
Samples were collected daily from five PRZ and two aquifer monitoring wells (Figure 3-2) to evaluate the distribution of polyphosphate solution during operations (Sections 3.2.1 and 4.2.1). Analytical results for the samples are in Appendix C of this report.

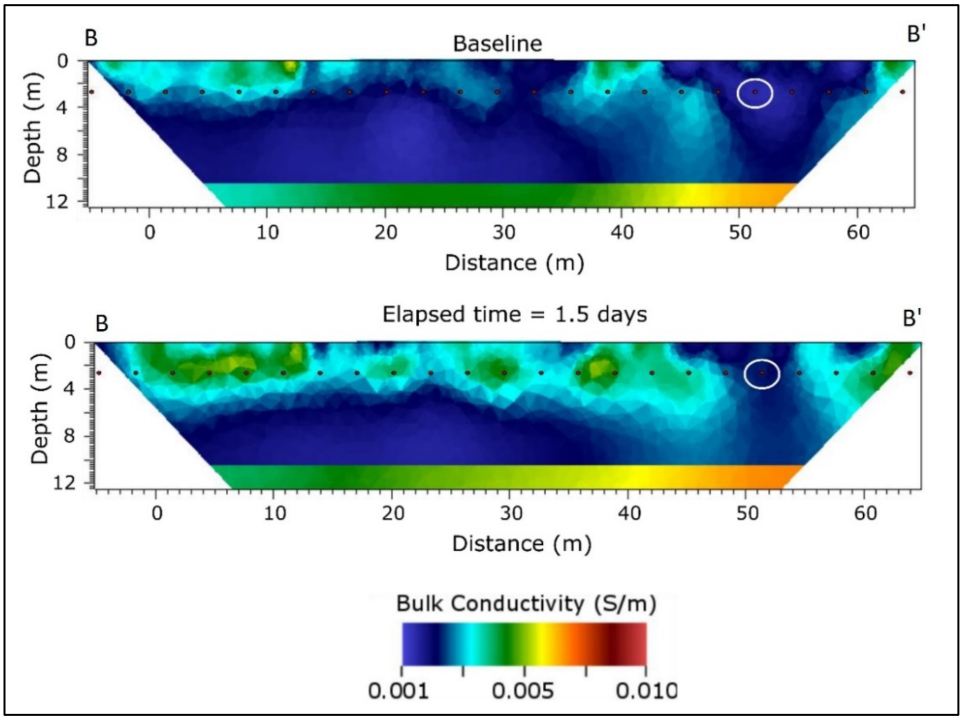
Automated monitoring was conducted at six aquifer monitoring wells (Figure 3-4) to evaluate the distribution of polyphosphate solution (Sections 3.2.2 and 4.2.2). The data are summarized in Appendix D of this report.

5.1.1 Polyphosphate Solution Distribution in the Vadose Zone During Infiltration

Figure 5-2 shows the ERT images beneath line A-A’ (east-west-oriented array) and line B-B’ (north-south-oriented array) (Figure 2-5) prior to treatment (baseline) and after an elapsed time of 1.5 days. As shown in the 1.5-day images, some areas beneath the infiltration area (white ellipses) show no change in electrical conductivity, indicating a lower rate of application of solution from some of the infiltration lines. However, time-lapse images (Figures 4-37 and 4-38) show that flow rates in these zones were sufficient for solution migration to the water table. It may be that low flows in these zones were compensated by lateral flow from adjacent infiltration lines with higher flow rates (Section 5.1 of PNNL-SA-25232, included in Appendix F of this report). Correspondingly, some areas beneath ERT lines show good function of infiltration lines and a high rate of application, such as on the northern, western, and eastern ends of the infiltration area.

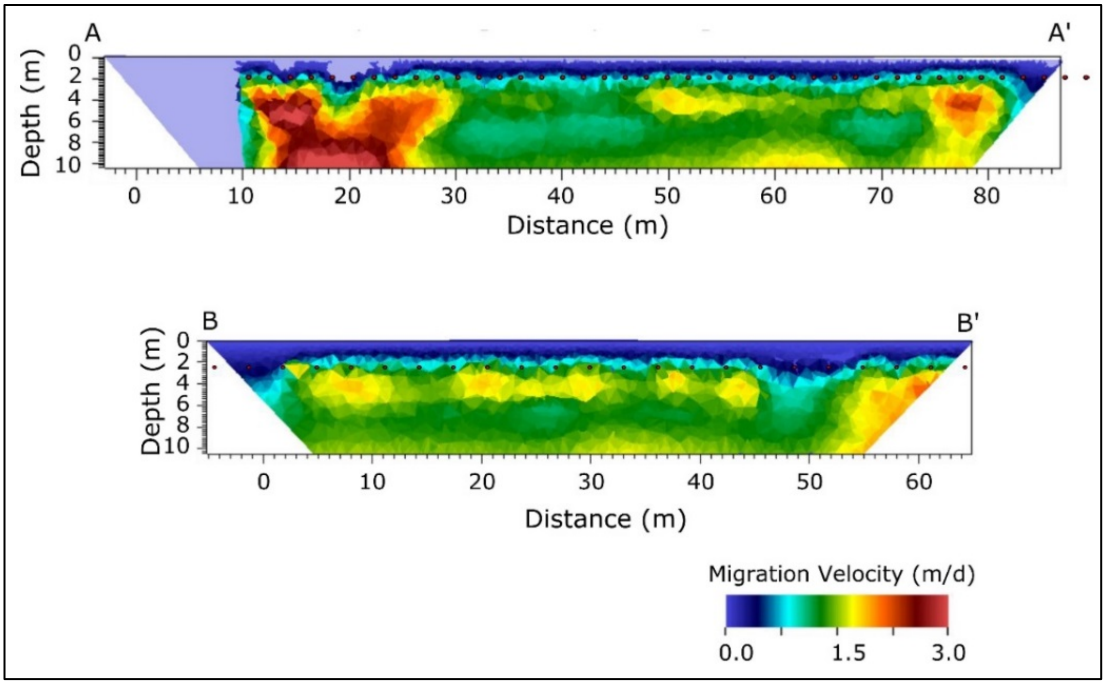
Figure 5-3 shows the depth-averaged vertical fluid migration velocity, or the rate of downward movement of infiltration fluids, across ERT lines A-A’ and B-B’. Interpretation of ERT data indicated polyphosphate solution wetting-front advancement rates ranging from 0.75 to 3.00 m/d (2.5 to 9.8 ft/d). Although the wetting-front velocity varied across the EA area, polyphosphate solution reached the water table across the entire infiltration area in 7 days or less after the start of infiltration (3 days prior to the end of infiltration).





Reference: Figures 5.1 and 5.2 in PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography* (included in Appendix F of this report).

Figure 5-2. Baseline and Day 1.5 ERT Images



Reference: Figure 5.6 in PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography* (included in Appendix F of this report).

Figure 5-3. Average Phosphate Solution Migration Velocity

The highest rates of migration were on the western end of line A-A’, along with areas of higher migration velocity on the eastern end of line A-A’ and on the farthest southern end of line B-B’. The central portion of the Stage A area generally showed slower velocities than those along the western, eastern, and southern ends.

With the exception of the western end of line A-A’, the vertical migration rates infer a horizontally stratified structure. These include a lower migration velocity zone of approximately 0.75 to 1.0 m/d (2.5 to 3.3 ft/d) bounded above and below by higher velocity zones of approximately 1.5 to 1.75 m/d (4.9 to 5.7 ft/d) (Figure 5-3). Estimates of solution arrival times suggest a decrease in hydraulic conductivity at an elevation of approximately 110 m (5 m [16.4 ft] bgs), which is consistent with patterns observed in the time-lapse images. For example, Figures 4-37 and 4-38 show the highest increase in bulk conductivity above approximately 110 m, which may have been caused by elevated polyphosphate solution saturation above this elevation because of reduced downward flow rate at and below this elevation. Interpretation of the time-lapse images indicates significant lateral migration above 110 m, which could have been caused by the presumed low hydraulic conductivity zone at and below this elevation. It appears this low hydraulic conductivity zone may have aided the overall performance of the infiltration system by promoting lateral flow above 110 m, thereby creating an even horizontal distribution of solution and compensating for variable application rates that appear to have occurred within the infiltration system (Section 5.4 of PNNL-SA-25232, included in Appendix F of this report).

During days 6 through 10 (November 11 through November 15, 2015), bulk conductivities greater than 0.004 S/m (black contour in Figure 4-38) were restricted to the region above an elevation of 109 m (6 m [19.7 ft] bgs), indicating high-concentration phosphate-bearing solutions were present in the sediments above the lower vadose zone and PRZ. The 0.002 S/m and 0.003 S/m contours (white and gray contours) reach the water table (Section 6.2 of ECF-300FF5-16-0091, included in Appendix G of this report).

The vertical profiles of phosphate concentrations in soil samples from the post-treatment boreholes are consistent with the ERT data (Figures 4-9 and 4-10). Borehole C9580 near the western end of line A-A' shows high phosphate concentrations throughout its depth profile, consistent with the relatively rapid migration of infiltrated polyphosphate solutions and higher bulk conductivity in that location. The sharp increase in phosphate concentration at about 5 m (16.4 ft) depth is due to the presence of a silt lens, which slowed the downward movement and increased saturation of polyphosphate solution at this depth. Borehole C9581 shows higher phosphate concentrations at elevations in the upper vadose zone, consistent with poor performing infiltration lines and lower solution application rates in the middle southern portion of the EA area where borehole C9581 is located. At borehole C9582, the amount of phosphate precipitation above the PRZ does not appear to be appreciable and may have been the result of local heterogeneities in permeability that could have precluded uniform distribution of phosphate at the far eastern end of the EA area (Section 6.3 of ECF-300FF5-16-0091).

5.1.2 Polyphosphate Distribution in the PRZ during PRZ Injection

PRZ injections were conducted from November 16 through 18, 2015, after completion of infiltration operations when moisture content in the PRZ was maximized.

Water levels were measured and groundwater samples were collected for analysis of phosphate and specific conductance in five PRZ monitoring wells (Figure 3-2). Groundwater elevation, phosphate concentration, and specific conductance at PRZ monitoring wells up to 10.4 m (34 ft) away from the nearest injection well showed positive hydraulic and chemical influence as a result of PRZ injections. Groundwater elevation increases on the order of 0.5 m (1.6 ft) were measured during PRZ injections (Figure 5-4). Spikes in phosphate concentrations ranged from 86 to 160 percent of the target in situ concentration of approximately 5,000 mg/L (phosphate associated with a mixture of 47.5 mM orthophosphate and 2.5 mM pyrophosphate)[1]. These spikes were also consistent with spikes in specific conductance, which increased from a background of approximately 500 µS/cm up to 4,404 to 9,790 µS/cm (Figure 5-5).

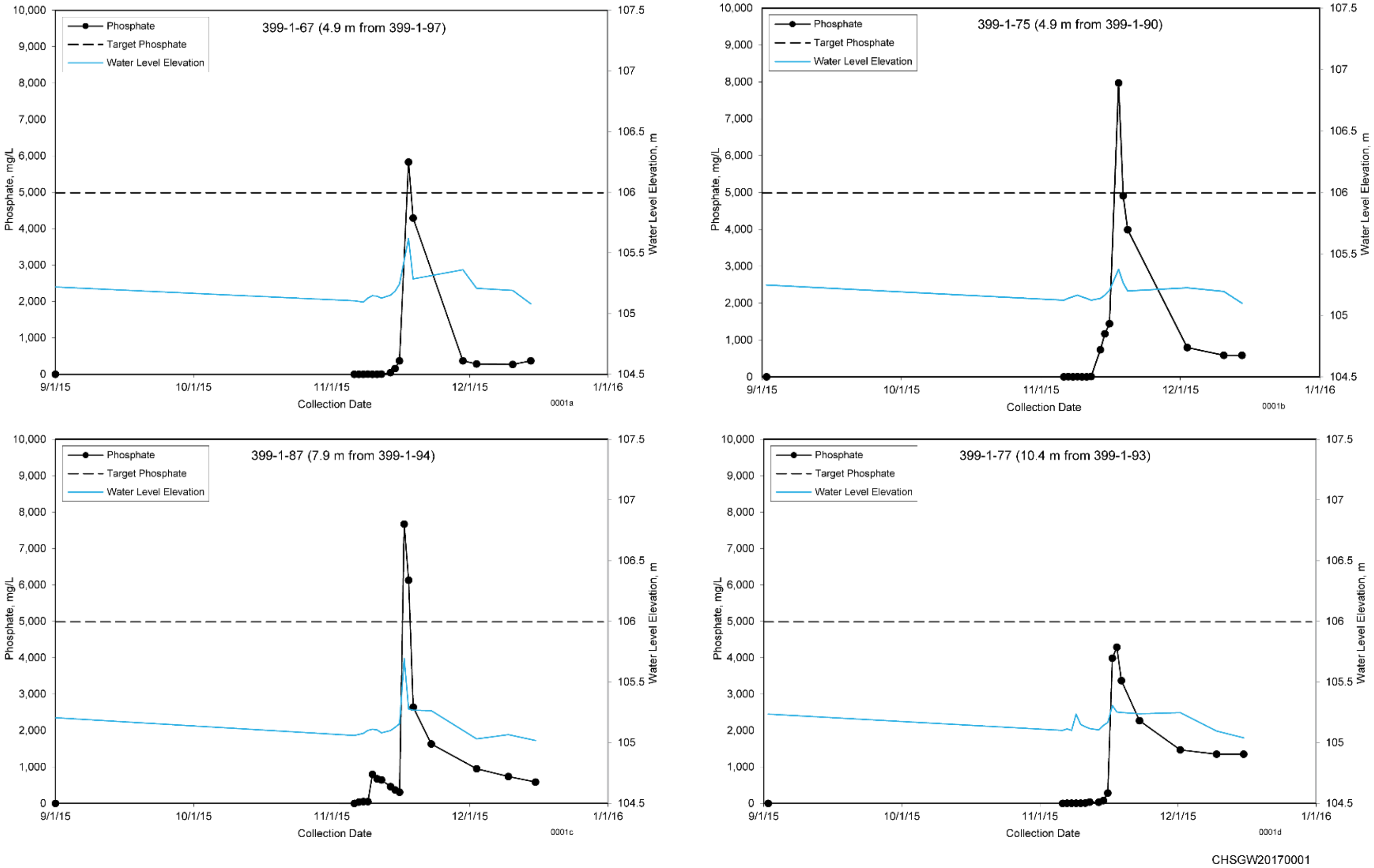
The ROI for PRZ injections during Stage A operations was estimated based on the phosphate concentrations and specific conductance in samples from the PRZ monitoring wells (Figures 4-19, 5-4, and 5-5). High levels of specific conductance and phosphate concentrations near or above the target in situ concentration of approximately 5,000 mg/L were detected in monitoring wells 399-1-67 and 399-1-75 (4.9 m [16 ft] from injection wells 399-1-97 and 399-1-90, respectively) and in monitoring well 399-1-77 (10.4 m [34 ft] from injection well 399-1-93). In monitoring well 399-1-81 (13.1 m [43 ft] from injection well 399-1-89), a steep drop-off in phosphate and specific conductance was observed compared to the wells located within 12.2 m (40 ft) of an injection well. Based on these observations, and assuming no preferential flow pathways, the average PRZ injection ROI during Stage A is judged to be around 10 to 12 m (33 to 40 ft). This ROI is expected to be variable within the vadose zone due to effects of heterogeneity in the geologic media, volume of injected solution, and injection time.

5.1.3 Polyphosphate Distribution in the Aquifer during PRZ and Aquifer Injection

Aquifer injections were conducted prior to, during, and immediately after polyphosphate solution infiltration (November 6, 9, and 16, 2015, respectively).

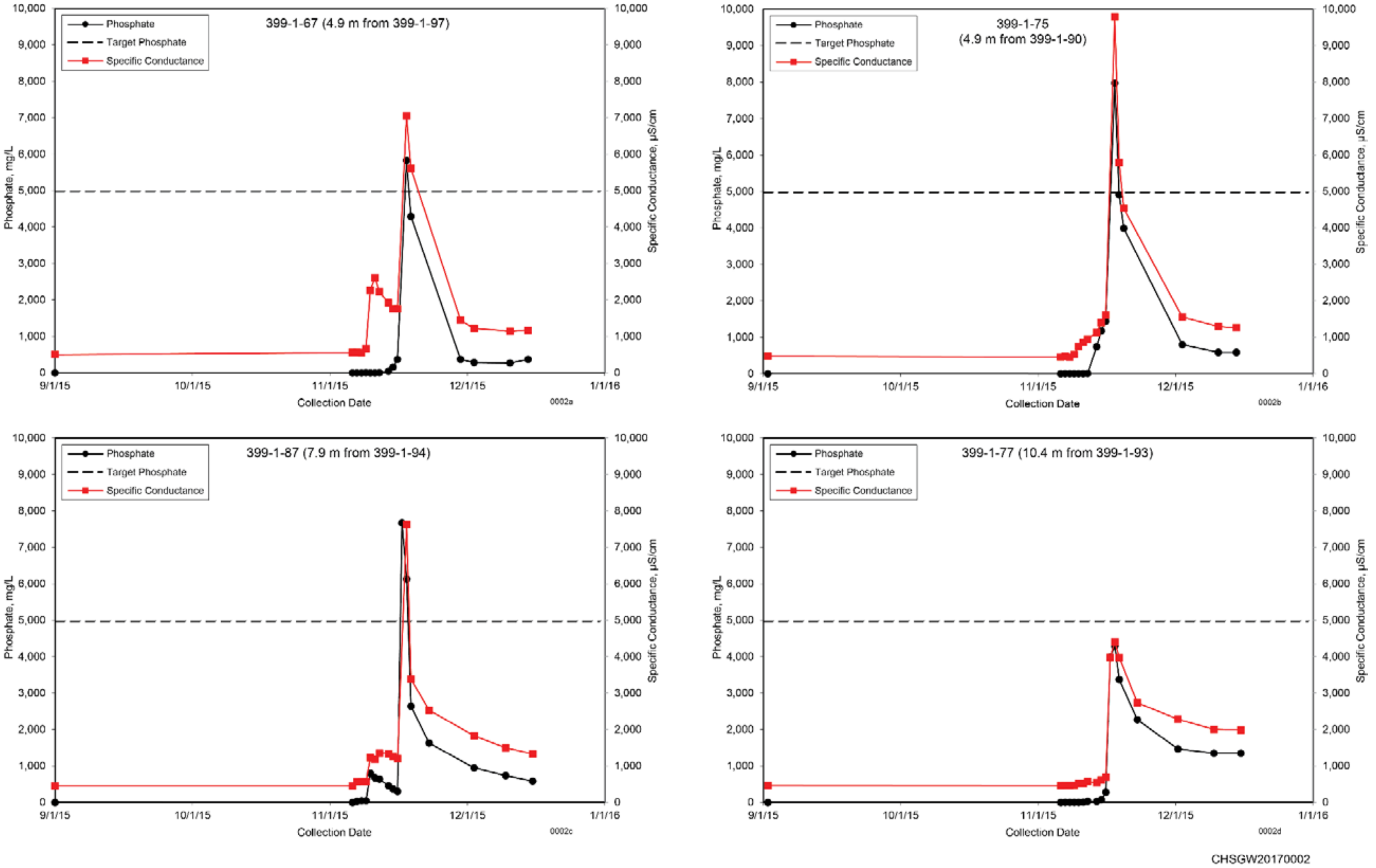
---

[1] To account for dilution in the PRZ and aquifer, the design injection concentration was increased in order to meet the target in situ concentration. The concentrations chosen for injection were 78.4 mM orthophosphate and 4.1 mM pyrophosphate, which leads to injected phosphate concentration of about 8,240 mg/L.



Note: The distance of each PRZ monitoring well to the nearest injection well is provided in the chart titles.

Figure 5-4. Groundwater Elevations and Phosphate Concentrations in PRZ Monitoring Wells during PRZ Injections (11/16/2015 through 11/18/2015)



Note: The distance of each PRZ monitoring well to the nearest injection well is provided in the chart titles.

Figure 5-5. Phosphate Concentrations and Specific Conductance in PRZ Monitoring Wells during PRZ Injections (11/16/2015 through 11/18/2015)

Water levels were measured and groundwater samples were collected for analysis of phosphate and specific conductance in two aquifer monitoring wells (Figure 3-2). These data show that aquifer injections resulted in lower chemical concentration changes in the aquifer monitoring wells than those changes observed during PRZ injections. Spikes in phosphate concentrations detected in aquifer monitoring wells 399-1-65 and 399-1-74 were 0.1 and 14 percent of the target in situ phosphate concentration of approximately 5,000 mg/L, respectively, whereas phosphate spikes during PRZ injections were 36 and 51 percent of the target in situ concentration, respectively (Figure 5-6). Phosphate spikes in the aquifer also persisted for several days longer after PRZ injections compared to aquifer injections.
The observations in phosphate concentration spikes were also generally consistent with spikes in specific conductance.

5.1.4 Phosphate Transport Modeling During Treatment and Post-Treatment Time Periods

Polyphosphate solution injection and infiltration were simulated based on the operational records for Stage A. The rate of injection and infiltration along with the timing and locations were consistent with the Stage A operation schedule presented in Table 2-1. Phosphate concentrations varied over time as well. The simulated plume maps of phosphate in the aquifer are presented in Figure 5-7 for times during treatment and following treatment.

The figure shows the phosphate plume increasing in size during phosphate solution applications and for a period afterwards. The figure shows how the phosphate plume is predicted to reduce significantly in size after about 1 year (December 2016).

5.1.5 Other Monitoring

Specific conductance, temperature, and pH were also monitored using automated sensors deployed in upgradient aquifer wells (399-1-70), aquifer wells within or at the edge of the Stage A area (399-1-80, 399-1-86, and 399-1-76), and downgradient aquifer wells (399-1-82 and 399-1-84) (Figure 3-4). General observations in parameter trends are summarized in the following paragraphs.

In upgradient well 399-1-70, minor increases in specific conductance and decreases in pH were observed during the aquifer and PRZ injection events, indicating some hydraulic influence from injections in the Stage A area. Well 399-1-91, the nearest injection well to well 399-1-70, is located approximately 21 m (69 ft) to the south.

Wells 399-1-86 and 399-1-76, located within and at the downgradient edge of the Stage A EA area, respectively, generally exhibited increases in specific conductance and decreases in temperature and pH during aquifer and PRZ injection events. Changes in parameters were more dramatic during PRZ injection events than aquifer injection events. Parameter changes in well 399-1-80, located slightly cross-gradient of the nearest injection well, were much less compared to the other two wells.
More dramatic increases in specific conductance and decreases in pH were observed 1 week after PRZ injections. These changes may be due to delayed arrival of polyphosphate solution from the cumulative infiltration and injection efforts.

Downgradient well 399-1-82, located approximately 43.6 m (143 ft) downgradient of the nearest injection well (399-1-92), exhibited a steady increase in specific conductance and decrease in pH with the increase starting several days after the first two aquifer injection events, indicating a groundwater velocity on the order of 15.2 m/d (50 ft/d). Parameter changes in downgradient well 399-1-84, located approximately 15.2 m (50 ft) southeast of the Stage A area, were more difficult to discern due to the variability in background groundwater conditions.

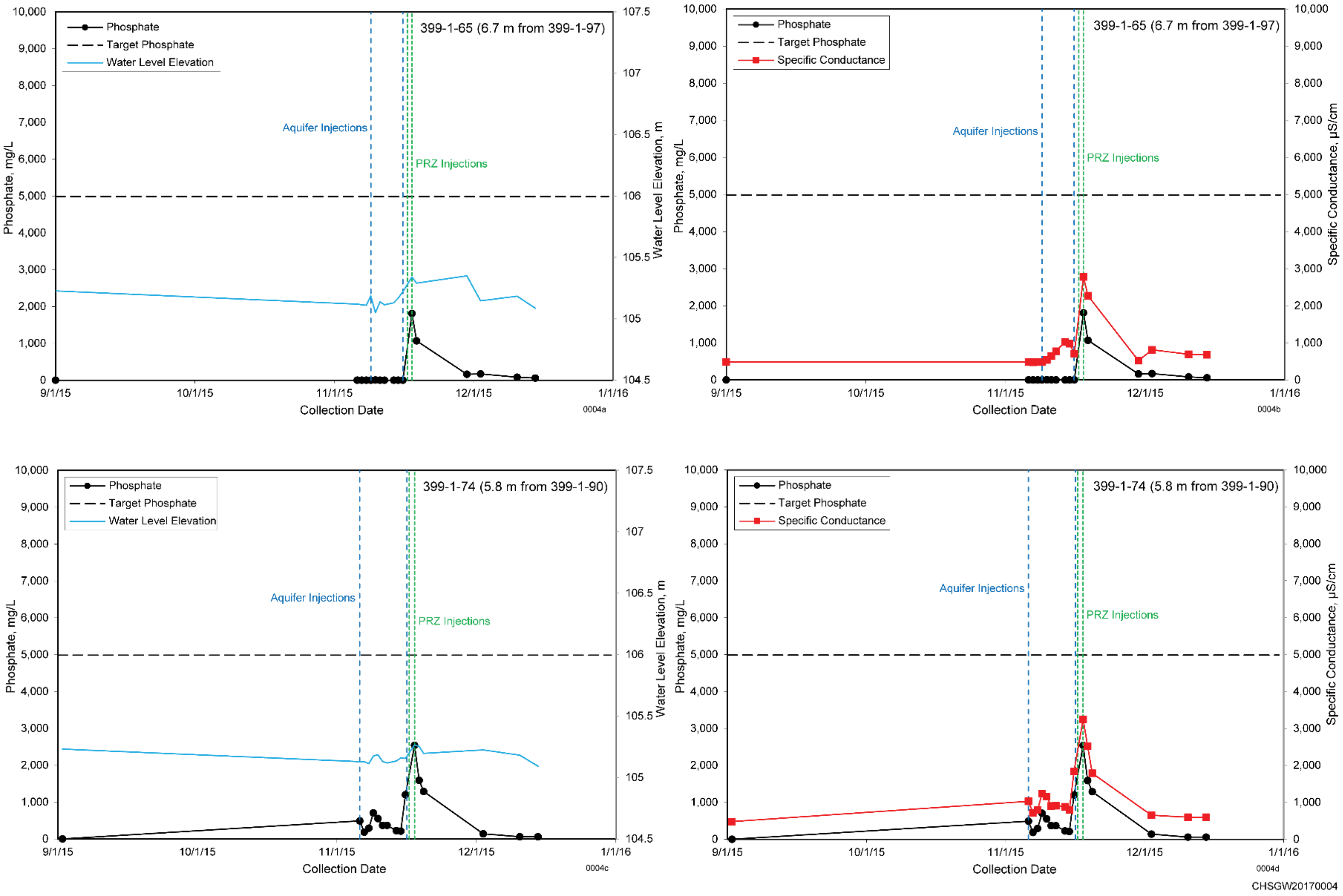
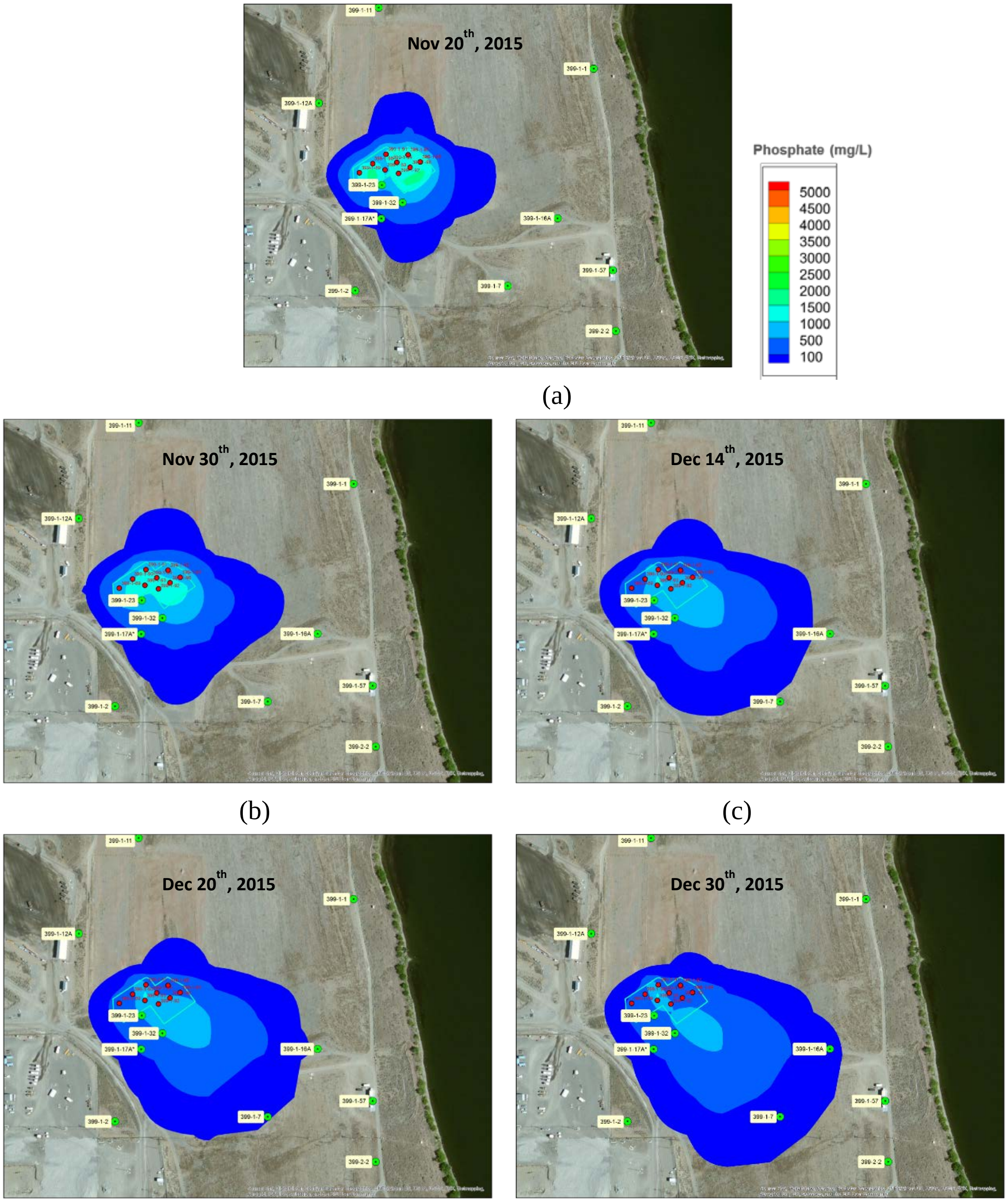


Figure 5-6. Groundwater Elevation, Phosphate Concentrations, and Specific Conductance in Aquifer Monitoring Wells during Aquifer and PRZ Injections



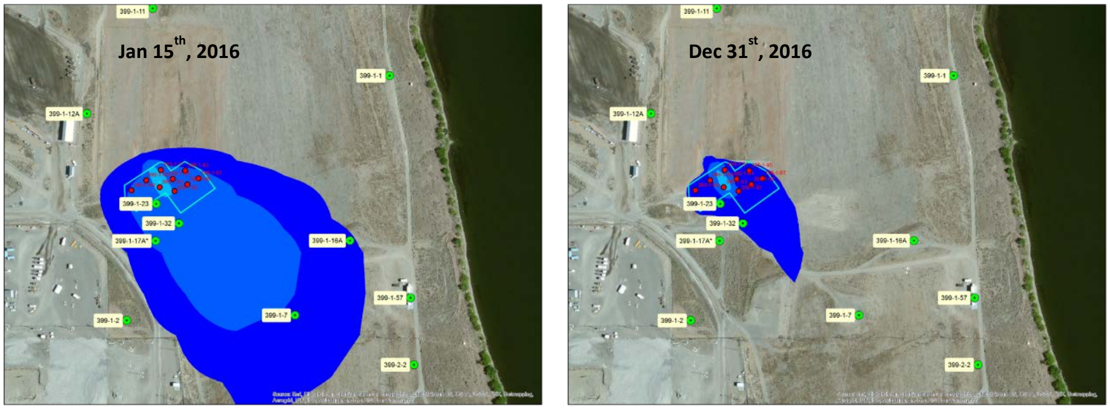
(a)

(b) (c)

(d) (e)

Source: Figure 7-20 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 5-7. Simulated Phosphate Concentration Distribution in the Aquifer for November 20, 2015, through December 31, 2016 (page 1 of 2)



(f) (g)

Source: Figure 7-20 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 5-7. Simulated Phosphate Concentration Distribution in the Aquifer for November 20, 2015, through December 31, 2016 (page 2 of 2)

5.2 Effect of Polyphosphate Applications on Geochemical Processes and Aquifer Properties

This section is supported by the leachability data line of evidence as well as the fate and transport modeling and groundwater data lines of evidence. The flow-through column and batch leach tests indicate residual uranium in the post-treatment samples is less leachable where higher concentrations of phosphate were delivered to the subsurface soils. The tests indicate injection of polyphosphate solution in the PRZ was more effective in delivering sufficient phosphate than infiltration of polyphosphate solutions from the near-surface through the vadose zone (Sections 6.2 and 8 of ECF-300FF5-16-0091, included in Appendix G of this report).

Results of the sequential extraction tests indicate the anticipated chemical interactions, which take place with the addition of polyphosphate solutions to the 300 Area vadose zone, PRZ, and aquifer, did occur as expected. The results indicate the interactions have resulted in the sequestration of uranium (ECF-300FF5-16-0091). In the pre-treatment samples, uranium is associated with crystalline iron oxides and clays, with a lesser amount complexed with carbonate minerals. In the post-treatment samples, uranium is strongly bound with carbonate minerals, weakly complexed with carbonate minerals, and present as silicate minerals. The data from the uranium leachability characteristics testing, particularly the sequential extraction tests, and field observations were used to develop a conceptual model of the geochemical processes resulting from application of the polyphosphate solutions to the vadose zone and PRZ. However, detailed laboratory testing has not been conducted to confirm the conceptual model or to evaluate potential secondary effects of adding high concentration polyphosphate solutions to the 300 Area sediments.

5.2.1 Conceptual Model of Geochemical Processes

In the sediments, uranium is found associated primarily with crystalline oxides of iron (including aluminum and manganese), clay minerals, and carbonate minerals (primarily the calcium carbonate mineral calcite, $CaCO_3$). Some of the uranium may also be associated with silicate minerals (PNNL-20004, *Uranium Sequestration in the Hanford Vadose Zone using Ammonia Gas: FY 2010 Laboratory-Scale Experiments*).

The uranium sequestration remedy depends on calcium being made available in solution to complex with phosphate leading to precipitation of amorphous monocalcium phosphate. Over a period of several weeks, the amorphous monocalcium phosphate recrystallizes to di- to octa-calcium phosphate and eventually forms hydroxyapatite over several months to years (PNNL-21733).

A conceptual model of possible reactions resulting from infiltration/injection of phosphate-bearing solutions is presented in Figure 5-8. Based on the column leach tests, sequential extraction leach tests, and the geochemical evaluations and reactive transport modeling described in Appendix B of ECF-300FF5-16-0091, the following sequence of primary reactions appears to have occurred during the Stage A application of polyphosphate solutions:

- As sodium-potassium-bearing polyphosphate solution contacts the sediment:
  - Cation-exchange reactions lead to release of calcium (Ca^{2+}) ions from the sediment into the solution (example shown for exchange with sodium):

    $$Na^{+} + 0.5\ Ca\text{-}X \leftrightarrow Na\text{-}X + 0.5\ Ca^{2+}$$

  - As more calcium becomes available in the solution, the aqueous complexation of Ca^{2+} with the phosphate species (e.g., HPO_4^{2-}) will lead to formation of calcium hydrogen phosphate ($CaHPO_4$) under the chemical conditions at the 300 Area. With continued addition of phosphate and reaction with Ca^{2+}, the aqueous concentrations would increase, leading to the precipitation of amorphous calcium phosphate that thermodynamically favors formation of calcium phosphate-bearing mineral phases, such as hydroxyapatite and whitlockite. In this process, hydrogen ions (H^{+}) are released:

    $$5\ Ca^{2+} + 3\ HPO_4^{2-} + H_2O \rightarrow \underset{\boxed{\text{Hydroxyapatite}}}{Ca_5(PO_4)_3OH} + 4\ H^{+}$$

    $$3\ Ca^{2+} + 2\ HPO_4^{2-} \rightarrow \underset{\boxed{\text{Whitlockite}}}{Ca_3(PO_4)_2} + 2\ H^{+}$$

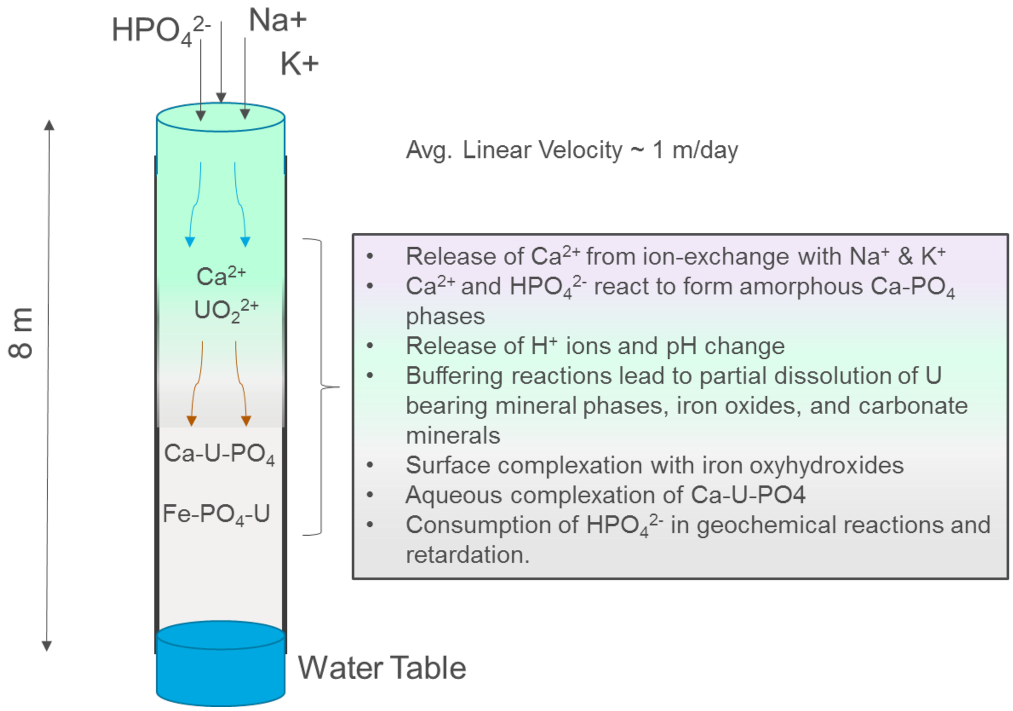
- As the pH starts to decline due to continued supply of H^{+}, buffering reactions start to occur where H^{+} ions are consumed and pH is buffered. The following reactions consume H^{+} ions:
  - Surface complexation-based reactions, primarily with reactive iron oxyhydroxide mineral surfaces (represented as $\equiv FeOH$), will occur to consume H^{+}:

    $$\equiv FeOH + H_2PO_4^{-} + H^{+} \leftrightarrow \equiv FeH_2PO_4 + H_2O$$

    $$\equiv FeOH + HPO_4^{2-} + H^{+} \leftrightarrow \equiv FeHPO_4^{-} + H_2O$$

  - Mineral reactions that lead to consumption of H^{+} ions can cause mineral phase dissolution. For uranium-bearing mineral phases that are associated with carbonates and silicates (represented by mineral uranophane as shown below), such reactions would lead to dissolution of the mineral and release of uranyl ion that could result in increased dissolved concentrations of uranium:

    $$\underset{\boxed{\text{Uranophane}}}{Ca(H_3O)_2(UO_2)_2(SiO_4)_2(H_2O)_3} + 6\ H^{+} \leftrightarrow Ca^{2+} + 2\ UO_2^{2+} + 2\ SiO_2 + 9\ H_2O$$



- Release of Ca^{2+} from ion-exchange with Na^+ & K^+
- Ca^{2+} and HPO_4^{2-} react to form amorphous Ca-PO_4 phases
- Release of H^+ ions and pH change
- Buffering reactions lead to partial dissolution of U bearing mineral phases, iron oxides, and carbonate minerals
- Surface complexation with iron oxyhydroxides
- Aqueous complexation of Ca-U-PO4
- Consumption of HPO_4^{2-} in geochemical reactions and retardation.

Reference: Figure 6-24 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 5-8. Conceptual Model of Probable Reactions Occurring in the Subsurface from Infiltration of Phosphate-Bearing Solutions

– Other carbonate-bearing mineral phases, predominantly calcite, that are present in the sediments will undergo dissolution in order to consume H^+ ions:

$$CaCO_3 + H^+ \rightarrow Ca^{2+} + HCO_3^-$$

- While there is continued supply of phosphate, the released Ca^{2+} made available from the reactions shown above will continue to bind with HPO_4^{2-} to form calcium phosphate-bearing mineral phases (e.g., hydroxyapatite), which then lead to release of H^+ ions (as shown previously). This cycle of release of H^+ ions followed by consumption of H^+ ions will continue as long as a supply of both phosphate and reacting iron oxyhydroxide surfaces and minerals (primarily uranium-bearing carbonates and silicates and calcite) is maintained. If and when the surface capacity is reached (i.e., all surface sorption sites are at equilibrium with the influent solution) and if the buffering mineral phases completely dissolve away, then phosphate concentrations will rise to match the influent solution concentrations. Some phosphate will also react with the calcium (that is made available from ion exchange reactions), leading to calcium phosphate-bearing mineral phases. In this process, any uranium in the solution will adsorb on the newly formed surfaces or become bound within the mineral and be sequestered.

- While surface reactions occur quickly and initially buffer the pH, the primary buffering reactions are likely to be controlled by mineral phase dissolution. As a result, the kinetics of the mineral dissolution along with initial available amount of reactants plays an important role in describing the behavior of the system.

- Due to varying pH, the aqueous speciation of phosphate will be dominated by either dihydrogen phosphate ($H_2PO_4^-$) or HPO_4^{2-}. As the pH reduces below approximately 7.2, $H_2PO_4^-$ becomes the dominant aqueous phosphate species:

$$HPO_4^{2-} + H^+ \leftarrow\rightarrow H_2PO_4^-$$

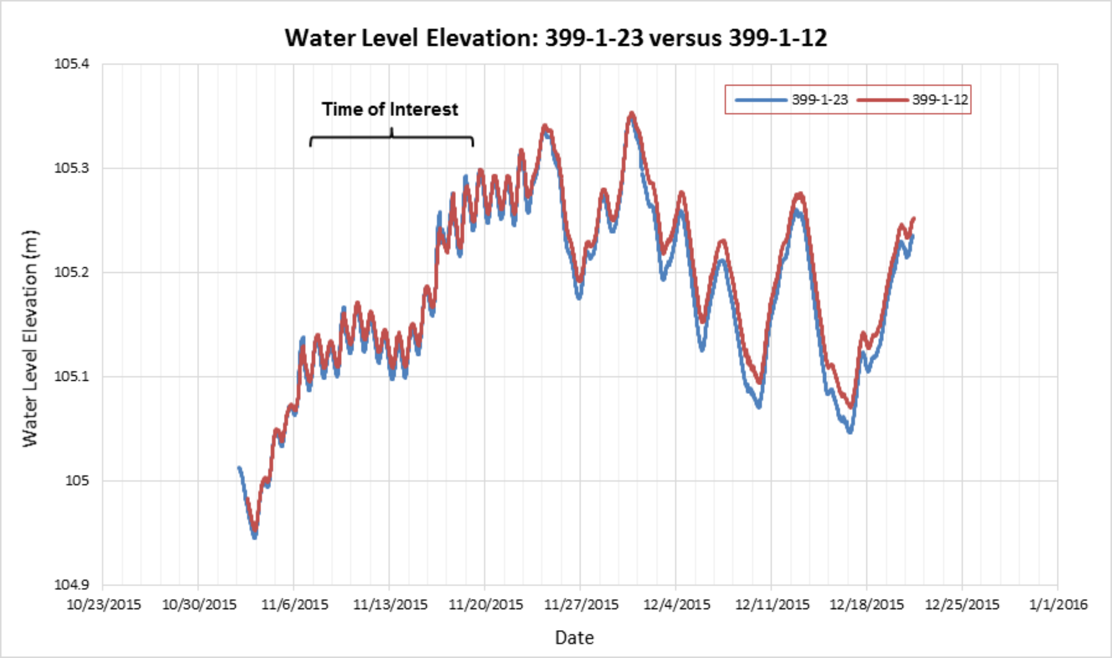
- The aqueous complexes formed by uranium will depend on the ratio of HPO_4^{2-}/HCO_3^- in the solution and pH. As long as the activity ratio of HPO_4^{2-}/HCO_3^- remains greater than 10^{-5} and pH is below 8, formation of uranyl orthophosphate mineral phase, $(UO_2)_3(PO_4)_2(H_2O)_4$, is favored assuming no other reactants are in the solution.

The conceptual model described above is consistent with the observations where dissolution and reprecipitation are noticed on sediment samples following treatment. The results of sequential extraction tests conducted on post-treatment samples indicate a relatively larger fraction of uranium associated with carbonate minerals and relatively lower fraction associated with iron oxides and clay minerals when compared to the pre-treatment samples. This is attributed to dissolution of uranium-bearing oxyhydroxides followed by incorporation of uranium with the calcium-carbonate-phosphate-bearing amorphous phases by surface adsorption and/or co-precipitation. Observed changes in association of calcium and iron, based on sequential extraction results from pre- and post-treatment samples, are consistent with the observations made for uranium and support the conceptual model. Further details are presented in ECF-300FF5-16-0091 (included in Appendix G of this report).

5.2.2 Aquifer Properties

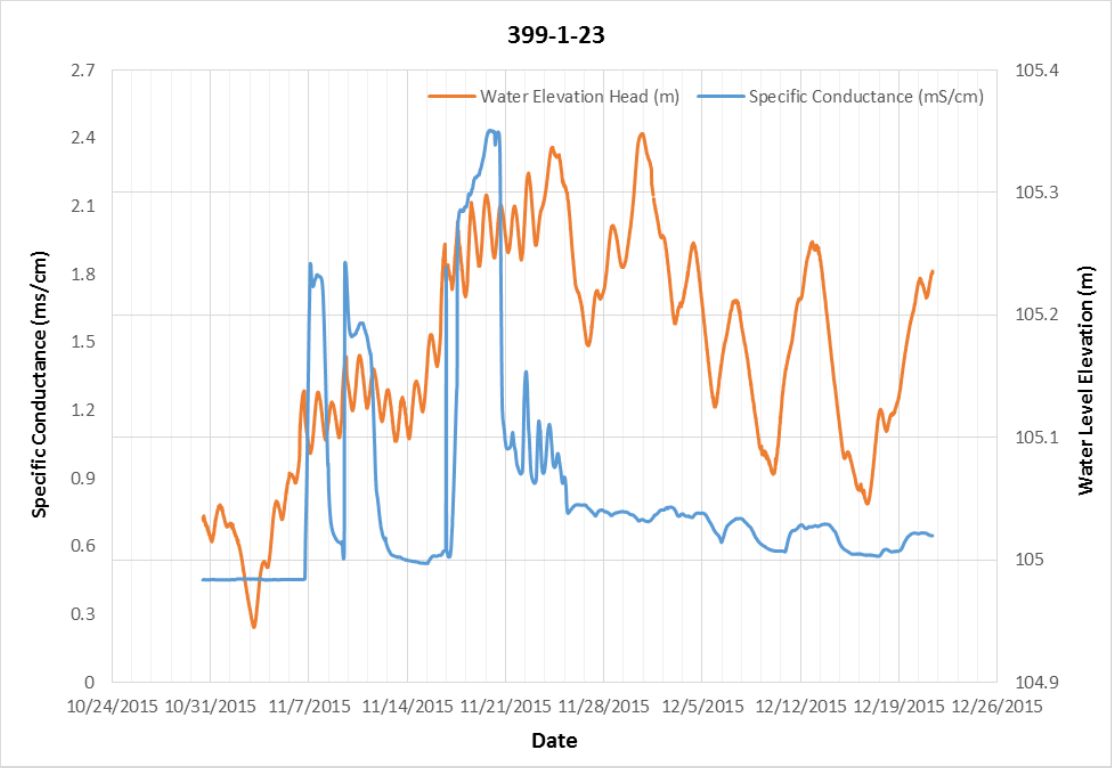
This section is supported by the aquifer properties line of evidence. The purpose of evaluating aquifer properties is to assess whether aquifer permeability was reduced due to the precipitation of phosphate minerals following infiltration and injection of polyphosphate solutions (Section B2.5 of DOE/RL-2014-42). Field testing methods, such as slug tests, were not conducted using the Stage A injection and monitoring wells. Instead, the effect of the polyphosphate applications was assessed by comparing aquifer hydraulic properties in the vicinity of the Stage A EA area before and after treatment. The assessment is summarized from Appendix E of ECF-300FF5-16-0091 (included in Appendix G of this report). The evaluation indicated the polyphosphate injections and infiltration did not alter the hydraulic conductivity of the aquifer (Appendix E of ECF-300FF5-16-0091).

Water levels in well 399-1-23 (located downgradient) were compared to water levels in well 399-1-12 (located upgradient) (Figure 3-5). The assumption for this analysis is that water levels in well 399-1-23 could be influenced by injections because of the proximity of the well to the injection sites, but that water levels in well 399-1-12 should not be affected by changes caused by injection because of its upgradient location and distance from the Stage A treatment area. Water level fluctuations in both wells before, during, and after treatment remained similar (Figure 5-9). During treatment, the specific conductance in well 399-1-23 increased, indicating it received polyphosphate solutions when they were applied in the Stage A treatment area (Figure 5-10). During this same time, specific conductance in well 399-1-12 remained at background levels, indicating no or negligible influence of polyphosphate solutions during treatment (Figure 5-11). Well 399-1-23 showed large increases in specific conductance during injection of polyphosphate solution but continued to have similar water levels as well 399-1-12 during and following treatment. Therefore, it can be concluded polyphosphate solution injections caused either no appreciable changes or only negligible changes in aquifer properties (porosity or permeability). Evaluation of the absolute difference in head between these two wells also indicated that no or only negligible change in aquifer properties occurred (Appendix E of ECF-300FF5-16-0091).



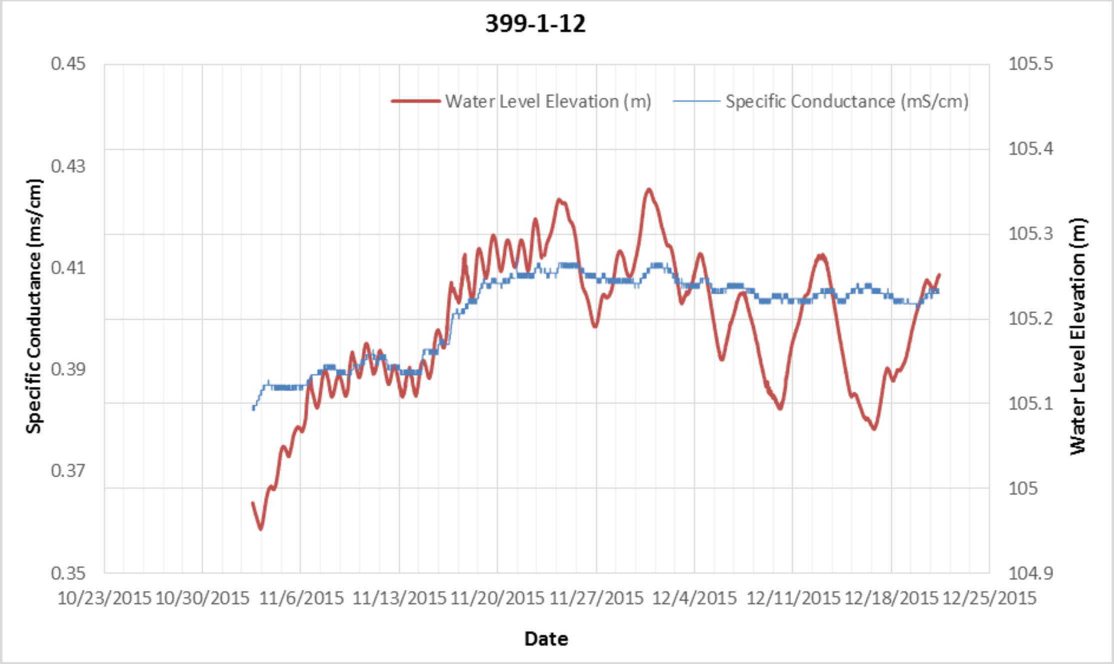
Reference: Figure E-2 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 5-9. Water Level Elevation in Wells 399-1-23 and 399-1-12



Reference: Figure E-3 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 5-10. Water Level Elevation and Specific Conductance in Well 399-1-23



Reference: Figure E-4 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

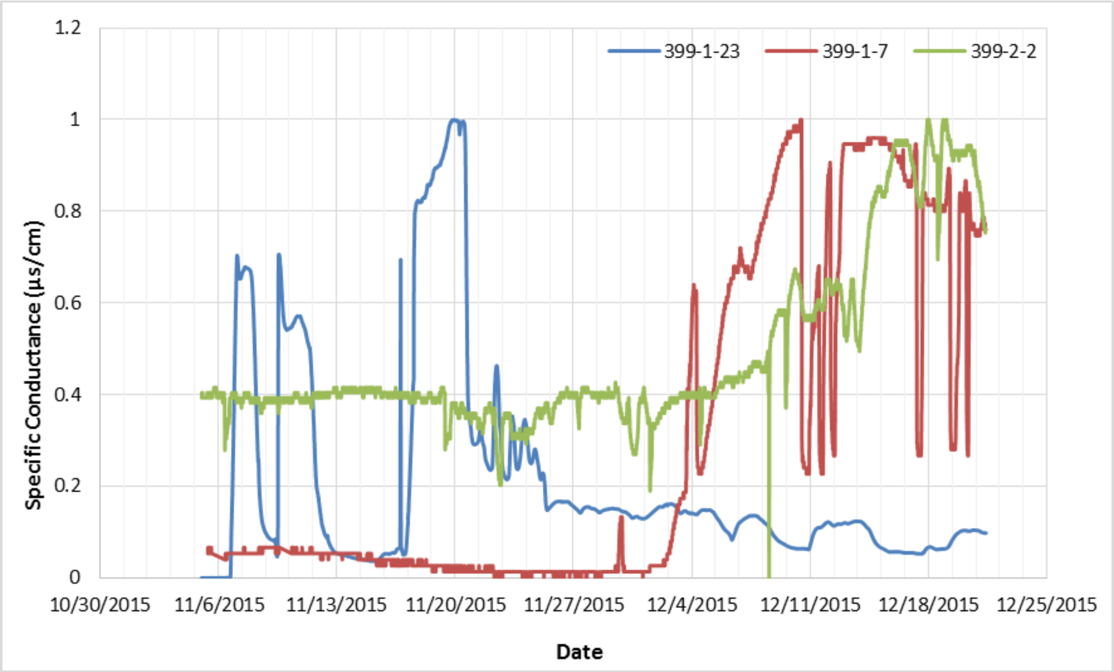
Figure 5-11. Water Level Elevation and Specific Conductance in Well 399-1-12

Estimated travel times were calculated for polyphosphate to reach three downstream monitoring wells located on an inferred flow path: 399-1-23, 399-1-7, and 399-2-2. The travel velocity from well 399-1-23 to the other two wells was calculated based on the arrival of the first peak specific conductance value (Figure 5-12). The estimated average linear velocity ranged from 9.2 m/d to 11.5 m/d with the average value of 10.3 m/d (Table 5-1). These average linear velocity estimates following injection are similar to the velocity estimated in previous studies (prior to injection) (PNNL-18529; PNNL-22048, *Updated Conceptual Model for the 300 Area Uranium Groundwater Plume*), indicating the aquifer properties have not been altered.

5.3 Mobilization of Uranium to Groundwater

This discussion is supported by the groundwater data line of evidence. Data obtained in the early (less than 1 year) post-treatment sample events are used to evaluate short-term changes in uranium concentrations due to sequestration and/or mobilization from the vadose zone and PRZ and the distribution efficiency of polyphosphate solution across the EA area groundwater (Section B2.5.4 of DOE/RL-2014-42).

Aquifer monitoring wells 399-1-65 and 399-1-74 were monitored before, during, and after infiltration and injections to assess changes in uranium concentrations and evaluate the potential for uranium mobilization to the aquifer during phosphate solution application (Figure 3-2). Uranium concentration trends in these two aquifer wells along with other aquifer wells within or at the edge of the Stage A EA area (wells 399-1-76, 399-1-78, 399-1-80, and 399-1-86) were compared with data collected from upgradient aquifer wells (399-1-66, 399-1-70, and 399-1-72) and downgradient aquifer wells (399-1-25, 399-1-36, 399-1-82, and 399-1-84) to differentiate between background changes in uranium concentrations and changes directly associated with the polyphosphate solution application.



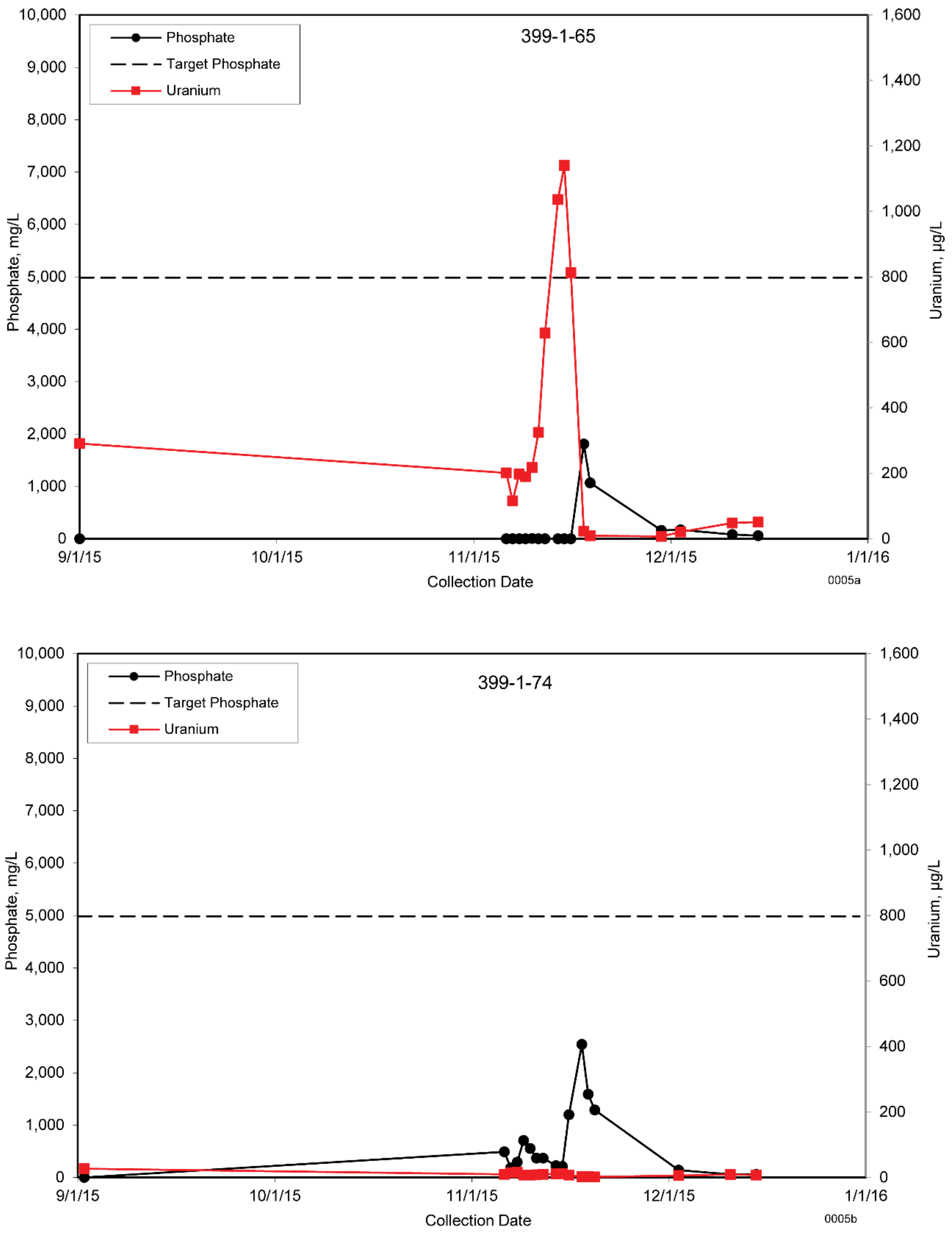
Reference: Figure E-6 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit.*

Figure 5-12. Specific Conductance in Wells 399-1-23, 399-1-7, and 399-2-2

Table 5-1. Travel Time Calculation Results

Well	**Travel Time from Well 399-1-23 (days)**	**Velocity (m/d)**
399-1-7	20.49	9.2
399-2-2	28	11.5
	Average Velocity	10.3

Daily monitoring data from aquifer wells 399-1-65 and 399-1-74 also provided insight into the potential for temporary uranium concentration spikes during polyphosphate solution application (Figure 5-13). No significant uranium concentration spikes were observed in aquifer well 399-1-74. In aquifer well 399-1-65, a uranium concentration spike of 1,036.5 µg/L occurred on the eighth day of infiltration. The spike dissipated within 3 to 4 days. The aquifer well downgradient of this concentration spike (399-1-84) also exhibited no significant change in uranium concentrations following polyphosphate solution application (Figure 4-24), indicating that a very limited mass of uranium was mobilized locally around aquifer well 399-1-65 and that temporary spikes of uranium in the aquifer due to polyphosphate solution application did not pose a significant impact to groundwater quality.



CHSGW2017005

Figure 5-13. Uranium and Phosphate Concentrations in Aquifer Monitoring Wells 399-1-65 and 399-1-74

5.4 Downgradient Uranium Groundwater Concentrations

Groundwater data collected at downgradient groundwater monitoring wells through June 2016 (7 months after the completion of polyphosphate solution injection and infiltration) were also reviewed to evaluate the occurrence and degree of uranium mobilization downgradient of the Stage A EA area (Figure 3-3).

Increases in specific conductance and phosphate concentrations were observed in the two wells (399-1-23 and 399-1-17A) closest to the Stage A area approximately 1 week after the start of polyphosphate solution application (Figures 4-25 and 4-26). During this same timeframe, uranium concentrations decreased below baseline (pre-treatment) concentrations collected between September 15 and 23, 2015 and also below the uranium cleanup level (30 µg/L). Uranium concentration trends in well 399-1-17A from 2010 through June 2016 are shown in Figure 5-14. The increasing concentrations in March through June 2016 may be a result of the rising water level mobilizing residual uranium. Approximately 1 month after the start of polyphosphate solution application, specific conductance and phosphate concentrations gradually increased and uranium decreased in well 399-1-7 (Figure 4-27). Longer term groundwater monitoring is needed to confirm these trends.

The data collected from the groundwater wells farther downgradient of the Stage A EA area corroborate the observations made at monitoring wells within and near the Stage A area, which show that any temporary spikes of uranium in the aquifer due to polyphosphate solution application have not impacted groundwater quality. Conversely, uranium concentrations downgradient of the Stage A EA area have decreased due to the Stage A phosphate solution application.

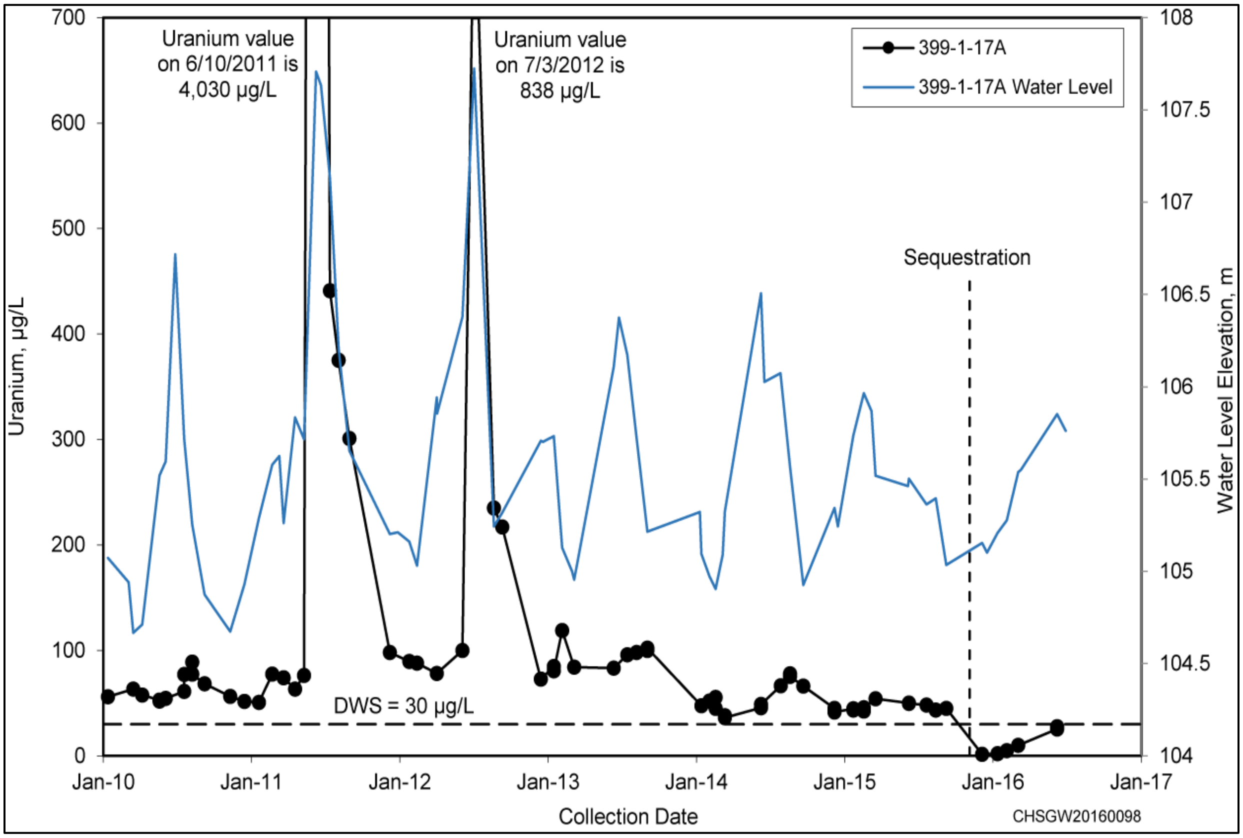


Figure 5-14. Uranium Concentrations and Water Level Elevations in Well 399-1-17A

Uranium concentration data collected approximately 1 month after completion of polyphosphate solution infiltration and injection were compared to baseline (pre-treatment) concentrations collected between August 28 and September 2, 2015. Overall, uranium concentrations in the aquifer upgradient, within, and downgradient of the Stage A EA area decreased after polyphosphate solution application. Uranium concentrations in upgradient aquifer wells decreased by 13 to 67 percent from baseline concentrations (from between 31 and 50 µg/L to between 16 and 44 µg/L). Changes in uranium concentrations in upgradient wells likely reflect normal seasonal variability. By comparison, uranium concentrations in the EA area aquifer wells decreased by 50 to 98 percent (from between 27 and 291 µg/L to between 4.8 and 85 µg/L), indicating further concentration decreases due to polyphosphate solution infiltration and injection. Downgradient aquifer wells, which represent groundwater flowing from the Stage A EA area during and after polyphosphate solution application, showed similar decreases in uranium concentrations (48 to 98 percent, or from between 3.5 and 61 µg/L to between 0.26 and 24 µg/L) as a result of polyphosphate solution application.

5.5 Uranium Fate and Transport Modeling

This discussion is supported by the fate and transport modeling and groundwater data lines of evidence. The discussion uses numerical modeling of the fate and transport of uranium in 300 Area soils and the unconfined aquifer to evaluate the effectiveness of the Stage A EA remedy. The model simulates fate and transport for cases in which no remedial action is implemented and in which Stage A application of polyphosphate solutions is implemented. Detailed documentation on development and calibration of the fate and transport modeling is provided in ECF-300FF5-16-0091 (included in Appendix G in this report). The uranium soil distribution and geologic framework used in the model was taken from ECF-300FF5-16-0087, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit, Hanford, Washington* (included in Appendix G in this report).

The fate and transport modeling results predict possible changes in groundwater uranium concentrations in the near future (1 year) and in the long term (over 20 years) as a result of the Stage A EA remedy. These results are compared to predictions of groundwater uranium concentrations that would result if no remedial action was taken (the hypothetical "no action" case).

Fate and transport modeling was performed in three stages:

1. Modeling uranium transport prior to Stage A treatment.

   The fate and transport model was developed to estimate the uranium soil and groundwater concentrations prior to Stage A treatment. The emphasis of this model was to match the uranium concentrations in the aquifer observed over the past approximately 20 years. The model was also extended for an additional 25 years in the future (until 2040) to project the concentrations under the hypothetical no action case. The results demonstrate the adequacy of the modeling methodology and choice of parameters at the scale of the model domain.

2. Modeling phosphate transport during Stage A treatment and post-treatment time periods.

   Phosphate transport was modeled based on information derived from experimental data on phosphate migration and retardation and from observations of phosphate concentrations made during the treatment and post-treatment time periods. Polyphosphate solution injection and infiltration operations were simulated, and phosphate concentrations were compared to the observations made in the PRZ and aquifer wells. The results were used to demonstrate adequacy of parameters for modeling polyphosphate solution transport in the vadose zone and aquifer and for projecting concentrations in the aquifer. The results of this monitoring stage are discussed in Section 5.1.4.

3. Modeling uranium transport during Stage A treatment and post-treatment time periods.

   The impact of injecting/infiltrating polyphosphate solutions on uranium transport was modeled by changing the kinetic sorption-desorption parameters. The choice of parameters was based on evaluation of flow-through column test results on post-treatment samples, phosphate concentrations measured in the samples, and observed changes in uranium concentrations in the aquifer.

5.5.1 Uranium Transport Without Treatment (No Action Case)

The fate and transport model was used to simulate uranium groundwater concentrations assuming no remedial action had occurred (no action case). The focus was on matching the trend in uranium concentrations in selected wells where long-term monitoring records exist and to be reasonably close to the magnitude of uranium concentrations observed in the aquifer. The exact reconstruction of the past was not the objective of the model due to limited information on the uranium soil distribution and various past remediation activities.

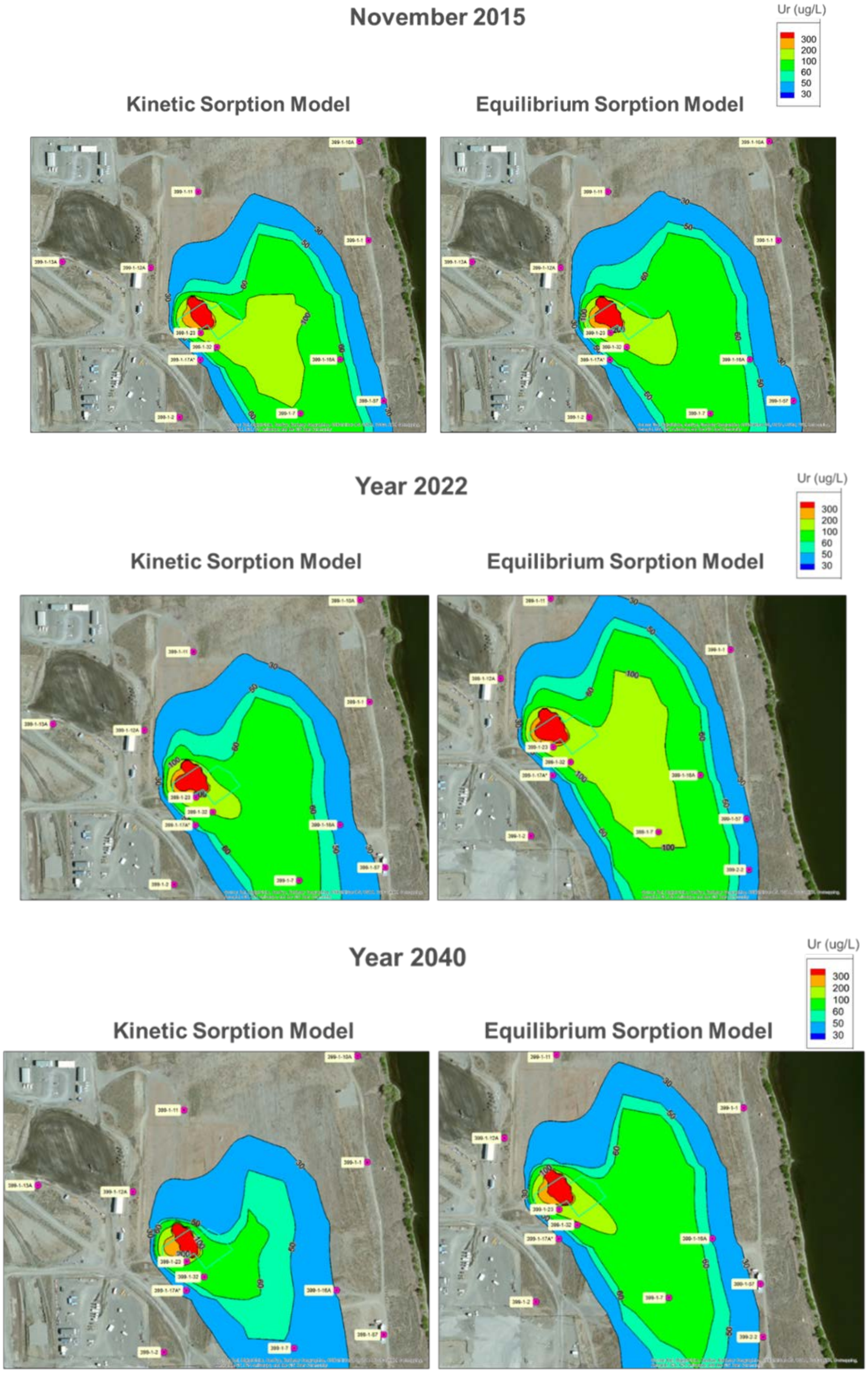
Calibration of the uranium model included adjusting the initial soil uranium concentrations by setting all saturated zone Hanford and Ringold unit soil concentrations to zero. This is based on the understanding that the labile fraction would have been removed over many decades of pore volume flushing prior to start of the model. The simulated uranium groundwater concentrations are compared to the observed concentration for selected monitoring wells using both an equilibrium and kinetic sorption model.

Figure 5-15 shows simulated uranium plume maps for equilibrium and kinetic sorption models for the years 2015, 2022, and 2040. The simulation results presented in ECF-300FF5-16-0091 (included in Appendix G of this report), when compared to the long-term monitoring records, indicate that the kinetic model better mimics the observed uranium groundwater concentrations than the equilibrium model. The modeling results show slow reduction in the uranium concentrations over the simulated time period (until 2040) under the no action case.

5.5.2 Uranium Transport during Treatment and Post-Treatment Time Periods

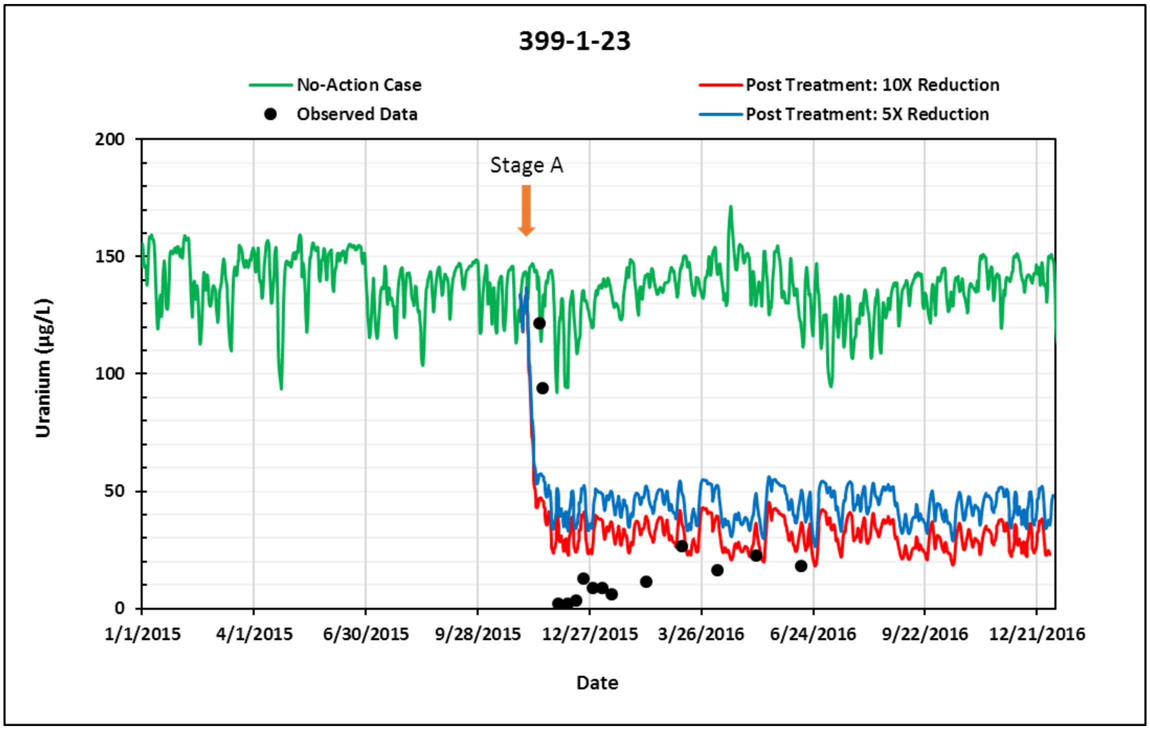
Fate and transport modeling of uranium during and following polyphosphate solution treatment was conducted by simulating the effects of injection and infiltration during the operation period. For this purpose, the kinetic sorption-desorption model was used. Prior to treatment, the uranium distribution within the vadose zone and aquifer was based on pre-treatment model results. During and following treatment, the desorption rate constant was reduced by factors of 5 and 10 within the treatment area to reflect the range of reduction over the scale of the Stage A treatment area. The choice of reduction factor was based on (a) evaluation of the flow-through column leaching tests conducted on pre- and post-treatment sediment samples from the PRZ, (b) changes in dissolution rate of uranium-rich calcite in the presence of polyphosphate amended solutions (PNNL-17818, *300 Area Treatability Test: Laboratory Development of Polyphosphate Remediation Technology for In Situ Treatment of Uranium Contamination in the Vadose Zone and Capillary Fringe*), and (c) observed concentration of uranium in the groundwater monitoring wells. Additional details are presented in Section 7.8.1.3 of ECF-300FF5-16-0091 (included in Appendix G of this report).

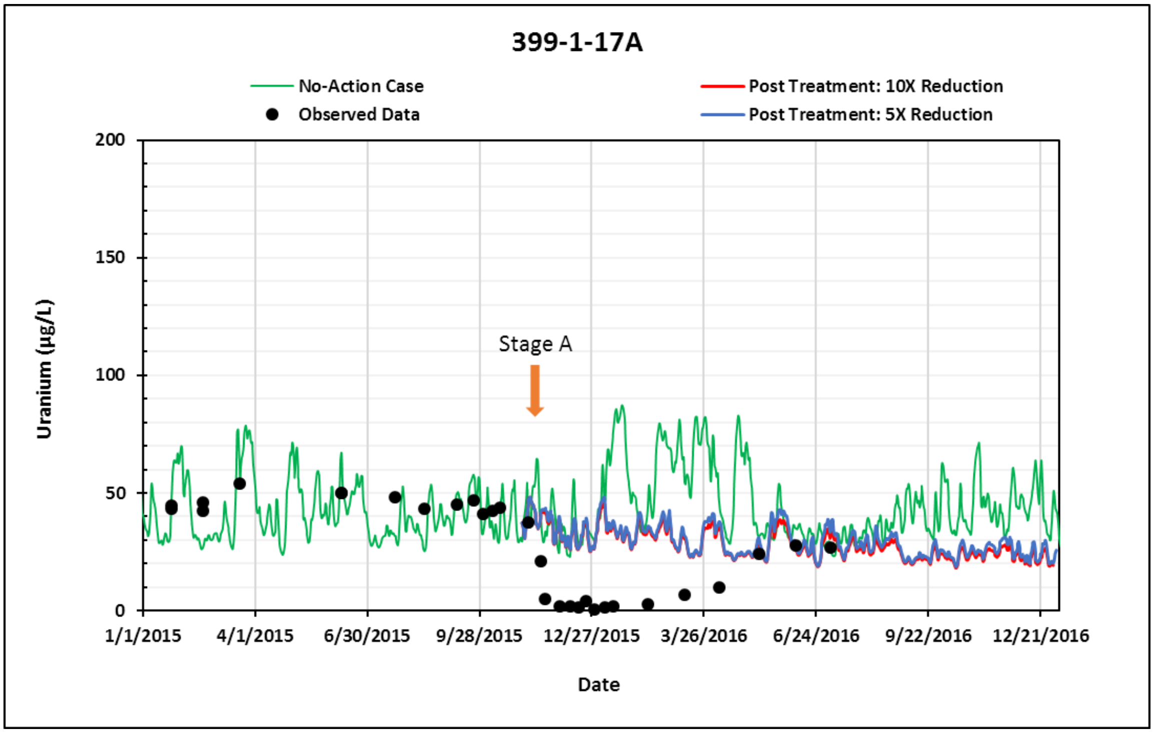
Modeled uranium concentrations before and after treatment are compared to the observed concentrations at wells 399-1-17A and 399-1-23 in Figure 5-16. The observed uranium concentrations show a sharp decline immediately following the Stage A treatment but then increase slowly over time. The last three monthly observations indicate establishment of newly equilibrated concentrations that vary within a narrow range and are expected to persist in the aquifer over the near future.



Source: Figure 7-18 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 5-15. Simulated Uranium Plumes in 2015, 2022, and 2040 under the No Action Scenario





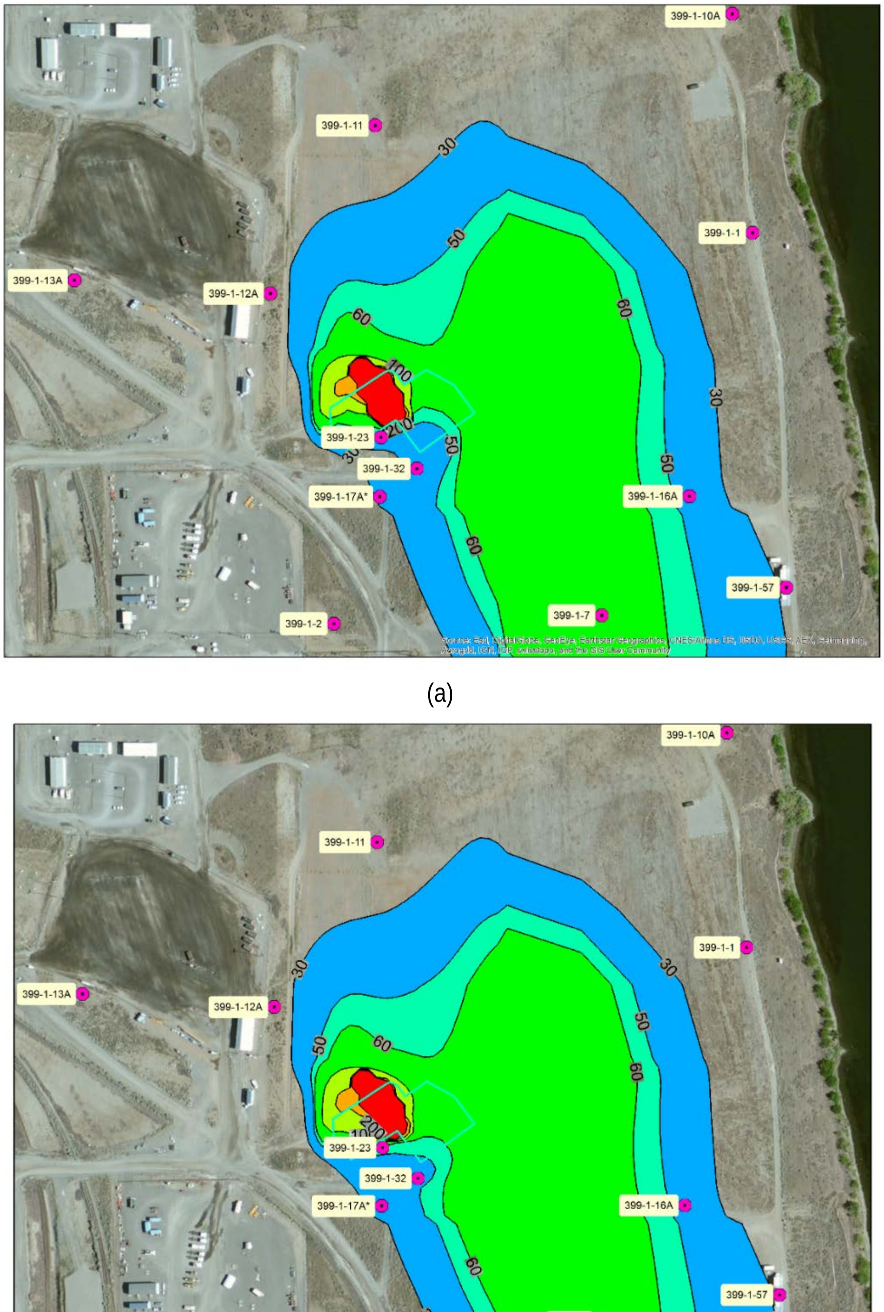
Source: Figure 7-23 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit* (included in Appendix G of this report).

Figure 5-16. Simulated Uranium Concentrations for Wells 399-1-23 and 399-1-17A Compared to Observed Data Before and After Treatment

The model-predicted results match reasonably well with observed post-treatment uranium concentration trends in groundwater, indicating desorption rates have indeed declined within the Stage A area as a result of polyphosphate solution injection and infiltration. A factor of 4 to 6 reduction in uranium concentrations is observed between the pre-treatment and post-treatment concentrations at well 399-1-23. This indicates the remedy implemented for Stage A has been successful. The simulated concentrations in well 399-1-17A following treatment decline less steeply than at well 399-1-23. Well 399-1-17A is located farther downgradient of the Stage A area and, therefore, is influenced by groundwater migrating from areas outside the Stage A area. Nevertheless, some reduction of the concentration (up to a factor of 2) along with the change in long-term trend is noticeable.

The footprint of the predicted uranium plume at the end of December 2016 for cases where the desorption kinetic rate constants were reduced by factors of 5 and 10 and for the no action case are shown in Figure 5-17. The model predicts that due to polyphosphate solution treatment, the extent of the groundwater uranium plume was considerably reduced in the Stage A EA area and remains reduced. This can be seen by comparing the predicted post-treatment plume maps (Figures 5-17a and 5-17b) to the plume map under the no action scenario (Figure 5-17c).

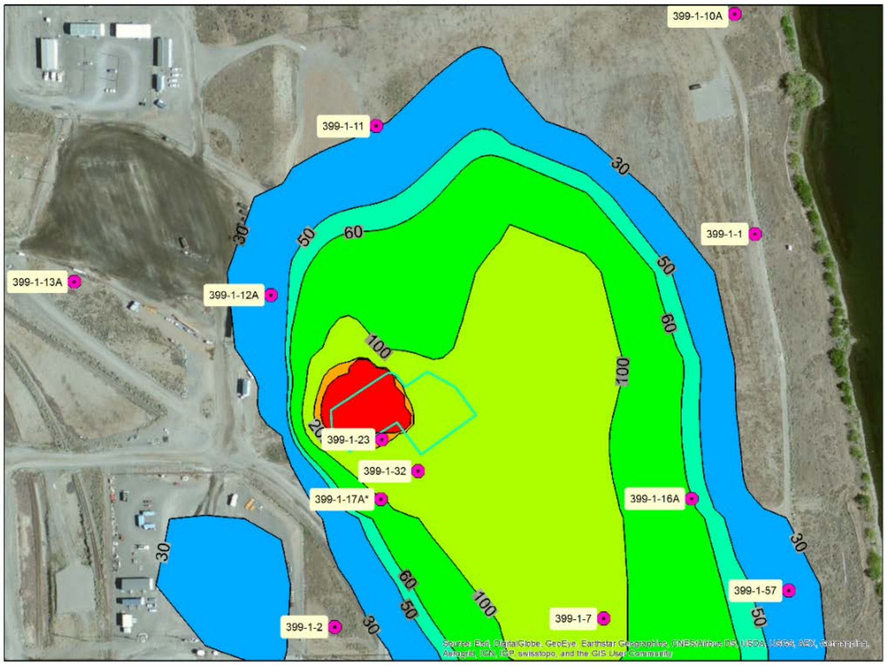
The model setup used for the short-term predictions presented in Figure 5-17 was extended to evaluate long-term uranium concentrations. For this purpose, post-treatment model parameters were kept unchanged, and the model was run up to year 2040. The results are presented in Figure 5-18 for cases where the desorption kinetic rate constants were reduced by factors of 5 and 10. Results for the no action case are presented to compare the change predicted from polyphosphate solution treatment in Stage A. The predictive cases are presented assuming the desorption rates are not going to change over the simulated time period. Due to these assumptions, the uncertainty in these estimates is high and needs to be considered when making any decisions based on model predictions. Long-term simulated uranium concentrations for well 399-1-23 show a gradual rise but remain below the concentrations predicted for the no action case. The gradual rise reflects the combined effect of slow continued desorption of uranium into the aquifer from the Stage A area and contribution to the aquifer from areas outside of the Stage A area. The long-term simulated concentrations for well 399-1-17A also continue to remain below the no action case.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

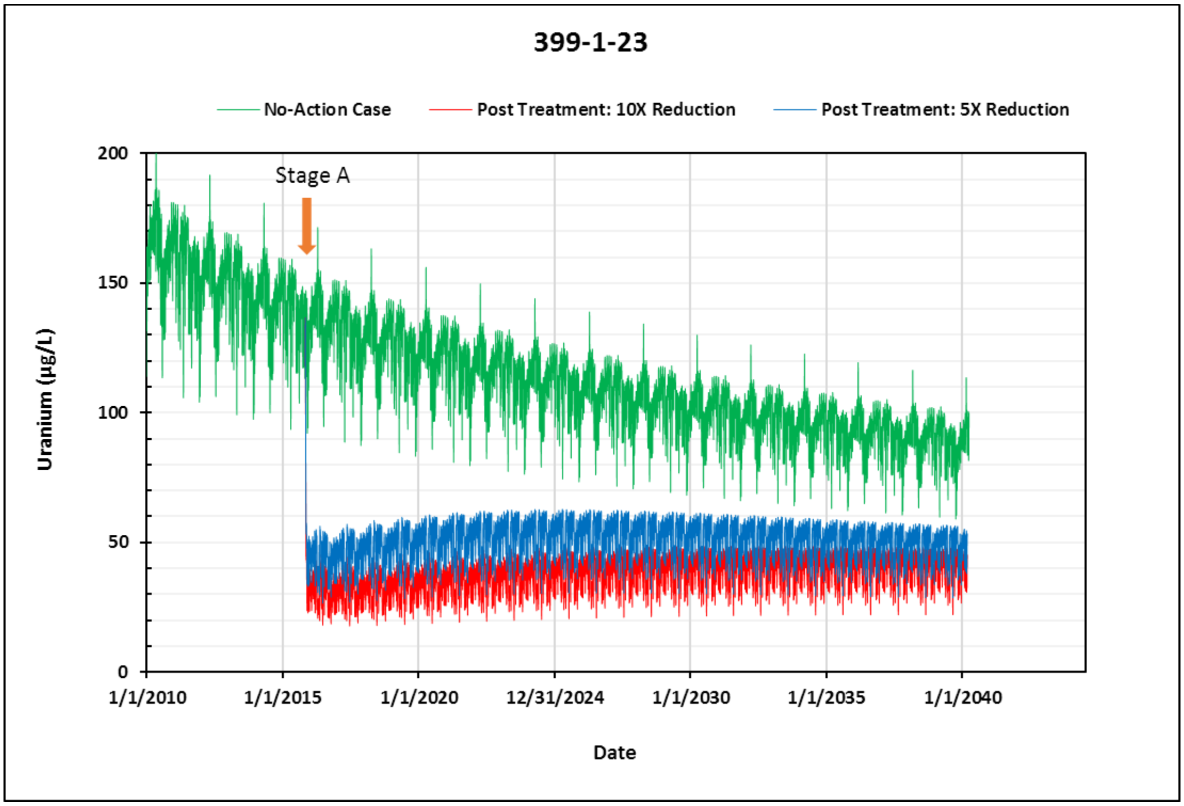
Figure 5-17. Post-Treatment Simulated Uranium Concentrations at the End of December 2016 for (a) 10 Times Reduction in Desorption Rate; (b) 5 Times Reduction in Desorption Rate; and (c) No Action Case (page 1 of 2)

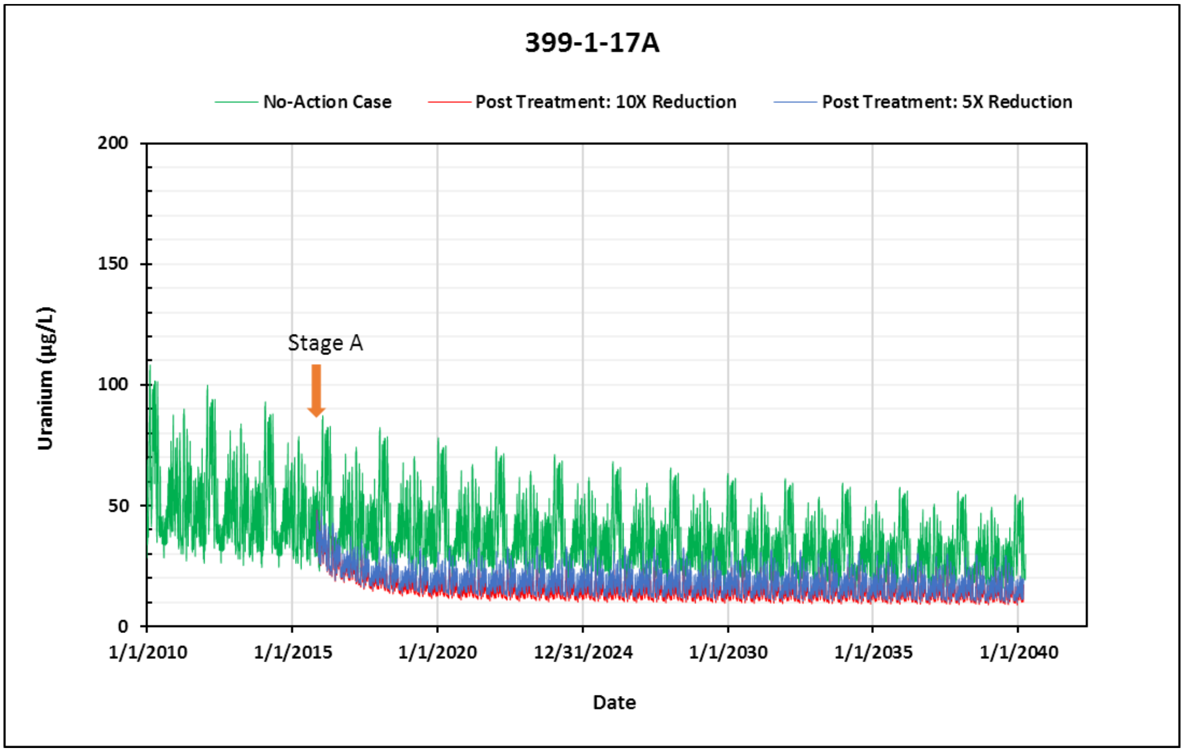


(c)

Source: Figure 7-24 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit*.

Figure 5-17. Post-Treatment Simulated Uranium Concentrations at the End of December 2016 for (a) 10 Times Reduction in Desorption Rate; (b) 5 Times Reduction in Desorption Rate; and (c) No Action Case (page 2 of 2)





Source: Figure 7-25 in ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit*.

Figure 5-18. Long-Term Simulated Uranium Concentrations for Well 399-1-23 and Well 399-1-17A Comparing the Predicted Post-Treatment Results to the No Action Case

This page intentionally left blank.

6 Conclusions

The operational objective of the EA of uranium remedy for the 300-FF-1 and 300-FF-2 OUs was to deliver polyphosphate-bearing solutions at high concentrations in the vadose zone and PRZ in order to sequester residual uranium in the sediments. For the 300-FF-5 OU, the operational objective of the remedy was to deliver polyphosphate-bearing solutions to the top of the aquifer underlying the waste sites in order to limit the mobility of untreated uranium in the aquifer.

The operational objectives of the Stage A uranium remedy have been met by optimizing two injection skids to infiltrate polyphosphate solutions over a 0.3 ha (0.75 ac) area and inject polyphosphate solutions into the PRZ and top of the aquifer. The application of polyphosphate solutions was effectively monitored using downhole instrumentation, ERT, and groundwater monitoring.

Post-treatment soil sampling and the ERT measurements indicate the delivery of polyphosphate solutions through infiltration was not uniform throughout the vadose zone. However, the data indicate injections in the PRZ effectively delivered high concentrations of polyphosphate solution to the treatment zone. Injection of polyphosphate solution to the top of the aquifer appears to be less effective due to dilution in the groundwater. Post-treatment leachability testing showed effective sequestration of uranium by phosphate minerals in areas where polyphosphate solution was delivered in higher concentrations, such as in the PRZ.

Groundwater monitoring indicated uranium was mobilized in some portions of the Stage A EA area when polyphosphate solutions were applied. However, uranium concentrations quickly decreased to pre-treatment levels and in some cases to below pre-treatment levels. Downgradient groundwater wells monitored following treatment showed trends of decreasing uranium concentrations. Fate and transport modeling predicted both short-term and long-term decreases in uranium concentrations in groundwater.

The following sections provide additional information on the effectiveness of the Stage A treatment applications and recommended refinements for the Stage B treatment applications that will complete the remedy implementation.

6.1 Operational Delivery of Treatment Solutions

Implementation of the remedy during the Stage A treatment application included infiltration of polyphosphate solutions to the vadose zone and injection of polyphosphate solutions into the PRZ and top of the aquifer at the treatment zone. The purpose of the coordinated application of polyphosphate solutions was to precipitate relatively insoluble phosphate-bearing phases that sequester, or bind, residual uranium in the vadose zone and PRZ. Based on the data collected and evaluated in the previous chapters, the following conclusions summarize the effectiveness of the Stage A treatment application.

6.1.1 Infiltration Delivery

ERT data collected during Stage A show the movement of the polyphosphate solution wetting front varied across the EA area, with downward velocities ranging from 0.75 to 3 m/d (2.5 to 9.8 ft/d). The variability in downward migration of the polyphosphate solution was primarily a result of lateral and vertical heterogeneity of the vadose zone soil, which caused preferential flow pathways. Delivery of solutions via the infiltration system was also affected by impaired performance of some infiltration lines in the central portion of the Stage A EA area (crushed tubing and/or clogged emitters). As shown by the ERT measurements discussed in Section 5.1.1, the polyphosphate solution wetting front reached the water table across the entire infiltration area in 7 days or less after the start of infiltration.

Distribution of polyphosphate solution across the vadose zone and PRZ from infiltration was affected by the subsurface heterogeneity that influenced the solution migration paths and velocities. Analysis of post-treatment soil samples collected from boreholes C9580, C9581, and C9582 showed the vertical distribution of phosphate from infiltration was impacted by differences in wetting-front velocity. In general, where infiltration was faster the phosphate concentrations were higher in soil samples from the lower vadose zone and PRZ. Phosphate concentrations were generally higher in soil samples from the upper vadose zone where infiltration was slower and phosphate precipitated out of solution. These data show the infiltration delivery of phosphate to the lower vadose zone and PRZ was spatially variable.

6.1.2 PRZ Injection Delivery

The effectiveness of PRZ injections in delivering polyphosphate to PRZ soil was evaluated by comparing groundwater monitoring data with phosphate concentrations in post-treatment soil samples collected from boreholes C9580, C9581, and C9582. Soil samples collected near PRZ monitoring wells that showed spikes in groundwater phosphate concentrations during PRZ injections also had the highest phosphate concentration in soil samples. This correlation was observed in PRZ soil samples from C9581 (approximately 9 m [30 ft] from injection well 399-1-93) and C9582 (approximately 6 m [20 ft] from injection well 399-1-97). Overall, the data show phosphate delivery to the PRZ via injections was effective and contributed more phosphate mass to the PRZ compared to phosphate delivered through infiltration.

Groundwater monitoring during Stage A PRZ injections and soil sampling after polyphosphate application indicates the average PRZ injection ROI was close to 12 m (40 ft). The average volume injected into each PRZ injection well during Stage A was 199,181 L (52,618 gal), compared to the design volume of 167,913 L (44,358 gal) per well specified in DOE/RL-2014-13.

6.1.3 Aquifer Injection Delivery

The design volume for Stage A aquifer injection also was 167,913 L (44,358 gal) per well (DOE/RL-2014-13). The average volume injected into each aquifer injection well during Stage A was 186,852 L (49,361 gal).

Based on the operational and performance monitoring data collected during Stage A, aquifer injections were able to deliver high concentrations of phosphate to the top of aquifer but due to dilution in the aquifer the concentrations declined relatively quickly following injection.

In summary, both the PRZ and aquifer injections effectively delivered high volumes of polyphosphate solution to the target depths containing residual uranium.

6.2 Effect of Polyphosphate Treatments

Flow-through column leach experiments on intact soil samples from pre-treatment borehole C8936 and collocated post-treatment borehole C9582 were conducted to evaluate the reduction in uranium leachability in post-treatment soil samples.

The flow-through column leaching behavior in the column effluent from the pre-treatment samples is similar to the leaching behavior observed for the post-treatment samples collected above the PRZ. These tests indicated uranium was not effectively sequestered in the post-treatment samples where high phosphate concentrations could not be effectively delivered by infiltration of the polyphosphate solution through the vadose zone. In contrast, leaching characteristics of the post-treatment samples collected from the PRZ show much lower leachability, indicating the effects of sequestration from polyphosphate injections. Uranium in PRZ soil exposed to high phosphate concentrations delivered via injection was sequestered through formation of calcium-uranium-phosphate bearing amorphous mineral phases. These amorphous minerals should eventually form hydroxyapatite over a time period of months to years.

Groundwater monitoring within and downgradient of the Stage A EA area indicates uranium concentrations in groundwater have decreased following treatment with polyphosphate solutions. Continued monitoring will be needed to confirm these trends. Fate and transport modeling predicted both short-term and long-term decreases in uranium concentrations in groundwater.

6.3 Refinements for Stage B

The following subsections provide information on refinements that are recommended for the Stage B treatment application. The refinements are based on data and lessons learned from the Stage A treatment application. The remaining 0.9 ha (2.25 ac) treatment area that comprises Stage B is presented in Figure 6-1. Configuration of the Stage B area was developed with the objective of remediating uranium in the lower vadose zone and PRZ soil in a region of high uranium concentration.

6.3.1 Elimination of Infiltration and Optimization of Lower Vadose Zone and PRZ Injections

Stage A infiltration performance data indicate a large proportion of polyphosphate delivered through infiltration precipitated on soils in the vadose zone above 6 m (20 ft) bgs. Much of the Stage B EA area overlies the former North Process Pond and 300 Area Process Trenches excavation areas, where contaminated soil was removed to depths of approximately 4.5 m (15 ft) to 6 m (20 ft) bgs. These areas were backfilled with clean fill. Therefore, use of infiltration is not recommended for Stage B. In order to maximize the delivery of phosphate to the lower vadose zone and PRZ where contamination is present, a combination of lower vadose zone and PRZ injections will be employed for Stage B. Each injection well will be constructed with two separate screens, one in the lower vadose zone and one in the PRZ.

One of the Stage A design objectives of combining polyphosphate infiltration with injection was to provide more uniform aerial coverage of the EA area than could be achieved with injection alone. In order to provide uniform coverage with the revised injection-only Stage B approach, the number of injection wells will be increased from 27 (based on the number [9] of Stage A injection wells scaled up by a factor of 3) to 48 (Figure 6-1). The recommended plan for Stage B is to inject a volume of polyphosphate solution equivalent to approximately 3 pore volumes of the lower vadose zone and PRZ. The polyphosphate solution concentration injected into both the lower vadose zone and PRZ will be the same as the concentration used for Stage A: 78 mM orthophosphate and 4 mM pyrophosphate.

6.3.2 Elimination of Aquifer Injections

Due to the level of dilution in the aquifer, polyphosphate injections into the top of the aquifer during the Stage B treatment application are not recommended. PRZ injections are recommended in lieu of aquifer injections during Stage B. Based on observations during Stage A, injecting into the PRZ at the onset of Stage B polyphosphate application will likely result in higher and more sustained phosphate concentrations in the aquifer compared to what could be achieved with multiple aquifer injections.

As noted in Section 2.4 , daily sampling at a limited number of monitoring wells presented challenges in evaluating the Stage A performance. Therefore, daily sampling at all monitoring locations is recommended during Stage B. Daily sampling may be implemented at both wells in a PRZ and aquifer monitoring well pair, or at only one well in the pair.

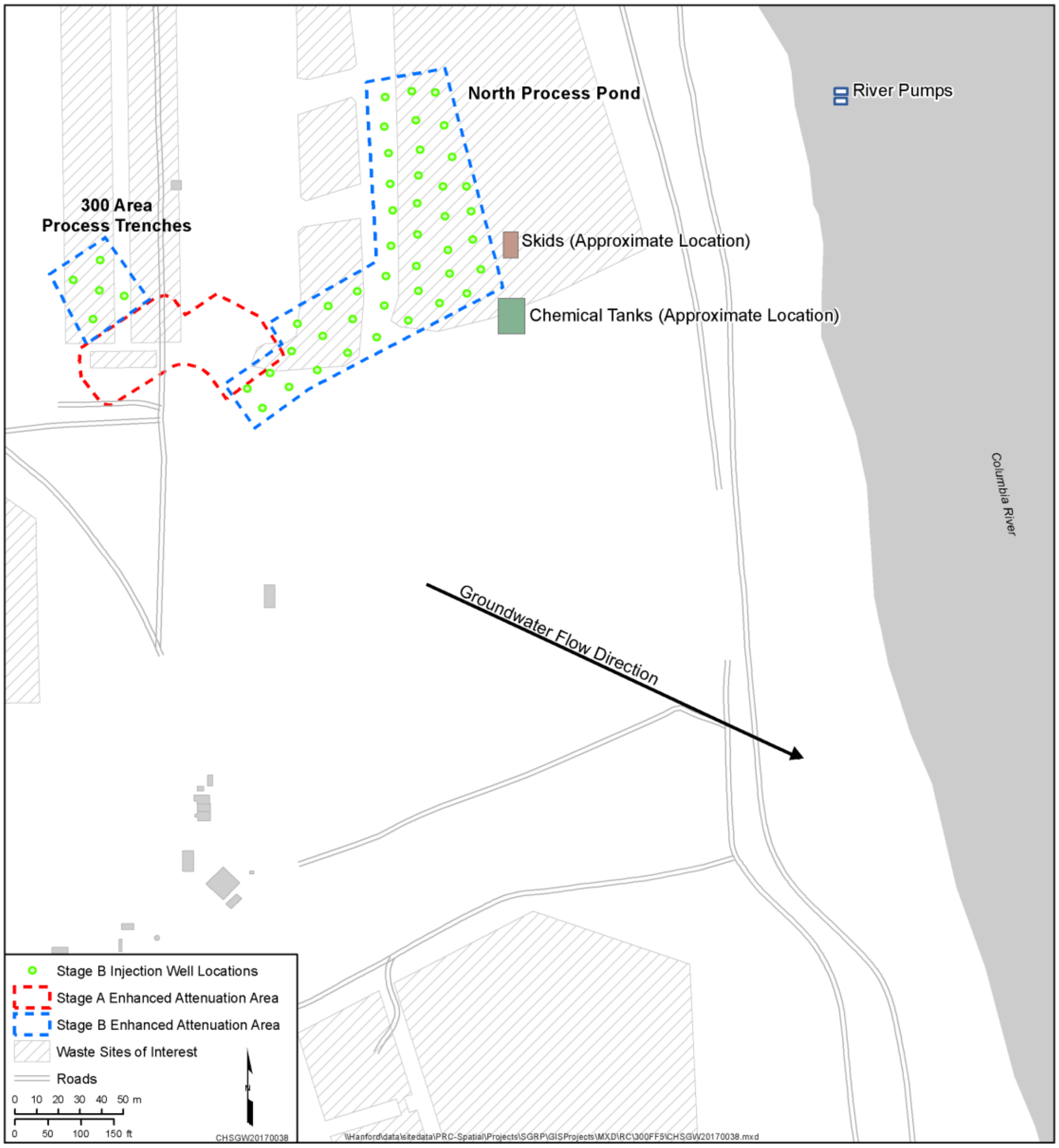


Figure 6-1. Layout of the Proposed Stage B EA Area and Lower Vadose Zone/PRZ Injection Wells

6.3.3 Expansion of Groundwater Monitoring

During Stage B, downgradient groundwater monitoring wells should be monitored at the same frequency as the Stage B monitoring wells. Although this downgradient monitoring was not part of the Stage A design, the groundwater monitoring results obtained by PNNL provided valuable input to the Stage A evaluation. Based on the impact of the Stage A polyphosphate application on downgradient uranium groundwater concentrations, this component is recommended for the Stage B design. Details on the revised Stage B monitoring well network layout and ERT imaging array will be presented in an addendum to the SAP (DOE/RL-2014-42).

7 Bibliography

After the *Hanford Federal Facility Agreement and Consent Order*, hereinafter called the Tri-Party Agreement (TPA) (Ecology et al., 1989), was signed in May 1989, CERCLA investigations, treatability studies, and decisions were completed for the 300-FF-5 OU. Table 7-1 provides a chronological summary of significant documents describing previous investigations, interim remedial actions, decision documents, and studies for the 300-FF-5 OU. The list is not intended to be comprehensive but provides a bibliography of key documents that have led to implementation of the EA using uranium sequestration remedy.

Table 7-1. Chronological Summary of Key Documents Associated with the 300-FF-5 Operable Unit

Document	Issue Date	Description
DOE/RL-89-14, *Remedial Investigation/Feasibility Study Work Plan for the 300-FF-5 Operable Unit, Hanford Site, Richland, Washington*	June 1990	The RI/FS work plan addresses the nature and extent of the threat posed by a release of hazardous substances to the environment and evaluates proposed remedies for such a release.
DOE/RL-94-85, *Remedial Investigation/ Feasibility Report for the 300-FF-5 Operable Unit*	May 1995	This RI/FS report addresses groundwater, contaminated saturated soils, river sediments, and river contamination associated with the 300 Area.
DOE/RL-95-88, *Proposed Plan for the 300-FF-1 and 300-FF-5 Operable Units*	November 1995	The recommended remedial alternative for the 300-FF-5 OU was natural attenuation with ICs.
EPA/ROD/R10-96/143, *Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington*	November 1996	The selected remedy for the 300-FF-5 OU is an interim remedial action that involves imposing restrictions on the use of the groundwater until such time as health-based criteria are met for uranium, trichloroethene, and 1,2-dichloroethene. The selected interim remedy included continued monitoring of groundwater that is contaminated above health-based levels to ensure that concentrations continue to decrease and ICs to ensure that groundwater use is restricted to prevent unacceptable exposures to groundwater contamination.
EPA/ESD/R10-00/524, *Explanation of Significant Difference for the 300-FF-5 Record of Decision*	June 2000	The ESD expanded the scope of the 300-FF-5 OU ROD to include all groundwater that underlies the 300 Area waste sites and burial grounds. The ESD also requires an update to the Operations and Maintenance Plan for the 300-FF-5 OU to ensure that an adequate monitoring and ICs plan is in place for groundwater beneath 300-FF-1 OU and 300-FF-2 OU waste sites.
PNNL-17034, *Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site, Washington*	February 2008	This report summarizes the measurements made to characterize uranium inventories in the 300 Area Industrial Complex.

Table 7-1. Chronological Summary of Key Documents Associated with the 300-FF-5 Operable Unit

Document	Issue Date	Description
PNNL-18529, *300 Area Uranium Stabilization Through Polyphosphate Injection: Final Report*	June 2009	This report summarizes a phosphate injection pilot study conducted to optimize phosphate formulations in the laboratory and to evaluate the effectiveness of phosphate in sequestering uranium in the aquifer by two methods: direct formation of the insoluble uranium mineral autunite and formation of the mineral apatite.
TPA (Ecology et al., 1989) Target Date M-016-110-T05 (Ecology et al., 1989)	August 2009	TPA target date established to have a remedy in place by 12/31/2015 designed to meet federal drinking water standards for uranium throughout the groundwater plume in the 300-FF-5 OU.
DOE/RL-2009-30, *300 Area Remedial Investigation/ Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*	April 2010	This RI/FS work plan proposed obtaining information to better define potential effects of residual soil contamination, extent of contamination in the unconfined aquifer, extent of uranium contamination in the deep vadose and periodically rewetted zone, persistent groundwater contamination, and hydraulic properties of the aquifer and river interaction.
DOE/RL-2009-45, *300 Area Remedial Investigation/ Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*	April 2010	This SAP is part of the RI/FS work plan for the 300 Area.
DOE/RL-2010-99, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*	February 2013	This RI/FS report summarizes the results of the RI and previous field investigations and remedial actions. The report supports remedy selection for the 300-FF-1 and 300-FF-2 Source OUs and the 300-FF-5 Groundwater OU.
DOE/RL-2011-47, *Proposed Plan for Remediation of the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*	July 2013	The 300-FF-1, 300-FF-2, and 300-FF-5 proposed plan was issued.
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*	November 2013	The final ROD specified EA of uranium at the top of the aquifer. The remedy also included MNA, groundwater monitoring, and ICs.
SGW-56993, *Sampling Instruction for the 300-FF-5 Operable Unit Supplemental Post ROD Field Investigation*	August 2014	This sampling instruction describes drilling and sampling procedures for refining the location of Stage A and Stage B EA areas.

Table 7-1. Chronological Summary of Key Documents Associated with the 300-FF-5 Operable Unit

Document	Issue Date	Description
SGW-58261, *Description of Work for Borehole Drilling, Sampling, and Construction of Monitoring Wells in Support of the 300-FF-5 OU Supplemental Post ROD Field Investigation*	October 2014	This DOW describes the drilling, construction, development, and sampling activities associated with installation of three characterization boreholes, two of which were completed as groundwater monitoring wells.
TPA-CN-656, TPA Change Notice for SGW-56993, *Sampling Instruction for the 300-FF-5 Operable Unit Supplemental Post-ROD Field Investigation*	April 2015	This change notice adds two boreholes to SGW-56993. Boreholes C8940 and C9451 were identified for pre-treatment soil sampling following selection of the refined Stage A EA area.
Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8933, C8936, and C8938	April 2015	Data report for soil samples collected from supplemental post-ROD boreholes C8933, C8936, and C8938.
SGW-58589, *Borehole Summary Report for the Installation of 2 Wells and Drilling of 1 Borehole in the 300-FF-5 Operable Unit, FY2015*	April 2015	This report summarizes field activities for the drilling and construction of two monitoring wells and one characterization borehole associated with the 300-FF-5 OU supplemental post-ROD field investigation.
SGW-58736, *300-FF-5 Enhanced Attenuation Area Stage A Location Selection*	April 2015	This technical memorandum summarizes the field effort conducted during the post-ROD field investigation and provides the proposed location of the Stage A EA area for polyphosphate injection/infiltration.
DOE/RL-2014-13, *Integrated Remedial Design Report/ Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units)*	May 2015	This integrated RDR/RAWP addresses all three OUs in the 300 Area and is accompanied by two addenda. The addenda correspond to the two distinct media (soil and groundwater).The document is written in three parts: an integrated RDR/RAWP that contains common information to support remedy implementation, an addendum containing information specific to waste site/soil-specific remedies for the 300-FF-2 OU, and an addendum containing information specific to groundwater-specific remedies for the 300-FF-5 OU and uranium sequestration elements implemented at the 300-FF-1 and 300-FF-2 OUs.
DOE/RL-2014-13-ADD2, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*	June 2015	The RDR/RAWP addendum for 300 Area Groundwater describes the work elements, construction management and oversight, schedule, and cost specific to EA using uranium sequestration in the vadose zone and periodically rewetted zone, MNA, and groundwater monitoring.
SGW-58830, *300-FF-5 Supplemental Post-ROD Field Investigation Summary*	June 2015	This report summarizes observations and measurements made during the field activities conducted as part of the supplemental post-ROD field investigation.

Table 7-1. Chronological Summary of Key Documents Associated with the 300-FF-5 Operable Unit

Document	Issue Date	Description
SGW-58553, *Description of Work for the Installation of Twenty Two Monitoring Wells and Nine Injection Wells in the 300-FF-5 Operable Unit, FY2015*	June 2015	This DOW describes the drilling, construction, development, and sampling activities associated with installation of 22 monitoring wells and 9 injection wells in the 300-FF-5 OU to support Stage A of the EA remedy.
SGW-58976, *Field Instructions for Uranium Sequestration in the 300 Area*	July 2015	This document provides the field instructions and technical guidance for implementation of the Stage A uranium sequestration activities in the 300 Area Industrial Complex.
DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*	September 2015	This SAP presents the plans for 300-FF-5 OU remedy implementation, performance monitoring, and groundwater monitoring.
DOE/RL-2015-55, *Administrative Record Index for the 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; and the 2015 Explanation of Significant Differences*	October 2015	This document is the Administrative Record Index for EPA and DOE, 2013; EPA/ROD/R10-96/143; and EPA/ESD/R10-00/524.
SGW-58883, *Methodology for the Calculation of Concentration Trends, Means, and Confidence Limits for Performance and Attainment Monitoring*	October 2015	This document describes the methodology to evaluate water quality sample results from individual monitoring wells and other monitoring devices in the 300-FF-5 OU to assess the progress toward, and attainment of, remedial action objectives.
ECF-300FF5-15-0017, *Calculation of Concentration Trends, Means, and Confidence Limits for cis-1,2-Dichloroethene, Gross Alpha, Nitrate, Trichloroethene, Tritium, and Uranium in the 300-FF-5 Operable Unit*	October 2015	This environmental calculation file presents estimates of concentration trends, yearly mean concentrations, and cleanup time for wells used in the 300-FF-5 OU for MNA of cis-1,2-dichloroethene, gross alpha, nitrate, trichloroethene, tritium, and uranium.
PNNL-24911, *Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8940 and C9451*	November 2015	Data report for soil samples collected from boreholes C8940 and C9451.
1232138, "100/300 Area Unit Manager Meeting Minutes"	November 12, 2015	M-016-110-T05 target date completed.

Table 7-1. Chronological Summary of Key Documents Associated with the 300-FF-5 Operable Unit

Document	Issue Date	Description
SGW-59369, *Description of Work for the Installation of Three Boreholes in the 300-FF-5 Groundwater Operable Unit, FY2016*	December 2015	This DOW describes the drilling, construction, decommissioning, and sampling activities associated with installation of three post-treatment characterization boreholes in the 300-FF-5 OU to support Stage A of the EA remedy.
SGW-59455, *300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report*	March 2016	This report provides the final design and installation of the Stage A uranium sequestration system. This report also provides lessons learned on the installation of the Stage A system.
PNNL-25420, *Analytical Data Report for Sediment Samples Collected from 300-FF-5: Boreholes C9580, C9581, and C9582*	May 2016	Data report for soil samples collected from boreholes C9580, C9581, and C9582.
SGW-59465, *Borehole Summary Report for the Installation of Nine Injection Wells, Twenty-One Monitoring Wells, and Three Boreholes in the 300-FF-5 Operable Unit*	July 2016	This borehole summary report describes field activities for installing and sampling 33 wells as part of the Stage A uranium sequestration remedial action for the 300-FF-5 OU.

DOW = description of work
EA = enhanced attenuation
ESD = explanation of significant difference
IC = institutional control
MNA = monitored natural attenuation
OU = operable unit
RAWP = remedial action work plan
RDR = remedial design report
RI/FS = remedial investigation/feasibility study
ROD = record of decision
SAP = sampling and analysis plan
TPA = Tri-Party Agreement

This page intentionally left blank.

8 References

1232138, 2015, “100/300 Area Unit Manager Meeting Minutes,” U.S. Department of Energy, Richland Operations Office, Washington State Department of Ecology, and U.S. Environmental Protection Agency, Richland, Washington, November 12. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1512230002.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

DOE/RL-89-14, 1990, *Remedial Investigation/Feasibility Study Work Plan for the 300-FF-5 Operable Unit, Hanford Site, Richland, Washington*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196008257.

DOE/RL-94-85, 1995, *Remedial Investigation/Feasibility Report for the 300-FF-5 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196019032.

DOE/RL-95-88, 1995, *Proposed Plan for the 300-FF-1 and 300-FF-5 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D1341829.

DOE/RL-2009-30, 2010, *300 Area Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084376.

DOE/RL-2009-45, 2010, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084377.

DOE/RL-2010-99, 2013, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088359. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088307. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088306. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088305.

DOE/RL-2011-47, 2013, *Proposed Plan for Remediation of the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088360.

DOE/RL-2014-13, 2015, *Integrated Remedial Design Report/Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units)*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081153H.

DOE/RL-2014-13-ADD2, 2015, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081151H.

DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079669H.

DOE/RL-2015-55, 2015, *Administrative Record Index for the 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; and the 2015 Explanation of Significant Differences*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079637H.

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

ECF-300FF5-15-0017, 2015, *Calculation of Concentration Trends, Means, and Confidence Limits for cis-1,2-Dichloroethene, Gross Alpha, Nitrate, Trichloroethene, Tritium, and Uranium in the 300-FF-5 Operable Unit*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079510H.

ECF-300FF5-16-0087, 2016, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit, Hanford, Washington*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-300FF5-16-0091, 2016, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

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

ECR-15-000692, 2015, *300 Area Chemical Injection System*, Engineering Change Request, Attachment A, CH2M HILL Plateau Remediation Company, Richland, Washington.

EPA/ESD/R10-00/524, 2000, *Explanation of Significant Difference for the 300-FF-5 Record of Decision,* U.S. Environmental Protection Agency, Region 10, Washington State Department of Ecology, and U.S. Department of Energy, Seattle, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/e1000524.pdf.

EPA/ROD/R10-96/143, 1996, *Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=1000544M.TXT.

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*, U.S. Environmental Protection Agency and U.S. Department of Energy, Richland, Washington, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087180.

PNNL-17034, 2008, *Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17034.pdf.

PNNL-17708, 2008, *Three-Dimensional Groundwater Models of the 300 Area at the Hanford Site, Washington State*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17708.pdf.

PNNL-17818, 2008, *300 Area Treatability Test: Laboratory Development of Polyphosphate Remediation Technology for In Situ Treatment of Uranium Contamination in the Vadose Zone and Capillary Fringe*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17818.pdf

PNNL-18529, 2009, *300 Area Uranium Stabilization Through Polyphosphate Injection: Final Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18529.pdf.

PNNL-20004, 2010, *Uranium Sequestration in the Hanford Vadose Zone using Ammonia Gas: FY 2010 Laboratory-Scale Experiments*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20004.pdf.

PNNL-21733, 2012, *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21733.pdf.

PNNL-22048, 2012, *Updated Conceptual Model for the 300 Area Uranium Groundwater Plume*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22048.pdf.

PNNL-24911, 2015, *Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8940 and C9451*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-25420, 2016, *Analytical Data Report for Sediment Samples Collected From 300-FF-5: Boreholes C9580, C9581, and C9582*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-SA-25232, 2016, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography*, Pacific Northwest National Laboratory, Richland, Washington.

SGW-56993, 2014, *Sampling Instruction for the 300-FF-5 Operable Unit Supplemental Post ROD Field Investigation*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079680H.

Modified by:

TPA-CN-656, 2015, *Tri-Party Agreement Change Notice Form: SGW-56993, Sampling Instruction for the 300-FF-5 Operable Unit Supplemental Post ROD Field Investigation, Rev 0*, dated March 31, U.S. Department of Energy, Richland Operations Office, and U.S. Environmental Protection Agency, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081527H.

SGW-58261, 2014, *Description of Work for Borehole Drilling, Sampling, and Construction of Monitoring Wells in Support of the 300-FF-5 OU Supplemental Post ROD Field Investigation*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-58553, 2015, *Description of Work for the Installation of Twenty Two Monitoring Wells and Nine Injection Wells in the 300-FF-5 Operable Unit, FY2015*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078186H.

SGW-58589, 2015, *Borehole Summary Report for the Installation of 2 Wells and Drilling of 1 Borehole in the 300-FF-5 Operable Unit, FY2015*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-58736, 2015, *300-FF-5 Enhanced Attenuation Area Stage A Location Selection*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-58830, 2015, *300-FF-5 Supplemental Post-ROD Field Investigation Summary*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079681H.

SGW-58883, 2015, *Methodology for the Calculation of Concentration Trends, Means, and Confidence Limits for Performance and Attainment Monitoring*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079695H.

SGW-58976, 2015, *Field Instructions for Uranium Sequestration in the 300 Area*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078185H.

SGW-59369, 2015, *Description of Work for the Installation of Three Boreholes in the 300-FF-5 Groundwater Operable Unit, FY2016*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-59455, 2016, *300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0077730H.

SGW-59465, 2016, *Borehole Summary Report for the Installation of Nine Injection Wells, Twenty-One Monitoring Wells, and Three Boreholes in the 300-FF-5 Operable Unit*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0074320H.

Appendix A

Soil Sample Analytical Data

This page intentionally left blank.

Contents

Tables

Supporting Information

This page intentionally left blank.

A1 Introduction

This appendix provides analytical results for soil samples collected in 2015 and 2016 from boreholes installed to implement the 300-FF-5 Operable Unit Stage A enhanced attenuation (EA) remedy.

A2 Pre-Treatment Soil Sample Results

Uranium concentrations were analyzed in samples collected from boreholes drilled in and near the Stage A EA area to characterize the contaminant levels prior to application of polyphosphate solutions. Table A-1 provides total uranium results for samples from three boreholes drilled as part of the post-record of decision (ROD) supplemental investigation to refine the location of the Stage A EA area. Table A-2 provides total uranium results for samples from two boreholes drilled prior to the Stage A polyphosphate treatment to characterize pre-treatment soil concentrations within the Stage A EA area. The data are stored in the Hanford Environmental Information System (HEIS) database, and users also may retrieve the data via the internet through the U.S. Department of Energy (DOE) Environmental Dashboard Application available at: https://ehs.hanford.gov/eda/.

Table A-1. Total Uranium Results for the Post-ROD Supplemental Borehole Samples

Sample Number	Sample Date	Sampling Interval (m [ft] bgs)		Total Uranium* (µg/kg)
		Top	Bottom	
Borehole C8936 (Well 399-1-67)				
B30508	01/13/2015	3.4 (11)	3.5 (11.5)	434 D
B30513	01/13/2015	4.1 (13.5)	4.3 (14)	14700 D
B30519	01/13/2015	4.9 (16)	5.0 (16.5)	16800 D
B30524	01/14/2015	5.6 (18.5)	5.8 (19)	34800 D
B30529	01/14/2015	6.6 (21.6)	6.7 (22.1)	26100 D
B30534	01/14/2015	7.4 (24.2)	7.5 (24.7)	16900 D
B30535	01/14/2015	7.4 (24.2)	7.5 (24.7)	20600 D
B30540	01/14/2015	8.3 (27.2)	8.4 (27.7)	41400 D
B30545	01/14/2015	9.1 (29.7)	9.2 (30.2)	20800 D
B30550	01/14/2015	10.1 (33)	10.2 (33.5)	25800 D
B309C9	01/14/2015	10.7 (35.2)	10.9 (35.7)	12300 D
B30552	01/14/2015	--	10.7 (35)	19900 D
Borehole C8938 (Well 399-1-68)				
B30556	01/08/2015	3.1 (10.1)	3.2 (10.6)	6590 D
B30557	01/08/2015	3.1 (10.1)	3.2 (10.6)	6520 D
B30562	01/08/2015	4.1 (13.3)	4.2 (13.8)	3120 D

Table A-1. Total Uranium Results for the Post-ROD Supplemental Borehole Samples

Sample Number	Sample Date	Sampling Interval (m [ft] bgs) Top	Sampling Interval (m [ft] bgs) Bottom	Total Uranium* (µg/kg)
B30567	01/08/2015	4.4 (14.5)	4.6 (15)	3390 D
B30572	01/08/2015	5.3 (17.3)	5.4 (17.8)	4210 D
B30577	01/08/2015	6.0 (19.7)	6.2 (20.2)	4420 D
B30583	01/12/2015	6.7 (22)	6.9 (22.5)	2010 D
B30588	01/12/2015	7.6 (25)	7.8 (25.5)	4390 D
B30593	01/12/2015	8.5 (27.9)	8.7 (28.4)	3090 D
B30598	01/12/2015	8.9 (29.2)	9.1 (29.7)	3200 D
B309F4	01/12/2015	9.7 (31.7)	9.8 (32.2)	2150 D
B305B0	01/12/2015	--	10.0 (32.9)	2030 D
Borehole C8933				
B304V0	12/31/2014	3.4 (11)	3.5 (11.5)	460 D
B304V5	12/31/2014	4.0 (13)	4.1 (13.5)	688 D
B304W0	12/31/2014	4.6 (15.1)	4.8 (15.6)	540 D
B304W5	12/31/2014	5.3 (17.5)	5.5 (18)	508 D
B304W6	12/31/2014	5.3 (17.5)	5.5 (18)	622 D
B304X1	12/31/2014	6.1 (20)	6.2 (20.5)	726 D
B304X6	12/31/2014	6.6 (21.5)	6.7 (22)	739 D
B304Y1	01/06/2015	8.0 (26.4)	8.2 (26.9)	8180 D
B304Y7	01/06/2015	9.1 (30)	9.3 (30.5)	7130 D
B30504	01/07/2015	10.8 (35.5)	12.1 (39.7)	2030 D

* EPA Method 6020.

bgs = below ground surface

D = compounds identified in an analysis at a secondary dilution factor

Table A-2. Total Uranium Results for the Pre-Treatment Borehole Samples

Sample Number	Sample Date	Sampling Interval (m [ft] bgs) Top	Bottom	Total Uranium* (µg/kg)
Borehole C8940 (Well 399-1-76)				
B31MY3	07/13/2015	3.4 (11)	3.8 (12.5)	987 D
B31MY8	07/13/2015	4.1 (13.5)	4.6 (15)	1300 D
B31N04	07/13/2015	4.9 (16)	5.3 (17.5)	1180 D
B31N14	07/13/2015	6.6 (21.5)	6.9 (22.5)	2540 D
B31N15	07/13/2015	6.6 (21.5)	6.7 (22)	2140 D
B31N20	07/13/2015	7.3 (24)	7.6 (25)	2500 D
B31N25	07/13/2015	7.9 (26)	8.4 (27.5)	5900 D
B31N30	07/13/2015	8.7 (28.5)	9.1 (30)	11500 D
B31N35	07/13/2015	9.4 (31)	9.9 (32.5)	4490 D
Borehole C9451 (Well 399-1-80)				
B31N65	07/14/2015	3.4 (11)	3.8 (12.5)	1440 D
B31N70	07/14/2015	4.1 (13.4)	4.6 (15)	1180 D
B31N75	07/14/2015	4.9 (16)	5.3 (17.5)	1270 D
B31N76	07/14/2015	4.9 (16)	5.3 (17.5)	1030 D
B31N81	07/14/2015	5.6 (18.5)	6.1 (20)	1100 D
B31N86	07/14/2015	6.4 (21)	6.6 (21.5)	12000 D
B31N91	07/14/2015	7.3 (24)	7.6 (25)	5440 D
B31N97	07/14/2015	8.1 (26.5)	8.4 (27.5)	10600 D
B31NB2	07/14/2015	8.7 (28.5)	8.8 (29)	9290 D
B31NB7	07/14/2015	9.6 (31.5)	9.9 (32.5)	6500 D

* EPA Method 6020.

bgs = below ground surface

D = compounds identified in an analysis at a secondary dilution factor

A3 Pre-Treatment Uranium Leachability Reports

Soil samples from boreholes drilled in and near the Stage A EA area prior to application of polyphosphate solutions were analyzed by Pacific Northwest National Laboratory (PNNL) to characterize the adsorption and leachability of uranium and to identify crystalline uranium compounds in the samples. Two reports were prepared by PNNL to provide the results:

- *Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8933, C8936 and C8938*
- PNNL-24911, *Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8940 and C9451*

The two reports are provided as supporting information to this appendix.

A4 Post-Treatment Soil Sample Results

Uranium, metal, and anion concentrations were analyzed in samples collected from boreholes drilled in the Stage A EA area to characterize the contaminant levels following application of polyphosphate solutions. Table A-3 provides results for total uranium, metals (calcium and phosphorus), and anions (chloride, fluoride, nitrate, nitrite, and phosphate) for three boreholes drilled to characterize post-treatment soil concentrations. The data are stored in the HEIS database, and users also may retrieve the data via the internet through the DOE Environmental Dashboard Application.

A5 Post-Treatment Uranium Leachability Report

Soil samples from boreholes drilled in the Stage A EA area following application of polyphosphate solutions were analyzed by PNNL to characterize the adsorption and leachability of uranium and to identify crystalline uranium compounds in the samples. One report was prepared by PNNL to provide the results:

- PNNL-25420, *Analytical Data Report for Sediment Samples Collected From 300-FF-5: Boreholes C9580, C9581, and C9582*

This report is also provided as supporting information to this appendix.

Table A-3. Total Uranium, Metal, and Anion Results for the Post-Treatment Borehole Samples

Sample Date	Sample Number	Sampling Interval (m [ft] bgs)		Metals[a] (µg/kg)			Anions[b] (µg/kg)					
		Top	Bottom	Calcium	Phosphorus	Uranium	Chloride	Fluoride	Nitrate	Nitrite	Phosphate	Sulfate
Borehole C9580												
04/19/2016	B356D9[c]	1.5 (5)	3.0 (10)	--	1700000	--	--	--	--	--	521000	--
04/19/2016	B356F0[c]	3.0 (10)	4.0 (13)	--	1500000	--	--	--	--	--	736000	--
04/19/2016	B356F1[c]	4.0 (13)	4.9 (16)	--	1900000	--	--	--	--	--	1350000	--
04/19/2016	B356F2[c]	4.9 (16)	5.2 (17)	--	1900000	--	--	--	--	--	3680000	--
04/19/2016	B356F3[c]	5.2 (17)	6.1 (20)	--	1700000	--	--	--	--	--	951000	--
01/05/2016	B347C7	6.6 (21.5)	6.7 (22)	4700000	1500000	2600	2200	1000 B	5425 U	2140 U	399000	6300 B
01/05/2016	B347C8	6.6 (21.5)	6.7 (22)	5300000	1500000	1700	2700	990 B	2225 B	2140 U	399000	8200 B
01/05/2016	B347D3	7.3 (24)	7.5 (24.5)	4500000	1300000	2000	1400 B	930 B	5425 U	2140 U	242000	5200 B
01/05/2016	B347D9	8.1 (26.5)	8.2 (27)	6100000	1500000	3200	1600 B	820 B	5700 U	2355 U	150000	5700 B
01/05/2016	B347F4	9.0 (29.5)	9.1 (30)	4600000	1300000	7600	1700 B	1200	1980 B	2355 U	92000	5000 B
01/05/2016	B347F9	9.3 (30.5)	9.4 (31)	6400000	1600000	1400	3800	1100	5425 U	2120 U	205000	8300 B
01/05/2016	B347H4	9.9 (32.5)	10.7 (35)	7000000	1300000	2600	2700	820 B	5970 U	2355 U	42900	8300 B
Borehole C9581												
04/19/2016	B356F4[c]	0.0 (0)	1.5 (5)	--	1000000	--	--	--	--	--	172000	--
04/19/2016	B356F5[c]	1.5 (5)	3.0 (10)	--	1700000	--	--	--	--	--	1230000	--
04/19/2016	B356F9[c]	1.5 (5)	3.0 (10)	--	940000	--	--	--	--	--	16900	--
04/19/2016	B356F7[c]	3.0 (10)	4.6 (15)	--	1300000	--	--	--	--	--	46000	--
04/19/2016	B356F8[c]		5.8 (19)	--	740000	--	--	--	--	--	23000	--
01/07/2016	B347J9	6.2 (20.5)	6.4 (21)	5800000	1400000	1200	4500	1200	8410 U	3050 U	20200	--
01/07/2016	B347K5	7.0 (23)	7.2 (23.5)	5900000	1300000	1600	5700	1400	8410 U	3190 U	20500	--

Table A-3. Total Uranium, Metal, and Anion Results for the Post-Treatment Borehole Samples

Sample Date	Sample Number	Sampling Interval (m [ft] bgs)		Metals[a] (µg/kg)			Anions[b] (µg/kg)					
		Top	**Bottom**	**Calcium**	**Phosphorus**	**Uranium**	**Chloride**	**Fluoride**	**Nitrate**	**Nitrite**	**Phosphate**	**Sulfate**
01/07/2016	B347L0	7.8 (25.5)	7.9 (26)	5000000	1100000	5300	6400	4600	7530 B	3120 U	7050	--
01/07/2016	B347L5	8.5 (28)	8.7 (28.5)	5500000	1700000	4300	4400	2100	9300 U	3280 U	304000	--
01/07/2016	B347L6	8.5 (28)	8.7 (28.5)	5200000	1800000	4400	3900	1400	8850 U	3220 U	736000	--
01/07/2016	B347M1	9.8 (32)	9.9 (32.5)	5600000	1700000	2900	5500	2400	7970 U	3020 U	399000	--
Borehole C9582												
04/19/2016	B356H0[c]	3.0 (10)	3.7 (12)	--	940000	--	--	--	--	--	16600	--
04/19/2016	B356H1[c]	3.7 (12)	4.3 (14)	--	1200000	--	--	--	--	--	2240	--
04/19/2016	B356H2[c]	4.3 (14)	4.4 (14.5)	--	1100000	--	--	--	--	--	2050	--
04/19/2016	B356H3[c]	4.4 (14.5)	5.5 (18)	--	960000	--	--	--	--	--	9810	--
04/19/2016	B356H4[c]	5.5 (18)	5.8 (19)	--	1200000	--	--	--	--	--	28800	--
04/19/2016	B356H5[c]	5.8 (19)	6.1 (20)	--	1200000	--	--	--	--	--	55200	--
01/11/2016	B347P1	6.2 (20.5)	6.4 (21)	6300000	1400000	71000	7300	3400	3360 B	3120 U	8590	--
01/11/2016	B347P6	7.0 (23)	7.2 (23.5)	7000000	1000000	100000 D	4000	19000	3280 B	2920 U	22400	--
01/11/2016	B347R2	7.8 (25.5)	7.9 (26)	6300000	1400000	32000	6000	15000	3720 B	3610 U	14100	--
01/11/2016	B347R3	7.8 (25.5)	7.9 (26)	6200000	1400000	31000	5200	11000	3190 B	3190 U	9810	--
01/11/2016	B347R8	9.0 (29.5)	9.1 (30)	5500000	2600000	39000	3900	34000	4870 B	3610 U	1230000	--
01/11/2016	B347T8	10.1 (33)	10.2 (33.5)	5700000	1800000	19000	2700	8500	4160 B	3220 U	221000	--

a. EPA Method 6010 for calcium and phosphorus. EPA Method 6020 for uranium.

b. EPA Method 300.

c, Samples analyzed only for phosphorus and phosphate.

bgs = below ground surface

Supporting Information

PNNL Reports

This page intentionally left blank.

U.S. DEPARTMENT OF ENERGY

Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8933, C8936 and C8938

MMV Snyder
KJ Cantrell

April 2015

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** *Since 1965*

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by **Battelle** *Since 1965*

To: Randy Hermann

From: Michelle Snyder and Kirk Cantrell

Environmental Sciences Laboratory
Energy and Environment Directorate, Pacific Northwest National Laboratory

Subject: Analytical Data Report of Samples Collected for the solubility testing of wells C8933, C8936 and C8938, sample delivery group (SDG) ESL150001, SAF F15-014.

This letter contains the following information for sample delivery group ESL150001

- Cover Sheet
- Narrative
- Analytical Results
- Quality Control

Introduction

Between January 8, 2015 and January 15, 2015 samples were received from the 300-FF5 OU for chemical analyses.

Analytical Results/Methodology

The analyses for this project were performed at the 331 building located in the 300 Area of the Hanford Site. The analyses were performed according to Pacific Northwest National Laboratory (PNNL) approved procedures and/or nationally recognized test procedures. The data sets include the sample identification numbers, analytical results, estimated quantification limits (EQL), and quality control data.

Quality Control

The preparatory and analytical quality control requirements, calibration requirements, acceptance criteria, and failure actions are defined in the on-line QA plan “Conducting Analytical Work in Support of Regulatory Programs” (CAW). This QA plan implements the Hanford Analytical Services Quality Assurance Requirements Documents (HASQARD) for PNNL.

Definitions

Dup	Duplicate
RPD	Relative Percent Difference
NR	No Recovery (percent recovery less than zero)
ND	Non-Detectable
%REC	Percent Recovery

Sample Receipt

Samples were received with a chain of custody (COC) and were analyzed according to the sample identification numbers supplied by the client. All Samples were refrigerated upon receipt until prepared for analysis.

All samples were received with custody seals intact unless noted in the Case Narrative.

Holding Times

Holding time is defined as the time from sample preparation to the time of analyses. The prescribed holding times were met for all analytes unless noted in the Case Narrative.

Analytical Results

All reported analytical results meet the requirements of the CAW or client specified SOW unless noted in the case narrative.

Case Narrative Report

Labile Uranium Selective Extraction

The labile or adsorbed uranium extraction was performed on the <2 mm, air dried sediment samples. A solution containing 0.0144 mol/L of sodium bicarbonate ($NaHCO_3$) and 0.0028 mol/L of sodium carbonate (Na_2CO_3) with a pH of approximately 9.45 was added to the sediment at a solid to solution ratio of 1 gram/2 mL, and allowed to agitate on an orbital shaker for 1 week.

Sequential Extractions

Four sequential extractions were performed on the <2mm, air dried sediment samples. The first extraction involved a weak acetic acid consisting of 1 mol/L sodium acetate with a final pH of approximately 5. The sample was agitated on an orbital shaker for 1 hour at a solid to solution ratio of 1 gram/2 mL. After 1 hour, the sample was centrifuged, the solution decanted and filtered (for ICP-MS and ICP-OES analysis), and the sample was weighed to determine the remaining residual solution prior to starting the next sequential extraction. The target uranium phase for this extraction is the adsorbed uranium and uranium associated with carbonate minerals. The second sequential extraction used a strong acetic acid (concentrated glacial acetic acid). After 5 days contact time, the same centrifuge and decanting procedure was used. The target phase for the strong acetic acid is the strongly bound uranium. The third extraction used a solution consisting of 0.1 mol/L ammonium oxalate with 0.1 mol/L oxalic acid. After 1 hour of contact time, the samples were centrifuged, decanted, filtered and weighed. The target phase for the oxalate solution are the amorphous Fe, Al, Mn and Si oxides. The final nitric acid extraction involved 8 mol/L of nitric acid. The samples were transferred to a glass beaker with a stir bar and heated at 95°C for 2 hours on a hot plate. Samples were weighed after this step so the final volume could be determined. The target phases for the nitric acid include clays, crystalline oxides, and Fe, Al, and Mn uranium oxides.

Column Leach Tests

Four column leach tests were performed on the 300FF5 sediments. The leach tests for samples B30538 and B30546 were conducted using the <2 mm size fraction that had been air dried. Glass columns were used that were 1" in diameter and 6"in length. The other 2 leach tests were performed on columns that were left intact. Samples B30541 and B30543 were fitted with end caps and fittings that would allow the lexan liners to be hooked up to pumps for the column tests. Kloehn pumps were used to push a simulated groundwater solution (recipe in the table below) through the columns in an up-flow direction. At two times during the column testing, the flow was stopped for a period of 46 hours and 72 hours and then restarted to allow release kinetics to be determined from the increased uranium concentrations found immediately after the flow in the column resumes. Column effluent was collected using a fraction collector. Samples were weighed to calculate pore volume. At the completion of testing, 50 ppm of bromide (using sodium bromide) was added to the simulated groundwater and was pumped through all four columns (at the same rate used during the leach test) to aid in determining the column porosities.

Table 1. Recipe for simulated groundwater used in column tests.

Reagent	g/L
CaCO3	0.1207
MgSO4	0.06135
NaHCO3	0.08695
KCl	0.01154
NaNO3	0.03995
****pH was adjusted to 7.3 using HCl**	

Sediment Spectroscopy Analysis

Cryogenic time-resolved laser induced U(VI) fluorescence spectroscopic (TRLIFS) measurements of the uranium-bearing sediment samples were performed at near liquid helium temperature (LHeT, 6 ±2 °K) using methods described previously (Wang, Zachara et al. 2004; Wang, Zachara et al. 2005). In brief, sediment solids were placed inside a 2 mm × 4 mm x 25 mm fused quartz cuvette, sealed with a silicone stopper, further wrapped with parafilm and attached to the cold-finger of a Cryo Industries model RC-152 cryogenic workstation and cooled with helium vapors to lower the sample temperature. For spectral and lifetime measurements, the samples are excited at 415 nm using a Spectra-Physics Nd:YAG laser pumped Lasertechnik-GWU MOPO laser. The emitted light was collected at 85° to the excitation beam, dispersed through an Acton SpectroPro 300i double monochromator spectrograph, and detected with a thermoelectrically cooled Princeton Instruments PIMAX intensified CCD camera that was triggered by the delayed output of the laser pulse and controlled by the WinSpec data acquisition software. The photofluorescence decay curves were constructed by plotting the spectral intensity of a series of time-delayed fluorescence spectra as a function of the corresponding delay time. The emission spectra and decay data were analyzed using commercial software, IGOR®, from Wavematrix, Inc.

DISCLAIMER

The following analyses were performed on the following samples included in this report:

Metals Special Extract by ICP-OES
Moisture Content
pH of Waters By Electrode
U Special Extract by ICP-MS
U from Flow through column leach tests by ICP-MS
Geologic Description
Spectroscopy

SAMPLES ANALYZED IN THIS REPORT

Sample No.	Laboratory ID	Matrix	Date Collected	Date Received
B304T7	1501009-01	SOIL	12/31/14 08:35	1/8/15 09:30
B304T8	1501009-02	SOIL	12/31/14 08:35	1/8/15 09:30
B304T9	1501009-03	SOIL	12/31/14 08:35	1/8/15 09:30
B304V1	1501009-04	SOIL	12/31/14 08:35	1/8/15 09:30
B304V3	1501009-05	SOIL	12/31/14 09:11	1/8/15 09:30
B304V4	1501009-06	SOIL	12/31/14 09:11	1/8/15 09:30
B304V6	1501009-07	SOIL	12/31/14 09:11	1/8/15 09:30
B304V7	1501009-08	SOIL	12/31/14 10:40	1/8/15 09:30
B304V8	1501009-09	SOIL	12/31/14 10:40	1/8/15 09:30
B304V9	1501009-10	SOIL	12/31/14 10:40	1/8/15 09:30
B304W1	1501009-11	SOIL	12/31/14 10:40	1/8/15 09:30
B304W2	1501009-12	SOIL	12/31/14 11:40	1/8/15 09:30
B304W3	1501009-13	SOIL	12/31/14 11:40	1/8/15 09:30
B304W4	1501009-14	SOIL	12/31/14 11:40	1/8/15 09:30
B304W7	1501009-15	SOIL	12/31/14 11:40	1/8/15 09:30
B304W8	1501009-16	SOIL	12/31/14 13:00	1/8/15 09:30
B304W9	1501009-17	SOIL	12/31/14 13:00	1/8/15 09:30
B304X0	1501009-18	SOIL	12/31/14 13:00	1/8/15 09:30
B304X2	1501009-19	SOIL	12/31/14 13:00	1/8/15 09:30
B304X5	1501009-20	SOIL	12/31/14 13:40	1/8/15 09:30
B304X7	1501009-21	SOIL	12/31/14 13:40	1/8/15 09:30
B304X8	1501009-22	SOIL	1/6/15 09:05	1/8/15 09:30
B304X9	1501009-23	SOIL	1/6/15 09:05	1/8/15 09:30
B304Y0	1501009-24	SOIL	1/6/15 09:05	1/8/15 09:30
B304Y3	1501009-25	SOIL	1/6/15 09:05	1/8/15 09:30
B304Y4	1501009-26	SOIL	1/6/15 09:40	1/8/15 09:30
B304Y5	1501009-27	SOIL	1/6/15 09:40	1/8/15 09:30
B304Y6	1501009-28	SOIL	1/6/15 09:40	1/8/15 09:30
B304Y8	1501009-29	SOIL	1/6/15 09:40	1/8/15 09:30
B30505	1501009-30	SOIL	1/13/15 13:00	1/15/15 09:40
B30506	1501009-31	SOIL	1/13/15 13:00	1/15/15 09:40
B30507	1501009-32	SOIL	1/13/15 13:00	1/15/15 09:40
B30509	1501009-33	SOIL	1/13/15 13:00	1/15/15 09:40
B30510	1501009-34	SOIL	1/13/15 13:00	1/15/15 09:40
B30511	1501009-35	SOIL	1/13/15 13:30	1/15/15 09:40
B30512	1501009-36	SOIL	1/13/15 13:30	1/15/15 09:40
B30515	1501009-37	SOIL	1/13/15 13:30	1/15/15 09:40
B30516	1501009-38	SOIL	1/13/15 14:48	1/15/15 09:40
B30517	1501009-39	SOIL	1/13/15 14:48	1/15/15 09:40
B30518	1501009-40	SOIL	1/13/15 14:48	1/15/15 09:40
B30520	1501009-41	SOIL	1/13/15 14:48	1/15/15 09:40
B30521	1501009-42	SOIL	1/14/15 08:20	1/15/15 09:40
B30522	1501009-43	SOIL	1/14/15 08:20	1/15/15 09:40
B30523	1501009-44	SOIL	1/14/15 08:20	1/15/15 09:40
B30525	1501009-45	SOIL	1/14/15 08:20	1/15/15 09:40
B30526	1501009-46	SOIL	1/14/15 09:30	1/15/15 09:40

SAMPLES ANALYZED IN THIS REPORT

Sample No.	Laboratory ID	Matrix	Date Collected	Date Received
B30527	1501009-47	SOIL	1/14/15 09:30	1/15/15 09:40
B30528	1501009-48	SOIL	1/14/15 09:30	1/15/15 09:40
B30530	1501009-49	SOIL	1/14/15 09:30	1/15/15 09:40
B30531	1501009-50	SOIL	1/14/15 10:20	1/15/15 09:40
B30532	1501009-51	SOIL	1/14/15 10:20	1/15/15 09:40
B30533	1501009-52	SOIL	1/14/15 10:20	1/15/15 09:40
B30536	1501009-53	SOIL	1/14/15 10:20	1/15/15 09:40
B30537	1501009-54	SOIL	1/14/15 11:30	1/15/15 09:40
B30538	1501009-55	SOIL	1/14/15 11:30	1/15/15 09:40
B30539	1501009-56	SOIL	1/14/15 11:30	1/15/15 09:40
B30541	1501009-57	SOIL	1/14/15 11:30	1/15/15 09:40
B30542	1501009-58	SOIL	1/14/15 12:30	1/15/15 09:40
B30543	1501009-59	SOIL	1/14/15 12:30	1/15/15 09:40
B30544	1501009-60	SOIL	1/14/15 12:30	1/15/15 09:40
B30546	1501009-61	SOIL	1/14/15 12:30	1/15/15 09:40
B30547	1501009-62	SOIL	1/14/15 13:20	1/15/15 09:40
B30548	1501009-63	SOIL	1/14/15 13:20	1/15/15 09:40
B30549	1501009-64	SOIL	1/14/15 13:20	1/15/15 09:40
B30551	1501009-65	SOIL	1/14/15 13:20	1/15/15 09:40
B309C6	1501009-66	SOIL	1/14/15 14:40	1/15/15 09:40
B309C7	1501009-67	SOIL	1/14/15 14:40	1/15/15 09:40
B309C8	1501009-68	SOIL	1/14/15 14:40	1/15/15 09:40
B309D0	1501009-69	SOIL	1/14/15 14:40	1/15/15 09:40
B30555	1501009-70	SOIL	1/8/15 10:19	1/13/15 08:50
B30558	1501009-71	SOIL	1/8/15 10:19	1/13/15 08:50
B30559	1501009-72	SOIL	1/8/15 11:00	1/13/15 08:50
B30560	1501009-73	SOIL	1/8/15 11:00	1/13/15 08:50
B30561	1501009-74	SOIL	1/8/15 11:00	1/13/15 08:50
B30563	1501009-75	SOIL	1/8/15 11:00	1/13/15 08:50
B30566	1501009-76	SOIL	1/8/15 11:30	1/13/15 08:50
B30568	1501009-77	SOIL	1/8/15 11:30	1/13/15 08:50
B30569	1501009-78	SOIL	1/8/15 13:10	1/13/15 08:50
B30570	1501009-79	SOIL	1/8/15 13:10	1/13/15 08:50
B30571	1501009-80	SOIL	1/8/15 13:10	1/13/15 08:50
B30573	1501009-81	SOIL	1/8/15 13:10	1/13/15 08:50
B30574	1501009-82	SOIL	1/8/15 13:35	1/13/15 08:50
B30575	1501009-83	SOIL	1/8/15 13:35	1/13/15 08:50
B30576	1501009-84	SOIL	1/8/15 13:35	1/13/15 08:50
B30579	1501009-85	SOIL	1/8/15 13:35	1/13/15 08:50
B30580	1501009-86	SOIL	1/12/15 08:20	1/13/15 08:50
B30581	1501009-87	SOIL	1/12/15 08:20	1/13/15 08:50
B30582	1501009-88	SOIL	1/12/15 08:20	1/13/15 08:50
B30584	1501009-89	SOIL	1/12/15 08:20	1/13/15 08:50
B30587	1501009-90	SOIL	1/12/15 08:40	1/13/15 08:50
B30589	1501009-91	SOIL	1/12/15 08:40	1/13/15 08:50
B30590	1501009-92	SOIL	1/12/15 10:00	1/13/15 08:50

SAMPLES ANALYZED IN THIS REPORT

Sample No.	Laboratory ID	Matrix	Date Collected	Date Received
B30591	1501009-93	SOIL	1/12/15 10:00	1/13/15 08:50
B30592	1501009-94	SOIL	1/12/15 10:00	1/13/15 08:50
B30594	1501009-95	SOIL	1/12/15 10:00	1/13/15 08:50
B30597	1501009-96	SOIL	1/12/15 11:00	1/13/15 08:50
B30599	1501009-97	SOIL	1/12/15 11:00	1/13/15 08:50
B309F2	1501009-98	SOIL	1/12/15 12:50	1/13/15 08:50
B309F3	1501009-99	SOIL	1/12/15 12:50	1/13/15 08:50
B309F5	1501009-AA	SOIL	1/12/15 12:50	1/13/15 08:50

Wet Chemistry

Moisture Content (% by Weight) by AGG-WC-001

Lab ID	**Client ID.**	Results	EQL	Analyzed	Batch
1501009-25	B304Y3	5.00E0	N/A	3/13/15	5B17006
1501009-27	B304Y5	7.63E0	N/A	3/13/15	5B17006
1501009-45	B30525	8.44E0	N/A	3/13/15	5B17006
1501009-55	B30538	8.22E0	N/A	3/13/15	5B17006
1501009-61	B30546	1.47E1	N/A	3/13/15	5B17006
1501009-91	B30589	6.31E0	N/A	3/13/15	5B17006
1501009-AB	B304Y3 <2mm air dried	1.98E0	N/A	2/17/15	5B16005
1501009-AC	B304Y5 <2mm air dried	1.67E0	N/A	2/17/15	5B16005
1501009-AD	B30525 <2mm air dried	1.35E0	N/A	2/17/15	5B16005
1501009-AE	B30538 <2mm air dried	2.41E0	N/A	2/17/15	5B16005
1501009-AF	B30546 <2mm air dried	1.88E0	N/A	2/17/15	5B16005
1501009-AG	B30589 <2mm air dried	1.42E0	N/A	2/17/15	5B16005

Wet Chemistry

pH (pH Units) by AGG-pH-001

Lab ID	**Client ID.**	Results	EQL	Analyzed	Batch
1501009-AB	B304Y3 <2mm air dried	7.88E0	N/A	2/18/15	5B19003
1501009-AC	B304Y5 <2mm air dried	7.95E0	N/A	2/18/15	5B19003
1501009-AD	B30525 <2mm air dried	8.38E0	N/A	2/18/15	5B19003
1501009-AE	B30538 <2mm air dried	7.42E0	N/A	2/18/15	5B19003
1501009-AF	B30546 <2mm air dried	7.50E0	N/A	2/18/15	5B19003
1501009-AG	B30589 <2mm air dried	7.97E0	N/A	2/18/15	5B19003

Sequential Extraction-ICP-OES Results

LabNumber	SampleName	Analyte	final concentration	Units	EQL
1502014-01	B304Y3 weak acetic acid	Aluminum	3.14E+01	ug/g	1650
1502014-02	B304Y5 weak acetic acid	Aluminum	2.92E+01	ug/g	1650
1502014-03	B30525 weak acetic acid	Aluminum	4.42E+01	ug/g	1650
1502014-04	B30538 weak acetic acid	Aluminum	5.36E+01	ug/g	1650
1502014-05	B30546 weak acetic acid	Aluminum	4.08E+01	ug/g	1650
1502014-07	B30589 weak acetic acid	Aluminum	3.10E+01	ug/g	1650
1502014-08	B304Y3 strong acetic acid	Aluminum	1.10E+01	ug/g	1650
1502014-09	B304Y5 strong acetic acid	Aluminum	8.63E+00	ug/g	1650
1502014-10	B30525 strong acetic acid	Aluminum	1.80E+01	ug/g	1650
1502014-11	B30538 strong acetic acid	Aluminum	3.66E+01	ug/g	1650
1502014-12	B30546 strong acetic acid	Aluminum	1.69E+01	ug/g	1650
1502014-14	B30589 strong acetic acid	Aluminum	1.23E+01	ug/g	1650
1502014-15	B304Y3 oxalate	Aluminum	6.95E+02	ug/g	1650
1502014-16	B304Y5 oxalate	Aluminum	4.77E+02	ug/g	1650
1502014-17	B30525 oxalate	Aluminum	7.63E+02	ug/g	1650
1502014-18	B30538 oxalate	Aluminum	1.54E+03	ug/g	1650
1502014-19	B30546 oxalate	Aluminum	8.97E+02	ug/g	1650
1502014-21	B30589 oxalate	Aluminum	6.16E+02	ug/g	1650
1502014-22	B304Y3 nitric acid	Aluminum	2.85E+04	ug/g	16500
1502014-23	B304Y5 nitric acid	Aluminum	1.62E+04	ug/g	1650
1502014-24	B30525 nitric acid	Aluminum	1.77E+04	ug/g	1650
1502014-25	B30538 nitric acid	Aluminum	4.51E+04	ug/g	16500
1502014-26	B30546 nitric acid	Aluminum	2.59E+04	ug/g	16500
1502014-28	B30589 nitric acid	Aluminum	1.43E+04	ug/g	1650
1502014-01	B304Y3 weak acetic acid	Calcium	1.60E+03	ug/g	4900
1502014-02	B304Y5 weak acetic acid	Calcium	1.27E+03	ug/g	4900
1502014-03	B30525 weak acetic acid	Calcium	2.00E+03	ug/g	4900
1502014-04	B30538 weak acetic acid	Calcium	1.61E+03	ug/g	4900
1502014-05	B30546 weak acetic acid	Calcium	1.39E+03	ug/g	4900
1502014-07	B30589 weak acetic acid	Calcium	1.45E+03	ug/g	4900
1502014-08	B304Y3 strong acetic acid	Calcium	2.70E+02	ug/g	4900
1502014-09	B304Y5 strong acetic acid	Calcium	2.21E+02	ug/g	4900
1502014-10	B30525 strong acetic acid	Calcium	3.95E+02	ug/g	4900
1502014-11	B30538 strong acetic acid	Calcium	4.24E+02	ug/g	4900
1502014-12	B30546 strong acetic acid	Calcium	2.31E+02	ug/g	4900
1502014-14	B30589 strong acetic acid	Calcium	3.11E+02	ug/g	4900
1502014-15	B304Y3 oxalate	Calcium	n/a	ug/g	4900
1502014-16	B304Y5 oxalate	Calcium	n/a	ug/g	4900
1502014-17	B30525 oxalate	Calcium	n/a	ug/g	4900
1502014-18	B30538 oxalate	Calcium	n/a	ug/g	4900
1502014-19	B30546 oxalate	Calcium	n/a	ug/g	4900
1502014-21	B30589 oxalate	Calcium	n/a	ug/g	4900
1502014-22	B304Y3 nitric acid	Calcium	1.19E+04	ug/g	4900
1502014-23	B304Y5 nitric acid	Calcium	1.24E+04	ug/g	4900
1502014-24	B30525 nitric acid	Calcium	1.14E+04	ug/g	4900
1502014-25	B30538 nitric acid	Calcium	1.07E+04	ug/g	4900
1502014-26	B30546 nitric acid	Calcium	1.30E+04	ug/g	4900
1502014-28	B30589 nitric acid	Calcium	1.05E+04	ug/g	4900

LabNumber	SampleName	Analyte	final concentration	Units	EQL
1502014-01	B304Y3 weak acetic acid	Iron	4.10E+00	ug/g	1000
1502014-02	B304Y5 weak acetic acid	Iron	9.36E+00	ug/g	1000
1502014-03	B30525 weak acetic acid	Iron	1.47E+01	ug/g	1000
1502014-04	B30538 weak acetic acid	Iron	7.32E+00	ug/g	1000
1502014-05	B30546 weak acetic acid	Iron	9.22E+00	ug/g	1000
1502014-07	B30589 weak acetic acid	Iron	4.66E+01	ug/g	1000
1502014-08	B304Y3 strong acetic acid	Iron	n/a	ug/g	1000
1502014-09	B304Y5 strong acetic acid	Iron	n/a	ug/g	1000
1502014-10	B30525 strong acetic acid	Iron	2.05E+01	ug/g	1000
1502014-11	B30538 strong acetic acid	Iron	4.44E+01	ug/g	1000
1502014-12	B30546 strong acetic acid	Iron	5.70E+01	ug/g	1000
1502014-14	B30589 strong acetic acid	Iron	7.79E+02	ug/g	1000
1502014-15	B304Y3 oxalate	Iron	9.05E+02	ug/g	1000
1502014-16	B304Y5 oxalate	Iron	2.39E+03	ug/g	1000
1502014-17	B30525 oxalate	Iron	1.54E+03	ug/g	1000
1502014-18	B30538 oxalate	Iron	7.82E+02	ug/g	1000
1502014-19	B30546 oxalate	Iron	1.45E+03	ug/g	1000
1502014-21	B30589 oxalate	Iron	3.69E+03	ug/g	1000
1502014-22	B304Y3 nitric acid	Iron	6.32E+04	ug/g	10000
1502014-23	B304Y5 nitric acid	Iron	5.45E+04	ug/g	10000
1502014-24	B30525 nitric acid	Iron	5.34E+04	ug/g	10000
1502014-25	B30538 nitric acid	Iron	5.42E+04	ug/g	10000
1502014-26	B30546 nitric acid	Iron	6.52E+04	ug/g	10000
1502014-28	B30589 nitric acid	Iron	5.21E+04	ug/g	10000
1502014-01	B304Y3 weak acetic acid	Manganese	3.74E+00	ug/g	941
1502014-02	B304Y5 weak acetic acid	Manganese	7.34E+00	ug/g	941
1502014-03	B30525 weak acetic acid	Manganese	1.03E+01	ug/g	941
1502014-04	B30538 weak acetic acid	Manganese	9.90E+00	ug/g	941
1502014-05	B30546 weak acetic acid	Manganese	9.02E+00	ug/g	941
1502014-07	B30589 weak acetic acid	Manganese	2.70E+01	ug/g	941
1502014-08	B304Y3 strong acetic acid	Manganese	1.71E+01	ug/g	941
1502014-09	B304Y5 strong acetic acid	Manganese	2.43E+01	ug/g	941
1502014-10	B30525 strong acetic acid	Manganese	3.67E+01	ug/g	941
1502014-11	B30538 strong acetic acid	Manganese	7.30E+01	ug/g	941
1502014-12	B30546 strong acetic acid	Manganese	3.91E+01	ug/g	941
1502014-14	B30589 strong acetic acid	Manganese	6.80E+01	ug/g	941
1502014-15	B304Y3 oxalate	Manganese	1.02E+02	ug/g	941
1502014-16	B304Y5 oxalate	Manganese	5.77E+01	ug/g	941
1502014-17	B30525 oxalate	Manganese	2.94E+01	ug/g	941
1502014-18	B30538 oxalate	Manganese	4.95E+01	ug/g	941
1502014-19	B30546 oxalate	Manganese	4.10E+01	ug/g	941
1502014-21	B30589 oxalate	Manganese	3.74E+01	ug/g	941
1502014-22	B304Y3 nitric acid	Manganese	6.94E+02	ug/g	941
1502014-23	B304Y5 nitric acid	Manganese	6.22E+02	ug/g	941
1502014-24	B30525 nitric acid	Manganese	5.50E+02	ug/g	941
1502014-25	B30538 nitric acid	Manganese	6.49E+02	ug/g	941
1502014-26	B30546 nitric acid	Manganese	7.12E+02	ug/g	941
1502014-28	B30589 nitric acid	Manganese	6.38E+02	ug/g	941

Sequential Extraction-ICPMS Uranium Results

LabNumber	SampleName	Analyte	final concentration	Units	EQL
1502014-01	B304Y3 weak acetic acid	Uranium 238	1.31E+01	ug/g	10.6
1502014-02	B304Y5 weak acetic acid	Uranium 238	5.98E+00	ug/g	10.6
1502014-03	B30525 weak acetic acid	Uranium 238	1.28E+01	ug/g	10.6
1502014-04	B30538 weak acetic acid	Uranium 238	5.38E+01	ug/g	10.6
1502014-05	B30546 weak acetic acid	Uranium 238	6.78E+00	ug/g	10.6
1502014-07	B30589 weak acetic acid	Uranium 238	2.96E+00	ug/g	10.6
1502014-08	B304Y3 strong acetic acid	Uranium 238	5.19E+00	ug/g	10.6
1502014-09	B304Y5 strong acetic acid	Uranium 238	2.93E+00	ug/g	10.6
1502014-10	B30525 strong acetic acid	Uranium 238	7.74E+00	ug/g	10.6
1502014-11	B30538 strong acetic acid	Uranium 238	2.41E+01	ug/g	10.6
1502014-12	B30546 strong acetic acid	Uranium 238	4.86E+00	ug/g	10.6
1502014-14	B30589 strong acetic acid	Uranium 238	1.28E+00	ug/g	10.6
1502014-15	B304Y3 oxalate	Uranium 238	2.52E+00	ug/g	10.6
1502014-16	B304Y5 oxalate	Uranium 238	1.57E+00	ug/g	10.6
1502014-17	B30525 oxalate	Uranium 238	5.20E+00	ug/g	10.6
1502014-18	B30538 oxalate	Uranium 238	1.31E+01	ug/g	10.6
1502014-19	B30546 oxalate	Uranium 238	3.93E+00	ug/g	10.6
1502014-21	B30589 oxalate	Uranium 238	8.44E-01	ug/g	10.6
1502014-22	B304Y3 nitric acid	Uranium 238	4.99E+00	ug/g	10.6
1502014-23	B304Y5 nitric acid	Uranium 238	4.18E+00	ug/g	10.6
1502014-24	B30525 nitric acid	Uranium 238	3.19E+01	ug/g	10.6
1502014-25	B30538 nitric acid	Uranium 238	3.48E+01	ug/g	10.6
1502014-26	B30546 nitric acid	Uranium 238	1.55E+01	ug/g	10.6
1502014-28	B30589 nitric acid	Uranium 238	1.76E+00	ug/g	10.6

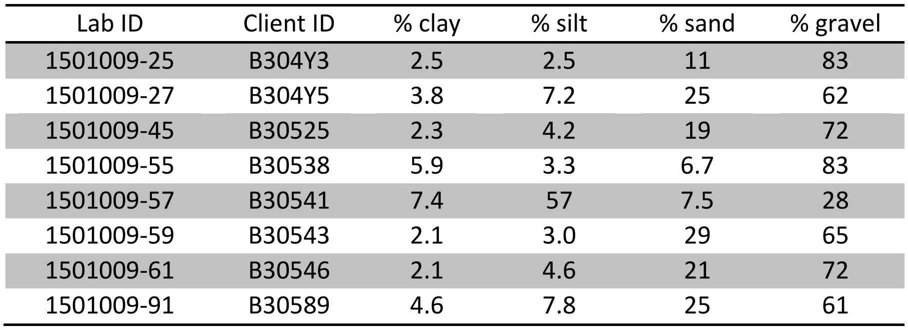
Total Metals by PNNL-AGG-ICP-AES/Special Extraction for Labile Uranium

CAS #	Analyte	Results	Units	EQL	Analyzed	Batch	Method
Client ID.	**B304Y3 <2mm air dried**	**Lab ID:**		**1501009-AB**			
7429-90-5	Aluminum	<6.38E-1	ug/g dry	6.38E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7440-70-2	Calcium	4.53E1	ug/g dry	3.08E0	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-89-6	Iron	<7.14E-1	ug/g dry	7.14E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<4.25E-1	ug/g dry	4.25E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
Client ID.	**B304Y5 <2mm air dried**	**Lab ID:**		**1501009-AC**			
7429-90-5	Aluminum	<6.35E-1	ug/g dry	6.35E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7440-70-2	Calcium	2.84E1	ug/g dry	3.06E0	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-89-6	Iron	<7.11E-1	ug/g dry	7.11E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<4.23E-1	ug/g dry	4.23E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
Client ID.	**B30525 <2mm air dried**	**Lab ID:**		**1501009-AD**			
7429-90-5	Aluminum	1.40E0	ug/g dry	6.33E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7440-70-2	Calcium	8.34E0	ug/g dry	3.06E0	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-89-6	Iron	1.58E0	ug/g dry	7.09E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<4.22E-1	ug/g dry	4.22E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
Client ID.	**B30538 <2mm air dried**	**Lab ID:**		**1501009-AE**			
7429-90-5	Aluminum	<6.40E-1	ug/g dry	6.40E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7440-70-2	Calcium	5.91E1	ug/g dry	3.09E0	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-89-6	Iron	<7.16E-1	ug/g dry	7.16E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<4.26E-1	ug/g dry	4.26E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
Client ID.	**B30546 <2mm air dried**	**Lab ID:**		**1501009-AF**			
7429-90-5	Aluminum	<6.37E-1	ug/g dry	6.37E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7440-70-2	Calcium	4.31E1	ug/g dry	3.07E0	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-89-6	Iron	<7.12E-1	ug/g dry	7.12E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<4.24E-1	ug/g dry	4.24E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
Client ID.	**B30589 <2mm air dried**	**Lab ID:**		**1501009-AG**			
7429-90-5	Aluminum	<6.34E-1	ug/g dry	6.34E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7440-70-2	Calcium	3.19E1	ug/g dry	3.06E0	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-89-6	Iron	<7.09E-1	ug/g dry	7.09E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<4.22E-1	ug/g dry	4.22E-1	3/05/15	5C05003	PNNL-AGG-ICP-AES

Radionuclides by ICP-MS/Special Extraction for Labile Uranium

CAS #	Analyte	Results	Units	EQL	Analyzed	Batch	Method
Client ID.	**B304Y3 <2mm air dried**	**Lab ID:**	**1501009-AB**				
U-238	Uranium 238	7.89E0	ug/g dry	3.27E-3	3/04/15	5C04003	PNNL-AGG-415
Client ID.	**B304Y5 <2mm air dried**	**Lab ID:**	**1501009-AC**				
U-238	Uranium 238	3.92E0	ug/g dry	3.25E-3	3/04/15	5C04003	PNNL-AGG-415
Client ID.	**B30525 <2mm air dried**	**Lab ID:**	**1501009-AD**				
U-238	Uranium 238	7.05E0	ug/g dry	3.24E-3	3/04/15	5C04003	PNNL-AGG-415
Client ID.	**B30538 <2mm air dried**	**Lab ID:**	**1501009-AE**				
U-238	Uranium 238	1.20E1	ug/g dry	3.28E-3	3/04/15	5C04003	PNNL-AGG-415
Client ID.	**B30546 <2mm air dried**	**Lab ID:**	**1501009-AF**				
U-238	Uranium 238	3.65E0	ug/g dry	3.26E-3	3/04/15	5C04003	PNNL-AGG-415
Client ID.	**B30589 <2mm air dried**	**Lab ID:**	**1501009-AG**				
U-238	Uranium 238	1.12E0	ug/g dry	3.25E-3	3/04/15	5C04003	PNNL-AGG-415

Particle Size Analysis



Lab ID	Client ID	% clay	% silt	% sand	% gravel
1501009-25	B304Y3	2.5	2.5	11	83
1501009-27	B304Y5	3.8	7.2	25	62
1501009-45	B30525	2.3	4.2	19	72
1501009-55	B30538	5.9	3.3	6.7	83
1501009-57	B30541	7.4	57	7.5	28
1501009-59	B30543	2.1	3.0	29	65
1501009-61	B30546	2.1	4.6	21	72
1501009-91	B30589	4.6	7.8	25	61

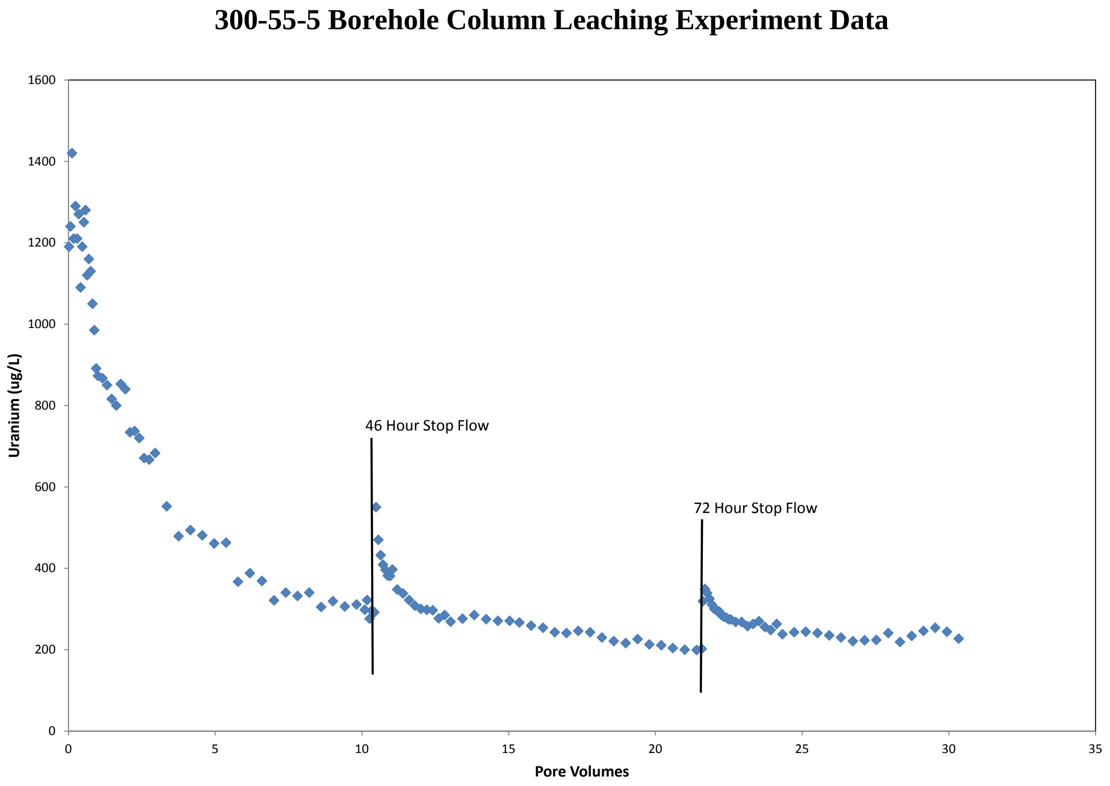


Figure 1. Uranium Concentration Versus Pore Volume and for Intact Core B30541 (estimated pore volume 345.0 mL, approximate flow rate 0.1519 pore volume per hour).

Table 2. Leachate Sample Pore and Uranium Concentration for Intact Core B30541 (estimated pore volume 345.0 mL, approximate flow rate 0.1519 pore volume per hour).

Pore Volume	Uranium (μg/L)	pH	Note
0.02	1190	8.31	
0.07	1240		
0.13	1420	8.35	
0.18	1210		
0.24	1290	8.41	
0.30	1210		
0.36	1270	8.37	
0.42	1090		
0.47	1190	8.38	
0.53	1250		
0.59	1280	8.34	
0.64	1120		
0.70	1160	8.41	
0.76	1130		

0.82	1050	8.38	
0.88	985		
0.94	891	8.32	
1.01	873		
1.16	867	8.47	
1.32	850		
1.48	816		
1.63	800		
1.79	853	8.30	
1.94	840		
2.10	734		
2.26	737		
2.42	720	8.29	
2.58	671		
2.75	667		
2.96	683		
3.35	552	8.31	
3.76	479		
4.16	494		
4.56	481		
4.97	461	8.24	
5.37	463		
5.78	367		
6.19	388		
6.60	369	8.29	
7.01	321		
7.41	340		
7.81	332		
8.21	340	8.08	
8.61	305		
9.02	319		
9.42	306		
9.82	311	8.31	
10.10	298		46 Hour Stop Flow
10.18	322	8.29	
10.26	276		
10.34	296	8.22	
10.43	292		
10.49	550	8.37	
10.56	470		
10.64	432	8.31	
10.72	409		
10.80	396	8.29	
10.88	382		
10.96	381	8.31	
11.04	397		
11.20	348	8.26	

11.40	338		
11.61	322		
11.81	308		
12.01	300	8.28	
12.22	298		
12.42	297		
12.62	277		
12.82	285	8.19	
13.03	269		
13.43	276		
13.83	285		
14.24	275	8.30	
14.64	271		
15.03	271		
15.37	267		
15.77	259	8.20	
16.17	254		
16.57	243		
16.97	241		
17.37	246	8.12	
17.78	243		
18.18	230		
18.59	221		
18.99	216	8.15	
19.39	226		
19.80	213		
20.20	211		
20.60	204	8.15	
21.00	200		
21.41	199	8.12	
21.58	202	8.00	72 Hour Stop Flow
21.62	319		
21.69	349	8.36	
21.77	339		
21.85	325	8.31	
21.93	311		
22.01	300	8.38	
22.09	297		
22.17	294	8.28	
22.25	285		
22.33	281	8.24	
22.41	279		
22.50	275	8.35	
22.58	274		
22.74	268	8.21	
22.94	268		
23.14	258		

23.34	263	
23.53	270	8.12
23.73	256	
23.93	248	
24.13	263	
24.33	238	8.13
24.73	243	
25.13	244	
25.53	241	
25.93	235	8.15
26.33	230	
26.73	221	
27.13	223	
27.53	224	8.20
27.94	241	
28.34	219	
28.74	234	
29.14	246	8.16
29.54	254	
29.94	244	
30.34	227	8.17

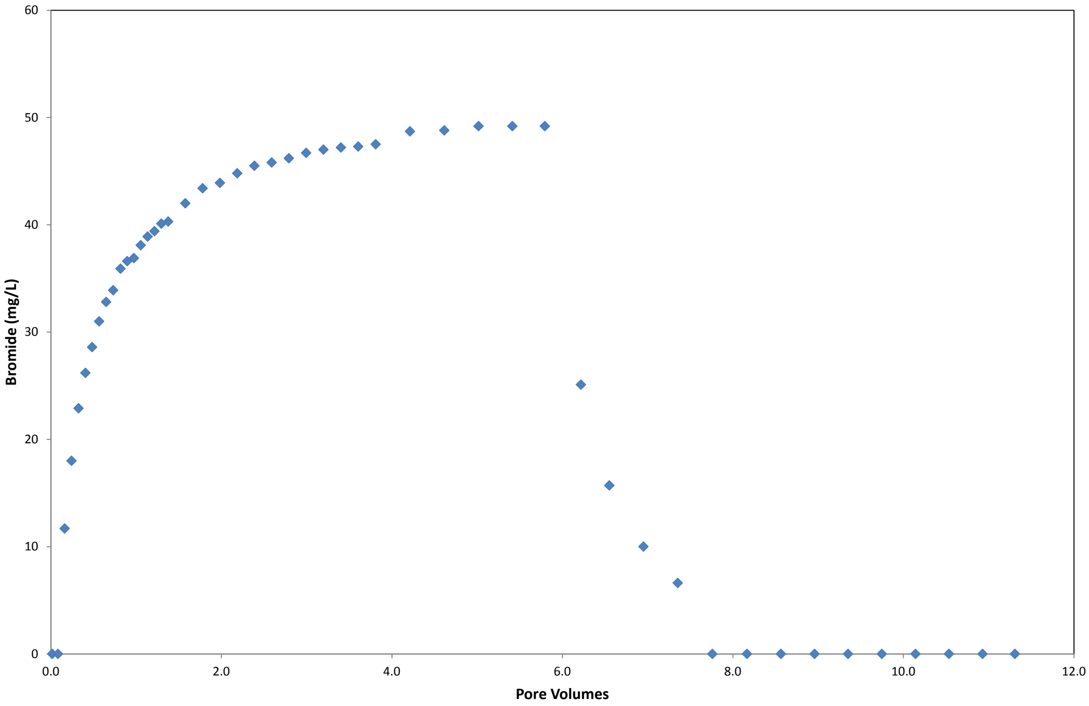


Figure 2. Bromide Concentration Versus Pore Volume and for Intact Core B30541 (estimated pore volume 345.0 mL, approximate flow rate 0.1519 pore volume per hour).

Table 3. Leachate Sample Pore Volume and Bromide Concentration for Intact Core B30541 (estimated pore volume 345.0 mL, approximate flow rate 0.1519 pore volume per hour).

Pore Volume	Bromide (mg/L)	Note
0.02	0.0	
0.08	0.0	
0.16	11.7	
0.24	18.0	
0.32	22.9	
0.41	26.2	
0.48	28.6	
0.57	31.0	
0.65	32.8	
0.73	33.9	
0.82	35.9	
0.90	36.6	
0.97	36.9	
1.05	38.1	
1.13	38.9	
1.22	39.4	
1.30	40.1	
1.38	40.3	
1.58	42.0	
1.78	43.4	
1.98	43.9	
2.19	44.8	
2.39	45.5	
2.59	45.8	
2.79	46.2	
2.99	46.7	
3.20	47.0	
3.40	47.2	
3.61	47.3	
3.81	47.5	
4.21	48.7	
4.62	48.8	
5.02	49.2	
5.41	49.2	
5.80	49.2	No Bromide
6.22	25.1	
6.55	15.7	
6.95	10.0	
7.35	6.6	
7.76	0.0	

8.17	0.0
8.56	0.0
8.96	0.0
9.35	0.0
9.75	0.0
10.14	0.0
10.53	0.0
10.93	0.0
11.31	0.0

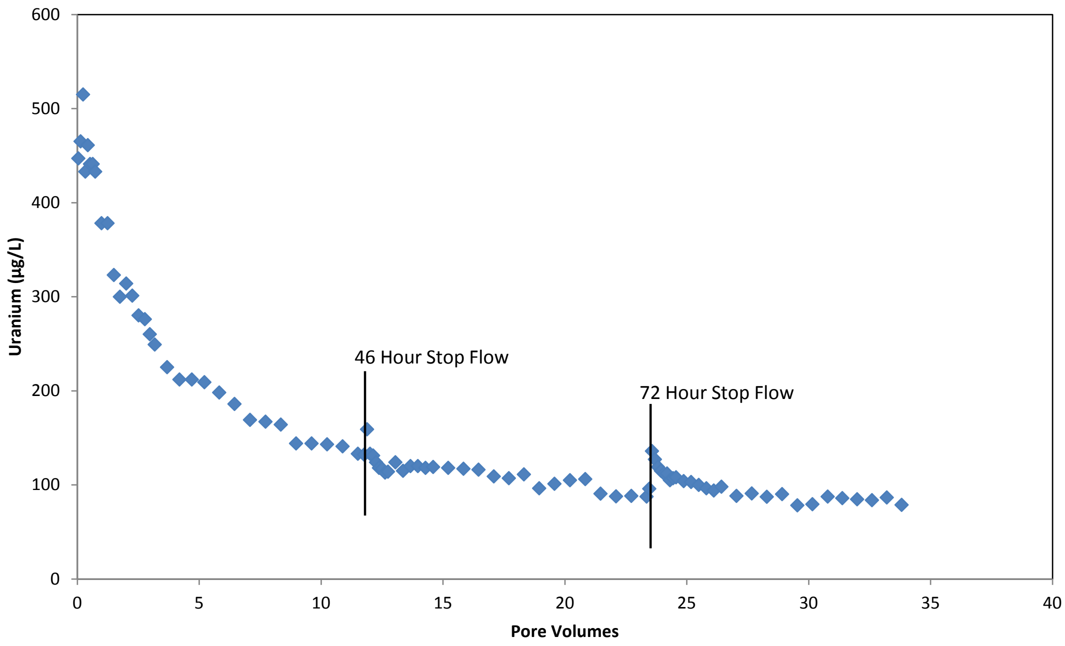


Figure 3. Uranium Concentration Versus Pore Volume and for Intact Core B30543 (estimated pore volume 223.5 mL, approximate flow rate 0.2476 pore volume per hour).

Table 4. Leachate Sample Pore Volume and Uranium Concentration for Intact Core B30543 (estimated pore volume 223.5 mL, approximate flow rate 0.2476 pore volume per hour).

Pore Volume	Uranium (µg/L)	pH	Note
0.04	447.00	8.38	
0.14	465.00		
0.23	515.00	8.33	
0.33	433.00		

0.43	461.00	8.32	
0.52	441.00		
0.63	441.00	8.17	
0.74	433.00		
0.99	378.00	8.23	
1.24	378.00		
1.50	323.00		
1.75	300.00	8.20	
2.00	314.00		
2.26	301.00		
2.51	280.00		
2.77	276.00	8.16	
2.97	260.00		
3.17	249.00		
3.68	225.00		
4.19	212.00	8.16	
4.70	212.00		
5.21	209.00		
5.82	198.00		
6.45	186.00	8.16	
7.08	169.00		
7.72	167.00		
8.34	164.00		
8.98	144.00	8.22	
9.61	144.00		
10.24	143.00		
10.88	141.00		
11.50	133.00	8.15	
11.76	132.00		46 Hour Stop Flow
11.89	159.00	8.22	
12.01	133.00		
12.13	131.00	8.19	
12.25	124.00		
12.38	118.00	8.26	
12.50	117.00		
12.62	113.00	8.29	
12.74	114.00		
13.05	124.00	8.11	
13.36	115.00		
13.67	120.00		
13.97	120.00		
14.28	118.00	8.12	
14.59	119.00		
15.21	118.00		
15.84	117.00		
16.46	116.00	8.14	
17.08	109.00		

17.70	107.00		
18.32	111.00		
18.95	96.20	8.21	
19.57	101.00		
20.21	105.00		
20.84	106.00		
21.47	90.60	8.12	
22.10	87.80		
22.73	88.20		
23.35	87.40	8.13	
23.46	95.80		72 Hour Stop Flow
23.57	136.00	8.29	
23.69	127.00		
23.82	119.00	8.23	
23.94	115.00		
24.07	112.00	8.22	
24.19	112.00		
24.31	105.00	8.24	
24.44	107.00		
24.56	108.00	8.26	
24.87	104.00	8.18	
25.18	103.00		
25.49	100.00		
25.80	96.40		
26.11	94.00	8.23	
26.42	97.90		
27.04	88.10		
27.66	90.80		
28.28	87.20	8.20	
28.91	90.00	8.14	
29.53	78.30		
30.16	79.50		
30.78	87.50		
31.38	85.90	8.13	
31.99	84.60		
32.60	83.60		
33.21	86.60		
33.81	78.70	8.19	

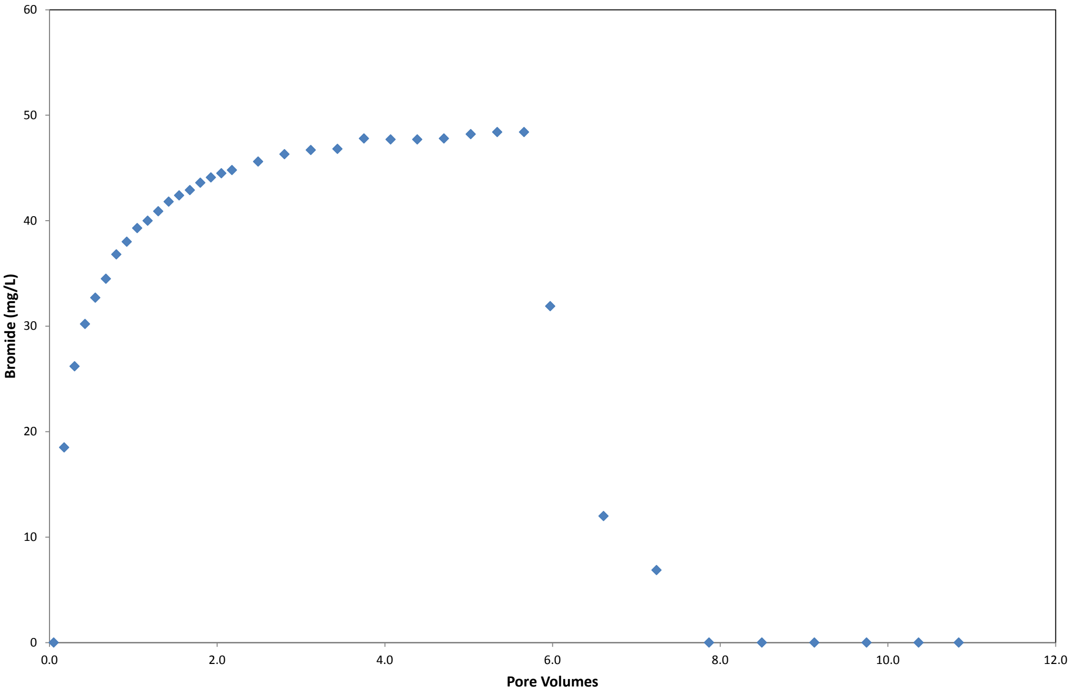


Figure 4. Bromide Concentration Versus Pore Volume and for Intact Core B30543 (estimated pore volume 223.5 mL, approximate flow rate 0.2476 pore volume per hour).

Table 5. Leachate Sample Pore Volume and Bromide Concentration for Intact Core B30543 (estimated pore volume 223.5 mL, approximate flow rate 0.2476 pore volume per hour).

Pore Volume	Bromide (mg/L)	Note
0.05	0.0	
0.17	18.5	
0.30	26.2	
0.42	30.2	
0.55	32.7	
0.67	34.5	
0.80	36.8	
0.92	38.0	
1.05	39.3	
1.17	40.0	
1.30	40.9	
1.42	41.8	
1.55	42.4	
1.67	42.9	
1.80	43.6	
1.93	44.1	
2.05	44.5	

2.18	44.8
2.49	45.6
2.80	46.3
3.12	46.7
3.43	46.8
3.75	47.8
4.07	47.7
4.39	47.7
4.71	47.8
5.02	48.2
5.34	48.4
5.66	48.4
5.97	31.9
6.61	12.0
7.24	6.9
7.87	0.0
8.50	0.0
9.12	0.0
9.75	0.0
10.37	0.0
10.85	0.0

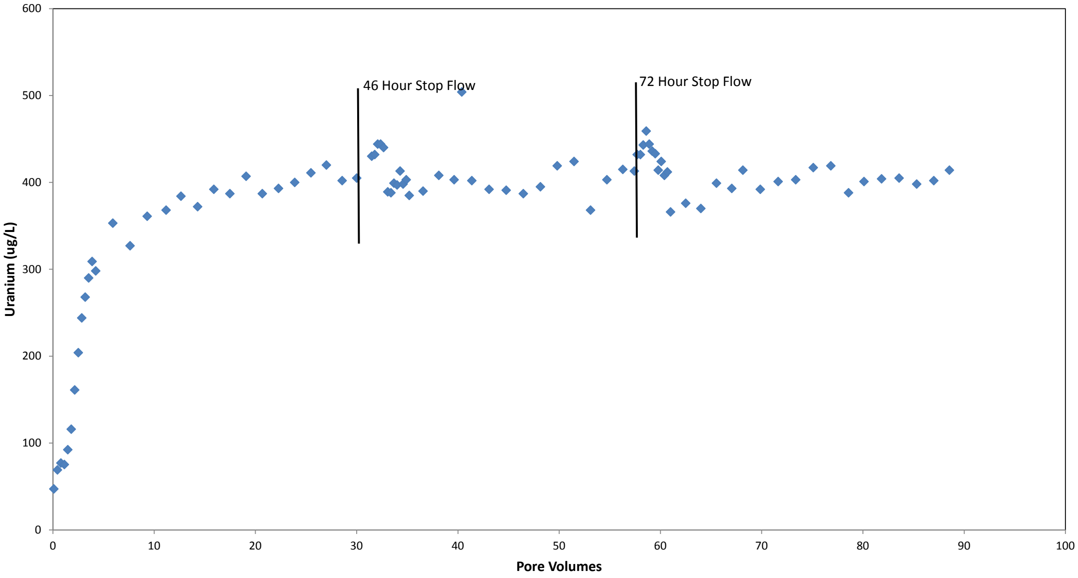


Figure 5. Uranium Concentration Versus Pore Volume and for Repacked (< 2mm) Column B30538 (estimated pore volume 28.65 mL, approximate flow rate 0.2193 pore volume per hour).

Table 6. Leachate Sample Pore and Uranium Concentration for Repacked (< 2mm) Column from Core B30538 (estimated pore volume 28.65 mL, approximate flow rate 0.2193 pore volume per hour).

Pore Volume	Uranium (µg/L)	pH	Note
0.10	47.2		
0.27		7.72	
0.44	69.1		
0.79	77.0		
0.96		7.69	
1.13	75.3		
1.47	92.3		
1.64		7.77	
1.81	116.0		
2.16	161.0		
2.33		8.00	
2.50	204.0		
2.85	244.0		
3.02		8.04	
3.19	268.0		
3.53	290.0		
3.70		8.20	
3.88	309.0		
4.22	298.0		
4.39		8.19	
5.08		8.09	

5.76		8.08
5.92	353.0	
6.43		8.04
7.11		8.02
7.62	327.0	
7.79		8.13
8.47		8.26
9.15		8.12
9.31	361.0	
9.83		8.06
10.51		8.16
11.17	368.0	8.20
11.83		8.25
12.49		8.17
12.65	384.0	
13.14		8.22
13.80		8.06
14.29	372.0	
14.46		8.27
14.62		8.21
15.10		8.23
15.90	392.0	
16.37		8.23
17.01		8.12
17.48	387.0	
17.64		8.11
18.28		7.98
18.92		8.14
19.08	407.0	
19.55		8.10
20.20		8.07
20.68	387.0	
20.84		8.07
21.48		8.07
22.12		8.06
22.28	393.0	
22.76		8.06
23.40		8.22
23.89	400.0	
24.05		8.03
24.69		8.08
25.33		8.08
25.49	411.0	
25.92		8.02
26.55		8.07
27.02	420.0	
27.18		8.01

27.80		8.10	
28.42		8.21	
28.57	402.0		
29.04		8.11	
29.66		8.01	
30.01	405.0		46 Hour Stop Flow
31.34		8.14	
31.49	430.0		
31.64		8.19	
31.78	432.0		
31.93		8.14	
32.08	444.0		
32.22		8.04	
32.37	444.0		
32.52		7.98	
32.67	440.0		
32.92		8.08	
33.07	389.0		
33.23		8.03	
33.38	388.0		
33.53		8.07	
33.68	399.0		
33.83		8.11	
33.99	397.0		
34.14		8.00	
34.29	413.0		
34.43		8.00	
34.58	398.0		
34.90	403.0		
35.04		8.24	
35.19	385.0		
35.66		8.05	
36.25		8.03	
36.56	390.0		
36.87		8.19	
37.49		8.16	
38.11	408.0	8.18	
38.71		8.20	
39.32		8.22	
39.63	403.0		
39.90		8.11	
40.19		8.16	
40.39	504.0		
40.71		8.06	
41.38	402.0	8.20	
42.06		8.07	
42.74		8.20	

43.08	392.0		
43.41		8.20	
44.09		8.23	
44.77	391.0	8.02	
45.43		8.12	
46.12		8.12	
46.46	387.0		
46.80		8.02	
47.48		8.11	
48.16	395.0	8.27	
48.33		8.22	
49.15		8.23	
49.81	419.0	8.26	
50.48		8.17	
51.14		8.17	
51.47	424.0		
51.79		8.19	
52.45		8.17	
53.10	368.0	8.11	
53.74		8.20	
54.39		8.13	
54.71	403.0		
55.03		8.11	
55.66		8.14	
56.29	415.0	8.12	
56.92		8.15	
57.42	413.0	8.05	72 Hour Stop Flow
57.72	432.0	8.04	
58.02	432.0	8.22	
58.31	443.0	8.13	
58.60	459.0	8.15	
58.90	444.0	8.26	
59.19	436.0	8.18	
59.49	433.0	8.18	
59.79	414.0	8.13	
60.09	424.0	8.22	
60.39	408.0		
60.69	412.0	8.11	
61.00	366.0		
61.30		8.23	
61.91		8.25	
62.50	376.0	8.21	
62.81		8.11	
63.11		8.17	
63.41		8.07	
63.70		8.07	
64.00	370.0	8.05	

64.31		8.11
64.62		8.14
64.92		8.15
65.22		8.10
65.54	399.0	
65.84		8.18
66.44		8.22
67.05	393.0	8.06
67.33		8.09
67.61		8.04
68.15	414.0	7.92
68.84		8.14
69.53		8.09
69.87	392.0	
70.23		8.19
70.93		8.10
71.64	401.0	8.09
72.33		8.07
73.04		8.10
73.36	403.0	
73.71		8.09
74.40		8.15
75.10	417.0	8.09
75.80		8.13
76.49		8.11
76.83	419.0	
77.18		8.22
77.89		8.12
78.59	388.0	8.19
79.26		8.22
79.78		8.20
80.12	401.0	8.11
80.81		8.14
81.50		8.08
81.85	404.0	
82.19		8.12
82.89		8.16
83.59	405.0	8.18
84.28		8.19
84.97		8.07
85.31	398.0	
85.65		8.15
86.33		8.16
87.01	402.0	8.08
87.69		8.13
88.20		8.08
88.54	414.0	
88.88		8.05

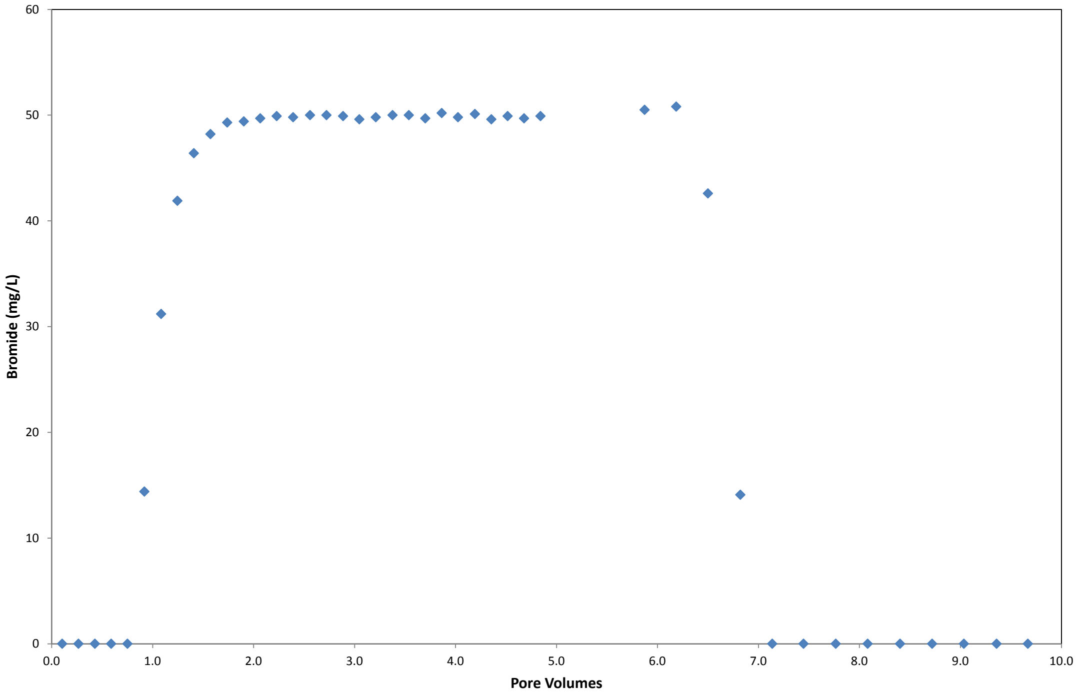


Figure 6. Bromide Concentration Versus Pore Volume and for Repacked (< 2mm) Column B30538 (estimated pore volume 28.65 mL, approximate flow rate 0.2193 pore volume per hour).

Table 7. Leachate Sample Pore and Bromide Concentration for Repacked (< 2mm) Column from Core B30538 (estimated pore volume 28.65 mL, approximate flow rate 0.2193 pore volume per hour).

Pore Volume	Bromide (mg/L)	Note
0.10	0.0	
0.27	0.0	
0.43	0.0	
0.59	0.0	
0.75	0.0	
0.92	14.4	
1.08	31.2	
1.25	41.9	
1.41	46.4	
1.57	48.2	
1.74	49.3	
1.90	49.4	
2.07	49.7	

2.23	49.9	
2.39	49.8	
2.56	50.0	
2.72	50.0	
2.89	49.9	
3.05	49.6	
3.21	49.8	
3.38	50.0	
3.54	50.0	
3.70	49.7	
3.86	50.2	
4.02	49.8	
4.19	50.1	
4.35	49.6	
4.52	49.9	
4.68	49.7	
4.84	49.9	
5.87	50.5	No Bromide
6.19	50.8	
6.50	42.6	
6.82	14.1	
7.14	0.0	
7.45	0.0	
7.77	0.0	
8.08	0.0	
8.40	0.0	
8.72	0.0	
9.03	0.0	
9.36	0.0	
9.67	0.0	
10.46	0.0	
11.24	0.0	
12.82	0.0	
14.39	0.0	

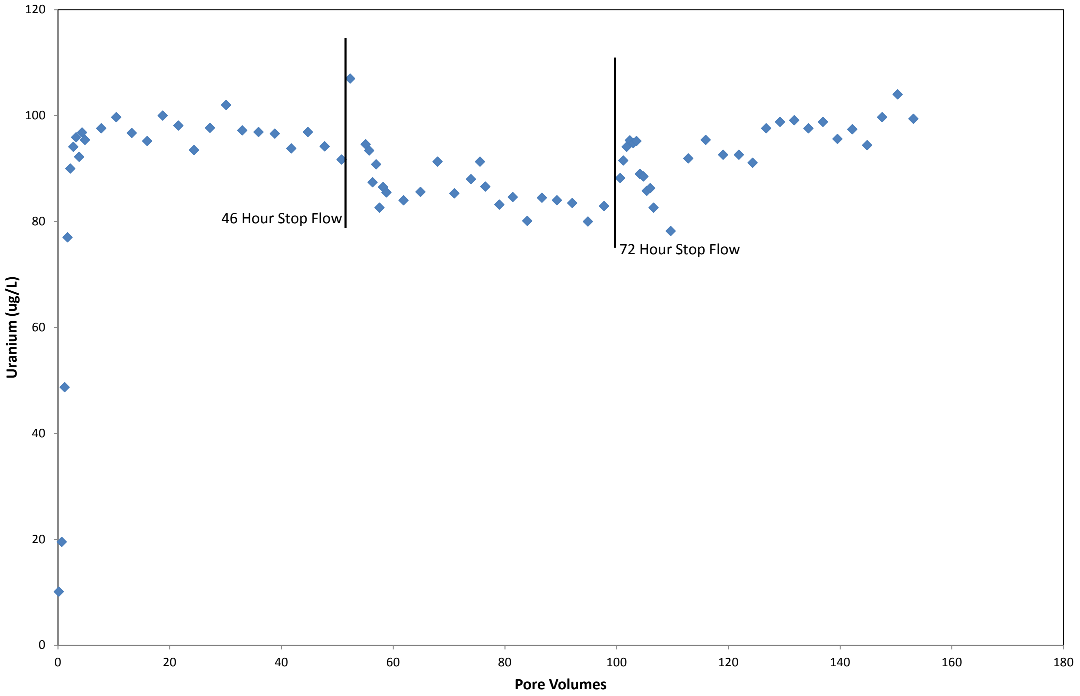


Figure 7. Uranium Concentration Versus Pore Volume and for Repacked (< 2mm) Column B30546 (estimated pore volume 24.50 mL, approximate flow rate 0.3581 pore volume per hour).

Table 8. Leachate Sample Pore and Uranium Concentration for Repacked (< 2mm) Column from Core B30546 (estimated pore volume 24.50 mL, approximate flow rate 0.3581 pore volume per hour).

Pore Volume	Uranium (µg/L)	pH	Note
0.2	10.1		
0.4		8.08	
0.7	19.5		
1.2	48.7		
1.5		8.14	
1.7	77		
2.2	90		
2.5		7.98	
2.8	94.1		
3.3	95.9		
3.5		8.23	
3.8	92.2		
4.3	96.8		
4.6		8.17	
4.9	95.4		

5.6		8.25
6.7		8.18
7.8	97.6	8.09
8.8		8.02
9.9		8.12
10.5	99.7	
11.0		8.14
12.1		8.15
13.2	96.7	8.16
14.3		8.3
15.4		8.18
16.0	95.2	
16.6		8.15
17.7		8.21
18.8	100	8.26
19.9		8.21
21.0		8.19
21.6	98.1	
22.1		8.26
23.3		8.22
24.4	93.5	8.16
25.5		8.08
26.7		8.17
27.2	97.7	
27.8		8.2
29.0		8.22
30.1	102	8.19
31.3		8.14
32.4		8.19
33.0	97.2	
33.6		8.19
34.8		8.15
35.9	96.9	8.05
37.1		8.18
38.3		8.16
38.8	96.6	
39.4		8.17
40.6		8.08
41.8	93.8	8.19
43.0		8.05
44.2		8.16
44.8	96.9	
45.4		8.16
46.6		8.16
47.8	94.2	8.19

49.0		8.17	
50.2		8.2	
50.8	91.7		
51.4		8.18	
52.3	107		46 Hour Stop Flow
54.8		8.15	
55.1	94.6		
55.4		8.25	
55.7	93.4		
56.0		8.22	
56.3	87.4		
56.7		8.18	
57.0	90.8		
57.3		8.08	
57.6	82.6		
57.9		8.18	
58.2	86.5		
58.5		8.21	
58.8	85.5		
59.1		8.17	
59.7		8.06	
60.4		8.14	
61.3		8.11	
61.9	84		
62.5		8.1	
63.7		8.16	
64.9	85.6	8.15	
66.1		8.07	
67.4		8.08	
68.0	91.3		
68.6		8.2	
69.8		8.2	
71.0	85.3	8.16	
72.2		8.14	
73.4		8.07	
74.0	88		
74.6		8.09	
75.6	91.3	8.12	
76.0		8.2	
76.5	86.6		
77.0		8.13	
78.0		8.17	
79.0	83.2	8.21	
80.0		8.18	

80.9		8.18	
81.4	84.6		
81.9		8.21	
83.0		8.15	
84.0	80.1	8.19	
84.6		8.16	
85.6		8.16	
86.7	84.5	8.15	
87.7		8.16	
88.8		8.12	
89.3	84		
89.9		8.09	
91.0		8.06	
92.1	83.5	8.15	
93.2		8.08	
94.3		8.04	
94.9	80		
95.5		8.19	
96.6		8.15	
97.8	82.9	8.08	
98.9		8.13	
100.1		8.19	
100.7	88.2		
101.2	91.5	8.14	
101.8	94.1	8.16	72 Hour Stop Flow
102.4	95.3	8.13	
103.0	94.8	8.05	
103.6	95.2	8.11	
104.2	89	8.16	
104.8	88.5	8.08	
105.4	85.8	8.08	
106.0	86.3	8.12	
106.6	82.6	8.1	
107.9		8.16	
109.1		8.19	
109.7	78.2		
110.3		8.08	
111.6		8.18	
112.8	91.9	8.06	
114.1		8.18	
115.3		8.18	
116.0	95.4		
116.6		8.12	
117.9		8.18	

119.1	92.6	8.13
120.4		8.05
121.6		8.11
121.9	92.6	
122.1		8.09
122.6		8.19
123.6		8.12
124.4	91.1	8.08
125.3		8.22
126.3		8.24
126.8	97.6	
127.3		8.2
128.3		8.15
129.3	98.8	8.19
130.3		8.16
131.3		8.13
131.8	99.1	
132.3		8.14
133.3		8.19
134.4	97.6	8.11
135.4		8.16
136.4		8.18
137.0	98.8	
137.5		8.25
138.5		8.13
139.6	95.6	8.18
140.6		8.13
141.7		8.14
142.2	97.4	
142.7		8.15
143.8		8.16
144.9	94.4	8.18
145.9		8.25
147.0		8.08
147.6	99.7	
148.1		8.14
149.2		8.2
150.3	104	8.25
151.5		8.2
152.6		8.22
153.2	99.4	
153.7		8.22
154.2		8.25

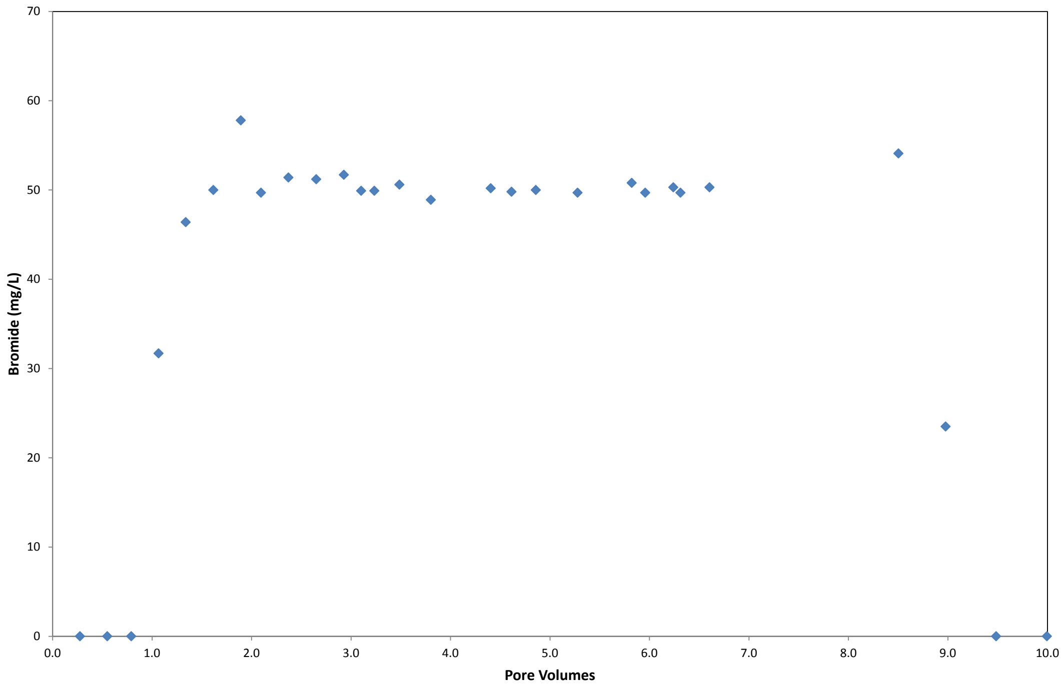


Figure 8. Bromide Concentration Versus Pore Volume and for Repacked (< 2mm) Column B30546 (estimated pore volume 24.50 mL, approximate flow rate 0.3581 pore volume per hour).

Table 9. Leachate Sample Pore and Bromide Concentration for Repacked (< 2mm) Column from Core B30546 (estimated pore volume 24.50 mL, approximate flow rate 0.3581 pore volume per hour).

Pore Volume	Bromide (mg/L)	Note
0.27	0.0	
0.55	0.0	
0.79	0.0	
1.06	31.7	
1.34	46.4	
1.62	50.0	
1.89	57.8	
2.09	49.7	
2.37	51.4	
2.65	51.2	
2.93	51.7	
3.10	49.9	
3.23	49.9	
3.49	50.6	
3.80	48.9	

4.40	50.2	
4.61	49.8	
4.86	50.0	
5.28	49.7	
5.82	50.8	
5.96	49.7	
6.24	50.3	
6.31	49.7	
6.60	50.3	
8.50	54.1	No Bromide
8.98	23.5	
9.48	0.0	
10.00	0.0	
10.50	0.0	
11.02	0.0	
11.53	0.0	
11.97	0.0	
12.49	0.0	
12.98	0.0	
14.16	0.0	
16.65	0.0	
19.26	0.0	
21.87	0.0	
23.72	0.0	

Wet Chemistry - Quality Control

Environmental Science Laboratory

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 5B19003 - 1:1 Water Extract (pH_EC_Alk)										
Blank (5B19003-BLK1)				Prepared & Analyzed: 02/18/15						
pH	5.05E0	N/A	pH Units							
Duplicate (5B19003-DUP1)		**Source: 1501009-AF**		Prepared & Analyzed: 02/18/15						
pH	7.46E0	N/A	pH Units		7.50E0			0.535	35	

Total Metals by PNNL-AGG-ICP-AES/Special Extract - Quality Control
Environmental Science Laboratory

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 5C05003 - Special Extract (ICP/ICPMS)										
Blank (5C05003-BLK1)				Prepared & Analyzed: 03/05/15						
Aluminum	<3.12E-1	3.12E-1	ug/g wet							
Calcium	<1.51E0	1.51E0	"							
Iron	<3.50E-1	3.50E-1	"							
Manganese	<2.08E-1	2.08E-1	"							
LCS (5C05003-BS1)				Prepared & Analyzed: 03/05/15						
Aluminum	6.64E0	3.12E-1	ug/g wet	7.50E0		88.6	80-120			
Calcium	7.25E0	1.51E0	"	7.50E0		96.7	80-120			
Iron	7.26E0	3.50E-1	"	7.50E0		96.9	80-120			
Manganese	7.36E0	2.08E-1	"	7.50E0		98.2	80-120			
Duplicate (5C05003-DUP1)		**Source: 1501009-AF**		Prepared & Analyzed: 03/05/15						
Aluminum	<6.37E-1	6.37E-1	ug/g dry		ND				35	
Calcium	4.34E1	3.07E0	"		4.31E1			0.849	35	
Iron	<7.12E-1	7.12E-1	"		ND				35	
Manganese	<4.24E-1	4.24E-1	"		ND				35	
Post Spike (5C05003-PS1)		**Source: 1501009-AG**		Prepared & Analyzed: 03/05/15						
Aluminum	4.64E2	N/A	ug/L	5.00E2	1.05E1	90.6	75-125			
Calcium	2.10E3	N/A	"	5.00E2	1.57E3	106	75-125			
Iron	5.13E2	N/A	"	5.00E2	9.95E0	101	75-125			
Manganese	2.52E2	N/A	"	2.50E2	1.92E-1	101	75-125			

Radionuclides by ICP-MS/Special Extraction - Quality Control
Environmental Science Laboratory

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 5C04003 - Special Extract (ICP/ICPMS)										
Blank (5C04003-BLK1)				Prepared: 03/02/15		Analyzed: 03/04/15				
Uranium 238	<1.60E-3	1.60E-3	ug/g wet							
Duplicate (5C04003-DUP1)		**Source: 1501009-AF**		Prepared: 03/02/15		Analyzed: 03/04/15				
Uranium 238	3.56E0	3.26E-3	ug/g dry		3.65E0			2.59	35	
Post Spike (5C04003-PS1)		**Source: 1501009-AG**		Prepared & Analyzed: 03/04/15						
Uranium 238	6.38E0	N/A	ug/L	1.00E0	5.53E0	85.4	75-125			

Sequential Extractions-Quality Control

Duplicates

LabNumber	SampleName	Analyte	Result ug/g	RPD %	RPD Limit
1502014-06	B30546 DUP weak acetic acid	Aluminum	3.54E+01	14%	35
1502014-13	B30546 DUP strong acetic acid	Aluminum	1.44E+01	16%	35
1502014-20	B30546 DUP oxalate	Aluminum	9.03E+02	1%	35
1502014-27	B30546 DUP nitric acid	Aluminum	1.92E+04	40%	35
1502014-06	B30546 DUP weak acetic acid	Calcium	1.36E+03	2%	35
1502014-13	B30546 DUP strong acetic acid	Calcium	2.27E+02	2%	35
1502014-27	B30546 DUP nitric acid	Calcium	1.15E+04	23%	35
1502014-06	B30546 DUP weak acetic acid	Iron	7.54E+00	20%	35
1502014-13	B30546 DUP strong acetic acid	Iron	1.69E+01	108%	35
1502014-20	B30546 DUP oxalate	Iron	1.34E+03	8%	35
1502014-27	B30546 DUP nitric acid	Iron	5.81E+04	22%	35
1502014-06	B30546 DUP weak acetic acid	Manganese	7.54E+00	18%	35
1502014-13	B30546 DUP strong acetic acid	Manganese	3.22E+01	19%	35
1502014-20	B30546 DUP oxalate	Manganese	3.86E+01	6%	35
1502014-27	B30546 DUP nitric acid	Manganese	6.24E+02	24%	35
1502014-06	B30546 DUP weak acetic acid	Uranium 238	6.72E+00	1%	35
1502014-13	B30546 DUP strong acetic acid	Uranium 238	4.97E+00	2%	35
1502014-20	B30546 DUP oxalate	Uranium 238	3.51E+00	11%	35
1502014-27	B30546 DUP nitric acid	Uranium 238	1.28E+01	30%	35

Note: duplicate analysis failed for aluminum in nitric acid and iron in strong acetic acid.

Blank Spikes

LabNumber	SampleName	Analyte	Result ug/L	EQL	% REC	% REC Limits
1502014-29	Weak Acid BS	Aluminum	ND	1.65E+03	n/a	80-120
1502014-30	Strong Acid BS	Aluminum	6.61E+03	1.65E+03	113	80-120
1502014-31	Oxalate BS	Aluminum	4.82E+03	1.65E+03	156	80-120
1502014-32	Nitric BS	Aluminum	9.68E+03	1.65E+03	138	80-120
1502014-29	Weak Acid BS	Calcium	7.19E+03	4.90E+03	104	80-120
1502014-30	Strong Acid BS	Calcium	8.43E+03	4.90E+03	89	80-120
1502014-31	Oxalate BS	Calcium	9.02E+03	4.90E+03	83	80-120
1502014-32	Nitric BS	Calcium	1.75E+04	4.90E+03	76	80-120
1502014-29	Weak Acid BS	Iron	5.28E+03	1.00E+03	142	80-120
1502014-30	Strong Acid BS	Iron	7.35E+03	1.00E+03	102	80-120
1502014-31	Oxalate BS	Iron	7.50E+03	1.00E+03	100	80-120
1502014-32	Nitric BS	Iron	1.39E+04	1.00E+03	96	80-120
1502014-29	Weak Acid BS	Manganese	5.29E+03	9.41E+02	142	80-120
1502014-30	Strong Acid BS	Manganese	7.11E+03	9.41E+02	105	80-120
1502014-31	Oxalate BS	Manganese	7.23E+03	9.41E+02	104	80-120
1502014-32	Nitric BS	Manganese	1.11E+04	9.41E+02	120	80-120

Note: BS analysis failed for aluminum (weak acid, oxalate and nitric acid). Aluminum data may be suspect. Calcium, iron and manganese fail for the weak acid. Recoveries for these are high.

Spectroscopy Results

All sediment samples displayed similar fluorescence spectra with vibronic band positions located at 500±2 nm, 519± nm and 540±2 nm, respectively, with the exception of sample 30589 which showed a single spectral maximum at 535 nm (Figure 1 and Table 1). There is a general trend that higher spectral intensity appears to correlate with higher uranium concentration in the sediment. The vibronic band spacings ranged from 665 cm^{-1} for sample 30525 to 798 cm^{-1} for sample 30546 (Table 1). Time resolved spectra for delay times up to 1700 µs showed little change for all sample (Figure 2) except sample 30525. For the latter, a better-resolved spectral pattern emerged at longer delay times with peak positions at 482 nm, 501 nm, 521 nm, 544 nm and 568 nm, respectively, and the peak spacing increased to 810 cm^{-1} (Figure 3). In the opposite, all other samples, the spectra became even less resolved. All fluorescence decays requires two exponential functions to fit (Figure 4). It was interesting to note that while samples 30538 and 30525 possess the highest uranium concentration, their fluorescence lifetimes happened to be the shortest. Possibly, due to the shallower depth of these samples and likely association with more concentrated waste solutions, fluorescence quenchers, such as transition metal ions (e.g. Cu^{2+}), were present at higher concentrations. These quenchers were in the vicinity of the U(VI) ions, leading to more effective quenching of the U(VI) fluorescence.

Although an exact match of the fluorescence spectra of the present sediment samples with the spectra of published spectra of known crystalline U(VI) compounds could not be found, the small peak spacing values (Typically < 800 cm^{-1}; Table 1) and the red-shifted spectra maxima (sample 30589), suggested that the primary spectral component could be associated with either silicates or oxyhydroxides (Wang, Zachara et al. 2008), or as adsorbates in minerals such as calcium carbonate or quartz (Wang, Zachara et al. 2005; Wang, Zachara et al. 2011; Ilton, Wang et al. 2012). The type of red-shifted spectra are almost exclusively shown by most uranyloxyhydroxide minerals such as meta-schoepite, schoepite and becquerelite (see Figure 5 for meta-schoepite for example). As uranium concentration in sample 30589 was only 4 ppm, precipitation of uranyloxyhydroxide is unlikely. A possible explanation will be that uranyl ion was incorporated into other metal oxide minerals, resulting a U(VI) coordination environment that resembles that of typical uranyloxyhydroxide. The featureless spectra of samples 304Y3, 304Y5, 30538 and 30546 observed at longer delay times possibly had the same spectral origin as sample 30589.

Both of the evolution of the time-resolved fluorescence spectra and the presence of two fluorescence lifetime components indicated that a minimum of two U(VI) coordination. For sample 30525, the vibronic band positions of the minor spectral component seen at long delay times are consistent with those observed for uranyl ion incorporated into aragonite (Reeder, Nugent et al. 2000; Reeder, Elzinga et al. 2004; Wang, Zachara et al. 2005), a calcium carbonate mineral. This is consistent with the site mineralogy where minor fractions of calcium carbonate are present (Zachara, Brown et al. 2007). As aragonite often co-exists with calcite, it could be that the main spectral component (except sample 30589) was due to uranyl ion incorporated into calcite mineral. In fact, the stead-state fluorescence spectra resemble closely to that of uranyl incorporated into calcite (Reeder, Nugent et al. 2000; Reeder, Elzinga et al. 2004; Wang, Zachara et al. 2005) although the overall spectral positions red-shifted about 5 nm. As quartz is a major mineralogical component at the Hanford site and it is a strong uranyl ion adsorbent (Qafoku, Zachara et al. 2005; Wang, Zachara et al. 2011; Ilton, Wang et al. 2012), it could be that such red-shift of the spectra included contributions of uranyl ion adsorbed to fine quartz particles in the sediment.

Because uranium in these sediments is either incorporated into other mineral solids or adsorbed into quartz or other sediment particles, which are often present as agglomerated of finer particles, it is expected that the desorption of uranium ions will be controlled by the dissolution of the solids as well as the nature and extent of the porosity of the particle agglomerates.

Table 10. Spectral characteristics of U(VI) in sediment samples

Sample ID	Depth (ft)	Core ID	U Conc. (ppm)	Peak Positions (nm)	Maximum Intensity	Lifetime (□s)	Band Spacing (cm^{-1})
304Y3	27	C8933 I-007A	8180	499.9, 519.1, 540.7	9.61×10^{6}	1683±145 177±12	756
304Y5	31	C8933 I-008A	7130	518.5, 537.7	6.11×10^{6}	2658±167 173±24	688
30589	25	C8938 I-007A	4390	535.3	4.40×10^{6}	2755±755 174±37	-
30525	19	C8936 I-004A	34800	502.1, 519.4, 538.0	1.37×10^{8}	303±24 79±11	665
30538	27	C8936 I-007A	41400	498.5, 519.1, 538.3	1.82×10^{7}	501±4 113±1	741
30546	30	C8936 I-008A	20800	498.5, 519.1, 541.5	4.33×10^{6}	1334±74 155±14	798

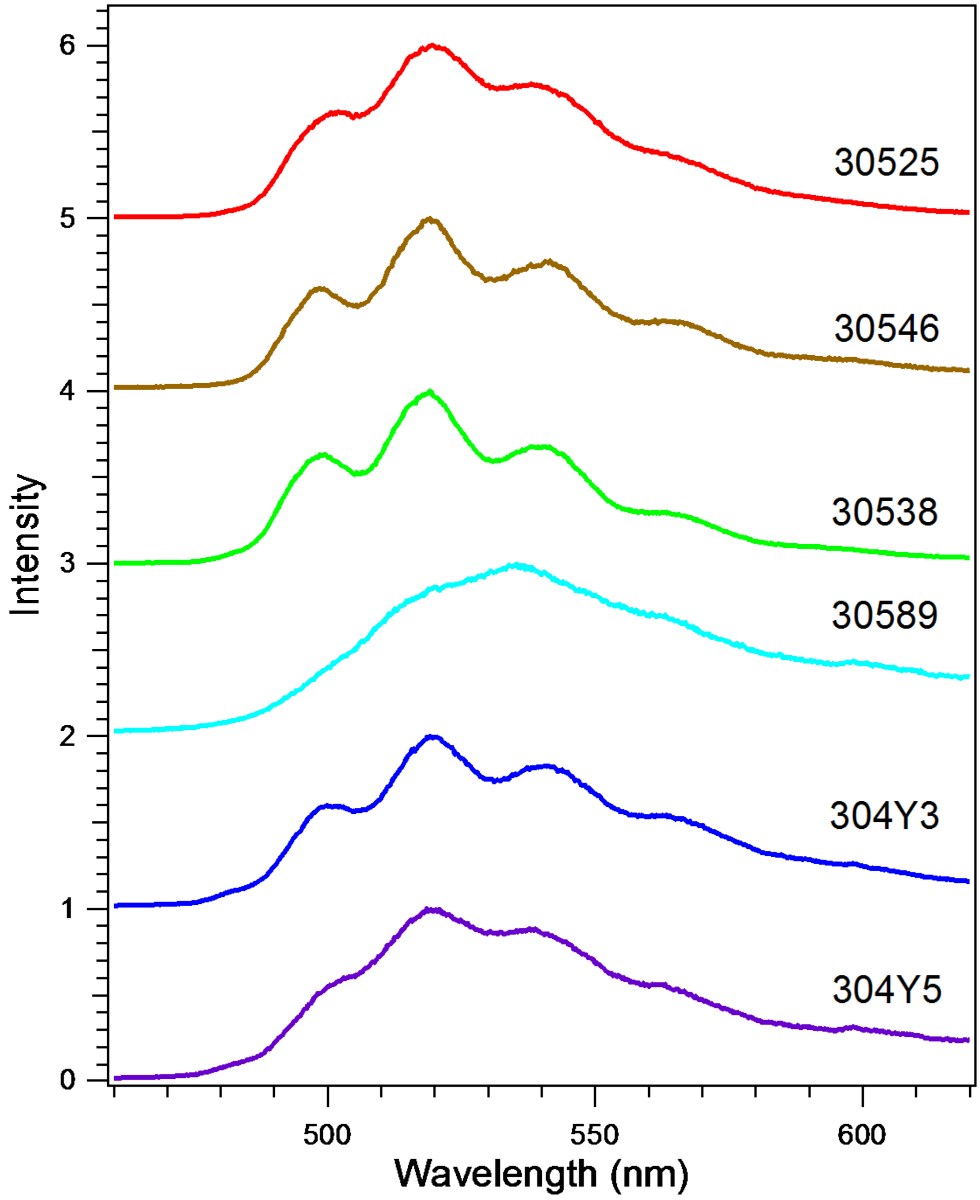


Figure 9. LHeT Fluorescence spectra of U-bearing sediments. λ_{ex} = 415 nm. For clarity of comparison, the spectra were normalized and offset along the Y-axis.

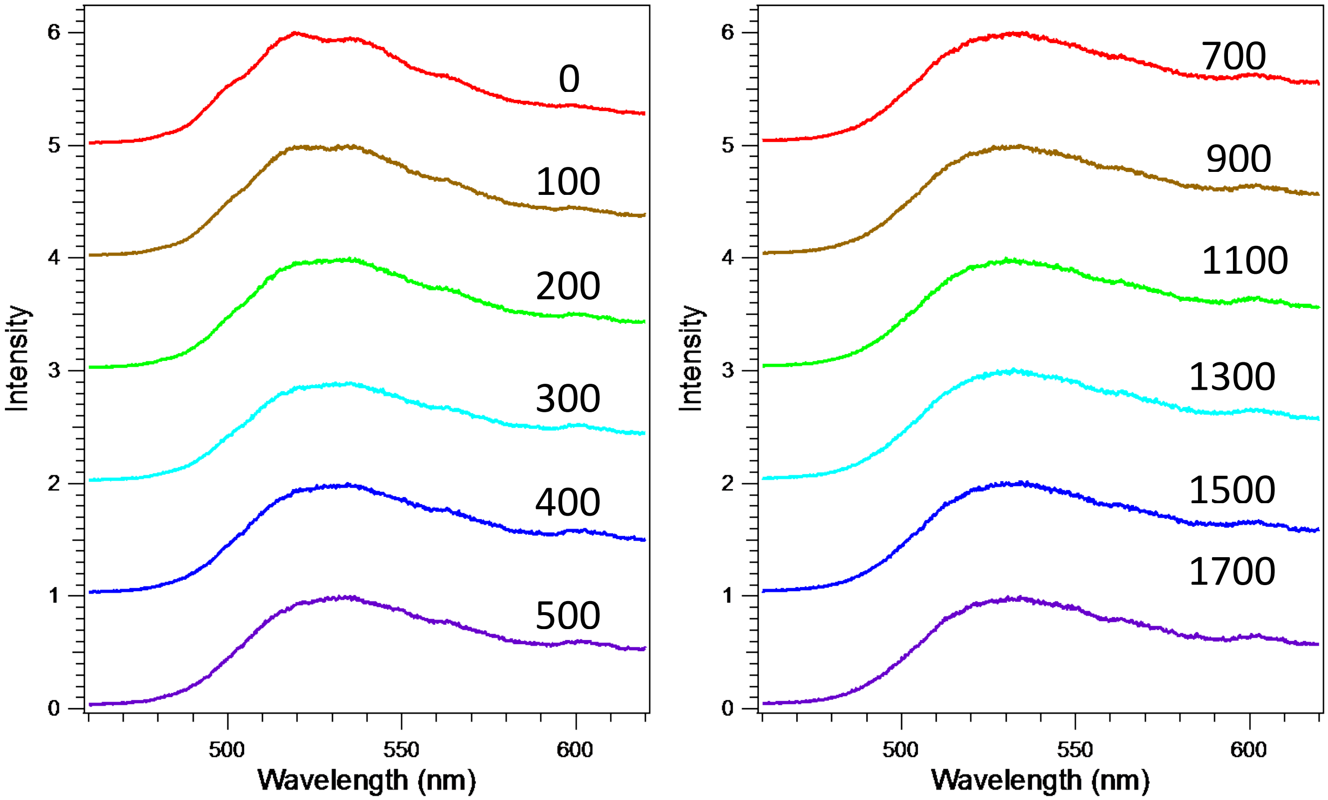


Figure 10. Time-resolved LHeT Fluorescence spectra of sample 304Y5. The delay times (in µs) are indicated on the right side of the spectra. All spectra were normalized to the same maximum intensity and were offset along the Y-axis for clarity. λ_{ex} = 415 nm.

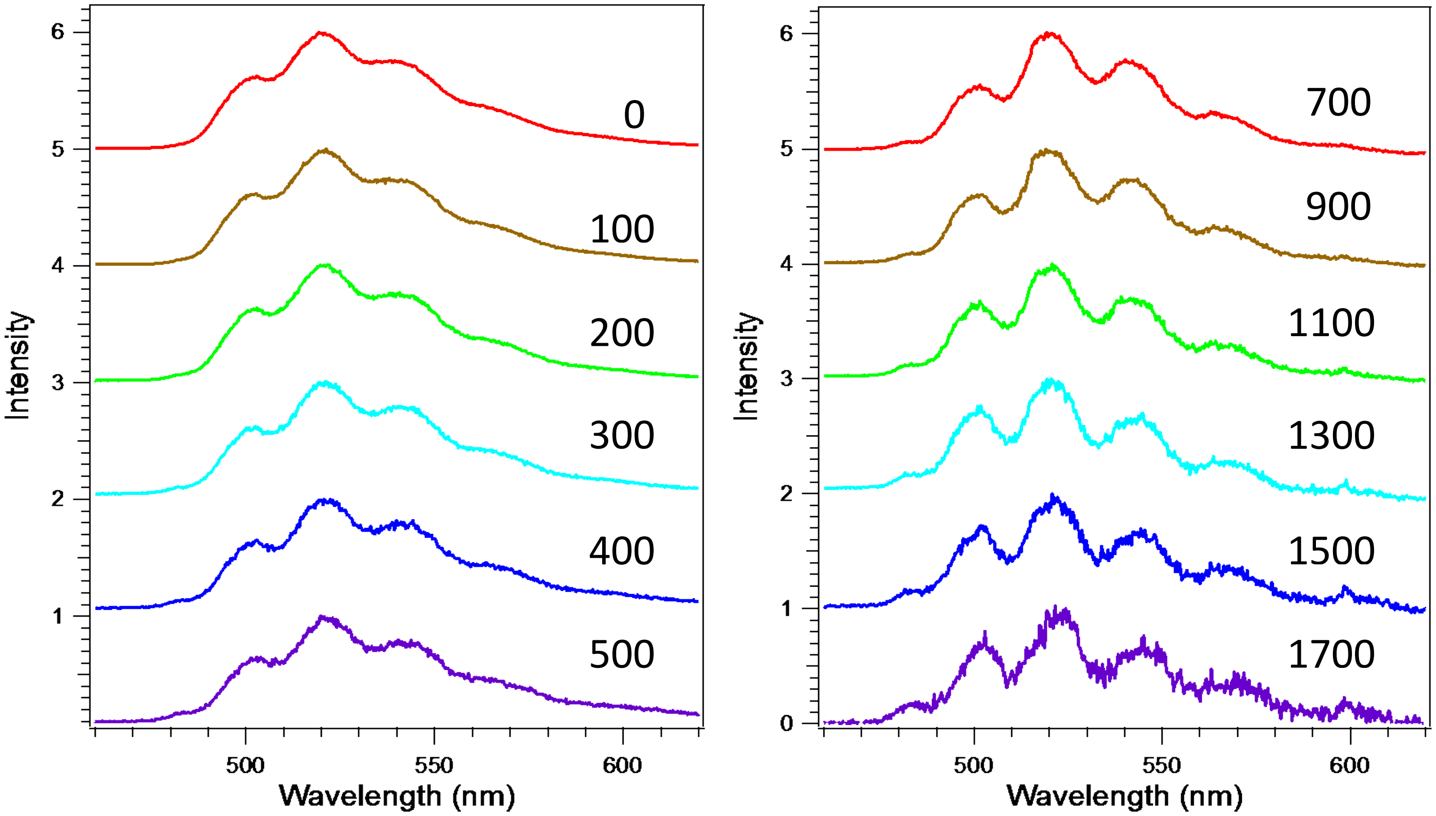


Figure 11. Time-resolved LHeT Fluorescence spectra of sample 30525. The delay times (in µs) are indicated on the right side of the spectra. All spectra were normalized to the same maximum intensity and were offset along the Y-axis for clarity. λ_{ex} = 415 nm.

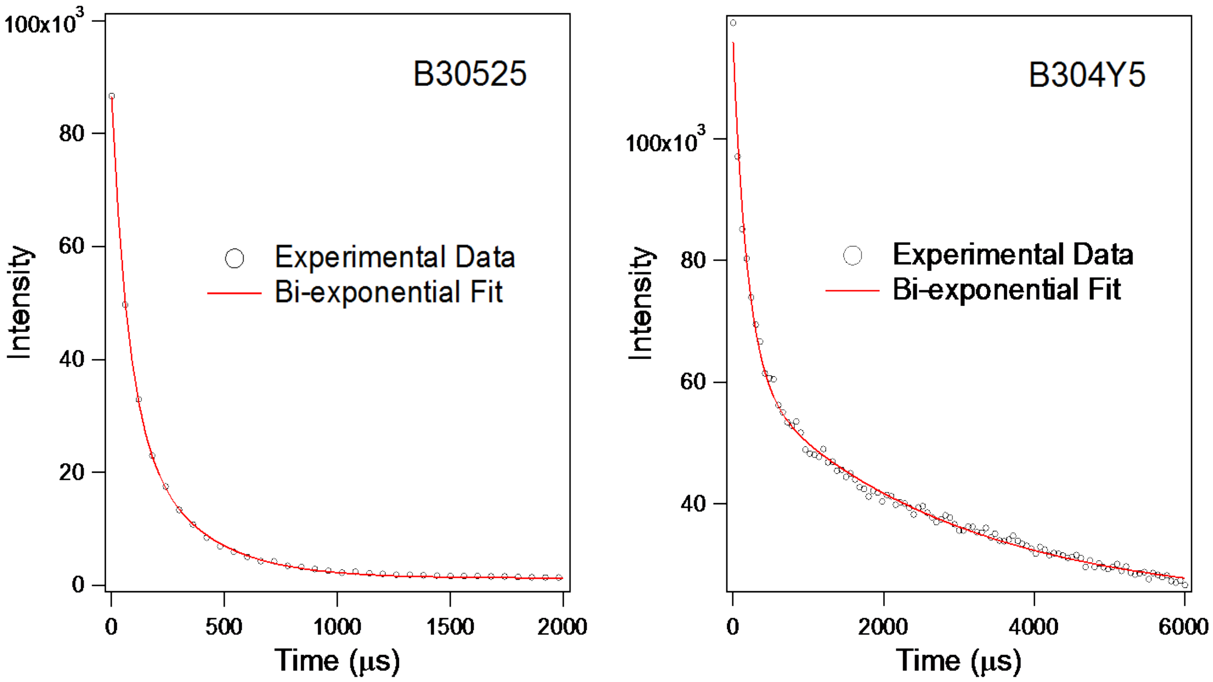


Figure 12. Representative Fluorescence decay curces and corresponding data fittings with double exponential functions. λ_{ex} = 415 nm.

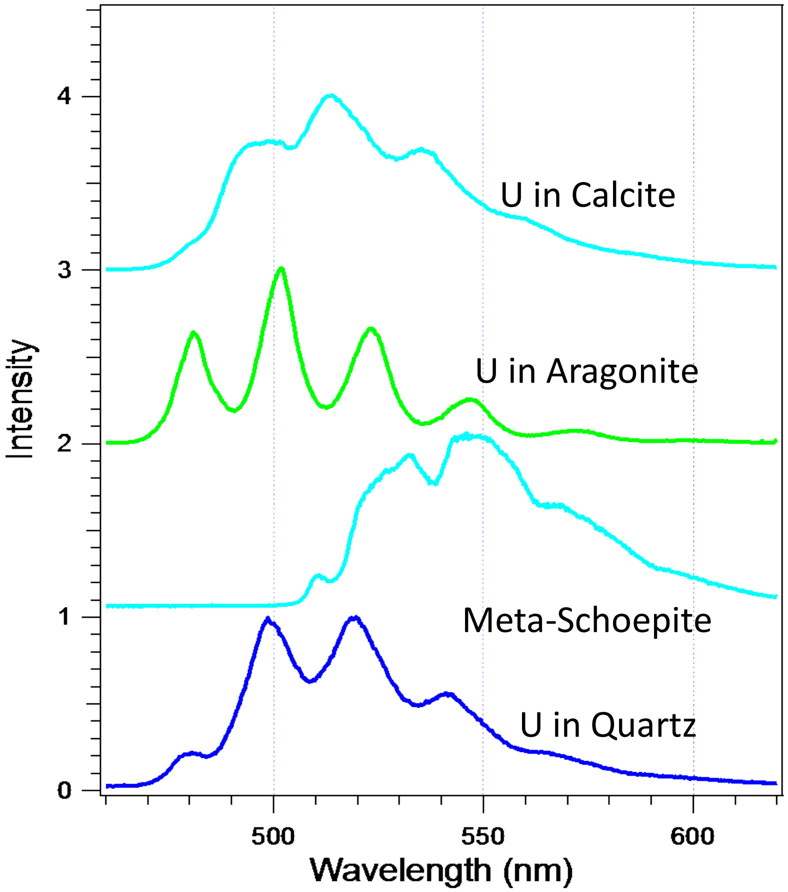


Figure 13. LheT fluorescence spectra of selected known samples. All spectra were normalized to the same maximum intensity and were offset along the Y-axis for clarity. λ_{ex} = 415 nm.

References

Ilton, E. S., Z. Wang, J.-F. Boily, O. Qafoku, K. M. Rosso and S. C. Smith (2012). "The Effect of pH and Time on the Extractability and Speciation of Uranium(VI) Sorbed to SiO2." Environ. Sci. Technol. 46(12): 6604-6611.

Qafoku, N. P., J. M. Zachara and C. Liu (2005). "Uranium(VI) desorption from long-term contaminated sediments." Geochim. Cosmochim. Acta 69(10): A470-A470.

Reeder, R., M. Nugent, G. Lamble, C. D. Tait and D. E. Morris (2000). "Uranyl incorporation into calcite and aragonite: XAFS and fluorescence studies." Environ. Sci. Technol. 34(4): 638-644.

Reeder, R. J., E. J. Elzinga, C. D. Tait, K. D. Rector, R. J. Donohoe and D. E. Morris (2004). "Site-specific incorporation of uranyl carbonate species at the calcite surface." Geochim. Cosmochim. Acta 68(23): 4799-4808.

Wang, Z., J. Zachara, J.-F. Boily, Y. X. Xia, C. T. Resch, D. Moore and C. Liu (2011). "Determining Individual Mineral Contributions To U(VI) Adsorption In A Contaminated Aquifer Sediment: A Fluorescence Spectroscopy Study." Geochim. Cosmochim. Acta 75(10): 2965–2979.

Wang, Z., J. M. Zachara, P. L. Gassman, C. Liu, O. Qafoku and J. G. Catalano (2005). "Fluorescence spectroscopy of U(VI)-silicate and U(VI)-contaminated Hanford sediment." Geochim. Cosmochim. Acta 69(6): 1391-1403.

Wang, Z., J. M. Zachara, C. Liu, P. L. Gassman, A. R. Felmy and S. B. Clark (2008). "A cryogenic fluorescence spectroscopic study of uranyl carbonate, phosphate and oxyhydroxide minerals." Radiochim. Acta 96(9-11): 591-598.

Wang, Z., J. M. Zachara, J. P. McKinely and S. C. Smith (2005). "Cryogenic Laser Induced U(VI) Fluorescence Studies of a U(VI) Substituted Natural Calcite: Implications to U(VI) Speciation in Contaminated Hanford Sediments." Environ. Sci. Technol. 39: 2651-2659.

Wang, Z., J. M. Zachara, W. Yantasee, P. L. Gassman, C. X. Liu and A. G. Joly (2004). "Cryogenic laser induced fluorescence characterization of U(VI) in Hanford vadose zone pore waters." Environ. Sci. Technol. 38(21): 5591-5597.

Zachara, J. M., C. Brown, J. Christensen, E. Dresel, S. Kelly, C. Liu, J. McKinley and W. Um (2007). A Site-Wide Perspective on Uranium Geochemistry at the Hanford Site. Richland, WA, Pacific Northwest National Laboratory.

Pacific Northwest National Laboratory

CORE LOG

Boring/Well No C8933
Depth 10 - 13 ft
Date 1/28/2015
Sheet 1 of 6
Logging to Location 331/170 Core Opening
Project 300-FF-5 OU

Logged by George Last (Print) George V Last (Sign)
Reviewed by (Print) (Sign)
Date
Lithologic Class. Scheme FOLK/WENTWORTH
Procedure DQTB1-99-GUL-D1
Rev 0
Drilling Contractor
Driller
Drill Method SPLITSPOON w/LEXAN LINERS

DEPTH (~~ft~~)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
10.5	C	~~1501009-11~~ B30417	D					C8933-1001D, BOTTOM OF SAMPLE LINER. SAMPLE IS 20% FULL, BROKEN COBBLE. SANDY GRAVEL. 90% GRAVEL UP TO >3 cm. 10% Sand, mostly coarse to medium. 5Y4/2 OLIVE GRAY. SAMPLE IS DRY, ~~weak to~~ no cementation. Weak reaction to 10% HCl. Gravel is 90% Basalt, some quartzite & granitic. Sand is 50% basaltic, 50% felsic.	C8933-1001D BOTTOM
11.0	C	~~1501009-12~~ B30418	D					Bottom of core liner. SILTY SANDY GRAVEL. 75% Gravel up to >3.5 cm. 20% sand, mostly coarse to very coarse; 5% SILT. Color is mostly 5Y4/1, dark gray. with a band and scattered clumps of 5Y8/1 whitish silt to very fine sand. Reaction is weak to HCl, both dark gray and whitish material. Gravel is 90% basalt, one quartzite clast. Sand is 60% basaltic, 40% felsic (quartzite?). ~~weakly to~~ uncemented. Dry	C8933-1001C BOTTOM
11-11.5	G	B304T9	D					SANDY GRAVEL. 60% Gravel, up to >3 cm, >35% SAND, <5% SILT. Gravel is rounded to subrounded, 80% basalt, 15% quartzite, 5% granitic. Sand is mostly coarse to medium, mostly basaltic (70%), 30% felsic. Color is 5Y4/1, dark grey. Sample is dry, with no reaction to HCl. No cementation.	C8933-1001B WHOLE SAMPLE
12.0	C	B304V1	D					SANDY GRAVEL. 35% Gravel up to >4 cm. 60% SAND, 5% SILT. Sand is mostly medium to coarse. Gravel is round to subround 60% basaltic, 40% felsic (quartzite, granitic). Sand is 80% basaltic, 20% felsic. Sample is moist to dry. Color 2.5Y 4/2, dark gray brown. No reaction to HCl. No cementation.	C8933-1001A 50% FULL, BOTTOM
13.0	C	B304V3	D					SANDY GRAVEL. 80% Gravel. 20% Sand, trace of silt. Gravel up to >3 cm. Rounded to subrounded where unbroken, lots of broken clasts as seen also in sample above. Gravel is >80% basalt. Sand is 60% basaltic, 40% mafic, mostly coarse to medium. Color is 2.5Y 4/2, dark greyish brown. Dry to moist. Weak reaction to HCl. No cementation.	C8933-1002C BOTTOM
								NOTE: B LINERS WERE SUPPOSEDLY SIEVED TO REMOVE <2mm SAMPLE FOR URANIUM ANALYSES.	

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

Pacific Northwest National Laboratory

CORE LOG

Boring/Well No C8933
Depth 13 - 16.1 ft
Date 1/28/2015
Logging Location 331/170 Core Opening
Project 300-FF-5 OU
Sheet 2 of 6

Logged by George Last (Print) George V Last (Sign)
Reviewed by ______ (Print) ______ (Sign) Date ______
Lithologic Class. Scheme FOLK/WENTWORTH
Procedure DTB1-~~20~~-GVL-01 Rev 0
Drilling Contractor ______
Driller ______
Drill Method SPLITSPOON w/LEXAN LINERS

DEPTH (ft)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOIS-TURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
13-13.5	G	B304V4	D-M					SANDY GRAVEL. 80% Gravel, 20% SAND, Trace of SILT. Gravel ranges up to >2.5 cm (broken), where unbroken gravel is rounded to subround, 80% basalt, 20% felsic (including quartzite). Sand is mostly coarse to very coarse, 50% basaltic, 50% felsic (e.g. quartzite). Sample is dry to moist, color is 5Y5/1, grey. No reaction to HCl, and no cementation. Some very fine sand.	C8933-1002B WHOLE SAMPLE
14.0	C	B304V6	D-M					SANDY GRAVEL. 80% Gravel, 20% SAND, Trace of silt. Gravel ranges to >3 cm (broken), rounded to subrounded where unbroken, 80% basaltic, 20% felsic (e.g. quartzite). Sand is mostly very coarse to medium, some very fine sand to silt, Sand is 70% basalt, fairly angular. Dry to moist, color is 2.5Y/4/2 olive gray. No reaction to HCl, no cementation.	C8933-1002A Bottom. Sample is 80% full.
14.6	C	B304V7	D-M					SANDY GRAVEL. 80% Gravel, 20% sand, trace of silt. Gravel ranges to >4 cm (well rounded). Sand is mostly medium, some v.fine sand to silt. Sand is 50% basaltic, 50% felsic. Dry to moist. color is 2.5Y 5/1, gray. No to weak reaction to HCl. No cementation.	C8933-1003D Bottom. Full.
15.1	C	B304V8	D-M					SANDY GRAVEL. 80% Gravel, 20% Sand, trace of silt. Gravel ranges to >4.5 cm (subrounded). 70% basalt, 30% felsic. Sand is mostly coarse, 60% basalt, 40% felsic. Dry to moist. Color is 2.5Y 4/1 dark grey. No reaction to HCl. No cementation.	C8933-1003C Bottom. Full.
16.1-15.6	G	B304V9	D-M					SANDY GRAVEL. 60% Gravel. 40% Sand, trace of silt. Gravel ranges to 2 cm. Rounded to subrounded where unbroken. 60% basaltic, 40% felsic (e.g. quartzite). Sand is mostly coarse. 70% basaltic, 30% felsic. subangular to subrounded. Dry to moist. Color is 2.5Y 4/2 olive grey. No reaction to HCl. No cementation.	C8933-1003B WHOLE SAMPLE.
16.1	C	B304W1	D-M					SANDY GRAVEL. 80% Gravel. 20% Sand, trace of silt. Gravel is mostly medium to fine pebble, ranges to 4 cm where unbroken. Rounded to subround. 80% basaltic, 20% felsic [Includes light colored Ringold rip up clast ~15 mm in diameter, color is 2.5Y 7/3, pale yellow, strong reaction to HCl]. Sand is mostly v.c-c. 80% basalt, 20% felsic. Moist. Color is 2.5Y 4/1, dark grey. No reaction to HCl (except rip up clast). No cementation	C8933-1003A BOTTOM. 60% FULL.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	**CORE LOG**	**Boring/Well No** C8933 **Depth** 16.5 - 19.5 ft **Date** 1/28/2015 1/29/2015 **Sheet** 3 **of** 6
		Location **Location** 331/170 Core Openning **Project** 300-FF-5 OU

Logged by George Last (Print) George Last (Sign)

Reviewed by ______ (Print) ______ (Sign) **Date** ______

Lithologic Class. Scheme FOLK/WENTWORTH **Procedure** DJTBI-99-GVL-01 **Rev** 0

Drilling Contractor ______

Driller ______

Drill Method SPLITSPOON w/LEXAN LINERS

DEPTH (FT.)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
17.0	C	B304W2	M-D					SANDY GRAVEL. 70% Gravel, 30% Sand, trace of silt. Gravel up to >2 cm (broken). Subrounded where unbroken; 60% basaltic, 40% felsic. Sand is mostly coarse, 50% basalt, 50% felsic. Dry to moist, Color is 2.5Y 4/1, dark grey. No reaction to HCl. No cementation.	C8933-I004D Bottom, Full
1/29/2015									
17.5	C	B304W3	M-D					SANDY GRAVEL. 80% Gravel, 20% Sand. Gravel is mostly fine to v. fine pebble, ranging up to >2.5 cm. Sand is mostly V.C. to coarse. Gravel is subrounded to rounded, 60% basalt, 40% felsic. Sand is 75% basalt, 25% mafic (perhaps some Ringold clasts). Dry to Moist. Color is 2.5Y 3/2, very dark grayish brown. No reaction to HCl. No cementation.	C8933-I004C Bottom, Full
17.5-18	G	B304W4	M-D					SANDY GRAVEL. 40% GRAVEL, 60% Sand. Gravel is mostly fine to very fine pebble, ranging up to 15 mm. Round to subround, 70% basalt, 30% felsic. Sand is mostly coarse to very coarse, subangular. 60% basaltic, 40% felsic. Moist to dry. Color is 2.5Y 3/1, very dark grey. No reaction to HCl. No cementation.	C8933-I004B WHOLE Sample
18.5	C	B304W7	M-D					SANDY GRAVEL. 65% GRAVEL, 35% Sand. Gravel ranges up to >4 cm, broken. Subrounded, where unbroken. 70% basalt, 30% felsic. Moist to dry, 2.5Y 3/1, very dark grey. Sand is mostly very coarse to medium. subangular, 60% basalt, 40% felsic. No reaction to HCl. No cementation.	C8933-I004A BOTTOM, 60% Full.
19.5	C	B304W8	M-D					SANDY GRAVEL. 75% Gravel, 25% Sand, trace of silt. Contains friable clasts of Ringold sandstone (2.5Y 7/3, pale yellow, and 10YR 5/3, brown). Gravel ranges up to >30 mm, subrounded, where unbroken, 70% basalt, 30% felsic (including Ringold ripup clasts - very deteriorated). Ripup clasts exhibit strong (pale yellow) to weak (brown) reaction to HCl. Sand is mostly very coarse to medium, subangular, 60% basalt, 40% felsic. No reaction to HCl. Sample is very compacted, with moderate cementation.	C8933-I005D Bottom, Full

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory

CORE LOG

Boring/Well No C8933
Depth 19.5 - 22.5 ft
Date 1/29/2015
Sheet 4 of 6
Location 331/170 Core Opening
Project 300-FF-5 OU

Logged by George Last (Print) George V. Last (Sign)
Reviewed by ______ (Print) ______ (Sign)
Date ______
Lithologic Class. Scheme Folk/Wentworth
Procedure DJSBJ-99-GVL-01
Rev 0
Drilling Contractor ______
Driller ______
Drill Method SPLITSPOON w/LEXAN LINERS

DEPTH (FT)	SAMPLES		MOIS-TURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	HEIS ID NUMBER		C	Z	S	G		
20.0	C	B304W9	M-D					SANDY GRAVEL. 70% Gravel, 30% Sand, trace of silt. Gravel ~~is~~ ranges up to >25mm, Round to subround, 70% basalt, 30% felsic. Sand is mostly very coarse to coarse, angular to subangular, 60% basalt, 40% felsic. Moist to dry. 2.5Y 3/1, very dark grey. No reaction to HCl. Very compacted/moderately cemented.	C8933-I005C Bottom, Full
20-20.5	G	B304X0	M-D					SANDY GRAVEL. 35% Gravel, 65% Sand, trace of silt. Gravel mostly Fine to very fine pebble, ranging up to 20 mm where unbroken. Rounded to subrounded. 60% basalt, 40% felsic, including occasional Ringold Ripap clasts (10 mm, 2.5Y 6/3, light yellowish brown, strong reaction to HCl). Sand is mostly very coarse to coarse, angular to subangular, 65% basaltic, 35% felsic. MOIST TO Dry. Color is 2.5Y 3/1, very dark grey. No reaction to HCl. No cementation.	C8933-I005B whole sample
21	C	B304X2	M-D					SANDY GRAVEL. 85% GRAVEL (MOSTLY ONE ~~LARGE~~ COBBLE), 35% SAND. Gravel ranges to >9 cm (broken - fills liner). 90% basaltic, 10% felsic. biased by ~~large~~ cobble, rounded to subrounded where unbroken. Sand is mostly coarse to very coarse, 70% basalt, 30% felsic, subangular. MOIST TO DRY. 2.5Y 3/2, very dark greyish brown. No reaction to HCl. compacted/moderate to weak cementation.	C8933-I005A Bottom, 90% FULL
21.5-~~20~~22	G	B304X5	D					GRAVELLY SAND. 25% Gravel. 75% Sand. Gravel ranges to >20mm where unbroken, subrounded, 80% basalt, 20% felsic (including quartzite). Sand mostly medium to fine, 60% felsic, 40% basaltic, subangular. ~~E~~ Sample is dry. 2.5Y 4/1, dark grey brown, slight color change from above. Weak reaction to HCl. No cementation.	C8933-I006B Whole sample
22-22.5	C	B304X7	M-D					SANDY GRAVEL. 45% Gravel, 55% Sand. Gravel ranges to >25mm, broken. 50% basaltic, 50% felsic, subrounded. Sand is poorly sorted, ranging from very coarse to very fine, mostly medium, angular to subangular, 60% felsic 40% mafic (basaltic). Moist to dry. 2.5Y 3/1 very dark greyish brown. No reaction. Compacted, weakly cemmented.	C8933-I006A Bottom, 85% Full

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	**CORE LOG**	Boring/Well No C8933 Logging Location 331/170 Core Opening	Depth 25.4-27.4 ft Date 1/29/2015 Project 320-FF-5 OU
			Sheet 5 of 6

Logged by George Last Print George V. Last Sign

Reviewed by ______ Print ______ Sign Date ______

Lithologic Class. Scheme Folk/Wentworth Procedure D9TBI-99-GVL-01 Rev 0

Drilling Contractor ______

Driller ______

Drill Method SPLITSPOON w/ LEXAN LINERS

DEPTH (ft)	SAMPLES		MOISTURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	HEIS ID NUMBER		C	Z	S	G		
25.9	C	B304X8	W					SANDY GRAVEL. 80% Gravel, 20% Sand. Gravel is mostly medium to very fine pebble, subrounded, 80% basaltic, 20% felsic. Sand is poorly sorted, mostly coarse, subangular, 50% basaltic, 50% felsic. Wet to moist. 2.5Y3/1, very dark grayish brown. No reaction to HCl. Compacted, weakly cemmented.	C8933-I007D Bottom, Full
26.4	C	B304X9	W					SILTY, SANDY, GRAVEL. 80% Gravel, 15% Sand, 5% mud (silt + clay). Silt/clay appears to be in nodules or ribbons, kind of Ringoldish, 2.56/3, light yellowish brown. Gravel is mostly medium to fine pebble, subround, 80% basaltic, 20% felsic. Sand is mostly coarse to very coarse, subangular, 50% basaltic, 50% felsic. Wet to moist. 2.5Y3/1, very dark grayish brown. No reaction to HCl. Sample is compacted and weakly cemmented.	C8933-I007C Bottom, Full
26.4-26.9	G	B304Y0	W					SILTY SANDY GRAVEL. 80% Gravel, 15% Sand, 5% mud (silt + clay). Sample was homogenized during previous sampling to extract <2mm seds for uranium analyses, so mud coats all clasts. GRAVEL is mostly fine to very fine pebble, ranging to >15 mm, subrounded, 70% basalt, 30% felsic, with some clasts looking like ripup clasts of Ringold that have been rounded off. SAND is mostly coarse to very coarse, subangular, 80% basalt? (difficult to see with coating of mud), 20%? felsic. Sample is wet. No reaction to HCl. No cementation obvious.	C8933-I007B Whole sample
26.9-27.4	C	B304Y3	W/D					SILTY SANDY GRAVEL. 90% Gravel, 7% Sand, 3% mud. GRAVEL Ranges up to >35 mm, rounded to subrounded, 80% basalt (seems friable - broken up), 20% felsic including at least one light colored granitic clast. SAND poorly sorted, mostly coarse to very coarse, angular to subangular, 60% basaltic, 40% felsic. Mud is mostly in nodules or lenses, including one ~7mm thick x 40 mm long in the bottom 25% of core. It is 10YR6/2, light brownish gray, with weak to no reaction to HCl. Overall sample is dry now with matrix color of 5Y7/2, light gray (mostly mud covering). No reaction to HCl. Sample shows signs of weak cementation - aglomerations.	C8933-I007A Whole core layed out in sample tray, dried over night - was wet

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

Pacific Northwest National Laboratory

CORE LOG

Boring/Well No C8933
Depth 29 - 31 ft
Date 1/29/2015
Sheet 6 of 6
Logging Location 331/17D Core Opening
Project 300-FF-5 OU

Logged by George Last (Print) George V. Last (Sign)
Reviewed by ______ (Print) ______ (Sign) Date ______
Lithologic Class. Scheme Folk/Wentworth
Procedure DSTBI-97-GYL-01 Rev 0
Drilling Contractor ______
Driller ______
Drill Method SPLITSPOON (LEXAN LINERS)

DEPTH (FT)	SAMPLES		MOISTURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	HEIS ID NUMBER		C	Z	S	G		
29.5	C	B304Y4	W					SILTY SANDY GRAVEL. Gravel 80%, Sand 18%, Silt 2% (mud). Gravel is medium to fine pebble, subrounded, 65% basaltic, 35% felsic. SAND is poorly sorted mostly coarse, subangular, 60% basaltic, 40% felsic. Sample is wet, 5Y3/2, dark olive gray. No reaction to 10% HCl. compacted and weakly cemented.	C8933-I008D Bottom, 60% full.
29.5-30	C	B304Y5	~~W~~D					SILTY SANDY GRAVEL. Gravel 70%, Sand 25%, Mud 5%. Gravel ranges to 3 cm, subrounded to rounded, 60% basaltic, 40% felsic. Sand is mostly coarse, subangular, 50% basaltic, 50% felsic. ~~lower~~ upper 30% of core is more muddy and weak to moderately cemented. Sample is now dry. Color is 5Y6/2, light olive gray. No reaction to HCl. Weak to no cementation.	C8933-I008C whole core layed out in tray, was wet, dried overnight.
30-30.5	G	B304Y6	W-M					SANDY GRAVEL. Gravel 80%, Sand = 20%, trace of silt. Gravel mostly medium pebble, ranges up to > 3 cm, subrounded. 70% basalt, 30% felsic. SAND is mostly coarse, subangular, 50% basaltic, 50% felsic. Sample is moist (probably originally wet), 2.5Y 3/1, very dark gray. No reaction to HCl. Unconsolidated - no cementation obvious.	C8933-I008B whole sample.
31	C	B304Y8						SANDY GRAVEL. 75% Gravel, 25% Sand, trace of silt (biased by large broken clasts of basalt & 1 quartzite (purple). Gravel ranges to > 3 cm, subrounded, 70% basalt, 30% felsic (e.g. quartzite). Sand is mostly coarse, subangular, 50% basalt, 50% felsic. Sample is moist to wet. 2.5Y 3/1, very dark gray. No reaction to HCl. No cementation.	C8933-I008A Bottom,

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

Pacific Northwest National Laboratory	**CORE LOG**	**Boring/Well No** C8936 **Depth** 10.5 - 13.5 **Date** 1/30/2015 Logging **Location** 331/170 Core Opening **Project**	**Sheet** 1 **of** 8

Logged by George Last (Print) George V Last (Sign)
Reviewed by (Print) (Sign) **Date**
Lithologic Class. Scheme Folk/Wentworth **Procedure** DJTB1-99-GVL-01 **Rev** 0
Drilling Contractor
Driller
Drill Method

DEPTH (FT)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
10.5	C	B30505	m					SANDY GRAVEL. 70% gravel, 30% sand, trace of silt. Gravel ranges to > 3cm, subrounded, 60% basaltic, 40% felsic. Sand is mostly coarse to medium, subangular, 30% basaltic, 70% felsic. Moist. 2.5Y3/1, very dark grayish brown. Weak to strong reaction to HCl. No cementation.	C8936-I001D Bottom, 40% Full.
11.0	C	B30506	m					GRAVELLY SAND. 25% gravel, 75% sand, trace of silt. Gravel ranges to 2.5cm, round to subround, 60% basaltic, 40% felsic. Sand is mostly medium, subangular, 30% basaltic, 70% felsic. Moist. 2.5Y4/2, dark grayish brown. Weak reaction to HCl. No cementation.	C8936-I001C Bottom, Full
11.0- 11.5	G	B30507	m					GRAVELLY SAND. 25% gravel, 5% Very Coarse Sand, 10% Coarse Sand, 40% medium sand, 15% fine sand, 5% Very fine sand, trace of silt. Gravel is ranges to 2 cm, Rounded to subround. 50% basaltic, 50% felsic. ~~MOIST~~ Sand is 75% felsic, 25% basaltic, subangular. MOIST. 2.5Y4/2, dark grayish brown. Weak reaction to HCl. No cementation.	C8936-I001B whole sample. Previously sieved to remove some <2mm for uranium analyses
12.0	C	B30509	m					SANDY GRAVEL. 35% gravel. 5% Very Coarse sand, 5% coarse sand, 35% medium 15% fine 5% very fine, 5% silt. Gravel ranges to 4 cm, round to subround, where unbroken. 50% basaltic, 50% felsic. Sand is subangular, 60% felsic, 40% basaltic. MOIST. 2.5Y3/1, very dark grayish brown. Weak reaction to HCl. No cementation.	C8936-I001A BOTTOM, 75% full.
13.0	C	B30510	m					SANDY GRAVEL. 50% gravel, 45% Sand, 5% silt. Gravel ranges up to 5cm, subrounded, 50% basalt, 50% felsic. Sand is mostly medium, subangular, 70% felsic, 30% basaltic. MOIST. 2.5Y 3/2, very dark grayish brown. Weak reaction to HCl. compacted, weakly cemented.	C8936-I002D Bottom, 95% Full CHEMICAL ODER?
13.5	C	B30511	m					SANDY GRAVEL. 80% gravel (biased by cobble), 20% sand, trace of silt. Gravel ranges to > 7 cm (broken), fills liner, subangular, 90% basalt (biased by cobble). Sand is mostly medium, poorly sorted, subangular, 60% felsic, 40% basaltic. MOIST. 2.5Y3/1, very dark grey. No reaction to HCl. compacted, weakly cemented.	C8936-I002C BOTTOM, FULL

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	CORE LOG	Boring/Well No C8936 Depth 13.5 - 17.0 Date 1/30/2015 Logging Location 331/170 Core Opening Project	Sheet 2 of 8

Logged by George Last (Print) George V. Last (Sign)
Reviewed by (Print) (Sign) Date
Lithologic Class. Scheme Folk/Wentworth
Procedure PNNL-99-GVL-01 Rev 0
Drilling Contractor
Driller
Drill Method

DEPTH (ft)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
13.5-14.0	G	B30512	M-D					SILTY, SANDY GRAVEL. 75% Gravel, 20% Sand, 5% silt. Gravel ranges to > 2.5cm (broken), subrounded, 50% basaltic, 50% felsic, Sand ~~is~~ is mostly fine, subangular, 60% felsic, 40% basaltic. Dry to moist. 2.5Y4/1, dark grey. No cementation. No reaction to HCl.	C8936-I002B whole sample, previous sieved to remove some <2mm. CHEMICAL ODER?
14.5	C	B30515	M-D					SILTY SANDY GRAVEL, with some volcanic ash present. 60% Gravel, 35% Sand, 5% silt. Gravel ranges up to 6cm (unbroken), rounded, 80% basaltic (biased by cobble), 20% felsic. Sand mostly fine, subangular, 70% felsic, poorly sorted. 5Y4/1, dark grey (moist). Tephra is very fine sand to silt size, angular to subangular. Dry, 5Y8/1, white, no reaction to HCl. Multilithic sand has weak reaction to HCl. No cementation.	C8936-I002A Bottom, 80% Full
15.5	C	B30516	M-D					SILTY SANDY GRAVEL. 60% Gravel, 30% Sand, 10% silt. Gravel ranges to 2cm (unbroken), rounded. 70% basaltic, 30% felsic. Sand is poorly sorted, mostly fine, 65% felsic, 40% basaltic, subangular. MOIST TO DRY, 5Y4/1, dark grey. Weak reaction to HCl. compacted, weak to no cementation.	C8936-I003D BOTTOM, Full CHEMICAL ODER?
16.0	C	B30517	M					SILTY SANDY GRAVEL. 60% Gravel, 30% Sand, 10% silt. Gravel ranges to >2cm (broken), rounded to subround where unbroken, 80% basaltic, 20% felsic. Sand is mostly fine, subangular, ~~or~~ 60% felsic, 40% basaltic. Moist. 5Y4/1, dark gray. Weak reaction to HCl. Compacted, weak to no cementation.	C8936-I003C Bottom, over full. CHEMICAL ODOR?
16.0-16.5	G	B30518	M					SILTY SANDY GRAVEL. 60% Gravel, 30% Sand, 10% silt. Gravel ranges to 2 cm (unbroken), round to subround, 80% basaltic, 20% felsic. Sand is poorly sorted, mostly fine, subangular, 60% felsic, 40% basaltic. Moist. 5Y4/1, dark gray. Weak reaction to HCl. No cementation.	C8936-I003B whole sample, some <2mm probably removed.
17.0	C	B30520	M-D					SILTY SANDY GRAVEL. 80% Gravel, 15% Sand, 5% silt. Gravel ranges to 2.5 cm (broken), subround, 50% basaltic, 50% felsic (one Ringold clast - 10YR 6/6, brownish yellow. Some white (tephra?) in fines. Sand is poorly sorted, mostly fine, Moist to dry. 5Y4/1, dark grey. No reaction to HCl, compacted, weakly cemented.	C8936-I003A Bottom, 70% full.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory

CORE LOG

Boring/Well No C8936 Depth 18- 21.1 Date 2/2/2015

Logging Location 331/170 Core Opening Project

Sheet 3 of 8

Logged by George Last (Print) George V. Last (Sign)

Reviewed by (Print) (Sign) Date

Lithologic Class. Scheme Folk/Wentworth Procedure DQTB1-99-GVL-01 Rev 0

Drilling Contractor

Driller

Drill Method

DEPTH (FT)	SAMPLES		MOISTURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	HEIS ID NUMBER		C	Z	S	G		
18.0	C	B30521	M-D					~~SILTY~~ SANDY GRAVEL. 35% Gravel, 60% Sand, 5% silt. Gravel ranges to 20 mm, subrounded to rounded (where unbroken), 80% basaltic, 20% felsic. Sand is mostly medium to fine, subangular, 60% felsic, 40% basaltic. Moist to dry color 2.5Y 4/1, dark gray. Weak reaction to HCl. Unconsolidated, no cementation.	C8936-I004D Bottom, 50% Full
18.5	C	B30522	M-D					SILTY SANDY GRAVEL. 75% Gravel, 20% Sand, 5% Silt. Gravel range up to >4.5 cm (broken), rounded to subround where unbroken, 50% basaltic, 50% felsic (e.g. quartzite, granodiorite). Sand is mostly coarse to very coarse, subangular, 50% basaltic, 50% felsic. Moist color is 2.5Y 4/1, dark gray. Weak to no reaction to HCl. Weak cementation. Lots of rock dust from breaking of cobbles.	C8936-I004C Bottom, Full. Some odor
18.5-19.0	G	B30523	M					SILTY SANDY GRAVEL. 60% Gravel, 35% Sand, 5% silt. Gravel ranges to >2 cm (broken), subrounded where unbroken, 50% basaltic, 50% felsic. Sand is poorly sorted, mostly coarse, subangular, 60% felsic, 40% basaltic. Moist color is 2.5Y 4/1, dark gray. No reaction to HCl. Unconsolidated no sign of cementation.	C8936-I004B whole sample, previously seived to remove some <2 mm. Some odor. (musky/earthy).
19.0-19.5	C	B30525	D					SILTY SANDY GRAVEL. 75% Gravel, 20% Sand, 5% silt. Gravel ranges to >7. cm (broken), ~~subang~~ subround to round where unbroken, 75% basaltic 25% felsic (e.g. granodiorite). Sand is poorly sorted, mostly coarse, subangular, 60% basaltic, 40% felsic. Dry color is 2.5Y 6/1, gray. No reaction to HCl. Weakly cemented.	C8936-I004A, whole core laid out in sample tray & dried over weekend.
21.1	C	B30526	M-D					SILTY SANDY GRAVEL. 50% Gravel, 45% Sand, 5% silt. Gravel up to >2.5 cm (broken), angular to subangular (broken), 40% basaltic, 60% felsic (~~andesite~~ e.g. quartzite). Sand is poorly sorted mostly medium to fine, subangular, 70% felsic, 30% basaltic. Moist to dry color is 2.5Y 4/1, dark gray. Weak reaction to HCl. No obvious cementation.	C8936-I005D Bottom of core, 40% Full

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

Pacific Northwest National Laboratory

CORE LOG

Boring/Well No C8936
Logging Location 331/170 Core Opening
Depth 21.6 - 24.2
Project
Date 2/2/2015
Sheet 4 of 8

Logged by George Last (Print) George V. Last (Sign)
Reviewed by (Print) (Sign) Date
Lithologic Class. Scheme Folk/Wentworth
Procedure DTTBI-99-GVL-01 Rev 0
Drilling Contractor
Driller
Drill Method

DEPTH (FT.)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	GRAPHIC LOG Z	GRAPHIC LOG S	GRAPHIC LOG G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
21.6	C	B30527	m					SILTY SANDY GRAVEL. 75% Gravel, 20% Sand, 5% SILT (silt + clay). Some ribbons/clods of silt to clay (2.5Y 5/3, light ~~olive~~ olive brown), coating gravel/~~sand~~ clasts. Gravel up to 2 cm, rounded to subround, 70% mafic (basaltic), 30% felsic (e.g. quartzite). Sand is poorly sorted, mostly medium, subangular, 60% felsic, 40% mafic (basaltic). Moist color is 2.5Y 3/1, very dark grey. Weak reaction to HCl. Compacted, weakly cemented.	C8936-I005C Bottom of core, full.
21.6-22.1	G	B30528	m					SILTY SANDY GRAVEL. 80% Gravel, 15% Sand, 5% silt (+clay). Gravel is mostly fine pebble, ranges up to 2 cm, rounded to subangular, 60% basalt, 40% felsic, occasional clasts of semi consolidated/cemented felsic sand (Ringold?). Sand is poorly sorted, mostly coarse, subangular, 50% felsic, 50% mafic (basaltic). Moist color is 3/2, very dark grayish brown. No reaction to HCl. Some weakly cemented clods.	C8936, I005B whole sample, previously seived to remove some <2mm.
22.6	C	B30530	m					SILTY SANDY GRAVEL, 75% Gravel, 15% Sand, 10% silt (+clay). Gravel up to >4 cm (broken), round to subround where unbroken, 70% basaltic (mafic), 30% felsic. Sand is poorly sorted, mostly medium to fine, angular to subangular, 60% mafic, 40% felsic. silty/clayey concentrations in matrix (2.5Y 5/3, light olive brown), coating clasts. No to weak reaction to HCl. Compacted & weakly cemented.	C8936-I005A, bottom of core, 80% full.
23.7	C	B30531	m					SILTY SANDY GRAVEL. 50% Gravel, 45% Sand, 5% Silt. Gravel ranges up to >2.5 cm (broken), angular to subround (broken), 50% mafic (eg. basalt), 50% felsic (eg. quartzite). Sand mostly medium to fine, subangular, 70% felsic, 30% mafic. moist color is 2.5Y 4/1, dark grey. Weak to no reaction to HCl. Some what compacted, no cementation obvious.	C8936-I006D bottom of core, nearly full?
24.2	C	B30532	m					~~SILTY~~ SANDY GRAVEL. 80% Gravel (biased by broken cobble), 15% Sand, 5% silt. Gravel ranges up to >7 cm (broken), angular to subangular (broken) 75% mafic (biased by broken basalt cobble). Sand is poorly sorted, mostly fine, subangular, 70% felsic, 30% mafic. Moist color is 2.5Y 4/1, dark grey. No reaction to HCl. Compacted, but no obvious signs of cementation.	C8936-I006C Bottom of core, full.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	**CORE LOG**	Boring/Well No C8936 ~~Location~~ Logging Location 331/170 core openning	Depth 24.2 - 27.7 Date 2/2/2015 Project	Sheet 5 of 8

Logged by George Last (Print) George V. Last (Sign) Reviewed by (Print) (Sign) Date Lithologic Class. Scheme Folk/Wentworth Procedure D9TB1-99-GVL-01 Rev 0	Drilling Contractor Driller Drill Method

DEPTH (FT)	SAMPLES TYPE	SAMPLES ~~HEIS~~ ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
24.2- 24.7	G	B30533	m					SILTY SANDY GRAVEL 50% Gravel, 45% Sand, 5% silt. Gravel ranges upto >2 cm (broken) subrounded where unbroken, 50% mafic (e.g. basalt), 50% felsic (e.g. quartzite). Sand is mostly coarse to medium, subangular, 60% felsic, 40% mafic. Moist color is 2.5Y 3/1, very dark gray. No reaction to HCl. No obvious signs of cementation.	C8936-I006B whole sample, previously seived to extract some <2 mm.
25.2	C	B30536	m					SANDY GRAVEL, 80% gravel, 20% sand, trace of silt. Gravel upto 2 cm (subrounded, 50% mafic, 50% felsic. Sand is poorly sorted, mostly medium to coarse, subangular, 60% mafic, 40% felsic. moist color is 2.5Y 3/1, very dark gray. No reaction to HCl. Compacted/weakly cemmented.	C8936-I006A Bottom of core. 75% Full.
26.7	C	B30537	m					SILTY SANDY GRAVEL. 80% gravel, 15% Sand, 5% silt (+clay). Gravel upto > 20 mm (broken), angular to subrounded, 70% mafic (e.g. basalt), 30% felsic (e.g. quartzite). Sand is poorly sorted, mostly medium to fine, subangular, 60% felsic, 40% mafic. Obvious increased consentration of mud (silt + clay) in sand matrix; nodules (2.5Y 6/3, ~~lite~~ light yellowish brown). No reaction to HCl. Very compacted and weakly cemmented.	C8936-I007D Bottom of core. 60% Full.
27.2	C	B30538	m-w					SILTY SANDY GRAVEL. 70% gravel, 25% Sand, 5% silt (+clay). Gravel ranges upto 2 cm, round to subround where unbroken, 60% mafic (e.g. basalt, 40% felsic (e.g. quartzite). Sand mostly coarse, subangular, 75% felsic, 25% mafic. Silt + clay occationally concentrated in nodules (2.5Y 6/3, light yellowish brown). No reaction to HCl. Very compacted, weakly cemmented. moist to wet color 2.5Y 4/2, dark grayish brown.	C8936-I007C Bottom of core. Full.
27.2- 27.7	G	B30539	m-w					SILTY SANDY GRAVEL. 80% gravel. 10% sand, 10% silt (+clay). Gravel ranges upto ≥ 3 cm (broken), subround where unbroken, 70% basaltic (mafic), 30% felsic (e.g. redish argilite). Sand is poorly sorted, mostly fine, subangular, 70% felsic, 30% mafic. Silt + clay well disseminated but also concentrated in nodules (2.5Y 6/4, light yellowish brown). Overall moist to wet matrix color is 2.5Y 4/2, dark grayish brown. No reaction to HCl. Weakly cemmented.	C8936-I007B whole sample, previously seived to extract some <2 mm material).

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

Pacific Northwest National Laboratory	**CORE LOG**	Boring/Well No C8936 Logging Location 331/170 core openning	Depth 28.2 - 30.7 Date 2/2/2015 Project
			Sheet 6 of 8

Logged by George Last (Print) George V. Last (Sign)

Reviewed by ______ (Print) ______ (Sign) Date ______

Lithologic Class. Scheme Folk/Wentworth

Procedure DSTBI-99-GVL-01 Rev 0

Drilling Contractor ______

Driller ______

Drill Method ______

DEPTH (FT)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
28.2	C	B30541	M					GRAVELLY SANDY MUD. 20% Gravel, 30% Sand, 50% mud (silt+clay). Gravel up to >30 mm (broken), basaltic, subround where unbroken. Sand mostly medium, subangular, 50% mafic, 50% felsic. Mud ranges in color from 10YR5/2, grayish brown, to 10YR 5/3 brown. Mostly silt but some clay, firm consistency. No reaction HCl. Compacted, weakly cemmented.	C8936-I007A, 80% Fu BOTTOM OF CORE ONLY, NO POKING AROUND
29.2	C	B30542	M-W					SILTY SANDY GRAVEL. 60% Gravel, 35% Sand, 5% Silt. Gravel up to 2.5 cm round to subround, 70% mafic (e.g. basalt), 30% felsic (e.g. granodiorite). Sand is poorly sorted, mostly coarse to medium, subangular, 50% mafic, 50% felsic. Silt is well/evenly distributed in matrix. Moist to wet color is 2.5Y3/1, very dark gray. No reaction to HCl. Compacted, weakly cemmented.	C8936-I008D BOTTOM OF CORE. FULL.
29.7	C	B30543	W					SILTY SANDY GRAVEL. 75% Gravel (biased by cobble), 20% Sand, 5-10% silt. Gravel up to > 5.5 cm (broken), round to subround, 75% basaltic (mafic), 25% felsic. Sand mostly coarse to medium, subangular, 60% mafic, 40% felsic. Silt is evenly distributed in matrix. Wet color is 2.5Y 3/1, very dark gray. No reaction to HCl. Compacted and weakly cemmented.	C8936-I008C. Bottom of core only - no poking around.
29.7-30.2	G	B30544	W					SILTY SANDY GRAVEL. 80% Gravel, 15-20% Sand, 10-5% silt. Gravel ranges up to ~15 mm (unbroken), rounded to subround, 75% mafic (e.g. basalt), 25% felsic (e.g. quartzite). Sand poorly sorted, mostly medium, subangular, 60% mafic, 40% felsic. Wet color 2.5Y 3/1, very dark gray. No reaction to HCl. Weakly cemmented.	C8936-I008B. whole sample, preserved, sieved to extract some <2mm materials
30.7	C	B30546	M-W					SILTY SANDY GRAVEL. 40% Gravel, 45% Sand, 15% silt (+clay). Gravel up to 3.5 cm (unbroken), subrounded, 60% mafic, 40% felsic (including some friable sandstone 10YR4/3, brown, most likely Ringold ripup clasts). Sand is mostly medium, subangular, 60% felsic, 40% mafic. Wet color is 2.5Y 3/1, very dark gray. Silt & clay is mostly concentrated in nodules/ribbons, 2.5Y 5/3, light olive brown, has firm consistency. No reaction to HCl. Compacted and weakly cemmented.	C8936-I008A. Bottom of core. 75% Full. [Later cut open and pictures taken.]

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	CORE LOG	Boring/Well No C8936 Logging Location 331/170 core openning	Depth 32.5 - 34.0 Date 2/3/2015 Project	Sheet 7 of 8

Logged by George Last (Print) George V. Last (Sign)
Reviewed by (Print) (Sign) Date
Lithologic Class. Scheme Folk/Wentworth Procedure DTTBI-99-GVL-01 Rev 0
Drilling Contractor
Driller
Drill Method

DEPTH (FT)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	GRAPHIC LOG Z	GRAPHIC LOG S	GRAPHIC LOG G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
32.5	C	B30547	W					SILTY SANDY GRAVEL. 80% Gravel, 12% Sand, 8% silt (+clay). Gravel mostly medium to fine pebble, max up to 2.0 cm (broken), subround where unbroken, 70% mafic (e.g. basalt), 30% felsic (e.g. red argilite) [masked by silt covering]. Sand is poorly sorted and non-discript, subangular, 60% felsic, 40% mafic. Silt+clay coats all clasts. Wet color 2.5Y3/1, very dark gray. Weak cemmentation. No reaction to HCl.	C8936-I009D. Bottom of core, nearly full.
33.0	C	B30548	W					SILTY SANDY GRAVEL. 80% gravel, 15% Sand, 5% silt (+clay). Gravel ranges to >2 cm, round to subround, 75% mafic (e.g. basalt), 25% felsic (e.g. diopside). Sand poorly sorted, mostly medium, ~~subround~~ subangular, 60% mafic, 40% felsic. Some mud (silt+clay) in pods, 2.5Y 6/3, light yellowish brown. Wet color of over all matrix is 2.5Y4/1, dark gray. No reaction to HCl. Compacted and weakly cemmented.	C8936-I009C, Bottom of core, full.
33.0-33.5	G	B30549	W					SILTY SANDY GRAVEL. 80% gravel, 15% Sand, 5% silt. Gravel is mostly fine to very fine pebble, ranges up to 15 mm, subround, 80% mafic (e.g. basalt), 20% felsic (e.g. orange argilite). Occasional clasts of moderately cemmented sandstone - Ringold ripup clasts (~~5~~ 10YR 5/4, yellowish brown) with some silt/clay matrix. Sand is poorly sorted, mostly coarse, subangular 60% felsic, 40% mafic. Silt+clay coats all clasts. No reaction to HCl. Weakly cemmented.	C8936-I009B. whole sample, previously seived to retrieve some <2 mm material.
34.0	C	B30551	W					SILTY SANDY GRAVEL. 70% gravel. 25% sand, 5% silt (+clay). Gravel ranges to 3 cm, subrounded 60% mafic (e.g. basalt, 40% felsic (e.g. quartzite. Sand is mostly medium, subangular, 70% felsic, 30% mafic Wet color is 2.5Y4/1, dark gray. Silt/clay well dispersed, coats all clasts. No reaction to HCl. Weakly cemmented.	C8936-I009A bottom of core. Core is 80% full.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	**CORE LOG**	**Boring/Well No** C8936 **Logging Location** 331/170 Core Opening	**Depth** 34.7-36.2 **Date** 2/3/2015 **Project**

Sheet 8 **of** 8

Logged by George Last (Print) George V. Last (Sign)

Reviewed by ______ (Print) ______ (Sign) **Date** ______

Lithologic Class. Scheme Folk/Wentworth **Procedure** DJT81-99-GVL-01 **Rev** 0

Drilling Contractor ______

Driller ______

Drill Method ______

DEPTH (FT)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS ID
34.7	C	B309C6	W					SANDY GRAVEL. 60% Gravel, 40% Sand. Gravel is mostly fine to very fine pebble, ranges up to >2.5cm (broken), subrounded where unbroken, 60% mafic (e.g. basalt), 40% felsic (e.g. quartzite). Sand is mostly coarse to medium, poorly sorted, 65% felsic, 35% mafic, subangular. Wet color is 2.5Y3/1, very dark gray. No reaction to HCl. Compacted, weakly cemmented.	C8936-I CONTINGENCY BOTTOM OF CORE. CORE 50% FULL
35.2	C	B309C7	W					SILTY SANDY GRAVEL. 80% Gravel, 35% Sand, 5% SILT. Gravel ranges to 3 cm (subround), mostly fine to ~~very~~ fine pebble, 75% mafic (e.g. basalt), 25% felsic (e.g. yellow brown argillite, ~~white quartzite~~). Sand is poorly sorted, mostly coarse to fine, subangular, 50% mafic, 50% felsic. Silt covers all clasts. Wet color is 2.5Y3/1, Very dark grey. No reaction to HCl. Compacted, weakly cemmented.	C8936-I CONTINGENCY-1C BOTTOM OF CORE. CORE IS FULL.
35.2-35.7	G	B309C8	W					~~SILTY~~ SANDY GRAVEL 40% gravel, 55% Sand, 5% Silt. Gravel is mostly fine to very fine pebble, ranges to 18 mm, round to subround, 70% mafic (eg. basalt), 30% felsic (yellow brown argillite). Sand is mostly coarse to medium, 50% mafic, 50% felsic. Wet color is 2.5Y3/1, very dark gray. No reaction to HCl. Weakly cemmented.	C8936-I CONTINGENCY 1B whole sample, previously seived to recover some <2mm material.
36.2	C	B309D0	W					SILTY SANDY GRAVEL. 65% gravel, 35% Sand, 5% Silt. Gravel ranges up to 3.5cm, round to subround, 60% mafic (e.g. basalt), 40% felsic (eg. granodiorite), Sand is poorly sorted, mostly coarse to medium, subangular, 60% felsic, 40% mafic. Silt coats all clasts. No reaction to HCl. Compacted, weakly cemmented. Wet color 2.5Y4/1, dark gray.	C8936-I CONTINGENCY 1A Bottom of core, Core is 75% Full.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	**CORE LOG**	**Boring/Well No** C8938 **Depth** 10.1 - 13.8 **Date** 2/3/2015 Logging **Location** 331/170 Core Opening **Project**	**Sheet** 1 **of** 7

Logged by George Last (Print) George V. Last (Sign) **Reviewed by** (Print) (Sign) **Date** **Lithologic Class. Scheme** Folk/Wentworth **Procedure** DBTBI-99-GVL-01 **Rev** 0	**Drilling Contractor** **Driller** **Drill Method**

DEPTH (FT)	SAMPLES		MOISTURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	HEIS ID NUMBER		C	Z	S	G		
10.1- 10.6	G	B30555	D-M					SILTY SANDY GRAVEL. 30% Gravel, 60% Sand, 10% Silt. Gravel ranges up to 2cm (broken), subround to subangular, 50% mafic, 50% felsic. Sand poorly sorted, mostly fine to very fine, subangular to subround, 50% mafic, 50% felsic. Dry to moist color is 2.5Y 5/1, gray. Weak to strong reaction to HCl. No cementation obvious.	C8938, I-001B whole sample, previously seived to recover some <2mm material. Oder-earthy?
11.1	C	B30558	D-M					SLIGHTLY SILTY GRAVELLY SAND. 15% Gravel, 5% V.C Sand, 15% C. Sand, 10% medium sand, 20% Fine Sand, 20% Vf. sand, 15% silt. Gravel ranges up to 15mm, subangular to subround, 60% mafic, 40% felsic. Sand poorly sorted, subangular, 50% mafic, 50% felsic. silt particles cover most clasts. Dry to moist color is 2.5Y 5/1, gray. Weak to strong reaction to HCl. No obvious cementation, very soft consistancy.	C8938, I-001A Bottom of core. Core is 80% Full
12.8	C	B30559	M-W					SANDY GRAVEL. 70% Gravel (biased by quartzite cobble), 30% Sand, ~~trace~~ of silt. Gravel ranges to > 6 cm (quartzite cobble, broken), subround to round where unbroken, 75% felsic (biased by quartzite cobble), 25% mafic. Sand is mostly medium, subangular, 60% mafic, 40% felsic. moist color 2.5Y3/1, very dark gray. No reaction to HCl. Compacted and weakly cemmented.	C8938, I-002D Bottom of core. Core is 95% Full.
13.3	C	B30560	M					SILTY SANDY GRAVEL. 70% Gravel, 25% Sand, 5% silt. Gravel ranges to >6 cm, round to subround, 60% felsic (biased by quartzite cobble), 40% mafic. Sand is mostly medium to fine, subangular, 60% mafic, 40% felsic. Cobble is coated with a very pale brown (10YR 7/3), muddy, weakly cemented sandstone which breaks up into clods (Ringold rip-up clast), strong reaction to HCl. Normal matrix is weak to no reaction to HCl, moist color is 2.5Y4/1, dark gray. Compacted and weakly cemmented.	C8938, I-002C Bottom of core.
13.3- 13.8	G	B30561						~~SILTY~~ SANDY GRAVEL. 40% Gravel, 55% Sand, 5% silt. Gravel mostly fine to very fine pebble, ranges to >15mm (broken). 50% mafic, 50% felsic (e.g. quartzite), subrounded where unbroken, occational clasts of Ringold (10YR8/3, very pale brown), strong reaction to HCl. Sand is mostly medium to fine, subangular, 50% mafic, 50% felsic. moist color is 2.5Y 3/2, very dark grayish brown. Weak reaction to HCl, some clods weakly cemmented.	C8938, I-002B. whole sample, previously seived to remove some <2mm material.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	CORE LOG	Boring/Well No C8938 Logging Location 331/170 Core Opening	Depth 14.3 - 17.3 Date 2/4/2015 Project	Sheet 2 of 7

Logged by George Last (Print) George V. Last (Sign)
Reviewed by (Print) (Sign) Date
Lithologic Class. Scheme Folk/Wentworth
Procedure DDT81-99-GVL-01 Rev 0
Drilling Contractor
Driller
Drill Method

DEPTH (FT)	SAMPLES		MOIS-TURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	HEIS ID NUMBER		C	Z	S	G		
14.3	C	B30563	m					SANDY GRAVEL. 75% Gravel, 25% Sand. Gravel ranges to 3cm, round to sub-round where unbroken. 70% mafic (eg. basalt), 30% felsic (e.g. purple quartzite). Sand is poorly sorted, mostly medium, subangular, 50% mafic, 50% felsic. Trace of silt (localized in ribbons). Moist to dry color is 2.5Y3/2, very dark grayish brown. No to weak reaction to HCl. Compacted, weakly cemmented.	C8938, I-002A Bottom of core. 80% full.
14.5-15	G	B30566	M-D					SILTY GRAVELLY SAND. 25% Gravel, 60% Sand, 15% Silt. Gravel ranges up to >18mm (broken), round to subround where unbroken. Sand poorly sorted, mostly coarse to fine, subangular, 50% mafic, 50% felsic. Gravel is 50% mafic (e.g. basalt), 50% felsic (e.g. quartzite). Silt covers all clasts. Moist to dry color is 2.5Y4/1, dark gray. No to weak reaction to HCl. No obvious cementation.	C8938, I-003B whole sample, previously seived to recover some <2mm material. Some Odor.
15.5	C	B30568	M-D					SILTY SANDY GRAVEL. 70% Gravel (biased by quartzite cobble), 25% Sand 5% silt, perhaps some volcanic ash (tephra) coating some gravel clasts. Gravel ranges up to >5.5cm (broken), 80% felsic (biased by quartzite cobble), 20% mafic. Sand poorly sorted, mostly medium, subangular, 60% felsic, 40% mafic. Moist to dry color varies from 2.5Y6/1, gray to 2.5Y4/2, dark grayish brown. Weak reaction to HCl. Compacted, some dark clods are weakly cemented.	C8938, I-003A Bottom of core. 75% full.
16.8	C	B30569	M-D					SILTY SANDY GRAVEL. 70% Gravel, 25% Sand, 5% Silt. Gravel ranges to 4cm (unbroken), round to subround, 60% mafic (e.g. basalt), 40% felsic (e.g. quartzite). Sand is poorly sorted mostly medium to fine, subangular to subround, 60% mafic, 40% felsic. Moist to dry color 2.5Y3/1, very dark gray. Weak reaction to HCl. Compacted. weakly cemented.	C8938, I-004D Bottom of core. 40% full. Note: should adjust depths to account for core recovery.
17.3	C	B30570	m					SILTY SANDY GRAVEL 55% Gravel, 40% Sand, 5% Silt. Gravel ranges up to >1.5cm (broken), subround where unbroken, 50% mafic (e.g. basalt), 50% felsic (e.g. quartzite). Sand is mostly medium, subangular, 50% mafic, 50% felsic. Silt covers most clasts. Weak reaction to HCl. Compacted. No obvious cemmentation.	C8938, I-004C Bottom of core. full.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory

CORE LOG

Boring/Well No C8938
Logging Location 331/170 Core Opening
Depth 17.3 - 20.2
Project
Date 2/4/2015 2/5/2015
Sheet 3 of 7

Logged by George Last (Print) George V. Last (Sign)
Reviewed by (Print) (Sign) Date
Lithologic Class. Scheme Folk/Wentworth
Procedure D9781-~~89~~-GRL-01 Rev ~~01~~ 0
Drilling Contractor
Driller
Drill Method

DEPTH (FT.)	SAMPLES		MOISTURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	HEIS ID NUMBER		C	Z	S	G		
17.3-17.8	G	B30571	m					SILTY SANDY GRAVEL. 70% Gravel, 25% Sand, 5% Silt. Gravel ranges to 2cm (broken), subrounded where unbroken, 50% mafic (e.g. basalt), 50% ~~mafic~~ felsic (e.g. quartzite, weakly cemmented yellowish sandstone w/ ~~strong~~ reaction to HCl - Ringold ripup clasts). Sand is mostly medium to fine, subangular, 50% mafic, 50% felsic. silt coats all clasts. Strong reaction to HCl, moist color is 2.5Y4/2, dark grayish brown. No obvious cemmentt.	C8938, I-004B whole sample, previously seived to recover some <2mm material for uranium analyses.
18.3	C	B30573	m					SILTY SANDY GRAVEL. 70% Gravel, 25% Sand, 5% silt. Gravel ranges upto 3cm (broken), rounded to subround where unbroken, 60% mafic (e.g. basalt), 40% felsic (eg. quartzite). Sand is mostly medium to fine, angular to subangular, 60% felsic, 40% mafic. Moist color is 2.5Y3/2, very dark grayish brown. No reaction to HCl. Some clods are weakly cemmented.	C8938, I004A Bottom of core. 70% full.
2/5/2015									
19.2	C	B30574	M					SILTY SANDY GRAVEL. 70% Gravel, 25% Sand, 5% Silt (+clay). Gravel ranges up to 2.5 cm, subround, 70% mafic (eg. basalt), 30% felsic (eg. quartzite). Sand is poorly sorted, mostly medium, 50% mafic, 50% felsic. Silt + clay seems concentrated in places and coats some gravel. clasts. Moist color is 2.5Y3/1, very dark gray. Some clayey/silty clumps are weakly cemmented. Compacted. No reaction to HCl.	C8938, I-005D Bottom of core. ~~95%~~ 60% full.
19.7	C	B30575	M					SILTY SANDY GRAVEL. 70% Gravel, 25% Sand, 5% Silt. Gravel ranges up to >3 cm (broken), round to subround where unbroken, 50% mafic (eg. basalt), 50% felsic (e.g. quartzite, argillite). Sand is poorly sorted, mostly med., subangular, 50% felsic, 50% mafic. moist color is 2.5Y4/1, dark gray. No reaction to HCl. Compacted. No obvious cemmentation.	C8938, I-005C. Bottom of core. full. some odor.
19.7-20.2	G	B30576	M					SILTY SANDY GRAVEL. 35% Gravel, 55% Sand, 10% Silt. Gravel mostly very fine pebble, ranges up to ~12 mm (broken), subangular to subround, 70% mafic (e.g. basalt), 30% felsic (e.g. quartzite). Sand mostly fine to medium, subangular, 50% mafic, 50% felsic. silt covers most clasts. moist color is 2.5Y3/1, very dark gray. Weak reaction to HCl. No obvious cemmentation.	C8938, I-005C. whole sample, previously seived to recover some <2 mm material. Some odor.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	**CORE LOG**	**Boring/Well No** C8938 **Depth** 20.7 - 23.0 **Date** 2/5/2015 Logging **Location** 331/170 core opening **Project**
Sheet 4 **of** 7		

Logged by George Last (Print) (Sign)

Reviewed by (Print) (Sign) **Date**

Lithologic Class. Scheme Folk/Wentworth **Procedure** DJPB1-99-GVL-01 **Rev** 0

Drilling Contractor

Driller

Drill Method

DEPTH (FT.)	SAMPLES TYPE	HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
20.7	C	B30579	M					SILTY SANDY GRAVEL. 50% Gravel, 45% Sand, 5% Silt. Gravel ranges upto >2.5 cm (broken), subround where unbroken, 70% mafic (eg. basalt), 30% felsic (eg. quartzite, granodiorite). Sand mostly medium to fine, subangular, 50% mafic, 50% felsic. Silt covers most clasts. Moist color is 2.5Y4/1, dark gray. Weak to strong reaction to HCl. No obvious cementation or structure.	C8938, I005A Bottom of core. 40% full. Some odor.
21.5	C	B30580	M-W					SILTY SANDY GRAVEL. 75% Gravel, 15% Sand, 10% Silt (+clay). Gravel is mostly fine to very fine pebble, ranges upto 1.5 cm, subround to round (where unbroken), 70% mafic (e.g. basalt), 30% felsic (e.g. quartzite). Sand is poorly sorted, mostly coarse, subangular, 50% mafic, 50% felsic) silt+clay covers all clasts and binds them together in clods, (weakly cemmented, moist-wet color is 2.5Y 3/1, very dark gray. No to weak reaction to HCl.	C8938, I-006D. Bottom of core. Nearly full.
22.0	C	B30581	M-W					~~SILTY SANDY~~ GRAVEL, 95% Gravel (biased by basalt cobble occupying entire bottom of core liner). 5% sand, 5% silt (+clay). Visual examination through core liner indictates rest of core is SILTY SANDY GRAVEL. Color is ~~3~~ 2.5Y 3/1 to 2.5Y 2.5/1, very dark grey to black (biased by basalt cobble). No reaction to HCl. Compacted. Basalt cobble >7 cm (broken).	C8938, I-006C Bottom of core. Over full - basalt cobble.
22.0-22.5	G	B30582	m					SILTY SANDY GRAVEL. 80% Gravel, 15% Sand, 5% Silt. Gravel is mostly fine to very fine pebble, ranges upto 12 mm, subangular to subround. 75% mafic (eg. basalt), 25% felsic (e.g. quartzite, clayey nodules). Sand poorly sorted, mostly medium to fine, subangular, 65% mafic, 35% felsic. Moist color 2.5Y 3/1, very dark gray to black (2.5Y 2.5/1). No reaction to HCl. Some clayey nodules/clods are weakly cemmented.	C8938, I-006B whole sample. Previously seived to remove some <2 mm material.
23.0	C	B30584	m					SILTY SANDY GRAVEL. 70% Gravel, 20% Sand, 10% Silt. Gravel ranges up to >2.5 cm (broken), angular (broken). 60% mafic (eg. basalt), 40% felsic (e.g. pink quartzite). Sand is poorly sorted, mostly fine, subangular, 60% mafic, 40% felsic. No reaction to HCl. Compacted. Moist color is 2.5Y 4/1, dark gray.	C8938, I-006A. Bottom of core. 80% full.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	CORE LOG	Boring/Well No C8938 Logging Location 331/170 Core Openning	Depth 25.0 - 28.4 Project	Date 2/5/2015	Sheet 5 of 7

Logged by George Last (Print) George V. Last (Sign)

Reviewed by (Print) (Sign) Date

Lithologic Class. Scheme Folk/Wentworth

Procedure DJTBI-99-GVL-01 Rev 0

Drilling Contractor

Driller

Drill Method

DEPTH (FT.)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
25.0-25.5	G	B30587	M					SILTY SANDY GRAVEL, 75% Gravel, 15% Sand, 10% Silt. Gravel mostly medium to very fine pebble, ranges up to 12 mm, subangular to subrounded, many broken clasts, 70% mafic (e.g. basalt), 30% felsic (e.g. quartzite). Sand mostly coarse to medium, subangular, 55% mafic, 45% felsic. No reaction to HCl. Some weakly cemmented clods. Moist color is 2.5Y 3/1, very dark gray.	C8938, I-007B whole sample, previously seived to recover some <2 mm material for Uranium analysis.
25.5-26.0	C	B30589	M-D					SILTY SANDY GRAVEL. 80% Gravel, 15% Sand, 5% Silt. Gravel ranges up to >3 cm (broken), many broken clasts, round to subround where unbroken, 60% basaltic, 40% nonbasalt (diorite, quartzite, granitic). Sand is poorly sorted, mostly medium to fine, subangular, 50% mafic, 50% felsic. Moist to dry color is 2.5Y 5/1, gray. No reaction. Some clods weakly cemmented. No obvious structure.	C8938, I- whole core laid out is sample tray, fell apart, dried, (90% full liner).
27.4	C	B30590	M					~~SILTY~~ SANDY GRAVEL. 75% Gravel, 25% Sand, trace of silt. Gravel ranges to >3 cm (broken), round to subround where unbroken, 40% basaltic 60% non-basalt (e.g. diorite, quartzite), or 60% mafic (basalt, diorite), 40% felsic (quartzite/argillite). Sand mostly coarse to medium, subangular, 60% mafic, 40% felsic. Moist color is 2.5Y 3/1; very dark gray. No reaction to HCl. Compacted. Weakly cemmented.	C8938, I-008D bottom of core. Full?
27.9	C	B30591	M-W					~~SILTY~~ SANDY GRAVEL. 70% Gravel, 30% Sand, trace of silt (localized along wall of liner). Gravel ranges to 2 cm (broken), round to subround where unbroken, 50% mafic (e.g. basalt, diorite), 50% felsic (e.g. brown quartzite, redish argillite). Sand is mostly coarse, fairly well sorted, subangular to subround, 55% mafic, 45% felsic. Moist to wet color is 2.5Y 4/1, dark gray. No reaction to HCl. Compacted, weakly cemmented.	C8938, I-008C. bottom of core. Full.
27.9-28.4	G	B30592	W					SILTY SANDY GRAVEL. 70% Gravel, 25% Sand, 5% Silt. Gravel is mostly fine to very fine pebble, ranges up to 16 mm, subrounded, 70% mafic, 30% felsic. Sand is mostly coarse to very coarse, fairly well sorted. Silt coats some clasts, ~~holdt~~ holding them together with moisture. Sand is subangular to subround, 50% mafic, 50% felsic. Moist to wet color is 2.5Y 3/1, very dark gray. No reaction to HCl. No to weak cemmentation.	C8938, I008B. whole sample, previously seived to remove some <2 mm material.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory

CORE LOG

Boring/Well No C8938 | Depth 28.9-32.2 | Date 2/5/2015 | Sheet 6 of 7
Logging Location 331/170 Core Openning | Project

Logged by George Last (Print) George V. Last (Sign)
Reviewed by Fu (Print) (Sign) Date
Lithologic Class. Scheme Folk/Wentworth | Procedure D9T81-89-GVL-01 | Rev 0

Drilling Contractor
Driller
Drill Method

DEPTH (FT.)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
28.9	C	B30594	W					SILTY SANDY GRAVEL. 70% Gravel, 20% Sand, 10% Silt (+clay?). Gravel ranges to >3 cm (broken), round to subround where unbroken, 60% mafic 40% felsic (coated with mud). Sand is poorly sorted, non discript, subangular, 60% mafic, 40% felsic (coated with mud). Mud (silt+clay) coats all clasts. Wet color is 2.5Y 4/1, dark gray. No ~~color to~~ reaction to HCl. Compacted. No to ~~weak reaction to HCl~~ weak cemmentation.	C8938, I-008A bottom of core. 80% Full.
29.2 29.7	G	B30597	W					SILTY SANDY GRAVEL. 80% Gravel, 15% Sand, 5% silt (+clay?). Gravel is mostly fine to very fine pebble, ranges up to 2 cm, subround; 65% mafic 35% felsic (coated with mud). Sand is poorly sorted, non-discripty subangular, 60% mafic, 40% felsic (coated with mud). Mud (silt+clay) coats all clasts. Wet color is 2.5Y 4/1, dark gray. Wet sample has no reaction to HCl. No signs of cemmentation.	C8938, I-009B whole sample, previosly seived to recover some <2 mm material.
30.2	C	B30599	W					SILTY SANDY GRAVEL 80% Gravel, 15% Sand, 5% silt (+clay). Gravel ranges up to 4 cm, round to subround, 70% mafic, 30% felsic (coated with mud). Sand is poorly sorted, mostly coarse, subangular, 70% mafic, 30% felsic (coated with mud). Mud (silt+clay) coats all clasts. Wet color is 2.5Y 3/1, very dark gray. Wet sample has no reaction to HCl. Compacted, but no obvious cementation.	C8938, I-009A bottom of core. 80% full.
31.7	C	B309F2	W					SANDY GRAVEL. 75% Gravel, 25% Sand, trace of silt. Gravel ranges to 5 cm, rounded to subround, 60% felsic (biased by very coarse granodiorite pebble). Sand is mostly coarse, subangular, 60% mafic, 40% felsic. Wet color is 2.5Y 2.5/1, black. Wet sample has no reaction to HCl. Compacted, but no obvious signs of cemmentation.	C8938, I-CONTINGENCY 1C bottom of core. 70% Full.
31.7 32.2	G	B309F3	W					SILTY SANDY GRAVEL. 45% Gravel, 40% Sand, 5% silt (+clay?). Gravel is mostly fine to very fine pebble, ranging up to 17 mm, subangular to subround, 70% mafic, 30% felsic (coated with mud). Sand is poorly sorted, mostly coarse to medium, subangular, 65% mafic, 35% felsic. Mud (silt+clay) coats all clasts. Wet color is 2.5Y 3/1, very dark gray. Wet sample has no reaction to HCl. No obvious cementation.	C8938, I-CONTINGENCY 1B ~~bottom of co~~ whole sample, previously seived to recover some <2 mm material.

W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

Pacific Northwest National Laboratory	CORE LOG	Boring/Well No C8938 Logging Location 331/170 Core Opening	Depth 32.7 Project	Date 2/5/2015	Sheet 7 of 7

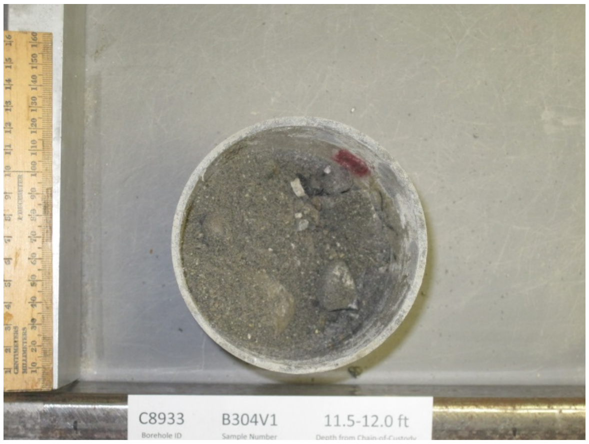
Logged by George Last (Print) George V. Last (Sign)
Reviewed by (Print) (Sign) Date
Lithologic Class. Scheme Fdk/Wentworth
Procedure DJT81-99-GSL-01 Rev 0
Drilling Contractor
Driller
Drill Method

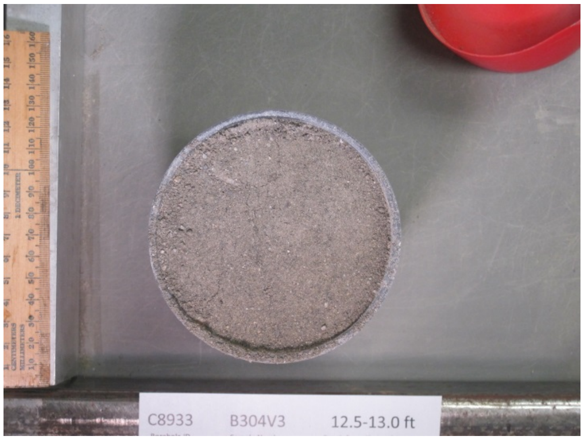
DEPTH (FT.)	SAMPLES		MOISTURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	HEIS ID NUMBER		C	Z	S	G		
32.7	C	B309F5	W					<u>SILTY SANDY GRAVEL</u> 70% Gravel, 25% Sand, 5% Silt(+clay). Gravel ranges up to 7 4cm (broken), round to subround where unbroken, 70% mafic, 30% felsic (coated with mud). Sand poorly sorted, mostly medium, subangular, 60% mafic, 40% felsic (coated with mud). mud (silt+clay) coats all clasts. Wet color = 2.5Y 3/1, very dark gray. wet sample has no reaction to HCl. Compacted. weakly cemmented.	C8938, 2-CONTINGENCY IN bottom of core.

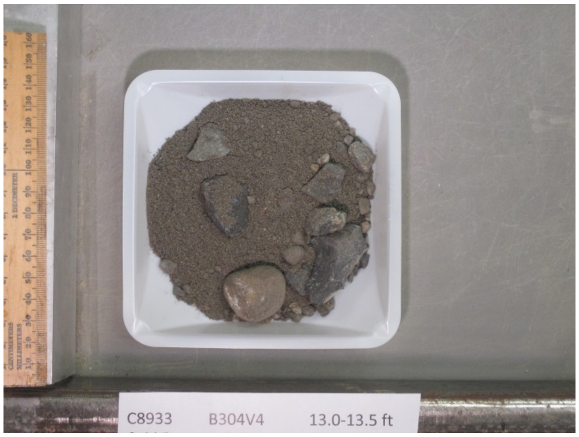
W = Wet, M = Moist, SM = Slightly Moist, D = Dry

2006/DCL/FORMS/CoreLog/001 (006/09)

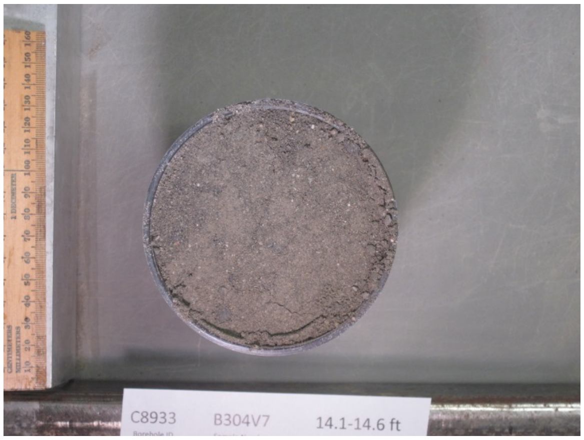
Photographs from borehole C8933


C8933
Borehole ID
B304V1
Sample Number
11.5-12.0 ft
Depth from Chain of Custody

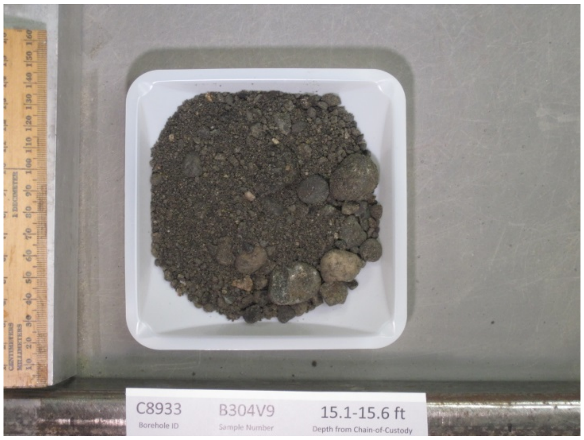

C8933
B304V3
12.5-13.0 ft


C8933
B304V4
13.0-13.5 ft


C8933
B304V6
13.5-14.0 ft


C8933
B304V7
14.1-14.6 ft


C8933
B304V8
14.6-15.1 ft

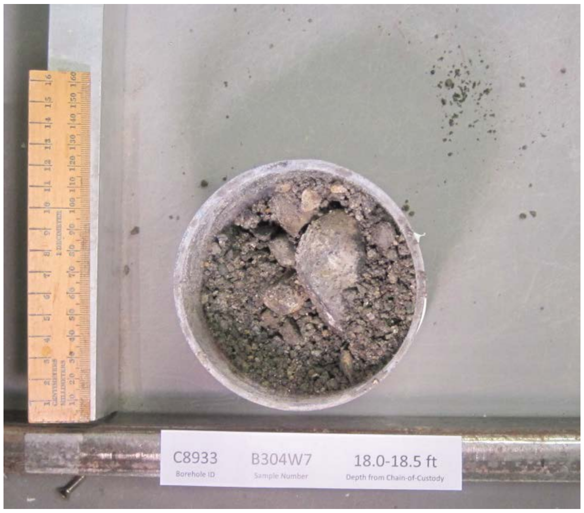

C8933
Borehole ID
B304V9
Sample Number
15.1-15.6 ft
Depth from Chain-of-Custody


C8933
Borehole ID
B304W1
Sample Number
15.6-16.1
Depth from Chain-of-Custody

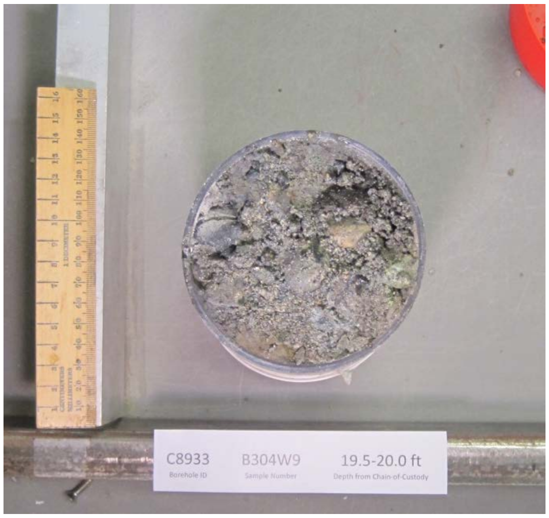

C8933
Borehole ID
B304W2
Sample Number
16.5-17.0 ft
Depth from Chain-of-Custody

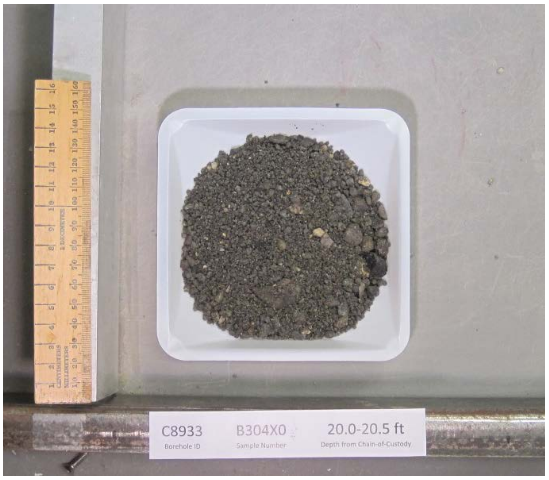

C8933
Borehole ID
B304W3
Sample Number
17.0-17.5 ft
Depth from Chain-of-Custody

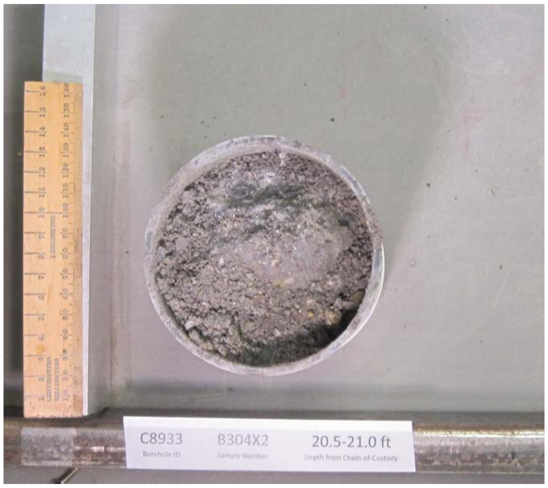

C8933
Borehole ID
B304W4
Sample Number
17.5-18.0 ft
Depth from Chain-of-Custody


C8933
Borehole ID
B304W7
Sample Number
18.0-18.5 ft
Depth from Chain-of-Custody


C8933
Borehole ID
B304W8
Sample Number
19.0-19.5 ft
Depth from Chain-of-Custody


C8933
Borehole ID
B304W9
Sample Number
19.5-20.0 ft
Depth from Chain-of-Custody

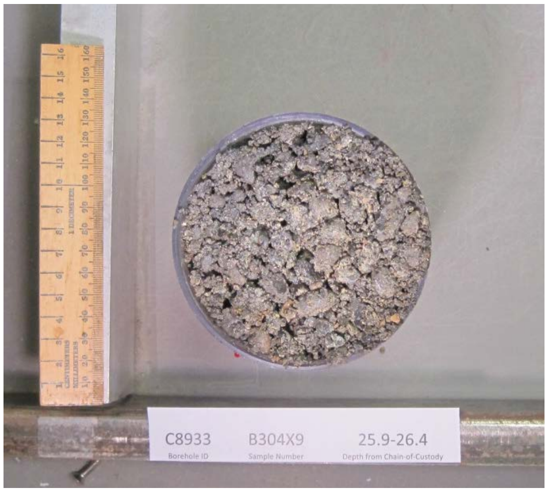

C8933
Borehole ID
B304X0
Sample Number
20.0-20.5 ft
Depth from Chain-of-Custody


C8933
Borehole ID
B304X2
Sample Number
20.5-21.0 ft
Depth from Chain-of-Custody


C8933
Borehole ID
B304X5
Sample Number
21.5-22.0 ft
Depth from Chain-of-Custody


C8933
Borehole ID
B304X7
Sample Number
22.0-22.5 ft
Depth from Chain-of-Custody

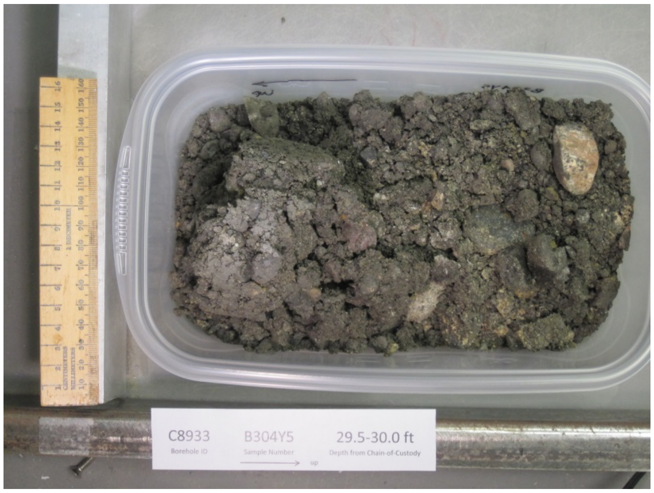

C8933
Borehole ID
B304X8
Sample Number
25.4-25.9 ft
Depth from Chain-of-Custody


C8933
Borehole ID
B304X9
Sample Number
25.9-26.4
Depth from Chain-of-Custody


C8933
Borehole ID
B304Y0
Sample Number
26.4-26.9 ft
Depth from Chain-of-Custody


C8933
Borehole ID
B304Y3
Sample Number
26.9-27.4 ft
Depth from Chain-of-Custody

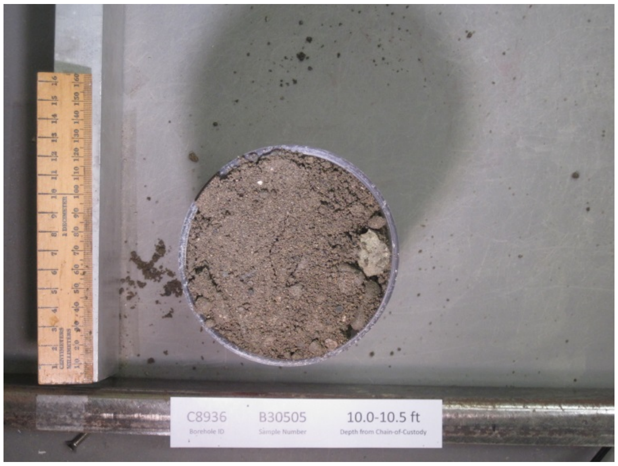

up
C8933
Borehole ID
B304Y4
Sample Number
29.0-29.5 ft
Depth from Chain-of-Custody

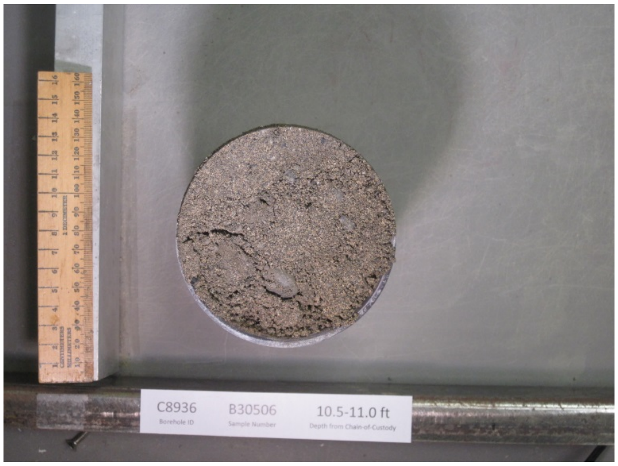

C8933
Borehole ID
B304Y5
Sample Number
29.5-30.0 ft
Depth from Chain-of-Custody
up

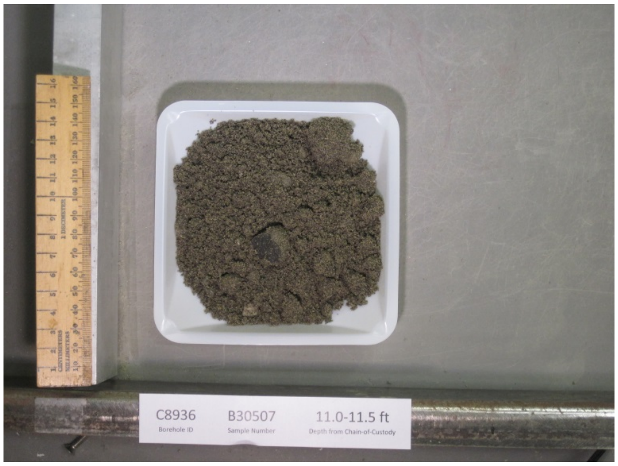

C8933
Borehole ID
B304Y6
Sample Number
30.0-30.5 ft
Depth from Chain-of-Custody

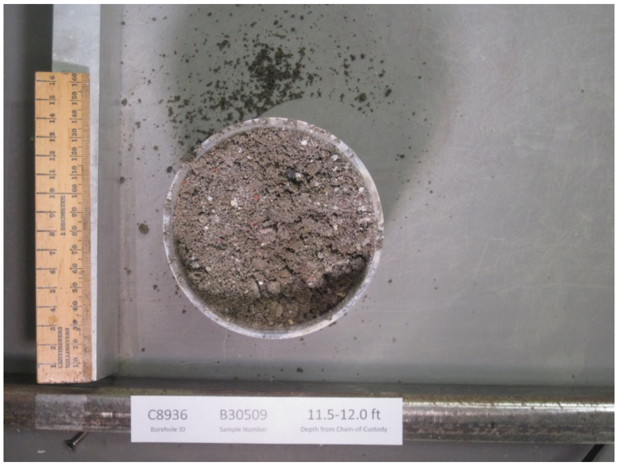

C8933
Borehole ID
B304Y8
Sample Number
30.5-31.0 ft
Depth from Chain-of-Custody

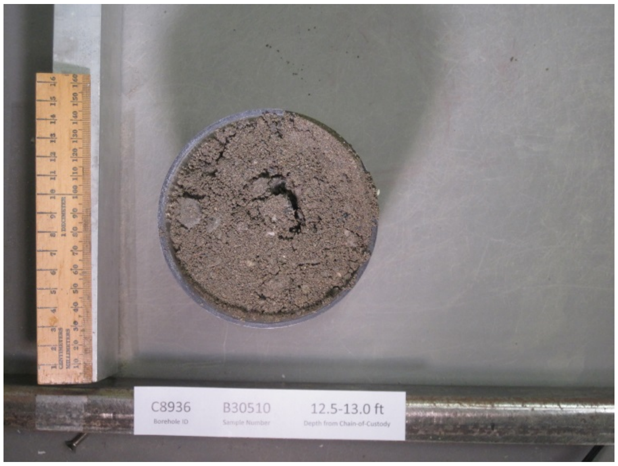
Photographs of Borehole C8936



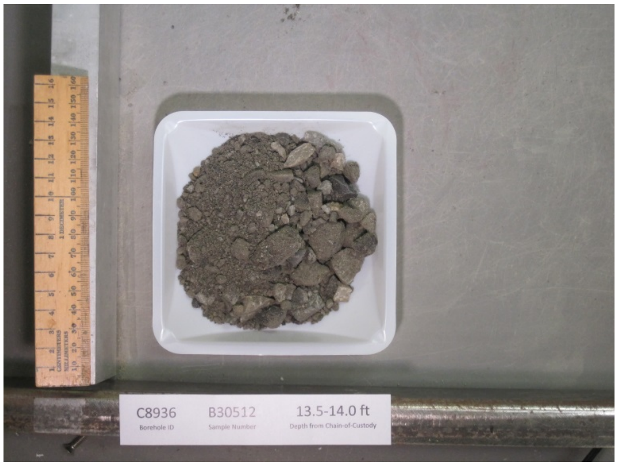


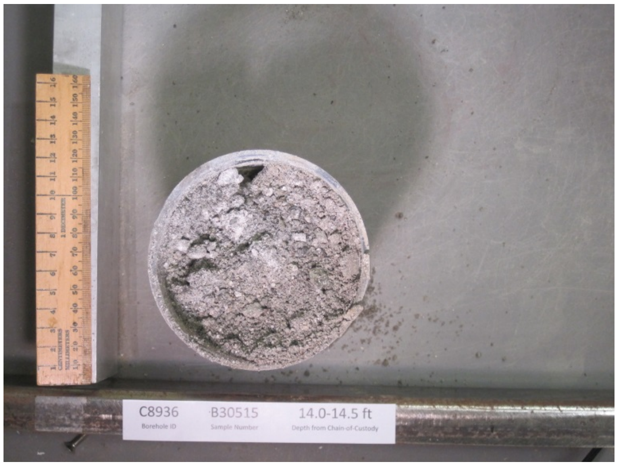


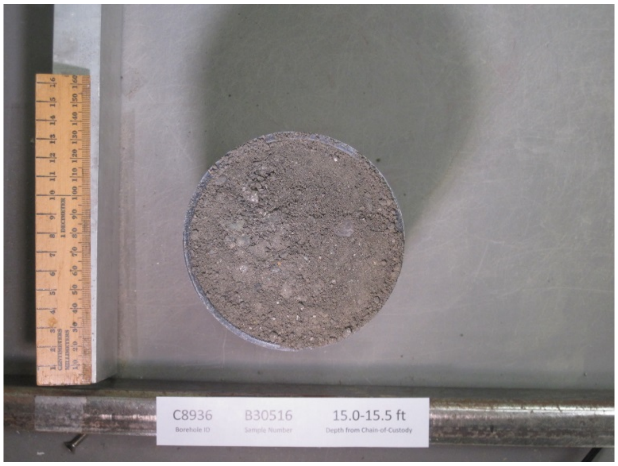

C8936
Borehole ID
B30509
Sample Number
11.5-12.0 ft
Depth from Chain-of-Custody

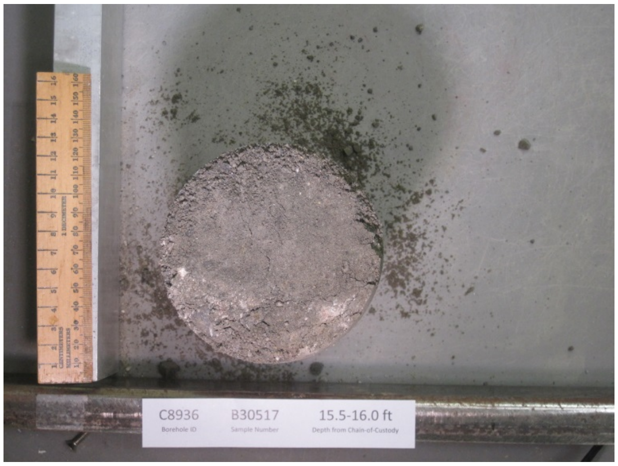

C8936
Borehole ID
B30510
Sample Number
12.5-13.0 ft
Depth from Chain-of-Custody

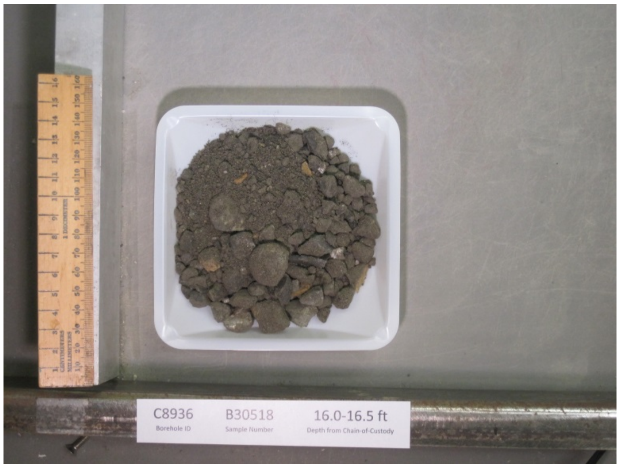

C8936
Borehole ID
B30511
Sample Number
13.0-13.5 ft
Depth from Chain-of-Custody

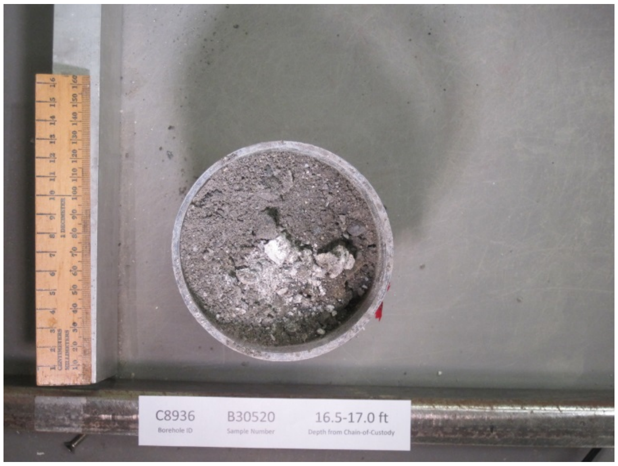

C8936
Borehole ID
B30512
Sample Number
13.5-14.0 ft
Depth from Chain-of-Custody

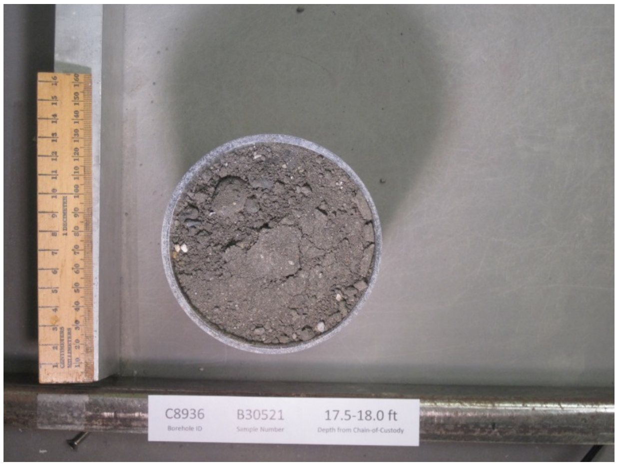

C8936
Borehole ID
B30515
Sample Number
14.0-14.5 ft
Depth from Chain-of-Custody

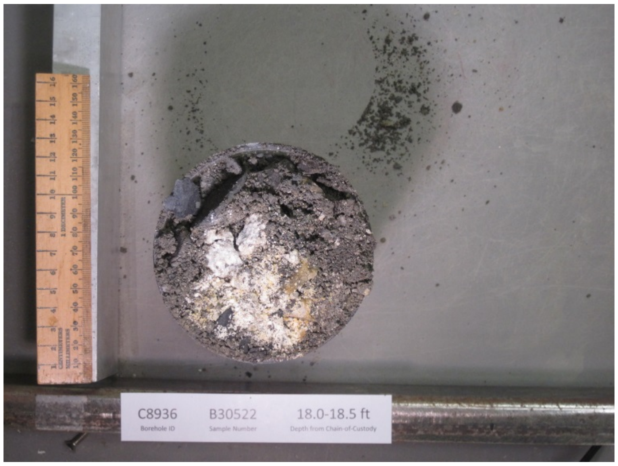

C8936
Borehole ID
B30516
Sample Number
15.0-15.5 ft
Depth from Chain-of-Custody

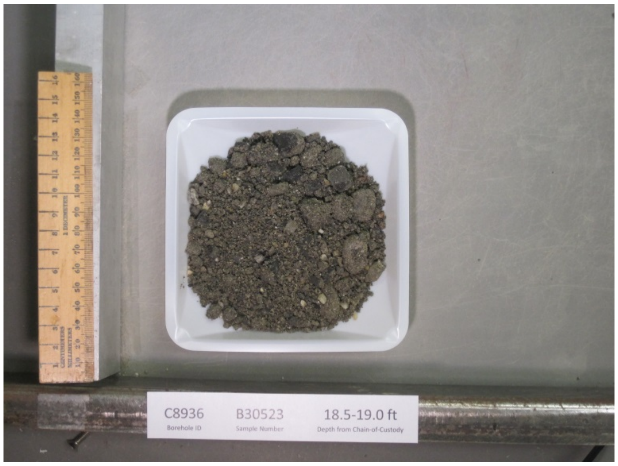

C8936
Borehole ID
B30517
Sample Number
15.5-16.0 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30518
Sample Number
16.0-16.5 ft
Depth from Chain-of-Custody

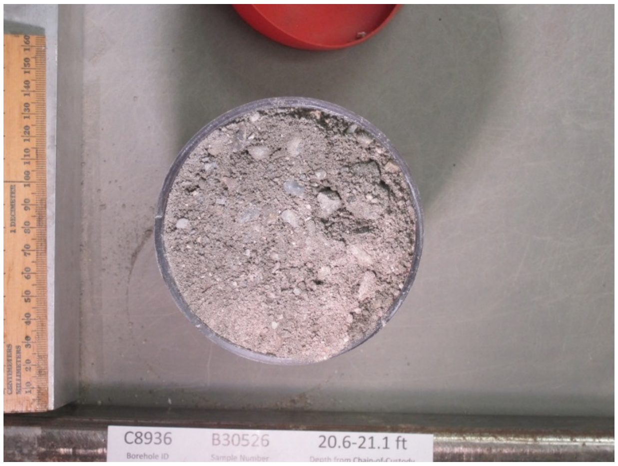

C8936
Borehole ID
B30520
Sample Number
16.5-17.0 ft
Depth from Chain-of-Custody

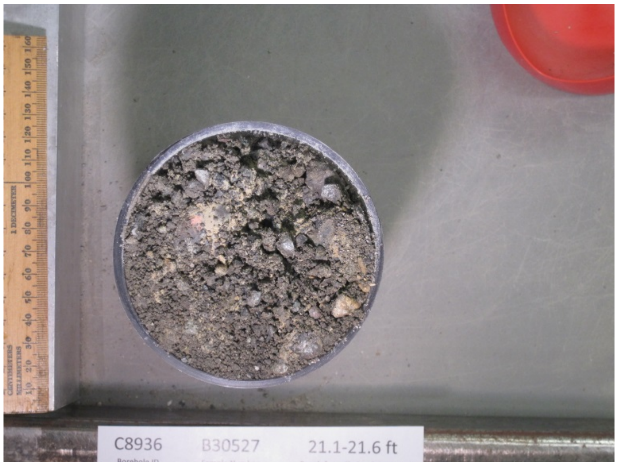

C8936
Borehole ID
B30521
Sample Number
17.5-18.0 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30522
Sample Number
18.0-18.5 ft
Depth from Chain-of-Custody

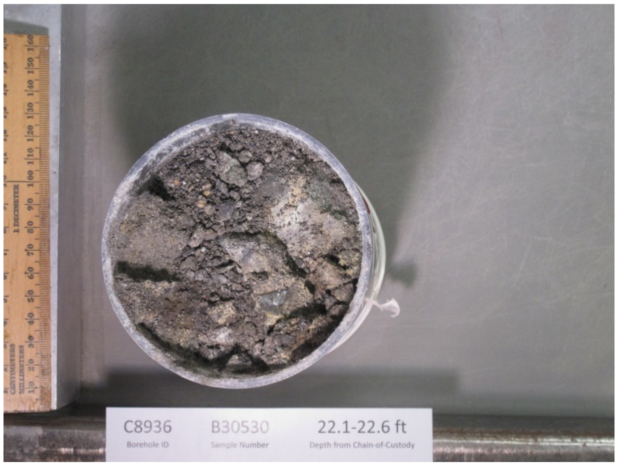

C8936
Borehole ID
B30523
Sample Number
18.5-19.0 ft
Depth from Chain-of-Custody

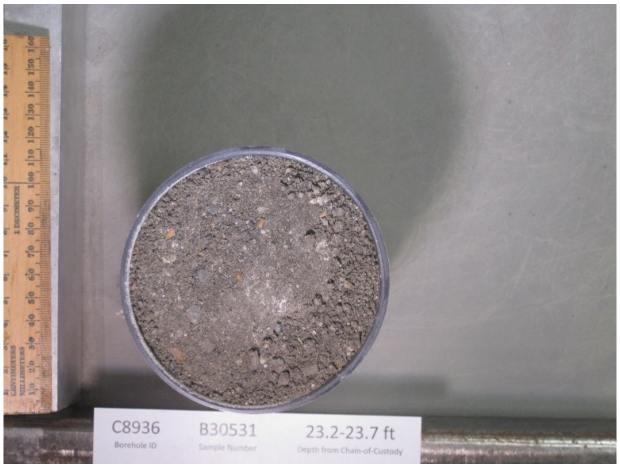

C8936
Borehole ID
B30525
Sample Number
19.0-19.5 ft
Depth From Chain-of-Custody

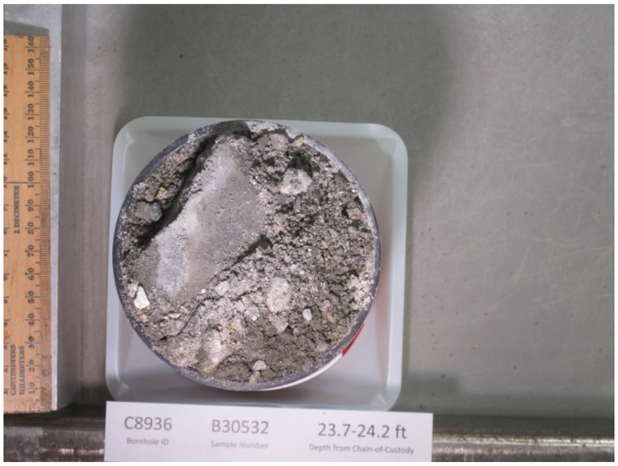

C8936
Borehole ID
B30526
Sample Number
20.6-21.1 ft

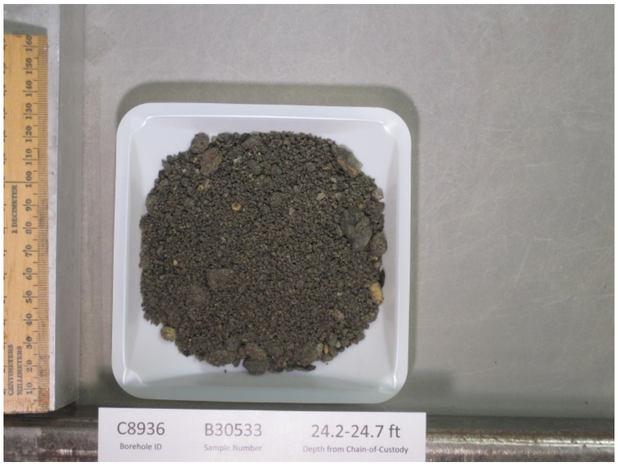

C8936
B30527
21.1-21.6 ft


C8936
Borehole ID
B30528
Sample Number
21.6-22.1 ft
Depth from Chain-of-Custody

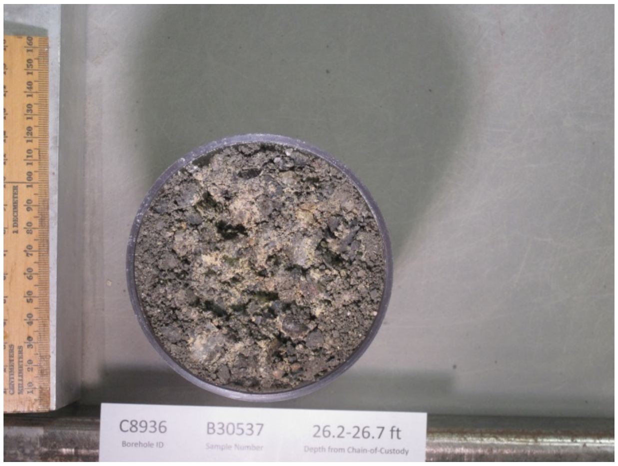

C8936
Borehole ID
B30530
Sample Number
22.1-22.6 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30531
Sample Number
23.2-23.7 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30532
Sample Number
23.7-24.2 ft
Depth from Chain-of-Custody

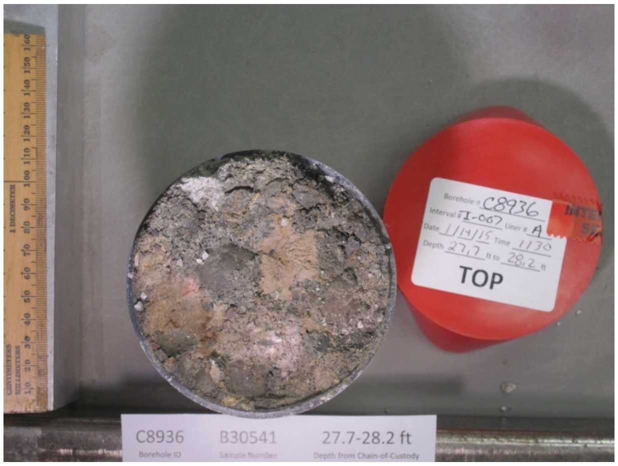

C8936
Borehole ID
B30533
Sample Number
24.2-24.7 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30536
Sample Number
24.7-25.2 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30537
Sample Number
26.2-26.7 ft
Depth from Chain-of-Custody

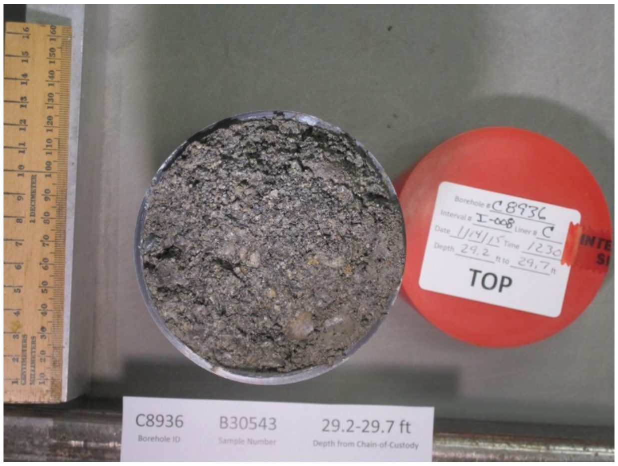

C8936
Borehole ID
B30538
6.7-27.2 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30539
Sample Number
27.2-27.7 ft
Depth from Chain-of-Custody


Borehole # C8936
Interval # I-007
Liner # A
Date 1/14/15
Time 1130
Depth 27.7 ft to 28.2 ft
TOP
C8936
Borehole ID
B30541
Sample Number
27.7-28.2 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30541
Sample Number
27.7-28.2 ft
Depth from Chain-of-Custody

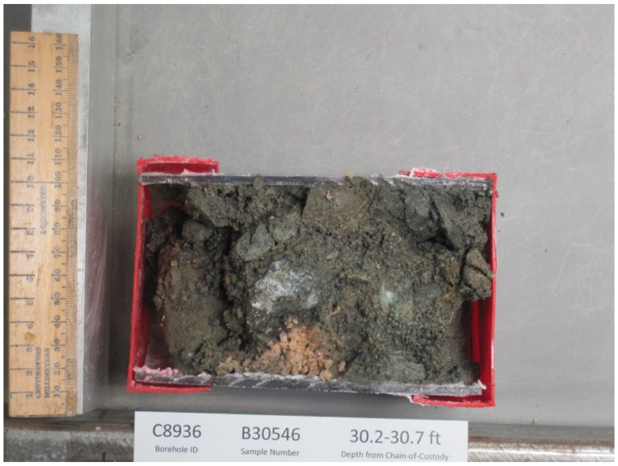

C8936
Borehole ID
B30542
Sample Number
28.7-29.2 ft
Depth from Chain-of-Custody

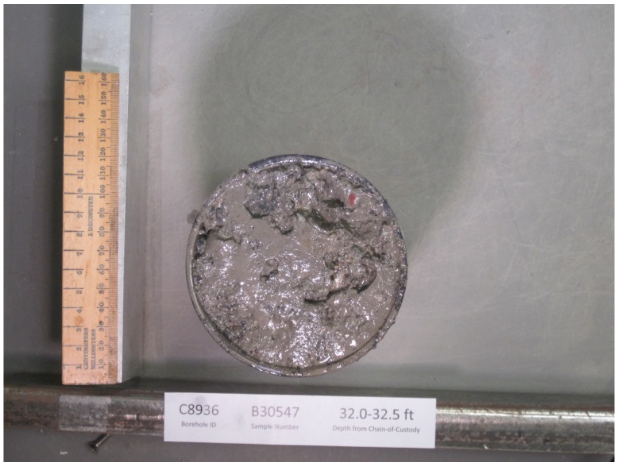

Borehole # C8936
Interval # I-008
Date 1/14/15 Liner # C
Time 1230
Depth 29.2 ft to 29.7 ft
TOP
C8936
Borehole ID
B30543
Sample Number
29.2-29.7 ft
Depth from Chain-of-Custody

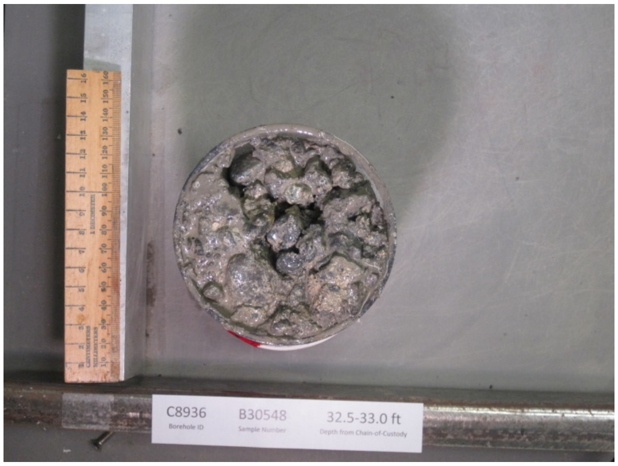

C8936
Borehole ID
B30543
Sample Number
29.2-29.7 ft
Depth from Chain-of-Custody

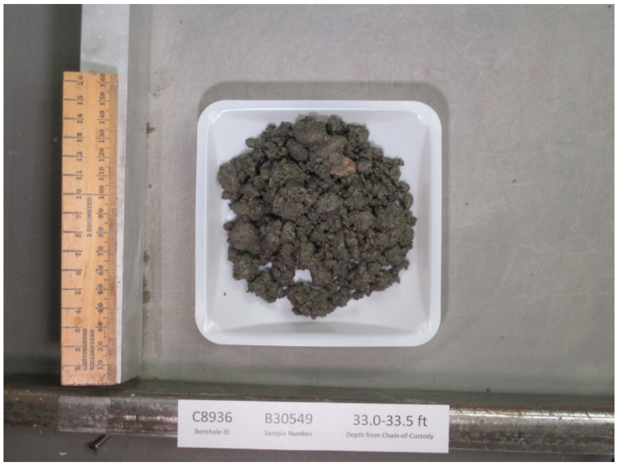

C8936
Borehole ID
B30544
Sample Number
29.7-30.2 ft
Depth from Chain-of-Custody

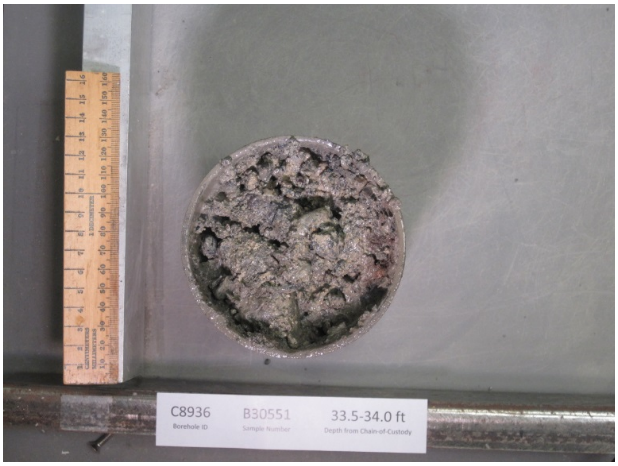

C8936
Borehole ID
B30546
Sample Number
30.2-30.7 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30546
Sample Number
30.2-30.7 ft
Depth from Chain-of-Custody

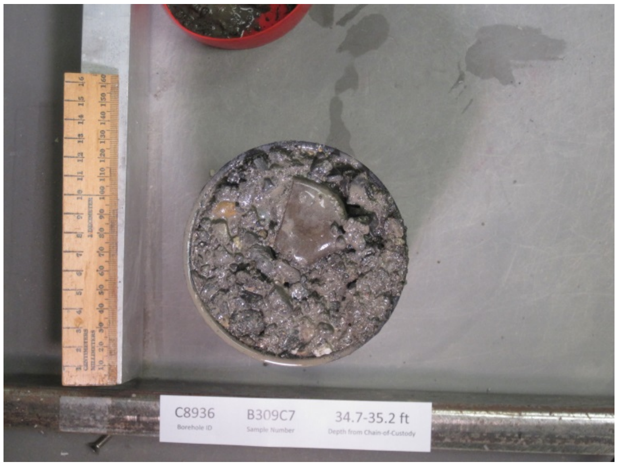

C8936
Borehole ID
B30547
Sample Number
32.0-32.5 ft
Depth from Chain-of-Custody

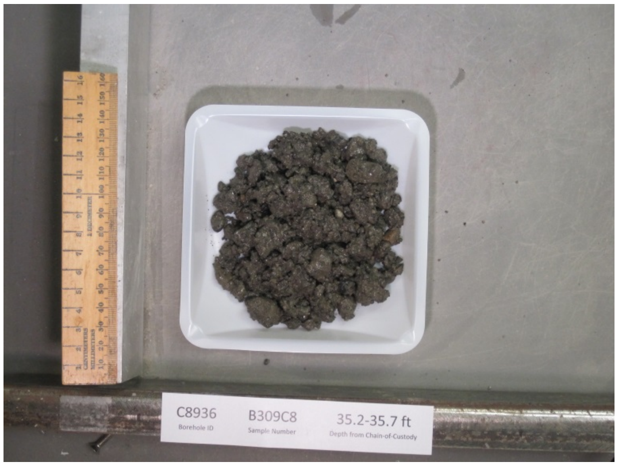

C8936
Borehole ID
B30548
Sample Number
32.5-33.0 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30549
Sample Number
33.0-33.5 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B30551
Sample Number
33.5-34.0 ft
Depth from Chain-of-Custody

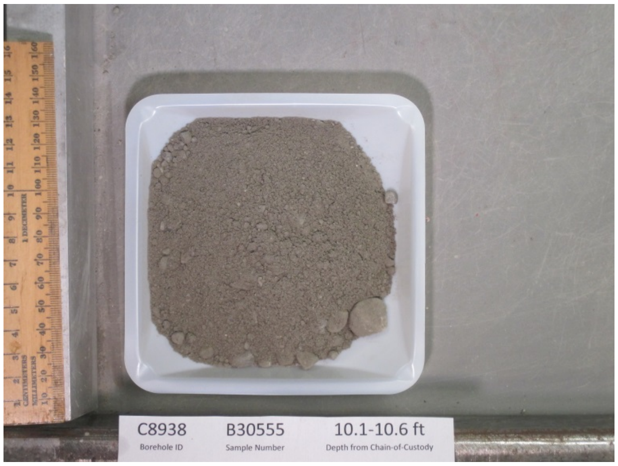

C8936
Borehole ID
B309C6
Sample Number
34.2-34.7 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B309C7
Sample Number
34.7-35.2 ft
Depth from Chain-of-Custody

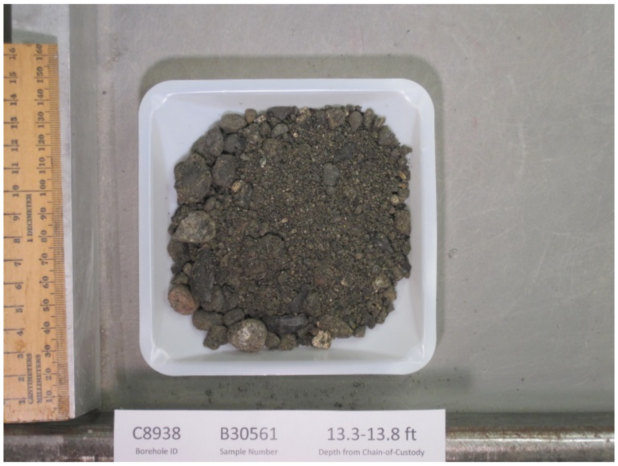

C8936
Borehole ID
B309C8
Sample Number
35.2-35.7 ft
Depth from Chain-of-Custody


C8936
Borehole ID
B309D0
Sample Number
35.7-36.2 ft
Depth from Chain-of-Custody

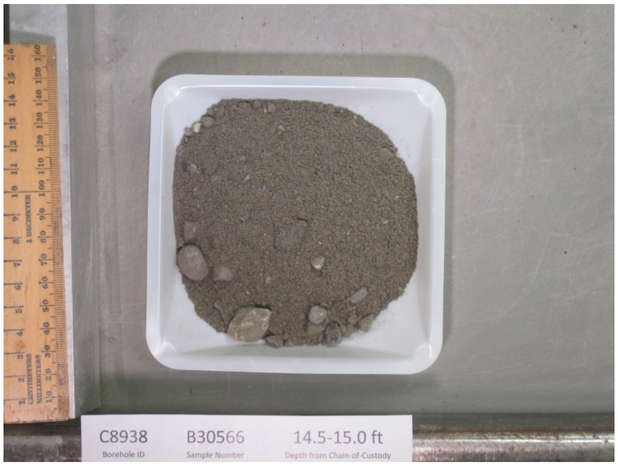
Photographs from Borehole C8938

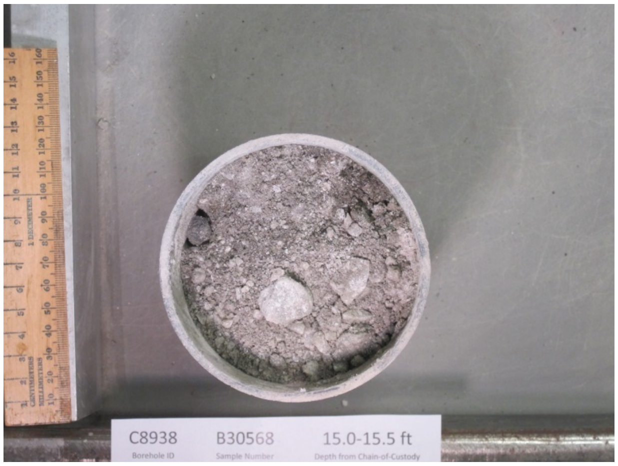


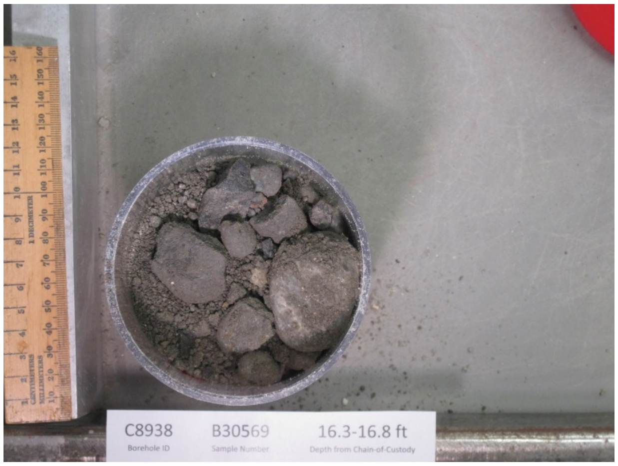

C8938
Borehole ID
B30560
Sample Number
12.8-13.3 ft
Depth from Chain-of-Custody

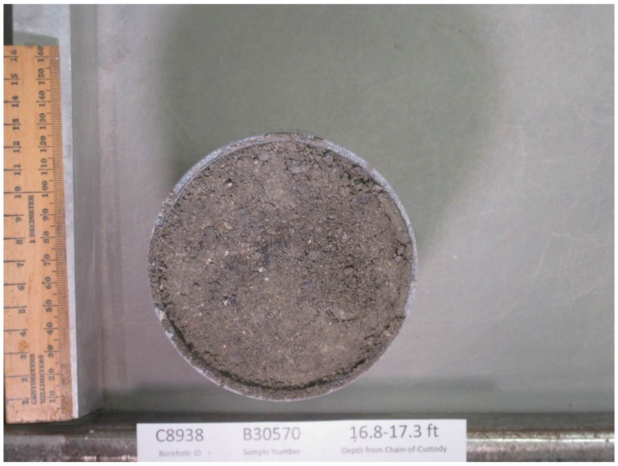

C8938
Borehole ID
B30561
Sample Number
13.3-13.8 ft
Depth from Chain-of-Custody

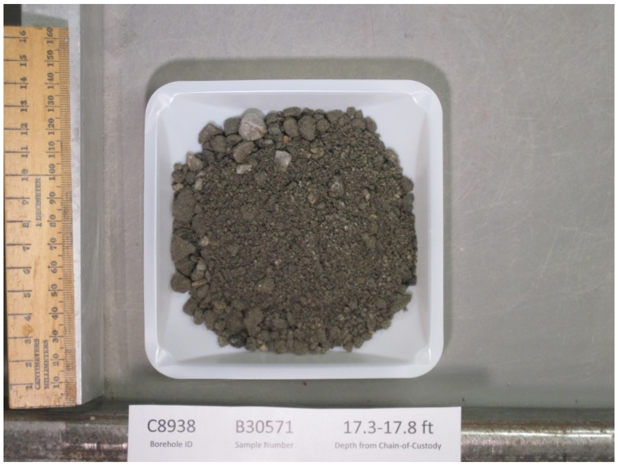

C8938
Borehole ID
B30563
Sample Number
13.8-14.3 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30566
Sample Number
14.5-15.0 ft
Depth from Chain-of-Custody

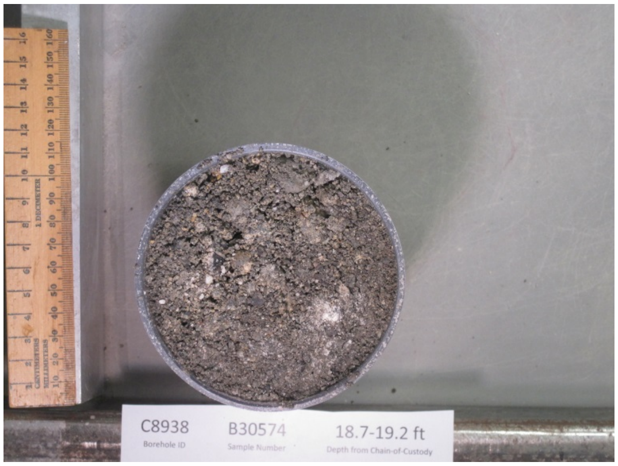

C8938
Borehole ID
B30568
Sample Number
15.0-15.5 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30569
Sample Number
16.3-16.8 ft
Depth from Chain-of-Custody

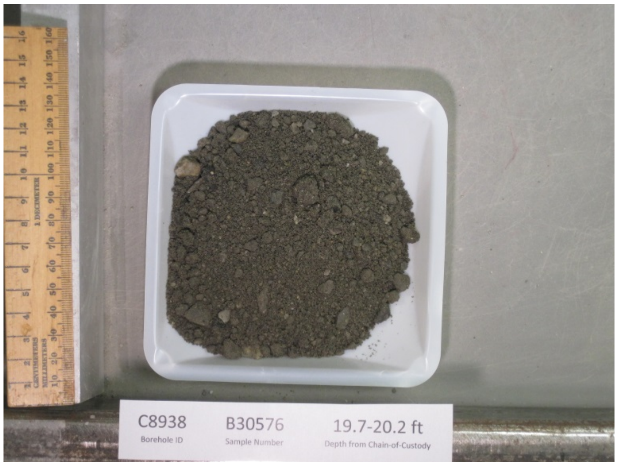

C8938
Borehole ID
B30570
Sample Number
16.8-17.3 ft
Depth from Chain-of-Custody

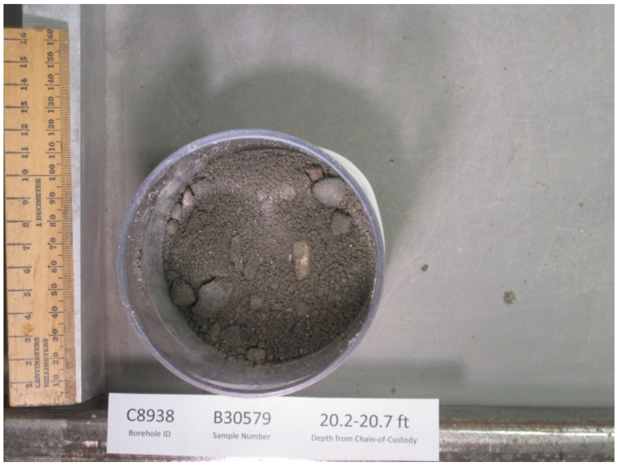

C8938
Borehole ID
B30571
Sample Number
17.3-17.8 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30573
Sample Number
17.8-18.3 ft
Depth from Chain-of-Custody

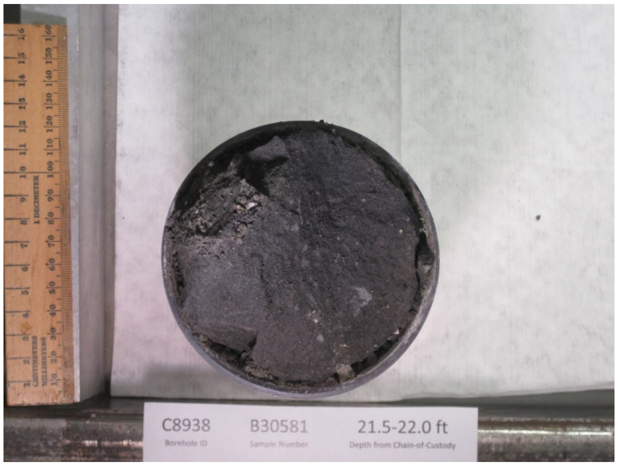

C8938
Borehole ID
B30574
Sample Number
18.7-19.2 ft
Depth from Chain-of-Custody

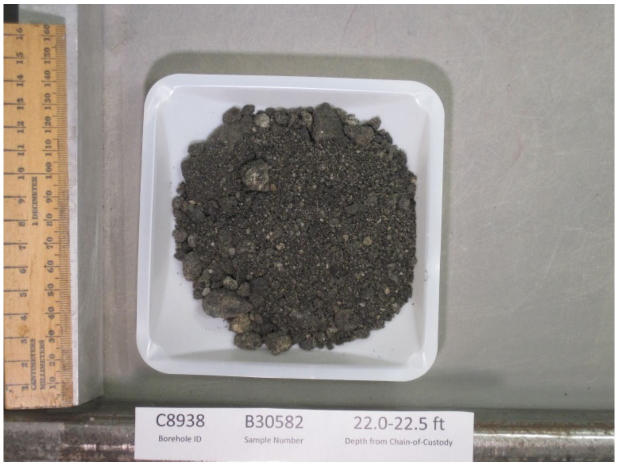

C8938
Borehole ID
B30575
Sample Number
19.2-19.7 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30576
Sample Number
19.7-20.2 ft
Depth from Chain-of-Custody

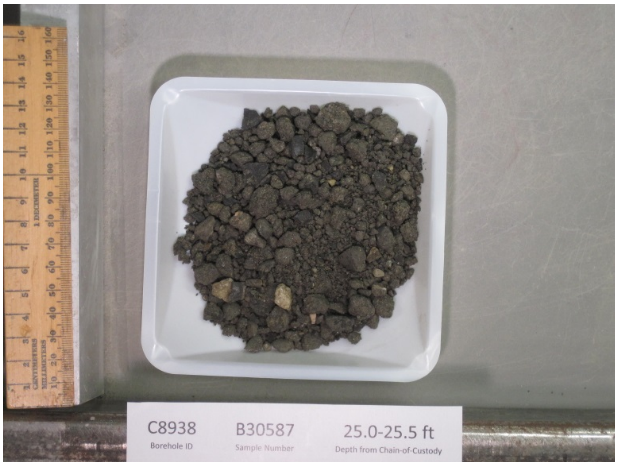

C8938
Borehole ID
B30579
Sample Number
20.2-20.7 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30580
Sample Number
21.0-21.5 ft
Depth from Chain-of-Custody

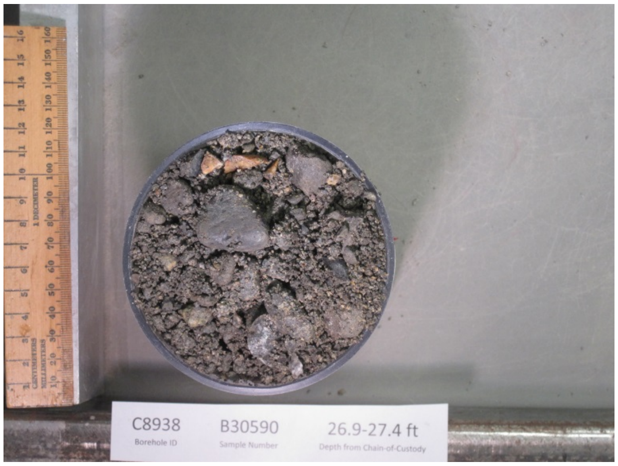

C8938
Borehole ID
B30581
Sample Number
21.5-22.0 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30582
Sample Number
22.0-22.5 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30584
Sample Number
22.5-23.0 ft
Depth from Chain-of-Custody

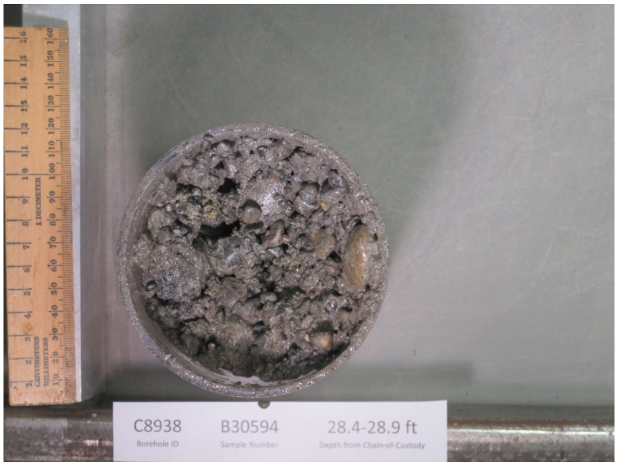

C8938
Borehole ID
B30587
Sample Number
25.0-25.5 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30589
Sample Number
25.5-26.0 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30590
Sample Number
26.9-27.4 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30591
Sample Number
27.4-27.9 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30592
Sample Number
27.9-28.4 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30594
Sample Number
28.4-28.9 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30597
Sample Number
29.2-29.7 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B30599
Sample Number
29.7-30.2 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B309F2
Sample Number
31.2-31.7 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B309F3
Sample Number
31.7-32.2 ft
Depth from Chain-of-Custody


C8938
Borehole ID
B309F5
Sample Number
32.2-32.7 ft
Depth from Chain-of-Custody

This page intentionally left blank.

PNNL-24911

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8940 and C9451

MMV Snyder
GV Last

November 2015

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

To: Randy Hermann

From: Michelle Snyder and George Last

Environmental Sciences Laboratory
Energy and Environment Directorate, Pacific Northwest National Laboratory

Subject: Analytical Data Report of Samples Collected for the solubility testing of wells C8940 and C9451, sample delivery group (SDG) ESL150001, SAF F15-014.

This letter contains the following information for sample delivery group ESL150001

- Cover Sheet
- Narrative
- Analytical Results
- Quality Control

Introduction

On July 16, 2015 samples were received from the 300-FF5 OU for chemical analyses.

Analytical Results/Methodology

The analyses for this project were performed at the 331 building located in the 300 Area of the Hanford Site. The analyses were performed according to Pacific Northwest National Laboratory (PNNL) approved procedures and/or nationally recognized test procedures. The data sets include the sample identification numbers, analytical results, estimated quantification limits (EQL), and quality control data.

Quality Control

The preparatory and analytical quality control requirements, calibration requirements, acceptance criteria, and failure actions are defined in the on-line QA plan “Conducting Analytical Work in Support of Regulatory Programs” (CAW). This QA plan implements the Hanford Analytical Services Quality Assurance Requirements Documents (HASQARD) for PNNL.

Definitions

Dup	Duplicate
RPD	Relative Percent Difference
NR	No Recovery (percent recovery less than zero)
ND	Non-Detectable
%REC	Percent Recovery

Sample Receipt

Samples were received with a chain of custody (COC) and were analyzed according to the sample identification numbers supplied by the client. All Samples were refrigerated upon receipt until prepared for analysis.

All samples were received with custody seals intact unless noted in the Case Narrative.

Holding Times

Holding time is defined as the time from sample preparation to the time of analyses. The prescribed holding times were met for all analytes unless noted in the Case Narrative.

Analytical Results

All reported analytical results meet the requirements of the CAW or client specified SOW unless noted in the case narrative.

Labile Uranium Selective Extraction

The labile or weakly adsorbed (easily removed) uranium extraction was performed on the <2 mm, air dried sediment samples. A solution containing 0.0144 mol/L of sodium bicarbonate ($NaHCO_3$) and 0.0028 mol/L of sodium carbonate (Na_2CO_3) with a pH of approximately 9.45 was added to the sediment at a solid to solution ratio of 1 gram/2 mL, and allowed to agitate on an orbital shaker for 1 week.

Sequential Extractions

Four sequential extractions were performed on the <2mm, air dried sediment samples. The first extraction involved a weak acetic acid consisting of 1 mol/L sodium acetate with a final pH of approximately 5. The sample was agitated on an orbital shaker for 1 hour at a solid to solution ratio of 1 gram/2 mL. After 1 hour, the sample was centrifuged, the solution decanted and filtered (for ICP-MS and ICP-OES analysis), and the sample was weighed to determine the remaining residual solution prior to starting the next sequential extraction. The target uranium phase for this extraction is the adsorbed uranium and uranium associated with carbonate minerals. The second sequential extraction used a strong acetic acid (concentrated glacial acetic acid). After 5 days contact time, the same centrifuge and decanting procedure was used. The target phase for the strong acetic acid is the strongly bound uranium. The third extraction used a solution consisting of 0.1 mol/L ammonium oxalate with 0.1 mol/L oxalic acid. After 1 hour of contact time, the samples were centrifuged, decanted, filtered and weighed. The target phase for the oxalate solution are the amorphous Fe, Al, Mn and Si oxides. The final nitric acid extraction involved 8 mol/L of nitric acid. The samples were transferred to a glass beaker with a stir bar and heated at 95°C for 2 hours on a hot plate. Samples were weighed after this step so the final volume could be determined. The target phases for the nitric acid include clays, crystalline oxides, and Fe, Al, and Mn uranium oxides.

Case Narrative Report

Hold Time:
No discrepancies noted.

Preparation Blank (PB):

The preparation blank recovery for the weak acetic acid extract (sample ID 1510007-06) had calcium >EQL for ICP-OES Vadose-NP. The PB concentration is <5% of the lowest measured concentration in the samples. There should be no impact to data as reported.

The preparation blank recovery for the nitric acid extract (sample ID 1510007-27) had calcium >EQL for ICP-OES Vadose-NP. The PB concentration is <5% of the lowest measured concentration in the samples. There should be no impact to data as reported.

The preparation blank recovery for the nitric acid extract (sample ID 1510007-27) had iron >EQL for ICP-OES Vadose-NP. The PB concentration is <5% of the lowest measured concentration in the samples. There should be no impact to data as reported.

Duplicate (DUP):
No discrepancies noted.

Laboratory Control Samples (LCS):
The preparation blank recovery (150%) for the weak acetic acid extract (sample ID 1510007-06) was outside acceptable limits (80-120%) for ICP-OES Vadose-NP. Aluminum associated with the weak acetic extractions were not reported.

Post Spike (PS):
No discrepancies noted.

The following analyses were performed on the following samples included in this report:

Geologic Description
Metals Special Extract by ICPOES
Moisture Content
Particle Size Analysis
pH of Water by Electrode
Sequential Extracts
U Special Extract by ICPMS

Sediment Samples Received from Boreholes C8940 and C9451

Laboratory ID	Sample No.	Borehole ID
1508009-01	B31MY0	C8940
1508009-02	B31MY1	C8940
1508009-03	B31MY2	C8940
1508009-04	B31MY4	C8940
1508009-05	B31MY6	C8940
1508009-06	B31MY7	C8940
1508009-07	B31N00	C8940
1508009-08	B31N03	C8940
1508009-09	B31N05	C8940
1508009-10	B31N13	C8940
1508009-11	B31N19	C8940
1508009-12	B31N22	C8940
1508009-13	B31N23	C8940
1508009-14	B31N24	C8940
1508009-15	B31N26	C8940
1508009-16	B31N27	C8940
1508009-17	B31N28	C8940
1508009-18	***B31N29***	***C8940***
1508009-19	B31N31	C8940
1508009-20	B31N33	C8940
1508009-21	B31N34	C8940
1508009-22	B31N62	C9451
1508009-23	B31N63	C9451
1508009-24	B31N64	C9451
1508009-25	B31N66	C9451
1508009-26	B31N69	C9451
1508009-27	B31N71	C9451
1508009-28	B31N72	C9451
1508009-29	B31N73	C9451
1508009-30	B31N74	C9451
1508009-31	B31N77	C9451
1508009-32	B31N78	C9451
1508009-33	B31N79	C9451
1508009-34	B31N80	C9451
1508009-35	B31N82	C9451
1508009-36	B31N84	C9451
1508009-37	***B31N85***	***C9451***
1508009-38	B31N87	C9451
1508009-39	B31N90	C9451
1508009-40	***B31N96***	***C9451***
1508009-41	B31NB0	C9451
1508009-42	***B31NB1***	***C9451***
1508009-43	B31NB3	C9451
1508009-44	B31NB6	C9451

Note: Samples in italics selected for analyses (personal communication from Randy Herman via email dated 8/19/2015)

Wet Chemistry

Moisture Content (% by Weight) by AGG-WC-001

Lab ID	**Client ID.**	Results	EQL	Analyzed	Batch
1508009-18	B31N29	4.87E0	N/A	10/19/15	5H19004
1508009-37	B31N85	1.46E1	N/A	10/19/15	5H19004
1508009-40	B31N96	9.54E0	N/A	10/19/15	5H19004
1508009-42	B31NB1	7.07E0	N/A	10/19/15	5H19004
1508009-45	B31N29 <2mm	1.97E0	N/A	9/17/15	5I11001
1508009-46	B31N85 <2mm	1.88E0	N/A	9/17/15	5I11001
1508009-47	B31N96 <2mm	1.78E0	N/A	9/17/15	5I11001
1508009-48	B31NB1 <2mm	1.76E0	N/A	9/17/15	5I11001

Wet Chemistry

pH (pH Units) by AGG-pH-001

Lab ID	**Client ID.**	Results	EQL	Analyzed	Batch
1508009-45	B31N29 <2mm	8.10E0	N/A	9/22/15	5I22001
1508009-46	B31N85 <2mm	7.74E0	N/A	9/22/15	5I22001
1508009-47	B31N96 <2mm	7.83E0	N/A	9/22/15	5I22001
1508009-48	B31NB1 <2mm	7.78E0	N/A	9/22/15	5I22001

Total Metals by PNNL-ESL-ICP-OES/Special Extract

CAS #	Analyte	Results	Units	EQL	Analyzed	Batch	Method
Client ID.	**B31N29 <2mm**	**Lab ID:**		**1508009-45**			
7429-90-5	Aluminum	2.08E0	ug/g dry	1.27E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7440-70-2	Calcium	1.80E1	ug/g dry	6.13E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7439-89-6	Iron	<1.42E0	ug/g dry	1.42E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<8.47E-1	ug/g dry	8.47E-1	10/15/15	5J15012	PNNL-AGG-ICP-AES
Client ID.	**B31N85 <2mm**	**Lab ID:**		**1508009-46**			
7429-90-5	Aluminum	2.28E0	ug/g dry	1.26E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7440-70-2	Calcium	2.95E1	ug/g dry	6.09E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7439-89-6	Iron	6.43E1	ug/g dry	1.41E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<8.42E-1	ug/g dry	8.42E-1	10/15/15	5J15012	PNNL-AGG-ICP-AES
Client ID.	**B31N96 <2mm**	**Lab ID:**		**1508009-47**			
7429-90-5	Aluminum	2.14E0	ug/g dry	1.27E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7440-70-2	Calcium	3.11E1	ug/g dry	6.13E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7439-89-6	Iron	<1.42E0	ug/g dry	1.42E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<8.47E-1	ug/g dry	8.47E-1	10/15/15	5J15012	PNNL-AGG-ICP-AES
Client ID.	**B31NB1 <2mm**	**Lab ID:**		**1508009-48**			
7429-90-5	Aluminum	1.87E0	ug/g dry	1.27E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7440-70-2	Calcium	2.24E1	ug/g dry	6.11E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7439-89-6	Iron	<1.42E0	ug/g dry	1.42E0	10/15/15	5J15012	PNNL-AGG-ICP-AES
7439-96-5	Manganese	<8.44E-1	ug/g dry	8.44E-1	10/15/15	5J15012	PNNL-AGG-ICP-AES

Radionuclides by ICP-MS/Special Extraction

CAS #	Analyte	Results	Units	EQL	Analyzed	Batch	Method
Client ID.	**B31N29 <2mm**	**Lab ID:**		**1508009-45**			
U-238	Uranium 238	2.20E0	ug/g dry	1.44E-2	10/15/15	5J14001	PNNL-ESL-ICPMS
Client ID.	**B31N85 <2mm**	**Lab ID:**		**1508009-46**			
U-238	Uranium 238	3.86E0	ug/g dry	1.43E-2	10/15/15	5J14001	PNNL-ESL-ICPMS
Client ID.	**B31N96 <2mm**	**Lab ID:**		**1508009-47**			
U-238	Uranium 238	4.06E0	ug/g dry	1.44E-2	10/15/15	5J14001	PNNL-ESL-ICPMS
Client ID.	**B31NB1 <2mm**	**Lab ID:**		**1508009-48**			
U-238	Uranium 238	4.10E0	ug/g dry	1.44E-2	10/15/15	5J14001	PNNL-ESL-ICPMS

Total Metals by PNNL-ESL-ICP-OES/Sequential Extractions

LabNumber	SampleName	Analyte	Final Concentration	Units	EQL	Analyzed
1510007-08	B31N29 strong acetic acid	Aluminum	3.82E+01	ug/g dry	3.94	11/10/2015
1510007-09	B31N85 strong acetic acid	Aluminum	1.54E+01	ug/g dry	3.93	11/10/2015
1510007-10	B31N96 strong acetic acid	Aluminum	1.62E+01	ug/g dry	3.82	11/10/2015
1510007-11	B31NB1 strong acetic acid	Aluminum	1.85E+01	ug/g dry	3.95	11/10/2015
1510007-15	B31N29 oxalate	Aluminum	1.12E+03	ug/g dry	4.17	11/10/2015
1510007-16	B31N85 oxalate	Aluminum	6.66E+02	ug/g dry	4.23	11/10/2015
1510007-17	B31N96 oxalate	Aluminum	6.36E+02	ug/g dry	4.18	11/10/2015
1510007-18	B31NB1 oxalate	Aluminum	6.62E+02	ug/g dry	4.17	11/10/2015
1510007-22	B31N29 nitric acid	Aluminum	9.21E+03	ug/g dry	32.4	11/10/2015
1510007-23	B31N85 nitric acid	Aluminum	8.31E+03	ug/g dry	29.7	11/10/2015
1510007-24	B31N96 nitric acid	Aluminum	8.10E+03	ug/g dry	31.0	11/10/2015
1510007-25	B31NB1 nitric acid	Aluminum	8.34E+03	ug/g dry	28.0	11/10/2015
1510007-01	B31N29 weak acetic acid	Calcium	1.76E+03	ug/g dry	6.85	11/10/2015
1510007-02	B31N85 weak acetic acid	Calcium	1.59E+03	ug/g dry	6.88	11/10/2015
1510007-03	B31N96 weak acetic acid	Calcium	1.78E+03	ug/g dry	6.83	11/10/2015
1510007-04	B31NB1 weak acetic acid	Calcium	1.68E+03	ug/g dry	6.81	11/10/2015
1510007-08	B31N29 strong acetic acid	Calcium	3.65E+02	ug/g dry	8.02	11/10/2015
1510007-09	B31N85 strong acetic acid	Calcium	2.34E+02	ug/g dry	8.01	11/10/2015
1510007-10	B31N96 strong acetic acid	Calcium	4.56E+02	ug/g dry	7.78	11/10/2015
1510007-11	B31NB1 strong acetic acid	Calcium	2.92E+02	ug/g dry	8.04	11/10/2015
1510007-15	B31N29 oxalate	Calcium	ND	ug/g dry	8.48	11/10/2015
1510007-16	B31N85 oxalate	Calcium	ND	ug/g dry	8.61	11/10/2015
1510007-17	B31N96 oxalate	Calcium	ND	ug/g dry	8.51	11/10/2015
1510007-18	B31NB1 oxalate	Calcium	ND	ug/g dry	8.49	11/10/2015
1510007-22	B31N29 nitric acid	Calcium	5.40E+03	ug/g dry	6.60	11/10/2015
1510007-23	B31N85 nitric acid	Calcium	5.34E+03	ug/g dry	6.04	11/10/2015
1510007-24	B31N96 nitric acid	Calcium	6.11E+03	ug/g dry	6.32	11/10/2015
1510007-25	B31NB1 nitric acid	Calcium	5.66E+03	ug/g dry	5.71	11/10/2015
1510007-01	B31N29 weak acetic acid	Iron	6.56E+00	ug/g dry	2.04	11/10/2015
1510007-02	B31N85 weak acetic acid	Iron	7.37E+00	ug/g dry	2.05	11/10/2015
1510007-03	B31N96 weak acetic acid	Iron	1.05E+01	ug/g dry	2.03	11/10/2015
1510007-04	B31NB1 weak acetic acid	Iron	1.45E+01	ug/g dry	2.03	11/10/2015
1510007-08	B31N29 strong acetic acid	Iron	ND	ug/g dry	2.39	11/10/2015
1510007-09	B31N85 strong acetic acid	Iron	ND	ug/g dry	2.38	11/10/2015
1510007-10	B31N96 strong acetic acid	Iron	4.96E+00	ug/g dry	2.32	11/10/2015
1510007-11	B31NB1 strong acetic acid	Iron	9.74E+00	ug/g dry	2.39	11/10/2015
1510007-15	B31N29 oxalate	Iron	1.91E+03	ug/g dry	2.52	11/10/2015
1510007-16	B31N85 oxalate	Iron	2.54E+03	ug/g dry	2.56	11/10/2015
1510007-17	B31N96 oxalate	Iron	3.37E+03	ug/g dry	2.53	11/10/2015
1510007-18	B31NB1 oxalate	Iron	2.93E+03	ug/g dry	2.53	11/10/2015

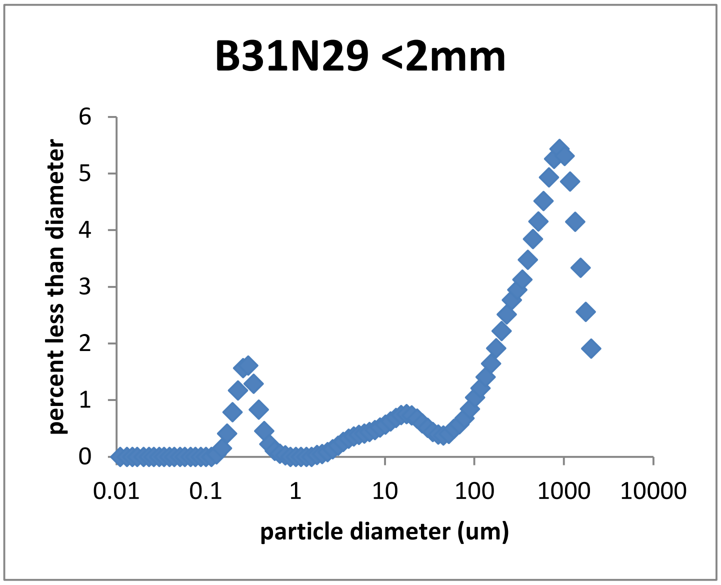
LabNumber	SampleName	Analyte	Final Concentration	Units	EQL	Analyzed
1510007-22	B31N29 nitric acid	Iron	2.49E+04	ug/g dry	19.6	11/10/2015
1510007-23	B31N85 nitric acid	Iron	2.37E+04	ug/g dry	18.0	11/10/2015
1510007-24	B31N96 nitric acid	Iron	2.35E+04	ug/g dry	18.8	11/10/2015
1510007-25	B31NB1 nitric acid	Iron	2.33E+04	ug/g dry	17.0	11/10/2015
1510007-01	B31N29 weak acetic acid	Manganese	7.64E+00	ug/g dry	0.487	11/10/2015
1510007-02	B31N85 weak acetic acid	Manganese	7.23E+00	ug/g dry	0.489	11/10/2015
1510007-03	B31N96 weak acetic acid	Manganese	1.47E+01	ug/g dry	0.486	11/10/2015
1510007-04	B31NB1 weak acetic acid	Manganese	1.89E+01	ug/g dry	0.484	11/10/2015
1510007-08	B31N29 strong acetic acid	Manganese	2.58E+01	ug/g dry	0.570	11/10/2015
1510007-09	B31N85 strong acetic acid	Manganese	2.05E+01	ug/g dry	0.570	11/10/2015
1510007-10	B31N96 strong acetic acid	Manganese	4.61E+01	ug/g dry	0.554	11/10/2015
1510007-11	B31NB1 strong acetic acid	Manganese	5.70E+01	ug/g dry	0.572	11/10/2015
1510007-15	B31N29 oxalate	Manganese	8.18E+01	ug/g dry	0.603	11/10/2015
1510007-16	B31N85 oxalate	Manganese	7.74E+01	ug/g dry	0.613	11/10/2015
1510007-17	B31N96 oxalate	Manganese	7.72E+01	ug/g dry	0.605	11/10/2015
1510007-18	B31NB1 oxalate	Manganese	7.88E+01	ug/g dry	0.604	11/10/2015
1510007-22	B31N29 nitric acid	Manganese	3.22E+02	ug/g dry	0.469	11/10/2015
1510007-23	B31N85 nitric acid	Manganese	2.86E+02	ug/g dry	0.430	11/10/2015
1510007-24	B31N96 nitric acid	Manganese	3.05E+02	ug/g dry	0.449	11/10/2015
1510007-25	B31NB1 nitric acid	Manganese	3.01E+02	ug/g dry	0.406	11/10/2015

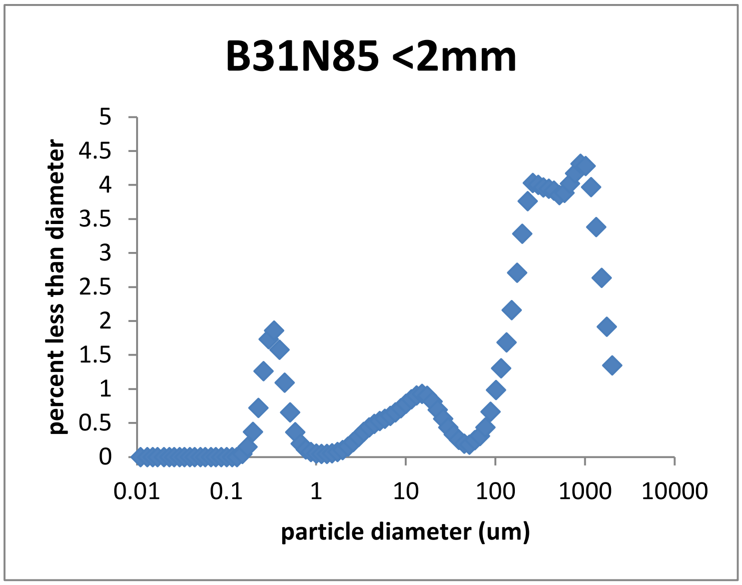
Radionuclides by PNNL-ESL-ICPMS/Sequential Extraction

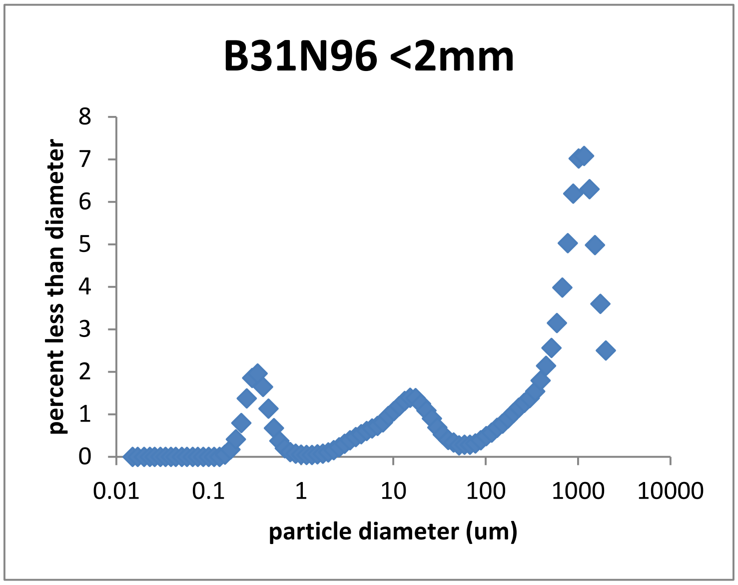
LabNumber	SampleName	Analyte	Final Concentration	Units	EQL	Analyzed
1510007-01	B31N29 weak acetic acid	Uranium 238	5.38E+00	ug/g	0.0144666	10/15/2015
1510007-02	B31N85 weak acetic acid	Uranium 238	4.54E+00	ug/g	0.0145341	10/15/2015
1510007-03	B31N96 weak acetic acid	Uranium 238	4.43E+00	ug/g	0.014439	10/15/2015
1510007-04	B31NB1 weak acetic acid	Uranium 238	5.07E+00	ug/g	0.0143882	10/15/2015
1510007-08	B31N29 strong acetic acid	Uranium 238	2.93E+00	ug/g	0.0169411	10/15/2015
1510007-09	B31N85 strong acetic acid	Uranium 238	2.74E+00	ug/g	0.0169308	10/15/2015
1510007-10	B31N96 strong acetic acid	Uranium 238	3.13E+00	ug/g	0.0164499	10/15/2015
1510007-11	B31NB1 strong acetic acid	Uranium 238	3.42E+00	ug/g	0.016992	10/15/2015
1510007-15	B31N29 oxalate	Uranium 238	2.88E+00	ug/g	0.0179262	10/15/2015
1510007-16	B31N85 oxalate	Uranium 238	3.95E+00	ug/g	0.0181983	10/15/2015
1510007-17	B31N96 oxalate	Uranium 238	3.75E+00	ug/g	0.0179792	10/15/2015
1510007-18	B31NB1 oxalate	Uranium 238	3.71E+00	ug/g	0.0179341	10/15/2015
1510007-22	B31N29 nitric acid	Uranium 238	4.34E+00	ug/g	0.01394	10/15/2015
1510007-23	B31N85 nitric acid	Uranium 238	2.61E+00	ug/g	0.0127643	10/15/2015
1510007-24	B31N96 nitric acid	Uranium 238	2.82E+00	ug/g	0.0133459	10/15/2015
1510007-25	B31NB1 nitric acid	Uranium 238	3.54E+00	ug/g	0.0120668	10/15/2015

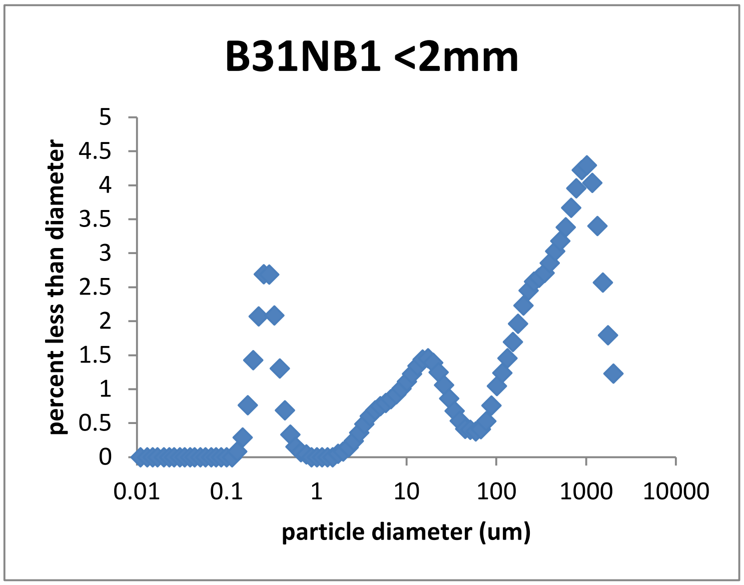
Particle Size Analysis/Combination ASTM D422-63 (2mm sieve separation) and HORIBA Laser-Scatter Particle Size Analyzer

Lab ID	Client ID	% clay	% silt	% sand	% gravel
1508009-18	B31N29	3.9	4.2	30	60
1508009-37	B31N85	8.9	8.6	54	26
1508009-40	B31N96	5.1	6.6	26	60
1508009-42	B31NB1	5.7	6.3	21	66






B31N96 <2mm
percent less than diameter
0
1
2
3
4
5
6
7
8
0.01
0.1
1
10
100
1000
10000
particle diameter (um)


B31NB1 <2mm
percent less than diameter
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0.01
0.1
1
10
100
1000
10000
particle diameter (um)

Wet Chemistry - Quality Control
Environmental Science Laboratory

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 5I22001 - 1:1 Water Extract (pH_EC_Alk)										
Blank (5I22001-BLK1)				Prepared & Analyzed: 09/22/15						
pH	5.73E0	N/A	pH Units							
Duplicate (5I22001-DUP1)		**Source: 1508009-45**		Prepared & Analyzed: 09/22/15						
pH	7.74E0	N/A	pH Units		8.10E0			4.55	35	

Total Metals by PNNL-AGG-ICP-AES/Special Extract - Quality Control
Environmental Science Laboratory

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 5J15012 - Special Extract (ICP/ICPMS)										
Blank (5J15012-BLK1)				Prepared & Analyzed: 10/15/15						
Aluminum	<1.56E-1	1.56E-1	ug/g wet							
Calcium	<7.54E-1	7.54E-1	"							
Iron	<1.75E-1	1.75E-1	"							
Manganese	<1.04E-1	1.04E-1	"							
LCS (5J15012-BS1)				Prepared & Analyzed: 10/15/15						
Aluminum	8.05E0	1.56E-1	ug/g wet	7.50E0		107	80-120			
Calcium	7.84E0	7.54E-1	"	7.50E0		105	80-120			
Iron	7.08E0	1.75E-1	"	7.50E0		94.4	80-120			
Manganese	7.72E0	1.04E-1	"	7.50E0		103	80-120			
Duplicate (5J15012-DUP1)	**Source: 1508009-46**			Prepared & Analyzed: 10/15/15						
Aluminum	<1.27E0	1.27E0	ug/g dry		2.28E0				35	
Calcium	4.10E1	6.14E0	"		2.95E1			32.5	35	
Iron	<1.42E0	1.42E0	"		6.43E1				35	
Manganese	<8.48E-1	8.48E-1	"		ND				35	
Post Spike (5J15012-PS1)	**Source: 1508009-48**			Prepared & Analyzed: 10/15/15						
Aluminum	5.23E2	N/A	ug/L	5.00E2	4.62E1	95.3	75-125			
Calcium	1.09E3	N/A	"	5.00E2	5.53E2	108	75-125			
Iron	4.92E2	N/A	"	5.00E2	ND	100	75-125			
Manganese	2.59E2	N/A	"	2.50E2	7.73E-1	103	75-125			

Radionuclides by ICP-MS/Special Extraction - Quality Control
Environmental Science Laboratory

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 5J14001 - Special Extract (ICP/ICPMS)										
Blank (5J14001-BLK1)				Prepared: 09/29/15		Analyzed: 10/15/15				
Uranium 238	<7.10E-3	7.10E-3	ug/g wet							
LCS (5J14001-BS1)				Prepared: 09/29/15		Analyzed: 10/15/15				
Uranium 238	<7.10E-3	7.10E-3	ug/g wet				80-120			
Duplicate (5J14001-DUP1)		**Source: 1508009-46**		Prepared: 09/29/15		Analyzed: 10/15/15				
Uranium 238	4.17E0	1.45E-2	ug/g dry		3.86E0			7.71	35	
Post Spike (5J14001-PS1)		**Source: 1508009-46**		Prepared: 10/14/15		Analyzed: 10/15/15				
Uranium 238	2.91E0	N/A	ug/L	1.00E0	1.91E0	100	75-125			

Sequential Extractions-Quality Control

Duplicates

LabNumber	SampleName	Analyte	final results ug/g	RPD (%)	RPD Limit	EQL ug/g	Analyzed
1510007-12	B31N85 DUP strong acetic acid	Aluminum	1.47E+01	5%	35	3.82	11/10/2015
1510007-19	B31N85 DUP oxalate	Aluminum	6.43E+02	4%	35	4.26	11/10/2015
1510007-26	B31N85 DUP nitric acid	Aluminum	8.16E+03	2%	35	32.2	11/10/2015
1510007-05	B31N85 DUP weak acetic acid	Calcium	1.57E+03	2%	35	6.82	11/10/2015
1510007-12	B31N85 DUP strong acetic acid	Calcium	2.02E+02	14%	35	7.78	11/10/2015
1510007-19	B31N85 DUP oxalate	Calcium	ND	ND	35	8.68	11/10/2015
1510007-26	B31N85 DUP nitric acid	Calcium	5.35E+03	0%	35	6.56	11/10/2015
1510007-05	B31N85 DUP weak acetic acid	Iron	6.74E+00	9%	35	2.03	11/10/2015
1510007-12	B31N85 DUP strong acetic acid	Iron	ND	ND	35	2.31	11/10/2015
1510007-19	B31N85 DUP oxalate	Iron	2.51E+03	1%	35	2.58	11/10/2015
1510007-26	B31N85 DUP nitric acid	Iron	2.34E+04	1%	35	19.5	11/10/2015
1510007-05	B31N85 DUP weak acetic acid	Manganese	7.06E+00	2%	35	0.485	11/10/2015
1510007-12	B31N85 DUP strong acetic acid	Manganese	2.38E+01	15%	35	0.553	11/10/2015
1510007-19	B31N85 DUP oxalate	Manganese	6.92E+01	11%	35	0.618	11/10/2015
1510007-26	B31N85 DUP nitric acid	Manganese	2.91E+02	2%	35	0.467	11/10/2015
1510007-05	B31N85 DUP weak acetic acid	Uranium 238	4.10E+00	10%	35	0.0144	10/15/2015
1510007-12	B31N85 DUP strong acetic acid	Uranium 238	2.52E+00	8%	35	0.0164	10/15/2015
1510007-19	B31N85 DUP oxalate	Uranium 238	3.75E+00	5%	35	0.0183	10/15/2015
1510007-26	B31N85 DUP nitric acid	Uranium 238	2.56E+00	2%	35	0.0139	10/15/2015

Blank Spikes

LabNumber	SampleName	Analyte	Result ug/L	EQL ug/L	% recovery	% REC Limits
1510007-14	Blank Spike strong acetic acid	Aluminum	4.32E+03	329	86	80-120
1510007-21	Blank Spike oxalate	Aluminum	5.41E+03	1650	108	80-120
1510007-28	Blank Spike nitric acid	Aluminum	5.79E+03	329	87	80-120
						80-120
1510007-07	Blank Spike weak acetic acid	Calcium	5.42E+03	672	108	80-120
1510007-14	Blank Spike strong acetic acid	Calcium	5.43E+03	672	109	80-120
1510007-21	Blank Spike oxalate	Calcium	4.14E+03	672	83	80-120
1510007-28	Blank Spike nitric acid	Calcium	7.39E+03	672	112	80-120
						80-120
1510007-07	Blank Spike weak acetic acid	Iron	4.42E+03	200	88	80-120
1510007-14	Blank Spike strong acetic acid	Iron	5.10E+03	200	102	80-120
1510007-21	Blank Spike oxalate	Iron	4.75E+03	200	95	80-120
1510007-28	Blank Spike nitric acid	Iron	6.64E+03	200	100	80-120
						80-120
1510007-07	Blank Spike weak acetic acid	Manganese	4.73E+03	47.9	95	80-120
1510007-14	Blank Spike strong acetic acid	Manganese	5.26E+03	47.9	105	80-120
1510007-21	Blank Spike oxalate	Manganese	4.87E+03	47.9	97	80-120
1510007-28	Blank Spike nitric acid	Manganese	6.48E+03	47.9	98	80-120

Preparation Blanks

LabNumber	SampleName	Analyte	Result ug/L	EQL ug/L	Analyzed
1510007-13	Prep blank strong acetic acid	Aluminum	ND	329	11/10/2015
1510007-20	Prep blank oxalate	Aluminum	ND	329	11/10/2015
1510007-27	Prep blank nitric acid	Aluminum	ND	329	11/10/2015
1510007-06	Prep blank weak acetic acid	Calcium	1.07E+03	672	11/10/2015
1510007-13	Prep blank strong acetic acid	Calcium	ND	672	11/10/2015
1510007-20	Prep blank oxalate	Calcium	ND	672	11/10/2015
1510007-27	Prep blank nitric acid	Calcium	9.18E+02	672	11/10/2015
1510007-06	Prep blank weak acetic acid	Iron	ND	200	11/10/2015
1510007-13	Prep blank strong acetic acid	Iron	ND	200	11/10/2015
1510007-20	Prep blank oxalate	Iron	ND	200	11/10/2015
1510007-27	Prep blank nitric acid	Iron	5.64E+02	200	11/10/2015
1510007-06	Prep blank weak acetic acid	Manganese	ND	47.9	11/10/2015
1510007-13	Prep blank strong acetic acid	Manganese	ND	47.9	11/10/2015
1510007-20	Prep blank oxalate	Manganese	ND	47.9	11/10/2015
1510007-27	Prep blank nitric acid	Manganese	ND	47.9	11/10/2015
1510007-06	Prep blank weak acetic acid	Uranium 238	ND	672	10/15/2015
1510007-13	Prep blank strong acetic acid	Uranium 238	ND	672	10/15/2015
1510007-20	Prep blank oxalate	Uranium 238	ND	672	10/15/2015
1510007-27	Prep blank nitric acid	Uranium 238	ND	672	10/15/2015

Pacific Northwest National Laboratory

BOREHOLE SAMPLE LOG

Boring/Well No C8940 **Depth** 28.5-29.0 **Date** 8/19/2015

Location 300 Area **Project** 300-FF-5

Sheet 1 **of** 1

Logged by George V. Last (Print) George V. Last (Sign)

Reviewed by (Print) (Sign) **Date**

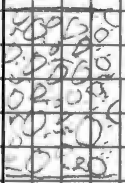
Lithologic Class. Scheme Folk/Wentworth **Procedure** PNNL-ESL-Geology **Rev** 1

Drilling Contractor

Driller

Drill Method

DEPTH (FT)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	GRAPHIC LOG Z	GRAPHIC LOG S	GRAPHIC LOG G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
28.5	G	B31N29	W					Silty Sandy Gravel. 75% Gravel, up to 2 cm, broken. 15% Sand, mostly very	Grab sample. ~1/2 liter.
								coarse to medium, 10% silt + clay. Some mud clasts, up to 1 cm.	
								Gravel is rounded to subround, where unbroken, ~80% basalt but coated	
								with mud. Sand is mostly basaltic. No reaction to HCl. Loose.	
								Color (wet) is 2.5Y 4/1. Color of mud clasts is 2.5Y 5/3 (wet).	
29.0									



C = Core, G = Grab

D = Dry, M = Moist, W = Wet

2015/GVL/GeosciencesGroup/Procedures/SampleLog/001 (02/06)

Pacific Northwest National Laboratory	BOREHOLE SAMPLE LOG	Boring/Well No C9451	Depth 21.0 - 29.0	Date 8/19/2015	Sheet 1 of 1
		Location 300 Area	Project 300-FF-5		

Logged by George V. Last (Print) George V. Last (Sign)

Reviewed by ______ (Print) ______ (Sign) Date ______

Lithologic Class. Scheme Folk/Wentworth

Procedure PNNL-ESL-Geology Rev 1

Drilling Contractor ______

Driller ______

Drill Method ______

DEPTH (FT)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
21.0	G	B31N85	W		Gravelly, Silty, Sand. 20% Gravel, 70% Sand, 10% Mud. Gravel upto 2 cm	Grab sample ~ 1/2
		21.0-21.5'			(broken). Sand is mostly very coarse to medium. Sand is 60% basaltic.	liter.
					Gravell is 90% basaltic, subround where unbroken. Color is 2.5Y4/1 to	
					4/2, wet. Gravel & sand coated with mud, some with a thicker (1-2 mm) mud.	
					No reaction to HCl	
21.5						
26.5	G	B31N96	W		Silty Sandy Gravel. 80% Gravel, 10% sand, 10% Mud. Gravel is upto 3cm,	Grab sample ~ 1/2
		26.5-27'			rounded to subround, 80% basaltic. Sand is mostly very coarse to medium,	liter.
					60% basaltic. Some mud balls (mud & sand) an artifact of drilling? Color is	
					2.5Y 4/1 (wet). Clasts are coated with mud. No reaction to HCl.	
27.0						
28.5	G	B31NB1	W		Silty, Sandy, Gravel. 75% Gravel. 15% Sand, 10% Mud. Gravel upto 3cm,	Grab sample ~ 1/2
		28.5-29'			mostly fine to very fine pebble, subrounded where unbroken, 70% basalt.	liter.
					Sand is mostly mostly very coarse to medium, 60% basalt. Color is	
					2.5Y4/1(wet). Clasts are coated with mud. No reaction to HCl.	
29.0						

C = Core, G = Grab

D = Dry, M = Moist, W = Wet

2015/GVL/GeosciencesGroup/Procedures/SampleLog/001 (01/06)

Pacific Northwest National Laboratory	**BOREHOLE SAMPLE LOG**	**Boring/Well No** C8940 **Depth** 28.5-29.0 **Date** 8/19/2015 **Location** 300 Area **Project** 300-FF-5	**Sheet** 1 **of** 1

Logged by George V. Last (Print) George V. Last (Sign)

Reviewed by ______ (Print) ______ (Sign) **Date** ______

Lithologic Class. Scheme Folk/Wentworth **Procedure** PNNL-ESL-Geology **Rev** 1

Drilling Contractor ______

Driller ______

Drill Method ______

DEPTH (FT)	SAMPLES TYPE	SAMPLES HEIS ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
28.5	G	B31N29	W					Silty Sandy Gravel. 75% Gravel, up to 2cm, broken. 15% Sand, mostly very coarse to medium, 10% silt + clay. Some mud clasts, up to 1cm. Gravel is rounded to subround, where unbroken, ~80% basalt but coated with mud. Sand is mostly basaltic. No reaction to HCl. Loose. Color (wet) is 2.5Y 4/1. Color of mud clasts is 2.5Y 5/3 (wet).	Grab sample. ~1/2 liter.
29.0									

C = Core, G = Grab

D = Dry, M = Moist, W = Wet

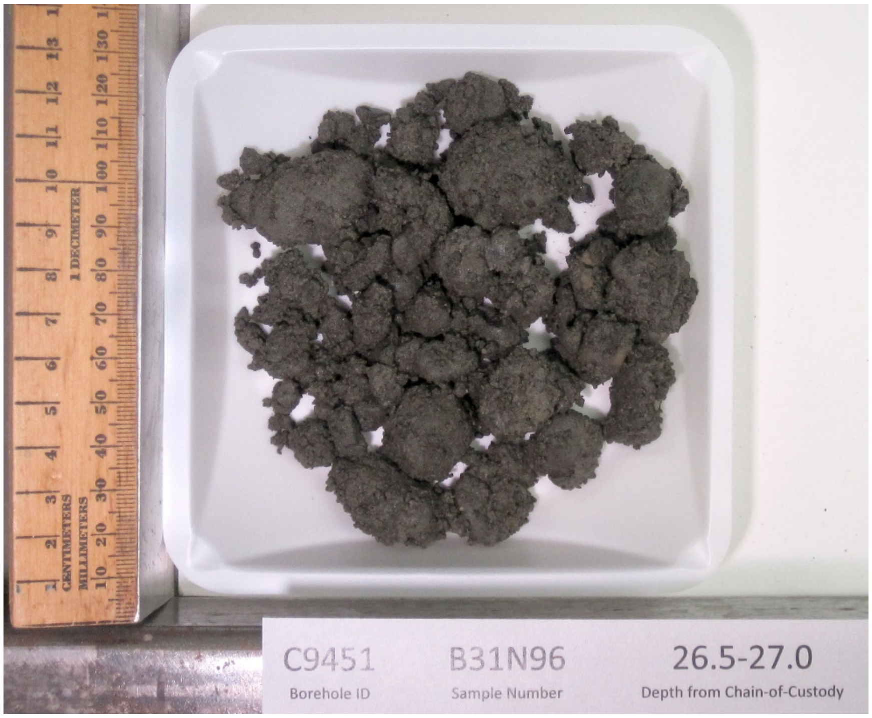
Photographs of C8940 and C9451 sediments

C8940 B31N29 28.5-29.0

Borehole ID Sample Number Depth from Chain-of-Custody

C9451 B31N85 21.0-21.5

Borehole ID Sample Number Depth from Chain-of-Custody



C9451
Borehole ID
B31N96
Sample Number
26.5-27.0
Depth from Chain-of-Custody

C9451
Borehole ID
B31NB1
Sample Number
28.5-29.0
Depth from Chain-of-Custody

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-190**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I[illegible]	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 10.00' - 10.5'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** CA 7-13-15 ~~HNF-N-507-33/2~~	N/A	**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. **SPECIAL HANDLING AND/OR STORAGE** N/A	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
		SAMPLE ANALYSIS	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31MY0	SOIL	7-13-15	0805	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** U. Snyder/ M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 7/8/2015 **FSR ID = FSR230** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-191	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, L001C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 10.50' - 11.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX*	POSSIBLE SAMPLE HAZARDS/ REMARKS		
A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31MY1	SOIL	7-13-15	0805	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES		SPECIAL INSTRUCTIONS
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 13 2015 1415	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 13 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 16 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 16 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 16 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M Snyder	**DATE/TIME** JUL 16 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 7/8/2015 **FSR ID = FSR231** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-192**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C8940, I-001B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 11.00' - 11.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31MY2	SOIL	7-13-15	0805	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES		SPECIAL INSTRUCTIONS
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 13 2015 1415	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JUL 13 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 16 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 16 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 16 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M.Snyder	**DATE/TIME** JUL 16 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 7/8/2015 **FSR ID = FSR232** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-194**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐
SAMPLING LOCATION C8940, I-001A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**DATA TURNAROUND** 30 Days / 30 Days
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33	**ACTUAL SAMPLE DEPTH** 11.50' - 12.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31MY4	SOIL	7-13-15	0805	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES		SPECIAL INSTRUCTIONS
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 7/8/2015 **FSR ID = FSR233** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-196**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-002C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 13.00' - 13.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31MY6	SOIL	7-13-15	0830	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 13 2015 1415	**RECEIVED BY/STORED IN** SSu #1	**DATE/TIME** JUL 13 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 16 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 16 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 16 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JUL 16 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR235** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-197**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-002B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-S07-33/2	**ACTUAL SAMPLE DEPTH** 13.50-14.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31MY7	SOIL	7-13-15	0830	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 1 3 2015 1415
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 0745
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder/M. Snyder	**DATE/TIME** JUL 1 6 2015 09-30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

TRVL-15-097

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR236** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-200**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-002A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 14.00' - 14.80'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*.	SAMPLE DATE	SAMPLE TIME	
B31N00	SOIL	7-13-15	0830	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES		SPECIAL INSTRUCTIONS
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BE Briggs	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BE Briggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder/ M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR238** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**	**F15-014-203**	**PAGE** 1 **OF** 1

COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C8940, I-003B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 16.00' - 16.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N03	SOIL	7-13-15	0908	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR241** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		F15-014-205	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-003A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 16.50' - 17.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N05	SOIL	7-13-15	0908	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES		SPECIAL INSTRUCTIONS
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	DATE/TIME JUL 13 2015 1415	RECEIVED BY/STORED IN SSU #1	DATE/TIME JUL 13 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	DATE/TIME JUL 16 2015 0745	RECEIVED BY/STORED IN B.E. Briggs CHPRC BeBriggs	DATE/TIME JUL 16 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	DATE/TIME JUL 16 2015 09:30	RECEIVED BY/STORED IN U. Snyder / M. Snyder	DATE/TIME JUL 16 2015 09:30	
RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME	
RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME	
RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME	
RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME	

LABORATORY SECTION	RECEIVED BY	TITLE	DATE/TIME
FINAL SAMPLE DISPOSITION	DISPOSAL METHOD	DISPOSED BY	DATE/TIME

PRINTED ON 5/26/2015 **FSR ID = FSR242** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-213**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-005B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 21.50'-22.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N13	SOIL	7-13-15	0955	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 13 2015 1415	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JUL 13 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 16 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BEBriggs	**DATE/TIME** JUL 16 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BEBriggs	**DATE/TIME** JUL 16 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M Snyder	**DATE/TIME** JUL 16 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR249** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-219**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-006B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 24.00'-24.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N19	SOIL	7-13-15	1030	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSu #1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR254** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-222**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-007D	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 25.00'-25.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. **SPECIAL HANDLING AND/OR STORAGE** N/A	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
		SAMPLE ANALYSIS	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N22	SOIL	7-13-15	1108	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSu #1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR256** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**	**F15-014-223**	**PAGE** 1 **OF** 1

COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-007C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 25.50'-26.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N23	SOIL	7-13-15	1108	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JUL 1 3 2015 1415	SSu #1	JUL 1 3 2015 1415
SSU-1	JUL 1 6 2015 0745	B.E. Briggs CHPRC BeBriggs	JUL 1 6 2015 0745
B.E. Briggs CHPRC BeBriggs	JUL 1 6 2015 09:30	U.Snyder / M.Snyder	JUL 1 6 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-097

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR257** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-224**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-007B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 26.00' - 26.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N24	SOIL	7-13-15	1108	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC / BeBriggs	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC / BeBriggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR258** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**	**F15-014-226**	**PAGE** 1 **OF** 1

COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-007A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 26.50' - 27.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N26	SOIL	7-13-15	1108	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES		SPECIAL INSTRUCTIONS
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSu #1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder/M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR259** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-227**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-008D	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 27.80'-28.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N27	SOIL	7-13-15	1225	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	TRVL-15-097
J.R. Aguilar/CHPRC	JUL 1 3 2015 1415	SSU #1	JUL 1 3 2015 1415	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
SSU-1	JUL 1 6 2015 0745	B.E. Briggs CHPRC B.E. Briggs	JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
B.E. Briggs CHPRC B Briggs	JUL 1 6 2015 09:30	M. Snyder / M. Snyder	JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR260** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**	**F15-014-228**	**PAGE 1 OF 1**

COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, L008C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 28.00' - 28.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N28	SOIL	7-13-15	1225	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 13 2015 1415	SSu#1	JUL 13 2015 1415
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
SSU-1	JUL 16 2015 0745	B.E. Briggs CHPRC BeBriggs	JUL 16 2015 0745
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
B.E. Briggs CHPRC BeBriggs	JUL 16 2015 09:30	M. Snyder / M. Snyder	JUL 16 2015 09:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

TRVL-15-097

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR261** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-229**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-008B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33 / 2	**ACTUAL SAMPLE DEPTH** 28.50'-29.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N29	SOIL	7-13-15	1225	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSu#1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC BeBriggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder/M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR262** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-231**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-008A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33	**ACTUAL SAMPLE DEPTH** 29.00'-29.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N31	SOIL	7-13-15	1225	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 1 3 2015 1415	SSU #1	JUL 1 3 2015 1415
SSU-1	JUL 1 6 2015 0745	B.E. Briggs CHPRC BeBriggs	JUL 1 6 2015 0745
B.E. Briggs CHPRC BeBriggs	JUL 1 6 2015 09:30	M. Snyder / M. Snyder	JUL 1 6 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-097

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR263** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-233**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-009C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 30.50'- 31.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N33	SOIL	7-13-15	1255	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 3 2015 1415	**RECEIVED BY/STORED IN** SSu #1	**DATE/TIME** JUL 1 3 2015 1415	TRVL-15-097
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** B.E. Briggs CHPRC B.E. Briggs	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM B.E. Briggs CHPRC B.E. Briggs	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR265** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-234**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C8940, I-009B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/2	**ACTUAL SAMPLE DEPTH** 31.00' - 31.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N34	SOIL	7-13-15	1255	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 1 3 2015 1415	SSu#1	JUL 1 3 2015 1415
SSU-1	JUL 1 6 2015 0745	B.E. Briggs CHPRC BeBriggs	JUL 1 6 2015 0745
B.E. Briggs CHPRC BeBriggs	JUL 1 6 2015 09:30	M. Snyder/M Snyder	JUL 1 6 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-097

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR266** **TRVL NUM = TRVL-15-097** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-258**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-001D	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 10.00' - 10.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N62	SOIL	7-14-15	0835	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 14 2015 1430	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 14 2015 1430	TRVL-15-098
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 16 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 16 2015 0745	
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 16 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder/M. Snyder	**DATE/TIME** JUL 16 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR300** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-259**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-001C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33 / 3	**ACTUAL SAMPLE DEPTH** 10.50' - 11.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.

SPECIAL HANDLING AND/OR STORAGE
N/A

PRESERVATION	None
HOLDING TIME	6 Months
TYPE OF CONTAINER	Split Spoon Liner
NO. OF CONTAINER(S)	1
VOLUME	1000g
SAMPLE ANALYSIS	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N63	SOIL	7-14-15	0835	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 1 4 2015 1430	SSu #1	JUL 1 4 2015 1430
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
SSU-1	JUL 1 6 2015 0745	K.C. Patterson/CHPRC	JUL 1 6 2015 0745
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
K.C. Patterson/CHPRC	JUL 1 6 2015 0930	M. Snyder / M. Snyder	JUL 1 6 2015 09:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR301** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-260**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-001B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 11.00' - 11.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.

SPECIAL HANDLING AND/OR STORAGE
N/A

PRESERVATION	None
HOLDING TIME	6 Months
TYPE OF CONTAINER	G/P
NO. OF CONTAINER(S)	1
VOLUME	1L
SAMPLE ANALYSIS	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N64	SOIL	7-14-15	0835	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 14 2015 1430	SSU#1	JUL 14 2015 1430
SSU-1	JUL 16 2015 0745	K.C. Patterson/CHPRC	JUL 16 2015 0745
K.C. Patterson/CHPRC	JUL 16 2015 09:30	M. Snyder / M. Snyder	JUL 16 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015

FSR ID = FSR302

TRVL NUM = TRVL-15-098

A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-262**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-001A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 11.50' - 12.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.

SPECIAL HANDLING AND/OR STORAGE
N/A

PRESERVATION	None
HOLDING TIME	6 Months
TYPE OF CONTAINER	Split Spoon Liner
NO. OF CONTAINER(S)	1
VOLUME	1000g
SAMPLE ANALYSIS	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N66	SOIL	7-14-15	0835	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	TRVL-15-098
J.R. Aguilar/CHPRC	JUL 1 4 2015 1430	SSU #1	JUL 1 4 2015 1430	
SSU-1	JUL 1 6 2015 0745	K.C. Patterson/CHPRC	JUL 1 6 2015 0745	
K.C. Patterson/CHPRC	JUL 1 6 2015 09:30	M. Snyder M. Snyder	JUL 1 6 2015 09:36	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR303** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**	**F15-014-265**	**PAGE 1 OF 1**

COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-002B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 13.4' - 13.9'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.

SPECIAL HANDLING AND/OR STORAGE
N/A

PRESERVATION	None
HOLDING TIME	6 Months
TYPE OF CONTAINER	~~Split Spoon Liner~~ 1lP CA 7-14-15
NO. OF CONTAINER(S)	1
VOLUME	~~1000g~~ 1l CA 7-14-15
SAMPLE ANALYSIS	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N69	SOIL	7-14-15	0915	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 14 2015 1430	SSU#1	JUL 14 2015 1430
SSU-1	JUL 16 2015 0745	K.C. Patterson/CHPRC	JUL 16 2015 0745
K.C. Patterson/CHPRC	JUL 16 2015 09:30	M. Snyder M. Snyder	JUL 16 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR306** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-267**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-002A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33	**ACTUAL SAMPLE DEPTH** 13.9' - 14.4'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N71	SOIL	7-14-15	0915	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 4 2015 1430	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 1 4 2015 1430	TRVL-15-098
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M-Snyder / M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR307** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-268**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-003D	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** ~~15.5~~ 15.00'-15.5' CD 7-14-15	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N72	SOIL	7-14-15	0945	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JUL 1 4 2015 1430	SSU#1	JUL 1 4 2015 1430
SSU-1	JUL 1 6 2015 0745	K.C. Patterson/CHPRC	JUL 1 6 2015 0745
K.C. Patterson/CHPRC	JUL 1 6 2015 09:30	M Snyder / M. Snyder	JUL 1 6 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	RECEIVED BY	TITLE	DATE/TIME
FINAL SAMPLE DISPOSITION	DISPOSAL METHOD	DISPOSED BY	DATE/TIME

PRINTED ON 5/26/2015 **FSR ID = FSR308** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-269**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-003C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 15.5' - 16'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N73	SOIL	7-14-15	0945	L

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	TRVL-15-098
J.R. Aguilar/CHPRC	JUL 1 4 2015 1430	SSU #1	JUL 1 4 2015 1430	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
SSU-1	JUL 1 6 2015 0745	K.C. Patterson/CHPRC	JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
K.C. Patterson/CHPRC	JUL 1 6 2015 09:30	M. Snyder/M. Snyder	JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR309** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-270**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-003B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 16' - 16.5'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N74	SOIL	7-14-15	0945	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 1 4 2015 1430	SSU #1	JUL 1 4 2015 1430
SSU-1	JUL 1 6 2015 0745	K.C. Patterson/CHPRC	JUL 1 6 2015 0745
K.C. Patterson/CHPRC	JUL 1 6 2015 09:30	M. Snyder / M. Snyder	JUL 1 6 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR310** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-273**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-003A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 16.5'-17'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N77	SOIL	7-14-15	0945	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 14 2015 1430	SSu #1	JUL 14 2015 1430
SSU-1	JUL 16 2015 0745	K.C. Patterson/CHPRC	JUL 16 2015 0745
K.C. Patterson/CHPRC	JUL 16 2015 07:30	U. Snyder / M Snyder	JUL 16 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR312** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-274**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-004D	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 17.5' - 18'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N78	SOIL	7-14-15	1040	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 4 2015 1430	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JUL 1 4 2015 1430	TRVL-15-098
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR313** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			F15-014-275	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-004C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 18.0' - 18.5'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.

SPECIAL HANDLING AND/OR STORAGE
N/A

PRESERVATION	None
HOLDING TIME	6 Months
TYPE OF CONTAINER	Split Spoon Liner
NO. OF CONTAINER(S)	1
VOLUME	1000g
SAMPLE ANALYSIS	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31N79	SOIL	7-14-15	1040	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JUL 14 2015 1430	SSU #1	JUL 14 2015 1430
SSU-1	JUL 16 2015 0745	K.C. Patterson/CHPRC	JUL 16 2015 0745
K.C. Patterson/CHPRC	JUL 16 2015 09:30	M. Snyder / M Snyder	JUL 16 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	RECEIVED BY	TITLE	DATE/TIME
FINAL SAMPLE DISPOSITION	DISPOSAL METHOD	DISPOSED BY	DATE/TIME

PRINTED ON 5/26/2015 **FSR ID = FSR314** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-276**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-004B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 18.5'-19'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N80	SOIL	7-14-15	1040	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 4 2015 1430	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 1 4 2015 1430	TRVL-15-098
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 0930	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR315** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-278**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-004A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 19.00'-19.5'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N82	SOIL	7-14-15	1040	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 4 2015 1430	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 1 4 2015 1430	TRVL-15-098
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder/M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR316** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-280**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-005C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 20.5'-21'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N84	SOIL	7-14-15	1105	✓

CHAIN OF POSSESSION **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JUL 1 4 2015 1430	SSU #1	JUL 1 4 2015 1430
SSU-1	JUL 1 6 2015 0745	K.C. Patterson/CHPRC	JUL 1 6 2015 0745
K.C. Patterson/CHPRC	JUL 1 6 2015 09:30	M Snyder / M. Snyder	JUL 1 6 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	RECEIVED BY	TITLE	DATE/TIME
FINAL SAMPLE DISPOSITION	DISPOSAL METHOD	DISPOSED BY	DATE/TIME

PRINTED ON 5/26/2015 **FSR ID = FSR318** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-281**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-005B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 21.0'- 21.5'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	~~Split Spoon Liner~~ 1L P 7-14-15
		NO. OF CONTAINER(S)	1
		VOLUME	~~1000g~~ 7/14/15 1 L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N85	SOIL	7-14-15	1105	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 4 2015 1430	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 1 4 2015 1430	TRVL-15-098
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR319** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-283**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-005A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 21.5' - 22'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N87	SOIL	7-14-15	1105	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 14 2015 1430	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JUL 14 2015 1430
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 16 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 16 2015 0745
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 16 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder/M. Snyder	**DATE/TIME** JUL 16 2015 09:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR320** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**	**F15-014-286**	**PAGE 1 OF 1**

COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-006B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 24' - 24.5'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N90	SOIL	7-14-15	1215	✓

Used Liner A For I-006B Sample
Depths were Liner A

CA
7-14-15

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 1 4 2015 1430	SSU#1	JUL 1 4 2015 1430
SSU-1	JUL 1 6 2015 0745	K.C. Patterson/CHPRC	JUL 1 6 2015 0745
K.C. Patterson/CHPRC	JUL 1 6 2015 09:30	M. Snyder / M Snyder	JUL 1 6 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR323** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-292**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-007B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 26.5'-27'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31N96	SOIL	7-14-15	1230	✓

Used Liner A for I-007B Sample

Depths were for Liner A

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 1 4 2015 1430	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JUL 1 4 2015 1430	TRVL-15-098
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 1 6 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 0745	
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 1 6 2015 09:30	**RECEIVED BY/STORED IN** U. Snyder / M. Snyder	**DATE/TIME** JUL 1 6 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR328** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-296**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-008C	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 28' - 28.5'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO **Environmental Sciences Laboratory**	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B31NB0	SOIL	7-14-15	1255	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 14 2015 1430	**RECEIVED BY/STORED IN** SSU-1	**DATE/TIME** JUL 14 2015 1430	TRVL-15-098
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 16 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 16 2015 0745	
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 16 2015 09:30	**RECEIVED BY/STORED IN** M. Snyder M. Snyder	**DATE/TIME** JUL 16 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR331** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-297**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-008B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 28.5' - 29'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31NB1	SOIL	7-14-15	1255	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 1 4 2015 1430	SSU-1	JUL 1 4 2015 1430
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
SSU	JUL 1 6 2015 0745	K.C. Patterson/CHPRC	JUL 1 6 2015 0745
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
K.C. Patterson/CHPRC	JUL 1 6 2015 09:30	M. Snyder / M. Snyder	JUL 1 6 2015 09:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR332** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-299**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-008A	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HNF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 29.0'-29.5'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	▨
B31NB3	SOIL	7-14-15	1255	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**		**SPECIAL INSTRUCTIONS**
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JUL 14 2015 1430	**RECEIVED BY/STORED IN** SSU-1	**DATE/TIME** JUL 14 2015 1430	TRVL-15-098
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JUL 16 2015 0745	**RECEIVED BY/STORED IN** K.C. Patterson/CHPRC	**DATE/TIME** JUL 16 2015 0745	
RELINQUISHED BY/REMOVED FROM K.C. Patterson/CHPRC	**DATE/TIME** JUL 16 2015 09:30	**RECEIVED BY/STORED IN** M Snyder / M. Snyder	**DATE/TIME** JUL 16 2015 09:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR333** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			F15-014-302	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9451, I-009B	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO. N/A	**FIELD LOGBOOK NO.** HWF-N-507-33/3	**ACTUAL SAMPLE DEPTH** 31.5' - 32'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.** N/A		**BILL OF LADING/AIR BILL NO.** N/A		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE N/A	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B31NB6	SOIL	7-14-15	1315	✓

Used Liner A For I-009B Sample

Depths were For Liner A

CA 7-14-15

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JUL 1 4 2015 1430	SSU-1	JUL 1 4 2015 1430
SSU-1	JUL 1 6 2015 0745	R.C. Patterson/CHPRC	JUL 1 6 2015 0745
K.C. Patterson/CHPRC	JUL 1 6 2015 09:30	M. Snyder / M Snyder	JUL 1 6 2015 09:30

SPECIAL INSTRUCTIONS
TRVL-15-098

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 5/26/2015 **FSR ID = FSR336** **TRVL NUM = TRVL-15-098** A-6003-618 (REV 2)

This page intentionally left blank.

PNNL-25420

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** *Since 1965*

Analytical Data Report for Sediment Samples Collected from 300-FF-5: Boreholes C9580, C9581, and C9582

May 2016

GV Last
Z Wang
JR Stephenson
BD Williams
MMV Snyder
O Qafoku
RE Clayton

U.S. DEPARTMENT OF
ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

DISCLAIMER

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service
5301 Shawnee Rd., Alexandria, VA 22312
ph: (800) 553-NTIS (6847)
email: orders@ntis.gov <http://www.ntis.gov/about/form.aspx>
Online ordering: http://www.ntis.gov

PNNL-25420

Analytical Data Report for Sediment Samples Collected from 300-FF-5: Boreholes C9580, C9581, and C9582

GV Last
Z Wang
JR Stephenson
BD Williams
MMV Snyder
O Qafoku
RE Clayton

May 2016

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

CH2M Hill Plateau Remediation Company is conducting remediation using injection and infiltration of a phosphate amendment to sequester uranium in a target source area within the Hanford Site 300-FF-5 Operable Unit. To provide technical input for evaluating this remedy's performance, Pacific Northwest National Laboratory conducted laboratory analysis on samples from three boreholes, C9580, C9581, and C9582, installed within the treatment zone after the phosphate amendment distribution for the initial stage of field treatment was completed. These boreholes are installed adjacent to boreholes that had been installed before the phosphate amendment. Laboratory tests consisted of sequential uranium extraction tests, labile uranium leach tests, flow-through column tests on both intact (field texture) splitspoon liner samples and <2-mm repacked columns, and identification of uranium mineral phase(s) and surface coating(s). By comparing data from these tests with data from pre-treatment samples, one can quantify changes in uranium mobility resulting from the phosphate treatment.

All sampled intervals were visibly very wet and very coarse grained, containing up to 86% gravel. Samples from boreholes C9580 and C9581 contained relatively low concentrations of uranium, while samples from borehole C9582 contained much higher uranium concentrations. In all but two sample intervals (C9580 I-001 and C9582 I-004), more than 50% of the uranium mass was extracted by the weakest two (acetic acid) solutions. Most of the phosphate (about 90%) was associated with the harshest extraction solutions (oxalate and nitric acid combined). Thus, for most samples, less than 50% of the uranium was associated with extractions where phosphate was also removed from the sediment.

Labile uranium concentrations continued to increase in all samples, even after 66 days, indicating that equilibrium was not reached in these experiments. These results suggest that non-equilibrium, kinetically controlled leaching will occur under field conditions. The flow-through column test results, for the medium-to-high concentration sample intervals tested, show initial high-concentration leaching that declines over time, and the uranium concentration increases during stop flow events. These data suggest that some of the uranium in these samples is still susceptible to rapid leaching and that kinetic leaching of uranium will also occur during the initial high concentration pulse and as it subsides. Results for sample intervals with lower uranium concentrations did not show an initial high concentration leaching response followed by a decrease in uranium concentrations over time. Instead, results suggest that the uranium in these samples is primarily released through kinetically controlled mechanisms.

Mineral phase and surface coating analyses suggest that all samples except those from the upper portion of borehole C9580 (i.e., sample intervals I-001 and I-003) were likely to have U(VI) absorbed on quartz, uranyl-tricarbonate(s) adsorbed on calcium carbonate minerals, and U(VI)-phosphate adsorbed on montmorillonite. In all samples interrogated by fluorescence spectroscopy, there has been no detection of the characteristic features of crystalline uranyl-phosphate solid phases, which usually occur as discrete "hot" spots in the sediments.

Scanning electron microscopy and energy-dispersive X-ray analysis and electron microprobe analyses found uranium in association with particles from only two samples: those from the upper portion (I-001 and I-003) of borehole C9580. Those same particles also appeared to be composed of Ca, P, and Fe. The analyses also found uranium to be homogeneously distributed throughout these particles, suggesting a uranium-surface coating or the presence of uranium as a sorbed species.

The results herein provide data to quantify the uranium mobility in selected samples collected after the Stage A phosphate treatment in the field for the 300-FF-5 Operable Unit. The experimental methods used for this effort were the same as those applied previously to samples collected in adjacent boreholes prior to the phosphate treatment. Therefore, these results are suitable for comparison to results from pre-treatment laboratory tests for evaluating the effect of the field phosphate treatment on uranium mobility.

Acknowledgments

Numerous individuals at Pacific Northwest National Laboratory contributed to this work. Ian Leavy, Steven Baum, and Erin McElroy performed the inductively coupled plasma – optical emission spectroscopy, inductively coupled plasma – mass spectroscopy and ion chromatography analyses. Keith Geizler, Amanda Lawter, and Nik Qafoku provided independent technical reviews of the experiments and chemical analyses. Nik Qafoku, Mike Truex, and Jim Szecsody provided oversight guidance and technical review of this report. Matt Wilburn provided editorial and document production support.

Acronyms and Abbreviations

ALS	ALS Environmental
BSE	backscattering electron detector
CAWSRP	*Conducting Analytical Work in Support of Regulatory Programs*
CHPRC	CH2M Hill Plateau Remediation Company
EDS	energy-dispersive spectroscopy
EDX	energy-dispersive X-ray
EPA	U.S. Environmental Protection Agency
ESL	Environmental Sciences Laboratory
HEIS	Hanford Environmental Information System
ICP-MS	inductively coupled plasma – mass spectroscopy
ICP-OES	inductively coupled plasma – optical emission spectroscopy
ID	identification (as in identification number)
IDMS	Integrated Document Management System
OU	operable unit
PNNL	Pacific Northwest National Laboratory
PRZ	periodically rewetted zone
ROD	record of decision
SE	secondary electron
SEM	scanning electron microscope

Contents

Figures

Tables

1.0 Introduction

CH2M Hill Plateau Remediation Company (CHPRC) is conducting remediation using injection and infiltration of a phosphate amendment to sequester uranium in a targeted source area within the Hanford Site 300-FF-5 Operable Unit (OU). To provide technical input for evaluating this remedy's performance, Pacific Northwest National Laboratory (PNNL) conducted laboratory analyses on three boreholes, C9580, C9581, and C9582, installed within the treatment zone after the phosphate amendment distribution was completed. These boreholes were installed adjacent to pre-treatment boreholes/monitoring wells, C9451 (399-1-80), C8940 (399-1-76), and C8936 (399-1-67), respectively, in the area of an initial stage (Stage A) of phosphate treatment aimed at enhancing attenuation of uranium in the vadose zone and periodically rewetted zone, or PRZ (Figure 1.1) (Jacques 2016). Data from these tests, compared to data from pre-treatment samples, provide a means to quantify how uranium mobility was changed by the phosphate treatment.

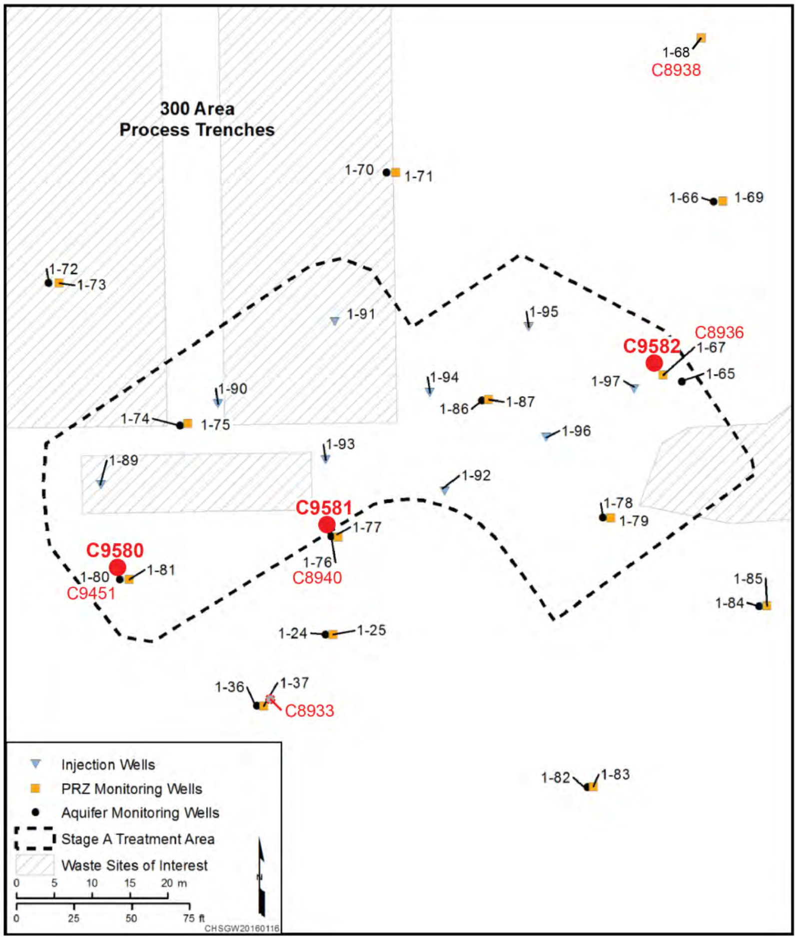


Figure 1.1. Locations of boreholes C9580, C9581, and C9582, modified after Jacques (2016). Note that all well names (e.g., 1-67) are formally preceded by 399-.

The purpose of the laboratory analyses is to support the supplemental post-record of decision (ROD) field investigation of the 300-FF-5 OU by providing data to quantify post-treatment uranium mobility in selected borehole samples. CHPRC will compare these data with similar data from pre-treatment borehole samples and will use these data as input to refine and evaluate the remedial design for enhanced attenuation of uranium using phosphate treatments (Sherwood 2014).

The approach for the leachability tests described herein was to test the post-treatment borehole samples (collected after injection of the phosphate treatment) in the same way as the pre-treatment borehole samples were tested (Snyder and Cantrell 2015; Snyder and Last 2015) to enable useful data comparison. These tests include the following:

- **Sequential Uranium Extraction Tests:** These tests quantify how uranium in sediment samples is distributed among surface phases that require different strengths of extraction solutions to remove the uranium from the sediment. Uranium phases that require stronger solutions have slower leaching characteristics under normal field conditions.
- **Labile Uranium Leach Tests:** These tests evaluate the quantity of uranium that is readily solubilized into the aqueous phase, helping define the most mobile portion of uranium in a sediment sample.
- **Field Texture Flow-Through Column Tests:** These tests provide information about the rate of uranium release into groundwater.
- **<2-mm Size Fraction Flow-Through Column Tests**: These tests provide information about the rate of uranium release into groundwater.
- I**dentification of Uranium Mineral Phase(s) and Surface Coating:** Identification of mineral phases can be used to interpret uranium leaching behavior based on the types of surface phases present.

The amount of phosphate precipitate in the sediments was measured because previous studies (Szecsody et al. 2012) have shown a correlation between the amount of phosphate precipitate and less leachable uranium.

2.0 Background

Past waste disposal in former infiltration ponds and trenches resulted in uranium contamination in the vadose zone and groundwater in the 300 Area. Although near-surface contamination at these sites has been removed by excavation, deep residual uranium is thought to contribute to high uranium concentrations detected in the groundwater in this area (Sherwood 2014). Uranium is identified as a contaminant of concern in the 300 Area ROD/ROD Amendment (EPA and DOE 2013). One of the selected remedies for uranium in soil (300-FF-1 and 300-FF-2 OUs) and groundwater (300-FF-5 OU) is enhanced attenuation of uranium using sequestration (Sherwood 2014).

CHPRC conducted Stage A of a planned two-stage in situ uranium sequestration treatment by applying a phosphate amendment to part of the enhanced attenuation area, on November 6 through December 18, 2015 (Johnson and Thomle 2016). Boreholes C9580, C9581, and C9582 were installed in the Stage A treatment area, located near the south end of the 316-5 process trenches (Figure 1.1), between January 5 and 11, 2016 (roughly 18 to 24 days after application of the phosphate amendment). Samples collected from these boreholes were provided to PNNL for laboratory analyses, including assessment of uranium leaching kinetics.

PNNL previously assessed uranium leaching kinetics on samples from two sets of pre-treatment boreholes (drilled prior to the injection of the phosphate amendments, Figure 1.1). These samples were from

- boreholes C8933, C8936, and C8938 (Snyder and Cantrell 2015) and
- boreholes C8940 and C9451 (Snyder and Last 2015).

3.0 Sample Inspection and Preparation

PNNL received 46 borehole samples, representing 18 sample intervals collected from the three post-treatment boreholes (Table 3.1) (i.e., 6 depth intervals/boreholes) from CHPRC on January 26, 2016. CHPRC selected nine of these sample intervals (corresponding to similar sample intervals from pre-treatment boreholes) for leachability testing (Table 3.1). Individual borehole samples from each sample interval had been collected in four 10.2-cm (4-inch) diameter by 15.2-cm (6-inch) long lexan liners inside a 0.76-m (2.5-ft) long splitspoon sampler (with 15.2-cm [6-inch] long drive shoe) driven with sonic drilling methods (Whitley 2015; draft borehole logs[1]). The liners are typically labeled “A,” “B,” “C,” and “D,” starting at the bottom of each sample interval, with each liner sample assigned a unique Hanford Environmental Information System (HEIS) sample identification (ID) number. The “B” liners had been previously opened and the sample split for total uranium and other analyses conducted by ALS Environmental (ALS), and the analyses to be conducted at PNNL’s Environmental Sciences Laboratory (ESL). Thus, sample materials from the “B” liner were received in 1-liter polyethylene jars. Samples from each identified interval in Table 3.1 were inspected and evaluated for their suitability to produce the quantity of <2-mm materials needed for the various tests, and/or for use in field texture flow-through column tests. Table 3.2 lists the specific samples selected for specific tests from each sample interval.

Table 3.1. List of samples received from CHPRC.

Borehole ID	Sample Interval[(a)]	HEIS Sample Number[(b)]	Beginning Depth (ft)	End Depth (ft)	ESL Lab Number
C9580	I-001	**B347C6**	21.5	22.0	1601046-01
	I-002	B347D2	24.0	24.5	1601046-02
	I-003	**B347D8**	26.5	27.0	1601046-03
	I-004	**B347F1**	29.0	29.5	1601046-04
		B347F3	29.5	30.0	1601046-05
	I-005	B347F6	31.5	32.0	1601046-06
		B347F7	31.0	31.5	1601046-07
		B347F8	30.5	31.0	1601046-08
	I-006	B347H1	34.0	34.5	1601046-09
		B347H2	33.5	34.0	1601046-10
		B347H3	33.0	33.5	1601046-11

---

[1] Email, R Hermman (CHPRC) to GV Last and M Truex (PNNL), January 20, 2016.

Borehole ID	Sample Interval[a]	HEIS Sample Number[b]	Beginning Depth (ft)	End Depth (ft)	ESL Lab Number
C9581	I-001	B347J6	21.5	22.0	1601046-12
		B347J7	21.0	21.5	1601046-13
		B347J8	20.5	21.0	1601046-14
	I-002	B347K2	24.0	24.5	1601046-15
		B347K3	23.5	24.0	1601046-16
		B347K4	23.0	23.5	1601046-17
	I-003	B347K7	26.5	27.0	1601046-18
		B347K8	26.0	26.5	1601046-19
		B347K9	25.5	26.0	1601046-20
		B347L1	25.0	25.5	1601046-21
	I-004	B347L2	29.0	29.5	1601046-22
		B347L3	28.5	29.0	1601046-23B
		B347L4	28.0	28.5	1601046-24
	I-005	B347M0	32.0	32.5	1601046-25
	I-006	B347M3	34.0	34.5	1601046-26
C9582	I-001	B347N8	21.5	22.0	1601046-27
		B347N9	21.0	21.5	1601046-28
		B347P0	20.5	21.0	1601046-29
	I-002	B347P3	24.0	24.5	1601046-30
		B347P4	23.5	24.0	1601046-31
		B347P5	23.0	23.5	1601046-32
		B347P8	22.5	23.0	1601046-33
	I-003	B347P9	26.5	27.0	1601046-34
		B347R0	26.0	26.5	1601046-35
		B347R1	25.5	26.0	1601046-36
		B347R4	25.0	25.5	1601046-37
	I-004	B347R5	29.0	29.5	1601046-38
		B347R6	28.5	29.0	1601046-39
		B347R7	29.5	30.0	1601046-40
	I-005	B347T0	31.5	32.0	1601046-41
		B347T1	31.0	31.5	1601046-42
	I-006	B347T5	34.0	34.5	1601046-43
		B347T6	33.5	34.0	1601046-44
		B347T7	33.0	33.5	1601046-45
		B347T9	32.5	33.0	1601046-46

(a) Yellow shaded sample intervals corresponding to similar sample intervals from pre-treatment boreholes (email, R Herman [CHPRC] to GV Last [PNNL], 1/20/2016).

(b) Bold sample numbers are the specific samples selected for analyses (email, R Hermann [CHPRC] to GV Last [PNNL}, 1/28/2016).

Table 3.2. Sample intervals targeted for selected tests (personal communication, R Hermann, 1/18/2016).

Borehole	Sample Interval	Total Uranium (µg/kg) (HEIS #)[(a)]	Selected <2-mm Batch and Column Tests	Selected Field Texture Column Tests
C9580	I-001	2,600 (B347C7)	Sequential extraction, labile leach, mineral phase *B347C6*[(b)]	
C9580	I-003	3,200 (B347D9)	Sequential extraction, labile leach, mineral phase *B347D8*	
C9580	I-004	7,600 (B347F4)	Sequential extraction, labile leach, mineral phase, and <2-mm column, phosphate extraction *B347F1 and B347F3 (Composited)*	None[(c)]
C9581	I-004	4,300 (B347L5)	Sequential extraction, labile leach, mineral phase *B347L4*	
C9582	I-001	71,000 (B347P1)	Sequential extraction, labile leach, mineral phase *B347P0*	
C9582	I-002	100,000 (B347P6)	Sequential extraction, labile leach, mineral phase, <2-mm column, phosphate extraction *B347P5 and B347P8 (Composited)*	Field texture column *B347P4*
C9582	I-003	32,000 (B347R2)	Sequential extraction, labile leach, mineral phase, <2-mm column, phosphate extraction *B347R1*	Field texture column *B347R0*
C9582	I-004	39,000 (B347R8)	Sequential extraction, labile leach, mineral phase *B347R7*	
C9582	I-006	19,000 (B347T8)	Sequential extraction, labile leach, mineral phase, <2-mm column, phosphate extraction *B347T7*	Field texture column *B347T6*

(a) Total uranium concentration from ALS (email, R Hermann to GV Last and MJ Truex, 1/20/2016; ALS Reports ALS1601118 and ALS1601062_R2).

(b) B347xx are the HEIS sample numbers of specific samples selected for analyses (email, R Hermann [CHPRC] to GV Last [PNNL], 1/28/2016).

(c) Inspection determined that there was insufficient sample material from one of the sample intervals for all tests, so the field texture column test was dropped (telecom, S Mehta [Intera] and GV Last [PNNL], 1/29/2016).

All samples from the selected sample intervals listed in Table 3.2 were opened, photographed, sampled for moisture content, and visually described. These samples were all very wet and dominated by gravel. For the 1-liter jar samples, a portion (>150 g) of the sample was poured into a large weigh boat for photography and geologic description. For splitspoon liner samples, both ends of the core liner were opened and left undisturbed for photography and geologic description. Note that there was some uncertainty in the sample depths, particularly from boreholes C9581 and C9582, at the time of photography and geologic descriptions.

An aliquot of approximately 50 g was taken from each sample (except core liners retained for possible field texture column tests) and placed into a tared moisture tin and weighed, as soon as possible after the sample container was opened. These were dried in an oven and then reweighed to calculate the weight-percent moisture content.

Those samples selected for the <2-mm fraction tests were placed in open trays inside a fume hood to air dry. Where necessary, multiple samples from a given sample interval (e.g., “A” liners adjacent to the jar samples) were composited and homogenized (as appropriate) into a single tray, to yield enough <2-mm material for the selected tests. Once deemed dry enough, each selected sample was passed through a 2-mm sieve to yield two size fractions: >2 mm and <2 mm. For each sample, the total weight and the weights of each size fraction were recorded. A suitable aliquot of the <2-mm size fraction was used for particle size analysis using both dry sieve and laser diffraction methods. The remainder of the <2-mm size fraction was used in the <2-mm tests.

4.0 Test Methodology

Error! Reference source not found. lists the samples tested and the preparations and tests performed on each. Each testing methodology is described in the following sections.

Table 4.1. Tests conducted on each selected sample.

Borehole ID	Sample Interval	HEIS Sample Number	Depth Interval (ft)	Sample Type	Sample Preparation	Selective Sequential Leach	Labile Leach	<2 mm Repack Column	Field Texture Column	Mineral Phase
C9580	I-001	B347C6	21.5-22.0	1L	< 2 mm	X	X			X
	I-003	B347D8	26.5-27.0	1L	< 2 mm	X	X			X
	I-004	B347F1, F347F3 composite	29.0-30.0	SS - D & 1L	< 2 mm	X	X	X		X
C9581	I-004	B347L4	28.0-28.5	1L	< 2 mm	X	X			X
C9582	I-001	B347P0	20.5-21.0	1L	< 2 mm	X	X			X
	I-002	B347P4	23.5-24.0	SS - C	Field texture				X	
		B347P5, B347P8 composite	23.0-23.5	1L	< 2 mm	X	X	X		X
	I-003	B347R0	26.0-26.5	SS - C	Field texture				X	
		B347R1	25.5-26.0	1L	< 2 mm	X	X	X		X
	I-004	B347R7	29.5-30.0	1L	< 2 mm	X	X			X
	I-006	B347T6	33.5-34.0	SS - C	Field texture				X	
		B347T7	33.0-33.5	1L	< 2 mm	X	X	X		X

1L = 1-liter jar sample.
SS = splitspoon sample, C or D are the liner positions.

4.1 Sequential Uranium Extraction Testing

Aliquots of the air-dried, <2-mm size fraction from the nine selected sample intervals (Table 4.1) were subjected to sequential uranium extraction testing. These tests used a sequential chemical extraction technique as described by Serne et al. (2002) and Szecsody et al. (2012). The tests can provide information on the relative amounts of uranium present in extractable phases of carbonate coatings, carbonate solid-bearing compounds, amorphous hydrous oxides, crystalline iron (III) oxides, and strong acid leachable compounds.

4.1.1 Weak Acetic Acid Extraction

The first extraction involved a weak acetic acid consisting of 1 mol/L sodium acetate with a final pH of approximately 5. Each sample was agitated on an orbital shaker for 1 hour at a solid-to-solution ratio of 1 g/2 mL. After 1 hour, the sample was centrifuged, the solution decanted and filtered (for inductively coupled plasma − mass spectrometry [ICP-MS] and inductively coupled plasma − optical emission spectroscopy [ICP-OES] analysis), and the sample was weighed to determine the remaining residual solution prior to starting the next sequential extraction. The target uranium phases for this extraction are the adsorbed (weakly bound) uranium and some of the uranium associated with carbonate minerals.

4.1.2 Strong Acetic Acid Extraction

The second sequential extraction used a strong acetic acid (concentrated glacial acetic acid). After 5 days contact time, the samples were centrifuged, decanted, and filtered as described above. The target phase for the strong acetic acid is the strongly bound uranium associated with carbonate minerals.

4.1.3 Ammonium Oxalate Extraction

The third extraction used a solution consisting of 0.1 mol/L ammonium oxalate with 0.1 mol/L oxalic acid. After 1 hour of contact time, the samples were centrifuged, decanted, and filtered. The target phases for the oxalate solution are the amorphous Fe, Al, Mn, and Si oxides.

4.1.4 Nitric Acid Extraction

The final extraction involved 8 mol/L of nitric acid. The samples were transferred to a glass beaker with a stir bar and heated at 95°C for 2 hours on a hot plate. Samples were then weighed to determine the final volume. The target phases for the nitric acid extraction included clays, crystalline oxides, and Fe, Al, and Mn uranium oxides.

4.1.5 Effluent Analyses

Each extractant solution was collected and analyzed for P, Ca, Al, Fe, and Mn via ICP-OES and uranium content via ICP-MS.

4.2 Labile Uranium Leach Testing

Aliquots of the air-dried, <2-mm size fraction from the nine selected sample intervals (Table 4.1) were subjected to labile uranium leach testing. The labile uranium leach test measures the readily leachable uranium to estimate the relative proportion of total uranium that is leachable during the river-stage dynamics observed in the PRZ.

Kohler et al. (2004) describe this method in detail. A solution containing 0.0144 mol/L of sodium bicarbonate ($NaHCO_3$) and 0.0028 mol/L of sodium carbonate (Na_2CO_3) with a pH of approximately 9.45 was added to the sediment at a solid-to-solution ratio of 1 g/2 mL, and was allowed to agitate on an orbital shaker for 1,000 hours (~ 42 days). The pH was measured once before the solution was removed and after the fresh reagent was added. As described by Brown et al. (2008), total dissolved uranium was measured periodically to determine the concentration as a function of time (e.g. 3, 7, 21, and 42 days) and evaluate equilibrium (with respect to uranium solution concentrations). An additional time sampling was done at 66 days and analyzed only for uranium. The solid-to-solution ratio was kept constant at 1 g/2 mL by adding fresh reagent to replace the small aliquot (e.g., 2 to 5 mL) removed at each sampling time.

The contact fluids were periodically sampled and filtered using 0.45-µm syringe filters and analyzed for uranium via ICP-MS and Al, Ca, Mn, and P using ICP-OES.

4.3 <2-mm Flow-Through Column Leach Tests

Column desorption tests were conducted using the air-dried, <2-mm size fraction from four selected sample intervals (Table 4.1). Glass columns 15.2 cm (6 inches) long and 2.5 cm (1 inch) in diameter were used to minimize wall effects and ensure uniform influent coverage inside the column. These columns were filled with the <2-mm size fraction material in increments, and tamped as they were filled to minimize void space and channelized flow in the columns. Once the columns were filled, they were saturated by slowly percolating synthetic groundwater (Table 4.2) in an upflow direction to remove as much trapped air as possible, creating a near-water-saturated condition. The gross weight of the dry sediment-filled column, the net weight of the dry <2-mm sediment placed in the column, and the gross weight of the water-saturated column were used to calculate the bulk density, porosity, and pore volume for each column.

Once the column was saturated, the flow-through leach tests began at an influent flowrate of approximately 0.1 cm^3/min. or 0.25 pore volumes per hour (similar to the 0.15 to 0.36 pore volumes per hour used by Snyder and Cantrell [2015]); yielding pore water velocities of about 70 to 90 cm/day. The column flow tests were run for a total of approximately 10 pore volumes with two stop flow events: one at approximately 4 pore volumes for about 48 hours and one at approximately 7 pore volumes for about 72 hours. At the end of this test, sodium bromide was added to the synthetic groundwater to achieve a Br concentration of 50 ppm and pumped through the columns (at the same rate used during the leach test) to determine the column porosities. Effluent samples were collected periodically and analyzed for uranium, pH, and bromide.

Table 4.2. Recipe for synthetic groundwater used in the flow-through column tests (from Snyder and Cantrell 2015) based on the average groundwater values from 42 wells in the 300 Area documented in Ma et al. 2010, Table 2 (email, S Mehta to GV Last, 2/3/2016).

Reagent	g/L
$CaCO_3$	0.1207
$MgSO_4$	0.06135
$NaHCO_3$	0.08695
KCl	0.01154
$NaNO_3$	0.03995
pH adjusted to 7.3 using HCl.	

4.4 Field Textured Flow-Through Column Leach Tests

Column desorption experiments were conducted on three selected intact splitspoon samples (C liners) approximately 15.2 cm (6 inches) long and 10.2 cm (4 inches) in diameter (Figure 4.1). The columns were fitted with end caps and fittings that allowed the lexan liners to be hooked up to pumps for the column tests. During this column preparation, a sample was collected and analyzed for moisture content. The columns were saturated by slowly percolating synthetic groundwater in an upflow direction to remove as much trapped air as possible. The final weight and volume of the core liner, the moisture content, and the weight of the water-saturated column were used to calculate the bulk density, porosity, and pore volume for each column.

Figure 4.1. Field texture flow-through column testing setup.

Once the column was saturated, the column leach tests began at a flowrate of approximately 1.5 cm^3/min, or 0.25 pore volumes per hour (similar to the 0.15 to 0.36 pore volumes per hour used by Snyder and Cantrell [2015]); yielding pore water velocities of about 110 to 180 cm/day. The column flow tests were run for a total of approximately 10 pore volumes with two stop flow events: one at approximately 4 pore volumes for about 48 hours and one at approximately 7 pore volumes for about 72 hours. At the end of this test, sodium bromide was added to the synthetic groundwater to achieve a Br concentration of 50 ppm and pumped through the columns (at the same rate used during the leach test) to help determine the column porosities. Effluent samples were collected periodically and analyzed for uranium, pH, and bromide.

4.5 Identification of Mineral Phase and Surface Coating

Aliquots of the air-dried, <2-mm size fraction from the nine selected sample intervals (Table 4.1) were evaluated to identify the primary uranium-bearing mineral phases and calcium phosphate precipitates using sequential application of surface analysis techniques, including cryogenic laser fluorescence spectroscopy, electron microprobe, and/or scanning electron microscope/energy dispersive x-ray (SEM/EDX) spectroscopy.

4.5.1 Cryogenic Laser Fluorescence Spectroscopy

Cryogenic time-resolved laser induced U(VI) fluorescence spectroscopic measurements of the selected sediment samples were performed at near-liquid helium temperature (LHeT, 6 ±2 K) using methods described in Wang et al. 2004 and 2005 (Figure 4.2). Sediment solids were placed inside a 2-mm by 4-mm by 25-mm fused quartz cuvette, sealed with a silicone stopper, further wrapped with parafilm, and attached to the cold-finger of a Cryo Industries model RC-152 cryogenic workstation and cooled with helium vapors to lower the sample temperature.

For spectral and lifetime measurements, the samples were excited at 415 nm using a Spectra-Physics Nd:YAG laser pumped Lasertechnik-GWU MOPO laser. The emitted light was collected at 85˚ to the excitation beam, dispersed through an Acton SpectroPro 300i double monochromator spectrograph, and detected with a thermoelectrically cooled Princeton Instruments PIMAX intensified charge-coupled device camera that was triggered by the delayed output of the laser pulse and controlled by the WinSpec data acquisition software. Photofluorescence decay curves were constructed by plotting the spectral intensity of a series of time-delayed fluorescence spectra as a function of the corresponding delay time. The emission spectra and decay data were analyzed using commercial software, IGOR®, from Wavematrix, Inc.

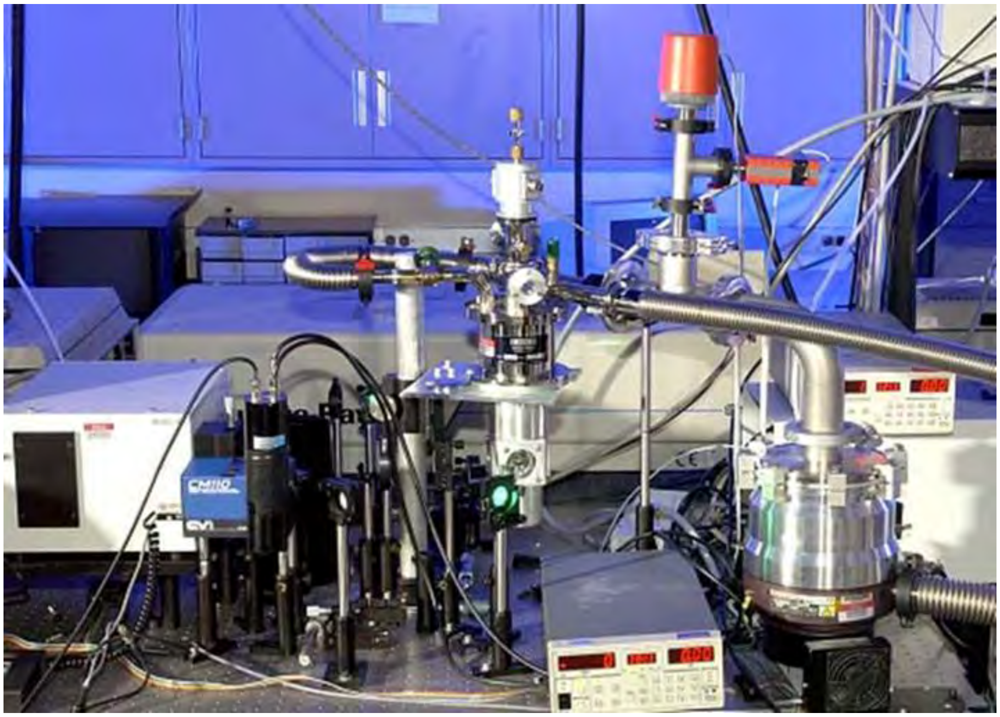


Figure 4.2. Spectrometer system.

4.5.2 Scanning Electron Microscope/Energy Dispersive X-ray Spectroscopy

A field emission focused ion beam SEM, equipped with an EDX detector, was used for compositional and morphological solid phase characterization (Quanta 3D FEG). The electron microscope can operate up to an acceleration voltage of 30 keV and beam current 1-2 nA. Prior to SEM analysis, selected samples were placed on carbon tape attached to an aluminum holder and coated with a 10 nm carbon layer to inhibit sample charging. The energy-dispersive spectroscopy (EDS) spectra for qualitative analysis were collected for 60 to 90 seconds using Oxford EDS INCA software.

4.5.3 Electron Microprobe

A complementing SEM analysis field emission electron microprobe with high spatial resolution was used to accurately quantify uranium and its distribution in individual grains. The electron microprobe (JEOL JXA-8200) can operate at accelerating potential of 20 keV and a beam current of 20 nA, focused at a spot size of ~1 µm.

4.6 Phosphate Measurement by Acid Extraction

Acid extractions using 0.5 M nitric acid for 15 minutes were conducted on selected post-treatment samples (from boreholes C9580, C9581, and C9582) as well as selected pre-treatment samples from boreholes C8940 and C9451. These extractions (similar to those performed by Szecsody et al. [2009 and

2010]) were conducted on samples that had not been subjected to leach testing as well as on samples that had completed the flow-through column leach tests (i.e., both pre-leach and post-leach). Table 4.3 lists the samples selected for phosphate measurements.

Table 4.3. Samples selected for phosphate measurement by acid extraction.

Pre-treatment Borehole ID (Well Name)	Post-treatment Borehole ID	Sample Interval	HEIS Sample ID[(a)]	Depth Interval (ft)	Unleached <2-mm Sample Material	Leached (Post-column Test) <2-mm Sample Material
C8940 (399-1-76)		I-008	B31N31	28.5–29.0	X	--
C9451 (399-1-80)		I-001	B31N64	11.0–11.5	X	--
C9451 (399-1-80)		I-005	B31N87	21.0–21.5	X	--
C9451 (399-1-80)		I-007	B31N96[(b)]	26.5–27.0	X	--
C9451 (399-1-80)		I-008	B31NB3	28.5–29.0	X	--
	C9580	I-001	B347C6	21.5–22.0	X	--
	C9580	I-004	B347F1 and B347F3 (Composited)	29.0–30.0	X	X
	C9581	I-004	B347L4	28.0–28.5	X	--
	C9582	I-002	B347P5 & B347P8 (Composited)	22.5–23.5	X	X
	C9582	I-003	B347R1	25.5–26.0	X	X
	C9582	I-006	B347T7	33.0–33.5	X	X

-- Post column test material unavailable.

(a) B347xx are the HEIS sample numbers of specific samples selected for analyses (based on correlations provided in R Hermann email to GV Last, 1/28/2016).

(b) Post-leach test materials may have been consolidated with residual sample materials for this sample interval.

For the samples that were post-column leach tested, one sample was taken approximately 3 cm from the top (or outflow end) of the column, and another was taken approximately 3 cm from the bottom of the column (or influent end of the column). Each sample is labeled with the HEIS number followed by “top” and “bottom” in the sample name

For each sample, 0.5 M nitric acid was added at a solid-to-solution ratio of 1 g/2 mL. The sample was then agitated on an orbital shaker for 15 minutes. After 15 minutes, the sample was centrifuged and the solution decanted and filtered. The filtered solution was then analyzed for phosphorus, calcium, aluminum, iron, and manganese via ICP-OES and uranium content via ICP-MS.

5.0 Results

This section summarizes some of the key analytical results of this study. Complete analytical and quality control results are provided in Appendix A. The prescribed holding times, defined as the time from sample preparation to the time of analyses, were met for all analytes. All reported analytical results meet the requirements of the CAWSRP (*Conducting Analytical Work in Support of Regulatory Programs*) and client-specified statement of work. The chain of custodies, geologic descriptions and photographs of each sample are provided in Appendix B.

5.1 Sequential Uranium Extraction Tests

Figure 5.1 summarizes the uranium concentration and relative fraction (percent) recovered from the sequential extraction tests. Total uranium concentrations determined by ALS are also provided in the chart on the left. The ALS results were generated using ICP-MS (U.S. Environmental Protection Agency [EPA] method 6020A) following acid digestion (EPA method SW 3050B).[1] Note that these are from a different sample from within the same sample interval. Those concentrations are nearly all lower, varying by 56% (B347F1&3 and B347T7) to 109% (B347C6) of the sum of the concentrations of all sequential extractions. This suggests that the sequential extractions drew more uranium from the sediment than a single extraction (from both different chemical interactions and possibly extraction time), and/or that there is some degree of heterogeneity between samples. The chart on the right shows that the uranium was more strongly sequestered in some samples, and that in all but three samples more than 50% of the uranium mass was extracted by the weakest two (acetic acid) solutions.

---

[1] ALS Environmental analytical reports ALS1601062 and ALS1601118 (accessed via the Enterprise Application to the Integrated Document Management System, IDMS).

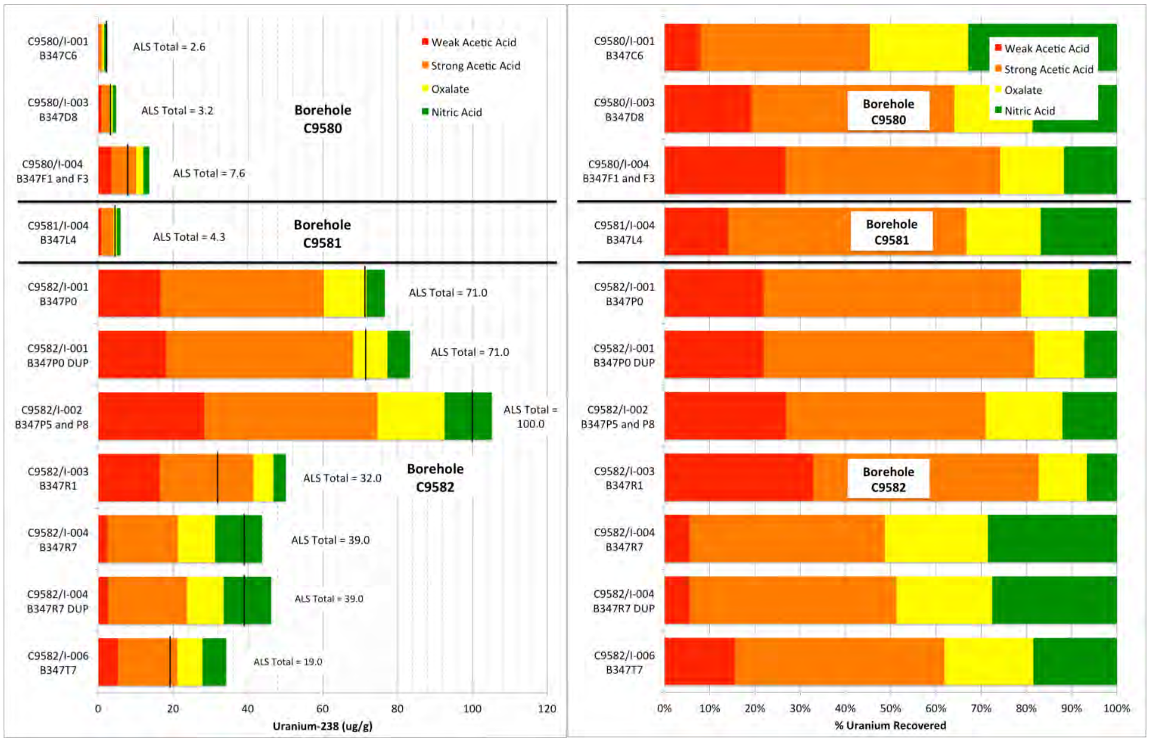


Figure 5.1. Uranium concentrations recovered from sequential extraction tests by borehole and sample depth interval. Note that the ALS total uranium concentrations are from ALS analytical reports ALS1601062 and ALS1601118 (accessed via the Enterprise Application to IDMS).

Figure 5.2 illustrates the phosphorus concentrations and relative fraction (percent) recovered from the selective extraction tests. Total phosphorus concentrations from borehole C9580 determined by ALS are provided in the chart on the left. The ALS results were generated using ICP-MS (EPA method 6010B) following acid digestion (EPA method SW 3050B).[1] Note that these are from a different sample from within the same sample interval. Those concentrations are all lower, varying by 78% to 93% of the sum of the concentrations of all sequential extractions. These results (chart on the right) show that in all but one sample, greater than 50% of the phosphate is associated with the harshest extraction solution (nitric acid), with 90% of the phosphate associated with the two harshest solutions (oxalate and nitric acid combined).

---

[1] ALS Environmental analytical report ALS1601062 (accessed via the Enterprise Application to IDMS).

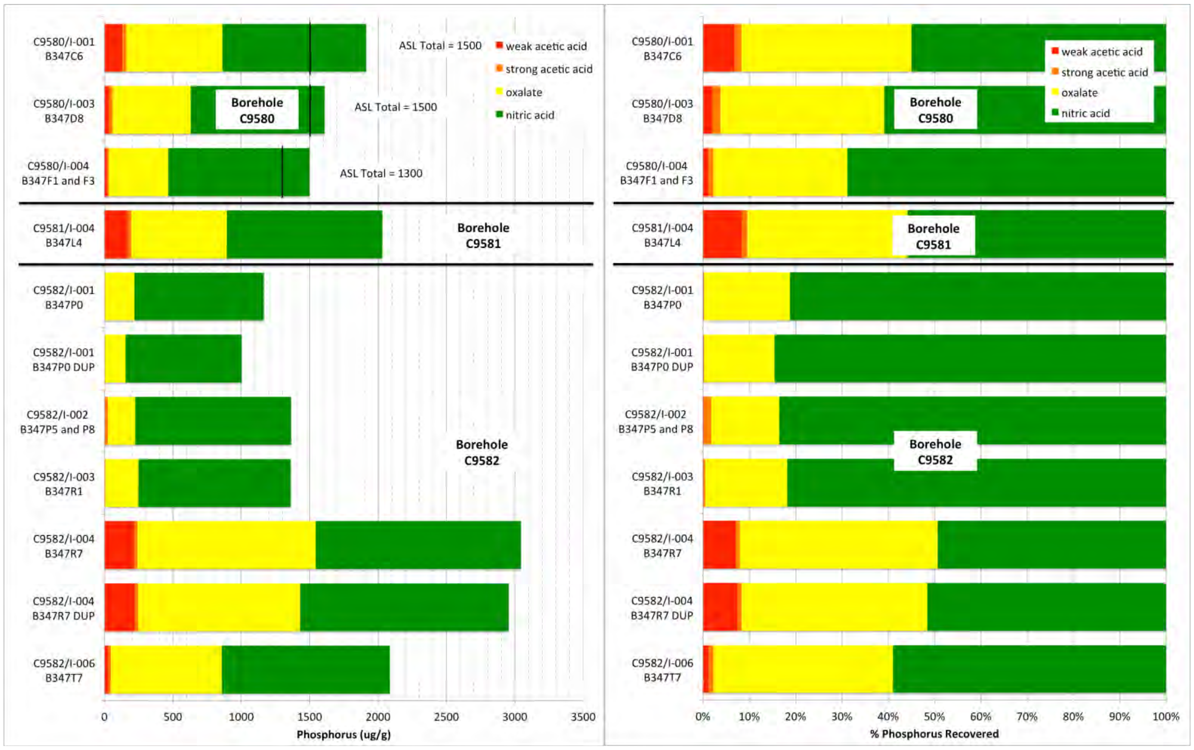


Figure 5.2. Phosphorus concentrations recovered from sequential extraction tests by borehole and sample depth interval. Note that the ALS total phosphorus concentrations are from ALS analytical report ALS1601062 (accessed via the Enterprise Application to IDMS).

Figure 5.3 illustrates the ratio of uranium to phosphorus concentrations and the relative fraction (percent) of the uranium to phosphorus ratios recovered from the selective extraction tests. These charts suggest that the weak acid extracts (i.e. acetic acid extracts) extracted higher concentrations of uranium than phosphorus, particularly in borehole C9582. Whereas in the stronger acid extracts, phosphorus was extracted in higher concentrations than uranium (uranium/phosphorus ratio < 1). These results suggest that most of the uranium in the samples is not associated with phosphate.

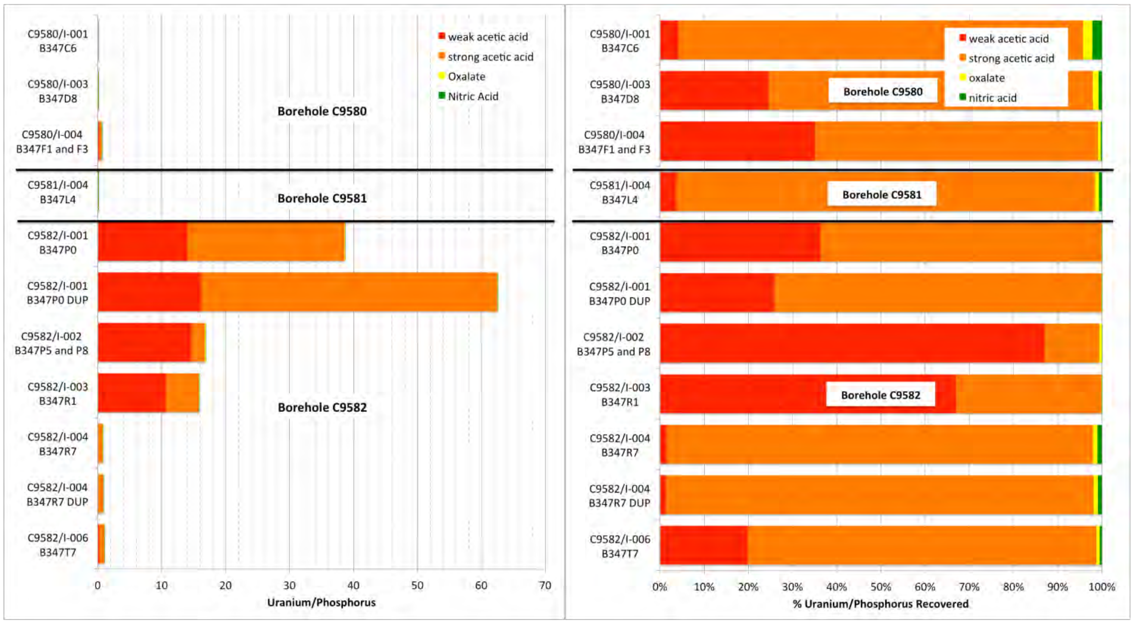


Figure 5.3. Ratio of uranium concentrations to phosphorus concentrations, by borehole and sample depth interval, as recovered from sequential extraction tests.

Figure 5.4 illustrates the ratio of uranium to calcium concentrations and the relative fraction (percent) of the uranium to calcium ratios recovered from the selective extraction tests. These charts suggest that the oxalate acid extracts extracted higher concentrations of uranium than calcium, particularly in boreholes C9580 and C9581. This is consistent with the significant incorporation of uranium into $CaCO_3$ that is found at the Hanford Site, which is dissolved with the two acetic acid extractions.

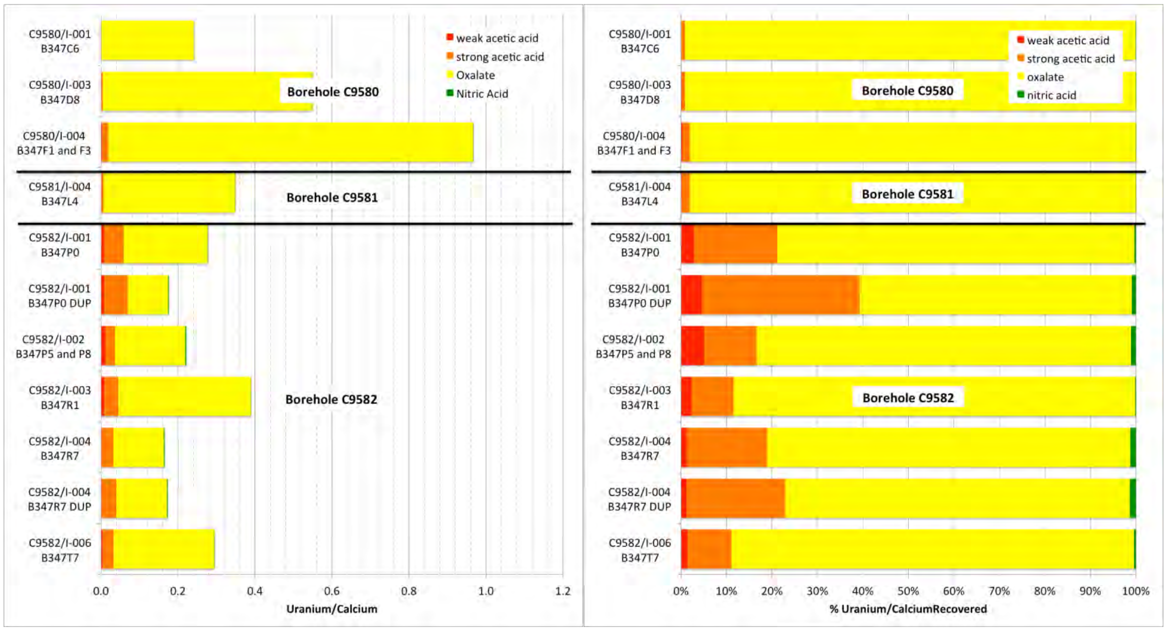


Figure 5.4. Ratio of uranium concentrations to calcium concentrations, by borehole and sample depth interval, as recovered from sequential extraction tests.

Figure 5.5 illustrates the ratio of calcium concentrations to phosphorus concentrations and the relative fraction (percent) of the calcium to phosphorus ratios recovered from the selective extraction tests. These charts suggest that the weak acid extracts extracted higher concentrations of calcium than phosphorus, particularly in the upper portion of borehole C9582. This result would be expected with dissolution of calcium carbonate by the acetic acid extraction solutions.

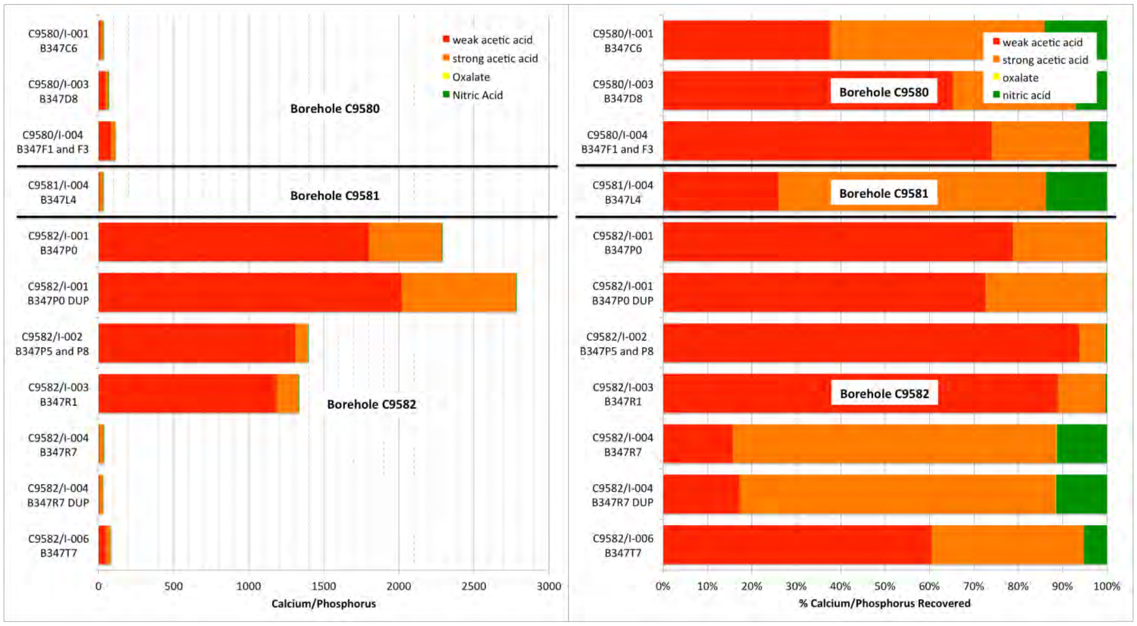


Figure 5.5. Ratio of calcium concentrations to phosphorus concentrations, by borehole and sample depth interval, as recovered from sequential extraction tests.

5.2 Labile Uranium

Figure 5.6 and Figure 5.7 summarize the uranium concentrations recovered at four different reaction times (3, 7, 21, and 42 days) during labile leach testing. From these analyses, it does not appear that equilibrium (with respect to uranium solution concentrations) was attained for any of the samples, even after 42 days of reaction time. Another round of samples was collected after 66 days and analyzed only for uranium. However, it still appears that equilibrium was not reached. These results may indicate carbonate exchange, where uranium-containing carbonates are dissolving and non-uranium carbonates are precipitating. This type of non-equilibrium, kinetically controlled leaching in contact with a bicarbonate water solution could be expected to continue under field conditions.

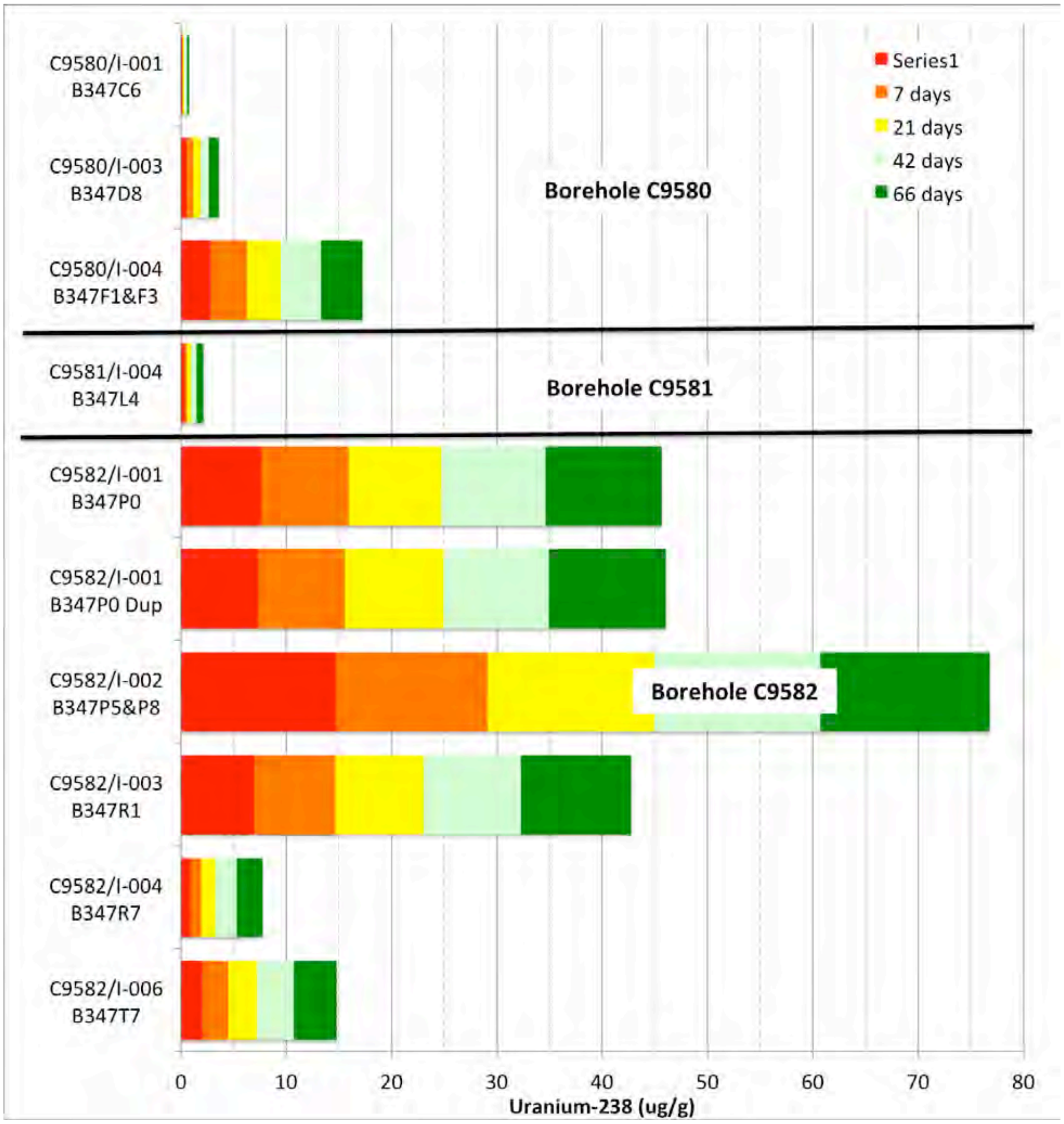


Figure 5.6. Composite uranium concentrations recovered during labile leach testing.

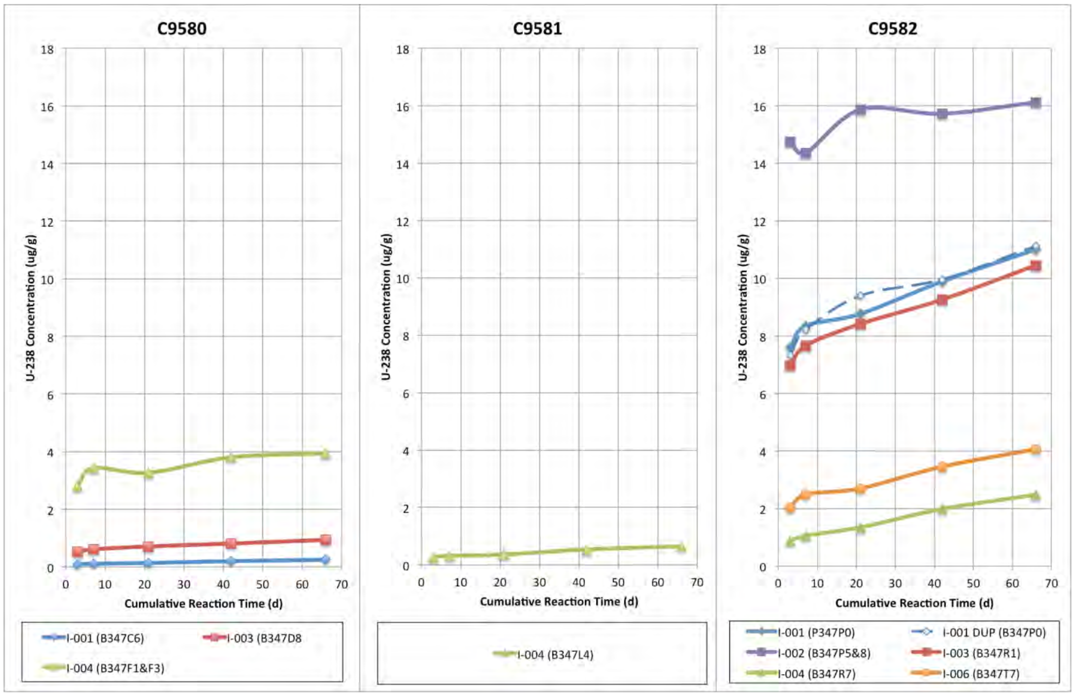


Figure 5.7. Uranium concentration recovered as a function of time during labile leach testing.

5.3 Flow-Through Column Tests

Column leach experiments were conducted using four repacked columns containing only the <2-mm-size material from three sample intervals and three intact (field texture) splitspoon liner samples from three sample intervals. The repacked columns were prepared using 15.2-cm (6-inch) long and 2.5-cm (1-inch) diameter glass columns. The column experiments were run for approximately 10 pore volumes, using stop flow methodology (Table 5.1).

Table 5.1. Flow-through column test parameters.

Borehole	HEIS Sample ID	Sample/Depth Interval (ft)	Preparation	Bulk Density (g/cm^3)	Porosity	Average Flow Rate (cm^3/min)	Average Pore Water Velocity (cm/day)$^{(a)}$	Total Pore Volumes$^{(b)}$
C9580	B347F1 F347F3	I-004 / 29.0-29.5 I-004 / 29.5-30.0	<2-mm composite	1.66	0.37	0.092	72.2	9.1
C9582	B347P4	I-002 / 23.5-24.0	Field texture	2.05	0.23	1.2	110	16.9
	B347P5 B347P8	I-002 / 23.0-23.5 I-002 / 23.5-24.0	<2-mm composite	1.72	0.35	0.092	77.1	10.7
	B347R0	I-003 / 26.0-26.5	Field texture	2.18	0.18	1.2	141	12.5
	B347R1	I-003 / 25.5-26.0	<2 mm	1.79	0.32	0.095	85.7	12.4
	B347T6	I-006 / 33.5-34.0	Field texture	2.26	0.15	1.2	167	16.2
	B347T7	I-006 / 33.0-33.5	<2 mm	1.78	0.33	0.093	83.7	11.9

(a) Average linear velocity
(b) Prior to bromide elution

5.3.1 <2-mm Repacked Flow-Through Column Results

Figure 5.8 shows a graph of the uranium concentration as a function of pore volume for the repacked <2-mm composite of samples B347F1 and B347F3 from borehole C9580, depth interval I-004. The data show some increase in the uranium concentrations following the stop flow events. Thus, there is some kinetically controlled leaching continuing from this low-concentration sample. Figure 5.9 shows the bromide breakthrough curve, demonstrating uniform flow characteristics in the column.

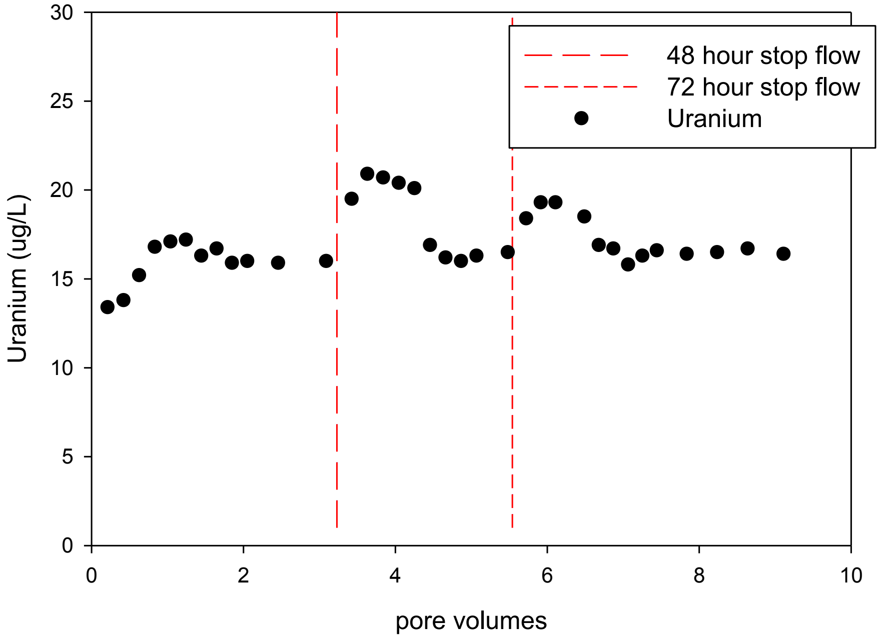


Figure 5.8. Uranium concentration vs. pore volume for repacked <2-mm column containing composite B347F1 and B347F3 (borehole C9580, depth interval I-004).

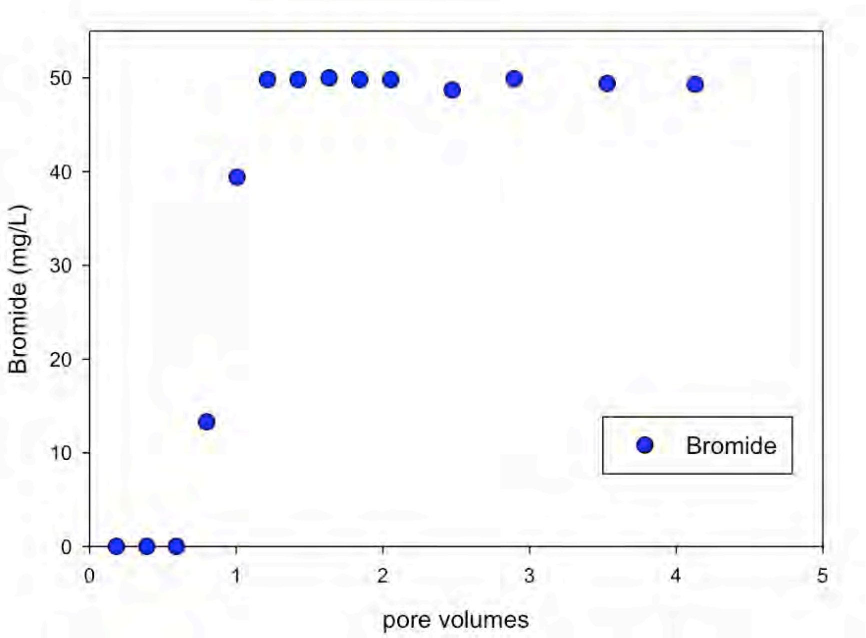


Figure 5.9. Bromide concentration vs. pore volume for repacked <2-mm column containing composite B347F1 and B347F3 (borehole C9580, depth interval I-004).

Figure 5.10 shows a graph of the uranium concentration as a function of pore volume for the repacked <2-mm composite of samples B347P5 and B347P8 from borehole C9582, depth interval I-002. These data show initial high concentration leaching that decreases rapidly over time. Concentration increases were observed during both stop flow events. This sample, with the highest uranium concentration, shows that some uranium in the sample is still labile to rapid leaching and kinetic leaching of uranium is expected during the initial high concentration pulse and as it subsides. Figure 5.11 shows the bromide breakthrough curve, demonstrating uniform flow characteristics in the column.

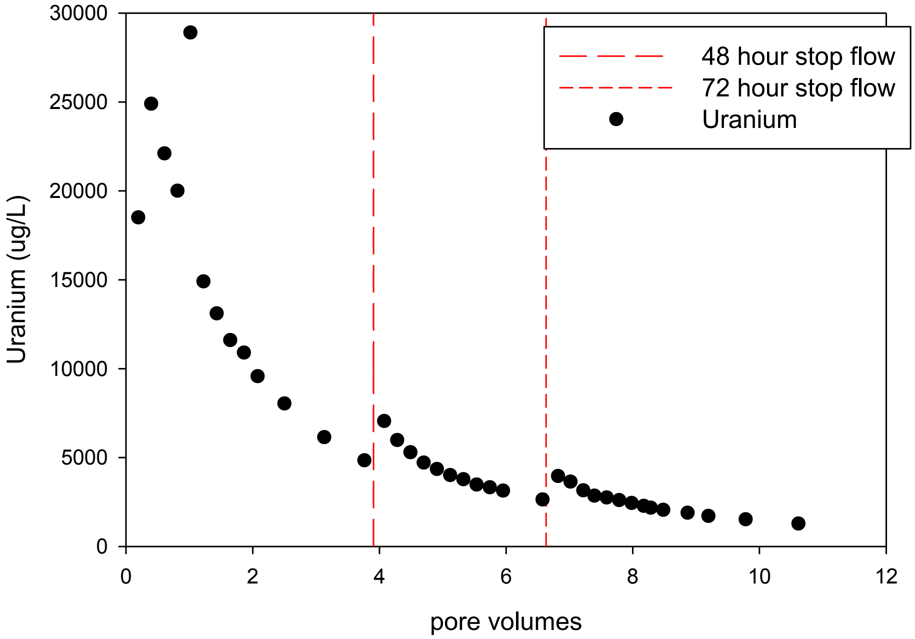


Figure 5.10. Uranium concentration vs. pore volume for repacked <2-mm column containing composite B347P5 and B347P8 (borehole C9582, depth interval I-002).

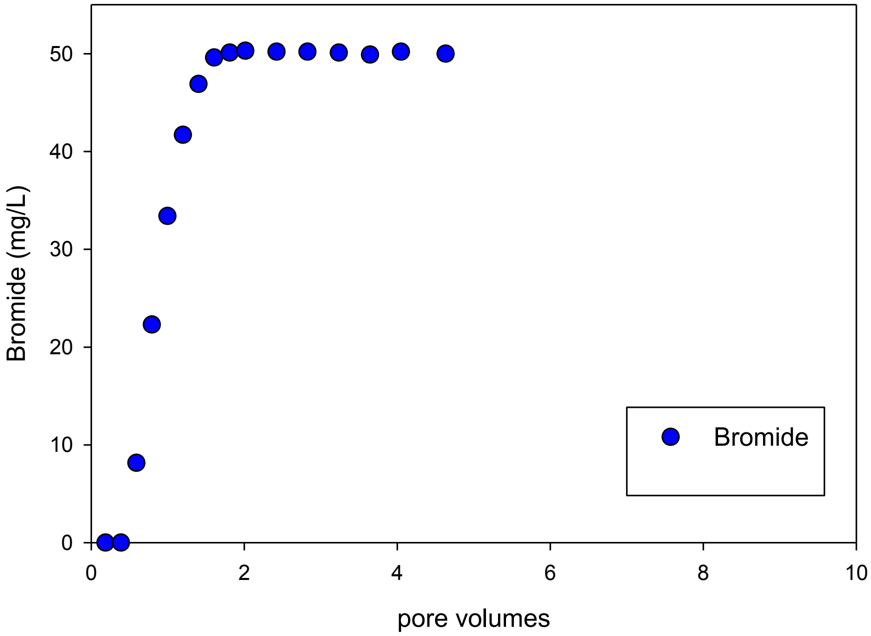


Figure 5.11. Bromide concentration vs. pore volume for repacked <2-mm column containing composite B347P5 and B347P8 (borehole C9582, depth interval I-002).

Figure 5.12 shows a graph of uranium concentration versus pore volume for repacked <2-mm sample B347R1 from borehole C9582, depth interval I-003. These data show initial moderately high concentration leaching that decreases over time. Concentration increases were observed during both stop flow events. This sample, with moderately high uranium concentration, shows that some uranium in the sample is still labile to rapid leaching and kinetic leaching of uranium is expected during the initial high-concentration pulse and as it subsides. Figure 5.13 shows the bromide breakthrough curve, demonstrating uniform flow characteristics in the column.

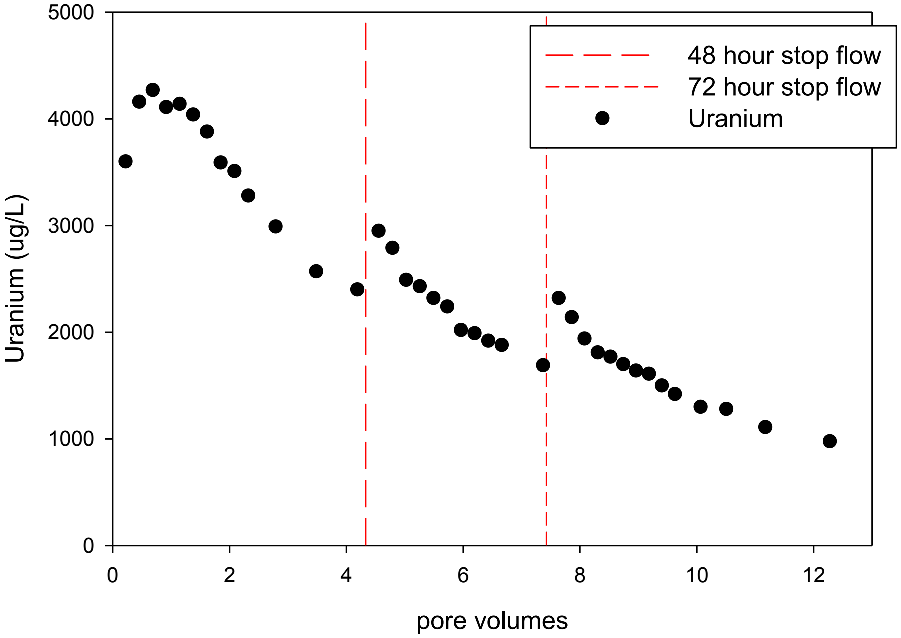


Figure 5.12. Uranium concentration vs. pore volume for repacked <2-mm B347R1 column (Borehole C9582, depth interval I-003).

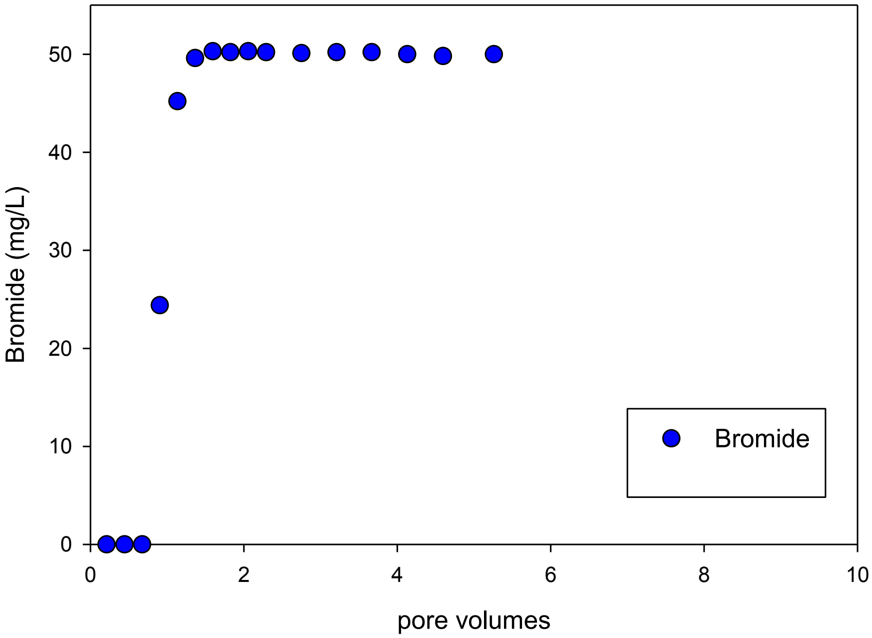


Figure 5.13. Bromide concentration vs. pore volume for repacked <2-mm B347R1 column (borehole C9582, depth interval I-003).

Figure 5.14 shows uranium concentration versus pore volume for repacked <2-mm material from sample B347T7 from borehole C9582, depth interval I-006. These data do not show the expected initial high concentration leaching that declines over time. The effluent uranium concentration in this sample is lower than the effluent concentration for the C9580, I-004 sample. However, the uranium soil concentration for C9582, I-006 is two to three times higher than the uranium soil concentration for C9580, I-004 (Figure 5.1). Sequential extraction results for these two samples show that there is more uranium associated with the oxalate and nitric acid extractions in the C9582, I-006 sample, though these extractions are still a small percentage of the sample's total uranium. The stop flow events show an increase in concentration, indicative of kinetic leaching. The increasing concentrations that tail upward following the last stop flow remain unexplained. A similar trend is seen in the intact (field texture) column from the same sample interval (see Section 5.3.2). Potentially, these data suggest that there is limited uranium available in a highly mobile form in this sample and that uranium is only released over time through kinetically controlled mechanisms. Figure 5.15 shows the bromide breakthrough curve, demonstrating uniform flow characteristics in the column.

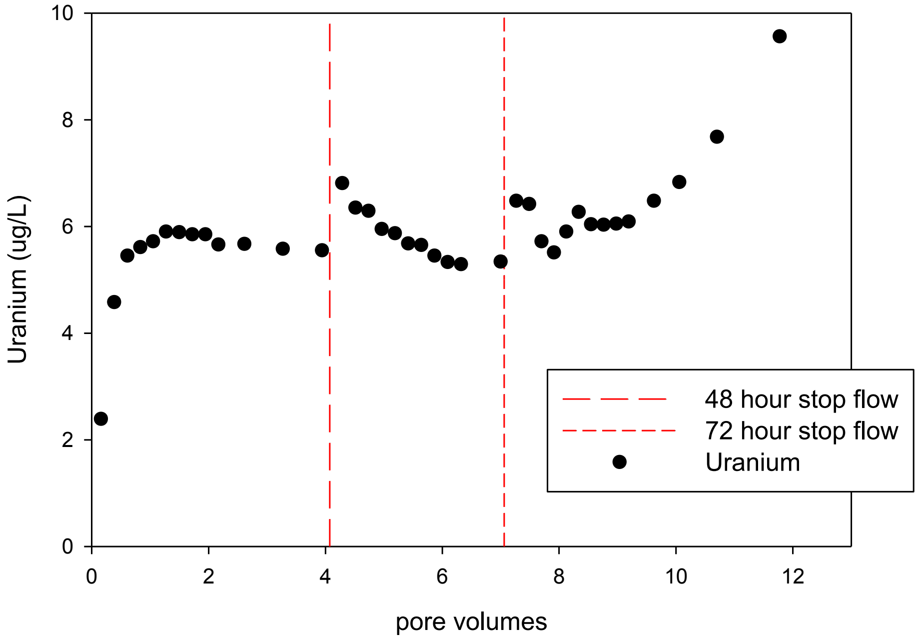


Figure 5.14. Uranium concentration vs. pore volume for repacked <2-mm B347T7 column (borehole C9582, depth interval I-006).

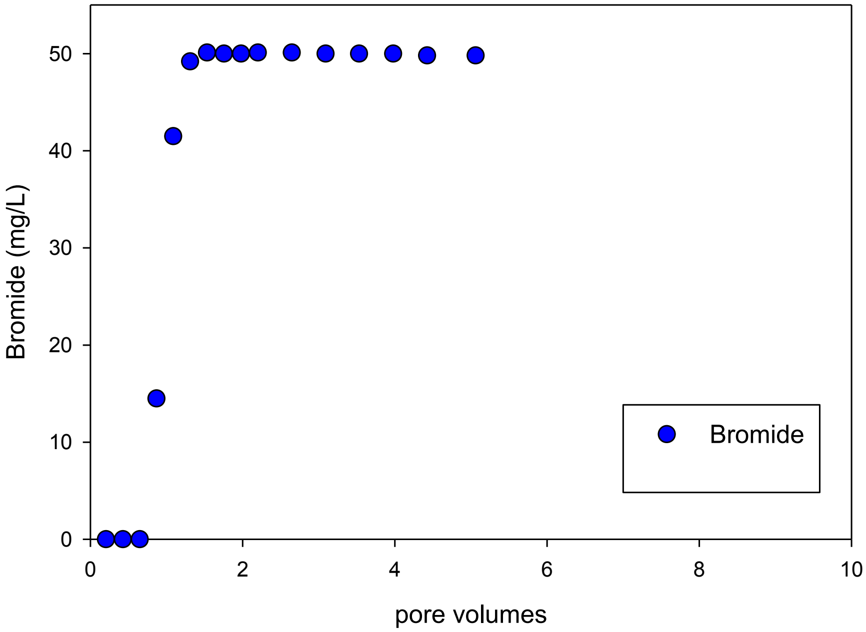


Figure 5.15. Bromide concentration vs. pore volume for repacked <2-mm B347T7 column (borehole C9582, depth interval I-006).

5.3.2 Intact Splitspoon Liner Flow-Through Column Results

Figure 5.16 shows uranium concentration as a function of pore volume for the intact (field texture) column experiment using sample B347P4 (borehole C9582, depth interval I-002. Similar to the <2-mm repacked column for the composite of samples B347P5 and B347P8 from the same sample interval (see Section 5.3.1), these data show initial high concentration leaching that decreases rapidly over time. Concentration increases were observed during both stop flow events. This sample, with the highest uranium concentration, shows that some uranium in the sample is still labile to rapid leaching and kinetic leaching of uranium that is expected during the initial high-concentration pulse and as it subsides. While trends are similar for the repacked and intact columns for this sample interval, the effluent concentrations are lower for the intact column tests, perhaps reflecting the effect of having a large portion (86 wt%) of sediment in the column consisting of >2-mm particles. Figure 5.17 shows the bromide breakthrough curve, demonstrating relatively uniform flow characteristics in the column, though with more dispersion than observed in the repacked columns.

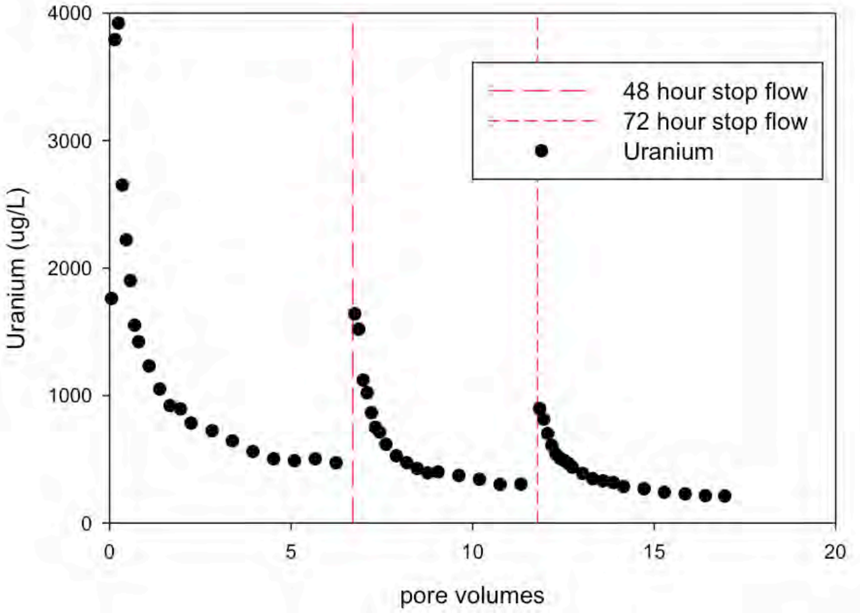


Figure 5.16. Uranium concentration vs. pore volume for intact (field texture) column B347P4 (borehole C9582, depth interval I-002).

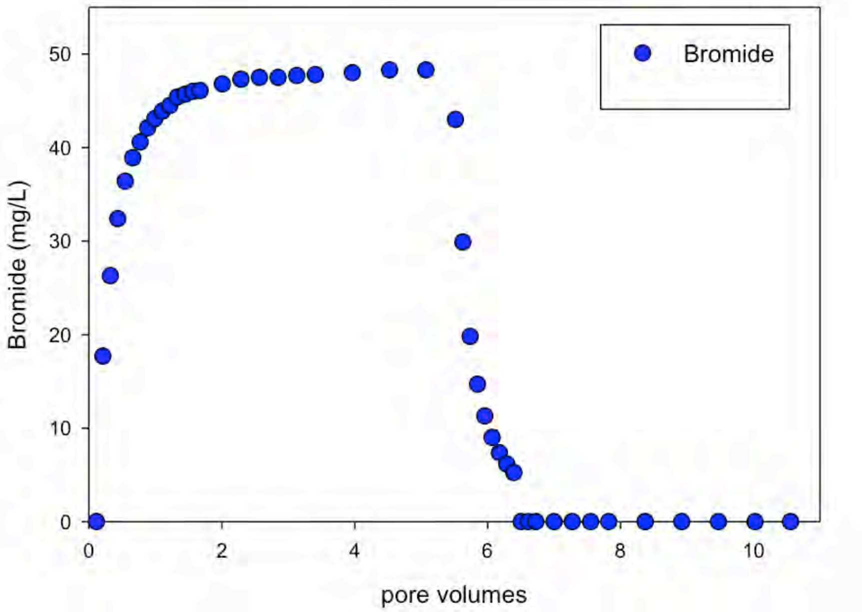


Figure 5.17. Bromide concentration vs. pore volume for intact column B347P4 (borehole C9582, depth interval I-002).

Figure 5.18 shows a graph of uranium concentration versus pore volume for intact (field texture) sample B347R0 from borehole C9582, depth interval I-003. Similar to the data for the <2-mm repacked column test from sample B347R1 from the same sample interval, the data show initial moderately high concentration leaching that decreases over time. Concentration increases were observed during both stop flow events. This sample, with moderately high uranium concentration, shows that some uranium in the sample is still labile to rapid leaching and kinetic leaching of uranium is expected during the initial high-concentration pulse and as it subsides. For the C9582, I-003 sample, the intact and repacked columns show similar effluent uranium concentrations during leaching. Figure 5.19 shows the bromide breakthrough curve, demonstrating relatively uniform flow characteristics in the column, though with more dispersion than observed in the repacked columns.

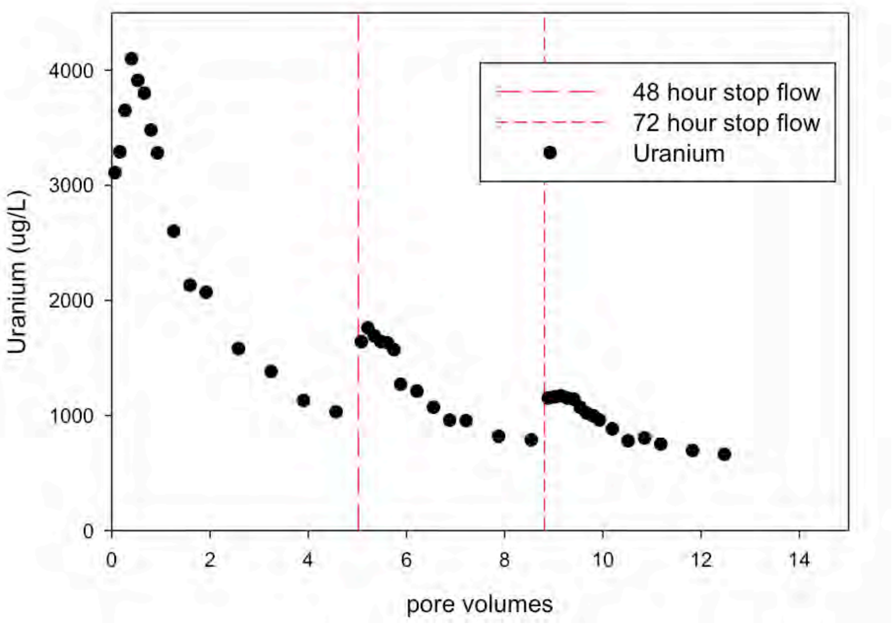


Figure 5.18. Uranium concentration vs. pore volume for intact column B347R0 (borehole C9582, depth interval I-003).

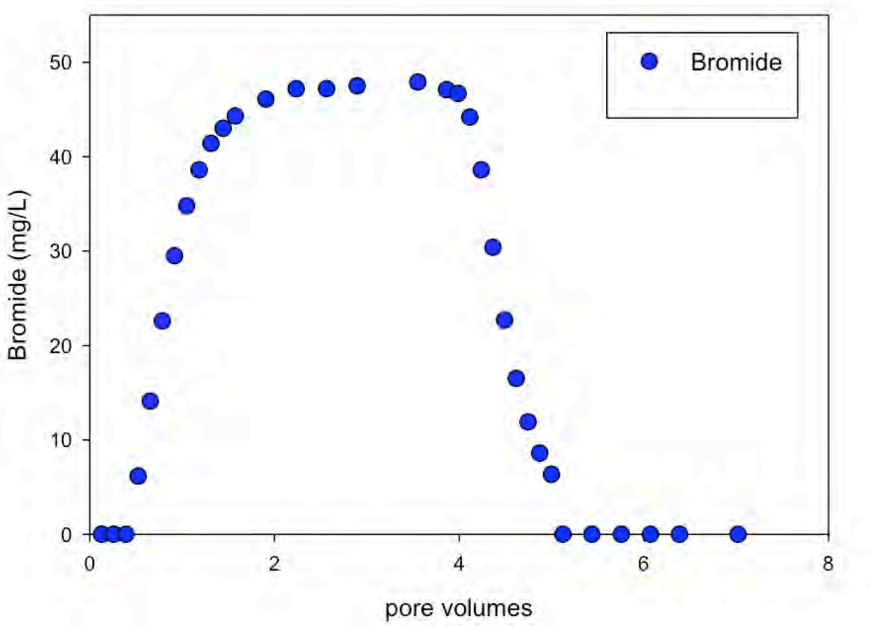


Figure 5.19. Bromide concentration vs. pore volume for intact column B347R0 (borehole C9582, depth interval I-003).

Figure 5.20 shows uranium concentration versus pore volume for the intact (field texture) sample B347T6, from borehole C9582, depth interval I-006. Unlike the <2-mm repacked column of material from sample B347T7 from the same sample interval, these data show an initial higher concentration of uranium in the effluent that declines rapidly by 4 to 6 pore volumes. After this period, effluent concentrations increase even during flowing conditions in the column. Concentration increases are also observed in the stop flow events. Like the <2-mm repacked column results for this sample, results may indicate that there is limited uranium available in a highly mobile form in this sample and that uranium is only released over time through kinetically controlled mechanisms. Figure 5.21 shows the bromide breakthrough curve, demonstrating relatively uniform flow characteristics in the column, though with more dispersion than observed in the repacked columns.

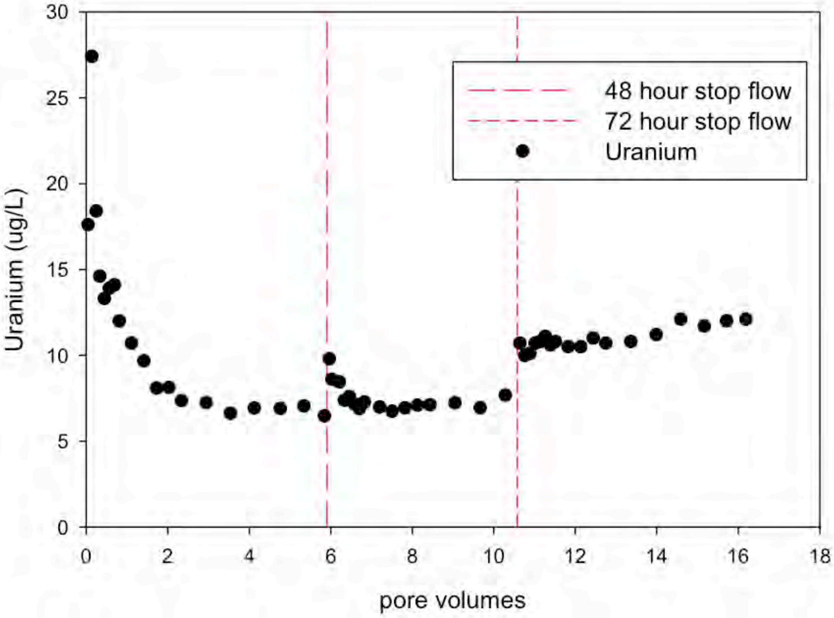


Figure 5.20. Uranium concentration vs. pore volume for intact column B347T6 (borehole C9582, depth interval I-006).

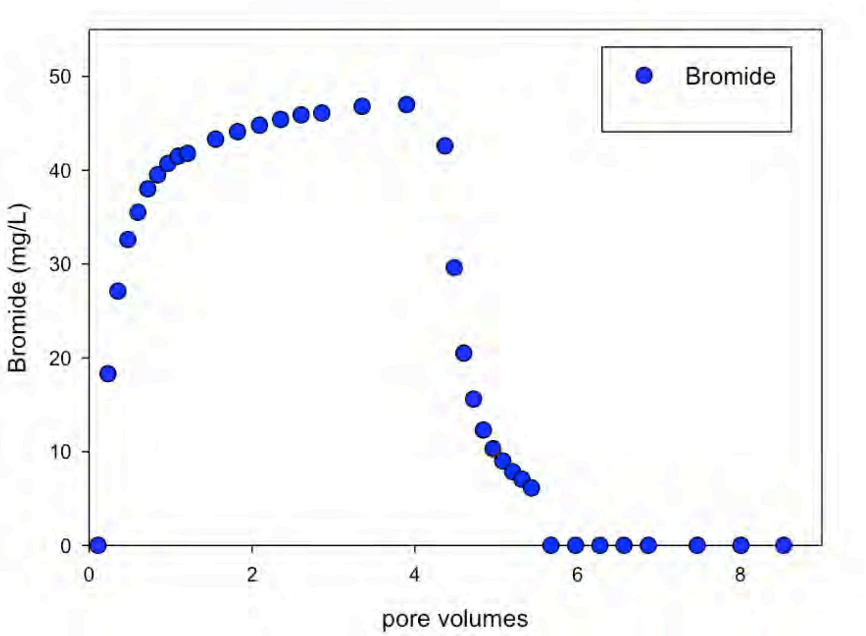


Figure 5.21. Bromide concentration vs. pore volume for intact column B347T6 (borehole C9582, depth interval I-006).

5.3.3 Cumulative Flow-Through Column Results

Figure 5.22 through Figure 5.25 show the cumulative mass of uranium recovered by pore volume for both the <2-mm and intact flow-through column tests (where available) for each sample interval tested. Note that much of the variability between the < 2-mm and intact flow-though column tests (such as that in Figure 5.23) is most likely due to the high percentage (up to 86 wt. %) of gravel (> 2 mm) in the intact core samples.

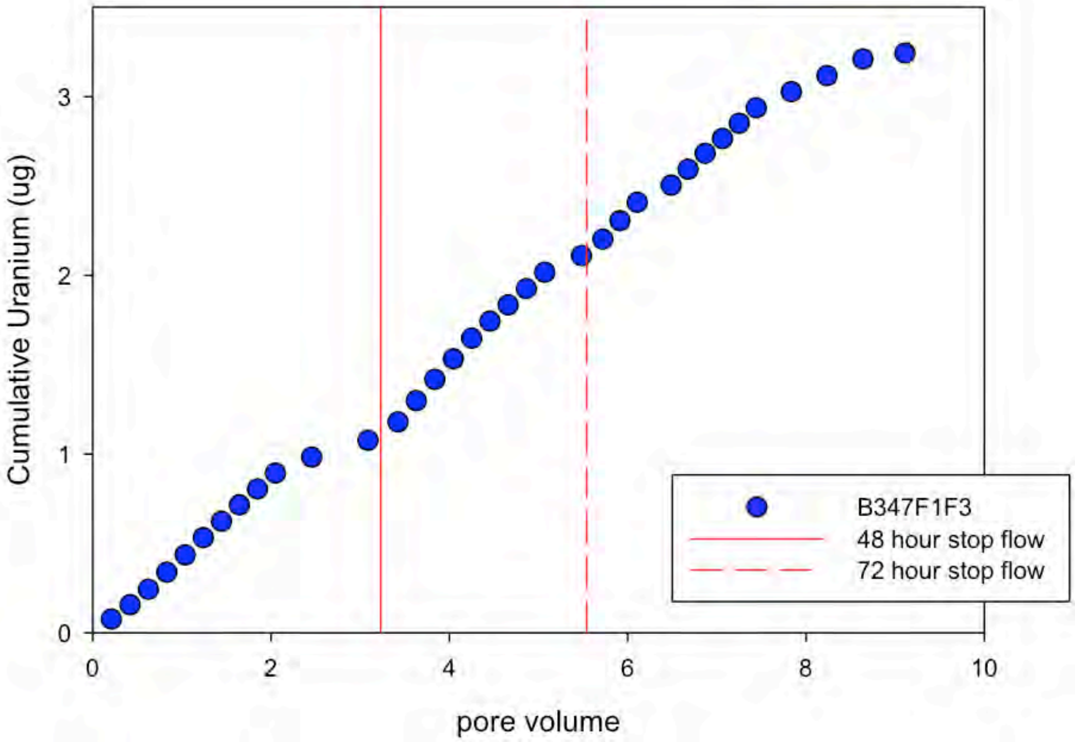


Figure 5.22. Cumulative mass of uranium mass recovered by pore volume for the < 2-mm flow-through column test of borehole C9580, sample interval I-004 (composite of samples B347F1 and B347F3).

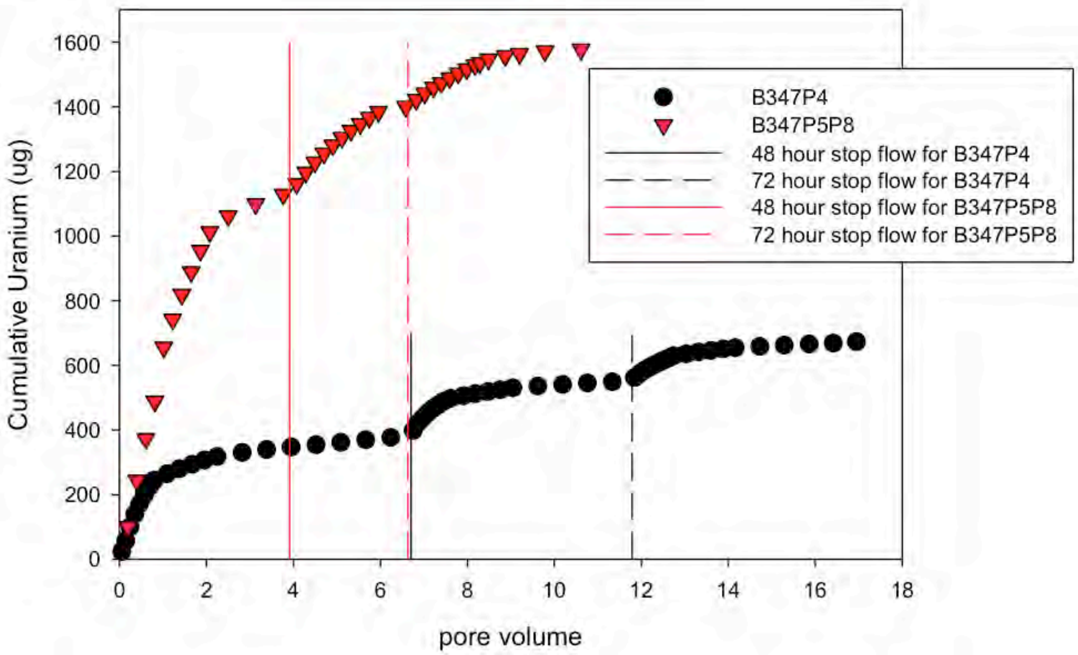


Figure 5.23. Cumulative mass of uranium recovered by pore volume for both the < 2-mm (composite of samples B347P5 and B347P8) and intact (sample B347P4) flow-through column tests of borehole C9582, sample interval I-002.

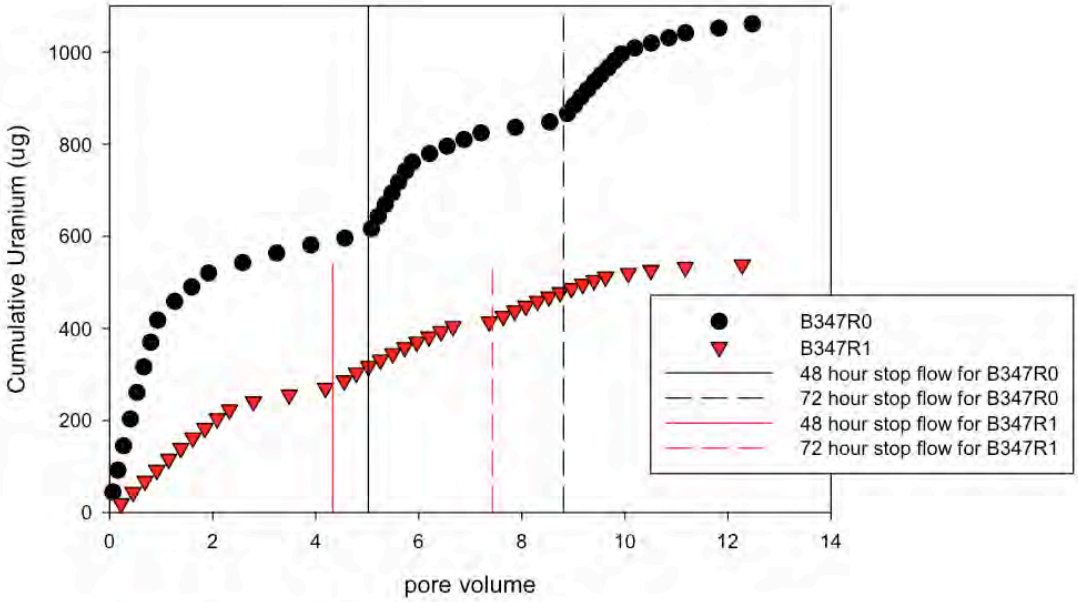


Figure 5.24. Cumulative mass of uranium recovered pore volume for both the < 2-mm (sample B347R1) and intact (sample B347R0) flow-through column tests of borehole C9582, sample interval I-003.

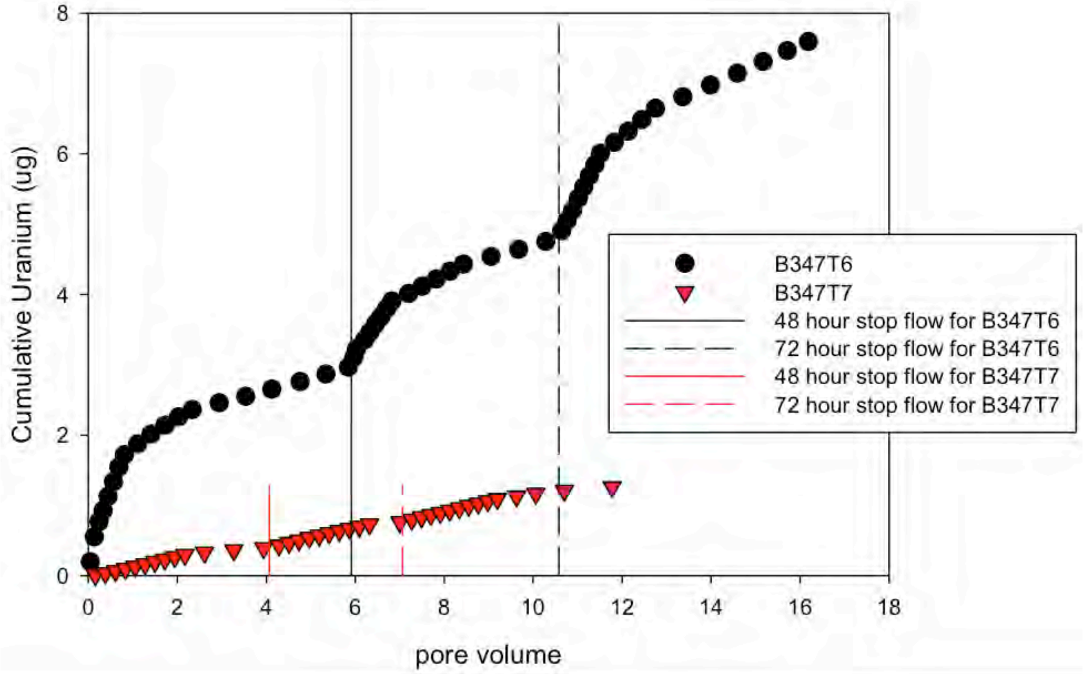


Figure 5.25. Cumulative mass of uranium recovered by pore volume for both the < 2-mm (sample B347T7) and intact (sample B347T6) flow-through column tests of borehole C9582, sample interval I-006.

5.4 Mineral Phase & Surface Coating

Selected sediment samples from the nine selected sample intervals (Table 4.1) were investigated using cryogenic U(VI) laser fluorescence spectroscopy and SEM/EDX analysis.

5.4.1 Cryogenic U(VI) Laser Fluorescence Spectroscopy

Based on the spectral profiles and spectral band positions, the samples appear to fall into three sample classes. The first class consists of the majority of samples, including all but the B347C6 and B347D8 samples (borehole C9580, depth intervals I-001 and I-003, respectively), with relatively high U(VI) concentrations. The samples in this first class typically display three or more broad, not well-resolved vibronic bands with the first band 496.6 to 502.6 nm and the second band, which is the strongest, at 515.4 nm to 519.5 nm (see Appendix C). These band positions are close to those of U(VI) adsorbed on quartz (Wang et al. 2011; Ilton et al. 2012) and U(VI)-phosphate surface complexes adsorbed on montmorillonite (Troyer et al. 2016). As quartz is the dominant mineral phase in Hanford vadose zone sediments and phyllosilicates often exist as fine surface coatings on soil and mineral grains, it is expected that such surface uranium complexes adsorbed to the mineral hosts should be distributed throughout the sediments.

The second class of samples consists of the B347C6 and B347D8 samples (borehole C9580, depth intervals I-001 and I-003, respectively) plus some spots in sample B347F1&F3 (borehole C9580, depth interval I-004), with some of the lowest U(VI) concentrations. These samples display weak, poorly resolved spectra with an ill-defined band maximum around 512.7 to 514.6 nm or 534.0 to 534.8 nm (Appendix C). Similar spectra are also observed for all samples at extremely long delay times as well as pristine Hanford sediments (unpublished data[1]). The origin of such spectral features has not been definitely identified. However, these could result from the slow uptake of uranium over geological times within the mineral grains in the form of oxyhydroxide at low concentrations. Indeed, such peak positions are similar to U(VI) oxyhydroxides (Wang et al. 2008).

The third class of samples includes only B347P0 and B347R1, as a subset of the first class of samples, and includes samples with some of the highest uranium concentrations. At long delay times, the fluorescence spectra of these samples display features of uranyl-tricarbonate, with peak positions at approximately 481, 501, 521, and 542 nm (Dong et al. 2005; Wang et al. 2005). These samples likely possess noticeable levels of calcium carbonate minerals with adsorbed U(VI). This information for these samples suggests that the phosphate treatment was not extensive enough to cause the uranyl-tricarbonate species to desorb and interact with the released uranium.

None of the samples analyzed showed the characteristic features of crystalline uranyl-phosphate precipitates, which are characterized by intense, well-resolved vibronic bands with peak spacings between 815 and 851 cm^{-1} (Wang et al. 2008). Given the relatively low concentrations of uranium in these sediments, if such crystalline uranyl-phosphates were present, they would be non-uniform, discrete “hot” spots in the sediments. The present results do not support such a hypothesis. A recent study of uranium speciation in the presence of phosphate and montmorillonite observed that such uranium-phosphate secondary precipitates only occurred at high uranium and phosphate concentrations, while surface adsorbed uranium dominates at lower uranium/phosphate concentrations (Troyer et al. 2016).

5.4.2 SEM/EDX Spectroscopy and Electron Microprobe Results

Selected sediment samples from the nine selected sample intervals (Table 4.1) were investigated with SEM/EDX analysis part of the sample was secured into a C-tape attached to an SEM aluminum holder. Particle morphology was examined using a secondary electron (SE) detector at acceleration voltage of 5 to 10 KeV and current of 0.34 nA while compositional data was collected using a backscattering electron detector (BSE) at acceleration voltage of 30 keV and current of 1.2 nA. Randomly selected areas/particles were initially investigated using the BSE detector, which identifies solid phases containing elements with a large atomic number (Z) due to the bright contrast. Uranium-containing solids could therefore be identified using this approach. Each sediment sample was investigated for approximately 3.5 to 4 hours. On average, 30 to 40 particles were initially examined using the point identification technique described above. EDS and EDX elemental mapping was collected on particles of interest that appeared also to have chemical compositions matching phosphate borehole treatments. Semi-quantitative analysis for these particles was completed using an acquisition time of 60 seconds. Mapping with acquisition time that varied from 400 to 500 seconds was also performed on selected particles that demonstrated elevated Z contrasts as well as enhanced Ca and P concentrations.

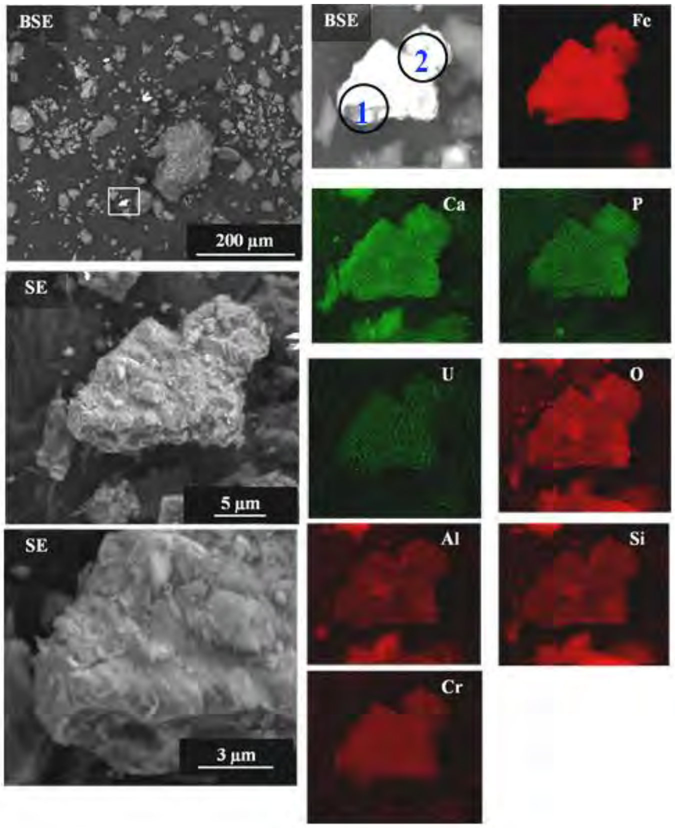
---

[1] Personal communication, Zheming Wang (PNNL).

Spot particle analysis did not detect uranium, likely due to the EDX detection limit being greater than uranium concentrations in all the samples (detection limit > 500 ppm). However, EDX elemental mapping analysis of the samples demonstrated some variation in uranium distribution among the samples.

5.4.2.1 Borehole C9580

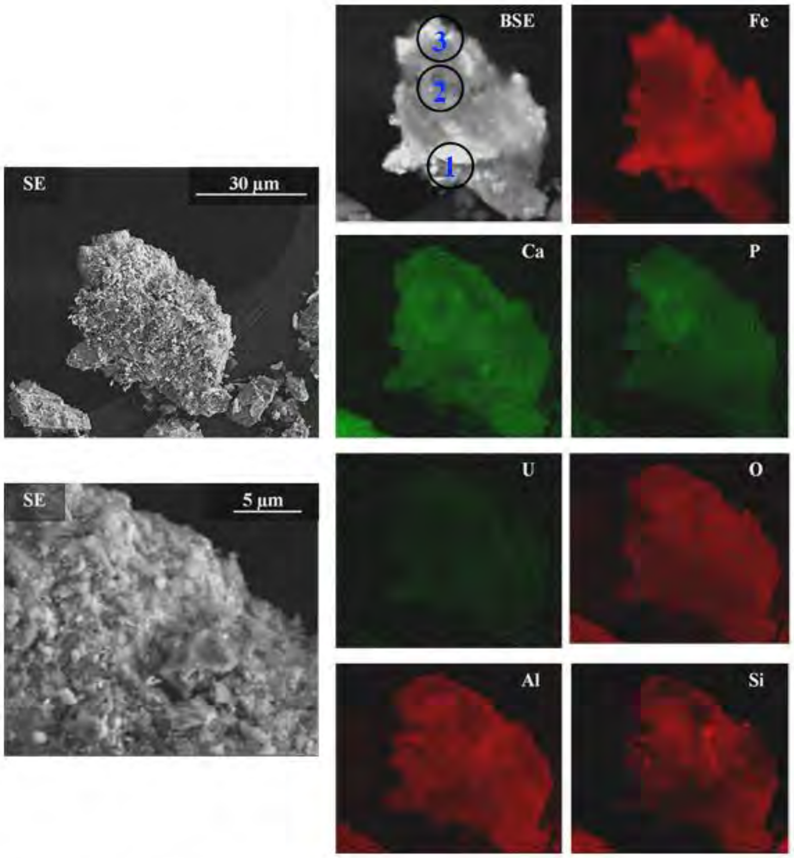
Samples B347C6, collected from depth interval I-001, and B347D8, collected from depth interval I-003, had several particles that demonstrated a slight degree of enhancement in uranium elemental mapping (Figure 5.26 through Figure 5.28). These particles appeared to be also composed of Ca, P, and Fe, as revealed by elemental mapping combined with EDX spectral data (see tables in Figure 5.26 through Figure 5.28). Based on elemental maps, Ca and P seem to be distributed uniformly throughout the selected particles. The EDX data, however, shows variation in the Fe content in Areas 1 and 3, unlike Area 2 (Figure 5.27). This variation could not be correlated to uranium due to weak contrast in the uranium-map. However, the U-maps appear to indicate that uranium is likely homogeneously distributed throughout the particles and not concentrated in “hot spots.” Such uniform distribution could indicate uranium-surface coating or the presence of uranium as sorbed species. Furthermore, mapping analysis of sample B347D8 demonstrates that uranium likely is associated with particles that contain P, Ca, and possibly Fe (Figure 5.28). Clearly, the particle on the left of the inserts in Figure 5.28, which appears to have content similar to calcium aluminum silicate phase, seems to lack uranium contrast. With respect to the morphology of these particles, the micrographs collected using the SE detector show small particles or aggregates on the surface of the large particles. The small aggregates do not appear to significantly vary in composition (see SE inserts in Figure 5.26 and Figure 5.27).

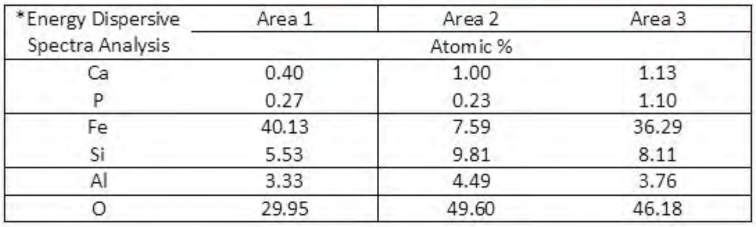


Energy Dispersive Spectra Analysis	Area 1	Area 2
	Atomic %	
Ca	0.32	0.34
P	0.20	0.34
Fe	33.86	24.13
Si	2.35	1.80
Al	1.20	0.84
O	21.43	22.68

*Undetectable levels of U from EDS analysis. EDS acquisition time was 60sec, Mapping acquisition time varied from 400-500seconds.

Figure 5.26. Sample B347C6, (collected from depth interval I-001, with total uranium concentration of 2.6 mg/kg [ALS1601062, accessed via the Enterprise Application to IDMS]), Area 1.





*Energy Dispersive Spectra Analysis	Area 1	Area 2	Area 3
		Atomic %	
Ca	0.40	1.00	1.13
P	0.27	0.23	1.10
Fe	40.13	7.59	36.29
Si	5.53	9.81	8.11
Al	3.33	4.49	3.76
O	29.95	49.60	46.18

*Undetectable levels of U from EDS analysis. EDS acquisition time was 60sec, Mapping acquisition time varied from 400-500seconds.

Figure 5.27. Sample B347C6 (collected from depth interval I-001, with total uranium concentration of 2.6-mg/kg [ALS1601062, accessed via the Enterprise Application to IDMS]), Area 2.

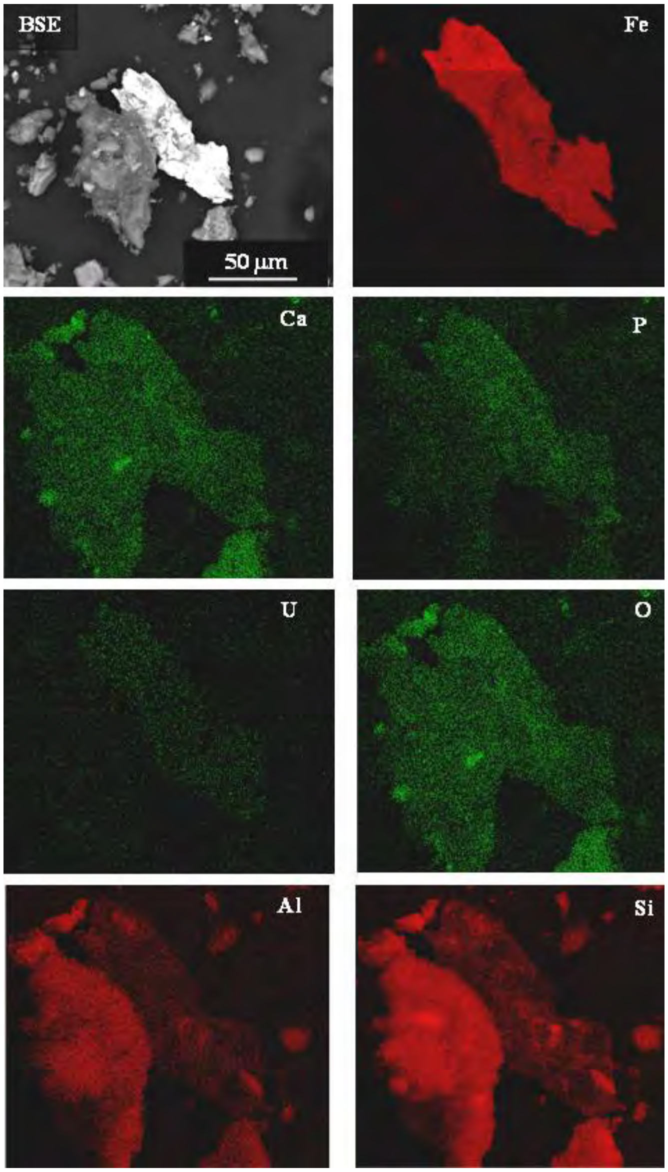


Figure 5.28. Sample 347D8 (collected from depth interval I-003, with total uranium concentration of 3.2 mg/kg [ALS1601062, accessed via the Enterprise Application to IDMS]).

Unlike the previous two samples, uranium was not detected in the B347F1&F3 sample, collected from depth interval I-004, although particles rich in Ca, P, and Fe in this sample were identified and examined. Figure 5.29 shows an example of such particles.

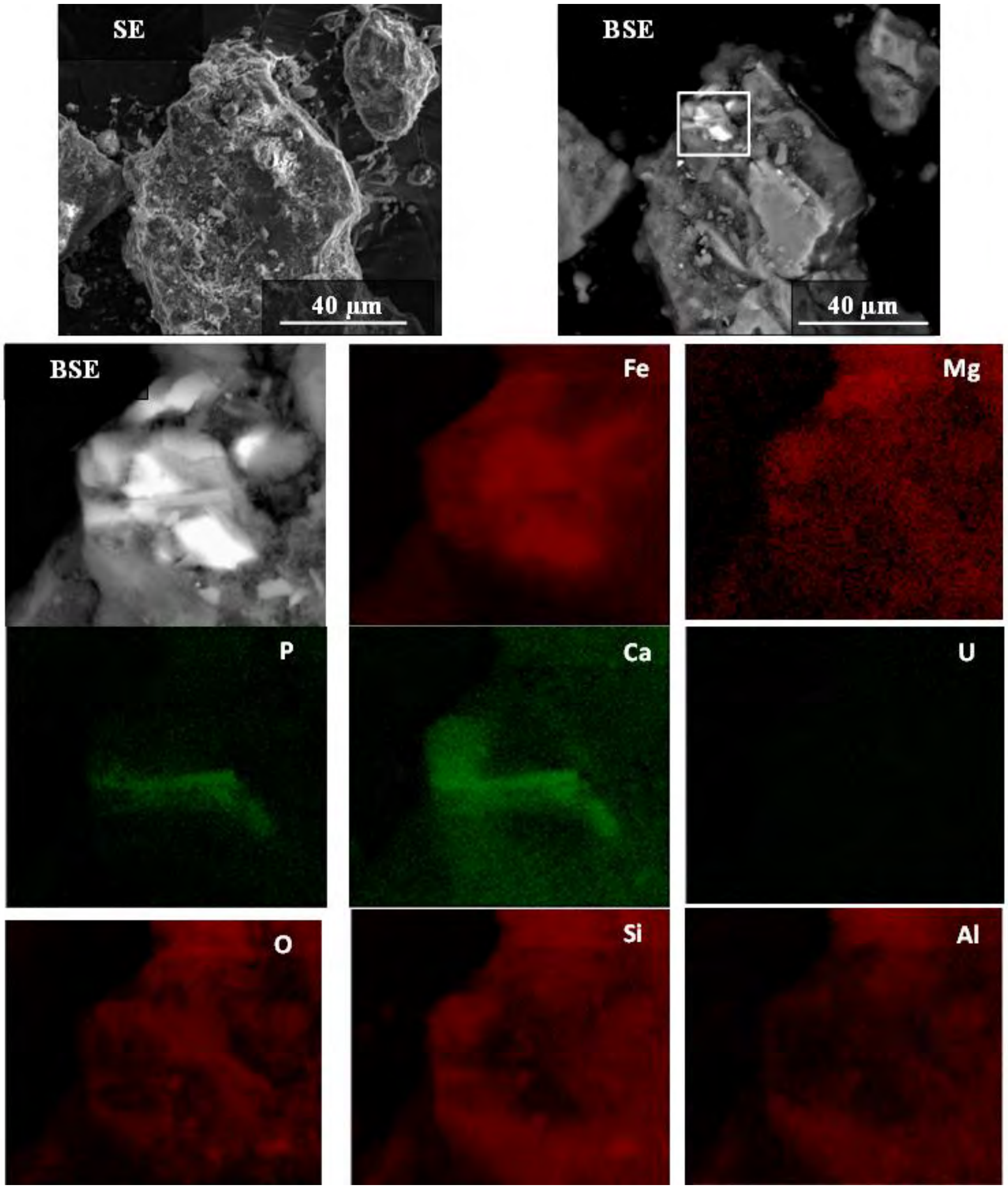


Figure 5.29. Sample B347F1&F3 (collected from depth interval I-004, with a total uranium concentration of 7.6 mg/kg [ALS1601062, accessed via the Enterprise Application to IDMS]).

5.4.2.2 Boreholes C9581 and C9582

SEM analysis of samples collected from boreholes C9581 (B347L4, depth interval I-004) and C9582 (B347P0, B347P5&P8, B347R1, B347R7, B347T7, depth intervals I-001 through I-006) did not reveal particles with detectable uranium concentration when EDX was used or enhancement in uranium elemental mapping, although equivalent time was used and an equivalent number of particles were investigated as in previous samples. Representatives of several particles examined from C9581 and C9582 are shown in Appendix D.

5.5 Phosphate Measurement

Phosphorus (and uranium) was analyzed in extracts taken from unleached samples from five sample intervals collected prior to phosphate treatment and both unleached and leached samples from six sample intervals collected following phosphate treatment. These samples were exposed to 0.5 M nitric acid for 15 minutes as the phosphorus extraction method. Table 5.2 and Table 5.3 summarize the phosphorus and uranium concentrations from these samples, and suggest that the post-treatment samples contain higher concentrations of phosphorus than the pre-treatment samples.

Table 5.2. Phosphate and uranium concentrations from 0.5 M nitric acid extraction.

			Unleached		Leached (Post-Column Test)	
Borehole ID	Sample Interval	HEIS Sample ID	Phosphorus (µg/g)	Uranium (µg/g)	Phosphorus (µg/g)[(a)]	Uranium (µg/g)[(a)]
			Pre-treatment Samples			
C8940	I-008	B31N31	576	4.44	--	--
C9451	I-001	B31N64	584	0.657	--	--
C9451	I-005	B31N87	600	17.4	--	--
C9451	I-007	B31N96[(a)]	561	8.1	--	--
C9451	I-008	B31NB3	532	5.28	--	--
			Post-treatment Samples			
C9580	I-001	B347C6	907	1.14	--	--
C9580	I-004	B347F1&F3	659	7.2	678	7.89
C9581	I-004	B347L4	923	3.19	--	--
C9582	I-002	B347P5&P8	362	43.6	362	33.3
C9582	I-003	B347R1	403	25.1	402	19.3
C9582	I-006	B347T7	988	19.3	911	18.7

-- = Post column test material unavailable.

(a) Results are the average of samples taken from the top and bottom of the columns.

(b) Post-leach test materials may have been consolidated with residual sample materials for this sample interval.

Table 5.3. Phosphorus concentrations extracted using 0.5 M nitric acid.

Sample Type	Number of Samples	Maximum (µg/g)	Minimum (µg/g)	Average (µg/g)	Standard Deviation (µg/g)
Pre-treatment Unleached	5	600	532	570.6	25.8
Post-treatment Unleached	6	988	362	707.0	275.5
Post-treatment Leached	8	968	346	588.1	154.8

5.6 Physical Property Results

Table 5.4 summarizes the hydraulic and physical property results from the bulk sediment samples.

Table 5.4. Hydraulic and physical properties of the bulk sediment samples

		Particle Size				Bulk		Saturated Hydraulic Conductivity
Borehole	Sample ID	% Gravel	% Sand	% Silt	% Clay	Density	Porosity	(cm/s)
C9580	B347C6	50.4	38.0	6.37	5.04	---	---	---
	B347D8	68.1	25.1	5.90	2.75	---	---	---
	B347F1, B347F3[a]	78.9	19.0	2.30	2.08	---	---	---
C9581	B347L4	55.6	37.1	4.39	3.10	---	---	---
C9582	B347P0	40.7	43.4	10.0	5.14	---	---	---
	B347P4	86.0	8.4	2.76	2.85	2.07	0.22	1.10E-03
	B347P5, B347P8[a]	84.7	13.6	2.74	2.32	---	---	---
	B347R0	72.5	22.6	2.52	2.32	2.21	0.17	1.46E-03
	B347R1	53.5	35.9	6.80	3.69	---	---	---
	B347R7	35.0	50.9	6.63	4.38	---	---	---
	B347T6	68.1	21.9	5.69	4.24	2.29	0.14	3.73E-06
	B347T7	73.9	23.0	3.40	2.06	---	---	---

--- Not analyzed

(a) Samples were composited after removal of gravel (>2 mm) fraction. The gravel fraction represents an average of the two samples. The sand, silt, and clay fractions are from the composite sample.

6.0 Summary

A series of laboratory analyses were applied to samples taken from boreholes installed after an initial stage (Stage A) of phosphate treatment in the field within the 300-FF-5 OU at the Hanford Site. The phosphate treatment was aimed at enhancing attenuation of uranium in the vadose zone and PRZ (Jacques 2016). Data from these tests, in comparison to data from pre-treatment samples, provide a means to quantify how uranium mobility was changed by the phosphate treatment. All sampled intervals were observed to be very wet and very coarse grained, containing 40% to 86% gravel by weight. Samples from boreholes C9580 and C9581 contained relatively low concentrations of uranium (ranging from 2.6 to 7.6 µg/g [ALS1601062 and ALS1601118]), while samples from borehole C9582 contained much higher uranium concentrations (ranging from 19 to 100 µg/g [ALS1601062 and ALS1601118]).

Sequential extraction results show that in all but two sample intervals (C9580 I-001 and C9582 I-004), more than 50% of the uranium mass was extracted by the weakest two (acetic acid) solutions. These results also show that in all but one sample interval (C9582 I-004), greater than 50% of the phosphate is associated with the harshest extraction solution (nitric acid), and in all sample intervals, 90% or more of the phosphate is associated with the two harshest solutions (oxalate and nitric acid combined). Thus, for most samples, less than 50% of the uranium was associated with extractions where phosphate was also removed from the sediment.

Labile uranium concentrations continued to increase in all samples, even after 66 days, indicating that equilibrium was not reached in these experiments. These results suggest that non-equilibrium, kinetically controlled leaching will occur under field conditions.

The flow-through column test results for all sample intervals tested, except those from borehole C9580 (I-004) and those from the lower most sample interval (I-006) of borehole C9582, show initial high concentration leaching that declines over time, and concentration increased following stop flow events. These data suggest that some uranium in these samples is still labile to rapid leaching and that kinetic leaching of uranium is expected during the initial high-concentration pulse and as it subsides. Results for sample intervals with lower uranium concentrations, C9580 (I-004) and C9582l (I-006), did not show an initial high concentration leaching response followed by a decrease in uranium concentrations over time. Instead, steady and then increasing uranium concentrations were observed during column flow periods. Concentration increases were also observed during stop flow events. These results suggest that the uranium in these samples is primarily released through kinetically controlled mechanisms.

Mineral phase and surface coating analyses suggest that all samples except those from the upper portion of borehole C9580 (i.e., sample intervals I-001 and I-003) were likely to have U(VI) absorbed on quartz, uranyl-tricarbonate(s) adsorbed on calcium carbonate minerals, and U(VI)-phosphate adsorbed on montmorillonite. None of the samples analyzed by fluorescence spectroscopy showed the characteristic features of crystalline uranyl-phosphate solid phases, which usually occur as discrete “hot” spots in the sediments. The samples from the upper portion of borehole C9580 (i.e., sample intervals I-001 and I-003), as well as some spots in the lower portion of the borehole (sample interval I-004), contained low concentrations of uranium with poorly resolved spectra that may be similar to U(VI) oxyhydroxides. None of the samples analyzed by fluorescence spectroscopy showed the characteristic features of crystalline uranyl-phosphate solid phases, which usually occur as discrete “hot” spots in the sediments.

SEM/EDX and electron microprobe analyses found uranium in association with particles from only two samples: those from the upper portion (I-001 and I-003) of borehole C9580. These same particles also appeared to be composed of Ca, P, and Fe. The analyses also found uranium to be homogeneously distributed throughout these particles, suggesting a uranium surface coating or the presence of uranium as a sorbed species.

The results herein provide data to quantify the uranium mobility in selected samples collected after the Stage A phosphate treatment in the field for the 300-FF-5 OU. The experimental methods for this effort were the same as those applied previously to samples collected in adjacent boreholes prior to the phosphate treatment. Therefore, these results are suitable for comparison to results from pre-treatment laboratory tests for evaluating the effect of the field phosphate treatment on uranium mobility.

7.0 References

Brown CF, W Um, and RJ Serne. 2008. *Uranium Contamination in the 300 Area: Emergent Data and Their Impact on the Source Term Conceptual Model*. PNNL-17793, Pacific Northwest National Laboratory, Richland, Washington.

Dong W, W Ball, C Liu, Z Wang, and A Stone. 2005. “Influence of Calcite and Dissolved Calcium on U(VI) Sorption to a Hanford Subsurface Sediment.” *Environ. Sci. Technol.* 39:7949-7955.

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*. U.S. Environmental Protection Agency, Region 10, U.S.

Department of Energy, Richland Operations Office, Richland, Washington. Available at http://pdw.hanford.gov/arpir/pdf.cfm?accession=0087180.

Ilton ES, Z Wang, JF Boily, O Qafoku, KM Rosso, and SC Smith. 2012. "The Effect of pH and Time on the Extractability and Speciation of Uranium(VI) Sorbed to SiO_2." *Environ. Sci. Technol.* 46(12):6604-6611.

Jacques DI. 2016. *300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report*. SGW-59455, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington.

Johnson TC and JN Thomle. 2016. *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography*. PNNL-SA-25232, Pacific Northwest National Laboratory, Richland, Washington.

Kohler M, DP Curtis, DE Meece, and JA Davis. 2004. "Methods for Estimating Adsorbed Uranium (VI) and Distribution Coefficients of Contaminated Sediments." *Environ. Sci. Technol.* 38:240-247.

Ma R, C Zheng, H Prommer, J Greskowiak, C Liu, J Zachara, and M Rockhold. 2010. "A field-scale reactive transport model for U(VI) migration influenced by coupled multirate mass transfer and surface complexation reactions." *Water Resour. Res.* 46, W05509. doi:10.1029/2009WR008168.

Serne RJ, CF Brown, HT Schaef, EM Pierce, J Lindberg, Z Wang, P Gassman, and J Catalano. 2002. *300 Area Uranium Leach and Adsorption Project*. PNNL-14022, Pacific Northwest National Laboratory, Richland, Washington.

Sherwood AR. 2014. S*ampling Instructions for the 300-FF-5 Operable Unit Supplemental post ROD Field Investigation*. SGW-56993, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington.

Snyder MMV and KJ Cantrell. 2015. *Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8933, C8936 and C8938*. PNNL-24308. Pacific Northwest National Laboratory, Richland, Washington.

Snyder MMV and GV Last. 2015. *Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8940 and C9451*. PNNL-24911, Pacific Northwest National Laboratory, Richland, Washington.

Szecsody JE, JS Fruchter, ML Rockhold, JP McKinley, M Oostrom, VR Vermeul, RC Moore, MT Covert, CA Burns, TW Wietsma, MD Williams, AT Breshears, L Zhong, and BJ Garcia. 2009. *Sequestration of Sr-90 Subsurface Contamination in the Hanford 100-N Area by Surface Infiltration of a Ca-Citrate-Phosphate Solution*. PNNL-18303, Pacific Northwest National Laboratory, Richland, Washington.

Szecsody JE, VR Vermeul, JS Fruchter, MD Williams, ML Rockhold, NP Qafoku, and JL Phillips. 2010. *Hanford 100-N Area In Situ Apatite and Phosphate Emplacement by Groundwater and Jet Injection: Geochemical and Physical Core Analysis*. PNNL-19524, Pacific Northwest National Laboratory, Richland, Washington.

Szecsody JE, VR Vermeul, L Zhong, JS Fruchter, M Oostrom, and MD Williams. 2012. *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediments*. PNNL-21733, Pacific Northwest National Laboratory, Richland, Washington.

Troyer LD, F Maillot, Z Wang, Z Wang, VS Mehta, DE Giammar, and JG Catalano. 2016. “Effect of phosphate on U(VI) sorption to montmorillonite: Ternary complexation and precipitation barriers.” *Geochim. Cosmochim. Acta* 175:86-99.

Wang Z, JM Zachara, W Yantasee, PL Gassman, CX Liu, and AG Joly. 2004. “Cryogenic laser induced fluorescence characterization of U(VI) in Hanford vadose zone pore waters.” *Environ. Sci. Technol.* 38(21):5591-5597.

Wang Z, JM Zachara, JP McKinely, and SC Smith. 2005. “Cryogenic Laser Induced U(VI) Fluorescence Studies of a U(VI) Substituted Natural Calcite: Implications to U(VI) Speciation in Contaminated Hanford Sediments.” *Environ. Sci. Technol.* 39:2651-2659.

Wang Z, JM Zachara, C Liu, PL Gassman, AR Felmy, and SB Clark. 2008. “A cryogenic fluorescence spectroscopic study of uranyl carbonate, phosphate and oxyhydroxide minerals.” *Radiochim. Acta* 96(9-11):591-598.

Wang Z, JM Zachara, JF Boily, Y Xia, TC Resch, DA Moore, and C Liu. 2011. “Determining Individual Mineral Contributions To U(VI) Adsorption In A Contaminated Aquifer Sediment: A Fluorescence Spectroscopy Study.” *Geochim. Cosmochim. Acta* 75(10):2965-2979.

Whitley KM. 2015. *Description of Work for the Installation of Three Boreholes in the 300-FF-5 Groundwater Operable Unit, FY2016*. SGW-59369, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington.

Appendix A

Case Narrative Analytical and Quality Control Results

Introduction

Between January 26, 2016 and April 7, 2016 samples were received from the 300-FF5 for chemical analyses.

Analytical Results/Methodology

The analyses for this project were performed at the 331 building located in the 300 Area of the Hanford Site. The analyses were performed according to Pacific Northwest National Laboratory (PNNL) approved procedures and/or nationally recognized test procedures. The data sets include the sample identification numbers, analytical results, estimated quantification limits (EQL), and quality control data.

Quality Control

The preparatory and analytical quality control requirements, calibration requirements, acceptance criteria, and failure actions are defined in the on-line QA plan "Conducting Analytical Work in Support of Regulatory Programs" (CAWSRP). This QA plan implements the Hanford Analytical Services Quality Assurance Requirements Documents (HASQARD) for PNNL.

Definitions

Dup	Duplicate
RPD	Relative Percent Difference
NR	No Recovery (percent recovery less than zero)
ND	Non-Detectable
%REC	Percent Recovery

Sample Receipt

Samples were received with a chain of custody (COC) and were analyzed according to the sample identification numbers supplied by the client. All Samples were refrigerated upon receipt until prepared for analysis.

All samples were received with custody seals intact unless noted in the Case Narrative.

Holding Times

Holding time is defined as the time from sample preparation to the time of analyses. The prescribed holding times were met for all analytes unless noted in the Case Narrative.

Analytical Results

All reported analytical results meet the requirements of the CAW or client specified SOW unless noted in the case narrative.

Case Narrative Report

Duplicate (DUP):

Duplicate RPD for Calcium for 1602078-31 (49%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity.

Duplicate RPD for Manganese for 1602078-46 (41%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity.

Duplicate RPD for Manganese for 1602078-31 (74%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity.

Duplicate RPD for Phosphorus for 1602078-20 (49%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity.

Duplicate RPD for Iron for 1602049-22 (74%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity.

Duplicate RPD for Iron for 1602049-47 (48%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity.

Duplicate RPD for Iron for 1602049-71 (71%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity.

Duplicate RPD for Manganese for 1602049-22 (59%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity.

Duplicate RPD for Phosphorus for 1602049-71 (52%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity.

Duplicate RPD for Phosphorus for 1602049-95 (84%) was above the acceptable limit (35%) for ICP-OES Vadose-NP. Duplicate failure may be due to sample heterogeneity

Post-spike recovery for Aluminum (937%) was outside acceptable limitis (75-125%) for sample 6D13005-PS1 for ICP-OES Vadose-AE. The concentration of the analyate in the original sample was greater than 5 times the spiked concentration. There should be no impact to the data as reported.

Post-spike recovery for Calcium (439%) was outside acceptable limitis (75-125%) for sample 6D13005-PS1 for ICP-OES Vadose-AE. The concentration of the analyate in the original sample was greater than 5 times the spiked concentration. There should be no impact to the data as reported.

Post-spike recovery for Iron (362%) was outside acceptable limitis (75-125%) for sample 6D13005-PS1 for ICP-OES Vadose-AE. The concentration of the analyate in the original sample was greater than 5 times the spiked concentration. There should be no impact to the data as reported.

Post-spike recovery for Manganese (150%) was outside acceptable limitis (75-125%) for sample 6D13005-PS1 for ICP-OES Vadose-AE. The concentration of the analyate in the original sample was greater than 5 times the spiked concentration. There should be no impact to the data as reported.

Post-spike recovery for Phosphate (285%) was outside acceptable limitis (75-125%) for sample 6D13005-PS1 for ICP-OES Vadose-AE. The concentration of the analyate in the original sample was greater than 5 times the spiked concentration. There should be no impact to the data as reported.

Post Spike (PS):

Preparation Blank:

Preparation Blank for Aluminum was greater than EQL for 1602078-59 for ICP-OES Vadose-NP. The measured concentration in the preparation blank was less than 20 times the concetration measured in the samples. There should be no impact to data as reported.

Preparation Blank for Calcium was greater than EQL for 1602078-43 for ICP-OES Vadose-NP. The measured concentration in the preparation blank was less than 20 times the concetration measured in the samples. There should be no impact to data as reported.

Preparation Blank for Calcium was greater than EQL for 1602078-55 for ICP-OES Vadose-NP. The measured concentration in the preparation blank was less than 20 times the concetration measured in the samples. There should be no impact to data as reported.

Preparation Blank for Calcium was greater than EQL for 1602078-59 for ICP-OES Vadose-NP. The measured concentration in the preparation blank was less than 20 times the concetration measured in the samples. There should be no impact to data as reported.

Preparation Blank for Iron was greater than EQL for 1602078-59 for ICP-OES Vadose-NP. The measured concentration in the preparation blank was less than 20 times the concetration measured in the samples. There should be no impact to data as reported.

Preparation Blank for Manganese was greater than EQL for 1602078-59 for ICP-OES Vadose-NP. The measured concentration in the preparation blank was less than 20 times the concetration measured in the samples. There should be no impact to data as reported
The Serial Dilution recovery for Uranium-238 (24.2%) was outside acceptable limits (within 10%) in E604022-SRD1 for ICPMS-Tc_U-AE. The sample concentration was not greater than 100 times the IDL. There should be no impact to data as reported.

Other QC Criteria:

Wet Chemistry

Moisture Content (% by Weight) by PNNL-ESL-WC

Client ID.
Lab ID

Results
EQL
Analyzed
Batch

1601046-01
B347C6
9.50E0
3/16/16
6A31001
N/A

1601046-03
B347D8
6.89E0
3/16/16
6A31001
N/A

1601046-04
B347F1
1.75E1
3/16/16
6A31001
N/A

1601046-05
B347F3
1.21E1
3/16/16
6A31001
N/A

1601046-22
B347L2
6.36E0
3/16/16
6A31001
N/A

1601046-24
B347L4
5.56E0
3/16/16
6A31001
N/A

1601046-29
B347P0
6.92E0
3/16/16
6A31001
N/A

1601046-32
B347P5
1.10E1
3/16/16
6A31001
N/A

1601046-36
B347R1
7.72E0
3/16/16
6A31001
N/A

1601046-40
B347R7
1.08E1
3/16/16
6A31001
N/A

1601046-45
B347T7
8.13E0
3/16/16
6A31001
N/A

Total Metals by PNNL-ESL-ICP-OES/Acid Extract

Lab ID: 1604032-01
Client ID. B31N31

CAS #	Analyte	Results	Units	EQL	Analyzed	Method	Batch
7429-90-5	Aluminum	1.38E3	ug/g dry	2.94E0	4/13/16	PNNL-ESL-ICP-OES	6D13005
7440-70-2	Calcium	3.14E3	ug/g dry	3.05E0	4/13/16	PNNL-ESL-ICP-OES	6D13005
7439-89-6	Iron	5.98E2	ug/g dry	7.90E-1	4/13/16	PNNL-ESL-ICP-OES	6D13005
7439-96-5	Manganese	6.57E1	ug/g dry	2.62E-1	4/13/16	PNNL-ESL-ICP-OES	6D13005
7723-14-0	Phosphorus	5.76E2	ug/g dry	3.88E0	4/13/16	PNNL-ESL-ICP-OES	6D13005

Lab ID: 1604032-02
Client ID. B31N64

CAS #	Analyte	Results	Units	EQL	Analyzed	Method	Batch
7429-90-5	Aluminum	6.12E2	ug/g dry	2.80E0	4/13/16	PNNL-ESL-ICP-OES	6D13005
7440-70-2	Calcium	2.97E3	ug/g dry	2.91E0	4/13/16	PNNL-ESL-ICP-OES	6D13005
7439-89-6		4.71E2	ug/g dry		4/13/16	PNNL-ESL-ICP-OES	

Iron

6D13005
7.53E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

4.84E1

Manganese

6D13005
2.50E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.84E2

Phosphorus

6D13005
3.70E0

1604032-03
Lab ID:
Client ID.
B31N87
7429-90-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

9.34E2

Aluminum

6D13005
2.84E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

3.31E3

Calcium

6D13005
2.95E0

7439-89-6

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.06E2

Iron

6D13005
7.63E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

8.54E1

Manganese

6D13005
2.54E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

6.00E2

Phosphorus

6D13005
3.75E0

1604032-04
Lab ID:
Client ID.
B31N96
7429-90-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

8.60E2

Aluminum

6D13005
2.91E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

3.31E3

Calcium

6D13005
3.02E0

7439-89-6

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

7.04E2

Iron

6D13005
7.83E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

1.08E2

Manganese

6D13005
2.60E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.61E2

Phosphorus

6D13005
3.85E0

1604032-05
Lab ID:
Client ID.
B31NB3
7429-90-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

8.60E2

Aluminum

6D13005
2.80E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

2.58E3

Calcium

6D13005
2.90E0

7439-89-6

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

4.46E2

Iron

6D13005
7.52E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.72E1

Manganese

6D13005
2.50E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.32E2

Phosphorus

6D13005
3.70E0

1604032-06
Lab ID:
Client ID.
B347C6
7429-90-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

7.43E2

Aluminum

6D13005
2.80E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

2.89E3

Calcium

6D13005
2.90E0

7439-89-6

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

1.12E3

Iron

6D13005
7.52E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

8.24E1

Manganese

6D13005
2.50E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

9.07E2

Phosphorus

6D13005
3.69E0

1604032-07
Lab ID:
Client ID.
B347F1 and F3
7429-90-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

9.74E2

Aluminum

6D13005
2.74E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

2.76E3

Calcium

6D13005
2.85E0

7439-89-6

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.07E2

Iron

6D13005
7.38E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

7.14E1

Manganese

6D13005
2.45E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

6.59E2

Phosphorus

6D13005
3.63E0

1604032-08
Lab ID:
Client ID.
B347L4
7429-90-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

9.13E2

Aluminum

6D13005
2.78E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

2.83E3

Calcium

6D13005
2.88E0

7439-89-6

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.50E2

Iron

6D13005
7.46E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

6.78E1

Manganese

6D13005
2.48E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

9.23E2

Phosphorus

6D13005
3.67E0

Total Metals by PNNL-ESL-ICP-OES/Acid Extract

Lab ID: 1604032-09
Client ID. B347P5 and P8

CAS #	Analyte	Results	Units	EQL	Analyzed	Method	Batch
7429-90-5	Aluminum	3.51E3	ug/g dry	2.77E0	4/13/16	PNNL-ESL-ICP-OES	6D13005
7440-70-2	Calcium	4.64E3	ug/g dry	2.88E0	4/13/16	PNNL-ESL-ICP-OES	6D13005
7439-89-6	Iron	4.67E2	ug/g dry	7.45E-1	4/13/16	PNNL-ESL-ICP-OES	6D13005
7439-96-5	Manganese	7.36E1	ug/g dry	2.48E-1	4/13/16	PNNL-ESL-ICP-OES	6D13005
7723-14-0	Phosphorus	3.62E2	ug/g dry	3.66E0	4/13/16	PNNL-ESL-ICP-OES	6D13005

Lab ID: 1604032-10
Client ID. B347R1

CAS #	Analyte	Results	Units	EQL	Analyzed	Method	Batch
7429-90-5	Aluminum	2.23E3	ug/g dry	2.86E0	4/13/16	PNNL-ESL-ICP-OES	6D13005
7440-70-2	Calcium	3.51E3	ug/g dry	2.96E0	4/13/16	PNNL-ESL-ICP-OES	6D13005
7439-89-6		5.20E2	ug/g dry		4/13/16	PNNL-ESL-ICP-OES	

Iron

6D13005
7.68E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.70E1

Manganese

6D13005
2.55E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

4.03E2

Phosphorus

6D13005
3.77E0

1604032-11
Lab ID:
Client ID.
B347T7
7429-90-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

2.24E3

Aluminum

6D13005
2.80E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

2.86E3

Calcium

6D13005
2.91E0

7439-89-6

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.28E2

Iron

6D13005
7.53E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

6.29E1

Manganese

6D13005
2.50E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

9.88E2

Phosphorus

6D13005
3.70E0

1604032-12
Lab ID:
Client ID.
B347F1 and F3 TOP
7429-90-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

1.15E3

Aluminum

6D13005
2.64E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

3.02E3
Calcium
6D13005
2.74E0
7439-89-6
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
5.71E2
Iron
6D13005
7.11E-1
7439-96-5
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
8.57E1
Manganese
6D13005
2.36E-1
7723-14-0
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
6.96E2
Phosphorus
6D13005
3.49E0

1604032-13
Lab ID:
Client ID.
B347F1 and F3 BOTTOM

7429-90-5
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
1.06E3
Aluminum
6D13005
2.89E0
7440-70-2
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
2.85E3
Calcium
6D13005
3.01E0
7439-89-6
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
5.96E2
Iron
6D13005
7.78E-1
7439-96-5
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
7.99E1
Manganese
6D13005
2.59E-1
7723-14-0
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
6.60E2
Phosphorus
6D13005
3.83E0

1604032-14
Lab ID:
Client ID.
B347P5 and P8 TOP

7429-90-5
ug/g dry
4/13/16

PNNL-ESL-ICP-OES

3.90E3

Aluminum

6D13005
2.75E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

4.84E3

Calcium

6D13005
2.85E0

7439-89-6

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.01E2

Iron

6D13005
7.39E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

9.42E1

Manganese

6D13005
2.46E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

3.46E2

Phosphorus

6D13005
3.63E0

1604032-15
Lab ID:
Client ID.
B347P5 and P8 BOTTOM
7429-90-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

4.01E3

Aluminum

6D13005
2.96E0

7440-70-2

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.42E3

Calcium

6D13005
3.07E0

7439-89-6

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

5.72E2

Iron

6D13005
7.95E-1

7439-96-5

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

9.38E1

Manganese

6D13005
2.64E-1

7723-14-0

ug/g dry
4/13/16

PNNL-ESL-ICP-OES

3.78E2

Phosphorus

6D13005
3.91E0

1604032-16
Lab ID:
Client ID.
B347R1 TOP

7429-90-5
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
2.38E3
Aluminum
6D13005
2.77E0

7440-70-2
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
3.52E3
Calcium
6D13005
2.87E0

7439-89-6
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
6.15E2
Iron
6D13005
7.44E-1

7439-96-5
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
6.05E1
Manganese
6D13005
2.47E-1

Total Metals by PNNL-ESL-ICP-OES/Acid Extract

Lab ID:	Client ID.	CAS #	Analyte	Method	Results	Units	EQL	Analyzed	Batch
1604032-16	**B347R1 TOP**	7723-14-0	Phosphorus	PNNL-ESL-ICP-OES	4.14E2	ug/g dry	3.66E0	4/13/16	6D13005
1604032-17	**B347R1 BOTTOM**	7429-90-5	Aluminum	PNNL-ESL-ICP-OES	2.20E3	ug/g dry	2.53E0	4/13/16	6D13005
		7440-70-2	Calcium	PNNL-ESL-ICP-OES	3.56E3	ug/g dry	2.63E0	4/13/16	6D13005
		7439-89-6	Iron	PNNL-ESL-ICP-OES	5.78E2	ug/g dry	6.80E-1	4/13/16	6D13005
		7439-96-5	Manganese	PNNL-ESL-ICP-OES	5.81E1	ug/g dry	2.26E-1	4/13/16	6D13005
		7723-14-0	Phosphorus	PNNL-ESL-ICP-OES	3.90E2	ug/g dry	3.34E0	4/13/16	6D13005
1604032-18	**B347T7 TOP**	7429-90-5	Aluminum	PNNL-ESL-ICP-OES	1.98E3	ug/g dry	3.10E0	4/13/16	6D13005
		7440-70-2							

ug/g dry
4/13/16
PNNL-ESL-ICP-OES
2.63E3
Calcium
6D13005
3.22E0
7439-89-6
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
5.30E2
Iron
6D13005
8.34E-1
7439-96-5
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
5.42E1
Manganese
6D13005
2.77E-1
7723-14-0
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
8.53E2
Phosphorus
6D13005
4.10E0

1604032-19
Lab ID:
Client ID.
B347T7 BOTTOM

7429-90-5
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
2.60E3
Aluminum
6D13005
2.71E0
7440-70-2
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
3.09E3
Calcium
6D13005
2.82E0
7439-89-6
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
6.26E2
Iron
6D13005
7.30E-1
7439-96-5
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
7.04E1
Manganese
6D13005
2.42E-1
7723-14-0
ug/g dry
4/13/16
PNNL-ESL-ICP-OES
9.68E2
Phosphorus
6D13005
3.59E0

Radionuclides by ICP-MS/Acid Extract

CAS #	Analyte	Results	Units	EQL	Analyzed	Method	Batch
Lab ID: 1604032-01	**Client ID. B31N31**						
U-238	Uranium 238	4.44E0	ug/g dry	1.54E-1	4/12/16	PNNL-ESL-ICPMS	6D12001
Lab ID: 1604032-02	**Client ID. B31N64**						
U-238	Uranium 238	6.57E-1	ug/g dry	1.47E-2	4/12/16	PNNL-ESL-ICPMS	6D12001
Lab ID: 1604032-03	**Client ID. B31N87**						
U-238	Uranium 238	1.74E1	ug/g dry	1.49E-1	4/12/16	PNNL-ESL-ICPMS	6D12001
Lab ID: 1604032-04	**Client ID. B31N96**						
U-238	Uranium 238	8.10E0	ug/g dry	1.53E-1	4/12/16	PNNL-ESL-ICPMS	6D12001
Lab ID: 1604032-05	**Client ID. B31NB3**						
U-238	Uranium 238	5.28E0	ug/g dry	1.47E-1	4/12/16	PNNL-ESL-ICPMS	6D12001
Lab ID: 1604032-06	**Client ID. B347C6**						
U-238		1.14E0	ug/g dry		4/12/16	PNNL-ESL-ICPMS	

Uranium 238

6D12001
1.47E-2

1604032-07
Lab ID:
Client ID.
B347F1 and F3
U-238

ug/g dry
4/12/16

PNNL-ESL-ICPMS

7.20E0

Uranium 238

6D12001
1.44E-1

1604032-08
Lab ID:
Client ID.
B347L4
U-238

ug/g dry
4/12/16

PNNL-ESL-ICPMS

3.19E0

Uranium 238

6D12001
1.46E-1

1604032-09
Lab ID:
Client ID.
B347P5 and P8
U-238

ug/g dry
4/12/16

PNNL-ESL-ICPMS

4.36E1

Uranium 238

6D12001
7.28E-1

1604032-10
Lab ID:
Client ID.
B347R1
U-238

ug/g dry
4/12/16

PNNL-ESL-ICPMS

2.51E1

Uranium 238

6D12001
7.50E-1

1604032-11
Lab ID:
Client ID.
B347T7
U-238

ug/g dry
4/12/16

PNNL-ESL-ICPMS

1.93E1

Uranium 238

6D12001
7.35E-1

1604032-12
Lab ID:
Client ID.
B347F1 and F3 TOP
U-238

ug/g dry
4/12/16

PNNL-ESL-ICPMS

8.05E0

Uranium 238

6D12001
1.39E-1

1604032-13
Lab ID:
Client ID.
B347F1 and F3 BOTTOM

U-238
ug/g dry
4/12/16
PNNL-ESL-ICPMS
7.72E0
Uranium 238
6D12001
1.52E-1

1604032-14
Lab ID:
Client ID.
B347P5 and P8 TOP
U-238
ug/g dry
4/12/16
PNNL-ESL-ICPMS
3.38E1
Uranium 238
6D12001
7.22E-1

1604032-15
Lab ID:
Client ID.
B347P5 and P8 BOTTOM
U-238
ug/g dry
4/12/16
PNNL-ESL-ICPMS
3.28E1
Uranium 238
6D12001
7.76E-1

1604032-16
Lab ID:
Client ID.
B347R1 TOP
U-238
ug/g dry
4/12/16
PNNL-ESL-ICPMS
2.18E1
Uranium 238
6D12001
7.27E-1

1604032-17
Lab ID:
Client ID.
B347R1 BOTTOM
U-238
ug/g dry
4/12/16
PNNL-ESL-ICPMS
1.68E1
Uranium 238
6D12001
6.64E-1

1604032-18
Lab ID:
Client ID.
B347T7 TOP
U-238
ug/g dry
4/12/16
PNNL-ESL-ICPMS
1.60E1
Uranium 238
6D12001
1.63E-1

1604032-19
Lab ID:
Client ID.
B347T7 BOTTOM
U-238
ug/g dry
4/12/16
PNNL-ESL-ICPMS
2.13E1
Uranium 238
6D12001

7.13E-1

Total Metals by PNNL-ESL-ICP-OES and Uranium by PNNL-ESL-ICPMS/Sequential Extraction

LabNumber	SampleName	Analyte	Result	EQL	Analyzed
			ug/g	ug/g	
1602078-23	B347C6 oxalate	Aluminum	533.2	4.1	3/16/2016
1602078-24	B347D8 oxalate	Aluminum	588.6	4.2	3/16/2016
1602078-25	B347F1 and F3 oxalate	Aluminum	756.5	4.4	3/16/2016
1602078-26	B347L4 oxalate	Aluminum	820.3	3.9	3/16/2016
1602078-27	B347P0 oxalate	Aluminum	2157.3	4.5	3/16/2016
1602078-28	B347P5 and P8 oxalate	Aluminum	3314.1	4.8	3/16/2016
1602078-29	B347R1 oxalate	Aluminum	2338.3	4.4	3/16/2016
1602078-53	B347R7 oxalate	Aluminum	2907.6	43.2	4/19/2016
1602078-30	B347T7 oxalate	Aluminum	2708.2	4.3	3/16/2016
1602078-34	B347C6 nitric acid	Aluminum	7285.1	3.7	3/16/2016
1602078-35	B347D8 nitric acid	Aluminum	7003.0	4.5	3/16/2016
1602078-36	B347F1 and F3 nitric acid	Aluminum	8830.6	4.0	3/16/2016
1602078-37	B347L4 nitric acid	Aluminum	123.7	3.5	3/16/2016
1602078-38	B347P0 nitric acid	Aluminum	8523.9	3.7	3/16/2016
1602078-39	B347P5 and P8 nitric acid	Aluminum	9599.6	3.7	3/16/2016
1602078-40	B347R1 nitric acid	Aluminum	6719.2	3.7	3/16/2016
1602078-57	B347R7 nitric acid	Aluminum	10233.2	35.8	4/19/2016
1602078-41	B347T7 nitric acid	Aluminum	8457.3	3.6	3/16/2016
1602078-01	B347C6 weak acetic acid	Calcium	1657.1	0.7	3/16/2016
1602078-02	B347D8 weak acetic acid	Calcium	1499.0	0.7	3/16/2016
1602078-03	B347F1 and F3 weak acetic acid	Calcium	1393.5	0.7	3/16/2016
1602078-04	B347L4 weak acetic acid	Calcium	1453.4	0.7	3/16/2016
1602078-05	B347P0 weak acetic acid	Calcium	2153.4	0.7	3/16/2016
1602078-06	B347P5 and P8 weak acetic acid	Calcium	2522.3	0.7	3/16/2016
1602078-07	B347R1 weak acetic acid	Calcium	1849.1	0.7	3/16/2016
1602078-45	B347R7 weak acetic acid	Calcium	1192.1	0.7	4/19/2016
1602078-08	B347T7 weak acetic acid	Calcium	1301.2	0.7	3/16/2016
1602078-12	B347C6 strong acetic acid	Calcium	465.8	0.8	3/16/2016
1602078-13	B347D8 strong acetic acid	Calcium	498.9	0.8	3/16/2016
1602078-14	B347F1 and F3 strong acetic acid	Calcium	401.5	0.8	3/16/2016
1602078-15	B347L4 strong acetic acid	Calcium	502.2	0.8	3/16/2016
1602078-16	B347P0 strong acetic acid	Calcium	853.3	0.8	3/16/2016
1602078-17	B347P5 and P8 strong acetic acid	Calcium	1817.9	0.8	3/16/2016
1602078-18	B347R1 strong acetic acid	Calcium	692.6	0.8	3/16/2016
1602078-49	B347R7 strong acetic acid	Calcium	644.0	0.0	4/19/2016
1602078-19	B347T7 strong acetic acid	Calcium	555.6	0.8	3/16/2016
1602078-23	B347C6 oxalate	Calcium	2.2	0.8	3/16/2016
1602078-24	B347D8 oxalate	Calcium	1.5	0.9	3/16/2016
1602078-25	B347F1 and F3 oxalate	Calcium	2.0	0.9	3/16/2016
1602078-26	B347L4 oxalate	Calcium	2.9	0.8	3/16/2016
1602078-27	B347P0 oxalate	Calcium	52.6	0.9	3/16/2016
1602078-28	B347P5 and P8 oxalate	Calcium	98.3	1.0	3/16/2016
1602078-29	B347R1 oxalate	Calcium	15.5	0.9	3/16/2016
1602078-53	B347R7 oxalate	Calcium	75.4	0.9	4/19/2016
1602078-30	B347T7 oxalate	Calcium	25.7	0.9	3/16/2016
1602078-34	B347C6 nitric acid	Calcium	4976.3	0.8	3/16/2016
1602078-35	B347D8 nitric acid	Calcium	4714.6	0.9	3/16/2016
1602078-36	B347F1 and F3 nitric acid	Calcium	4764.2	0.8	3/16/2016
1602078-37	B347L4 nitric acid	Calcium	5199.0	0.7	3/16/2016
1602078-38	B347P0 nitric acid	Calcium	4768.0	0.8	3/16/2016
1602078-39	B347P5 and P8 nitric acid	Calcium	5423.9	0.8	3/16/2016
1602078-40	B347R1 nitric acid	Calcium	4627.8	0.7	3/16/2016
1602078-57	B347R7 nitric acid	Calcium	5983.8	0.7	4/19/2016
1602078-41	B347T7 nitric acid	Calcium	5242.7	0.7	3/16/2016
1602078-01	B347C6 weak acetic acid	Iron	0.3	0.2	3/16/2016

1602078-02	B347D8 weak acetic acid	Iron	0.9	0.2	3/16/2016
1602078-03	B347F1 and F3 weak acetic acid	Iron	1.8	0.2	3/16/2016
1602078-04	B347L4 weak acetic acid	Iron	ND	0.2	3/16/2016
1602078-05	B347P0 weak acetic acid	Iron	16.0	0.2	3/16/2016
1602078-06	B347P5 and P8 weak acetic acid	Iron	7.2	0.2	3/16/2016
1602078-07	B347R1 weak acetic acid	Iron	7.3	0.2	3/16/2016
1602078-45	B347R7 weak acetic acid	Iron	ND	0.2	4/19/2016
1602078-08	B347T7 weak acetic acid	Iron	ND	0.2	3/16/2016
1602078-12	B347C6 strong acetic acid	Iron	2603.8	2.4	3/16/2016
1602078-13	B347D8 strong acetic acid	Iron	2450.1	2.5	3/16/2016
1602078-14	B347F1 and F3 strong acetic acid	Iron	1651.3	2.5	3/16/2016
1602078-15	B347L4 strong acetic acid	Iron	2748.1	2.4	3/16/2016
1602078-16	B347P0 strong acetic acid	Iron	3368.8	2.5	3/16/2016
1602078-17	B347P5 and P8 strong acetic acid	Iron	1614.8	2.4	3/16/2016
1602078-18	B347R1 strong acetic acid	Iron	1823.1	2.5	3/16/2016
1602078-49	B347R7 strong acetic acid	Iron	1350.6	25.1	4/19/2016
1602078-19	B347T7 strong acetic acid	Iron	800.0	2.5	3/16/2016
1602078-23	B347C6 oxalate	Iron	1896.7	2.5	3/16/2016
1602078-24	B347D8 oxalate	Iron	2186.9	2.5	3/16/2016
1602078-25	B347F1 and F3 oxalate	Iron	1755.4	2.7	3/16/2016
1602078-26	B347L4 oxalate	Iron	2294.5	2.4	3/16/2016
1602078-27	B347P0 oxalate	Iron	3500.6	2.7	3/16/2016
1602078-28	B347P5 and P8 oxalate	Iron	2532.1	2.9	3/16/2016
1602078-29	B347R1 oxalate	Iron	2470.5	2.6	3/16/2016
1602078-53	B347R7 oxalate	Iron	1440.7	26.2	4/19/2016
1602078-30	B347T7 oxalate	Iron	1664.0	2.6	3/16/2016
1602078-34	B347C6 nitric acid	Iron	22236.5	22.4	3/16/2016
1602078-35	B347D8 nitric acid	Iron	19851.2	27.6	3/16/2016
1602078-36	B347F1 and F3 nitric acid	Iron	22858.4	24.1	3/16/2016
1602078-37	B347L4 nitric acid	Iron	23060.2	21.0	3/16/2016
1602078-38	B347P0 nitric acid	Iron	19341.9	22.5	3/16/2016
1602078-39	B347P5 and P8 nitric acid	Iron	20447.3	22.7	3/16/2016
1602078-40	B347R1 nitric acid	Iron	18177.5	22.2	3/16/2016
1602078-57	B347R7 nitric acid	Iron	25799.7	21.7	4/19/2016
1602078-41	B347T7 nitric acid	Iron	21121.7	21.6	3/16/2016
1602078-01	B347C6 weak acetic acid	Manganese	11.8	0.05	3/16/2016
1602078-02	B347D8 weak acetic acid	Manganese	13.4	0.05	3/16/2016
1602078-03	B347F1 and F3 weak acetic acid	Manganese	4.2	0.05	3/16/2016
1602078-04	B347L4 weak acetic acid	Manganese	8.0	0.05	3/16/2016
1602078-05	B347P0 weak acetic acid	Manganese	12.5	0.05	3/16/2016
1602078-06	B347P5 and P8 weak acetic acid	Manganese	10.2	0.05	3/16/2016
1602078-07	B347R1 weak acetic acid	Manganese	6.7	0.05	3/16/2016
1602078-45	B347R7 weak acetic acid	Manganese	7.9	0.05	4/19/2016
1602078-08	B347T7 weak acetic acid	Manganese	7.1	0.05	3/16/2016
1602078-12	B347C6 strong acetic acid	Manganese	90.3	0.1	3/16/2016
1602078-13	B347D8 strong acetic acid	Manganese	103.7	0.1	3/16/2016
1602078-14	B347F1 and F3 strong acetic acid	Manganese	104.0	0.1	3/16/2016
1602078-15	B347L4 strong acetic acid	Manganese	102.1	0.1	3/16/2016
1602078-16	B347P0 strong acetic acid	Manganese	132.5	0.1	3/16/2016
1602078-17	B347P5 and P8 strong acetic acid	Manganese	131.0	0.1	3/16/2016
1602078-18	B347R1 strong acetic acid	Manganese	96.0	0.1	3/16/2016
1602078-49	B347R7 strong acetic acid	Manganese	105.5	0.1	4/19/2016
1602078-19	B347T7 strong acetic acid	Manganese	73.6	0.1	3/16/2016
1602078-23	B347C6 oxalate	Manganese	32.9	0.1	3/16/2016
1602078-24	B347D8 oxalate	Manganese	29.9	0.1	3/16/2016
1602078-25	B347F1 and F3 oxalate	Manganese	39.7	0.1	3/16/2016
1602078-26	B347L4 oxalate	Manganese	28.3	0.1	3/16/2016
1602078-27	B347P0 oxalate	Manganese	38.3	0.1	3/16/2016
1602078-28	B347P5 and P8 oxalate	Manganese	44.5	0.1	3/16/2016
1602078-29	B347R1 oxalate	Manganese	29.9	0.1	3/16/2016
1602078-53	B347R7 oxalate	Manganese	41.1	0.1	4/19/2016
1602078-30	B347T7 oxalate	Manganese	29.7	0.1	3/16/2016
1602078-34	B347C6 nitric acid	Manganese	222.6	0.1	3/16/2016
1602078-35	B347D8 nitric acid	Manganese	206.5	0.1	3/16/2016
1602078-36	B347F1 and F3 nitric acid	Manganese	257.5	0.1	3/16/2016

1602078-37	B347L4 nitric acid	Manganese	224.3	0.1	3/16/2016
1602078-38	B347P0 nitric acid	Manganese	189.6	0.1	3/16/2016
1602078-39	B347P5 and P8 nitric acid	Manganese	207.0	0.1	3/16/2016
1602078-40	B347R1 nitric acid	Manganese	187.3	0.1	3/16/2016
1602078-57	B347R7 nitric acid	Manganese	249.3	0.0	4/19/2016
1602078-41	B347T7 nitric acid	Manganese	213.4	0.1	3/16/2016
1602078-01	B347C6 weak acetic acid	Phosphorus	130.2	0.8	3/16/2016
1602078-02	B347D8 weak acetic acid	Phosphorus	33.3	0.8	3/16/2016
1602078-03	B347F1 and F3 weak acetic acid	Phosphorus	16.5	0.9	3/16/2016
1602078-04	B347L4 weak acetic acid	Phosphorus	169.2	0.8	3/16/2016
1602078-05	B347P0 weak acetic acid	Phosphorus	1.2	0.9	3/16/2016
1602078-06	B347P5 and P8 weak acetic acid	Phosphorus	1.9	0.8	3/16/2016
1602078-07	B347R1 weak acetic acid	Phosphorus	1.6	0.9	3/16/2016
1602078-45	B347R7 weak acetic acid	Phosphorus	215.6	0.9	4/19/2016
1602078-08	B347T7 weak acetic acid	Phosphorus	26.1	0.8	3/16/2016
1602078-12	B347C6 strong acetic acid	Phosphorus	28.4	1.0	3/16/2016
1602078-13	B347D8 strong acetic acid	Phosphorus	25.9	1.0	3/16/2016
1602078-14	B347F1 and F3 strong acetic acid	Phosphorus	16.0	1.0	3/16/2016
1602078-15	B347L4 strong acetic acid	Phosphorus	24.9	1.0	3/16/2016
1602078-16	B347P0 strong acetic acid	Phosphorus	1.8	1.0	3/16/2016
1602078-17	B347P5 and P8 strong acetic acid	Phosphorus	22.1	1.0	3/16/2016
1602078-18	B347R1 strong acetic acid	Phosphorus	4.8	1.0	3/16/2016
1602078-49	B347R7 strong acetic acid	Phosphorus	25.0	1.0	4/19/2016
1602078-19	B347T7 strong acetic acid	Phosphorus	19.6	1.0	3/16/2016
1602078-23	B347C6 oxalate	Phosphorus	702.7	1.0	3/16/2016
1602078-24	B347D8 oxalate	Phosphorus	570.8	1.0	3/16/2016
1602078-25	B347F1 and F3 oxalate	Phosphorus	434.2	1.1	3/16/2016
1602078-26	B347L4 oxalate	Phosphorus	701.4	1.0	3/16/2016
1602078-27	B347P0 oxalate	Phosphorus	215.5	1.1	3/16/2016
1602078-28	B347P5 and P8 oxalate	Phosphorus	199.7	1.2	3/16/2016
1602078-29	B347R1 oxalate	Phosphorus	241.8	1.1	3/16/2016
1602078-53	B347R7 oxalate	Phosphorus	1301.9	1.1	4/19/2016
1602078-30	B347T7 oxalate	Phosphorus	809.9	1.1	3/16/2016
1602078-34	B347C6 nitric acid	Phosphorus	1051.3	0.9	3/16/2016
1602078-35	B347D8 nitric acid	Phosphorus	978.8	1.1	3/16/2016
1602078-36	B347F1 and F3 nitric acid	Phosphorus	1029.8	1.0	3/16/2016
1602078-37	B347L4 nitric acid	Phosphorus	1134.1	0.9	3/16/2016
1602078-38	B347P0 nitric acid	Phosphorus	944.6	0.9	3/16/2016
1602078-39	B347P5 and P8 nitric acid	Phosphorus	1139.2	0.9	3/16/2016
1602078-40	B347R1 nitric acid	Phosphorus	1112.5	0.9	3/16/2016
1602078-57	B347R7 nitric acid	Phosphorus	1500.3	0.9	4/19/2016
1602078-41	B347T7 nitric acid	Phosphorus	1229.8	0.9	3/16/2016
1602078-01	B347C6 weak acetic acid	Uranium 238	0.2	0.01	3/16/2016
1602078-02	B347D8 weak acetic acid	Uranium 238	0.9	0.01	3/16/2016
1602078-03	B347F1 and F3 weak acetic acid	Uranium 238	3.6	0.02	3/16/2016
1602078-04	B347L4 weak acetic acid	Uranium 238	0.8	0.01	3/16/2016
1602078-05	B347P0 weak acetic acid	Uranium 238	16.8	0.01	3/16/2016
1602078-06	B347P5 and P8 weak acetic acid	Uranium 238	28.3	0.01	3/16/2016
1602078-07	B347R1 weak acetic acid	Uranium 238	16.5	0.02	3/16/2016
1602078-45	B347R7 weak acetic acid	Uranium 238	2.5	0.02	4/12/2016
1602078-08	B347T7 weak acetic acid	Uranium 238	5.3	0.01	3/16/2016
1602078-12	B347C6 strong acetic acid	Uranium 238	0.9	0.02	3/16/2016
1602078-13	B347D8 strong acetic acid	Uranium 238	2.1	0.02	3/16/2016
1602078-14	B347F1 and F3 strong acetic acid	Uranium 238	6.5	0.02	3/16/2016
1602078-15	B347L4 strong acetic acid	Uranium 238	3.1	0.02	3/16/2016
1602078-16	B347P0 strong acetic acid	Uranium 238	43.5	0.02	3/16/2016
1602078-17	B347P5 and P8 strong acetic acid	Uranium 238	46.4	0.02	3/16/2016
1602078-18	B347R1 strong acetic acid	Uranium 238	25.0	0.02	3/16/2016
1602078-49	B347R7 strong acetic acid	Uranium 238	18.8	0.02	4/12/2016
1602078-19	B347T7 strong acetic acid	Uranium 238	15.8	0.02	3/16/2016
1602078-23	B347C6 oxalate	Uranium 238	0.5	0.02	3/16/2016
1602078-24	B347D8 oxalate	Uranium 238	0.8	0.02	3/16/2016
1602078-25	B347F1 and F3 oxalate	Uranium 238	1.9	0.02	3/16/2016
1602078-26	B347L4 oxalate	Uranium 238	1.0	0.02	3/16/2016
1602078-27	B347P0 oxalate	Uranium 238	11.5	0.02	3/16/2016

1602078-28	B347P5 and P8 oxalate	Uranium 238	17.9	0.02	3/16/2016
1602078-29	B347R1 oxalate	Uranium 238	5.3	0.02	3/16/2016
1602078-53	B347R7 oxalate	Uranium 238	10.0	0.02	4/12/2016
1602078-30	B347T7 oxalate	Uranium 238	6.7	0.02	3/16/2016
1602078-34	B347C6 nitric acid	Uranium 238	0.8	0.02	3/16/2016
1602078-35	B347D8 nitric acid	Uranium 238	0.9	0.02	3/16/2016
1602078-36	B347F1 and F3 nitric acid	Uranium 238	1.6	0.02	3/16/2016
1602078-37	B347L4 nitric acid	Uranium 238	1.0	0.01	3/16/2016
1602078-38	B347P0 nitric acid	Uranium 238	4.8	0.02	3/16/2016
1602078-39	B347P5 and P8 nitric acid	Uranium 238	12.7	0.02	3/16/2016
1602078-40	B347R1 nitric acid	Uranium 238	3.3	0.02	3/16/2016
1602078-57	B347R7 nitric acid	Uranium 238	12.5	0.02	4/12/2016
1602078-41	B347T7 nitric acid	Uranium 238	6.3	0.02	3/16/2016

Total Metals by PNNL-ESL-ICP-OES and Uranium by PNNL-ESL-ICPMS/Labile Extraction

	LabNumber	SampleName	Analyte	Result	EQL	Analyzed	Method
				ug/g	ug/g		
Cumulative reaction time: 3 days	1602049-13	B347P5&P8-3d1	Calcium	11.7	0.346	4/14/2016	PNNL-ESL-ICP-OES
	1602049-14	B347F1&F3-3d1	Calcium	78.8	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-15	B347R1-3d1	Calcium	16.4	0.351	4/14/2016	PNNL-ESL-ICP-OES
	1602049-16	B347L4-3d1	Calcium	36.9	0.343	4/14/2016	PNNL-ESL-ICP-OES
	1602049-17	B347P0-3d1	Calcium	10.2	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-18	B347C6-3d1	Calcium	36.5	0.342	4/14/2016	PNNL-ESL-ICP-OES
	1602049-19	B347D8-3d1	Calcium	56.9	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-20	B347T7-3d1	Calcium	37.2	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-21	B347R7-3d1	Calcium	13.0	0.343	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 7 days	1602049-38	B347P5&P8-7d1	Calcium	12.9	0.346	4/14/2016	PNNL-ESL-ICP-OES
	1602049-39	B347F1&F3-7d1	Calcium	81.3	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-40	B347R1-7d1	Calcium	17.5	0.351	4/14/2016	PNNL-ESL-ICP-OES
	1602049-41	B347L4-7d1	Calcium	37.4	0.343	4/14/2016	PNNL-ESL-ICP-OES
	1602049-42	B347P0-7d1	Calcium	11.7	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-43	B347C6-7d1	Calcium	39.5	0.342	4/14/2016	PNNL-ESL-ICP-OES
	1602049-44	B347D8-7d1	Calcium	58.8	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-45	B347T7-7d1	Calcium	34.4	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-46	B347R7-7d1	Calcium	13.5	0.343	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 21 days	1602049-62	B347P5&P8-21d1	Calcium	12.8	0.346	4/14/2016	PNNL-ESL-ICP-OES
	1602049-63	B347F1&F3-21d1	Calcium	72.5	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-64	B347R1-21d1	Calcium	17.4	0.351	4/14/2016	PNNL-ESL-ICP-OES
	1602049-65	B347L4-21d1	Calcium	33.1	0.343	4/14/2016	PNNL-ESL-ICP-OES
	1602049-66	B347P0-21d1	Calcium	9.52	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-67	B347C6-21d1	Calcium	35.1	0.342	4/14/2016	PNNL-ESL-ICP-OES
	1602049-68	B347D8-21d1	Calcium	53.3	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-69	B347T7-21d1	Calcium	29.6	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-70	B347R7-21d1	Calcium	17.1	0.343	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 42 days	1602049-86	B347P5&P8-42d1	Calcium	13.4	0.346	4/14/2016	PNNL-ESL-ICP-OES
	1602049-87	B347F1&F3-42d1	Calcium	64.5	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-88	B347R1-42d1	Calcium	16.3	0.351	4/14/2016	PNNL-ESL-ICP-OES
	1602049-89	B347L4-42d1	Calcium	29.8	0.343	4/14/2016	PNNL-ESL-ICP-OES
	1602049-90	B347P0-42d1	Calcium	7.37	0.344	4/14/2016	PNNL-ESL-ICP-OES

	1602049-91	B347C6-42d1	Calcium	31.8	0.342	4/14/2016	PNNL-ESL-ICP-OES
	1602049-92	B347D8-42d1	Calcium	51.5	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-93	B347T7-42d1	Calcium	27.3	0.344	4/14/2016	PNNL-ESL-ICP-OES
	1602049-94	B347R7-42d1	Calcium	14.7	0.343	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 3 days	1602049-13	B347P5&P8-3d1	Iron	2.37	0.103	4/14/2016	PNNL-ESL-ICP-OES
	1602049-14	B347F1&F3-3d1	Iron	0.138	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-15	B347R1-3d1	Iron	0.347	0.104	4/14/2016	PNNL-ESL-ICP-OES
	1602049-16	B347L4-3d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-17	B347P0-3d1	Iron	1.93	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-18	B347C6-3d1	Iron	0.110	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-19	B347D8-3d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-20	B347T7-3d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-21	B347R7-3d1	Iron	1.24	0.102	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 7 days	1602049-38	B347P5&P8-7d1	Iron	1.96	0.103	4/14/2016	PNNL-ESL-ICP-OES
	1602049-39	B347F1&F3-7d1	Iron	0.014	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-40	B347R1-7d1	Iron	0.416	0.104	4/14/2016	PNNL-ESL-ICP-OES
	1602049-41	B347L4-7d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-42	B347P0-7d1	Iron	1.29	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-43	B347C6-7d1	Iron	0.915	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-44	B347D8-7d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-45	B347T7-7d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-46	B347R7-7d1	Iron	1.38	0.102	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 21 days	1602049-62	B347P5&P8-21d1	Iron	1.75	0.103	4/14/2016	PNNL-ESL-ICP-OES
	1602049-63	B347F1&F3-21d1	Iron	0.001	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-64	B347R1-21d1	Iron	1.30	0.104	4/14/2016	PNNL-ESL-ICP-OES
	1602049-65	B347L4-21d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-66	B347P0-21d1	Iron	2.95	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-67	B347C6-21d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-68	B347D8-21d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-69	B347T7-21d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-70	B347R7-21d1	Iron	3.71	0.102	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 42 days	1602049-86	B347P5&P8-42d1	Iron	2.79	0.103	4/14/2016	PNNL-ESL-ICP-OES
	1602049-87	B347F1&F3-42d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-88	B347R1-42d1	Iron	3.11	0.104	4/14/2016	PNNL-ESL-ICP-OES
	1602049-89	B347L4-42d1	Iron	ND	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-90	B347P0-42d1	Iron	1.64	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-91	B347C6-42d1	Iron	0.569	0.102	4/14/2016	PNNL-ESL-ICP-OES

	1602049-92	B347D8-42d1	Iron	0.655	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-93	B347T7-42d1	Iron	0.254	0.102	4/14/2016	PNNL-ESL-ICP-OES
	1602049-94	B347R7-42d1	Iron	7.93	0.102	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 3 days	1602049-13	B347P5&P8-3d1	Manganese	0.051	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-14	B347F1&F3-3d1	Manganese	ND	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-15	B347R1-3d1	Manganese	ND	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-16	B347L4-3d1	Manganese	ND	0.024	4/14/2016	PNNL-ESL-ICP-OES
	1602049-17	B347P0-3d1	Manganese	0.028	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-18	B347C6-3d1	Manganese	ND	0.024	4/14/2016	PNNL-ESL-ICP-OES
	1602049-19	B347D8-3d1	Manganese	0.034	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-20	B347T7-3d1	Manganese	0.025	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-21	B347R7-3d1	Manganese	0.029	0.025	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 7 days	1602049-38	B347P5&P8-7d1	Manganese	0.084	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-39	B347F1&F3-7d1	Manganese	ND	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-40	B347R1-7d1	Manganese	ND	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-41	B347L4-7d1	Manganese	ND	0.024	4/14/2016	PNNL-ESL-ICP-OES
	1602049-42	B347P0-7d1	Manganese	0.003	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-43	B347C6-7d1	Manganese	0.034	0.024	4/14/2016	PNNL-ESL-ICP-OES
	1602049-44	B347D8-7d1	Manganese	0.031	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-45	B347T7-7d1	Manganese	ND	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-46	B347R7-7d1	Manganese	0.031	0.025	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 21 days	1602049-62	B347P5&P8-21d1	Manganese	0.093	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-63	B347F1&F3-21d1	Manganese	ND	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-64	B347R1-21d1	Manganese	0.026	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-65	B347L4-21d1	Manganese	ND	0.024	4/14/2016	PNNL-ESL-ICP-OES
	1602049-66	B347P0-21d1	Manganese	0.041	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-67	B347C6-21d1	Manganese	0.003	0.024	4/14/2016	PNNL-ESL-ICP-OES
	1602049-68	B347D8-21d1	Manganese	0.032	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-69	B347T7-21d1	Manganese	0.000	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-70	B347R7-21d1	Manganese	0.068	0.025	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 42 days	1602049-86	B347P5&P8-42d1	Manganese	0.119	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-87	B347F1&F3-42d1	Manganese	ND	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-88	B347R1-42d1	Manganese	0.056	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-89	B347L4-42d1	Manganese	ND	0.024	4/14/2016	PNNL-ESL-ICP-OES
	1602049-90	B347P0-42d1	Manganese	0.004	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-91	B347C6-42d1	Manganese	0.026	0.024	4/14/2016	PNNL-ESL-ICP-OES
	1602049-92	B347D8-42d1	Manganese	0.036	0.025	4/14/2016	PNNL-ESL-ICP-OES

	1602049-93	B347T7-42d1	Manganese	ND	0.025	4/14/2016	PNNL-ESL-ICP-OES
	1602049-94	B347R7-42d1	Manganese	0.148	0.025	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 3 days	1602049-13	B347P5&P8-3d1	Phosphorus	3.11	0.420	4/14/2016	PNNL-ESL-ICP-OES
	1602049-14	B347F1&F3-3d1	Phosphorus	21.1	0.418	4/14/2016	PNNL-ESL-ICP-OES
	1602049-15	B347R1-3d1	Phosphorus	ND	0.426	4/14/2016	PNNL-ESL-ICP-OES
	1602049-16	B347L4-3d1	Phosphorus	79.6	0.416	4/14/2016	PNNL-ESL-ICP-OES
	1602049-17	B347P0-3d1	Phosphorus	1.15	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-18	B347C6-3d1	Phosphorus	72.3	0.416	4/14/2016	PNNL-ESL-ICP-OES
	1602049-19	B347D8-3d1	Phosphorus	29.0	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-20	B347T7-3d1	Phosphorus	35.6	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-21	B347R7-3d1	Phosphorus	239	0.417	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 7 days	1602049-38	B347P5&P8-7d1	Phosphorus	3.23	0.420	4/14/2016	PNNL-ESL-ICP-OES
	1602049-39	B347F1&F3-7d1	Phosphorus	23.2	0.418	4/14/2016	PNNL-ESL-ICP-OES
	1602049-40	B347R1-7d1	Phosphorus	ND	0.426	4/14/2016	PNNL-ESL-ICP-OES
	1602049-41	B347L4-7d1	Phosphorus	78.5	0.416	4/14/2016	PNNL-ESL-ICP-OES
	1602049-42	B347P0-7d1	Phosphorus	1.17	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-43	B347C6-7d1	Phosphorus	81.7	0.416	4/14/2016	PNNL-ESL-ICP-OES
	1602049-44	B347D8-7d1	Phosphorus	31.7	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-45	B347T7-7d1	Phosphorus	42.6	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-46	B347R7-7d1	Phosphorus	253	0.417	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 21 days	1602049-62	B347P5&P8-21d1	Phosphorus	2.92	0.420	4/14/2016	PNNL-ESL-ICP-OES
	1602049-63	B347F1&F3-21d1	Phosphorus	22.2	0.418	4/14/2016	PNNL-ESL-ICP-OES
	1602049-64	B347R1-21d1	Phosphorus	0.470	0.426	4/14/2016	PNNL-ESL-ICP-OES
	1602049-65	B347L4-21d1	Phosphorus	68.0	0.416	4/14/2016	PNNL-ESL-ICP-OES
	1602049-66	B347P0-21d1	Phosphorus	1.09	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-67	B347C6-21d1	Phosphorus	71.9	0.416	4/14/2016	PNNL-ESL-ICP-OES
	1602049-68	B347D8-21d1	Phosphorus	28.7	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-69	B347T7-21d1	Phosphorus	40.6	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-70	B347R7-21d1	Phosphorus	238	0.417	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 42 days	1602049-86	B347P5&P8-42d1	Phosphorus	2.66	0.420	4/14/2016	PNNL-ESL-ICP-OES
	1602049-87	B347F1&F3-42d1	Phosphorus	22.0	0.418	4/14/2016	PNNL-ESL-ICP-OES
	1602049-88	B347R1-42d1	Phosphorus	0.046	0.426	4/14/2016	PNNL-ESL-ICP-OES
	1602049-89	B347L4-42d1	Phosphorus	53.5	0.416	4/14/2016	PNNL-ESL-ICP-OES
	1602049-90	B347P0-42d1	Phosphorus	0.746	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-91	B347C6-42d1	Phosphorus	54.8	0.416	4/14/2016	PNNL-ESL-ICP-OES
	1602049-92	B347D8-42d1	Phosphorus	27.0	0.417	4/14/2016	PNNL-ESL-ICP-OES
	1602049-93	B347T7-42d1	Phosphorus	36.5	0.417	4/14/2016	PNNL-ESL-ICP-OES

	1602049-94	B347R7-42d1	Phosphorus	203	0.417	4/14/2016	PNNL-ESL-ICP-OES
Cumulative reaction time: 3 days	1602049-13	B347P5&P8-3d1	Uranium 238	14.7	0.146	3/15/2016	PNNL-ESL-ICPMS
	1602049-14	B347F1&F3-3d1	Uranium 238	2.80	0.145	3/15/2016	PNNL-ESL-ICPMS
	1602049-15	B347R1-3d1	Uranium 238	6.97	0.148	3/15/2016	PNNL-ESL-ICPMS
	1602049-16	B347L4-3d1	Uranium 238	0.282	0.014	3/15/2016	PNNL-ESL-ICPMS
	1602049-17	B347P0-3d1	Uranium 238	7.61	0.145	3/15/2016	PNNL-ESL-ICPMS
	1602049-18	B347C6-3d1	Uranium 238	0.094	0.001	3/15/2016	PNNL-ESL-ICPMS
	1602049-19	B347D8-3d1	Uranium 238	0.534	0.015	3/15/2016	PNNL-ESL-ICPMS
	1602049-20	B347T7-3d1	Uranium 238	2.04	0.145	3/15/2016	PNNL-ESL-ICPMS
	1602049-21	B347R7-3d1	Uranium 238	0.874	0.015	3/15/2016	PNNL-ESL-ICPMS
Cumulative reaction time: 7 days	1602049-38	B347P5&P8-7d1	Uranium 238	14.4	0.146	3/15/2016	PNNL-ESL-ICPMS
	1602049-39	B347F1&F3-7d1	Uranium 238	3.43	0.145	3/15/2016	PNNL-ESL-ICPMS
	1602049-40	B347R1-7d1	Uranium 238	7.66	0.148	3/15/2016	PNNL-ESL-ICPMS
	1602049-41	B347L4-7d1	Uranium 238	0.318	0.014	3/15/2016	PNNL-ESL-ICPMS
	1602049-42	B347P0-7d1	Uranium 238	8.35	0.145	3/15/2016	PNNL-ESL-ICPMS
	1602049-43	B347C6-7d1	Uranium 238	0.110	0.001	3/15/2016	PNNL-ESL-ICPMS
	1602049-44	B347D8-7d1	Uranium 238	0.609	0.015	3/15/2016	PNNL-ESL-ICPMS
	1602049-45	B347T7-7d1	Uranium 238	2.49	0.145	3/15/2016	PNNL-ESL-ICPMS
	1602049-46	B347R7-7d1	Uranium 238	1.06	0.015	3/15/2016	PNNL-ESL-ICPMS
Cumulative reaction time: 21 days	1602049-62	B347P5&P8-21d1	Uranium 238	15.9	0.146	3/15/2016	PNNL-ESL-ICPMS
	1602049-63	B347F1&F3-21d1	Uranium 238	3.27	0.145	3/15/2016	PNNL-ESL-ICPMS
	1602049-64	B347R1-21d1	Uranium 238	8.42	0.148	3/15/2016	PNNL-ESL-ICPMS
	1602049-65	B347L4-21d1	Uranium 238	0.364	0.014	3/15/2016	PNNL-ESL-ICPMS
	1602049-66	B347P0-21d1	Uranium 238	8.77	0.145	3/15/2016	PNNL-ESL-ICPMS
	1602049-67	B347C6-21d1	Uranium 238	0.138	0.001	3/15/2016	PNNL-ESL-ICPMS
	1602049-68	B347D8-21d1	Uranium 238	0.709	0.015	3/15/2016	PNNL-ESL-ICPMS
	1602049-69	B347T7-21d1	Uranium 238	2.70	0.145	3/15/2016	PNNL-ESL-ICPMS
	1602049-70	B347R7-21d1	Uranium 238	1.35	0.015	3/15/2016	PNNL-ESL-ICPMS
Cumulative reaction time: 42 days	1602049-86	B347P5&P8-42d1	Uranium 238	15.7	0.073	3/29/2016	PNNL-ESL-ICPMS
	1602049-87	B347F1&F3-42d1	Uranium 238	3.80	0.073	3/29/2016	PNNL-ESL-ICPMS
	1602049-88	B347R1-42d1	Uranium 238	9.26	0.074	3/29/2016	PNNL-ESL-ICPMS
	1602049-89	B347L4-42d1	Uranium 238	0.538	0.072	3/29/2016	PNNL-ESL-ICPMS
	1602049-90	B347P0-42d1	Uranium 238	9.89	0.073	3/29/2016	PNNL-ESL-ICPMS
	1602049-91	B347C6-42d1	Uranium 238	0.199	0.072	3/29/2016	PNNL-ESL-ICPMS
	1602049-92	B347D8-42d1	Uranium 238	0.811	0.073	3/29/2016	PNNL-ESL-ICPMS
	1602049-93	B347T7-42d1	Uranium 238	3.46	0.073	3/29/2016	PNNL-ESL-ICPMS
	1602049-94	B347R7-42d1	Uranium 238	1.99	0.073	3/29/2016	PNNL-ESL-ICPMS

Cumulative reaction time: 66 days	1602049-AK	B347P5&P8-66d1	Uranium 238	16.1	0.073	4/19/2016	PNNL-ESL-ICPMS
	1602049-AL	B347F1&F3-66d1	Uranium 238	3.94	0.073	4/19/2016	PNNL-ESL-ICPMS
	1602049-AM	B347R1-66d1	Uranium 238	10.5	0.074	4/19/2016	PNNL-ESL-ICPMS
	1602049-AN	B347L4-66d1	Uranium 238	0.647	0.072	4/19/2016	PNNL-ESL-ICPMS
	1602049-AO	B347P0-66d1	Uranium 238	11.0	0.073	4/19/2016	PNNL-ESL-ICPMS
	1602049-AP	B347C6-66d1	Uranium 238	0.248	0.072	4/19/2016	PNNL-ESL-ICPMS
	1602049-AQ	B347D8-66d1	Uranium 238	0.940	0.073	4/19/2016	PNNL-ESL-ICPMS
	1602049-AR	B347T7-66d1	Uranium 238	4.06	0.073	4/19/2016	PNNL-ESL-ICPMS
	1602049-AS	B347R7-66d1	Uranium 238	2.49	0.073	4/19/2016	PNNL-ESL-ICPMS

Total Metals by PNNL-ESL-ICP-OES and Uranium by PNNL-ESL-ICPMS/Sequential Extraction

Quality Control

Duplicates

LabNumber	SampleName	Analyte	Results ug/g	RPD (%)	RPD Limit	EQL ug/g	Analyzed
1602078-31	B347P0 DUP oxalate	Aluminum	2.01E+03	7.0%	35	4.4	3/16/2016
1602078-54	B347R7 DUP oxalate	Aluminum	2.87E+03	1.3%	35	41.5	4/19/2016
1602078-42	B347P0 DUP nitric acid	Aluminum	6.12E+03	33%	35	3.7	3/16/2016
1602078-58	B347R7 DUP nitric acid	Aluminum	8.97E+03	13%	35	34.2	4/19/2016
1602078-09	B347P0 DUP weak acetic acid	Calcium	2.29E+03	6.1%	35	0.7	3/16/2016
1602078-46	B347R7 DUP weak acetic acid	Calcium	1.21E+03	1.5%	35	0.7	4/19/2016
1602078-20	B347P0 DUP strong acetic acid	Calcium	8.16E+02	4.4%	35	0.8	3/16/2016
1602078-50	B347R7 DUP strong acetic acid	Calcium	5.64E+02	13%	35	0.0	4/19/2016
1602078-31	B347P0 DUP oxalate	Calcium	8.71E+01	49%	35	0.9	3/16/2016
1602078-54	B347R7 DUP oxalate	Calcium	7.45E+01	1.2%	35	0.8	4/19/2016
1602078-42	B347P0 DUP nitric acid	Calcium	3.65E+03	27%	35	0.7	3/16/2016
1602078-58	B347R7 DUP nitric acid	Calcium	5.55E+03	7.5%	35	0.7	4/19/2016
1602078-09	B347P0 DUP weak acetic acid	Iron	2.14E+01	29%	35	0.2	3/16/2016
1602078-46	B347R7 DUP weak acetic acid	Iron	ND	NA	35	0.2	4/19/2016
1602078-20	B347P0 DUP strong acetic acid	Iron	4.39E+03	26%	35	2.5	3/16/2016
1602078-50	B347R7 DUP strong acetic acid	Iron	1.20E+03	12%	35	23.8	4/19/2016
1602078-31	B347P0 DUP oxalate	Iron	3.78E+03	7.8%	35	2.7	3/16/2016
1602078-54	B347R7 DUP oxalate	Iron	1.44E+03	0.02%	35	25.2	4/19/2016
1602078-42	B347P0 DUP nitric acid	Iron	1.37E+04	34%	35	22.2	3/16/2016
1602078-58	B347R7 DUP nitric acid	Iron	2.34E+04	9.7%	35	20.7	4/19/2016
1602078-09	B347P0 DUP weak acetic acid	Manganese	1.55E+01	22%	35	0.05	3/16/2016
1602078-46	B347R7 DUP weak acetic acid	Manganese	1.20E+01	41%	35	0.05	4/19/2016
1602078-20	B347P0 DUP strong acetic acid	Manganese	1.51E+02	13%	35	0.1	3/16/2016
1602078-50	B347R7 DUP strong acetic acid	Manganese	9.61E+01	9.3%	35	0.1	4/19/2016
1602078-31	B347P0 DUP oxalate	Manganese	1.76E+01	74%	35	0.1	3/16/2016
1602078-54	B347R7 DUP oxalate	Manganese	3.93E+01	4.6%	35	0.1	4/19/2016
1602078-42	B347P0 DUP nitric acid	Manganese	1.49E+02	24%	35	0.1	3/16/2016
1602078-58	B347R7 DUP nitric acid	Manganese	2.34E+02	6.3%	35	0.0	4/19/2016
1602078-09	B347P0 DUP weak acetic acid	Phosphorus	1.13E+00	5.1%	35	0.8	3/16/2016
1602078-46	B347R7 DUP weak acetic acid	Phosphorus	2.22E+02	2.7%	35	0.8	4/19/2016
1602078-20	B347P0 DUP strong acetic acid	Phosphorus	1.08E+00	49%	35	1.0	3/16/2016
1602078-50	B347R7 DUP strong acetic acid	Phosphorus	2.50E+01	0.1%	35	1.0	4/19/2016
1602078-31	B347P0 DUP oxalate	Phosphorus	1.52E+02	34%	35	1.1	3/16/2016
1602078-54	B347R7 DUP oxalate	Phosphorus	1.18E+03	9.5%	35	1.0	4/19/2016
1602078-42	B347P0 DUP nitric acid	Phosphorus	8.47E+02	11%	35	0.9	3/16/2016
1602078-58	B347R7 DUP nitric acid	Phosphorus	1.52E+03	1.6%	35	0.8	4/19/2016
1602078-09	B347P0 DUP weak acetic acid	Uranium 238	1.83E+01	8.6%	35	0.01	3/16/2016
1602078-46	B347R7 DUP weak acetic acid	Uranium 238	2.60E+00	4.9%	35	0.01	4/12/2016
1602078-20	B347P0 DUP strong acetic acid	Uranium 238	4.98E+01	13%	35	0.02	3/16/2016
1602078-50	B347R7 DUP strong acetic acid	Uranium 238	2.11E+01	12%	35	0.02	4/12/2016
1602078-31	B347P0 DUP oxalate	Uranium 238	9.16E+00	22%	35	0.02	3/16/2016
1602078-54	B347R7 DUP oxalate	Uranium 238	9.80E+00	1.9%	35	0.02	4/12/2016
1602078-42	B347P0 DUP nitric acid	Uranium 238	6.03E+00	22%	35	0.02	3/16/2016
1602078-58	B347R7 DUP nitric acid	Uranium 238	1.28E+01	2.1%	35	0.01	4/12/2016

Preparation Blanks

LabNumber	**SampleName**	**Analyte**	**Result ug/L**	**EQL**	**Analyzed**
1602078-32	PB oxalate	Aluminum	ND	165	3/16/2016
1602078-43	PB nitric acid	Aluminum	ND	165	3/16/2016
1602078-55	B347R7 oxalate PB	Aluminum	ND	165	4/19/2016
1602078-59	B347R7 nitric acid PB	Aluminum	5.06E+02	165	4/19/2016
1602078-10	PB weak acetic acid	Calcium	ND	336	3/16/2016
1602078-21	PB strong acetic acid	Calcium	ND	336	3/16/2016
1602078-32	PB oxalate	Calcium	ND	336	3/16/2016
1602078-43	PB nitric acid	Calcium	4.09E+02	336	3/16/2016

1602078-55	B347R7 oxalate PB	Calcium	3.69E+02	336	4/19/2016
1602078-59	B347R7 nitric acid PB	Calcium	9.69E+02	336	4/19/2016
1602078-10	PB weak acetic acid	Iron	ND	100	3/16/2016
1602078-21	PB strong acetic acid	Iron	ND	1000	3/16/2016
1602078-32	PB oxalate	Iron	ND	1000	3/16/2016
1602078-43	PB nitric acid	Iron	ND	10000	3/16/2016
1602078-47	B347R7 weak acetic acid PB	Iron	ND	100	4/19/2016
1602078-51	B347R7 strong acetic acid PB	Iron	ND	100	4/19/2016
1602078-55	B347R7 oxalate PB	Iron	ND	100	4/19/2016
1602078-59	B347R7 nitric acid PB	Iron	2.10E+03	100	4/19/2016
1602078-10	PB weak acetic acid	Manganese	ND	23.9	3/16/2016
1602078-21	PB strong acetic acid	Manganese	ND	23.9	3/16/2016
1602078-32	PB oxalate	Manganese	ND	23.9	3/16/2016
1602078-43	PB nitric acid	Manganese	ND	23.9	3/16/2016
1602078-47	B347R7 weak acetic acid PB	Manganese	ND	23.9	4/19/2016
1602078-51	B347R7 strong acetic acid PB	Manganese	ND	23.9	4/19/2016
1602078-55	B347R7 oxalate PB	Manganese	ND	23.9	4/19/2016
1602078-59	B347R7 nitric acid PB	Manganese	3.87E+01	23.9	4/19/2016
1602078-10	PB weak acetic acid	Phosphorus	ND	408	3/16/2016
1602078-21	PB strong acetic acid	Phosphorus	ND	408	3/16/2016
1602078-32	PB oxalate	Phosphorus	ND	408	3/16/2016
1602078-43	PB nitric acid	Phosphorus	ND	408	3/16/2016
1602078-47	B347R7 weak acetic acid PB	Phosphorus	ND	408	4/19/2016
1602078-51	B347R7 strong acetic acid PB	Phosphorus	ND	408	4/19/2016
1602078-55	B347R7 oxalate PB	Phosphorus	ND	408	4/19/2016
1602078-59	B347R7 nitric acid PB	Phosphorus	ND	408	4/19/2016
1602078-10	PB weak acetic acid	Uranium 238	ND	7.1	3/16/2016
1602078-21	PB strong acetic acid	Uranium 238	ND	7.1	3/16/2016
1602078-32	PB oxalate	Uranium 238	ND	7.1	3/16/2016
1602078-43	PB nitric acid	Uranium 238	ND	7.1	3/16/2016
1602078-47	B347R7 weak acetic acid PB	Uranium 238	ND	7.1	4/12/2016
1602078-51	B347R7 strong acetic acid PB	Uranium 238	ND	7.1	4/12/2016
1602078-55	B347R7 oxalate PB	Uranium 238	ND	7.1	4/12/2016
1602078-59	B347R7 nitric acid PB	Uranium 238	ND	7.1	4/12/2016

Laboratory Control Samples

LabNumber	SampleName	Analyte	Result ug/L	EQL	% recovery	%REC LIMITS	Analyzed
1602078-33	BS oxalate	Aluminum	4020	165	80.4	80-120	3/16/2016
1602078-44	BS nitric acid	Aluminum	4850	165	95.7	80-120	3/16/2016
1602078-56	B347R7 oxalate BS	Aluminum	4120	165	82.4	80-120	4/19/2016
1602078-60	B347R7 nitric acid BS	Aluminum	5550	165	97.6	80-120	4/19/2016
1602078-11	BS weak acetic acid	Calcium	5010	336	100	80-120	3/16/2016
1602078-22	BS strong acetic acid	Calcium	4460	336	89.2	80-120	3/16/2016
1602078-33	BS oxalate	Calcium	5110	336	102	80-120	3/16/2016
1602078-44	BS nitric acid	Calcium	5420	336	107	80-120	3/16/2016
1602078-48	B347R7 weak acetic acid BS	Calcium	4840	336	96.8	80-120	4/19/2016
1602078-52	B347R7 strong acetic acid BS	Calcium	4600	336	92.0	80-120	4/19/2016
1602078-56	B347R7 oxalate BS	Calcium	4610	336	92.2	80-120	4/19/2016
1602078-60	B347R7 nitric acid BS	Calcium	6250	336	110	80-120	4/19/2016

1602078-11	BS weak acetic acid	Iron	4720	100	94.4	80-120	3/16/2016
1602078-22	BS strong acetic acid	Iron	5000	1000	100	80-120	3/16/2016
1602078-33	BS oxalate	Iron	5000	1000	100	80-120	3/16/2016
1602078-44	BS nitric acid	Iron	5300	1000	105	80-120	3/16/2016
1602078-48	B347R7 weak acetic acid BS	Iron	4670	100	93.4	80-120	4/19/2016
1602078-52	B347R7 strong acetic acid BS	Iron	5100	100	102	80-120	4/19/2016
1602078-56	B347R7 oxalate BS	Iron	4930	100	98.6	80-120	4/19/2016
1602078-60	B347R7 nitric acid BS	Iron	5830	100	102	80-120	4/19/2016
1602078-11	BS weak acetic acid	Manganese	4720	23.9	94.4	80-120	3/16/2016
1602078-22	BS strong acetic acid	Manganese	4750	23.9	95.0	80-120	3/16/2016
1602078-33	BS oxalate	Manganese	4690	23.9	93.8	80-120	3/16/2016
1602078-44	BS nitric acid	Manganese	5020	23.9	99.1	80-120	3/16/2016
1602078-48	B347R7 weak acetic acid BS	Manganese	4600	23.9	92.0	80-120	4/19/2016
1602078-52	B347R7 strong acetic acid BS	Manganese	4910	23.9	98.2	80-120	4/19/2016
1602078-56	B347R7 oxalate BS	Manganese	4660	23.9	93.2	80-120	4/19/2016
1602078-60	B347R7 nitric acid BS	Manganese	5440	23.9	95.6	80-120	4/19/2016

Total Metals by PNNL-ESL-ICP-OES and Uranium by PNNL-ESL-ICPMS/Labile Extraction

Quality Control

Duplicates

Cumulative reaction time	LabNumber	SampleName	Analyte	Results	RPD (%)	RPD	EQL	Analyzed
days				ug/g		Limit	ug/g	
3	1602049-22	B347P0 Dup-3d1	Calcium	10.7	5.0%	35	0.343	4/14/2016
7	1602049-47	B347P0 Dup-7d1	Calcium	10.9	6.4%	35	0.343	4/14/2016
21	1602049-71	B347P0 Dup-21d1	Calcium	8.26	14%	35	0.343	4/14/2016
42	1602049-95	B347P0 Dup-42d1	Calcium	7.36	0.14%	35	0.343	4/14/2016
3	1602049-22	B347P0 Dup-3d1	Iron	4.19	74%	35	0.102	4/14/2016
7	1602049-47	B347P0 Dup-7d1	Iron	2.11	48%	35	0.102	4/14/2016
21	1602049-71	B347P0 Dup-21d1	Iron	1.41	71%	35	0.102	4/14/2016
42	1602049-95	B347P0 Dup-42d1	Iron	1.37	18%	35	0.102	4/14/2016
3	1602049-22	B347P0 Dup-3d1	Manganese	0.051	59%	35	0.025	4/14/2016
7	1602049-47	B347P0 Dup-7d1	Manganese	0.005	NA	35	0.025	4/14/2016
21	1602049-71	B347P0 Dup-21d1	Manganese	0.001	NA	35	0.025	4/14/2016
42	1602049-95	B347P0 Dup-42d1	Manganese	ND	NA	35	0.025	4/14/2016
3	1602049-22	B347P0 Dup-3d1	Phosphorus	1.30	12%	35	0.417	4/14/2016
7	1602049-47	B347P0 Dup-7d1	Phosphorus	1.52	26%	35	0.417	4/14/2016
21	1602049-71	B347P0 Dup-21d1	Phosphorus	1.85	52%	35	0.417	4/14/2016
42	1602049-95	B347P0 Dup-42d1	Phosphorus	1.83	84%	35	0.417	4/14/2016
3	1602049-22	B347P0 Dup-3d1	Uranium 238	7.34	3.7%	35	0.145	3/15/2016
7	1602049-47	B347P0 Dup-7d1	Uranium 238	8.21	1.7%	35	0.145	3/15/2016
21	1602049-71	B347P0 Dup-21d1	Uranium 238	9.40	6.9%	35	0.145	3/15/2016
42	1602049-95	B347P0 Dup-42d1	Uranium 238	10.0	0.7%	35	0.073	3/29/2016
66	1602049-AT	B347P0 Dup-66d1	Uranium 238	11.1	1.1%	35	0.073	4/20/2016

Preparation Blanks

LabNumber	SampleName	Analyte	Result	EQL	Analyzed
			ug/L	ug/L	
1602049-23	PB-3d1	Calcium	ND	168	4/14/2016
1602049-48	PB-7d1	Calcium	ND	168	4/14/2016
1602049-72	PB-21d1	Calcium	ND	168	4/14/2016
1602049-96	PB-42d1	Calcium	ND	168	4/14/2016
1602049-23	PB-3d1	Iron	ND	50	4/14/2016
1602049-48	PB-7d1	Iron	ND	50	4/14/2016
1602049-72	PB-21d1	Iron	ND	50	4/14/2016
1602049-96	PB-42d1	Iron	ND	50	4/14/2016
1602049-23	PB-3d1	Manganese	ND	12	4/14/2016
1602049-48	PB-7d1	Manganese	ND	12	4/14/2016

1602049-72	PB-21d1	Manganese	ND	12	4/14/2016
1602049-96	PB-42d1	Manganese	ND	12	4/14/2016
1602049-23	PB-3d1	Phosphorus	ND	204	4/14/2016
1602049-48	PB-7d1	Phosphorus	ND	204	4/14/2016
1602049-72	PB-21d1	Phosphorus	ND	204	4/14/2016
1602049-96	PB-42d1	Phosphorus	ND	204	4/14/2016
1602049-23	PB-3d1	Uranium 238	ND	0.71	3/15/2016
1602049-48	PB-7d1	Uranium 238	ND	0.71	3/15/2016
1602049-72	PB-21d1	Uranium 238	ND	0.71	3/15/2016
1602049-96	PB-42d1	Uranium 238	ND	0.71	3/29/2016

Laboratory Control Samples

LabNumber	**SampleName**	**Analyte**	**Result**	**% recovery**	**%REC**	**Analyzed**
			ug/L		**Limits**	
1602049-24	ICP BS-3d1	Calcium	4920	98.4	80-120	4/14/2016
1602049-49	ICP BS-7d1	Calcium	4390	97.6	80-120	4/14/2016
1602049-73	ICP BS-21d1	Calcium	4000	100	80-120	4/14/2016
1602049-97	ICP BS-42d1	Calcium	3690	105	80-120	4/14/2016
1602049-24	ICP BS-3d1	Iron	4630	92.6	80-120	4/14/2016
1602049-49	ICP BS-7d1	Iron	4270	94.9	80-120	4/14/2016
1602049-73	ICP BS-21d1	Iron	3700	92.5	80-120	4/14/2016
1602049-97	ICP BS-42d1	Iron	3340	95.4	80-120	4/14/2016
1602049-24	ICP BS-3d1	Manganese	4670	93.4	80-120	4/14/2016
1602049-49	ICP BS-7d1	Manganese	4200	93.3	80-120	4/14/2016
1602049-73	ICP BS-21d1	Manganese	3720	93.0	80-120	4/14/2016
1602049-97	ICP BS-42d1	Manganese	3340	95.4	80-120	4/14/2016

Total Metals by PNNL-ESL-ICP-AES/Acid Extract - Quality Control
Environmental Science Laboratory

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 6D13005 - ASTM D 5198 (ICP/ICPMS)										
Blank (6D13005-BLK1)										
Prepared & Analyzed: 04/13/16										
Aluminum	<1.35E0	1.35E0	ug/g wet							
Calcium	<1.40E0	1.40E0	"							
Iron	<3.64E-1	3.64E-1	"							
Manganese	<1.21E-1	1.21E-1	"							
Phosphorus	<1.79E0	1.79E0	"							
LCS (6D13005-BS1)										
Prepared & Analyzed: 04/13/16										
Aluminum	4.04E0	1.35E0	ug/g wet	5.00E0		80.7	80-120			
Calcium	5.01E0	1.40E0	"	5.00E0		100	80-120			
Iron	4.69E0	3.64E-1	"	5.00E0		93.7	80-120			
Manganese	4.69E0	1.21E-1	"	5.00E0		93.8	80-120			
Phosphorus	<1.79E0	1.79E0	"				80-120			
Duplicate (6D13005-DUP1)										
Prepared & Analyzed: 04/13/16										
Source: 1604032-10										
Aluminum	2.20E3	2.81E0	ug/g dry		2.23E3			1.36	35	

"
3.51E3
35
3.95
3.38E3
Calcium
2.92E0

"
5.20E2
35
2.25
5.32E2
Iron
7.56E-1

"
5.70E1
35
0.116
5.71E1
Manganese
2.51E-1

"
4.03E2
35
0.782
4.06E2
Phosphorus
3.72E0

Post Spike (6D13005-PS1)
Prepared & Analyzed: 04/13/16
Source: 1604032-19

ug/L
5.00E2
1.30E5
75-125
937
1.34E5
Aluminum
N/A

"
5.00E2
1.54E5
75-125
439
1.56E5
Calcium
N/A

"
5.00E2
3.12E4
75-125
362
3.30E4
Iron
N/A

"
2.50E2
3.51E3
75-125
150
3.88E3
Manganese
N/A

"
1.25E3
4.82E4
75-125
285
5.18E4
Phosphorus
N/A

Radionuclides by ICP-MS/Acid Extract - Quality Control
Environmental Science Laboratory

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 6D12001 - ASTM D 5198 (ICP/ICPMS)										
Blank (6D12001-BLK1)										
Prepared: 04/07/16 Analyzed: 04/12/16										
Uranium 238	<7.10E-4	7.10E-4	ug/g wet							
LCS (6D12001-BS1)										
Prepared: 04/07/16 Analyzed: 04/12/16										
Uranium 238	<7.10E-4	7.10E-4	ug/g wet				80-120			
Duplicate (6D12001-DUP1)										
Prepared: 04/07/16 Analyzed: 04/12/16										
Source: 1604032-10										
Uranium 238	2.40E1	7.39E-1	ug/g dry		2.51E1			4.52	35	
Post Spike (6D12001-PS1)										
Prepared & Analyzed: 04/12/16										
Source: 1604032-19										
Uranium 238	1.10E0	N/A	ug/L	1.00E0	2.12E-1	89	75-125			

Analytical Data for <2mm composite column B347F1 and B347F3

LabNumber	SampleName	Analyte	Result	Units	EQL	Analysis
1602092-01	F1F3-1	pH	7.7	pH Units		pH-NP
1602092-01	F1F3-1	Uranium 238	13.4	ug/L	1.42	ICPMS-Tc_U-NP
1602092-02	F1F3-2	Uranium 238	13.8	ug/L	1.42	ICPMS-Tc_U-NP
1602092-03	F1F3-3	pH	7.92	pH Units		pH-NP
1602092-03	F1F3-3	Uranium 238	15.2	ug/L	1.42	ICPMS-Tc_U-NP
1602092-04	F1F3-4	Uranium 238	16.8	ug/L	1.42	ICPMS-Tc_U-NP
1602092-05	F1F3-5	pH	8.07	pH Units		pH-NP
1602092-05	F1F3-5	Uranium 238	17.1	ug/L	1.42	ICPMS-Tc_U-NP
1602092-06	F1F3-6	Uranium 238	17.2	ug/L	1.42	ICPMS-Tc_U-NP
1602092-07	F1F3-7	Uranium 238	16.3	ug/L	1.42	ICPMS-Tc_U-NP
1602092-08	F1F3-8	Uranium 238	16.7	ug/L	1.42	ICPMS-Tc_U-NP
1602092-09	F1F3-9	pH	8.43	pH Units		pH-NP
1602092-09	F1F3-9	Uranium 238	15.9	ug/L	1.42	ICPMS-Tc_U-NP
1602092-10	F1F3-10	Uranium 238	16	ug/L	1.42	ICPMS-Tc_U-NP
1602092-12	F1F3-12	Uranium 238	15.9	ug/L	1.42	ICPMS-Tc_U-NP
1602092-13	F1F3-13	pH	8.16	pH Units		pH-NP
1602092-15	F1F3-15	Uranium 238	16	ug/L	1.42	ICPMS-Tc_U-NP
1602092-17	F1F3-17	pH	8.06	pH Units		pH-NP
1602092-17	F1F3-17	Uranium 238	19.5	ug/L	1.42	ICPMS-Tc_U-NP
1602092-18	F1F3-18	Uranium 238	20.9	ug/L	1.42	ICPMS-Tc_U-NP
1602092-19	F1F3-19	pH	8.49	pH Units		pH-NP
1602092-19	F1F3-19	Uranium 238	20.7	ug/L	1.42	ICPMS-Tc_U-NP
1602092-20	F1F3-20	Uranium 238	20.4	ug/L	1.42	ICPMS-Tc_U-NP
1602092-21	F1F3-21	pH	8.19	pH Units		pH-NP
1602092-21	F1F3-21	Uranium 238	20.1	ug/L	1.42	ICPMS-Tc_U-NP
1602092-23	F1F3-23	Uranium 238	16.9	ug/L	1.42	ICPMS-Tc_U-NP
1602092-24	F1F3-24	Uranium 238	16.2	ug/L	1.42	ICPMS-Tc_U-NP
1602092-25	F1F3-25	pH	8.18	pH Units		pH-NP
1602092-25	F1F3-25	Uranium 238	16	ug/L	1.42	ICPMS-Tc_U-NP
1602092-26	F1F3-26	Uranium 238	16.3	ug/L	1.42	ICPMS-Tc_U-NP
1602092-28	F1F3-28	Uranium 238	16.5	ug/L	1.42	ICPMS-Tc_U-NP
1602092-30	F1F3-30	pH	8.4	pH Units		pH-NP

1602092-30	F1F3-30	Uranium 238	18.4	ug/L	1.42	ICPMS-Tc_U-NP
1602092-31	F1F3-31	Uranium 238	19.3	ug/L	1.42	ICPMS-Tc_U-NP
1602092-32	F1F3-32	pH	8.25	pH Units		pH-NP
1602092-32	F1F3-32	Uranium 238	19.3	ug/L	1.42	ICPMS-Tc_U-NP
1602092-34	F1F3-34	pH	8.24	pH Units		pH-NP
1602092-34	F1F3-34	Uranium 238	18.5	ug/L	1.42	ICPMS-Tc_U-NP
1602092-35	F1F3-35	Uranium 238	16.9	ug/L	1.42	ICPMS-Tc_U-NP
1602092-36	F1F3-36	Uranium 238	16.7	ug/L	1.42	ICPMS-Tc_U-NP
1602092-37	F1F3-37	Uranium 238	15.8	ug/L	1.42	ICPMS-Tc_U-NP
1602092-38	F1F3-38	Uranium 238	16.3	ug/L	1.42	ICPMS-Tc_U-NP
1602092-39	F1F3-39	pH	8.26	pH Units		pH-NP
1602092-39	F1F3-39	Uranium 238	16.6	ug/L	1.42	ICPMS-Tc_U-NP
1602092-41	F1F3-41	Uranium 238	16.4	ug/L	1.42	ICPMS-Tc_U-NP
1602092-43	F1F3-43	Uranium 238	16.5	ug/L	1.42	ICPMS-Tc_U-NP
1602092-44	F1F3-44	pH	8.43	pH Units		pH-NP
1602092-45	F1F3-45	Uranium 238	16.7	ug/L	1.42	ICPMS-Tc_U-NP
1602092-48	F1F3-48	pH	8.43	pH Units		pH-NP
1602092-48	F1F3-48	Uranium 238	16.4	ug/L	1.42	ICPMS-Tc_U-NP
1602092-49	F1F3-49	Bromide	ND	ug/mL	5	Anions by IC-NP
1602092-50	F1F3-50	Bromide	ND	ug/mL	5	Anions by IC-NP
1602092-51	F1F3-51	Bromide	ND	ug/mL	5	Anions by IC-NP
1602092-52	F1F3-52	Bromide	13.3	ug/mL	5	Anions by IC-NP
1602092-53	F1F3-53	Bromide	39.4	ug/mL	5	Anions by IC-NP
1602092-54	F1F3-54	Bromide	49.8	ug/mL	5	Anions by IC-NP
1602092-55	F1F3-55	Bromide	49.8	ug/mL	5	Anions by IC-NP
1602092-56	F1F3-56	Bromide	50	ug/mL	5	Anions by IC-NP
1602092-57	F1F3-57	Bromide	49.8	ug/mL	5	Anions by IC-NP
1602092-58	F1F3-58	Bromide	49.8	ug/mL	5	Anions by IC-NP
1602092-60	F1F3-60	Bromide	48.7	ug/mL	5	Anions by IC-NP
1602092-62	F1F3-62	Bromide	49.9	ug/mL	5	Anions by IC-NP
1602092-65	F1F3-65	Bromide	49.4	ug/mL	5	Anions by IC-NP
1602092-68	F1F3-68	Bromide	49.3	ug/mL	5	Anions by IC-NP

Pore Volume and stop flow data for <2mm composite column B347F1 and B347F3

Vial #	Pore volumes	COMMENTS
1	0.21	Start
2	0.42	
3	0.63	
4	0.83	

5	1.04	
6	1.24	
7	1.44	
8	1.64	
9	1.85	
10	2.05	
11	2.25	
12	2.46	
13	2.66	
14	2.87	
15	3.09	
16	3.23	48 hour stop flow
17	3.42	
18	3.63	
19	3.84	
20	4.04	
21	4.25	
22	4.25	
23	4.45	
24	4.66	
25	4.86	
26	5.07	
27	5.27	
28	5.48	
29	5.54	72 hour stop flow
30	5.72	
31	5.92	
32	6.11	
33	6.30	
34	6.49	
35	6.68	
36	6.87	
37	7.06	
38	7.25	
39	7.44	
40	7.64	
41	7.84	
42	8.04	
43	8.24	
44	8.44	
45	8.64	
46	8.84	
47	9.04	
48	9.11	Stop

Analytical Data for <2mm composite column B347P5 and B347P8

LabNumber	SampleName	Analyte	Result	Units	EQL	Analysis
1602093-01	P5P8-1	pH	8.31	pH Units		pH-NP
1602093-01	P5P8-1	Uranium 238	18500	ug/L	1420	ICPMS-Tc_U-NP
1602093-02	P5P8-2	Uranium 238	24900	ug/L	1420	ICPMS-Tc_U-NP
1602093-03	P5P8-3	pH	8.61	pH Units		pH-NP
1602093-03	P5P8-3	Uranium 238	22100	ug/L	1420	ICPMS-Tc_U-NP
1602093-04	P5P8-4	Uranium 238	20000	ug/L	1420	ICPMS-Tc_U-NP
1602093-05	P5P8-5	pH	8.66	pH Units		pH-NP
1602093-05	P5P8-5	Uranium 238	28900	ug/L	1420	ICPMS-Tc_U-NP
1602093-06	P5P8-6	Uranium 238	14900	ug/L	1420	ICPMS-Tc_U-NP
1602093-07	P5P8-7	Uranium 238	13100	ug/L	142	ICPMS-Tc_U-NP
1602093-08	P5P8-8	Uranium 238	11600	ug/L	142	ICPMS-Tc_U-NP

1602093-09	P5P8-9	Uranium 238	10900	ug/L	1.42	ICPMS-Tc_U-NP
1602093-10	P5P8-10	pH	8.78	pH Units		pH-NP
1602093-10	P5P8-10	Uranium 238	9570	ug/L	1.42	ICPMS-Tc_U-NP
1602093-12	P5P8-12	Uranium 238	8040	ug/L	1.42	ICPMS-Tc_U-NP
1602093-15	P5P8-15	pH	8.81	pH Units		pH-NP
1602093-15	P5P8-15	Uranium 238	6140	ug/L	1.42	ICPMS-Tc_U-NP
1602093-18	P5P8-18	Uranium 238	4840	ug/L	1.42	ICPMS-Tc_U-NP
1602093-20	P5P8-20	pH	8.74	pH Units		pH-NP
1602093-20	P5P8-20	Uranium 238	7050	ug/L	1.42	ICPMS-Tc_U-NP
1602093-21	P5P8-21	Uranium 238	5980	ug/L	1.42	ICPMS-Tc_U-NP
1602093-22	P5P8-22	pH	8.69	pH Units		pH-NP
1602093-22	P5P8-22	Uranium 238	5290	ug/L	1.42	ICPMS-Tc_U-NP
1602093-23	P5P8-23	Uranium 238	4710	ug/L	1.42	ICPMS-Tc_U-NP
1602093-24	P5P8-24	pH	8.77	pH Units		pH-NP
1602093-24	P5P8-24	Uranium 238	4350	ug/L	1.42	ICPMS-Tc_U-NP
1602093-25	P5P8-25	Uranium 238	4010	ug/L	1.42	ICPMS-Tc_U-NP
1602093-26	P5P8-26	Uranium 238	3780	ug/L	1.42	ICPMS-Tc_U-NP
1602093-27	P5P8-27	Uranium 238	3480	ug/L	1.42	ICPMS-Tc_U-NP
1602093-28	P5P8-28	Uranium 238	3320	ug/L	1.42	ICPMS-Tc_U-NP
1602093-29	P5P8-29	pH	8.73	pH Units		pH-NP
1602093-29	P5P8-29	Uranium 238	3130	ug/L	1.42	ICPMS-Tc_U-NP
1602093-32	P5P8-32	Uranium 238	2640	ug/L	1.42	ICPMS-Tc_U-NP
1602093-34	P5P8-34	pH	8.84	pH Units		pH-NP
1602093-34	P5P8-34	Uranium 238	3960	ug/L	1.42	ICPMS-Tc_U-NP
1602093-35	P5P8-35	Uranium 238	3640	ug/L	1.42	ICPMS-Tc_U-NP
1602093-36	P5P8-36	pH	8.92	pH Units		pH-NP
1602093-36	P5P8-36	Uranium 238	3150	ug/L	1.42	ICPMS-Tc_U-NP
1602093-37	P5P8-37	Uranium 238	2850	ug/L	1.42	ICPMS-Tc_U-NP
1602093-38	P5P8-38	pH	8.79	pH Units		pH-NP
1602093-38	P5P8-38	Uranium 238	2750	ug/L	1.42	ICPMS-Tc_U-NP
1602093-39	P5P8-39	Uranium 238	2600	ug/L	1.42	ICPMS-Tc_U-NP
1602093-40	P5P8-40	Uranium 238	2440	ug/L	1.42	ICPMS-Tc_U-NP
1602093-41	P5P8-41	Uranium 238	2280	ug/L	1.42	ICPMS-Tc_U-NP
1602093-42	P5P8-42	Uranium 238	2170	ug/L	1.42	ICPMS-Tc_U-NP
1602093-43	P5P8-43	pH	8.74	pH Units		pH-NP
1602093-43	P5P8-43	Uranium 238	2050	ug/L	1.42	ICPMS-Tc_U-NP
1602093-45	P5P8-45	Uranium 238	1890	ug/L	1.42	ICPMS-Tc_U-NP
1602093-47	P5P8-47	pH	8.78	pH Units		pH-NP
1602093-47	P5P8-47	Uranium 238	1710	ug/L	1.42	ICPMS-Tc_U-NP
1602093-50	P5P8-50	Uranium 238	1520	ug/L	1.42	ICPMS-Tc_U-NP
1602093-51	P5P8-51	pH	8.7	pH Units		pH-NP
1602093-55	P5P8-55	Uranium 238	1280	ug/L	1.42	ICPMS-Tc_U-NP
1602093-56	P5P8-56	pH	8.64	pH Units		pH-NP

1602093-57	P5P8-57	Bromide	ND	ug/mL	5	Anions by IC-NP
1602093-58	P5P8-58	Bromide	ND	ug/mL	5	Anions by IC-NP
1602093-59	P5P8-59	Bromide	8.16	ug/mL	5	Anions by IC-NP
1602093-60	P5P8-60	Bromide	22.3	ug/mL	5	Anions by IC-NP
1602093-61	P5P8-61	Bromide	33.4	ug/mL	5	Anions by IC-NP
1602093-62	P5P8-62	Bromide	41.7	ug/mL	5	Anions by IC-NP
1602093-63	P5P8-63	Bromide	46.9	ug/mL	5	Anions by IC-NP
1602093-64	P5P8-64	Bromide	49.6	ug/mL	5	Anions by IC-NP
1602093-65	P5P8-65	Bromide	50.1	ug/mL	5	Anions by IC-NP
1602093-66	P5P8-66	Bromide	50.3	ug/mL	5	Anions by IC-NP
1602093-68	P5P8-68	Bromide	50.2	ug/mL	5	Anions by IC-NP
1602093-70	P5P8-70	Bromide	50.2	ug/mL	5	Anions by IC-NP
1602093-72	P5P8-72	Bromide	50.1	ug/mL	5	Anions by IC-NP
1602093-74	P5P8-74	Bromide	49.9	ug/mL	5	Anions by IC-NP
1602093-76	P5P8-76	Bromide	50.2	ug/mL	5	Anions by IC-NP
1602093-79	P5P8-79	Bromide	50	ug/mL	5	Anions by IC-NP

Pore Volume and stop flow data for <2mm composite column B347P5 and B347P8

Vial #	Pore volumes	COMMENTS
1	0.19	Start
2	0.40	
3	0.61	
4	0.81	
5	1.02	
6	1.22	
7	1.43	
8	1.65	
9	1.86	
10	2.08	
11	2.28	
12	2.50	
13	2.71	
14	2.91	
15	3.13	
16	3.34	
17	3.55	
18	3.76	
19	3.91	48 hour stop flow
20	4.07	
21	4.28	
22	4.49	
23	4.70	
24	4.91	
25	5.11	
26	5.32	
27	5.53	
28	5.74	
29	5.95	
30	6.16	
31	6.37	
32	6.58	
33	6.63	72 hour stop flow
34	6.82	

35	7.02	
36	7.22	
37	7.40	
38	7.59	
39	7.79	
40	7.98	
41	8.18	
42	8.29	
43	8.48	
44	8.67	
45	8.87	
46	9.06	
47	9.20	
48	9.39	
49	9.59	
50	9.78	
51	9.98	
52	10.12	
53	10.27	
54	10.47	
55	10.62	
56	10.70	Stop

Analytical Data for <2mm column B347R1

LabNumber	SampleName	Analyte	Result	Units	EQL	Analysis
1602094-01	7R1-1	pH	8.07	pH Units		pH-NP
1602094-01	7R1-1	Uranium 238	3600	ug/L	14.2	ICPMS-Tc_U-NP
1602094-02	7R1-2	Uranium 238	4160	ug/L	14.2	ICPMS-Tc_U-NP
1602094-03	7R1-3	pH	8.68	pH Units		pH-NP
1602094-03	7R1-3	Uranium 238	4270	ug/L	14.2	ICPMS-Tc_U-NP
1602094-04	7R1-4	Uranium 238	4110	ug/L	14.2	ICPMS-Tc_U-NP
1602094-05	7R1-5	pH	8.5	pH Units		pH-NP
1602094-05	7R1-5	Uranium 238	4140	ug/L	14.2	ICPMS-Tc_U-NP
1602094-06	7R1-6	Uranium 238	4040	ug/L	14.2	ICPMS-Tc_U-NP
1602094-07	7R1-7	Uranium 238	3880	ug/L	14.2	ICPMS-Tc_U-NP
1602094-08	7R1-8	Uranium 238	3590	ug/L	14.2	ICPMS-Tc_U-NP
1602094-09	7R1-9	Uranium 238	3510	ug/L	14.2	ICPMS-Tc_U-NP
1602094-10	7R1-10	pH	8.59	pH Units		pH-NP
1602094-10	7R1-10	Uranium 238	3280	ug/L	14.2	ICPMS-Tc_U-NP
1602094-12	7R1-12	Uranium 238	2990	ug/L	14.2	ICPMS-Tc_U-NP
1602094-15	7R1-15	pH	8.43	pH Units		pH-NP
1602094-15	7R1-15	Uranium 238	2570	ug/L	14.2	ICPMS-Tc_U-NP
1602094-18	7R1-18	Uranium 238	2400	ug/L	14.2	ICPMS-Tc_U-NP
1602094-20	7R1-20	pH	8.41	pH Units		pH-NP
1602094-20	7R1-20	Uranium 238	2950	ug/L	14.2	ICPMS-Tc_U-NP
1602094-21	7R1-21	Uranium 238	2790	ug/L	14.2	ICPMS-Tc_U-NP
1602094-22	7R1-22	pH	8.42	pH Units		pH-NP
1602094-22	7R1-22	Uranium 238	2490	ug/L	14.2	ICPMS-Tc_U-NP
1602094-23	7R1-23	Uranium 238	2430	ug/L	14.2	ICPMS-Tc_U-NP
1602094-24	7R1-24	pH	8.46	pH Units		pH-NP

1602094-24	7R1-24	Uranium 238	2320	ug/L	14.2	ICPMS-Tc_U-NP
1602094-25	7R1-25	Uranium 238	2240	ug/L	14.2	ICPMS-Tc_U-NP
1602094-26	7R1-26	Uranium 238	2020	ug/L	14.2	ICPMS-Tc_U-NP
1602094-27	7R1-27	Uranium 238	1990	ug/L	14.2	ICPMS-Tc_U-NP
1602094-28	7R1-28	Uranium 238	1920	ug/L	14.2	ICPMS-Tc_U-NP
1602094-29	7R1-29	pH	8.41	pH Units		pH-NP
1602094-29	7R1-29	Uranium 238	1880	ug/L	14.2	ICPMS-Tc_U-NP
1602094-32	7R1-32	Uranium 238	1690	ug/L	14.2	ICPMS-Tc_U-NP
1602094-34	7R1-34	pH	8.47	pH Units		pH-NP
1602094-34	7R1-34	Uranium 238	2320	ug/L	14.2	ICPMS-Tc_U-NP
1602094-35	7R1-35	Uranium 238	2140	ug/L	14.2	ICPMS-Tc_U-NP
1602094-36	7R1-36	pH	8.5	pH Units		pH-NP
1602094-36	7R1-36	Uranium 238	1940	ug/L	14.2	ICPMS-Tc_U-NP
1602094-37	7R1-37	Uranium 238	1810	ug/L	14.2	ICPMS-Tc_U-NP
1602094-38	7R1-38	pH	8.48	pH Units		pH-NP
1602094-38	7R1-38	Uranium 238	1770	ug/L	14.2	ICPMS-Tc_U-NP
1602094-39	7R1-39	Uranium 238	1700	ug/L	14.2	ICPMS-Tc_U-NP
1602094-40	7R1-40	Uranium 238	1640	ug/L	14.2	ICPMS-Tc_U-NP
1602094-41	7R1-41	Uranium 238	1610	ug/L	14.2	ICPMS-Tc_U-NP
1602094-42	7R1-42	Uranium 238	1500	ug/L	14.2	ICPMS-Tc_U-NP
1602094-43	7R1-43	pH	8.51	pH Units		pH-NP
1602094-43	7R1-43	Uranium 238	1420	ug/L	14.2	ICPMS-Tc_U-NP
1602094-45	7R1-45	Uranium 238	1300	ug/L	14.2	ICPMS-Tc_U-NP
1602094-47	7R1-47	pH	8.46	pH Units		pH-NP
1602094-47	7R1-47	Uranium 238	1280	ug/L	14.2	ICPMS-Tc_U-NP
1602094-50	7R1-50	Uranium 238	1110	ug/L	14.2	ICPMS-Tc_U-NP
1602094-51	7R1-51	pH	8.55	pH Units		pH-NP
1602094-55	7R1-55	Uranium 238	977	ug/L	14.2	ICPMS-Tc_U-NP
1602094-56	7R1-56	pH	8.33	pH Units		pH-NP
1602094-57	7R1-57	Bromide	ND	ug/mL	5	Anions by IC-NP
1602094-58	7R1-58	Bromide	ND	ug/mL	5	Anions by IC-NP
1602094-59	7R1-59	Bromide	ND	ug/mL	5	Anions by IC-NP
1602094-60	7R1-60	Bromide	24.4	ug/mL	5	Anions by IC-NP
1602094-61	7R1-61	Bromide	45.2	ug/mL	5	Anions by IC-NP
1602094-62	7R1-62	Bromide	49.6	ug/mL	5	Anions by IC-NP
1602094-63	7R1-63	Bromide	50.3	ug/mL	5	Anions by IC-NP
1602094-64	7R1-64	Bromide	50.2	ug/mL	5	Anions by IC-NP
1602094-65	7R1-65	Bromide	50.3	ug/mL	5	Anions by IC-NP
1602094-66	7R1-66	Bromide	50.2	ug/mL	5	Anions by IC-NP
1602094-68	7R1-68	Bromide	50.1	ug/mL	5	Anions by IC-NP
1602094-70	7R1-70	Bromide	50.2	ug/mL	5	Anions by IC-NP

1602094-72	7R1-72	Bromide	50.2	ug/mL	5	Anions by IC-NP
1602094-74	7R1-74	Bromide	50	ug/mL	5	Anions by IC-NP
1602094-76	7R1-76	Bromide	49.8	ug/mL	5	Anions by IC-NP
1602094-79	7R1-79	Bromide	50	ug/mL	5	Anions by IC-NP

Pore Volume and stop flow data for <2mm column B347R1

Vial #	Pore volumes	COMMENTS
1	0.22	Start
2	0.45	
3	0.69	
4	0.91	
5	1.14	
6	1.38	
7	1.61	
8	1.85	
9	2.08	
10	2.32	
11	2.56	
12	2.79	
13	3.02	
14	3.25	
15	3.48	
16	3.71	
17	3.95	
18	4.19	
19	4.33	48 hour stop flow
20	4.55	
21	4.79	
22	5.02	
23	5.26	
24	5.49	
25	5.73	
26	5.96	
27	6.20	
28	6.43	
29	6.66	
30	6.90	
31	7.13	
32	7.37	
33	7.43	72 hour stop flow
34	7.64	
35	7.86	
36	8.08	
37	8.30	
38	8.52	
39	8.74	
40	8.96	
41	9.18	
42	9.40	
43	9.63	
44	9.84	
45	10.07	
46	10.29	
47	10.50	
48	10.72	
49	10.95	
50	11.17	
51	11.39	
52	11.62	
53	11.84	
54	12.06	
55	12.28	
56	12.37	stop

Analytical Data for <2mm column B347T7

LabNumber	SampleName	Analyte	Result	Units	EQL	Analysis
1602095-01	7T7-1	pH	7.67	pH Units		pH-NP
1602095-01	7T7-1	Uranium 238	2.39	ug/L	0.071	ICPMS-Tc_U-NP
1602095-02	7T7-2	Uranium 238	4.58	ug/L	0.071	ICPMS-Tc_U-NP
1602095-03	7T7-3	pH	8.27	pH Units		pH-NP
1602095-03	7T7-3	Uranium 238	5.45	ug/L	0.071	ICPMS-Tc_U-NP
1602095-04	7T7-4	Uranium 238	5.61	ug/L	0.071	ICPMS-Tc_U-NP
1602095-05	7T7-5	pH	8.06	pH Units		pH-NP
1602095-05	7T7-5	Uranium 238	5.72	ug/L	0.071	ICPMS-Tc_U-NP
1602095-06	7T7-6	Uranium 238	5.9	ug/L	0.071	ICPMS-Tc_U-NP
1602095-07	7T7-7	Uranium 238	5.89	ug/L	0.071	ICPMS-Tc_U-NP
1602095-08	7T7-8	Uranium 238	5.85	ug/L	0.071	ICPMS-Tc_U-NP
1602095-09	7T7-9	Uranium 238	5.85	ug/L	0.071	ICPMS-Tc_U-NP
1602095-10	7T7-10	pH	8.17	pH Units		pH-NP
1602095-10	7T7-10	Uranium 238	5.66	ug/L	0.071	ICPMS-Tc_U-NP
1602095-12	7T7-12	Uranium 238	5.67	ug/L	0.071	ICPMS-Tc_U-NP
1602095-15	7T7-15	pH	8.19	pH Units		pH-NP
1602095-15	7T7-15	Uranium 238	5.58	ug/L	0.071	ICPMS-Tc_U-NP
1602095-18	7T7-18	Uranium 238	5.55	ug/L	0.071	ICPMS-Tc_U-NP
1602095-20	7T7-20	pH	8.25	pH Units		pH-NP
1602095-20	7T7-20	Uranium 238	6.81	ug/L	0.071	ICPMS-Tc_U-NP
1602095-21	7T7-21	Uranium 238	6.35	ug/L	0.071	ICPMS-Tc_U-NP
1602095-22	7T7-22	pH	8.2	pH Units		pH-NP
1602095-22	7T7-22	Uranium 238	6.29	ug/L	0.071	ICPMS-Tc_U-NP
1602095-23	7T7-23	Uranium 238	5.95	ug/L	0.071	ICPMS-Tc_U-NP
1602095-24	7T7-24	pH	8.21	pH Units		pH-NP
1602095-24	7T7-24	Uranium 238	5.87	ug/L	0.071	ICPMS-Tc_U-NP
1602095-25	7T7-25	Uranium 238	5.68	ug/L	0.071	ICPMS-Tc_U-NP
1602095-26	7T7-26	Uranium 238	5.65	ug/L	0.071	ICPMS-Tc_U-NP
1602095-27	7T7-27	Uranium 238	5.45	ug/L	0.071	ICPMS-Tc_U-NP
1602095-28	7T7-28	Uranium 238	5.33	ug/L	0.071	ICPMS-Tc_U-NP
1602095-29	7T7-29	pH	8.21	pH Units		pH-NP
1602095-29	7T7-29	Uranium 238	5.29	ug/L	0.071	ICPMS-Tc_U-NP
1602095-32	7T7-32	Uranium 238	5.34	ug/L	0.071	ICPMS-Tc_U-NP
1602095-34	7T7-34	pH	8.24	pH Units		pH-NP
1602095-34	7T7-34	Uranium 238	6.48	ug/L	0.071	ICPMS-Tc_U-NP
1602095-35	7T7-35	Uranium 238	6.42	ug/L	0.071	ICPMS-Tc_U-NP
1602095-36	7T7-36	pH	8.26	pH Units		pH-NP
1602095-36	7T7-36	Uranium 238	5.72	ug/L	0.071	ICPMS-Tc_U-NP
1602095-37	7T7-37	Uranium 238	5.51	ug/L	0.071	ICPMS-Tc_U-NP
1602095-38	7T7-38	pH	8.33	pH Units		pH-NP
1602095-38	7T7-38	Uranium 238	5.9	ug/L	0.071	ICPMS-Tc_U-NP
1602095-39	7T7-39	Uranium 238	6.27	ug/L	0.071	ICPMS-Tc_U-NP
1602095-40	7T7-40	Uranium 238	6.04	ug/L	0.071	ICPMS-Tc_U-NP
1602095-41	7T7-41	Uranium 238	6.03	ug/L	0.071	ICPMS-Tc_U-NP
1602095-42	7T7-42	Uranium 238	6.05	ug/L	0.071	ICPMS-Tc_U-NP
1602095-43	7T7-43	pH	8.21	pH Units		pH-NP
1602095-43	7T7-43	Uranium 238	6.09	ug/L	0.071	ICPMS-Tc_U-NP
1602095-45	7T7-45	Uranium 238	6.48	ug/L	0.071	ICPMS-Tc_U-NP
1602095-47	7T7-47	pH	8.42	pH Units		pH-NP
1602095-47	7T7-47	Uranium 238	6.83	ug/L	0.071	ICPMS-Tc_U-NP
1602095-50	7T7-50	Uranium 238	7.68	ug/L	0.071	ICPMS-Tc_U-NP
1602095-51	7T7-51	pH	8.37	pH Units		pH-NP
1602095-55	7T7-55	Uranium 238	9.56	ug/L	0.071	ICPMS-Tc_U-NP
1602095-56	7T7-56	pH	8.3	pH Units		pH-NP
1602095-57	7T7-57	Bromide	ND	ug/mL	5	Anions by IC-NP
1602095-58	7T7-58	Bromide	ND	ug/mL	5	Anions by IC-NP
1602095-59	7T7-59	Bromide	ND	ug/mL	5	Anions by IC-NP
1602095-60	7T7-60	Bromide	14.5	ug/mL	5	Anions by IC-NP
1602095-61	7T7-61	Bromide	41.5	ug/mL	5	Anions by IC-NP
1602095-62	7T7-62	Bromide	49.2	ug/mL	5	Anions by IC-NP
1602095-63	7T7-63	Bromide	50.1	ug/mL	5	Anions by IC-NP
1602095-64	7T7-64	Bromide	50	ug/mL	5	Anions by IC-NP
1602095-65	7T7-65	Bromide	50	ug/mL	5	Anions by IC-NP
1602095-66	7T7-66	Bromide	50.1	ug/mL	5	Anions by IC-NP
1602095-68	7T7-68	Bromide	50.1	ug/mL	5	Anions by IC-NP

1602095-70	7T7-70	Bromide	50	ug/mL	5	Anions by IC-NP
1602095-72	7T7-72	Bromide	50	ug/mL	5	Anions by IC-NP
1602095-74	7T7-74	Bromide	50	ug/mL	5	Anions by IC-NP
1602095-76	7T7-76	Bromide	49.8	ug/mL	5	Anions by IC-NP
1602095-79	7T7-79	Bromide	49.8	ug/mL	5	Anions by IC-NP

Pore Volume and stop flow data for <2mm column B347T7

Vial #	Pore volumes	COMMENTS
1	0.16	Start
2	0.38	
3	0.61	
4	0.83	
5	1.05	
6	1.27	
7	1.50	
8	1.72	
9	1.94	
10	2.17	
11	2.39	
12	2.61	
13	2.83	
14	3.05	
15	3.27	
16	3.49	
17	3.71	
18	3.94	
19	4.07	48 hour stop flow
20	4.29	
21	4.51	
22	4.74	
23	4.96	
24	5.19	
25	5.41	
26	5.64	
27	5.87	
28	6.09	
29	6.32	
30	6.55	
31	6.77	
32	7.00	
33	7.06	72 hour stop flow
34	7.27	
35	7.49	
36	7.70	
37	7.91	
38	8.12	
39	8.34	
40	8.55	
41	8.76	
42	8.98	
43	9.19	
44	9.40	
45	9.62	
46	9.84	
47	10.06	
48	10.27	
49	10.49	
50	10.70	
51	10.92	
52	11.13	
53	11.35	
54	11.56	
55	11.78	
56	11.87	stop

Analytical Data for in-tact column B347P4

LabNumber	SampleName	Analyte	Result	Units	EQL	Analysis
1602051-01	B347P4 vial 1	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-01	B347P4 vial 1	Calcium	26400	ug/L	336	ICP-OES Vadose-NP
1602051-01	B347P4 vial 1	Chloride	67	ug/mL	2.5	Anions by IC-NP
1602051-01	B347P4 vial 1	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-01	B347P4 vial 1	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-01	B347P4 vial 1	Nitrate	28.7	ug/mL	5	Anions by IC-NP
1602051-01	B347P4 vial 1	pH	8.42	pH Units		pH-NP
1602051-01	B347P4 vial 1	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-01	B347P4 vial 1	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-01	B347P4 vial 1	Sulfate	50.3	ug/mL	7.5	Anions by IC-NP
1602051-01	B347P4 vial 1	Uranium 238	1760	ug/L	14.2	ICPMS-Tc_U-NP
1602051-03	B347P4 vial 3	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-03	B347P4 vial 3	Calcium	17100	ug/L	336	ICP-OES Vadose-NP
1602051-03	B347P4 vial 3	Chloride	65.6	ug/mL	2.5	Anions by IC-NP
1602051-03	B347P4 vial 3	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-03	B347P4 vial 3	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-03	B347P4 vial 3	Nitrate	28	ug/mL	5	Anions by IC-NP
1602051-03	B347P4 vial 3	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-03	B347P4 vial 3	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-03	B347P4 vial 3	Sulfate	56.2	ug/mL	7.5	Anions by IC-NP
1602051-03	B347P4 vial 3	Uranium 238	3790	ug/L	14.2	ICPMS-Tc_U-NP
1602051-05	B347P4 vial 5	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-05	B347P4 vial 5	Calcium	17000	ug/L	336	ICP-OES Vadose-NP
1602051-05	B347P4 vial 5	Chloride	67.5	ug/mL	2.5	Anions by IC-NP
1602051-05	B347P4 vial 5	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-05	B347P4 vial 5	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-05	B347P4 vial 5	Nitrate	27.5	ug/mL	5	Anions by IC-NP
1602051-05	B347P4 vial 5	pH	8.58	pH Units		pH-NP
1602051-05	B347P4 vial 5	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-05	B347P4 vial 5	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-05	B347P4 vial 5	Sulfate	57.5	ug/mL	7.5	Anions by IC-NP
1602051-05	B347P4 vial 5	Uranium 238	3920	ug/L	14.2	ICPMS-Tc_U-NP
1602051-07	B347P4 vial 7	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-07	B347P4 vial 7	Calcium	20100	ug/L	336	ICP-OES Vadose-NP
1602051-07	B347P4 vial 7	Chloride	65.6	ug/mL	2.5	Anions by IC-NP
1602051-07	B347P4 vial 7	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-07	B347P4 vial 7	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-07	B347P4 vial 7	Nitrate	27.6	ug/mL	5	Anions by IC-NP
1602051-07	B347P4 vial 7	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-07	B347P4 vial 7	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-07	B347P4 vial 7	Sulfate	51.8	ug/mL	7.5	Anions by IC-NP
1602051-07	B347P4 vial 7	Uranium 238	2650	ug/L	14.2	ICPMS-Tc_U-NP
1602051-09	B347P4 vial 9	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-09	B347P4 vial 9	Calcium	23700	ug/L	336	ICP-OES Vadose-NP
1602051-09	B347P4 vial 9	Chloride	66.3	ug/mL	2.5	Anions by IC-NP
1602051-09	B347P4 vial 9	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-09	B347P4 vial 9	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP

1602051-09	B347P4 vial 9	Nitrate	27.5	ug/mL	5	Anions by IC-NP
1602051-09	B347P4 vial 9	pH	8.29	pH Units		pH-NP
1602051-09	B347P4 vial 9	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-09	B347P4 vial 9	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-09	B347P4 vial 9	Sulfate	49	ug/mL	7.5	Anions by IC-NP
1602051-09	B347P4 vial 9	Uranium 238	2220	ug/L	14.2	ICPMS-Tc_U-NP
1602051-11	B347P4 vial 11	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-11	B347P4 vial 11	Calcium	24900	ug/L	336	ICP-OES Vadose-NP
1602051-11	B347P4 vial 11	Chloride	64.6	ug/mL	2.5	Anions by IC-NP
1602051-11	B347P4 vial 11	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-11	B347P4 vial 11	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-11	B347P4 vial 11	Nitrate	27.5	ug/mL	5	Anions by IC-NP
1602051-11	B347P4 vial 11	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-11	B347P4 vial 11	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-11	B347P4 vial 11	Sulfate	47.7	ug/mL	7.5	Anions by IC-NP
1602051-11	B347P4 vial 11	Uranium 238	1900	ug/L	14.2	ICPMS-Tc_U-NP
1602051-13	B347P4 vial 13	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-13	B347P4 vial 13	Calcium	26400	ug/L	336	ICP-OES Vadose-NP
1602051-13	B347P4 vial 13	Chloride	64.8	ug/mL	2.5	Anions by IC-NP
1602051-13	B347P4 vial 13	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-13	B347P4 vial 13	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-13	B347P4 vial 13	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602051-13	B347P4 vial 13	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-13	B347P4 vial 13	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-13	B347P4 vial 13	Sulfate	47.1	ug/mL	7.5	Anions by IC-NP
1602051-13	B347P4 vial 13	Uranium 238	1550	ug/L	14.2	ICPMS-Tc_U-NP
1602051-15	B347P4 vial 15	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-15	B347P4 vial 15	Calcium	28000	ug/L	336	ICP-OES Vadose-NP
1602051-15	B347P4 vial 15	Chloride	65.7	ug/mL	2.5	Anions by IC-NP
1602051-15	B347P4 vial 15	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-15	B347P4 vial 15	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-15	B347P4 vial 15	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602051-15	B347P4 vial 15	pH	8.11	pH Units		pH-NP
1602051-15	B347P4 vial 15	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-15	B347P4 vial 15	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-15	B347P4 vial 15	Sulfate	46.4	ug/mL	7.5	Anions by IC-NP
1602051-15	B347P4 vial 15	Uranium 238	1420	ug/L	14.2	ICPMS-Tc_U-NP
1602051-20	B347P4 vial 20	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-20	B347P4 vial 20	Calcium	30700	ug/L	336	ICP-OES Vadose-NP
1602051-20	B347P4 vial 20	Chloride	65.6	ug/mL	2.5	Anions by IC-NP
1602051-20	B347P4 vial 20	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-20	B347P4 vial 20	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-20	B347P4 vial 20	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602051-20	B347P4 vial 20	pH	8.1	pH Units		pH-NP
1602051-20	B347P4 vial 20	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-20	B347P4 vial 20	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-20	B347P4 vial 20	Sulfate	45.4	ug/mL	7.5	Anions by IC-NP
1602051-20	B347P4 vial 20	Uranium 238	1230	ug/L	14.2	ICPMS-Tc_U-NP
1602051-25	B347P4 vial 25	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-25	B347P4 vial 25	Calcium	32200	ug/L	336	ICP-OES Vadose-NP
1602051-25	B347P4 vial 25	Chloride	64.2	ug/mL	2.5	Anions by IC-NP

1602051-25	B347P4 vial 25	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-25	B347P4 vial 25	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-25	B347P4 vial 25	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602051-25	B347P4 vial 25	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-25	B347P4 vial 25	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-25	B347P4 vial 25	Sulfate	44.6	ug/mL	7.5	Anions by IC-NP
1602051-25	B347P4 vial 25	Uranium 238	1050	ug/L	14.2	ICPMS-Tc_U-NP
1602051-30	B347P4 vial 30	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-30	B347P4 vial 30	Calcium	32600	ug/L	336	ICP-OES Vadose-NP
1602051-30	B347P4 vial 30	Chloride	65	ug/mL	2.5	Anions by IC-NP
1602051-30	B347P4 vial 30	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-30	B347P4 vial 30	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-30	B347P4 vial 30	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602051-30	B347P4 vial 30	pH	7.98	pH Units		pH-NP
1602051-30	B347P4 vial 30	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-30	B347P4 vial 30	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-30	B347P4 vial 30	Sulfate	44.2	ug/mL	7.5	Anions by IC-NP
1602051-30	B347P4 vial 30	Uranium 238	920	ug/L	14.2	ICPMS-Tc_U-NP
1602051-35	B347P4 vial 35	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-35	B347P4 vial 35	Calcium	32700	ug/L	336	ICP-OES Vadose-NP
1602051-35	B347P4 vial 35	Chloride	63.9	ug/mL	2.5	Anions by IC-NP
1602051-35	B347P4 vial 35	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-35	B347P4 vial 35	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-35	B347P4 vial 35	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602051-35	B347P4 vial 35	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-35	B347P4 vial 35	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-35	B347P4 vial 35	Sulfate	44	ug/mL	7.5	Anions by IC-NP
1602051-35	B347P4 vial 35	Uranium 238	893	ug/L	14.2	ICPMS-Tc_U-NP
1602051-40	B347P4 vial 40	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-40	B347P4 vial 40	Calcium	34000	ug/L	336	ICP-OES Vadose-NP
1602051-40	B347P4 vial 40	Chloride	65	ug/mL	2.5	Anions by IC-NP
1602051-40	B347P4 vial 40	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-40	B347P4 vial 40	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-40	B347P4 vial 40	Nitrate	27.9	ug/mL	5	Anions by IC-NP
1602051-40	B347P4 vial 40	pH	8.12	pH Units		pH-NP
1602051-40	B347P4 vial 40	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-40	B347P4 vial 40	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-40	B347P4 vial 40	Sulfate	43.8	ug/mL	7.5	Anions by IC-NP
1602051-40	B347P4 vial 40	Uranium 238	782	ug/L	14.2	ICPMS-Tc_U-NP
1602051-50	B347P4 vial 50	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-50	B347P4 vial 50	Calcium	35300	ug/L	336	ICP-OES Vadose-NP
1602051-50	B347P4 vial 50	Chloride	66.1	ug/mL	2.5	Anions by IC-NP
1602051-50	B347P4 vial 50	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-50	B347P4 vial 50	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-50	B347P4 vial 50	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-50	B347P4 vial 50	pH	8.09	pH Units		pH-NP
1602051-50	B347P4 vial 50	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-50	B347P4 vial 50	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-50	B347P4 vial 50	Sulfate	44.2	ug/mL	7.5	Anions by IC-NP
1602051-50	B347P4 vial 50	Uranium 238	722	ug/L	14.2	ICPMS-Tc_U-NP

1602051-60	B347P4 vial 60	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-60	B347P4 vial 60	Calcium	35300	ug/L	336	ICP-OES Vadose-NP
1602051-60	B347P4 vial 60	Chloride	65.7	ug/mL	2.5	Anions by IC-NP
1602051-60	B347P4 vial 60	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-60	B347P4 vial 60	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-60	B347P4 vial 60	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602051-60	B347P4 vial 60	pH	8.15	pH Units		pH-NP
1602051-60	B347P4 vial 60	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-60	B347P4 vial 60	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-60	B347P4 vial 60	Sulfate	43.4	ug/mL	7.5	Anions by IC-NP
1602051-60	B347P4 vial 60	Uranium 238	643	ug/L	14.2	ICPMS-Tc_U-NP
1602051-70	B347P4 vial 70	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-70	B347P4 vial 70	Calcium	36200	ug/L	336	ICP-OES Vadose-NP
1602051-70	B347P4 vial 70	Chloride	65.1	ug/mL	2.5	Anions by IC-NP
1602051-70	B347P4 vial 70	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-70	B347P4 vial 70	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-70	B347P4 vial 70	Nitrate	28	ug/mL	5	Anions by IC-NP
1602051-70	B347P4 vial 70	pH	8.1	pH Units		pH-NP
1602051-70	B347P4 vial 70	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-70	B347P4 vial 70	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-70	B347P4 vial 70	Sulfate	42.9	ug/mL	7.5	Anions by IC-NP
1602051-70	B347P4 vial 70	Uranium 238	560	ug/L	14.2	ICPMS-Tc_U-NP
1602051-80	B347P4 vial 80	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-80	B347P4 vial 80	Calcium	36800	ug/L	336	ICP-OES Vadose-NP
1602051-80	B347P4 vial 80	Chloride	65.6	ug/mL	2.5	Anions by IC-NP
1602051-80	B347P4 vial 80	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-80	B347P4 vial 80	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-80	B347P4 vial 80	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602051-80	B347P4 vial 80	pH	8.09	pH Units		pH-NP
1602051-80	B347P4 vial 80	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-80	B347P4 vial 80	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-80	B347P4 vial 80	Sulfate	43	ug/mL	7.5	Anions by IC-NP
1602051-80	B347P4 vial 80	Uranium 238	502	ug/L	14.2	ICPMS-Tc_U-NP
1602051-90	B347P4 vial 90	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-90	B347P4 vial 90	Calcium	36500	ug/L	336	ICP-OES Vadose-NP
1602051-90	B347P4 vial 90	Chloride	65	ug/mL	2.5	Anions by IC-NP
1602051-90	B347P4 vial 90	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-90	B347P4 vial 90	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-90	B347P4 vial 90	Nitrate	28.1	ug/mL	5	Anions by IC-NP
1602051-90	B347P4 vial 90	pH	8.05	pH Units		pH-NP
1602051-90	B347P4 vial 90	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-90	B347P4 vial 90	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-90	B347P4 vial 90	Sulfate	42.8	ug/mL	7.5	Anions by IC-NP
1602051-90	B347P4 vial 90	Uranium 238	487	ug/L	14.2	ICPMS-Tc_U-NP
1602051-AA	B347P4 vial 100	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-AA	B347P4 vial 100	Calcium	36200	ug/L	336	ICP-OES Vadose-NP
1602051-AA	B347P4 vial 100	Chloride	65.5	ug/mL	2.5	Anions by IC-NP
1602051-AA	B347P4 vial 100	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-AA	B347P4 vial 100	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-AA	B347P4 vial 100	Nitrate	28.1	ug/mL	5	Anions by IC-NP

1602051-AA	B347P4 vial 100	pH	8.02	pH Units		pH-NP
1602051-AA	B347P4 vial 100	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-AA	B347P4 vial 100	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-AA	B347P4 vial 100	Sulfate	42.8	ug/mL	7.5	Anions by IC-NP
1602051-AA	B347P4 vial 100	Uranium 238	502	ug/L	14.2	ICPMS-Tc_U-NP
1602051-AK	B347P4 vial 110	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-AK	B347P4 vial 110	Calcium	37100	ug/L	336	ICP-OES Vadose-NP
1602051-AK	B347P4 vial 110	Chloride	66.5	ug/mL	2.5	Anions by IC-NP
1602051-AK	B347P4 vial 110	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-AK	B347P4 vial 110	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-AK	B347P4 vial 110	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602051-AK	B347P4 vial 110	pH	8.07	pH Units		pH-NP
1602051-AK	B347P4 vial 110	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-AK	B347P4 vial 110	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-AK	B347P4 vial 110	Sulfate	42.9	ug/mL	7.5	Anions by IC-NP
1602051-AK	B347P4 vial 110	Uranium 238	472	ug/L	14.2	ICPMS-Tc_U-NP
1602051-AU	B347P4 vial 120	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-AU	B347P4 vial 120	Calcium	24700	ug/L	336	ICP-OES Vadose-NP
1602051-AU	B347P4 vial 120	Chloride	65.6	ug/mL	2.5	Anions by IC-NP
1602051-AU	B347P4 vial 120	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-AU	B347P4 vial 120	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-AU	B347P4 vial 120	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-AU	B347P4 vial 120	pH	8.3	pH Units		pH-NP
1602051-AU	B347P4 vial 120	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-AU	B347P4 vial 120	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-AU	B347P4 vial 120	Sulfate	49.3	ug/mL	7.5	Anions by IC-NP
1602051-AU	B347P4 vial 120	Uranium 238	1640	ug/L	14.2	ICPMS-Tc_U-NP
1602051-AW	B347P4 vial 122	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-AW	B347P4 vial 122	Calcium	25400	ug/L	336	ICP-OES Vadose-NP
1602051-AW	B347P4 vial 122	Chloride	65.3	ug/mL	2.5	Anions by IC-NP
1602051-AW	B347P4 vial 122	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-AW	B347P4 vial 122	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-AW	B347P4 vial 122	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602051-AW	B347P4 vial 122	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-AW	B347P4 vial 122	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-AW	B347P4 vial 122	Sulfate	48.7	ug/mL	7.5	Anions by IC-NP
1602051-AW	B347P4 vial 122	Uranium 238	1520	ug/L	14.2	ICPMS-Tc_U-NP
1602051-AY	B347P4 vial 124	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-AY	B347P4 vial 124	Calcium	28400	ug/L	336	ICP-OES Vadose-NP
1602051-AY	B347P4 vial 124	Chloride	65.2	ug/mL	2.5	Anions by IC-NP
1602051-AY	B347P4 vial 124	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-AY	B347P4 vial 124	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-AY	B347P4 vial 124	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602051-AY	B347P4 vial 124	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-AY	B347P4 vial 124	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-AY	B347P4 vial 124	Sulfate	47.1	ug/mL	7.5	Anions by IC-NP
1602051-AY	B347P4 vial 124	Uranium 238	1120	ug/L	14.2	ICPMS-Tc_U-NP
1602051-AZ	B347P4 vial 125	pH	8.41	pH Units		pH-NP
1602051-BA	B347P4 vial 126	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-BA	B347P4 vial 126	Calcium	29800	ug/L	336	ICP-OES Vadose-NP
1602051-BA	B347P4 vial 126	Chloride	64.9	ug/mL	2.5	Anions by IC-NP

1602051-BA	B347P4 vial 126	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-BA	B347P4 vial 126	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-BA	B347P4 vial 126	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602051-BA	B347P4 vial 126	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-BA	B347P4 vial 126	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-BA	B347P4 vial 126	Sulfate	46.2	ug/mL	7.5	Anions by IC-NP
1602051-BA	B347P4 vial 126	Uranium 238	1020	ug/L	14.2	ICPMS-Tc_U-NP
1602051-BC	B347P4 vial 128	Aluminum	942	ug/L	165	ICP-OES Vadose-NP
1602051-BC	B347P4 vial 128	Calcium	31800	ug/L	336	ICP-OES Vadose-NP
1602051-BC	B347P4 vial 128	Chloride	64.7	ug/mL	2.5	Anions by IC-NP
1602051-BC	B347P4 vial 128	Iron	3550	ug/L	100	ICP-OES Vadose-NP
1602051-BC	B347P4 vial 128	Manganese	73.8	ug/L	23.9	ICP-OES Vadose-NP
1602051-BC	B347P4 vial 128	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602051-BC	B347P4 vial 128	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-BC	B347P4 vial 128	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-BC	B347P4 vial 128	Sulfate	45.6	ug/mL	7.5	Anions by IC-NP
1602051-BC	B347P4 vial 128	Uranium 238	864	ug/L	14.2	ICPMS-Tc_U-NP
1602051-BE	B347P4 vial 130	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-BE	B347P4 vial 130	Calcium	32700	ug/L	336	ICP-OES Vadose-NP
1602051-BE	B347P4 vial 130	Chloride	64.5	ug/mL	2.5	Anions by IC-NP
1602051-BE	B347P4 vial 130	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-BE	B347P4 vial 130	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-BE	B347P4 vial 130	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602051-BE	B347P4 vial 130	pH	8.15	pH Units		pH-NP
1602051-BE	B347P4 vial 130	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-BE	B347P4 vial 130	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-BE	B347P4 vial 130	Sulfate	45	ug/mL	7.5	Anions by IC-NP
1602051-BE	B347P4 vial 130	Uranium 238	749	ug/L	14.2	ICPMS-Tc_U-NP
1602051-BG	B347P4 vial 132	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-BG	B347P4 vial 132	Calcium	33900	ug/L	336	ICP-OES Vadose-NP
1602051-BG	B347P4 vial 132	Chloride	64.3	ug/mL	2.5	Anions by IC-NP
1602051-BG	B347P4 vial 132	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-BG	B347P4 vial 132	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-BG	B347P4 vial 132	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-BG	B347P4 vial 132	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-BG	B347P4 vial 132	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-BG	B347P4 vial 132	Sulfate	44.6	ug/mL	7.5	Anions by IC-NP
1602051-BG	B347P4 vial 132	Uranium 238	712	ug/L	14.2	ICPMS-Tc_U-NP
1602051-BJ	B347P4 vial 135	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-BJ	B347P4 vial 135	Calcium	35000	ug/L	336	ICP-OES Vadose-NP
1602051-BJ	B347P4 vial 135	Chloride	64.5	ug/mL	2.5	Anions by IC-NP
1602051-BJ	B347P4 vial 135	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-BJ	B347P4 vial 135	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-BJ	B347P4 vial 135	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-BJ	B347P4 vial 135	pH	8.23	pH Units		pH-NP
1602051-BJ	B347P4 vial 135	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-BJ	B347P4 vial 135	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-BJ	B347P4 vial 135	Sulfate	44.3	ug/mL	7.5	Anions by IC-NP
1602051-BJ	B347P4 vial 135	Uranium 238	615	ug/L	14.2	ICPMS-Tc_U-NP
1602051-BO	B347P4 vial 140	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP

1602051-BO	B347P4 vial 140	Calcium	35000	ug/L	336	ICP-OES Vadose-NP
1602051-BO	B347P4 vial 140	Chloride	64.3	ug/mL	2.5	Anions by IC-NP
1602051-BO	B347P4 vial 140	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-BO	B347P4 vial 140	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-BO	B347P4 vial 140	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-BO	B347P4 vial 140	pH	8.23	pH Units		pH-NP
1602051-BO	B347P4 vial 140	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-BO	B347P4 vial 140	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-BO	B347P4 vial 140	Sulfate	43.9	ug/mL	7.5	Anions by IC-NP
1602051-BO	B347P4 vial 140	Uranium 238	525	ug/L	14.2	ICPMS-Tc_U-NP
1602051-BT	B347P4 vial 145	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-BT	B347P4 vial 145	Calcium	37000	ug/L	336	ICP-OES Vadose-NP
1602051-BT	B347P4 vial 145	Chloride	64.4	ug/mL	2.5	Anions by IC-NP
1602051-BT	B347P4 vial 145	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-BT	B347P4 vial 145	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-BT	B347P4 vial 145	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-BT	B347P4 vial 145	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-BT	B347P4 vial 145	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-BT	B347P4 vial 145	Sulfate	43.8	ug/mL	7.5	Anions by IC-NP
1602051-BT	B347P4 vial 145	Uranium 238	471	ug/L	14.2	ICPMS-Tc_U-NP
1602051-BY	B347P4 vial 150	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-BY	B347P4 vial 150	Calcium	37300	ug/L	336	ICP-OES Vadose-NP
1602051-BY	B347P4 vial 150	Chloride	64.2	ug/mL	2.5	Anions by IC-NP
1602051-BY	B347P4 vial 150	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-BY	B347P4 vial 150	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-BY	B347P4 vial 150	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-BY	B347P4 vial 150	pH	8.2	pH Units		pH-NP
1602051-BY	B347P4 vial 150	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-BY	B347P4 vial 150	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-BY	B347P4 vial 150	Sulfate	43.5	ug/mL	7.5	Anions by IC-NP
1602051-BY	B347P4 vial 150	Uranium 238	426	ug/L	14.2	ICPMS-Tc_U-NP
1602051-CD	B347P4 vial 155	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-CD	B347P4 vial 155	Calcium	37500	ug/L	336	ICP-OES Vadose-NP
1602051-CD	B347P4 vial 155	Chloride	64.1	ug/mL	2.5	Anions by IC-NP
1602051-CD	B347P4 vial 155	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-CD	B347P4 vial 155	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-CD	B347P4 vial 155	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602051-CD	B347P4 vial 155	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-CD	B347P4 vial 155	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-CD	B347P4 vial 155	Sulfate	43.4	ug/mL	7.5	Anions by IC-NP
1602051-CD	B347P4 vial 155	Uranium 238	392	ug/L	14.2	ICPMS-Tc_U-NP
1602051-CI	B347P4 vial 160	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-CI	B347P4 vial 160	Calcium	37300	ug/L	336	ICP-OES Vadose-NP
1602051-CI	B347P4 vial 160	Chloride	64.1	ug/mL	2.5	Anions by IC-NP
1602051-CI	B347P4 vial 160	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-CI	B347P4 vial 160	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-CI	B347P4 vial 160	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602051-CI	B347P4 vial 160	pH	8.21	pH Units		pH-NP
1602051-CI	B347P4 vial 160	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-CI	B347P4 vial 160	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP

1602051-CI	B347P4 vial 160	Sulfate	43.2	ug/mL	7.5	Anions by IC-NP
1602051-CI	B347P4 vial 160	Uranium 238	399	ug/L	14.2	ICPMS-Tc_U-NP
1602051-CS	B347P4 vial 170	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-CS	B347P4 vial 170	Calcium	38900	ug/L	336	ICP-OES Vadose-NP
1602051-CS	B347P4 vial 170	Chloride	64.4	ug/mL	2.5	Anions by IC-NP
1602051-CS	B347P4 vial 170	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-CS	B347P4 vial 170	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-CS	B347P4 vial 170	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-CS	B347P4 vial 170	pH	8.19	pH Units		pH-NP
1602051-CS	B347P4 vial 170	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-CS	B347P4 vial 170	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-CS	B347P4 vial 170	Sulfate	43.4	ug/mL	7.5	Anions by IC-NP
1602051-CS	B347P4 vial 170	Uranium 238	371	ug/L	14.2	ICPMS-Tc_U-NP
1602051-DC	B347P4 vial 180	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-DC	B347P4 vial 180	Calcium	39300	ug/L	336	ICP-OES Vadose-NP
1602051-DC	B347P4 vial 180	Chloride	64.3	ug/mL	2.5	Anions by IC-NP
1602051-DC	B347P4 vial 180	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-DC	B347P4 vial 180	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-DC	B347P4 vial 180	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-DC	B347P4 vial 180	pH	8.28	pH Units		pH-NP
1602051-DC	B347P4 vial 180	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-DC	B347P4 vial 180	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-DC	B347P4 vial 180	Sulfate	43.3	ug/mL	7.5	Anions by IC-NP
1602051-DC	B347P4 vial 180	Uranium 238	341	ug/L	14.2	ICPMS-Tc_U-NP
1602051-DM	B347P4 vial 190	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-DM	B347P4 vial 190	Calcium	39100	ug/L	336	ICP-OES Vadose-NP
1602051-DM	B347P4 vial 190	Chloride	64.4	ug/mL	2.5	Anions by IC-NP
1602051-DM	B347P4 vial 190	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-DM	B347P4 vial 190	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-DM	B347P4 vial 190	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-DM	B347P4 vial 190	pH	8.27	pH Units		pH-NP
1602051-DM	B347P4 vial 190	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-DM	B347P4 vial 190	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-DM	B347P4 vial 190	Sulfate	43.3	ug/mL	7.5	Anions by IC-NP
1602051-DM	B347P4 vial 190	Uranium 238	301	ug/L	14.2	ICPMS-Tc_U-NP
1602051-DW	B347P4 vial 200	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-DW	B347P4 vial 200	Calcium	39000	ug/L	336	ICP-OES Vadose-NP
1602051-DW	B347P4 vial 200	Chloride	64.2	ug/mL	2.5	Anions by IC-NP
1602051-DW	B347P4 vial 200	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-DW	B347P4 vial 200	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-DW	B347P4 vial 200	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-DW	B347P4 vial 200	pH	8.16	pH Units		pH-NP
1602051-DW	B347P4 vial 200	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-DW	B347P4 vial 200	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-DW	B347P4 vial 200	Sulfate	43.2	ug/mL	7.5	Anions by IC-NP
1602051-DW	B347P4 vial 200	Uranium 238	303	ug/L	14.2	ICPMS-Tc_U-NP
1602051-EF	B347P4 vial 209	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-EF	B347P4 vial 209	Calcium	34100	ug/L	336	ICP-OES Vadose-NP
1602051-EF	B347P4 vial 209	Chloride	65.6	ug/mL	2.5	Anions by IC-NP
1602051-EF	B347P4 vial 209	Iron	ND	ug/L	100	ICP-OES Vadose-NP

1602051-EF	B347P4 vial 209	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-EF	B347P4 vial 209	Nitrate	28	ug/mL	5	Anions by IC-NP
1602051-EF	B347P4 vial 209	pH	8.21	pH Units		pH-NP
1602051-EF	B347P4 vial 209	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-EF	B347P4 vial 209	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-EF	B347P4 vial 209	Sulfate	47	ug/mL	7.5	Anions by IC-NP
1602051-EF	B347P4 vial 209	Uranium 238	898	ug/L	14.2	ICPMS-Tc_U-NP
1602051-EH	B347P4 vial 211	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-EH	B347P4 vial 211	Calcium	33400	ug/L	336	ICP-OES Vadose-NP
1602051-EH	B347P4 vial 211	Chloride	66.6	ug/mL	2.5	Anions by IC-NP
1602051-EH	B347P4 vial 211	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-EH	B347P4 vial 211	Manganese	24.6	ug/L	23.9	ICP-OES Vadose-NP
1602051-EH	B347P4 vial 211	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602051-EH	B347P4 vial 211	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-EH	B347P4 vial 211	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-EH	B347P4 vial 211	Sulfate	47	ug/mL	7.5	Anions by IC-NP
1602051-EH	B347P4 vial 211	Uranium 238	813	ug/L	14.2	ICPMS-Tc_U-NP
1602051-EJ	B347P4 vial 213	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-EJ	B347P4 vial 213	Calcium	36500	ug/L	336	ICP-OES Vadose-NP
1602051-EJ	B347P4 vial 213	Chloride	64.5	ug/mL	2.5	Anions by IC-NP
1602051-EJ	B347P4 vial 213	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-EJ	B347P4 vial 213	Manganese	23.9	ug/L	23.9	ICP-OES Vadose-NP
1602051-EJ	B347P4 vial 213	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602051-EJ	B347P4 vial 213	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-EJ	B347P4 vial 213	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-EJ	B347P4 vial 213	Sulfate	45.6	ug/mL	7.5	Anions by IC-NP
1602051-EJ	B347P4 vial 213	Uranium 238	700	ug/L	14.2	ICPMS-Tc_U-NP
1602051-EL	B347P4 vial 215	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-EL	B347P4 vial 215	Calcium	36000	ug/L	336	ICP-OES Vadose-NP
1602051-EL	B347P4 vial 215	Chloride	63.7	ug/mL	2.5	Anions by IC-NP
1602051-EL	B347P4 vial 215	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-EL	B347P4 vial 215	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-EL	B347P4 vial 215	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-EL	B347P4 vial 215	pH	8.27	pH Units		pH-NP
1602051-EL	B347P4 vial 215	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-EL	B347P4 vial 215	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-EL	B347P4 vial 215	Sulfate	45.3	ug/mL	7.5	Anions by IC-NP
1602051-EL	B347P4 vial 215	Uranium 238	606	ug/L	14.2	ICPMS-Tc_U-NP
1602051-EN	B347P4 vial 217	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-EN	B347P4 vial 217	Calcium	37400	ug/L	336	ICP-OES Vadose-NP
1602051-EN	B347P4 vial 217	Chloride	63	ug/mL	2.5	Anions by IC-NP
1602051-EN	B347P4 vial 217	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-EN	B347P4 vial 217	Manganese	24	ug/L	23.9	ICP-OES Vadose-NP
1602051-EN	B347P4 vial 217	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-EN	B347P4 vial 217	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-EN	B347P4 vial 217	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-EN	B347P4 vial 217	Sulfate	45	ug/mL	7.5	Anions by IC-NP
1602051-EN	B347P4 vial 217	Uranium 238	540	ug/L	14.2	ICPMS-Tc_U-NP
1602051-EP	B347P4 vial 219	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-EP	B347P4 vial 219	Calcium	39200	ug/L	336	ICP-OES Vadose-NP

1602051-EP	B347P4 vial 219	Chloride	63.2	ug/mL	2.5	Anions by IC-NP
1602051-EP	B347P4 vial 219	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-EP	B347P4 vial 219	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-EP	B347P4 vial 219	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-EP	B347P4 vial 219	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-EP	B347P4 vial 219	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-EP	B347P4 vial 219	Sulfate	44.8	ug/mL	7.5	Anions by IC-NP
1602051-EP	B347P4 vial 219	Uranium 238	507	ug/L	14.2	ICPMS-Tc_U-NP
1602051-EQ	B347P4 vial 220	pH	8.36	pH Units		pH-NP
1602051-ER	B347P4 vial 221	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-ER	B347P4 vial 221	Calcium	37700	ug/L	336	ICP-OES Vadose-NP
1602051-ER	B347P4 vial 221	Chloride	62.3	ug/mL	2.5	Anions by IC-NP
1602051-ER	B347P4 vial 221	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-ER	B347P4 vial 221	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-ER	B347P4 vial 221	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-ER	B347P4 vial 221	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-ER	B347P4 vial 221	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-ER	B347P4 vial 221	Sulfate	44.7	ug/mL	7.5	Anions by IC-NP
1602051-ER	B347P4 vial 221	Uranium 238	489	ug/L	14.2	ICPMS-Tc_U-NP
1602051-ET	B347P4 vial 223	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-ET	B347P4 vial 223	Calcium	38300	ug/L	336	ICP-OES Vadose-NP
1602051-ET	B347P4 vial 223	Chloride	62.3	ug/mL	2.5	Anions by IC-NP
1602051-ET	B347P4 vial 223	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-ET	B347P4 vial 223	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-ET	B347P4 vial 223	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-ET	B347P4 vial 223	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-ET	B347P4 vial 223	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-ET	B347P4 vial 223	Sulfate	44.2	ug/mL	7.5	Anions by IC-NP
1602051-ET	B347P4 vial 223	Uranium 238	466	ug/L	14.2	ICPMS-Tc_U-NP
1602051-EV	B347P4 vial 225	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-EV	B347P4 vial 225	Calcium	38900	ug/L	336	ICP-OES Vadose-NP
1602051-EV	B347P4 vial 225	Chloride	62.3	ug/mL	2.5	Anions by IC-NP
1602051-EV	B347P4 vial 225	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-EV	B347P4 vial 225	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-EV	B347P4 vial 225	Nitrate	28.6	ug/mL	5	Anions by IC-NP
1602051-EV	B347P4 vial 225	pH	8.21	pH Units		pH-NP
1602051-EV	B347P4 vial 225	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-EV	B347P4 vial 225	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-EV	B347P4 vial 225	Sulfate	44.3	ug/mL	7.5	Anions by IC-NP
1602051-EV	B347P4 vial 225	Uranium 238	436	ug/L	14.2	ICPMS-Tc_U-NP
1602051-FA	B347P4 vial 230	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-FA	B347P4 vial 230	Calcium	39400	ug/L	336	ICP-OES Vadose-NP
1602051-FA	B347P4 vial 230	Chloride	62.1	ug/mL	2.5	Anions by IC-NP
1602051-FA	B347P4 vial 230	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-FA	B347P4 vial 230	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-FA	B347P4 vial 230	Nitrate	28.7	ug/mL	5	Anions by IC-NP
1602051-FA	B347P4 vial 230	pH	8.2	pH Units		pH-NP
1602051-FA	B347P4 vial 230	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-FA	B347P4 vial 230	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-FA	B347P4 vial 230	Sulfate	44	ug/mL	7.5	Anions by IC-NP
1602051-FA	B347P4 vial 230	Uranium 238	387	ug/L	14.2	ICPMS-Tc_U-NP

1602051-FF	B347P4 vial 235	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-FF	B347P4 vial 235	Calcium	39000	ug/L	336	ICP-OES Vadose-NP
1602051-FF	B347P4 vial 235	Chloride	61.6	ug/mL	2.5	Anions by IC-NP
1602051-FF	B347P4 vial 235	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-FF	B347P4 vial 235	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-FF	B347P4 vial 235	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-FF	B347P4 vial 235	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-FF	B347P4 vial 235	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-FF	B347P4 vial 235	Sulfate	43.6	ug/mL	7.5	Anions by IC-NP
1602051-FF	B347P4 vial 235	Uranium 238	346	ug/L	14.2	ICPMS-Tc_U-NP
1602051-FK	B347P4 vial 240	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-FK	B347P4 vial 240	Calcium	39600	ug/L	336	ICP-OES Vadose-NP
1602051-FK	B347P4 vial 240	Chloride	61.8	ug/mL	2.5	Anions by IC-NP
1602051-FK	B347P4 vial 240	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-FK	B347P4 vial 240	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-FK	B347P4 vial 240	Nitrate	28.6	ug/mL	5	Anions by IC-NP
1602051-FK	B347P4 vial 240	pH	8.22	pH Units		pH-NP
1602051-FK	B347P4 vial 240	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-FK	B347P4 vial 240	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-FK	B347P4 vial 240	Sulfate	43.7	ug/mL	7.5	Anions by IC-NP
1602051-FK	B347P4 vial 240	Uranium 238	329	ug/L	14.2	ICPMS-Tc_U-NP
1602051-FP	B347P4 vial 245	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-FP	B347P4 vial 245	Calcium	39400	ug/L	336	ICP-OES Vadose-NP
1602051-FP	B347P4 vial 245	Chloride	61.4	ug/mL	2.5	Anions by IC-NP
1602051-FP	B347P4 vial 245	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-FP	B347P4 vial 245	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-FP	B347P4 vial 245	Nitrate	28.7	ug/mL	5	Anions by IC-NP
1602051-FP	B347P4 vial 245	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-FP	B347P4 vial 245	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-FP	B347P4 vial 245	Sulfate	43.6	ug/mL	7.5	Anions by IC-NP
1602051-FP	B347P4 vial 245	Uranium 238	316	ug/L	14.2	ICPMS-Tc_U-NP
1602051-FU	B347P4 vial 250	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-FU	B347P4 vial 250	Calcium	39900	ug/L	336	ICP-OES Vadose-NP
1602051-FU	B347P4 vial 250	Chloride	61.8	ug/mL	2.5	Anions by IC-NP
1602051-FU	B347P4 vial 250	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-FU	B347P4 vial 250	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-FU	B347P4 vial 250	Nitrate	28.7	ug/mL	5	Anions by IC-NP
1602051-FU	B347P4 vial 250	pH	8.24	pH Units		pH-NP
1602051-FU	B347P4 vial 250	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-FU	B347P4 vial 250	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-FU	B347P4 vial 250	Sulfate	43.6	ug/mL	7.5	Anions by IC-NP
1602051-FU	B347P4 vial 250	Uranium 238	284	ug/L	14.2	ICPMS-Tc_U-NP
1602051-GE	B347P4 vial 260	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-GE	B347P4 vial 260	Calcium	40200	ug/L	336	ICP-OES Vadose-NP
1602051-GE	B347P4 vial 260	Chloride	61.4	ug/mL	2.5	Anions by IC-NP
1602051-GE	B347P4 vial 260	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-GE	B347P4 vial 260	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-GE	B347P4 vial 260	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-GE	B347P4 vial 260	pH	8.25	pH Units		pH-NP
1602051-GE	B347P4 vial 260	Phosphate	ND	ug/mL	7.5	Anions by IC-NP

1602051-GE	B347P4 vial 260	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-GE	B347P4 vial 260	Sulfate	43.4	ug/mL	7.5	Anions by IC-NP
1602051-GE	B347P4 vial 260	Uranium 238	267	ug/L	14.2	ICPMS-Tc_U-NP
1602051-GO	B347P4 vial 270	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-GO	B347P4 vial 270	Calcium	38800	ug/L	336	ICP-OES Vadose-NP
1602051-GO	B347P4 vial 270	Chloride	61.4	ug/mL	2.5	Anions by IC-NP
1602051-GO	B347P4 vial 270	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-GO	B347P4 vial 270	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-GO	B347P4 vial 270	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-GO	B347P4 vial 270	pH	8.2	pH Units		pH-NP
1602051-GO	B347P4 vial 270	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-GO	B347P4 vial 270	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-GO	B347P4 vial 270	Sulfate	43.3	ug/mL	7.5	Anions by IC-NP
1602051-GO	B347P4 vial 270	Uranium 238	239	ug/L	14.2	ICPMS-Tc_U-NP
1602051-GY	B347P4 vial 280	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-GY	B347P4 vial 280	Calcium	41100	ug/L	336	ICP-OES Vadose-NP
1602051-GY	B347P4 vial 280	Chloride	61.4	ug/mL	2.5	Anions by IC-NP
1602051-GY	B347P4 vial 280	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-GY	B347P4 vial 280	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-GY	B347P4 vial 280	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602051-GY	B347P4 vial 280	pH	8.28	pH Units		pH-NP
1602051-GY	B347P4 vial 280	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-GY	B347P4 vial 280	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-GY	B347P4 vial 280	Sulfate	43.3	ug/mL	7.5	Anions by IC-NP
1602051-GY	B347P4 vial 280	Uranium 238	227	ug/L	14.2	ICPMS-Tc_U-NP
1602051-HI	B347P4 vial 290	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-HI	B347P4 vial 290	Calcium	41900	ug/L	336	ICP-OES Vadose-NP
1602051-HI	B347P4 vial 290	Chloride	61.6	ug/mL	2.5	Anions by IC-NP
1602051-HI	B347P4 vial 290	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-HI	B347P4 vial 290	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-HI	B347P4 vial 290	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602051-HI	B347P4 vial 290	pH	8.23	pH Units		pH-NP
1602051-HI	B347P4 vial 290	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602051-HI	B347P4 vial 290	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-HI	B347P4 vial 290	Sulfate	43.4	ug/mL	7.5	Anions by IC-NP
1602051-HI	B347P4 vial 290	Uranium 238	213	ug/L	14.2	ICPMS-Tc_U-NP
1602051-HR	B347P4 vial 299	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602051-HR	B347P4 vial 299	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-HR	B347P4 vial 299	Calcium	41200	ug/L	336	ICP-OES Vadose-NP
1602051-HR	B347P4 vial 299	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602051-HR	B347P4 vial 299	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602051-HR	B347P4 vial 299	pH	8.18	pH Units		pH-NP
1602051-HR	B347P4 vial 299	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602051-HR	B347P4 vial 299	Uranium 238	210	ug/L	14.2	ICPMS-Tc_U-NP
1602051-HT	B347P4 vial 301	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-HV	B347P4 vial 303	Bromide	17.7	ug/mL	5	Anions by IC-NP
1602051-HX	B347P4 vial 305	Bromide	26.3	ug/mL	5	Anions by IC-NP
1602051-HZ	B347P4 vial 307	Bromide	32.4	ug/mL	5	Anions by IC-NP
1602051-IB	B347P4 vial 309	Bromide	36.4	ug/mL	5	Anions by IC-NP
1602051-ID	B347P4 vial 311	Bromide	38.9	ug/mL	5	Anions by IC-NP
1602051-IF	B347P4 vial 313	Bromide	40.6	ug/mL	5	Anions by IC-NP
1602051-IH	B347P4 vial 315	Bromide	42.1	ug/mL	5	Anions by IC-NP

1602051-IJ	B347P4 vial 317	Bromide	43.1	ug/mL	5	Anions by IC-NP
1602051-IL	B347P4 vial 319	Bromide	43.9	ug/mL	5	Anions by IC-NP
1602051-IN	B347P4 vial 321	Bromide	44.5	ug/mL	5	Anions by IC-NP
1602051-IP	B347P4 vial 323	Bromide	45.4	ug/mL	5	Anions by IC-NP
1602051-IR	B347P4 vial 325	Bromide	45.7	ug/mL	5	Anions by IC-NP
1602051-IT	B347P4 vial 327	Bromide	46	ug/mL	5	Anions by IC-NP
1602051-IV	B347P4 vial 329	Bromide	46.1	ug/mL	5	Anions by IC-NP
1602051-JB	B347P4 vial 335	Bromide	46.8	ug/mL	5	Anions by IC-NP
1602051-JG	B347P4 vial 340	Bromide	47.3	ug/mL	5	Anions by IC-NP
1602051-JL	B347P4 vial 345	Bromide	47.5	ug/mL	5	Anions by IC-NP
1602051-JQ	B347P4 vial 350	Bromide	47.5	ug/mL	5	Anions by IC-NP
1602051-JV	B347P4 vial 355	Bromide	47.7	ug/mL	5	Anions by IC-NP
1602051-KA	B347P4 vial 360	Bromide	47.8	ug/mL	5	Anions by IC-NP
1602051-KK	B347P4 vial 370	Bromide	48	ug/mL	5	Anions by IC-NP
1602051-KU	B347P4 vial 380	Bromide	48.3	ug/mL	5	Anions by IC-NP
1602051-LE	B347P4 vial 390	Bromide	48.3	ug/mL	5	Anions by IC-NP
1602051-LM	B347P4 vial 398	Bromide	43	ug/mL	5	Anions by IC-NP
1602051-LO	B347P4 vial 400	Bromide	29.9	ug/mL	5	Anions by IC-NP
1602051-LQ	B347P4 vial 402	Bromide	19.8	ug/mL	5	Anions by IC-NP
1602051-LS	B347P4 vial 404	Bromide	14.7	ug/mL	5	Anions by IC-NP
1602051-LU	B347P4 vial 406	Bromide	11.3	ug/mL	5	Anions by IC-NP
1602051-LW	B347P4 vial 408	Bromide	9.01	ug/mL	5	Anions by IC-NP
1602051-LY	B347P4 vial 410	Bromide	7.36	ug/mL	5	Anions by IC-NP
1602051-MA	B347P4 vial 412	Bromide	6.16	ug/mL	5	Anions by IC-NP
1602051-MC	B347P4 vial 414	Bromide	5.25	ug/mL	5	Anions by IC-NP
1602051-ME	B347P4 vial 416	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-MG	B347P4 vial 418	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-MI	B347P4 vial 420	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-MN	B347P4 vial 425	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-MS	B347P4 vial 430	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-MX	B347P4 vial 435	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-NC	B347P4 vial 440	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-NM	B347P4 vial 450	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-NW	B347P4 vial 460	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-OG	B347P4 vial 470	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-OQ	B347P4 vial 480	Bromide	ND	ug/mL	5	Anions by IC-NP
1602051-PA	B347P4 vial 490	Bromide	ND	ug/mL	5	Anions by IC-NP

Pore Volume and stop flow data for in-tact column B347P4

Vial #	Pore volume	Comments
1	0.00	saturating column
2	0.01	
3	0.01	start column
4	0.02	
5	0.02	
6	0.02	
7	0.03	
8	0.03	
9	0.03	
10	0.04	
11	0.04	
12	0.05	
13	0.05	
14	0.05	
15	0.06	
16	0.06	
17	0.06	
18	0.07	
19	0.07	
20	0.08	
21	0.08	
22	0.08	
23	0.09	
24	0.09	
25	0.10	
26	0.10	
27	0.10	

28	0.11	
29	0.11	
30	0.11	
31	0.12	
32	0.12	
33	0.13	
34	0.13	
35	0.13	
36	0.14	
37	0.14	
38	0.14	
39	0.15	
40	0.15	
41	0.16	
42	0.16	
43	0.16	
44	0.17	
45	0.17	
46	0.18	
47	0.18	
48	0.18	
49	0.19	
50	0.19	
51	0.19	
52	0.20	
53	0.20	
54	0.21	
55	0.21	
56	0.21	
57	0.22	
58	0.22	
59	0.22	
60	0.23	
61	0.23	
62	0.24	
63	0.24	
64	0.24	
65	0.25	
66	0.25	
67	0.26	
68	0.26	
69	0.26	
70	0.27	
71	0.27	
72	0.27	
73	0.28	
74	0.28	
75	0.29	
76	0.29	
77	0.29	
78	0.30	
79	0.30	
80	0.30	
81	0.31	
82	0.31	
83	0.32	
84	0.32	
85	0.32	
86	0.33	
87	0.33	
88	0.34	
89	0.34	
90	0.34	
91	0.35	
92	0.35	
93	0.35	

94	0.36	
95	0.36	
96	0.37	
97	0.37	
98	0.37	
99	0.38	
100	0.38	
101	0.38	
102	0.39	
103	0.39	
104	0.40	
105	0.40	
106	0.40	
107	0.41	
108	0.41	
109	0.42	
110	0.42	
111	0.42	
112	0.43	
113	0.43	
114	0.43	
115	0.44	
116	0.44	
117	0.45	
118	0.45	
119	0.45	48 hour stop flow
120	0.46	
121	0.46	
122	0.46	
123	0.47	
124	0.47	
125	0.48	
126	0.48	
127	0.48	
128	0.49	
129	0.49	
130	0.50	
131	0.50	
132	0.50	
133	0.51	
134	0.51	
135	0.51	
136	0.52	
137	0.52	
138	0.53	
139	0.53	
140	0.53	
141	0.54	
142	0.54	
143	0.54	
144	0.55	
145	0.55	
146	0.56	
147	0.56	
148	0.56	
149	0.57	
150	0.57	
151	0.58	
152	0.58	
153	0.58	
154	0.59	
155	0.59	
156	0.59	
157	0.60	
158	0.60	
159	0.61	

160	0.61	
161	0.61	
162	0.62	
163	0.62	
164	0.62	
165	0.63	
166	0.63	
167	0.64	
168	0.64	
169	0.64	
170	0.65	
171	0.65	
172	0.66	
173	0.66	
174	0.66	
175	0.67	
176	0.67	
177	0.67	
178	0.68	
179	0.68	
180	0.69	
181	0.69	
182	0.69	
183	0.70	
184	0.70	
185	0.70	
186	0.71	
187	0.71	
188	0.72	
189	0.72	
190	0.72	
191	0.73	
192	0.73	
193	0.74	
194	0.74	
195	0.74	
196	0.75	
197	0.75	
198	0.75	
199	0.76	
200	0.76	
201	0.77	
202	0.77	
203	0.77	
204	0.78	
205	0.78	
206	0.78	
207	0.79	
208	0.79	72 hour stop flow
209	0.80	
210	0.80	
211	0.80	
212	0.81	
213	0.81	
214	0.81	
215	0.82	
216	0.82	
217	0.83	
218	0.83	
219	0.83	
220	0.84	
221	0.84	
222	0.85	
223	0.85	
224	0.85	
225	0.86	

226	0.86	
227	0.86	
228	0.87	
229	0.87	
230	0.88	
231	0.88	
232	0.88	
233	0.89	
234	0.89	
235	0.89	
236	0.90	
237	0.90	
238	0.91	
239	0.91	
240	0.91	
241	0.92	
242	0.92	
243	0.93	
244	0.93	
245	0.93	
246	0.94	
247	0.94	
248	0.94	
249	0.95	
250	0.95	
251	0.96	
252	0.96	
253	0.96	
254	0.97	
255	0.97	
256	0.97	
257	0.98	
258	0.98	
259	0.99	
260	0.99	
261	0.99	
262	1.00	
263	1.00	
264	1.01	
265	1.01	
266	1.01	
267	1.02	
268	1.02	
269	1.02	
270	1.03	
271	1.03	
272	1.04	
273	1.04	
274	1.04	
275	1.05	
276	1.05	
277	1.05	
278	1.06	
279	1.06	
280	1.07	
281	1.07	
282	1.07	
283	1.08	
284	1.08	
285	1.09	
286	1.09	
287	1.09	
288	1.10	
289	1.10	
290	1.10	
291	1.11	

292	1.11	
293	1.12	
294	1.12	
295	1.12	
296	1.13	
297	1.13	
298	1.13	
299	1.14	stop

Analytical Data for in-tact column B347R0

LabNumber	SampleName	Analyte	Result	Units	EQL	Analysis
1602052-01	B347R0 vial 1	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-01	B347R0 vial 1	Calcium	12000	ug/L	336	ICP-OES Vadose-NP
1602052-01	B347R0 vial 1	Chloride	70.4	ug/mL	2.5	Anions by IC-NP
1602052-01	B347R0 vial 1	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-01	B347R0 vial 1	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-01	B347R0 vial 1	Nitrate	29.2	ug/mL	5	Anions by IC-NP
1602052-01	B347R0 vial 1	pH	8.47	pH Units		pH-NP
1602052-01	B347R0 vial 1	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-01	B347R0 vial 1	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-01	B347R0 vial 1	Sulfate	46.3	ug/mL	7.5	Anions by IC-NP
1602052-01	B347R0 vial 1	Uranium 238	3110	ug/L	14.2	ICPMS-Tc_U-NP
1602052-03	B347R0 vial 3	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-03	B347R0 vial 3	Calcium	14700	ug/L	336	ICP-OES Vadose-NP
1602052-03	B347R0 vial 3	Chloride	65.8	ug/mL	2.5	Anions by IC-NP
1602052-03	B347R0 vial 3	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-03	B347R0 vial 3	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-03	B347R0 vial 3	Nitrate	27.3	ug/mL	5	Anions by IC-NP
1602052-03	B347R0 vial 3	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-03	B347R0 vial 3	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-03	B347R0 vial 3	Sulfate	43.6	ug/mL	7.5	Anions by IC-NP
1602052-03	B347R0 vial 3	Uranium 238	3290	ug/L	14.2	ICPMS-Tc_U-NP
1602052-05	B347R0 vial 5	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-05	B347R0 vial 5	Calcium	15800	ug/L	336	ICP-OES Vadose-NP
1602052-05	B347R0 vial 5	Chloride	66.4	ug/mL	2.5	Anions by IC-NP
1602052-05	B347R0 vial 5	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-05	B347R0 vial 5	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-05	B347R0 vial 5	Nitrate	27.3	ug/mL	5	Anions by IC-NP
1602052-05	B347R0 vial 5	pH	8.48	pH Units		pH-NP
1602052-05	B347R0 vial 5	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-05	B347R0 vial 5	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-05	B347R0 vial 5	Sulfate	42.8	ug/mL	7.5	Anions by IC-NP
1602052-05	B347R0 vial 5	Uranium 238	3650	ug/L	14.2	ICPMS-Tc_U-NP
1602052-07	B347R0 vial 7	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-07	B347R0 vial 7	Calcium	16100	ug/L	336	ICP-OES Vadose-NP
1602052-07	B347R0 vial 7	Chloride	64.5	ug/mL	2.5	Anions by IC-NP
1602052-07	B347R0 vial 7	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-07	B347R0 vial 7	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-07	B347R0 vial 7	Nitrate	27.3	ug/mL	5	Anions by IC-NP

1602052-07	B347R0 vial 7	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-07	B347R0 vial 7	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-07	B347R0 vial 7	Sulfate	42.8	ug/mL	7.5	Anions by IC-NP
1602052-07	B347R0 vial 7	Uranium 238	4100	ug/L	14.2	ICPMS-Tc_U-NP
1602052-09	B347R0 vial 9	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-09	B347R0 vial 9	Calcium	15700	ug/L	336	ICP-OES Vadose-NP
1602052-09	B347R0 vial 9	Chloride	65.8	ug/mL	2.5	Anions by IC-NP
1602052-09	B347R0 vial 9	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-09	B347R0 vial 9	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-09	B347R0 vial 9	Nitrate	27.5	ug/mL	5	Anions by IC-NP
1602052-09	B347R0 vial 9	pH	8.57	pH Units		pH-NP
1602052-09	B347R0 vial 9	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-09	B347R0 vial 9	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-09	B347R0 vial 9	Sulfate	43	ug/mL	7.5	Anions by IC-NP
1602052-09	B347R0 vial 9	Uranium 238	3910	ug/L	14.2	ICPMS-Tc_U-NP
1602052-11	B347R0 vial 11	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-11	B347R0 vial 11	Calcium	14600	ug/L	336	ICP-OES Vadose-NP
1602052-11	B347R0 vial 11	Chloride	65.1	ug/mL	2.5	Anions by IC-NP
1602052-11	B347R0 vial 11	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-11	B347R0 vial 11	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-11	B347R0 vial 11	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602052-11	B347R0 vial 11	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-11	B347R0 vial 11	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-11	B347R0 vial 11	Sulfate	43.2	ug/mL	7.5	Anions by IC-NP
1602052-11	B347R0 vial 11	Uranium 238	3800	ug/L	14.2	ICPMS-Tc_U-NP
1602052-13	B347R0 vial 13	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-13	B347R0 vial 13	Calcium	14000	ug/L	336	ICP-OES Vadose-NP
1602052-13	B347R0 vial 13	Chloride	65.1	ug/mL	2.5	Anions by IC-NP
1602052-13	B347R0 vial 13	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-13	B347R0 vial 13	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-13	B347R0 vial 13	Nitrate	28.1	ug/mL	5	Anions by IC-NP
1602052-13	B347R0 vial 13	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-13	B347R0 vial 13	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-13	B347R0 vial 13	Sulfate	43.1	ug/mL	7.5	Anions by IC-NP
1602052-13	B347R0 vial 13	Uranium 238	3480	ug/L	14.2	ICPMS-Tc_U-NP
1602052-15	B347R0 vial 15	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-15	B347R0 vial 15	Calcium	13100	ug/L	336	ICP-OES Vadose-NP
1602052-15	B347R0 vial 15	Chloride	66.9	ug/mL	2.5	Anions by IC-NP
1602052-15	B347R0 vial 15	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-15	B347R0 vial 15	Manganese	ND	ug/L	23.9	ICP-OES
						Vadose-NP
1602052-15	B347R0 vial 15	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-15	B347R0 vial 15	pH	8.43	pH Units		pH-NP
1602052-15	B347R0 vial 15	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-15	B347R0 vial 15	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-15	B347R0 vial 15	Sulfate	43.3	ug/mL	7.5	Anions by IC-NP
1602052-15	B347R0 vial 15	Uranium 238	3280	ug/L	14.2	ICPMS-Tc_U-NP
1602052-20	B347R0 vial 20	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-20	B347R0 vial 20	Calcium	11600	ug/L	336	ICP-OES Vadose-NP
1602052-20	B347R0 vial 20	Chloride	65.7	ug/mL	2.5	Anions by IC-NP
1602052-20	B347R0 vial 20	Iron	ND	ug/L	100	ICP-OES Vadose-NP

1602052-20	B347R0 vial 20	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-20	B347R0 vial 20	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-20	B347R0 vial 20	pH	8.43	pH Units		pH-NP
1602052-20	B347R0 vial 20	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-20	B347R0 vial 20	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-20	B347R0 vial 20	Sulfate	42.4	ug/mL	7.5	Anions by IC-NP
1602052-20	B347R0 vial 20	Uranium 238	2600	ug/L	14.2	ICPMS-Tc_U-NP
1602052-25	B347R0 vial 25	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-25	B347R0 vial 25	Calcium	10900	ug/L	336	ICP-OES Vadose-NP
1602052-25	B347R0 vial 25	Chloride	64.3	ug/mL	2.5	Anions by IC-NP
1602052-25	B347R0 vial 25	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-25	B347R0 vial 25	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-25	B347R0 vial 25	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-25	B347R0 vial 25	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-25	B347R0 vial 25	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-25	B347R0 vial 25	Sulfate	42.1	ug/mL	7.5	Anions by IC-NP
1602052-25	B347R0 vial 25	Uranium 238	2130	ug/L	14.2	ICPMS-Tc_U-NP
1602052-30	B347R0 vial 30	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-30	B347R0 vial 30	Calcium	10400	ug/L	336	ICP-OES Vadose-NP
1602052-30	B347R0 vial 30	Chloride	66.5	ug/mL	2.5	Anions by IC-NP
1602052-30	B347R0 vial 30	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-30	B347R0 vial 30	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-30	B347R0 vial 30	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-30	B347R0 vial 30	pH	8.3	pH Units		pH-NP
1602052-30	B347R0 vial 30	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-30	B347R0 vial 30	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-30	B347R0 vial 30	Sulfate	42.3	ug/mL	7.5	Anions by IC-NP
1602052-30	B347R0 vial 30	Uranium 238	2070	ug/L	14.2	ICPMS-Tc_U-NP
1602052-40	B347R0 vial 40	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-40	B347R0 vial 40	Calcium	10300	ug/L	336	ICP-OES Vadose-NP
1602052-40	B347R0 vial 40	Chloride	65.3	ug/mL	2.5	Anions by IC-NP
1602052-40	B347R0 vial 40	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-40	B347R0 vial 40	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-40	B347R0 vial 40	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-40	B347R0 vial 40	pH	8.27	pH Units		pH-NP
1602052-40	B347R0 vial 40	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-40	B347R0 vial 40	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-40	B347R0 vial 40	Sulfate	41.8	ug/mL	7.5	Anions by IC-NP
1602052-40	B347R0 vial 40	Uranium 238	1580	ug/L	14.2	ICPMS-Tc_U-NP
1602052-50	B347R0 vial 50	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-50	B347R0 vial 50	Calcium	10700	ug/L	336	ICP-OES Vadose-NP
1602052-50	B347R0 vial 50	Chloride	65.3	ug/mL	2.5	Anions by IC-NP
1602052-50	B347R0 vial 50	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-50	B347R0 vial 50	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-50	B347R0 vial 50	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-50	B347R0 vial 50	pH	8.24	pH Units		pH-NP
1602052-50	B347R0 vial 50	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-50	B347R0 vial 50	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-50	B347R0 vial 50	Sulfate	42	ug/mL	7.5	Anions by IC-NP
1602052-50	B347R0 vial 50	Uranium 238	1380	ug/L	14.2	ICPMS-Tc_U-NP
1602052-60	B347R0 vial 60	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP

1602052-60	B347R0 vial 60	Calcium	11200	ug/L	336	ICP-OES Vadose-NP
1602052-60	B347R0 vial 60	Chloride	65	ug/mL	2.5	Anions by IC-NP
1602052-60	B347R0 vial 60	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-60	B347R0 vial 60	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-60	B347R0 vial 60	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602052-60	B347R0 vial 60	pH	8.2	pH Units		pH-NP
1602052-60	B347R0 vial 60	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-60	B347R0 vial 60	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-60	B347R0 vial 60	Sulfate	41.8	ug/mL	7.5	Anions by IC-NP
1602052-60	B347R0 vial 60	Uranium 238	1130	ug/L	14.2	ICPMS-Tc_U-NP
1602052-70	B347R0 vial 70	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-70	B347R0 vial 70	Calcium	11700	ug/L	336	ICP-OES Vadose-NP
1602052-70	B347R0 vial 70	Chloride	64.8	ug/mL	2.5	Anions by IC-NP
1602052-70	B347R0 vial 70	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-70	B347R0 vial 70	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-70	B347R0 vial 70	Nitrate	28.1	ug/mL	5	Anions by IC-NP
1602052-70	B347R0 vial 70	pH	8.21	pH Units		pH-NP
1602052-70	B347R0 vial 70	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-70	B347R0 vial 70	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-70	B347R0 vial 70	Sulfate	41.6	ug/mL	7.5	Anions by IC-NP
1602052-70	B347R0 vial 70	Uranium 238	1030	ug/L	14.2	ICPMS-Tc_U-NP
1602052-78	B347R0 vial 78	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-78	B347R0 vial 78	Calcium	15700	ug/L	336	ICP-OES Vadose-NP
1602052-78	B347R0 vial 78	Chloride	65	ug/mL	2.5	Anions by IC-NP
1602052-78	B347R0 vial 78	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-78	B347R0 vial 78	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-78	B347R0 vial 78	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602052-78	B347R0 vial 78	pH	8.31	pH Units		pH-NP
1602052-78	B347R0 vial 78	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-78	B347R0 vial 78	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-78	B347R0 vial 78	Sulfate	42.8	ug/mL	7.5	Anions by IC-NP
1602052-78	B347R0 vial 78	Uranium 238	1640	ug/L	14.2	ICPMS-Tc_U-NP
1602052-80	B347R0 vial 80	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-80	B347R0 vial 80	Calcium	15300	ug/L	336	ICP-OES Vadose-NP
1602052-80	B347R0 vial 80	Chloride	64.2	ug/mL	2.5	Anions by IC-NP
1602052-80	B347R0 vial 80	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-80	B347R0 vial 80	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-80	B347R0 vial 80	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-80	B347R0 vial 80	pH	8.37	pH Units		pH-NP
1602052-80	B347R0 vial 80	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-80	B347R0 vial 80	Phosphorus	ND	ug/L	408	ICP-OES
						Vadose-NP
1602052-80	B347R0 vial 80	Sulfate	42.4	ug/mL	7.5	Anions by IC-NP
1602052-80	B347R0 vial 80	Uranium 238	1760	ug/L	14.2	ICPMS-Tc_U-NP
1602052-82	B347R0 vial 82	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-82	B347R0 vial 82	Calcium	15100	ug/L	336	ICP-OES Vadose-NP
1602052-82	B347R0 vial 82	Chloride	64.3	ug/mL	2.5	Anions by IC-NP
1602052-82	B347R0 vial 82	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-82	B347R0 vial 82	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-82	B347R0 vial 82	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602052-82	B347R0 vial 82	Phosphate	ND	ug/mL	7.5	Anions by IC-NP

1602052-82	B347R0 vial 82	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-82	B347R0 vial 82	Sulfate	42.6	ug/mL	7.5	Anions by IC-NP
1602052-82	B347R0 vial 82	Uranium 238	1690	ug/L	14.2	ICPMS-Tc_U-NP
1602052-84	B347R0 vial 84	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-84	B347R0 vial 84	Calcium	15200	ug/L	336	ICP-OES Vadose-NP
1602052-84	B347R0 vial 84	Chloride	65.1	ug/mL	2.5	Anions by IC-NP
1602052-84	B347R0 vial 84	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-84	B347R0 vial 84	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-84	B347R0 vial 84	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-84	B347R0 vial 84	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-84	B347R0 vial 84	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-84	B347R0 vial 84	Sulfate	43	ug/mL	7.5	Anions by IC-NP
1602052-84	B347R0 vial 84	Uranium 238	1640	ug/L	14.2	ICPMS-Tc_U-NP
1602052-85	B347R0 vial 85	pH	8.43	pH Units		pH-NP
1602052-86	B347R0 vial 86	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-86	B347R0 vial 86	Calcium	14500	ug/L	336	ICP-OES Vadose-NP
1602052-86	B347R0 vial 86	Chloride	64.5	ug/mL	2.5	Anions by IC-NP
1602052-86	B347R0 vial 86	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-86	B347R0 vial 86	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-86	B347R0 vial 86	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-86	B347R0 vial 86	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-86	B347R0 vial 86	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-86	B347R0 vial 86	Sulfate	42.7	ug/mL	7.5	Anions by IC-NP
1602052-86	B347R0 vial 86	Uranium 238	1630	ug/L	14.2	ICPMS-Tc_U-NP
1602052-88	B347R0 vial 88	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-88	B347R0 vial 88	Calcium	14700	ug/L	336	ICP-OES Vadose-NP
1602052-88	B347R0 vial 88	Chloride	64.8	ug/mL	2.5	Anions by IC-NP
1602052-88	B347R0 vial 88	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-88	B347R0 vial 88	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-88	B347R0 vial 88	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602052-88	B347R0 vial 88	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-88	B347R0 vial 88	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-88	B347R0 vial 88	Sulfate	42.8	ug/mL	7.5	Anions by IC-NP
1602052-88	B347R0 vial 88	Uranium 238	1570	ug/L	14.2	ICPMS-Tc_U-NP
1602052-90	B347R0 vial 90	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-90	B347R0 vial 90	Calcium	14300	ug/L	336	ICP-OES Vadose-NP
1602052-90	B347R0 vial 90	Chloride	64.8	ug/mL	2.5	Anions by IC-NP
1602052-90	B347R0 vial 90	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-90	B347R0 vial 90	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-90	B347R0 vial 90	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602052-90	B347R0 vial 90	pH	8.29	pH Units		pH-NP
1602052-90	B347R0 vial 90	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-90	B347R0 vial 90	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-90	B347R0 vial 90	Sulfate	42.7	ug/mL	7.5	Anions by IC-NP
1602052-90	B347R0 vial 90	Uranium 238	1270	ug/L	14.2	ICPMS-Tc_U-NP
1602052-95	B347R0 vial 95	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-95	B347R0 vial 95	Calcium	13900	ug/L	336	ICP-OES Vadose-NP
1602052-95	B347R0 vial 95	Chloride	64.4	ug/mL	2.5	Anions by IC-NP
1602052-95	B347R0 vial 95	Iron	ND	ug/L	100	ICP-OES Vadose-NP

1602052-95	B347R0 vial 95	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-95	B347R0 vial 95	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-95	B347R0 vial 95	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-95	B347R0 vial 95	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-95	B347R0 vial 95	Sulfate	42.2	ug/mL	7.5	Anions by IC-NP
1602052-95	B347R0 vial 95	Uranium 238	1210	ug/L	14.2	ICPMS-Tc_U-NP
1602052-AA	B347R0 vial 100	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-AA	B347R0 vial 100	Calcium	14100	ug/L	336	ICP-OES Vadose-NP
1602052-AA	B347R0 vial 100	Chloride	64.4	ug/mL	2.5	Anions by IC-NP
1602052-AA	B347R0 vial 100	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-AA	B347R0 vial 100	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-AA	B347R0 vial 100	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-AA	B347R0 vial 100	pH	8.23	pH Units		pH-NP
1602052-AA	B347R0 vial 100	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-AA	B347R0 vial 100	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-AA	B347R0 vial 100	Sulfate	41.9	ug/mL	7.5	Anions by IC-NP
1602052-AA	B347R0 vial 100	Uranium 238	1070	ug/L	14.2	ICPMS-Tc_U-NP
1602052-AF	B347R0 vial 105	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-AF	B347R0 vial 105	Calcium	14100	ug/L	336	ICP-OES Vadose-NP
1602052-AF	B347R0 vial 105	Chloride	64.1	ug/mL	2.5	Anions by IC-NP
1602052-AF	B347R0 vial 105	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-AF	B347R0 vial 105	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-AF	B347R0 vial 105	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602052-AF	B347R0 vial 105	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-AF	B347R0 vial 105	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-AF	B347R0 vial 105	Sulfate	41.8	ug/mL	7.5	Anions by IC-NP
1602052-AF	B347R0 vial 105	Uranium 238	959	ug/L	14.2	ICPMS-Tc_U-NP
1602052-AK	B347R0 vial 110	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-AK	B347R0 vial 110	Calcium	14800	ug/L	336	ICP-OES Vadose-NP
1602052-AK	B347R0 vial 110	Chloride	64.3	ug/mL	2.5	Anions by IC-NP
1602052-AK	B347R0 vial 110	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-AK	B347R0 vial 110	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-AK	B347R0 vial 110	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-AK	B347R0 vial 110	pH	8.22	pH Units		pH-NP
1602052-AK	B347R0 vial 110	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-AK	B347R0 vial 110	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-AK	B347R0 vial 110	Sulfate	41.9	ug/mL	7.5	Anions by IC-NP
1602052-AK	B347R0 vial 110	Uranium 238	953	ug/L	14.2	ICPMS-Tc_U-NP
1602052-AU	B347R0 vial 120	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-AU	B347R0 vial 120	Calcium	15700	ug/L	336	ICP-OES Vadose-NP
1602052-AU	B347R0 vial 120	Chloride	64.5	ug/mL	2.5	Anions by IC-NP
1602052-AU	B347R0 vial 120	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-AU	B347R0 vial 120	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-AU	B347R0 vial 120	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-AU	B347R0 vial 120	pH	8.22	pH Units		pH-NP
1602052-AU	B347R0 vial 120	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-AU	B347R0 vial 120	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-AU	B347R0 vial 120	Sulfate	42.1	ug/mL	7.5	Anions by IC-NP
1602052-AU	B347R0 vial 120	Uranium 238	819	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BE	B347R0 vial 130	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP

1602052-BE	B347R0 vial 130	Calcium	17000	ug/L	336	ICP-OES Vadose-NP
1602052-BE	B347R0 vial 130	Chloride	64.3	ug/mL	2.5	Anions by IC-NP
1602052-BE	B347R0 vial 130	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-BE	B347R0 vial 130	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BE	B347R0 vial 130	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-BE	B347R0 vial 130	pH	8.1	pH Units		pH-NP
1602052-BE	B347R0 vial 130	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BE	B347R0 vial 130	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-BE	B347R0 vial 130	Sulfate	42.2	ug/mL	7.5	Anions by IC-NP
1602052-BE	B347R0 vial 130	Uranium 238	787	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BJ	B347R0 vial 135	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-BJ	B347R0 vial 135	Calcium	19200	ug/L	336	ICP-OES Vadose-NP
1602052-BJ	B347R0 vial 135	Chloride	64	ug/mL	2.5	Anions by IC-NP
1602052-BJ	B347R0 vial 135	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-BJ	B347R0 vial 135	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BJ	B347R0 vial 135	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-BJ	B347R0 vial 135	pH	8.24	pH Units		pH-NP
1602052-BJ	B347R0 vial 135	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BJ	B347R0 vial 135	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-BJ	B347R0 vial 135	Sulfate	42.3	ug/mL	7.5	Anions by IC-NP
1602052-BJ	B347R0 vial 135	Uranium 238	1150	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BL	B347R0 vial 137	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-BL	B347R0 vial 137	Calcium	19100	ug/L	336	ICP-OES Vadose-NP
1602052-BL	B347R0 vial 137	Chloride	64	ug/mL	2.5	Anions by IC-NP
1602052-BL	B347R0 vial 137	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-BL	B347R0 vial 137	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BL	B347R0 vial 137	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602052-BL	B347R0 vial 137	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BL	B347R0 vial 137	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-BL	B347R0 vial 137	Sulfate	42.3	ug/mL	7.5	Anions by IC-NP
1602052-BL	B347R0 vial 137	Uranium 238	1160	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BN	B347R0 vial 139	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-BN	B347R0 vial 139	Calcium	18300	ug/L	336	ICP-OES Vadose-NP
1602052-BN	B347R0 vial 139	Chloride	64.1	ug/mL	2.5	Anions by IC-NP
1602052-BN	B347R0 vial 139	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-BN	B347R0 vial 139	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BN	B347R0 vial 139	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602052-BN	B347R0 vial 139	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BN	B347R0 vial 139	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-BN	B347R0 vial 139	Sulfate	42.5	ug/mL	7.5	Anions by IC-NP
1602052-BN	B347R0 vial 139	Uranium 238	1170	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BO	B347R0 vial 140	pH	8.42	pH Units		pH-NP
1602052-BP	B347R0 vial 141	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-BP	B347R0 vial 141	Calcium	18400	ug/L	336	ICP-OES Vadose-NP
1602052-BP	B347R0 vial 141	Chloride	63.1	ug/mL	2.5	Anions by IC-NP
1602052-BP	B347R0 vial 141	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-BP	B347R0 vial 141	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BP	B347R0 vial 141	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-BP	B347R0 vial 141	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BP	B347R0 vial 141	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP

1602052-BP	B347R0 vial 141	Sulfate	42.7	ug/mL	7.5	Anions by IC-NP
1602052-BP	B347R0 vial 141	Uranium 238	1150	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BR	B347R0 vial 143	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-BR	B347R0 vial 143	Calcium	18000	ug/L	336	ICP-OES Vadose-NP
1602052-BR	B347R0 vial 143	Chloride	61.3	ug/mL	2.5	Anions by IC-NP
1602052-BR	B347R0 vial 143	Iron	564	ug/L	100	ICP-OES Vadose-NP
1602052-BR	B347R0 vial 143	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BR	B347R0 vial 143	Nitrate	28.7	ug/mL	5	Anions by IC-NP
1602052-BR	B347R0 vial 143	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BR	B347R0 vial 143	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-BR	B347R0 vial 143	Sulfate	43.1	ug/mL	7.5	Anions by IC-NP
1602052-BR	B347R0 vial 143	Uranium 238	1140	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BT	B347R0 vial 145	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-BT	B347R0 vial 145	Calcium	17400	ug/L	336	ICP-OES Vadose-NP
1602052-BT	B347R0 vial 145	Chloride	58	ug/mL	2.5	Anions by IC-NP
1602052-BT	B347R0 vial 145	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-BT	B347R0 vial 145	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BT	B347R0 vial 145	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-BT	B347R0 vial 145	pH	8.29	pH Units		pH-NP
1602052-BT	B347R0 vial 145	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BT	B347R0 vial 145	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-BT	B347R0 vial 145	Sulfate	42.7	ug/mL	7.5	Anions by IC-NP
1602052-BT	B347R0 vial 145	Uranium 238	1070	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BV	B347R0 vial 147	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-BV	B347R0 vial 147	Calcium	17200	ug/L	336	ICP-OES Vadose-NP
1602052-BV	B347R0 vial 147	Chloride	55	ug/mL	2.5	Anions by IC-NP
1602052-BV	B347R0 vial 147	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-BV	B347R0 vial 147	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BV	B347R0 vial 147	Nitrate	28.5	ug/mL	5	Anions by IC-NP
1602052-BV	B347R0 vial 147	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BV	B347R0 vial 147	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-BV	B347R0 vial 147	Sulfate	42.6	ug/mL	7.5	Anions by IC-NP
1602052-BV	B347R0 vial 147	Uranium 238	1020	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BX	B347R0 vial 149	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-BX	B347R0 vial 149	Calcium	17100	ug/L	336	ICP-OES Vadose-NP
1602052-BX	B347R0 vial 149	Chloride	52.8	ug/mL	2.5	Anions by IC-NP
1602052-BX	B347R0 vial 149	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-BX	B347R0 vial 149	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BX	B347R0 vial 149	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-BX	B347R0 vial 149	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BX	B347R0 vial 149	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-BX	B347R0 vial 149	Sulfate	42.5	ug/mL	7.5	Anions by IC-NP
1602052-BX	B347R0 vial 149	Uranium 238	996	ug/L	14.2	ICPMS-Tc_U-NP
1602052-BY	B347R0 vial 150	pH	8.41	pH Units		pH-NP
1602052-BZ	B347R0 vial 151	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-BZ	B347R0 vial 151	Calcium	16800	ug/L	336	ICP-OES Vadose-NP
1602052-BZ	B347R0 vial 151	Chloride	51.2	ug/mL	2.5	Anions by IC-NP
1602052-BZ	B347R0 vial 151	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-BZ	B347R0 vial 151	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-BZ	B347R0 vial 151	Nitrate	28.5	ug/mL	5	Anions by IC-NP

1602052-BZ	B347R0 vial 151	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-BZ	B347R0 vial 151	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-BZ	B347R0 vial 151	Sulfate	42.6	ug/mL	7.5	Anions by IC-NP
1602052-BZ	B347R0 vial 151	Uranium 238	960	ug/L	14.2	ICPMS-Tc_U-NP
1602052-CD	B347R0 vial 155	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-CD	B347R0 vial 155	Calcium	16900	ug/L	336	ICP-OES Vadose-NP
1602052-CD	B347R0 vial 155	Chloride	49	ug/mL	2.5	Anions by IC-NP
1602052-CD	B347R0 vial 155	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-CD	B347R0 vial 155	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-CD	B347R0 vial 155	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602052-CD	B347R0 vial 155	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-CD	B347R0 vial 155	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-CD	B347R0 vial 155	Sulfate	42.3	ug/mL	7.5	Anions by IC-NP
1602052-CD	B347R0 vial 155	Uranium 238	883	ug/L	14.2	ICPMS-Tc_U-NP
1602052-CI	B347R0 vial 160	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-CI	B347R0 vial 160	Calcium	17400	ug/L	336	ICP-OES Vadose-NP
1602052-CI	B347R0 vial 160	Chloride	47.5	ug/mL	2.5	Anions by IC-NP
1602052-CI	B347R0 vial 160	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-CI	B347R0 vial 160	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-CI	B347R0 vial 160	Nitrate	28.3	ug/mL	5	Anions by IC-NP
1602052-CI	B347R0 vial 160	pH	8.27	pH Units		pH-NP
1602052-CI	B347R0 vial 160	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-CI	B347R0 vial 160	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-CI	B347R0 vial 160	Sulfate	41.8	ug/mL	7.5	Anions by IC-NP
1602052-CI	B347R0 vial 160	Uranium 238	779	ug/L	14.2	ICPMS-Tc_U-NP
1602052-CN	B347R0 vial 165	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-CN	B347R0 vial 165	Calcium	18100	ug/L	336	ICP-OES Vadose-NP
1602052-CN	B347R0 vial 165	Chloride	47.1	ug/mL	2.5	Anions by IC-NP
1602052-CN	B347R0 vial 165	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-CN	B347R0 vial 165	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-CN	B347R0 vial 165	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602052-CN	B347R0 vial 165	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-CN	B347R0 vial 165	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-CN	B347R0 vial 165	Sulfate	41.8	ug/mL	7.5	Anions by IC-NP
1602052-CN	B347R0 vial 165	Uranium 238	804	ug/L	14.2	ICPMS-Tc_U-NP
1602052-CS	B347R0 vial 170	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-CS	B347R0 vial 170	Calcium	18800	ug/L	336	ICP-OES Vadose-NP
1602052-CS	B347R0 vial 170	Chloride	46.8	ug/mL	2.5	Anions by IC-NP
1602052-CS	B347R0 vial 170	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-CS	B347R0 vial 170	Manganese	ND	ug/L	23.9	ICP-OES
						Vadose-NP
1602052-CS	B347R0 vial 170	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602052-CS	B347R0 vial 170	pH	8.23	pH Units		pH-NP
1602052-CS	B347R0 vial 170	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-CS	B347R0 vial 170	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-CS	B347R0 vial 170	Sulfate	41.6	ug/mL	7.5	Anions by IC-NP
1602052-CS	B347R0 vial 170	Uranium 238	750	ug/L	14.2	ICPMS-Tc_U-NP
1602052-DC	B347R0 vial 180	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-DC	B347R0 vial 180	Calcium	20400	ug/L	336	ICP-OES Vadose-NP
1602052-DC	B347R0 vial 180	Chloride	46.6	ug/mL	2.5	Anions by IC-NP
1602052-DC	B347R0 vial 180	Iron	ND	ug/L	100	ICP-OES Vadose-NP

1602052-DC	B347R0 vial 180	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-DC	B347R0 vial 180	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602052-DC	B347R0 vial 180	pH	8.26	pH Units		pH-NP
1602052-DC	B347R0 vial 180	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-DC	B347R0 vial 180	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-DC	B347R0 vial 180	Sulfate	41.5	ug/mL	7.5	Anions by IC-NP
1602052-DC	B347R0 vial 180	Uranium 238	695	ug/L	14.2	ICPMS-Tc_U-NP
1602052-DM	B347R0 vial 190	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602052-DM	B347R0 vial 190	Calcium	21500	ug/L	336	ICP-OES Vadose-NP
1602052-DM	B347R0 vial 190	Chloride	46.5	ug/mL	2.5	Anions by IC-NP
1602052-DM	B347R0 vial 190	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602052-DM	B347R0 vial 190	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602052-DM	B347R0 vial 190	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602052-DM	B347R0 vial 190	pH	8.26	pH Units		pH-NP
1602052-DM	B347R0 vial 190	Phosphate	ND	ug/mL	7.5	Anions by IC-NP
1602052-DM	B347R0 vial 190	Phosphorus	ND	ug/L	408	ICP-OES Vadose-NP
1602052-DM	B347R0 vial 190	Sulfate	41.6	ug/mL	7.5	Anions by IC-NP
1602052-DM	B347R0 vial 190	Uranium 238	662	ug/L	14.2	ICPMS-Tc_U-NP
1602052-DP	B347R0 vial 193	Bromide	ND	ug/mL	5	Anions by IC-NP
1602052-DR	B347R0 vial 195	Bromide	ND	ug/mL	5	Anions by IC-NP
1602052-DT	B347R0 vial 197	Bromide	ND	ug/mL	5	Anions by IC-NP
1602052-DV	B347R0 vial 199	Bromide	6.16	ug/mL	5	Anions by IC-NP
1602052-DX	B347R0 vial 201	Bromide	14.1	ug/mL	5	Anions by IC-NP
1602052-DZ	B347R0 vial 203	Bromide	22.6	ug/mL	5	Anions by IC-NP
1602052-EB	B347R0 vial 205	Bromide	29.5	ug/mL	5	Anions by IC-NP
1602052-ED	B347R0 vial 207	Bromide	34.8	ug/mL	5	Anions by IC-NP
1602052-EF	B347R0 vial 209	Bromide	38.6	ug/mL	5	Anions by IC-NP
1602052-EH	B347R0 vial 211	Bromide	41.4	ug/mL	5	Anions by IC-NP
1602052-EJ	B347R0 vial 213	Bromide	43	ug/mL	5	Anions by IC-NP
1602052-EL	B347R0 vial 215	Bromide	44.3	ug/mL	5	Anions by IC-NP
1602052-EQ	B347R0 vial 220	Bromide	46.1	ug/mL	5	Anions by IC-NP
1602052-EV	B347R0 vial 225	Bromide	47.2	ug/mL	5	Anions by IC-NP
1602052-FA	B347R0 vial 230	Bromide	47.2	ug/mL	5	Anions by IC-NP
1602052-FF	B347R0 vial 235	Bromide	47.5	ug/mL	5	Anions by IC-NP
1602052-FP	B347R0 vial 245	Bromide	47.9	ug/mL	5	Anions by IC-NP
1602052-FU	B347R0 vial 250	Bromide	47.1	ug/mL	5	Anions by IC-NP
1602052-FW	B347R0 vial 252	Bromide	46.7	ug/mL	5	Anions by IC-NP
1602052-FY	B347R0 vial 254	Bromide	44.2	ug/mL	5	Anions by IC-NP
1602052-GA	B347R0 vial 256	Bromide	38.6	ug/mL	5	Anions by IC-NP
1602052-GC	B347R0 vial 258	Bromide	30.4	ug/mL	5	Anions by IC-NP
1602052-GE	B347R0 vial 260	Bromide	22.7	ug/mL	5	Anions by IC-NP
1602052-GG	B347R0 vial 262	Bromide	16.5	ug/mL	5	Anions by IC-NP
1602052-GI	B347R0 vial 264	Bromide	11.9	ug/mL	5	Anions by IC-NP
1602052-GK	B347R0 vial 266	Bromide	8.61	ug/mL	5	Anions by IC-NP
1602052-GM	B347R0 vial 268	Bromide	6.36	ug/mL	5	Anions by IC-NP
1602052-GO	B347R0 vial 270	Bromide	ND	ug/mL	5	Anions by IC-NP
1602052-GT	B347R0 vial 275	Bromide	ND	ug/mL	5	Anions by IC-NP
1602052-GY	B347R0 vial 280	Bromide	ND	ug/mL	5	Anions by IC-NP
1602052-HD	B347R0 vial 285	Bromide	ND	ug/mL	5	Anions by IC-NP
1602052-HI	B347R0 vial 290	Bromide	ND	ug/mL	5	Anions by IC-NP
1602052-HS	B347R0 vial 300	Bromide	ND	ug/mL	5	Anions by IC-NP

Pore Volume and stop flow data for in-tact column B347R0

Vial #	Pore volume	Comments
1	0.00	saturating column
2	0.01	
3	0.01	Start
4	0.02	
5	0.02	
6	0.03	
7	0.03	

8	0.04	
9	0.04	
10	0.04	
11	0.05	
12	0.05	
13	0.06	
14	0.06	
15	0.07	
16	0.07	
17	0.08	
18	0.08	
19	0.08	
20	0.09	
21	0.09	
22	0.10	
23	0.10	
24	0.11	
25	0.11	
26	0.12	
27	0.12	
28	0.12	
29	0.13	
30	0.13	
31	0.14	
32	0.14	
33	0.15	
34	0.15	
35	0.16	
36	0.16	
37	0.16	
38	0.17	
39	0.17	
40	0.18	
41	0.18	
42	0.19	
43	0.19	
44	0.19	
45	0.20	
46	0.20	
47	0.21	
48	0.21	
49	0.22	
50	0.22	
51	0.23	
52	0.23	
53	0.23	
54	0.24	
55	0.24	
56	0.25	
57	0.25	
58	0.26	
59	0.26	
60	0.27	
61	0.27	
62	0.27	
63	0.28	
64	0.28	
65	0.29	
66	0.29	
67	0.30	
68	0.30	
69	0.31	
70	0.31	
71	0.31	
72	0.32	
73	0.32	

74	0.33	
75	0.33	
76	0.34	
77	0.34	48 hour stop flow
78	0.35	
79	0.35	
80	0.35	
81	0.36	
82	0.36	
83	0.37	
84	0.37	
85	0.38	
86	0.38	
87	0.39	
88	0.39	
89	0.39	
90	0.40	
91	0.40	
92	0.41	
93	0.41	
94	0.42	
95	0.42	
96	0.43	
97	0.43	
98	0.43	
99	0.44	
100	0.44	
101	0.45	
102	0.45	
103	0.46	
104	0.46	
105	0.47	
106	0.47	
107	0.47	
108	0.48	
109	0.48	
110	0.49	
111	0.49	
112	0.50	
113	0.50	
114	0.50	
115	0.51	
116	0.51	
117	0.52	
118	0.52	
119	0.53	
120	0.53	
121	0.54	
122	0.54	
123	0.54	
124	0.55	
125	0.55	
126	0.56	
127	0.56	
128	0.57	
129	0.57	
130	0.58	
131	0.58	
132	0.58	
133	0.59	
134	0.59	72 hour stop flow
135	0.60	
136	0.60	
137	0.61	
138	0.61	
139	0.62	

140	0.62	
141	0.62	
142	0.63	
143	0.63	
144	0.64	
145	0.64	
146	0.65	
147	0.65	
148	0.66	
149	0.66	
150	0.66	
151	0.67	
152	0.67	
153	0.68	
154	0.68	
155	0.69	
156	0.69	
157	0.70	
158	0.70	
159	0.70	
160	0.71	
161	0.71	
162	0.72	
163	0.72	
164	0.73	
165	0.73	
166	0.74	
167	0.74	
168	0.74	
169	0.75	
170	0.75	
171	0.76	
172	0.76	
173	0.77	
174	0.77	
175	0.78	
176	0.78	
177	0.78	
178	0.79	
179	0.79	
180	0.80	
181	0.80	
182	0.81	
183	0.81	
184	0.81	
185	0.82	
186	0.82	
187	0.83	
188	0.83	
189	0.84	
190	0.84	
191	0.85	stop

Analytical Data for in-tact column B347T6

LabNumber	SampleName	Analyte	Result	Units	EQL	Analysis
1602053-01	B347T6 vial 1	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-01	B347T6 vial 1	Calcium	12600	ug/L	336	ICP-OES Vadose-NP
1602053-01	B347T6 vial 1	Chloride	59.2	ug/mL	2.5	Anions by IC-NP

1602053-01	B347T6 vial 1	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-01	B347T6 vial 1	Manganese	44.9	ug/L	23.9	ICP-OES Vadose-NP
1602053-01	B347T6 vial 1	Nitrate	30.1	ug/mL	5	Anions by IC-NP
1602053-01	B347T6 vial 1	pH	8.47	pH Units		pH-NP
1602053-01	B347T6 vial 1	Phosphate	128	ug/mL	7.5	Anions by IC-NP
1602053-01	B347T6 vial 1	Phosphorus	40300	ug/L	408	ICP-OES Vadose-NP
1602053-01	B347T6 vial 1	Sulfate	65.8	ug/mL	7.5	Anions by IC-NP
1602053-01	B347T6 vial 1	Uranium 238	17.6	ug/L	0.71	ICPMS-Tc_U-NP
1602053-03	B347T6 vial 3	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-03	B347T6 vial 3	Calcium	11600	ug/L	336	ICP-OES Vadose-NP
1602053-03	B347T6 vial 3	Chloride	48.5	ug/mL	2.5	Anions by IC-NP
1602053-03	B347T6 vial 3	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-03	B347T6 vial 3	Manganese	30.2	ug/L	23.9	ICP-OES Vadose-NP
1602053-03	B347T6 vial 3	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602053-03	B347T6 vial 3	Phosphate	124	ug/mL	7.5	Anions by IC-NP
1602053-03	B347T6 vial 3	Phosphorus	39000	ug/L	408	ICP-OES Vadose-NP
1602053-03	B347T6 vial 3	Sulfate	84.4	ug/mL	7.5	Anions by IC-NP
1602053-03	B347T6 vial 3	Uranium 238	27.4	ug/L	0.71	ICPMS-Tc_U-NP
1602053-05	B347T6 vial 5	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-05	B347T6 vial 5	Calcium	11600	ug/L	336	ICP-OES Vadose-NP
1602053-05	B347T6 vial 5	Chloride	55.2	ug/mL	2.5	Anions by IC-NP
1602053-05	B347T6 vial 5	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-05	B347T6 vial 5	Manganese	29.2	ug/L	23.9	ICP-OES Vadose-NP
1602053-05	B347T6 vial 5	Nitrate	28	ug/mL	5	Anions by IC-NP
1602053-05	B347T6 vial 5	pH	8.51	pH Units		pH-NP
1602053-05	B347T6 vial 5	Phosphate	110	ug/mL	7.5	Anions by IC-NP
1602053-05	B347T6 vial 5	Phosphorus	34100	ug/L	408	ICP-OES Vadose-NP
1602053-05	B347T6 vial 5	Sulfate	69	ug/mL	7.5	Anions by IC-NP
1602053-05	B347T6 vial 5	Uranium 238	18.4	ug/L	0.71	ICPMS-Tc_U-NP
1602053-07	B347T6 vial 7	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-07	B347T6 vial 7	Calcium	11000	ug/L	336	ICP-OES Vadose-NP
1602053-07	B347T6 vial 7	Chloride	56.6	ug/mL	2.5	Anions by IC-NP
1602053-07	B347T6 vial 7	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-07	B347T6 vial 7	Manganese	25.8	ug/L	23.9	ICP-OES Vadose-NP
1602053-07	B347T6 vial 7	Nitrate	27.9	ug/mL	5	Anions by IC-NP
1602053-07	B347T6 vial 7	Phosphate	103	ug/mL	7.5	Anions by IC-NP
1602053-07	B347T6 vial 7	Phosphorus	32000	ug/L	408	ICP-OES Vadose-NP
1602053-07	B347T6 vial 7	Sulfate	62.6	ug/mL	7.5	Anions by IC-NP
1602053-07	B347T6 vial 7	Uranium 238	14.6	ug/L	0.71	ICPMS-Tc_U-NP
1602053-09	B347T6 vial 9	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-09	B347T6 vial 9	Calcium	10800	ug/L	336	ICP-OES Vadose-NP
1602053-09	B347T6 vial 9	Chloride	58.9	ug/mL	2.5	Anions by IC-NP
1602053-09	B347T6 vial 9	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-09	B347T6 vial 9	Manganese	25.1	ug/L	23.9	ICP-OES Vadose-NP
1602053-09	B347T6 vial 9	Nitrate	27.9	ug/mL	5	Anions by IC-NP
1602053-09	B347T6 vial 9	pH	8.43	pH Units		pH-NP
1602053-09	B347T6 vial 9	Phosphate	93.7	ug/mL	7.5	Anions by IC-NP
1602053-09	B347T6 vial 9	Phosphorus	28800	ug/L	408	ICP-OES Vadose-NP
1602053-09	B347T6 vial 9	Sulfate	60.2	ug/mL	7.5	Anions by IC-NP
1602053-09	B347T6 vial 9	Uranium 238	13.3	ug/L	0.71	ICPMS-Tc_U-NP

1602053-11	B347T6 vial 11	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-11	B347T6 vial 11	Calcium	10800	ug/L	336	ICP-OES Vadose-NP
1602053-11	B347T6 vial 11	Chloride	57.4	ug/mL	2.5	Anions by IC-NP
1602053-11	B347T6 vial 11	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-11	B347T6 vial 11	Manganese	24.3	ug/L	23.9	ICP-OES Vadose-NP
1602053-11	B347T6 vial 11	Nitrate	28	ug/mL	5	Anions by IC-NP
1602053-11	B347T6 vial 11	Phosphate	88	ug/mL	7.5	Anions by IC-NP
1602053-11	B347T6 vial 11	Phosphorus	27700	ug/L	408	ICP-OES Vadose-NP
1602053-11	B347T6 vial 11	Sulfate	59.6	ug/mL	7.5	Anions by IC-NP
1602053-11	B347T6 vial 11	Uranium 238	13.9	ug/L	0.71	ICPMS-Tc_U-NP
1602053-13	B347T6 vial 13	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-13	B347T6 vial 13	Calcium	13000	ug/L	336	ICP-OES Vadose-NP
1602053-13	B347T6 vial 13	Chloride	57.9	ug/mL	2.5	Anions by IC-NP
1602053-13	B347T6 vial 13	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-13	B347T6 vial 13	Manganese	26.6	ug/L	23.9	ICP-OES Vadose-NP
1602053-13	B347T6 vial 13	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602053-13	B347T6 vial 13	Phosphate	79.8	ug/mL	7.5	Anions by IC-NP
1602053-13	B347T6 vial 13	Phosphorus	25000	ug/L	408	ICP-OES Vadose-NP
1602053-13	B347T6 vial 13	Sulfate	58.4	ug/mL	7.5	Anions by IC-NP
1602053-13	B347T6 vial 13	Uranium 238	14.1	ug/L	0.71	ICPMS-Tc_U-NP
1602053-15	B347T6 vial 15	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-15	B347T6 vial 15	Calcium	11800	ug/L	336	ICP-OES Vadose-NP
1602053-15	B347T6 vial 15	Chloride	60.2	ug/mL	2.5	Anions by IC-NP
1602053-15	B347T6 vial 15	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-15	B347T6 vial 15	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602053-15	B347T6 vial 15	Nitrate	27.9	ug/mL	5	Anions by IC-NP
1602053-15	B347T6 vial 15	pH	8.42	pH Units		pH-NP
1602053-15	B347T6 vial 15	Phosphate	75.6	ug/mL	7.5	Anions by IC-NP
1602053-15	B347T6 vial 15	Phosphorus	23700	ug/L	408	ICP-OES Vadose-NP
1602053-15	B347T6 vial 15	Sulfate	55.6	ug/mL	7.5	Anions by IC-NP
1602053-15	B347T6 vial 15	Uranium 238	12	ug/L	0.71	ICPMS-Tc_U-NP
1602053-20	B347T6 vial 20	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-20	B347T6 vial 20	Calcium	13700	ug/L	336	ICP-OES Vadose-NP
1602053-20	B347T6 vial 20	Chloride	61.2	ug/mL	2.5	Anions by IC-NP
1602053-20	B347T6 vial 20	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-20	B347T6 vial 20	Manganese	24.7	ug/L	23.9	ICP-OES Vadose-NP
1602053-20	B347T6 vial 20	Nitrate	28	ug/mL	5	Anions by IC-NP
1602053-20	B347T6 vial 20	pH	8.39	pH Units		pH-NP
1602053-20	B347T6 vial 20	Phosphate	68.5	ug/mL	7.5	Anions by IC-NP
1602053-20	B347T6 vial 20	Phosphorus	21400	ug/L	408	ICP-OES Vadose-NP
1602053-20	B347T6 vial 20	Sulfate	52.8	ug/mL	7.5	Anions by IC-NP
1602053-20	B347T6 vial 20	Uranium 238	10.7	ug/L	0.71	ICPMS-Tc_U-NP
1602053-25	B347T6 vial 25	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-25	B347T6 vial 25	Calcium	15900	ug/L	336	ICP-OES Vadose-NP
1602053-25	B347T6 vial 25	Chloride	60.7	ug/mL	2.5	Anions by IC-NP
1602053-25	B347T6 vial 25	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-25	B347T6 vial 25	Manganese	25.2	ug/L	23.9	ICP-OES Vadose-NP
1602053-25	B347T6 vial 25	Nitrate	28.1	ug/mL	5	Anions by IC-NP
1602053-25	B347T6 vial 25	Phosphate	66.5	ug/mL	7.5	Anions by IC-NP

1602053-25	B347T6 vial 25	Phosphorus	20400	ug/L	408	ICP-OES Vadose-NP
1602053-25	B347T6 vial 25	Sulfate	50.6	ug/mL	7.5	Anions by IC-NP
1602053-25	B347T6 vial 25	Uranium 238	9.67	ug/L	0.71	ICPMS-Tc_U-NP
1602053-30	B347T6 vial 30	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-30	B347T6 vial 30	Calcium	18700	ug/L	336	ICP-OES Vadose-NP
1602053-30	B347T6 vial 30	Chloride	63.6	ug/mL	2.5	Anions by IC-NP
1602053-30	B347T6 vial 30	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-30	B347T6 vial 30	Manganese	28.5	ug/L	23.9	ICP-OES Vadose-NP
1602053-30	B347T6 vial 30	Nitrate	28.2	ug/mL	5	Anions by IC-NP
1602053-30	B347T6 vial 30	pH	8.22	pH Units		pH-NP
1602053-30	B347T6 vial 30	Phosphate	60.2	ug/mL	7.5	Anions by IC-NP
1602053-30	B347T6 vial 30	Phosphorus	18500	ug/L	408	ICP-OES Vadose-NP
1602053-30	B347T6 vial 30	Sulfate	48.7	ug/mL	7.5	Anions by IC-NP
1602053-30	B347T6 vial 30	Uranium 238	8.09	ug/L	0.71	ICPMS-Tc_U-NP
1602053-35	B347T6 vial 35	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-35	B347T6 vial 35	Calcium	19100	ug/L	336	ICP-OES Vadose-NP
1602053-35	B347T6 vial 35	Chloride	62.2	ug/mL	2.5	Anions by IC-NP
1602053-35	B347T6 vial 35	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-35	B347T6 vial 35	Manganese	28.2	ug/L	23.9	ICP-OES Vadose-NP
1602053-35	B347T6 vial 35	Nitrate	27.9	ug/mL	5	Anions by IC-NP
1602053-35	B347T6 vial 35	Phosphate	57.1	ug/mL	7.5	Anions by IC-NP
1602053-35	B347T6 vial 35	Phosphorus	17700	ug/L	408	ICP-OES Vadose-NP
1602053-35	B347T6 vial 35	Sulfate	47.1	ug/mL	7.5	Anions by IC-NP
1602053-35	B347T6 vial 35	Uranium 238	8.12	ug/L	0.71	ICPMS-Tc_U-NP
1602053-40	B347T6 vial 40	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-40	B347T6 vial 40	Calcium	21200	ug/L	336	ICP-OES Vadose-NP
1602053-40	B347T6 vial 40	Chloride	64.1	ug/mL	2.5	Anions by IC-NP
1602053-40	B347T6 vial 40	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-40	B347T6 vial 40	Manganese	29	ug/L	23.9	ICP-OES Vadose-NP
1602053-40	B347T6 vial 40	Nitrate	28.1	ug/mL	5	Anions by IC-NP
1602053-40	B347T6 vial 40	pH	8.23	pH Units		pH-NP
1602053-40	B347T6 vial 40	Phosphate	54.6	ug/mL	7.5	Anions by IC-NP
1602053-40	B347T6 vial 40	Phosphorus	16700	ug/L	408	ICP-OES Vadose-NP
1602053-40	B347T6 vial 40	Sulfate	46.5	ug/mL	7.5	Anions by IC-NP
1602053-40	B347T6 vial 40	Uranium 238	7.35	ug/L	0.71	ICPMS-Tc_U-NP
1602053-50	B347T6 vial 50	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-50	B347T6 vial 50	Calcium	21900	ug/L	336	ICP-OES
						Vadose-NP
1602053-50	B347T6 vial 50	Chloride	64.5	ug/mL	2.5	Anions by IC-NP
1602053-50	B347T6 vial 50	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-50	B347T6 vial 50	Manganese	30.3	ug/L	23.9	ICP-OES Vadose-NP
1602053-50	B347T6 vial 50	Nitrate	27.9	ug/mL	5	Anions by IC-NP
1602053-50	B347T6 vial 50	pH	8.24	pH Units		pH-NP
1602053-50	B347T6 vial 50	Phosphate	53	ug/mL	7.5	Anions by IC-NP
1602053-50	B347T6 vial 50	Phosphorus	16600	ug/L	408	ICP-OES Vadose-NP
1602053-50	B347T6 vial 50	Sulfate	45.4	ug/mL	7.5	Anions by IC-NP
1602053-50	B347T6 vial 50	Uranium 238	7.24	ug/L	0.71	ICPMS-Tc_U-NP
1602053-60	B347T6 vial 60	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-60	B347T6 vial 60	Calcium	23100	ug/L	336	ICP-OES Vadose-NP
1602053-60	B347T6 vial 60	Chloride	64.1	ug/mL	2.5	Anions by IC-NP
1602053-60	B347T6 vial 60	Iron	ND	ug/L	100	ICP-OES Vadose-NP

1602053-60	B347T6 vial 60	Manganese	31.6	ug/L	23.9	ICP-OES Vadose-NP
1602053-60	B347T6 vial 60	Nitrate	28	ug/mL	5	Anions by IC-NP
1602053-60	B347T6 vial 60	pH	8.19	pH Units		pH-NP
1602053-60	B347T6 vial 60	Phosphate	49.2	ug/mL	7.5	Anions by IC-NP
1602053-60	B347T6 vial 60	Phosphorus	15200	ug/L	408	ICP-OES Vadose-NP
1602053-60	B347T6 vial 60	Sulfate	44.7	ug/mL	7.5	Anions by IC-NP
1602053-60	B347T6 vial 60	Uranium 238	6.62	ug/L	0.71	ICPMS-Tc_U-NP
1602053-70	B347T6 vial 70	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-70	B347T6 vial 70	Calcium	24500	ug/L	336	ICP-OES Vadose-NP
1602053-70	B347T6 vial 70	Chloride	64.5	ug/mL	2.5	Anions by IC-NP
1602053-70	B347T6 vial 70	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-70	B347T6 vial 70	Manganese	34.8	ug/L	23.9	ICP-OES Vadose-NP
1602053-70	B347T6 vial 70	Nitrate	28	ug/mL	5	Anions by IC-NP
1602053-70	B347T6 vial 70	pH	8.1	pH Units		pH-NP
1602053-70	B347T6 vial 70	Phosphate	50	ug/mL	7.5	Anions by IC-NP
1602053-70	B347T6 vial 70	Phosphorus	16200	ug/L	408	ICP-OES Vadose-NP
1602053-70	B347T6 vial 70	Sulfate	44.2	ug/mL	7.5	Anions by IC-NP
1602053-70	B347T6 vial 70	Uranium 238	6.92	ug/L	0.71	ICPMS-Tc_U-NP
1602053-80	B347T6 vial 80	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-80	B347T6 vial 80	Calcium	25000	ug/L	336	ICP-OES Vadose-NP
1602053-80	B347T6 vial 80	Chloride	64.2	ug/mL	2.5	Anions by IC-NP
1602053-80	B347T6 vial 80	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-80	B347T6 vial 80	Manganese	34.4	ug/L	23.9	ICP-OES Vadose-NP
1602053-80	B347T6 vial 80	Nitrate	28	ug/mL	5	Anions by IC-NP
1602053-80	B347T6 vial 80	pH	8.12	pH Units		pH-NP
1602053-80	B347T6 vial 80	Phosphate	46.1	ug/mL	7.5	Anions by IC-NP
1602053-80	B347T6 vial 80	Phosphorus	14700	ug/L	408	ICP-OES Vadose-NP
1602053-80	B347T6 vial 80	Sulfate	43.7	ug/mL	7.5	Anions by IC-NP
1602053-80	B347T6 vial 80	Uranium 238	6.9	ug/L	0.71	ICPMS-Tc_U-NP
1602053-90	B347T6 vial 90	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-90	B347T6 vial 90	Calcium	26400	ug/L	336	ICP-OES Vadose-NP
1602053-90	B347T6 vial 90	Chloride	64.6	ug/mL	2.5	Anions by IC-NP
1602053-90	B347T6 vial 90	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-90	B347T6 vial 90	Manganese	34.7	ug/L	23.9	ICP-OES Vadose-NP
1602053-90	B347T6 vial 90	Nitrate	28	ug/mL	5	Anions by IC-NP
1602053-90	B347T6 vial 90	pH	8.09	pH Units		pH-NP
1602053-90	B347T6 vial 90	Phosphate	40.2	ug/mL	7.5	Anions by IC-NP
1602053-90	B347T6 vial 90	Phosphorus	12300	ug/L	408	ICP-OES Vadose-NP
1602053-90	B347T6 vial 90	Sulfate	43.4	ug/mL	7.5	Anions by IC-NP
1602053-90	B347T6 vial 90	Uranium 238	7.04	ug/L	0.71	ICPMS-Tc_U-NP
1602053-99	B347T6 vial 99	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-99	B347T6 vial 99	Calcium	28100	ug/L	336	ICP-OES Vadose-NP
1602053-99	B347T6 vial 99	Chloride	64.2	ug/mL	2.5	Anions by IC-NP
1602053-99	B347T6 vial 99	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-99	B347T6 vial 99	Manganese	38.1	ug/L	23.9	ICP-OES Vadose-NP
1602053-99	B347T6 vial 99	Nitrate	27.7	ug/mL	5	Anions by IC-NP
1602053-99	B347T6 vial 99	pH	8.07	pH Units		pH-NP
1602053-99	B347T6 vial 99	Phosphate	36	ug/mL	7.5	Anions by IC-NP
1602053-99	B347T6 vial 99	Phosphorus	11700	ug/L	408	ICP-OES Vadose-NP
1602053-99	B347T6 vial 99	Sulfate	42.9	ug/mL	7.5	Anions by IC-NP
1602053-99	B347T6 vial 99	Uranium 238	6.47	ug/L	0.71	ICPMS-Tc_U-NP

1602053-AA	B347T6 vial 100	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AA	B347T6 vial 100	Calcium	5100	ug/L	336	ICP-OES Vadose-NP
1602053-AA	B347T6 vial 100	Chloride	66.8	ug/mL	2.5	Anions by IC-NP
1602053-AA	B347T6 vial 100	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-AA	B347T6 vial 100	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602053-AA	B347T6 vial 100	Nitrate	19.8	ug/mL	5	Anions by IC-NP
1602053-AA	B347T6 vial 100	pH	7.82	pH Units		pH-NP
1602053-AA	B347T6 vial 100	Phosphate	50.7	ug/mL	7.5	Anions by IC-NP
1602053-AA	B347T6 vial 100	Phosphorus	5050	ug/L	408	ICP-OES Vadose-NP
1602053-AA	B347T6 vial 100	Sulfate	46.1	ug/mL	7.5	Anions by IC-NP
1602053-AA	B347T6 vial 100	Uranium 238	9.79	ug/L	0.71	ICPMS-Tc_U-NP
1602053-AB	B347T6 vial 101	Chloride	63.5	ug/mL	2.5	Anions by IC-NP
1602053-AB	B347T6 vial 101	Nitrate	27.4	ug/mL	5	Anions by IC-NP
1602053-AB	B347T6 vial 101	Phosphate	63.4	ug/mL	7.5	Anions by IC-NP
1602053-AB	B347T6 vial 101	Sulfate	46.1	ug/mL	7.5	Anions by IC-NP
1602053-AB	B347T6 vial 101	Uranium 238	8.59	ug/L	0.71	ICPMS-Tc_U-NP
1602053-AC	B347T6 vial 102	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AC	B347T6 vial 102	Calcium	20400	ug/L	336	ICP-OES Vadose-NP
1602053-AC	B347T6 vial 102	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-AC	B347T6 vial 102	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602053-AC	B347T6 vial 102	Phosphorus	20200	ug/L	408	ICP-OES Vadose-NP
1602053-AE	B347T6 vial 104	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AE	B347T6 vial 104	Calcium	20000	ug/L	336	ICP-OES Vadose-NP
1602053-AE	B347T6 vial 104	Chloride	65.7	ug/mL	2.5	Anions by IC-NP
1602053-AE	B347T6 vial 104	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-AE	B347T6 vial 104	Manganese	29.6	ug/L	23.9	ICP-OES Vadose-NP
1602053-AE	B347T6 vial 104	Nitrate	28.1	ug/mL	5	Anions by IC-NP
1602053-AE	B347T6 vial 104	Phosphate	50.2	ug/mL	7.5	Anions by IC-NP
1602053-AE	B347T6 vial 104	Phosphorus	16800	ug/L	408	ICP-OES Vadose-NP
1602053-AE	B347T6 vial 104	Sulfate	45.6	ug/mL	7.5	Anions by IC-NP
1602053-AE	B347T6 vial 104	Uranium 238	8.45	ug/L	0.71	ICPMS-Tc_U-NP
1602053-AF	B347T6 vial 105	pH	8.34	pH Units		pH-NP
1602053-AG	B347T6 vial 106	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AG	B347T6 vial 106	Calcium	22900	ug/L	336	ICP-OES Vadose-NP
1602053-AG	B347T6 vial 106	Chloride	65.8	ug/mL	2.5	Anions by IC-NP
1602053-AG	B347T6 vial 106	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-AG	B347T6 vial 106	Manganese	29.6	ug/L	23.9	ICP-OES Vadose-NP
1602053-AG	B347T6 vial 106	Nitrate	27.9	ug/mL	5	Anions by IC-NP
1602053-AG	B347T6 vial 106	Phosphate	46.4	ug/mL	7.5	Anions by IC-NP
1602053-AG	B347T6 vial 106	Phosphorus	14800	ug/L	408	ICP-OES Vadose-NP
1602053-AG	B347T6 vial 106	Sulfate	44.7	ug/mL	7.5	Anions by IC-NP
1602053-AG	B347T6 vial 106	Uranium 238	7.38	ug/L	0.71	ICPMS-Tc_U-NP
1602053-AI	B347T6 vial 108	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AI	B347T6 vial 108	Calcium	23300	ug/L	336	ICP-OES Vadose-NP
1602053-AI	B347T6 vial 108	Chloride	66.2	ug/mL	2.5	Anions by IC-NP
1602053-AI	B347T6 vial 108	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-AI	B347T6 vial 108	Manganese	30.2	ug/L	23.9	ICP-OES Vadose-NP
1602053-AI	B347T6 vial 108	Nitrate	28.4	ug/mL	5	Anions by IC-NP
1602053-AI	B347T6 vial 108	Phosphate	44.3	ug/mL	7.5	Anions by IC-NP

1602053-AI	B347T6 vial 108	Phosphorus	14100	ug/L	408	ICP-OES Vadose-NP
1602053-AI	B347T6 vial 108	Sulfate	44.3	ug/mL	7.5	Anions by IC-NP
1602053-AI	B347T6 vial 108	Uranium 238	7.59	ug/L	0.71	ICPMS-Tc_U-NP
1602053-AK	B347T6 vial 110	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AK	B347T6 vial 110	Calcium	24100	ug/L	336	ICP-OES Vadose-NP
1602053-AK	B347T6 vial 110	Chloride	66.5	ug/mL	2.5	Anions by IC-NP
1602053-AK	B347T6 vial 110	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-AK	B347T6 vial 110	Manganese	31.6	ug/L	23.9	ICP-OES Vadose-NP
1602053-AK	B347T6 vial 110	Nitrate	28	ug/mL	5	Anions by IC-NP
1602053-AK	B347T6 vial 110	pH	8.03	pH Units		pH-NP
1602053-AK	B347T6 vial 110	Phosphate	42.8	ug/mL	7.5	Anions by IC-NP
1602053-AK	B347T6 vial 110	Phosphorus	14000	ug/L	408	ICP-OES Vadose-NP
1602053-AK	B347T6 vial 110	Sulfate	44	ug/mL	7.5	Anions by IC-NP
1602053-AK	B347T6 vial 110	Uranium 238	7.16	ug/L	0.71	ICPMS-Tc_U-NP
1602053-AM	B347T6 vial 112	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AM	B347T6 vial 112	Calcium	24300	ug/L	336	ICP-OES Vadose-NP
1602053-AM	B347T6 vial 112	Chloride	66.8	ug/mL	2.5	Anions by IC-NP
1602053-AM	B347T6 vial 112	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-AM	B347T6 vial 112	Manganese	32.2	ug/L	23.9	ICP-OES Vadose-NP
1602053-AM	B347T6 vial 112	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602053-AM	B347T6 vial 112	Phosphate	41.7	ug/mL	7.5	Anions by IC-NP
1602053-AM	B347T6 vial 112	Phosphorus	13200	ug/L	408	ICP-OES Vadose-NP
1602053-AM	B347T6 vial 112	Sulfate	43.8	ug/mL	7.5	Anions by IC-NP
1602053-AM	B347T6 vial 112	Uranium 238	6.89	ug/L	0.71	ICPMS-Tc_U-NP
1602053-AO	B347T6 vial 114	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AO	B347T6 vial 114	Calcium	24900	ug/L	336	ICP-OES Vadose-NP
1602053-AO	B347T6 vial 114	Chloride	67	ug/mL	2.5	Anions by IC-NP
1602053-AO	B347T6 vial 114	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-AO	B347T6 vial 114	Manganese	31.6	ug/L	23.9	ICP-OES Vadose-NP
1602053-AO	B347T6 vial 114	Nitrate	28.1	ug/mL	5	Anions by IC-NP
1602053-AO	B347T6 vial 114	Phosphate	41.6	ug/mL	7.5	Anions by IC-NP
1602053-AO	B347T6 vial 114	Phosphorus	12800	ug/L	408	ICP-OES Vadose-NP
1602053-AO	B347T6 vial 114	Sulfate	44.3	ug/mL	7.5	Anions by IC-NP
1602053-AO	B347T6 vial 114	Uranium 238	7.27	ug/L	0.71	ICPMS-Tc_U-NP
1602053-AP	B347T6 vial 115	pH	8.24	pH Units		pH-NP
1602053-AU	B347T6 vial 120	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AU	B347T6 vial 120	Calcium	26600	ug/L	336	ICP-OES Vadose-NP
1602053-AU	B347T6 vial 120	Chloride	66.9	ug/mL	2.5	Anions by IC-NP
1602053-AU	B347T6 vial 120	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-AU	B347T6 vial 120	Manganese	32.5	ug/L	23.9	ICP-OES Vadose-NP
1602053-AU	B347T6 vial 120	Nitrate	28.1	ug/mL	5	Anions by IC-NP
1602053-AU	B347T6 vial 120	pH	8.03	pH Units		pH-NP
1602053-AU	B347T6 vial 120	Phosphate	39.7	ug/mL	7.5	Anions by IC-NP
1602053-AU	B347T6 vial 120	Phosphorus	12800	ug/L	408	ICP-OES Vadose-NP
1602053-AU	B347T6 vial 120	Sulfate	43.4	ug/mL	7.5	Anions by IC-NP
1602053-AU	B347T6 vial 120	Uranium 238	6.98	ug/L	0.71	ICPMS-Tc_U-NP
1602053-AZ	B347T6 vial 125	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-AZ	B347T6 vial 125	Calcium	28300	ug/L	336	ICP-OES Vadose-NP
1602053-AZ	B347T6 vial 125	Chloride	66.6	ug/mL	2.5	Anions by IC-NP
1602053-AZ	B347T6 vial 125	Iron	ND	ug/L	100	ICP-OES Vadose-NP

1602053-AZ	B347T6 vial 125	Manganese	36.8	ug/L	23.9	ICP-OES Vadose-NP
1602053-AZ	B347T6 vial 125	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602053-AZ	B347T6 vial 125	Phosphate	36.8	ug/mL	7.5	Anions by IC-NP
1602053-AZ	B347T6 vial 125	Phosphorus	12200	ug/L	408	ICP-OES Vadose-NP
1602053-AZ	B347T6 vial 125	Sulfate	42.9	ug/mL	7.5	Anions by IC-NP
1602053-AZ	B347T6 vial 125	Uranium 238	6.74	ug/L	0.71	ICPMS-Tc_U-NP
1602053-BE	B347T6 vial 130	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-BE	B347T6 vial 130	Calcium	27400	ug/L	336	ICP-OES Vadose-NP
1602053-BE	B347T6 vial 130	Chloride	66.9	ug/mL	2.5	Anions by IC-NP
1602053-BE	B347T6 vial 130	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-BE	B347T6 vial 130	Manganese	34	ug/L	23.9	ICP-OES Vadose-NP
1602053-BE	B347T6 vial 130	Nitrate	28	ug/mL	5	Anions by IC-NP
1602053-BE	B347T6 vial 130	pH	8.03	pH Units		pH-NP
1602053-BE	B347T6 vial 130	Phosphate	37.5	ug/mL	7.5	Anions by IC-NP
1602053-BE	B347T6 vial 130	Phosphorus	11600	ug/L	408	ICP-OES Vadose-NP
1602053-BE	B347T6 vial 130	Sulfate	43.3	ug/mL	7.5	Anions by IC-NP
1602053-BE	B347T6 vial 130	Uranium 238	6.93	ug/L	0.71	ICPMS-Tc_U-NP
1602053-BJ	B347T6 vial 135	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-BJ	B347T6 vial 135	Calcium	28900	ug/L	336	ICP-OES Vadose-NP
1602053-BJ	B347T6 vial 135	Chloride	66.7	ug/mL	2.5	Anions by IC-NP
1602053-BJ	B347T6 vial 135	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-BJ	B347T6 vial 135	Manganese	31.6	ug/L	23.9	ICP-OES Vadose-NP
1602053-BJ	B347T6 vial 135	Nitrate	27.7	ug/mL	5	Anions by IC-NP
1602053-BJ	B347T6 vial 135	Phosphate	35.8	ug/mL	7.5	Anions by IC-NP
1602053-BJ	B347T6 vial 135	Phosphorus	11300	ug/L	408	ICP-OES Vadose-NP
1602053-BJ	B347T6 vial 135	Sulfate	42.8	ug/mL	7.5	Anions by IC-NP
1602053-BJ	B347T6 vial 135	Uranium 238	7.09	ug/L	0.71	ICPMS-Tc_U-NP
1602053-BO	B347T6 vial 140	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-BO	B347T6 vial 140	Calcium	29400	ug/L	336	ICP-OES Vadose-NP
1602053-BO	B347T6 vial 140	Chloride	66.7	ug/mL	2.5	Anions by IC-NP
1602053-BO	B347T6 vial 140	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-BO	B347T6 vial 140	Manganese	35.7	ug/L	23.9	ICP-OES Vadose-NP
1602053-BO	B347T6 vial 140	Nitrate	27.9	ug/mL	5	Anions by IC-NP
1602053-BO	B347T6 vial 140	pH	8.06	pH Units		pH-NP
1602053-BO	B347T6 vial 140	Phosphate	33.8	ug/mL	7.5	Anions by IC-NP
1602053-BO	B347T6 vial 140	Phosphorus	10600	ug/L	408	ICP-OES Vadose-NP
1602053-BO	B347T6 vial 140	Sulfate	42.8	ug/mL	7.5	Anions by IC-NP
1602053-BO	B347T6 vial 140	Uranium 238	7.11	ug/L	0.71	ICPMS-Tc_U-NP
1602053-BY	B347T6 vial 150	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-BY	B347T6 vial 150	Calcium	29900	ug/L	336	ICP-OES Vadose-NP
1602053-BY	B347T6 vial 150	Chloride	66.9	ug/mL	2.5	Anions by IC-NP
1602053-BY	B347T6 vial 150	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-BY	B347T6 vial 150	Manganese	39	ug/L	23.9	ICP-OES Vadose-NP
1602053-BY	B347T6 vial 150	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602053-BY	B347T6 vial 150	pH	8.03	pH Units		pH-NP
1602053-BY	B347T6 vial 150	Phosphate	35.2	ug/mL	7.5	Anions by IC-NP
1602053-BY	B347T6 vial 150	Phosphorus	11200	ug/L	408	ICP-OES Vadose-NP
1602053-BY	B347T6 vial 150	Sulfate	43	ug/mL	7.5	Anions by IC-NP
1602053-BY	B347T6 vial 150	Uranium 238	7.23	ug/L	0.71	ICPMS-Tc_U-NP
1602053-CI	B347T6 vial 160	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP

1602053-CI	B347T6 vial 160	Calcium	10700	ug/L	336	ICP-OES Vadose-NP
1602053-CI	B347T6 vial 160	Chloride	66.5	ug/mL	2.5	Anions by IC-NP
1602053-CI	B347T6 vial 160	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-CI	B347T6 vial 160	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602053-CI	B347T6 vial 160	Nitrate	27.6	ug/mL	5	Anions by IC-NP
1602053-CI	B347T6 vial 160	pH	8.01	pH Units		pH-NP
1602053-CI	B347T6 vial 160	Phosphate	35.3	ug/mL	7.5	Anions by IC-NP
1602053-CI	B347T6 vial 160	Phosphorus	4000	ug/L	408	ICP-OES Vadose-NP
1602053-CI	B347T6 vial 160	Sulfate	42.5	ug/mL	7.5	Anions by IC-NP
1602053-CI	B347T6 vial 160	Uranium 238	6.94	ug/L	0.71	ICPMS-Tc_U-NP
1602053-CS	B347T6 vial 170	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-CS	B347T6 vial 170	Calcium	26200	ug/L	336	ICP-OES Vadose-NP
1602053-CS	B347T6 vial 170	Chloride	66.5	ug/mL	2.5	Anions by IC-NP
1602053-CS	B347T6 vial 170	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-CS	B347T6 vial 170	Manganese	41.9	ug/L	23.9	ICP-OES Vadose-NP
1602053-CS	B347T6 vial 170	Nitrate	27.5	ug/mL	5	Anions by IC-NP
1602053-CS	B347T6 vial 170	pH	8.02	pH Units		pH-NP
1602053-CS	B347T6 vial 170	Phosphate	32.6	ug/mL	7.5	Anions by IC-NP
1602053-CS	B347T6 vial 170	Phosphorus	10600	ug/L	408	ICP-OES Vadose-NP
1602053-CS	B347T6 vial 170	Sulfate	42.3	ug/mL	7.5	Anions by IC-NP
1602053-CS	B347T6 vial 170	Uranium 238	7.68	ug/L	0.71	ICPMS-Tc_U-NP
1602053-CY	B347T6 vial 176	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-CY	B347T6 vial 176	Calcium	23800	ug/L	336	ICP-OES Vadose-NP
1602053-CY	B347T6 vial 176	Chloride	67.7	ug/mL	2.5	Anions by IC-NP
1602053-CY	B347T6 vial 176	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-CY	B347T6 vial 176	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602053-CY	B347T6 vial 176	Nitrate	12.2	ug/mL	5	Anions by IC-NP
1602053-CY	B347T6 vial 176	pH	7.98	pH Units		pH-NP
1602053-CY	B347T6 vial 176	Phosphate	49.3	ug/mL	7.5	Anions by IC-NP
1602053-CY	B347T6 vial 176	Phosphorus	15000	ug/L	408	ICP-OES Vadose-NP
1602053-CY	B347T6 vial 176	Sulfate	43.9	ug/mL	7.5	Anions by IC-NP
1602053-CY	B347T6 vial 176	Uranium 238	10.7	ug/L	0.71	ICPMS-Tc_U-NP
1602053-DA	B347T6 vial 178	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-DA	B347T6 vial 178	Calcium	23600	ug/L	336	ICP-OES Vadose-NP
1602053-DA	B347T6 vial 178	Chloride	60.4	ug/mL	2.5	Anions by IC-NP
1602053-DA	B347T6 vial 178	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-DA	B347T6 vial 178	Manganese	24.4	ug/L	23.9	ICP-OES
						Vadose-NP
1602053-DA	B347T6 vial 178	Nitrate	27	ug/mL	5	Anions by IC-NP
1602053-DA	B347T6 vial 178	Phosphate	47.5	ug/mL	7.5	Anions by IC-NP
1602053-DA	B347T6 vial 178	Phosphorus	14800	ug/L	408	ICP-OES Vadose-NP
1602053-DA	B347T6 vial 178	Sulfate	44.9	ug/mL	7.5	Anions by IC-NP
1602053-DA	B347T6 vial 178	Uranium 238	9.98	ug/L	0.71	ICPMS-Tc_U-NP
1602053-DC	B347T6 vial 180	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-DC	B347T6 vial 180	Calcium	24000	ug/L	336	ICP-OES Vadose-NP
1602053-DC	B347T6 vial 180	Chloride	54.9	ug/mL	2.5	Anions by IC-NP
1602053-DC	B347T6 vial 180	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-DC	B347T6 vial 180	Manganese	28.1	ug/L	23.9	ICP-OES Vadose-NP
1602053-DC	B347T6 vial 180	Nitrate	27.4	ug/mL	5	Anions by IC-NP
1602053-DC	B347T6 vial 180	pH	8.1	pH Units		pH-NP
1602053-DC	B347T6 vial 180	Phosphate	43	ug/mL	7.5	Anions by IC-NP

1602053-DC	B347T6 vial 180	Phosphorus	14100	ug/L	408	ICP-OES Vadose-NP
1602053-DC	B347T6 vial 180	Sulfate	44.4	ug/mL	7.5	Anions by IC-NP
1602053-DC	B347T6 vial 180	Uranium 238	10.1	ug/L	0.71	ICPMS-Tc_U-NP
1602053-DE	B347T6 vial 182	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-DE	B347T6 vial 182	Calcium	23900	ug/L	336	ICP-OES Vadose-NP
1602053-DE	B347T6 vial 182	Chloride	52	ug/mL	2.5	Anions by IC-NP
1602053-DE	B347T6 vial 182	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-DE	B347T6 vial 182	Manganese	28	ug/L	23.9	ICP-OES Vadose-NP
1602053-DE	B347T6 vial 182	Nitrate	27.6	ug/mL	5	Anions by IC-NP
1602053-DE	B347T6 vial 182	Phosphate	40.2	ug/mL	7.5	Anions by IC-NP
1602053-DE	B347T6 vial 182	Phosphorus	12700	ug/L	408	ICP-OES Vadose-NP
1602053-DE	B347T6 vial 182	Sulfate	43.9	ug/mL	7.5	Anions by IC-NP
1602053-DE	B347T6 vial 182	Uranium 238	10.7	ug/L	0.71	ICPMS-Tc_U-NP
1602053-DG	B347T6 vial 184	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-DG	B347T6 vial 184	Calcium	24000	ug/L	336	ICP-OES Vadose-NP
1602053-DG	B347T6 vial 184	Chloride	49.9	ug/mL	2.5	Anions by IC-NP
1602053-DG	B347T6 vial 184	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-DG	B347T6 vial 184	Manganese	30.5	ug/L	23.9	ICP-OES Vadose-NP
1602053-DG	B347T6 vial 184	Nitrate	27.6	ug/mL	5	Anions by IC-NP
1602053-DG	B347T6 vial 184	Phosphate	39	ug/mL	7.5	Anions by IC-NP
1602053-DG	B347T6 vial 184	Phosphorus	12200	ug/L	408	ICP-OES Vadose-NP
1602053-DG	B347T6 vial 184	Sulfate	43.4	ug/mL	7.5	Anions by IC-NP
1602053-DG	B347T6 vial 184	Uranium 238	10.8	ug/L	0.71	ICPMS-Tc_U-NP
1602053-DH	B347T6 vial 185	pH	8.31	pH Units		pH-NP
1602053-DI	B347T6 vial 186	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-DI	B347T6 vial 186	Calcium	24400	ug/L	336	ICP-OES Vadose-NP
1602053-DI	B347T6 vial 186	Chloride	48.6	ug/mL	2.5	Anions by IC-NP
1602053-DI	B347T6 vial 186	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-DI	B347T6 vial 186	Manganese	24.4	ug/L	23.9	ICP-OES Vadose-NP
1602053-DI	B347T6 vial 186	Nitrate	27.3	ug/mL	5	Anions by IC-NP
1602053-DI	B347T6 vial 186	Phosphate	37.7	ug/mL	7.5	Anions by IC-NP
1602053-DI	B347T6 vial 186	Phosphorus	11800	ug/L	408	ICP-OES Vadose-NP
1602053-DI	B347T6 vial 186	Sulfate	43.1	ug/mL	7.5	Anions by IC-NP
1602053-DI	B347T6 vial 186	Uranium 238	11.1	ug/L	0.71	ICPMS-Tc_U-NP
1602053-DK	B347T6 vial 188	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-DK	B347T6 vial 188	Calcium	24600	ug/L	336	ICP-OES Vadose-NP
1602053-DK	B347T6 vial 188	Chloride	47.7	ug/mL	2.5	Anions by IC-NP
1602053-DK	B347T6 vial 188	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-DK	B347T6 vial 188	Manganese	28.5	ug/L	23.9	ICP-OES Vadose-NP
1602053-DK	B347T6 vial 188	Nitrate	27.7	ug/mL	5	Anions by IC-NP
1602053-DK	B347T6 vial 188	Phosphate	36.9	ug/mL	7.5	Anions by IC-NP
1602053-DK	B347T6 vial 188	Phosphorus	11700	ug/L	408	ICP-OES Vadose-NP
1602053-DK	B347T6 vial 188	Sulfate	43.1	ug/mL	7.5	Anions by IC-NP
1602053-DK	B347T6 vial 188	Uranium 238	10.6	ug/L	0.71	ICPMS-Tc_U-NP
1602053-DM	B347T6 vial 190	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-DM	B347T6 vial 190	Calcium	25500	ug/L	336	ICP-OES Vadose-NP
1602053-DM	B347T6 vial 190	Chloride	47.1	ug/mL	2.5	Anions by IC-NP
1602053-DM	B347T6 vial 190	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-DM	B347T6 vial 190	Manganese	27.2	ug/L	23.9	ICP-OES Vadose-NP

1602053-DM	B347T6 vial 190	Nitrate	27.4	ug/mL	5	Anions by IC-NP
1602053-DM	B347T6 vial 190	pH	8.17	pH Units		pH-NP
1602053-DM	B347T6 vial 190	Phosphate	36.7	ug/mL	7.5	Anions by IC-NP
1602053-DM	B347T6 vial 190	Phosphorus	11300	ug/L	408	ICP-OES Vadose-NP
1602053-DM	B347T6 vial 190	Sulfate	42.8	ug/mL	7.5	Anions by IC-NP
1602053-DM	B347T6 vial 190	Uranium 238	10.8	ug/L	0.71	ICPMS-Tc_U-NP
1602053-DR	B347T6 vial 195	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-DR	B347T6 vial 195	Calcium	25800	ug/L	336	ICP-OES Vadose-NP
1602053-DR	B347T6 vial 195	Chloride	46.3	ug/mL	2.5	Anions by IC-NP
1602053-DR	B347T6 vial 195	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-DR	B347T6 vial 195	Manganese	30.2	ug/L	23.9	ICP-OES Vadose-NP
1602053-DR	B347T6 vial 195	Nitrate	27.6	ug/mL	5	Anions by IC-NP
1602053-DR	B347T6 vial 195	Phosphate	36.3	ug/mL	7.5	Anions by IC-NP
1602053-DR	B347T6 vial 195	Phosphorus	11100	ug/L	408	ICP-OES Vadose-NP
1602053-DR	B347T6 vial 195	Sulfate	42.9	ug/mL	7.5	Anions by IC-NP
1602053-DR	B347T6 vial 195	Uranium 238	10.5	ug/L	0.71	ICPMS-Tc_U-NP
1602053-DW	B347T6 vial 200	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-DW	B347T6 vial 200	Calcium	26200	ug/L	336	ICP-OES Vadose-NP
1602053-DW	B347T6 vial 200	Chloride	45.5	ug/mL	2.5	Anions by IC-NP
1602053-DW	B347T6 vial 200	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-DW	B347T6 vial 200	Manganese	29.2	ug/L	23.9	ICP-OES Vadose-NP
1602053-DW	B347T6 vial 200	Nitrate	27.3	ug/mL	5	Anions by IC-NP
1602053-DW	B347T6 vial 200	pH	8.11	pH Units		pH-NP
1602053-DW	B347T6 vial 200	Phosphate	36.4	ug/mL	7.5	Anions by IC-NP
1602053-DW	B347T6 vial 200	Phosphorus	11200	ug/L	408	ICP-OES Vadose-NP
1602053-DW	B347T6 vial 200	Sulfate	42.6	ug/mL	7.5	Anions by IC-NP
1602053-DW	B347T6 vial 200	Uranium 238	10.5	ug/L	0.71	ICPMS-Tc_U-NP
1602053-EB	B347T6 vial 205	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-EB	B347T6 vial 205	Calcium	27400	ug/L	336	ICP-OES Vadose-NP
1602053-EB	B347T6 vial 205	Chloride	45.3	ug/mL	2.5	Anions by IC-NP
1602053-EB	B347T6 vial 205	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-EB	B347T6 vial 205	Manganese	30.7	ug/L	23.9	ICP-OES Vadose-NP
1602053-EB	B347T6 vial 205	Nitrate	27.4	ug/mL	5	Anions by IC-NP
1602053-EB	B347T6 vial 205	Phosphate	36.2	ug/mL	7.5	Anions by IC-NP
1602053-EB	B347T6 vial 205	Phosphorus	11600	ug/L	408	ICP-OES Vadose-NP
1602053-EB	B347T6 vial 205	Sulfate	42.5	ug/mL	7.5	Anions by IC-NP
1602053-EB	B347T6 vial 205	Uranium 238	11	ug/L	0.71	ICPMS-Tc_U-NP
1602053-EG	B347T6 vial 210	Aluminum	ND	ug/L	165	ICP-OES
						Vadose-NP
1602053-EG	B347T6 vial 210	Calcium	29300	ug/L	336	ICP-OES Vadose-NP
1602053-EG	B347T6 vial 210	Chloride	44.9	ug/mL	2.5	Anions by IC-NP
1602053-EG	B347T6 vial 210	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-EG	B347T6 vial 210	Manganese	31.7	ug/L	23.9	ICP-OES Vadose-NP
1602053-EG	B347T6 vial 210	Nitrate	27.4	ug/mL	5	Anions by IC-NP
1602053-EG	B347T6 vial 210	pH	8.06	pH Units		pH-NP
1602053-EG	B347T6 vial 210	Phosphate	33.5	ug/mL	7.5	Anions by IC-NP
1602053-EG	B347T6 vial 210	Phosphorus	10800	ug/L	408	ICP-OES Vadose-NP
1602053-EG	B347T6 vial 210	Sulfate	42.5	ug/mL	7.5	Anions by IC-NP
1602053-EG	B347T6 vial 210	Uranium 238	10.7	ug/L	0.71	ICPMS-Tc_U-NP
1602053-EQ	B347T6 vial 220	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-EQ	B347T6 vial 220	Calcium	28200	ug/L	336	ICP-OES Vadose-NP
1602053-EQ	B347T6 vial 220	Chloride	45.1	ug/mL	2.5	Anions by IC-NP

1602053-EQ	B347T6 vial 220	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-EQ	B347T6 vial 220	Manganese	33.6	ug/L	23.9	ICP-OES Vadose-NP
1602053-EQ	B347T6 vial 220	Nitrate	27.8	ug/mL	5	Anions by IC-NP
1602053-EQ	B347T6 vial 220	pH	8.24	pH Units		pH-NP
1602053-EQ	B347T6 vial 220	Phosphate	36	ug/mL	7.5	Anions by IC-NP
1602053-EQ	B347T6 vial 220	Phosphorus	11100	ug/L	408	ICP-OES Vadose-NP
1602053-EQ	B347T6 vial 220	Sulfate	43	ug/mL	7.5	Anions by IC-NP
1602053-EQ	B347T6 vial 220	Uranium 238	10.8	ug/L	0.71	ICPMS-Tc_U-NP
1602053-FA	B347T6 vial 230	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-FA	B347T6 vial 230	Calcium	10400	ug/L	336	ICP-OES Vadose-NP
1602053-FA	B347T6 vial 230	Chloride	44.3	ug/mL	2.5	Anions by IC-NP
1602053-FA	B347T6 vial 230	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-FA	B347T6 vial 230	Manganese	30.7	ug/L	23.9	ICP-OES Vadose-NP
1602053-FA	B347T6 vial 230	Nitrate	27.7	ug/mL	5	Anions by IC-NP
1602053-FA	B347T6 vial 230	pH	8.14	pH Units		pH-NP
1602053-FA	B347T6 vial 230	Phosphate	34.8	ug/mL	7.5	Anions by IC-NP
1602053-FA	B347T6 vial 230	Phosphorus	7700	ug/L	408	ICP-OES Vadose-NP
1602053-FA	B347T6 vial 230	Sulfate	42.3	ug/mL	7.5	Anions by IC-NP
1602053-FA	B347T6 vial 230	Uranium 238	11.2	ug/L	0.71	ICPMS-Tc_U-NP
1602053-FK	B347T6 vial 240	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-FK	B347T6 vial 240	Calcium	9650	ug/L	336	ICP-OES Vadose-NP
1602053-FK	B347T6 vial 240	Chloride	43.8	ug/mL	2.5	Anions by IC-NP
1602053-FK	B347T6 vial 240	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-FK	B347T6 vial 240	Manganese	ND	ug/L	23.9	ICP-OES Vadose-NP
1602053-FK	B347T6 vial 240	Nitrate	27.4	ug/mL	5	Anions by IC-NP
1602053-FK	B347T6 vial 240	pH	8.19	pH Units		pH-NP
1602053-FK	B347T6 vial 240	Phosphate	35.6	ug/mL	7.5	Anions by IC-NP
1602053-FK	B347T6 vial 240	Phosphorus	4780	ug/L	408	ICP-OES Vadose-NP
1602053-FK	B347T6 vial 240	Sulfate	42	ug/mL	7.5	Anions by IC-NP
1602053-FK	B347T6 vial 240	Uranium 238	12.1	ug/L	0.71	ICPMS-Tc_U-NP
1602053-FU	B347T6 vial 250	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-FU	B347T6 vial 250	Calcium	29500	ug/L	336	ICP-OES Vadose-NP
1602053-FU	B347T6 vial 250	Chloride	43.5	ug/mL	2.5	Anions by IC-NP
1602053-FU	B347T6 vial 250	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-FU	B347T6 vial 250	Manganese	39.1	ug/L	23.9	ICP-OES Vadose-NP
1602053-FU	B347T6 vial 250	Nitrate	27.4	ug/mL	5	Anions by IC-NP
1602053-FU	B347T6 vial 250	pH	8.15	pH Units		pH-NP
1602053-FU	B347T6 vial 250	Phosphate	35.5	ug/mL	7.5	Anions by IC-NP
1602053-FU	B347T6 vial 250	Phosphorus	11300	ug/L	408	ICP-OES Vadose-NP
1602053-FU	B347T6 vial 250	Sulfate	42	ug/mL	7.5	Anions by IC-NP
1602053-FU	B347T6 vial 250	Uranium 238	11.7	ug/L	0.71	ICPMS-Tc_U-NP
1602053-GE	B347T6 vial 260	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-GE	B347T6 vial 260	Calcium	29800	ug/L	336	ICP-OES Vadose-NP
1602053-GE	B347T6 vial 260	Chloride	43.6	ug/mL	2.5	Anions by IC-NP
1602053-GE	B347T6 vial 260	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-GE	B347T6 vial 260	Manganese	39.7	ug/L	23.9	ICP-OES Vadose-NP
1602053-GE	B347T6 vial 260	Nitrate	27.3	ug/mL	5	Anions by IC-NP
1602053-GE	B347T6 vial 260	pH	8.12	pH Units		pH-NP
1602053-GE	B347T6 vial 260	Phosphate	33.9	ug/mL	7.5	Anions by IC-NP
1602053-GE	B347T6 vial 260	Phosphorus	10800	ug/L	408	ICP-OES Vadose-NP
1602053-GE	B347T6 vial 260	Sulfate	42.1	ug/mL	7.5	Anions by IC-NP

1602053-GE	B347T6 vial 260	Uranium 238	12	ug/L	0.71	ICPMS-Tc_U-NP
1602053-GN	B347T6 vial 269	Aluminum	ND	ug/L	165	ICP-OES Vadose-NP
1602053-GN	B347T6 vial 269	Calcium	28200	ug/L	336	ICP-OES Vadose-NP
1602053-GN	B347T6 vial 269	Chloride	43.3	ug/mL	2.5	Anions by IC-NP
1602053-GN	B347T6 vial 269	Iron	ND	ug/L	100	ICP-OES Vadose-NP
1602053-GN	B347T6 vial 269	Manganese	35.3	ug/L	23.9	ICP-OES Vadose-NP
1602053-GN	B347T6 vial 269	Nitrate	27.2	ug/mL	5	Anions by IC-NP
1602053-GN	B347T6 vial 269	pH	8.14	pH Units		pH-NP
1602053-GN	B347T6 vial 269	Phosphate	36.6	ug/mL	7.5	Anions by IC-NP
1602053-GN	B347T6 vial 269	Phosphorus	11100	ug/L	408	ICP-OES Vadose-NP
1602053-GN	B347T6 vial 269	Sulfate	42	ug/mL	7.5	Anions by IC-NP
1602053-GN	B347T6 vial 269	Uranium 238	12.1	ug/L	0.71	ICPMS-Tc_U-NP
1602053-GP	B347T6 vial 271	Bromide	ND	ug/mL	5	Anions by IC-NP
1602053-GR	B347T6 vial 273	Bromide	18.3	ug/mL	5	Anions by IC-NP
1602053-GT	B347T6 vial 275	Bromide	27.1	ug/mL	5	Anions by IC-NP
1602053-GV	B347T6 vial 277	Bromide	32.6	ug/mL	5	Anions by IC-NP
1602053-GX	B347T6 vial 279	Bromide	35.5	ug/mL	5	Anions by IC-NP
1602053-GZ	B347T6 vial 281	Bromide	38	ug/mL	5	Anions by IC-NP
1602053-HB	B347T6 vial 283	Bromide	39.5	ug/mL	5	Anions by IC-NP
1602053-HD	B347T6 vial 285	Bromide	40.7	ug/mL	5	Anions by IC-NP
1602053-HF	B347T6 vial 287	Bromide	41.5	ug/mL	5	Anions by IC-NP
1602053-HH	B347T6 vial 289	Bromide	41.8	ug/mL	5	Anions by IC-NP
1602053-HN	B347T6 vial 295	Bromide	43.3	ug/mL	5	Anions by IC-NP
1602053-HS	B347T6 vial 300	Bromide	44.1	ug/mL	5	Anions by IC-NP
1602053-HX	B347T6 vial 305	Bromide	44.8	ug/mL	5	Anions by IC-NP
1602053-IC	B347T6 vial 310	Bromide	45.4	ug/mL	5	Anions by IC-NP
1602053-IH	B347T6 vial 315	Bromide	45.9	ug/mL	5	Anions by IC-NP
1602053-IM	B347T6 vial 320	Bromide	46.1	ug/mL	5	Anions by IC-NP
1602053-IW	B347T6 vial 330	Bromide	46.8	ug/mL	5	Anions by IC-NP
1602053-JG	B347T6 vial 340	Bromide	47	ug/mL	5	Anions by IC-NP
1602053-JO	B347T6 vial 348	Bromide	42.6	ug/mL	5	Anions by IC-NP
1602053-JQ	B347T6 vial 350	Bromide	29.6	ug/mL	5	Anions by IC-NP
1602053-JS	B347T6 vial 352	Bromide	20.5	ug/mL	5	Anions by IC-NP
1602053-JU	B347T6 vial 354	Bromide	15.6	ug/mL	5	Anions by IC-NP
1602053-JW	B347T6 vial 356	Bromide	12.3	ug/mL	5	Anions by IC-NP
1602053-JY	B347T6 vial 358	Bromide	10.3	ug/mL	5	Anions by IC-NP
1602053-KA	B347T6 vial 360	Bromide	8.99	ug/mL	5	Anions by IC-NP
1602053-KC	B347T6 vial 362	Bromide	7.85	ug/mL	5	Anions by IC-NP
1602053-KE	B347T6 vial 364	Bromide	7.05	ug/mL	5	Anions by IC-NP
1602053-KG	B347T6 vial 366	Bromide	6.12	ug/mL	5	Anions by IC-NP
1602053-KK	B347T6 vial 370	Bromide	ND	ug/mL	5	Anions by IC-NP
1602053-KP	B347T6 vial 375	Bromide	ND	ug/mL	5	Anions by IC-NP
1602053-KU	B347T6 vial 380	Bromide	ND	ug/mL	5	Anions by IC-NP
1602053-KZ	B347T6 vial 385	Bromide	ND	ug/mL	5	Anions by IC-NP
1602053-LE	B347T6 vial 390	Bromide	ND	ug/mL	5	Anions by IC-NP
1602053-LO	B347T6 vial 400	Bromide	ND	ug/mL	5	Anions by IC-NP
1602053-LY	B347T6 vial 410	Bromide	ND	ug/mL	5	Anions by IC-NP
1602053-MI	B347T6 vial 420	Bromide	ND	ug/mL	5	Anions by IC-NP

Pore Volume and stop flow data for in-tact column B347T6

Vial #	Pore volume	Comments
1	0.00	saturating column
2	0.01	start column
3	0.01	
4	0.02	
5	0.02	
6	0.02	
7	0.03	
8	0.03	
9	0.04	
10	0.04	
11	0.05	
12	0.05	

13	0.05	
14	0.06	
15	0.06	
16	0.07	
17	0.07	
18	0.07	
19	0.08	
20	0.08	
21	0.09	
22	0.09	
23	0.10	
24	0.10	
25	0.10	
26	0.11	
27	0.11	
28	0.12	
29	0.12	
30	0.12	
31	0.13	
32	0.13	
33	0.14	
34	0.14	
35	0.15	
36	0.15	
37	0.15	
38	0.16	
39	0.16	
40	0.17	
41	0.17	
42	0.17	
43	0.18	
44	0.18	
45	0.19	
46	0.19	
47	0.19	
48	0.20	
49	0.20	
50	0.21	
51	0.21	
52	0.22	
53	0.22	
54	0.22	
55	0.23	
56	0.23	
57	0.24	
58	0.24	
59	0.24	
60	0.25	
61	0.25	
62	0.26	
63	0.26	
64	0.27	
65	0.27	
66	0.27	
67	0.28	
68	0.28	
69	0.29	
70	0.29	
71	0.29	
72	0.30	
73	0.30	
74	0.31	
75	0.31	
76	0.32	
77	0.32	
78	0.32	

79	0.33	
80	0.33	
81	0.34	
82	0.34	
83	0.34	
84	0.35	
85	0.35	
86	0.36	
87	0.36	
88	0.37	
89	0.37	
90	0.37	
91	0.38	
92	0.38	
93	0.39	
94	0.39	
95	0.39	
96	0.40	
97	0.40	
98	0.41	
99	0.41	48 hour stop flow
100	0.41	
101	0.42	
102	0.42	
103	0.43	
104	0.43	
105	0.44	
106	0.44	
107	0.44	
108	0.45	
109	0.45	
110	0.46	
111	0.46	
112	0.46	
113	0.47	
114	0.47	
115	0.48	
116	0.48	
117	0.49	
118	0.49	
119	0.49	
120	0.50	
121	0.50	
122	0.51	
123	0.51	
124	0.51	
125	0.52	
126	0.52	
127	0.53	
128	0.53	
129	0.54	
130	0.54	
131	0.54	
132	0.55	
133	0.55	
134	0.56	
135	0.56	
136	0.56	
137	0.57	
138	0.57	
139	0.58	
140	0.58	
141	0.58	
142	0.59	
143	0.59	
144	0.60	

145	0.60	
146	0.61	
147	0.61	
148	0.61	
149	0.62	
150	0.62	
151	0.63	
152	0.63	
153	0.63	
154	0.64	
155	0.64	
156	0.65	
157	0.65	
158	0.66	
159	0.66	
160	0.66	
161	0.67	
162	0.67	
163	0.68	
164	0.68	
165	0.68	
166	0.69	
167	0.69	
168	0.70	
169	0.70	
170	0.71	
171	0.71	
172	0.71	
173	0.72	
174	0.72	
175	0.73	72 hour stop flow
176	0.73	
177	0.73	
178	0.74	
179	0.74	
180	0.75	
181	0.75	
182	0.75	
183	0.76	
184	0.76	
185	0.77	
186	0.77	
187	0.78	
188	0.78	
189	0.78	
190	0.79	
191	0.79	
192	0.80	
193	0.80	
194	0.80	
195	0.81	
196	0.81	
197	0.82	
198	0.82	
199	0.83	
200	0.83	
201	0.83	
202	0.84	
203	0.84	
204	0.85	
205	0.85	
206	0.85	
207	0.86	
208	0.86	
209	0.87	
210	0.87	

211	0.88	
212	0.88	
213	0.88	
214	0.89	
215	0.89	
216	0.90	
217	0.90	
218	0.90	
219	0.91	
220	0.91	
221	0.92	
222	0.92	
223	0.92	
224	0.93	
225	0.93	
226	0.94	
227	0.94	
228	0.95	
229	0.95	
230	0.95	
231	0.96	
232	0.96	
233	0.97	
234	0.97	
235	0.97	
236	0.98	
237	0.98	
238	0.99	
239	0.99	
240	1.00	
241	1.00	
242	1.00	
243	1.01	
244	1.01	
245	1.02	
246	1.02	
247	1.02	
248	1.03	
249	1.03	
250	1.04	
251	1.04	
252	1.05	
253	1.05	
254	1.05	
255	1.06	
256	1.06	
257	1.07	
258	1.07	
259	1.07	
260	1.08	
261	1.08	
262	1.09	
263	1.09	
264	1.10	
265	1.10	
266	1.10	
267	1.11	
268	1.11	
269	1.12	Stop

Appendix B

Chain of Custodies, Geologic Descriptions and Sample Photographs

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-348**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H
SAMPLING LOCATION C9580, I-001	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg 24	**ACTUAL SAMPLE DEPTH** 21.50'- 22.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE
SHIPPED TO DNNL-331 ~~Environmental Sciences Laboratory~~ 92 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	

DATA TURNAROUND
30 Days / 30 Days

ORIGINAL

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A

SPECIAL HANDLING AND/OR STORAGE

PRESERVATION	~~None~~ CA 01-05-16 Cool 4°C
HOLDING TIME	6 Months
TYPE OF CONTAINER	G/P
NO. OF CONTAINER(S)	1
VOLUME	1L
SAMPLE ANALYSIS	Generic Testing (No CAS);

used Liner D due to 25% recovery
CA 01-05-16

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347C6	SOIL	01-05-16	1035	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 0 5 ~~2015~~ 2016 1540	SSU #1	JAN 0 5 ~~2015~~ 2016 1540
SSU-1	JAN 2 6 ~~2016~~ 2016 0930 CA	R.A. Shepard/CHPRC	CA 1-26 JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 1130	A.Lawter	JAN 2 6 2016 1130

SPECIAL INSTRUCTIONS
** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15648** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-354**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9580, I-002	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg 24	**ACTUAL SAMPLE DEPTH** 24.00' - 24.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 9-21-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ CA 01-05-16 Cool 4°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347D2	SOIL	01-05-16	1105	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JAN 0 5 ~~2015~~ 2016 1540	SSU#1	JAN 0 5 ~~2015~~ 2016 1540
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	CA 1- JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 1130	A. Lauster	JAN 2 6 2016 1130

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15650** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-360**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H
SAMPLING LOCATION C9580, I-003	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐
				DATA TURNAROUND 30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 Pg 24	**ACTUAL SAMPLE DEPTH** 26.50' - 27.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-16	**OFFSITE PROPERTY NO.** 0		**BILL OF LADING/AIR BILL NO.**	**ORIGINAL**

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ CA 01-05-16 Cool 4°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347D8	SOIL	01-05-16	1320	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 0 5 ~~2015~~ 2016 1540	SSU#1	JAN 0 5 ~~2015~~ 2016 1540
SSU-1	JAN 2 6 2016 CA 1-7-16 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 CA 1-7-16 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 1130	A. Lawter	JAN 2 6 2016 1130

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15652** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-363**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9580, I-004	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 24	**ACTUAL SAMPLE DEPTH** 29.00'- 29.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO **Environmental Sciences Laboratory**	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ CA 01-05-16 Cool 4°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347F1	SOIL	01-05-16	1350	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JAN 0 5 ~~2015~~ 2016 1540	SSU#1	JAN 0 5 ~~2015~~ 2016 1540
SSU#1	CA 1-7-16 0930 JAN 2 6 2016	R.A. Shepard/CHPRC	CA 1-7-16 0930 JAN 2 6 2016
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder / M. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15653** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-365	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9580, I-004	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 24	**ACTUAL SAMPLE DEPTH** 29.50' - 30.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*	POSSIBLE SAMPLE HAZARDS/ REMARKS		
A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A **SPECIAL HANDLING AND/OR STORAGE**	**PRESERVATION**	~~None~~ CA 01-05-16 Cool 4°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
		SAMPLE ANALYSIS	Generic Testing {No CAS};

Sample Taken From Shoe

CA 01-05-16

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347F3	SOIL	01-05-16	1350	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 5 ~~2015~~ 2016 1540	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JAN 0 5 ~~2015~~ 2016 1540
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** CA JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** CA 1- JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 1130	**RECEIVED BY/STORED IN** A. Lawter	**DATE/TIME** JAN 2 6 2016 1130
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 FSR ID = FSR15653 TRVL NUM = TRVL-16-054 A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-368**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9580, I-005	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/ Pg 24	**ACTUAL SAMPLE DEPTH** 31.50' - 32.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A

SPECIAL HANDLING AND/OR STORAGE

PRESERVATION	~~None~~ dA 01-05-16 cool 4°C
HOLDING TIME	6 Months
TYPE OF CONTAINER	Split Spoon Liner
NO. OF CONTAINER(S)	1
VOLUME	1000g
SAMPLE ANALYSIS	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347F6	SOIL	01-05-16	1415	✓

CHAIN OF POSSESSION | **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 0 5 ~~2015~~ 2016 1540	SSU#1	JAN 0 5 ~~2015~~ 2016 1540
SSU-1	JAN 2 6 2016 cp 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 cp 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M.Snyder / M. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS
** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	RECEIVED BY	TITLE	DATE/TIME
FINAL SAMPLE DISPOSITION	DISPOSAL METHOD	DISPOSED BY	DATE/TIME

PRINTED ON 12/29/2015 **FSR ID = FSR15654** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-369**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H
SAMPLING LOCATION C9580, I-005	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐
				DATA TURNAROUND 30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg 24	**ACTUAL SAMPLE DEPTH** 31.00' - 31.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	**ORIGINAL**

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ CA 01-05-16 Cool 4°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347F7	SOIL	01-05-16	1415	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JAN 0 5 ~~2015~~ 2016 1540	SSU#1	JAN 0 5 ~~2015~~ 2016 1540
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
SSU-1	CA 1-7-16 JAN 2 6 2016 0930	R.A. Shepard/CHPRC	CA 1-7-16 JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M Snyder/M. Snyder	JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15654** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-370**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9580, I-005	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-331 Pg 24	**ACTUAL SAMPLE DEPTH** 30.50'- 31.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ cool 4°C ca 01-05-16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347F8	SOIL	01-05-16	1415	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 5 ~~2015~~ 2016 1540 ca 1-7-16	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 0 5 ~~2015~~ 2016 1540 ca 1-7-16
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 1130	**RECEIVED BY/STORED IN** ~~R.A. Shepard/CHPRC~~ RS 1/26/16 A. Lauter	**DATE/TIME** JAN 2 6 2016 1130
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15654** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-373**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H
SAMPLING LOCATION C9580, I-006	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg 24	**ACTUAL SAMPLE DEPTH** 34.00' - 34.50'	**COA** 303492	**DATA TURNAROUND** 30 Days / 30 Days
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE

ORIGINAL

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ CA 01-05-16 Cool 4°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347H1	SOIL	01-05-16	1440	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 5 ~~2015~~ 2016 1540 CA 1-7-16	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 0 5 ~~2015~~ 2016 1540 CA 1-7-16
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder/M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15655** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-374**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H
SAMPLING LOCATION C9580, I-006	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐
				DATA TURNAROUND 30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg24	**ACTUAL SAMPLE DEPTH** ~~34.00'-33.~~ ED 01-05-16 33.50'-34.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE
SHIPPED TO Environmental Sciences Laboratory	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	**ORIGINAL**

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ EA 01-05-16 cool 4°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347H2	SOIL	01-05-16	1440	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	2016 JAN 05 ~~2015~~ 1540	SSU # 1	2016 JAN 05 ~~2015~~ 1540
SSU-1	JAN 26 2016 0930	R.A. Shepard/CHPRC	JAN 26 2016 0930
R.A. Shepard/CHPRC	JAN 26 2016 11:30	M. Snyder/M. Conyau	JAN 26 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15655** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

F15-014-375 **PAGE** 1 **OF** 1

COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9580, I-006	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 24	**ACTUAL SAMPLE DEPTH** 33.00' - 33.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ ca 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ ca 01-05-16 cool 4°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347H3	SOIL	01-05-16	1440	✓

CHAIN OF POSSESSION **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JAN 0 5 ~~2015~~ 2016 1540	SSU #1	JAN 0 5 ~~2015~~ 2016 1540
SSU-1	JAN 2 6 2016 0930 ca 1-7-16	R.A. Shepard/CHPRC	JAN 2 6 2016 0930 ca 1-7-16
R.A. Shepard/CHPRC	JAN 2 6 2016 1130	A. Lauter	JAN 2 6 2016 1130

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**		**TITLE**		**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**		**DISPOSED BY**		**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15655** **TRVL NUM = TRVL-16-054** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-388	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9581, I-001	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 Pg 25	**ACTUAL SAMPLE DEPTH** 21.50' - 22.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ RZ 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*	POSSIBLE SAMPLE HAZARDS/ REMARKS		
A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ Cool 6°C JD 1/7/16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347J6	SOIL	01-07-16	1140	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 7 2016 ~~JAN 0 7 2015~~ JR 1-7-16 1330	**RECEIVED BY/STORED IN** Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 2016 ~~JAN 0 7 2015~~ JR 1-7-16 1330
RELINQUISHED BY/REMOVED FROM Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 2016 1415	**RECEIVED BY/STORED IN** SSU-1	**DATE/TIME** JAN 0 7 2016 1415
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0830	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0830
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M.Snyder / M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15657** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-389**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9581, I-001	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 25	**ACTUAL SAMPLE DEPTH** 21.00' - 21.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 9C 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JD 1/7/16 Cool 6°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347J7	SOIL	01-07-16	1140	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 0 7 2016 ~~JAN 0 7 2015~~ JR 1-7-16 1330	Kevin Patterson CHPRC	JAN 0 7 2016 ~~JAN 0 7 2015~~ JR 1-7-16 1330
evin Patterson CHPRC	JAN 0 7 2016 1415	SSU-1	JAN 0 7 2016 1415
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder / M. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15657** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-390**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9581, I-001	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 Pg 25	**ACTUAL SAMPLE DEPTH** 20.50' - 21.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 92 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JJ 1/7/16 Cool 6°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347J8	SOIL	01-07-16	1140	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 0 7 2016 ~~JAN 0 7 2015~~ 1-7-16 1330	Kevin Patterson CHPRC	JAN 0 7 2016 ~~JAN 0 7 2015~~ 1-7-16 1330
Kevin Patterson CHPRC	JAN 0 7 2016 1415	SSU-1	JAN 0 7 2016 1415
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 1130	A.Lauter	JAN 2 6 2016 1130

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15657** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-394	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9581, I-002	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg25	**ACTUAL SAMPLE DEPTH** 24.00' - 24.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ JJ 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A

SPECIAL HANDLING AND/OR STORAGE

PRESERVATION	~~None~~ JJ 1/7/16 Cool 6°C
HOLDING TIME	6 Months
TYPE OF CONTAINER	Split Spoon Liner
NO. OF CONTAINER(S)	1
VOLUME	1000g
SAMPLE ANALYSIS	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347K2	SOIL	01-07-16	1202	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330	**RECEIVED BY/STORED IN** Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330
RELINQUISHED BY/REMOVED FROM Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 2016 1415	**RECEIVED BY/STORED IN** SSU-1	**DATE/TIME** JAN 0 7 2016 1415
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0830	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15658** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-395	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9581, I-002	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/ Pg 25	**ACTUAL SAMPLE DEPTH** 23.50' - 24.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JP 1/7/16 Cool 6°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347K3	SOIL	01-07-16	1202	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330 JP 1-7-16	**RECEIVED BY/STORED IN** Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330 KP 1-7-16
RELINQUISHED BY/REMOVED FROM Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 2016 1415	**RECEIVED BY/STORED IN** SSU-1	**DATE/TIME** JAN 0 7 2016 1415
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder / M Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15658** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-396	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9581, I-002	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg 25	**ACTUAL SAMPLE DEPTH** 23.00'-23.50	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	ORIGINAL
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 021-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*	POSSIBLE SAMPLE HAZARDS/ REMARKS		
A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JD 1/7/16 Cool 6°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347K4	SOIL	01-07-16	1202	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 0 7 ~~2015~~ 2016 1330	Kevin Patterson CHPRC	JAN 0 7 ~~2015~~ 2016 1330
Kevin Patterson CHPRC	JAN 0 7 2016 1415	SSU-1	JAN 0 7 2016 1415
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 1130	A. Lawter	JAN 2 6 2016 1130

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15658** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-399**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9581, I-003	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/ Pg 25	**ACTUAL SAMPLE DEPTH** 26.50'-27.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331/ ~~Environmental Sciences Laboratory~~ 921-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ Cool 6°c JJ 1/7/16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing -(No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347K7	SOIL	01-07-16	1220	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 7 2016 ~~JAN 0 7 2015~~ 1330 JA 1/7/16	**RECEIVED BY/STORED IN** Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 2016 ~~JAN 0 7 2015~~ 1330 JA 1-7-16
RELINQUISHED BY/REMOVED FROM Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 2016 1415	**RECEIVED BY/STORED IN** SSU-1	**DATE/TIME** JAN 0 7 2016 1415
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** U Snyder / [illegible]	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15659** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-400**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9581, I-003	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg 25	**ACTUAL SAMPLE DEPTH** 26.00'- 26.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 9Z 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JO 1/7/16 Cool 6°c
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347K8	SOIL	01-07-16	1220	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JAN 0 7 ~~2015~~ 2016 1330	Kevin Patterson CHPRC	JAN 0 7 ~~2015~~ 2016 1330
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
Kevin Patterson CHPRC	JAN 0 7 2016 1415	SSU-1	JAN 0 7 2016 1415
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
SSU-1	JAN 2 6 2016 0830	R.A. Shepard/CHPRC	JAN 2 6 2016 0830
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	N. Snyder / J.M. Snyder	JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15659** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-401	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9581, I-003	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 25	**ACTUAL SAMPLE DEPTH** 25.50'-26.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	ORIGINAL
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ [illegible]	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*	POSSIBLE SAMPLE HAZARDS/ REMARKS		
A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A **SPECIAL HANDLING AND/OR STORAGE**	**PRESERVATION**	~~None~~ JJ 1/7/16 Cool 6°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
		SAMPLE ANALYSIS	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347K9	SOIL	01-07-16	1220	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330	**RECEIVED BY/STORED IN** Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330
RELINQUISHED BY/REMOVED FROM Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 2016 1415	**RECEIVED BY/STORED IN** SSU-1	**DATE/TIME** JAN 0 7 2016 1415
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 1130	**RECEIVED BY/STORED IN** A. Lawter	**DATE/TIME** JAN 2 6 2016 1130
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15659** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-403**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **DATA TURNAROUND**
SAMPLING LOCATION C9581, I-003	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐ 30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 25	**ACTUAL SAMPLE DEPTH** 25.00' - 25.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 9 21-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JD 1/7/16 Cool 6°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347L1	SOIL	01-07-16	1220	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330	**RECEIVED BY/STORED IN** Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330
RELINQUISHED BY/REMOVED FROM Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 2016 1415	**RECEIVED BY/STORED IN** SSU-1 RJS 1/26/16	**DATE/TIME** JAN 0 7 2016 1415
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder / JD Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION A

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15659** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-404**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9581, I-004	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 25	**ACTUAL SAMPLE DEPTH** 29.00' - 29.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ [illegible] 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JD 1/7/16 Cool 6°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347L2	SOIL	01-07-16	1313	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330	**RECEIVED BY/STORED IN** Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 ~~2015~~ 2016 1330
RELINQUISHED BY/REMOVED FROM Kevin Patterson CHPRC	**DATE/TIME** JAN 0 7 2016 1415	**RECEIVED BY/STORED IN** SSU-1	**DATE/TIME** JAN 0 7 2016 1415
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 1130	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JAN 2 6 2016 1130
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15660** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-405**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9581, I-004	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 25	**ACTUAL SAMPLE DEPTH** 28.50 - 29.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ JJ 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JJ 1/7/16 Cool 6°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347L3	SOIL	01-07-16	1313	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 0 7 ~~2015~~ 2016 1330	Kevin Patterson CHPRC	JAN 0 7 ~~2015~~ 2016 1330
Kevin Patterson CHPRC	JAN 0 7 2016 1415	SSU-1	JAN 0 7 2016 1415
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder M. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15660** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-406**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9581, I-004	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 25	**ACTUAL SAMPLE DEPTH** 28.00' - 28.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO ~~Environmental Sciences Laboratory~~ PNNL-331 [illegible] 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JJ 1/7/16 Cool 6°c
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347L4	SOIL	01-07-16	1313	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JAN 0 7 ~~2015~~ 2016 1330 JJ 1-7-16	Kevin Patterson CHPRC	JAN 0 7 ~~2015~~ 2016 1330 JJ 1-7-16
Kevin Patterson CHPRC	JAN 0 7 2016 1415	SSU-1	JAN 0 7 2016 1415
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 1130	A. Lawter	JAN 2 6 2016 1130

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15660** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-412**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9581, I-005	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 25	**ACTUAL SAMPLE DEPTH** 32.00' - 32.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 321-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JCH 1/7/16 Cool 6C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

Sample From Shoe
CA 01-07-16

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347M0	SOIL	01-07-16	1335	✓

CHAIN OF POSSESSION JAN 07 2016		SIGN/ PRINT NAMES JAN 07 2016	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** ~~JAN 07 2015~~ CA 1-7-16 1505	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** ~~JAN 07 2015~~ 1-7-16 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 26 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 26 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 26 2016 1130	**RECEIVED BY/STORED IN** A. Lawter	**DATE/TIME** JAN 26 2016 1130
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15661** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-415**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐ **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9581, I-006	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/ Pg 25	**ACTUAL SAMPLE DEPTH** 34.00'- 34.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO **Environmental Sciences Laboratory**	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JJ 1/7/16 Cool 6°C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347M3	SOIL	01-07-16	1355	✓

CHAIN OF POSSESSION JAN 0 7 2016		**SIGN/ PRINT NAMES** JAN 0 7 2016	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** ~~JAN 0 7 2015~~ 1505 CA 1-7-16	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** ~~JAN 0 7 2015~~ 1505 CA 1-7-16
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15662** **TRVL NUM = TRVL-16-055** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-430**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-001	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg 26	**ACTUAL SAMPLE DEPTH** 21.50'-22.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL 331 ~~Environmental Sciences Laboratory~~ 9Z1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A

SPECIAL HANDLING AND/OR STORAGE

PRESERVATION	~~None~~ JLH 1/7/16 Cool 6C
HOLDING TIME	6 Months
TYPE OF CONTAINER	Split Spoon Liner
NO. OF CONTAINER(S)	1
VOLUME	1000g
SAMPLE ANALYSIS	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347N8	SOIL	1-11-16	1210	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS
** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15665** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-431**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-001	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 26	**ACTUAL SAMPLE DEPTH** 21.00'-21.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JAH 1/7/16 Cool 6C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347N9	SOIL	01-11-16	1210	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JAN 1 1 2016 1505	SSU #1	JAN 1 1 2016 1505
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder / M. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15665** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-432**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-001	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/ Pg 26	**ACTUAL SAMPLE DEPTH** 20.50' 21.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-14	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A **SPECIAL HANDLING AND/OR STORAGE**	**PRESERVATION**	~~None~~ JLA 1/7/16 Cool 6C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
		SAMPLE ANALYSIS	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347P0	SOIL	01-11-16	1210	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSu #1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 1130	**RECEIVED BY/STORED IN** A. Lawter	**DATE/TIME** JAN 2 6 2016 1130
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15665** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-435**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-002	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014		
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg 26	**ACTUAL SAMPLE DEPTH** 24.00' - 24.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ AZ 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JAH 1/11/16 Cool 6C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347P3	SOIL	01-11-16	1232	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 1 1 2016 1505	SSU#1	JAN 1 1 2016 1505
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder/M Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15666** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST		F15-014-436	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **AIR QUALITY** ☐
SAMPLING LOCATION C9582, I-002	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**DATA TURNAROUND** 30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 24	**ACTUAL SAMPLE DEPTH** 23.50' - 24.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE ORIGINAL
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 1-21-2016	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A

SPECIAL HANDLING AND/OR STORAGE

PRESERVATION	~~None~~ JJH 1/7/16 Cool 6C
HOLDING TIME	6 Months
TYPE OF CONTAINER	Split Spoon Liner
NO. OF CONTAINER(S)	1
VOLUME	1000g
SAMPLE ANALYSIS	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347P4	SOIL	01-11-16	1232	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS
** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15666** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-437**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-002	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 26	**ACTUAL SAMPLE DEPTH** 23.00' - 23.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ [illegible] 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ J.H 1/7/16 Cool 6C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347P5	SOIL	01-11-16	1232	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 1130	**RECEIVED BY/STORED IN** A.Lauter	**DATE/TIME** JAN 2 6 2016 1130
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15666** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-440	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-002	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 26	**ACTUAL SAMPLE DEPTH** 22.50' - 23.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 9C-1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*	POSSIBLE SAMPLE HAZARDS/ REMARKS		
A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ Cool 6C J.L.U. 1/7/16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347P8	SOIL	01-11-16	1232	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 1 1 2016 1505	SSU #1	JAN 1 1 2016 1505
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder M Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION A

LABORATORY SECTION	RECEIVED BY	TITLE	DATE/TIME
FINAL SAMPLE DISPOSITION	DISPOSAL METHOD	DISPOSED BY	DATE/TIME

PRINTED ON 12/29/2015 **FSR ID = FSR15666** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-441**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9582, I-003	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 /Pg 26	**ACTUAL SAMPLE DEPTH** 26.50' - 27.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 9Z 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ Cool 6C JLH 1/7/16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347P9	SOIL	01-11-16	1255	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 1 1 2016 1505	SSU #1	JAN 1 1 2016 1505
SSU 4	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	U. Snyder / U. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15667** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-442**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-003	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 26	**ACTUAL SAMPLE DEPTH** 26.00'- 26.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 92 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ Cool 6C JLH 1/7/16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347R0	SOIL	01-11-16	1255	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15667** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-443**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9582, I-003	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/ Pg 26	**ACTUAL SAMPLE DEPTH** 25.50' - 26.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ JZ1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ Cool 6C JZH 1/7/16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347R1	SOIL	01-11-16	1255	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU#1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** A Lawter	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15667** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-446**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-003	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg26	**ACTUAL SAMPLE DEPTH** 25.00'-25.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ gc-1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ Cool 6C JH 1/7/16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347R4	SOIL	01-11-16	1255	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSu #1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder M Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION A

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15667** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-447**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9582, I-004	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/Pg 26	**ACTUAL SAMPLE DEPTH** 29.00'-29.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 92 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ Cool 6C JC4 1/7/16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347R5	SOIL	01-11-16	1318	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15668** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-448	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-004	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/ Pg 26	**ACTUAL SAMPLE DEPTH** 28.50' - 29.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ JE 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*	POSSIBLE SAMPLE HAZARDS/ REMARKS		
A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JCH 1/7/16 Cool 6C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347R6	SOIL	01-11-16	1318	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 1 1 2016 1505	SSU #1	JAN 1 1 2016 1505
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder / M. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	RECEIVED BY	TITLE	DATE/TIME
FINAL SAMPLE DISPOSITION	DISPOSAL METHOD	DISPOSED BY	DATE/TIME

PRINTED ON 12/29/2015 **FSR ID = FSR15668** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-449**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9582, I-004	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 /Pg 26	**ACTUAL SAMPLE DEPTH** 29.50'-30.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JLH 1/7/16 Cool 6C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347R7	SOIL	01-11-16	1318	✓

Used Shoe For Sample
CA 01-11-16

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** A. Lanter	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15668** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-452**	**PAGE** 1 **OF** 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-005	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 26	**ACTUAL SAMPLE DEPTH** 31.50' - 32.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 92 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A **SPECIAL HANDLING AND/OR STORAGE**	**PRESERVATION**	None
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
		SAMPLE ANALYSIS	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347T0	SOIL	01-11-16	1340	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JAN 1 1 2016 1505	SSU#1	JAN 1 1 2016 1505
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder / M. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15669** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**			**F15-014-453**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-005	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 26	**ACTUAL SAMPLE DEPTH** 31.00' - 31.50	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ gc 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ J.4 1/7/16 Cool 6C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing {No CAS};

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347T1	SOIL	01-11-16	1340	✓

CHAIN OF POSSESSION		**SIGN/ PRINT NAMES**	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder / M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15669** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company | **CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST** | **F15-014-457** | **PAGE 1 OF 1**

COLLECTOR J.R. Aguilar/CHPRC

COMPANY CONTACT TODAK, D

TELEPHONE NO. 376-6427

PROJECT COORDINATOR TODAK, D

PRICE CODE 8H

DATA TURNAROUND 30 Days / 30 Days

SAMPLING LOCATION C9582, I-006

PROJECT DESIGNATION 300-FF-5 Post ROD Field Investigation - Soils

SAF NO. F15-014

AIR QUALITY ☐

ICE CHEST NO.

FIELD LOGBOOK NO. HNF-N-507-33/Pg 26

ACTUAL SAMPLE DEPTH 34.00' - 34.50'

COA 303492

METHOD OF SHIPMENT GOVERNMENT VEHICLE

ORIGINAL

SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-16

OFFSITE PROPERTY NO.

BILL OF LADING/AIR BILL NO.

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A

SPECIAL HANDLING AND/OR STORAGE

PRESERVATION	~~None~~ Cool 6C JCH 1/7/16
HOLDING TIME	6 Months
TYPE OF CONTAINER	Split Spoon Liner
NO. OF CONTAINER(S)	1
VOLUME	1000g
SAMPLE ANALYSIS	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347T5	SOIL	01-11-16	1400	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	DATE/TIME	RECEIVED BY/STORED IN	DATE/TIME
J.R. Aguilar/CHPRC	JAN 1 1 2016 1505	SSU#1	JAN 1 1 2016 1505
SSU-1	JAN 2 6 2016 0830	R.A. Shepard/CHPRC	JAN 2 6 2016 0830
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder/M. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS
** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION D

LABORATORY SECTION — **RECEIVED BY** — **TITLE** — **DATE/TIME**

FINAL SAMPLE DISPOSITION — **DISPOSAL METHOD** — **DISPOSED BY** — **DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15670** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-458**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **DATA TURNAROUND** 30 Days / 30 Days
SAMPLING LOCATION C9582, I-006	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 26	**ACTUAL SAMPLE DEPTH** 33.50' - 34.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	

MATRIX*
A=Air
DL=Drum Liquids
DS=Drum Solids
L=Liquid
O=Oil
S=Soil
SE=Sediment
T=Tissue
V=Vegetation
W=Water
WI=Wipe
X=Other

POSSIBLE SAMPLE HAZARDS/ REMARKS
*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A

SPECIAL HANDLING AND/OR STORAGE

PRESERVATION	~~None~~ SE 1/7/16 Cool 6C
HOLDING TIME	6 Months
TYPE OF CONTAINER	Split Spoon Liner
NO. OF CONTAINER(S)	1
VOLUME	1000g
SAMPLE ANALYSIS	Generic Testing (No CAS);

SAMPLE NO.	**MATRIX***	**SAMPLE DATE**	**SAMPLE TIME**	
B347T6	SOIL	01-11-16	1400	✓

CHAIN OF POSSESSION — **SIGN/ PRINT NAMES**

RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
J.R. Aguilar/CHPRC	JAN 1 1 2016 1505	SSU#1	JAN 1 1 2016 1505
SSU-1	JAN 2 6 2016 0930	R.A. Shepard/CHPRC	JAN 2 6 2016 0930
R.A. Shepard/CHPRC	JAN 2 6 2016 11:30	M. Snyder / M. Snyder	JAN 2 6 2016 11:30

SPECIAL INSTRUCTIONS
** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION C

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15670** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	**CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST**		**F15-014-459**	**PAGE 1 OF 1**
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H **DATA TURNAROUND**
SAMPLING LOCATION C9582, I-006	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐ 30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33 / Pg 26	**ACTUAL SAMPLE DEPTH** 33.00' - 33.50'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE **ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ ac 1-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**	

MATRIX* A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	**POSSIBLE SAMPLE HAZARDS/ REMARKS** *Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ Cool 6C JCH 1/7/16
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	G/P
		NO. OF CONTAINER(S)	1
		VOLUME	1L
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347T7	SOIL	01-11-16	1400	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES	
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 1 1 2016 1505
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0930	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0930
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** A.Lawter	**DATE/TIME** JAN 2 6 2016 11:30
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**

SPECIAL INSTRUCTIONS

** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION B

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15670** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

CH2MHill Plateau Remediation Company	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST			F15-014-461	PAGE 1 OF 1
COLLECTOR J.R. Aguilar/CHPRC	**COMPANY CONTACT** TODAK, D	**TELEPHONE NO.** 376-6427	**PROJECT COORDINATOR** TODAK, D	**PRICE CODE** 8H	**DATA TURNAROUND**
SAMPLING LOCATION C9582, I-006	**PROJECT DESIGNATION** 300-FF-5 Post ROD Field Investigation - Soils		**SAF NO.** F15-014	**AIR QUALITY** ☐	30 Days / 30 Days
ICE CHEST NO.	**FIELD LOGBOOK NO.** HNF-N-507-33/ Pg 26	**ACTUAL SAMPLE DEPTH** 32.50' - 33.00'	**COA** 303492	**METHOD OF SHIPMENT** GOVERNMENT VEHICLE	**ORIGINAL**
SHIPPED TO PNNL-331 ~~Environmental Sciences Laboratory~~ 921-26-16	**OFFSITE PROPERTY NO.**		**BILL OF LADING/AIR BILL NO.**		

MATRIX*	POSSIBLE SAMPLE HAZARDS/ REMARKS		
A=Air DL=Drum Liquids DS=Drum Solids L=Liquid O=Oil S=Soil SE=Sediment T=Tissue V=Vegetation W=Water WI=Wipe X=Other	*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1. N/A	**PRESERVATION**	~~None~~ JiH 1/7/16 Cool 6C
		HOLDING TIME	6 Months
		TYPE OF CONTAINER	Split Spoon Liner
		NO. OF CONTAINER(S)	1
		VOLUME	1000g
	SPECIAL HANDLING AND/OR STORAGE	**SAMPLE ANALYSIS**	Generic Testing (No CAS);

SAMPLE NO.	MATRIX*	SAMPLE DATE	SAMPLE TIME	
B347T9	SOIL	01-11-16	1400	✓

CHAIN OF POSSESSION		SIGN/ PRINT NAMES		SPECIAL INSTRUCTIONS
RELINQUISHED BY/REMOVED FROM J.R. Aguilar/CHPRC	**DATE/TIME** JAN 1 1 2016 1505	**RECEIVED BY/STORED IN** SSU #1	**DATE/TIME** JAN 1 1 2016 1505	** One liter bottle being sent to ESL is comprised of the residual homogenized material from Liner B after Total Uranium subsampling. It is to be used for the Leachabilty characteristic tests and predominate Uranium bearing mineral phase analysis. PORTION A
RELINQUISHED BY/REMOVED FROM SSU-1	**DATE/TIME** JAN 2 6 2016 0830	**RECEIVED BY/STORED IN** R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 0830	
RELINQUISHED BY/REMOVED FROM R.A. Shepard/CHPRC	**DATE/TIME** JAN 2 6 2016 11:30	**RECEIVED BY/STORED IN** M. Snyder M. Snyder	**DATE/TIME** JAN 2 6 2016 11:30	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	
RELINQUISHED BY/REMOVED FROM	**DATE/TIME**	**RECEIVED BY/STORED IN**	**DATE/TIME**	

LABORATORY SECTION	**RECEIVED BY**	**TITLE**	**DATE/TIME**
FINAL SAMPLE DISPOSITION	**DISPOSAL METHOD**	**DISPOSED BY**	**DATE/TIME**

PRINTED ON 12/29/2015 **FSR ID = FSR15670** **TRVL NUM = TRVL-16-056** A-6003-618 (REV 2)

Pacific Northwest National Laboratory

BOREHOLE SAMPLE LOG

Boring/Well No C9580 **Depth** 21.5 - 30 **Date** 1/28/2016

Location 300 Area **Project**

Sheet 1 **of** 1

Logged by G.V. LAST Print G.V. Last Sign

Reviewed by Print Sign **Date**

Lithologic Class. Scheme Folk/Wentworth **Procedure** PNNL-ESL-GEOLOGY **Rev** 1

Drilling Contractor

Driller

Drill Method SONIC

DEPTH (FT)	SAMPLES		MOISTURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	ID NUMBER		C	Z	S	G		
21.5									
.6	G	B347C6	W					SILTY SANDY GRAVEL. 50% Gravel up to 3cm, rounded. 35% Sand, mostly	1 liter jar, full.
.7								very coarse to medium. 15% silt (in clumps). Wet color is 2.5Y 4/1. Clasts	
.8								are covered with mud - hard to see lithology. No reaction to 10% HCl.	
.9									
22.0									
26.6	G	B347D8	W					SILTY SANDY GRAVEL. 60% Gravel up to 2.5cm, round to sub-round, mostly	1 LITER JAR - FULL.
.7								basaltic? (mud covered). 40% Sand, mostly coarse. Wet color is 2.5Y 4/1.	
.8								No reaction to 10% HCl.	
.9									
27.0									
29.1	C	B347F1	W					GRAVEL. 80% Gravel, 15% Sand, 5% silt. Gravel up to 3cm. Sand is	Splitspoon liner D. 80% Full
.2								mostly coarse to very coarse. Gravel is round to subround. Wet color	Looked at bottom only.
.3								is 2.5Y 5/1 to 4/1. No reaction to 10% HCl.	Thermax says 84°F
.4									
.5									
.6	G	B347F3	W					GRAVEL. 80% Gravel, 15% Sand, 5% silt. Gravel is up to 3cm. subround to	1 Liter Jar - 1/4 full.
.7								subangular, mostly basalt? (mud covered). Sand is mostly coarse to very	
.8								coarse. Silt is mostly in clumps. Wet color is 2.5Y 5/1 to 4/1.	
.9									
30.0									

C = Core, G = Grab D = Dry, M = Moist, W = Wet

2015/GVL/GeosciencesGroup/Procedures/SampleLog/001 (02/06)

Pacific Northwest National Laboratory

BOREHOLE SAMPLE LOG

Boring/Well No C9581 **Depth** 28 – 29.5 **Date** 1/29/2016

Location 300 AREA **Project**

Sheet 1 **of** 1

Logged by George Last (Print) G.V. Last (Sign)

Reviewed by (Print) (Sign) **Date**

Lithologic Class. Scheme Folk/Wentworth **Procedure** PNNL-ESL-GEOLOGY **Rev** 1

Drilling Contractor

Driller

Drill Method Sonic

DEPTH (FT)	SAMPLES		MOISTURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	ID NUMBER		C	Z	S	G		
28.0									
.1	G	B347L4	W					SANDY GRAVEL. 60% Gravel, 35% Sand, 5% Silt. Gravel up to 2cm, mostly	1 Liter Jar, Full.
.2								basalt. Sand is mostly coarse to very coarse, 50% mafic, 50% felsic. Wet	
.3								color is 2.5Y4/1. No reaction 10% HCl.	[DEPTHS maybe off]
.4									
.5									
.6	C	B347L3	W					GRAVEL. 80% Gravel, 20% Sand, some silt (minor). Gravel is subround up to ~	Splitspoon, Liner C.
.7								2cm, 60% basaltic. Looks clast supported. Sand 50% basalt, 50% felsic,	95% Full. Viewing top
.8								mostly coarse to very coarse. Wet color is 2.5Y4/1. No reaction	only.
.9								to 10% HCl.	
29.0									
.1	C	B347L2	W					GRAVEL. 80% Gravel, 20% Sand, Some (trace) Silt. Gravel is subround,	Splitspoon, Liner D,
.2								60% mafic, 40% felsic. Sand is mostly coarse to very coarse, 50% mafic &	70% full. Viewing top
.3								50% felsic. Wet color is 2.5Y 4/1. No reaction to 10% HCl.	only.
.4									
.5									[DEPTHS MAYBE OFF]

C = Core, G = Grab D = Dry, M = Moist, W = Wet 2015/GVL/GeosciencesGroup/Procedures/SampleLog/001 (02/06)

Pacific Northwest National Laboratory	BOREHOLE SAMPLE LOG	Boring/Well No C9582	Depth 20.5-22.0	Date 1/29/2016	Sheet 1 of 5
		Location 300-Area	Project		

Logged by George V. Last (Print) G.V. Last (Sign)
Reviewed by (Print) (Sign) Date
Lithologic Class. Scheme Folk/Wentworth
Procedure PNNL-ESL-Geology Rev 1
Drilling Contractor
Driller
Drill Method Sonic

DEPTH (FT)	SAMPLES		MOISTURE	GRAPHIC LOG				LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
	TYPE	ID NUMBER		C	Z	S	G		
20.5									
.6	G	B347PD	W					SILTY GRAVELLY SAND. 25% Gravel, 65% Sand, 10% Silt (in clumps). Gravel	1 Liter Jar, Full.
.7								is 70% basaltic, 30% felsic, subround, up to 1 cm. Sand is mostly coarse to	
.8								very coarse, 50% mafic, 50% felsic. Wet color is 2.5Y 4/1, but looks more	[DEPTHS MAYBE OFF]
.9								brown than previous samples. No reaction to 10% HCl.	
21.0									
.1	C	B347N9	W					SILTY SANDY GRAVEL. 40% Gravel, 45% Sand, 15% silt. Gravel is up to 0.5	Splitspoon, liner C.
.2								cm, mostly very fine pebble to granule, mostly mafic, subround to subangular.	Nearly full. Looked at
.3								Sand is mostly coarse. Wet color is 2.5Y 3/1. Not reaction to 10% HCl.	Top only.
.4									
.5									
.6		B347N8	W					SILTY SANDY GRAVEL. 60% Gravel, 25% Sand, 15% Silt. Gravel is round to	Splitspoon liner D.
.7								subround, up to 3 cm. 60% mafic, 40% felsic. Sand is finer, mostly	80% full. Look at top
.8								medium to fine, 60% felsic, 40% mafic. ~~Wet~~ color is 2.5Y 4/2, more brown.	only.
.9								looks clast supported. No reaction to 10% HCl	
22.0									[DEPTHS MAYBE OFF

C = Core, G = Grab D = Dry, M = Moist, W = Wet 2015/GVL/GeosciencesGroup/Procedures/SampleLog/001 (02/06)

Pacific Northwest National Laboratory	**BOREHOLE SAMPLE LOG**	**Boring/Well No** C9582 **Depth** **Date** 1/29/2016 **Location** 300 AREA **Project**	**Sheet** 2 **of** 5

Logged by George V. Last (Print) G.V. Last (Sign)

Reviewed by (Print) (Sign) **Date**

Lithologic Class. Scheme Folk/Wentworth **Procedure** PNNL-ESL-GEOLOGY **Rev** 1

Drilling Contractor

Driller

Drill Method SONIC

DEPTH (FT)	SAMPLES TYPE	SAMPLES ID NUMBER	MOIS-TURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
22.5						
.6	C	B347P8	W		GRAVEL. 80% Gravel, 15% Sand, 5% Silt. Gravel is rounded, mostly	SPLITSPOON LINER A.
.7					basalt (mafic), up to at least 1.5cm. Sand is mostly coarse to	FULL. Looking at Top
.8					medium. Wet color is 2.5Y 3/1. Very compacted. Not reaction to	only.
.9					10% HCl.	
23.0						[DEPTHS MAYBE OFF]
.1	G	B347P5	W		GRAVEL. 90% Gravel, 5% Sand, 5% Silt. Gravel is subround to subangular:	1LITER JAR, ½ FULL.
.2					up to 3cm, mostly basalt (mafic). Sand is mostly medium. Wet	Question if <2mm material
.3					color is 2.5Y 4/1.	alredy extruded for previous
.4						analyses.
.5						
.6	C	B347P4	W		GRAVEL. 90% Gravel, up to at least 4cm, subrounded, mostly basalt.	SPLITSPOON LINER C,
.7					wet color of fine sand & silt is 2.5Y 5/3. No reaction to 10% HCl.	Full. Looked at top
.8						only.
.9						
24.0						
.1	C	B347P3	W		SANDY GRAVEL. 75% Gravel, up to 6cm, 70% basaltic, 30% felsic. Sand	SPLITSPOON LINER D.
.2					(20%) is mostly coarse to very coarse, salt & pepper, 50% mafic, 50%	Look at top only.
.3					felsic. Wet color of matrix is 2.5Y 4/1 to 3/1. No reaction to 10% HCl.	
.4						
.5						[DEPTHS MAY BE OFF]

C = Core, G = Grab

D = Dry, M = Moist, W = Wet

2015/GVL/GeosciencesGroup/Procedures/SampleLog/001 (02/06)

Pacific Northwest National Laboratory	BORESHOLE SAMPLE LOG	Boring/Well No C9582 Location 300 AREA	Depth 25.0 - 27.0' Date 1/29/2016 Project	Sheet 3 of 5

Logged by George Last (Print) GV Last (Sign)

Reviewed by (Print) (Sign) Date

Lithologic Class. Scheme Folk/Wentworth

Procedure PNNL-ESL-GEOLOGY Rev 1

Drilling Contractor

Driller

Drill Method SONIC

DEPTH (FT)	SAMPLES TYPE	SAMPLES ID NUMBER	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
25.0						
.1	C	B347R4	W		GRAVEL. 80% Gravel, up to 4 cm (broken). Subround to subangular where	SPLITSPOON LINER A.
.2					unbroken, 60% basaltic/mafic, 40% felsic. Wet color is 2.5Y 3/1.	50% FULL. View from Top.
.3					No reaction to 10% Cl.	
.4						[DEPTHS MAY BE OFF]
.5						
.6	G	B347R1	W		SANDY GRAVEL. 40% Gravel, 55% Sand, 5% silt. Gravel up to 3 cm,	1 Liter jar, full.
.7					subround where up broken, 80% basaltic/mafic, 20% Felsic (eg.	
.8					argillite). Sand is mostly coarse to very coarse. Wet color is 2.5Y 3/1.	
.9					No reaction to HCl.	
26.0						
.1	C	B347R0	W		SILTY SANDY GRAVEL. 60% Gravel, 35% Sand, 5% silt. Gravel up to 1.5 cm.	SPLITSPOON LINER C.
.2					subround 60% basaltic/mafic, 40% felsic. Sand is mostly coarse, salt & pepper -	FULL (Nearly). Viewing
.3					50% mafic, 50% felsic. Wet color is 2.5Y 4/1. No reaction to 10% HCl.	top only.
.4						
.5						
.6	C	B347P9	W		SILTY SANDY GRAVEL. 75% Gravel, 20% Sand, 5% silt. Gravel up to 5 cm.	SPLITSPOON LINER D
.7					subround where unbroken, mostly basalt/mafic. Sand is mostly coarse,	85% FULL. Viewing from
.8					50% mafic/50% felsic. Wet color is 2.5Y 4/1. No reaction to 10% HCl	top
.9						
27.0						

C = Core, G = Grab D = Dry, M = Moist, W = Wet 2015/GVL/GeosciencesGroup/Procedures/SampleLog/001 (02/06)

Pacific Northwest National Laboratory	BOREHOLE SAMPLE LOG	Boring/Well No C9582	Depth 28.5 - 30'	Date 1/29/2016	Sheet 4 of 5
		Location 300 AREA	Project		

Logged by George V. Last (Print) G.V. Last (Sign)

Reviewed by (Print) (Sign) Date

Lithologic Class. Scheme Folk/wentworth Procedure PNNL-ESL-Geology Rev 1

Drilling Contractor

Driller

Drill Method SONIC

DEPTH (FT)	SAMPLES TYPE	SAMPLES ID NUMBER	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
28.5									
.6	C	B347R6	W					GRAVEL. 80% Gravel, 20% Sand, some silt. Gravel up to at least 6cm	SPLITSPOON LINER (C.)
.7								(broken), mostly basaltic. Sand is mostly coarse to very coarse.	80% FULL (Big Rocks).
.8								Wet color is 2.5Y 4/1. No to weak reaction to 10% HCl.	Viewed top only.
.9									{DEPTH MAYBE OFF}
29.0									
.1	C	B347R5	W					SILTY SANDY GRAVEL. 70% Gravel, 20% Sand, 5% Silt. Gravel greater than	SPLITSPOON, LINER (D)
.2								5cm (broken). 50% basaltic? Sand is mostly coarse to very coarse.	90% FULL (Big Rocks)
.3								Clasts covered with mud. Wet color is 2.5Y 4/1 to 4/2. No to weak	Viewed top only.
.4								reaction to 10% HCl	
.5									
.6	G	B347R7	W					SILTY SANDY GRAVEL. 40% Gravel, 50% Sand, 10% Silt. Gravel up to 3cm,	1 LITER JAR 1/4 full.
.7								subround, 80% basaltic, 20% felsic. Sand is mostly coarse. Wet color	
.8								is 2.5Y 4/1. No reaction to 10% HCl.	
.9									
30.0									

C = Core, G = Grab D = Dry, M = Moist, W = Wet 2015/GVL/GeosciencesGroup/Procedures/SampleLog/001 (02/06)

Pacific Northwest National Laboratory	**BOREHOLE SAMPLE LOG**	Boring/Well No C958~~0~~2 GVL Location 300 Area	Depth 32.5-34.5 Date 1/29/2016 Project	Sheet 5 of 5

Logged by George V. Last (Print) GV Last (Sign)

Reviewed by (Print) (Sign) Date

Lithologic Class. Scheme Folk/Wentworth

Procedure PNNL-ESL-GEOLOGY Rev 1

Drilling Contractor

Driller

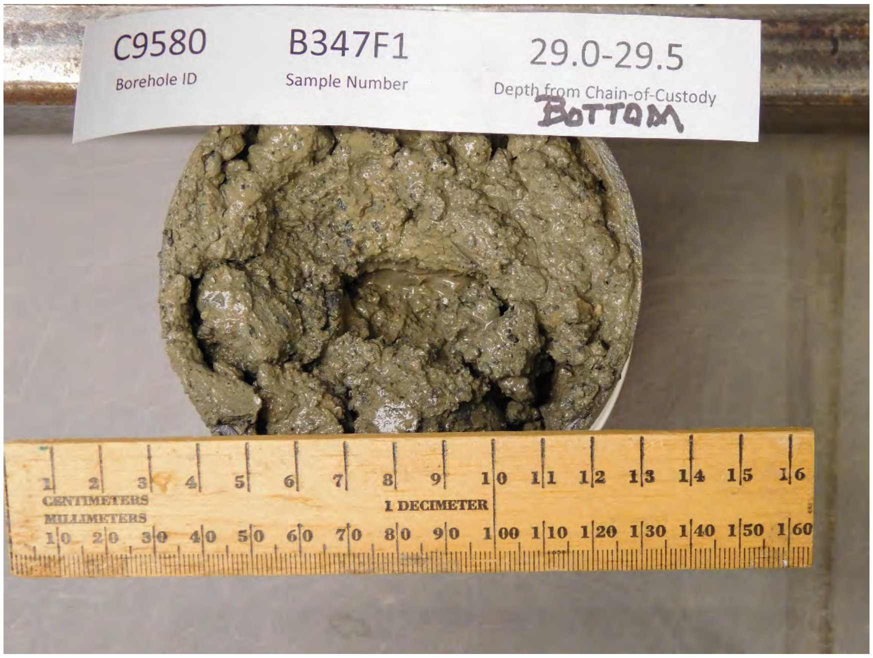
Drill Method SONIC

DEPTH (FT)	SAMPLES TYPE	SAMPLES ID NUMBER	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, maximum grain size, consolidation, structure, etc.)	COMMENTS
32.5						
.6	C	B347T9	W		SILTY SANDY GRAVEL. 70% Gravel, 15% Sand, 10% silt (mud). Gravel up to	SPLITSPOON LINER A,
.7					>5cm (broken), subround where unbroken. Sand is mostly coarse to	80% full. Viewed top
.8					very coarse. Very muddy. Color is 2.5Y 4/1 to 4/2. No reaction to	only.
.9					10% Cl.	[DEPTHS MAY BE OFF}
33.0						
.1	G	B347T7	W		SILTY SANDY GRAVEL. 75% Gravel, 20% Sand, 10% silt/mud. Gravel up to	1 Liter Jar nearly full.
.2					3 cm. Sand is mostly coarse to very coarse. Silt in clumps.	
.3					Wet color is 2.5Y 4/1. No reaction to 10% HCl.	
.4						
.5						
.6	C	B347T6	W		SILTY SANDY GRAVEL. 70% Gravel, 15% Sand, 15% silt/mud. Gravel up to	SPLITSPOON LINER C
.7					7cm, broken. Sand is mostly coarse. Lots of silt/mud. Wet color	90% full. Viewed top
.8					is 2.5Y 4/1. No reaction to 10% HCl.	only. and bottom
.9					– looked at bottom also – sandy Gravel	
34.0						
.1	C	B347T5	W		SANDY GRAVEL. 70% Gravel, 30% Sand, trace of silt. Gravel up to	SPLITSPOON LINER D
.2					4 cm, subround to subangular. 60% basaltic/mafic, 40% felsic,	80% full. Viewed from
.3					Sand is mostly coarse to very coarse, salt and pepper (50% mafic/50%	top only.
.4					felsic). Wet color is 2.5Y 3/1. No reaction to 10% HCl.	
.5						

C = Core, G = Grab D = Dry, M = Moist, W = Wet

2015/GVL/GeosciencesGroup/Procedures/SampleLog/001 (02/06)

Photographs of samples from borehole C9580


C9580
Borehole ID
B347F1
Sample Number
29.0-29.5
Depth from Chain-of-Custody
BOTTOM
CENTIMETERS
MILLIMETERS
1 DECIMETER


C9580
Borehole ID
B347F3
Sample Number
29.5-30.0
Depth from Chain-of-Custody
CENTIMETERS
MILLIMETERS
1 DECIMETER

Photographs of samples from borehole C9581


C9581
Borehole ID
B347L2
Sample Number
29.0-29.5
Depth from Chain-of-Custody
TOP
CENTIMETERS
MILLIMETERS
1 DECIMETER

Photographs of samples from borehole C9582


CENTIMETERS
MILLIMETERS
1 DECIMETER
C9582
Borehole ID
B347N8
Sample Number
21.5-22.0
Depth from Chain-of-Custody
TOP


C9582
Borehole ID
P347P8
Sample Number
22.5-23.0
Depth from Chain-of-Custody


C9582
Borehole ID
B347P5
Sample Number
23.0-23.5
Depth from Chain-of-Custody


C9582
Borehole ID
B347P4
Sample Number
23.5-24.0
Depth from Chain-of-Custody
TOP

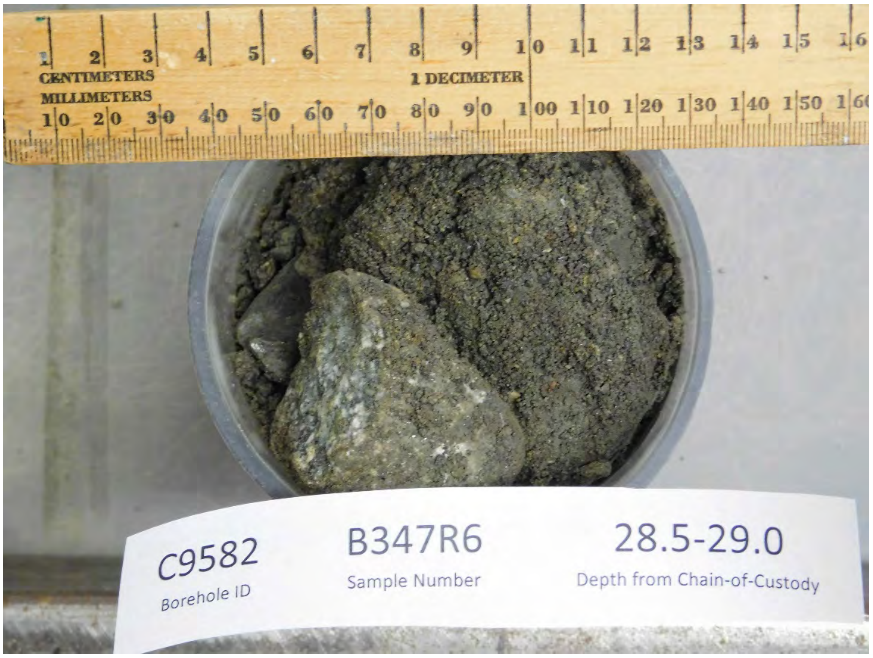

METERS
METERS
1 DECIMETER
C9582
Borehole ID
B347P3
Sample Number
24.0-24.5
Depth from Chain-of-Custody
TOP


CENTIMETERS
MILLIMETERS
1 DECIMETER
C9582
Borehole ID
B347R4
Sample Number
TOP
25.0-25.5
Depth from Chain-of-Custody


C9582
Borehole ID
B347R1
Sample Number
25.5-26.0
Depth from Chain-of-Custody
CENTIMETERS
MILLIMETERS
1 DECIMETER


C9582
Borehole ID
B347R0
Sample Number
TOP
26.0-26.5
Depth from Chain-of-Custody
CENTIMETERS
MILLIMETERS
1 DECIMETER

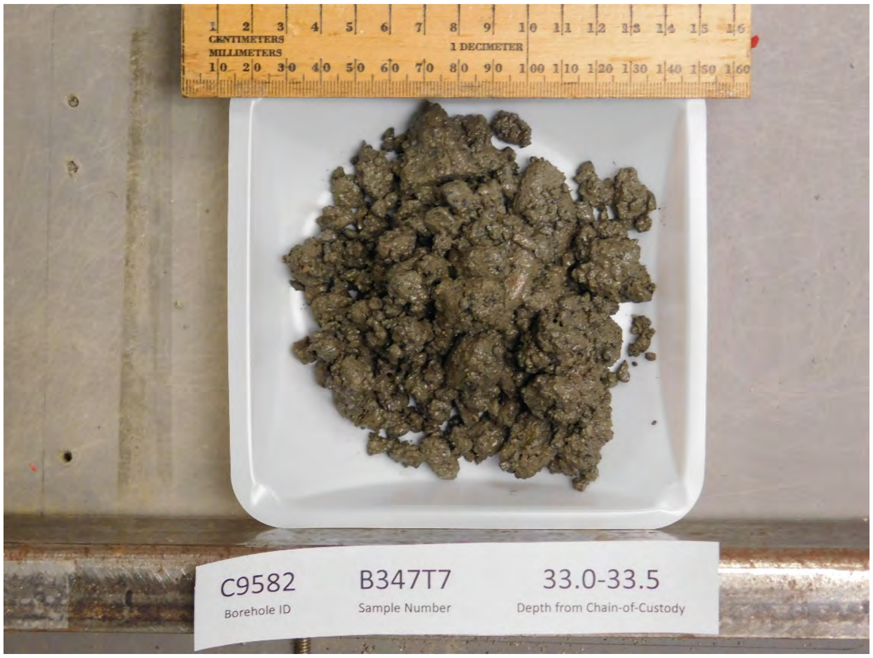

C9582
Borehole ID
B347P9
Sample Number
TOP
26.5-27.0
Depth from Chain-of-Custody


C9582
Borehole ID
B347R6
Sample Number
28.5-29.0
Depth from Chain-of-Custody


CENTIMETERS
MILLIMETERS
1 DECIMETER
TOP
C9582
Borehole ID
B347R5
Sample Number
29.0-29.5
Depth from Chain-of-Custody


CENTIMETERS
MILLIMETERS
1 DECIMETER
C9582
Borehole ID
B347R7
Sample Number
29.5-30.0
Depth from Chain-of-Custody


CENTIMETERS
MILLIMETERS
1 DECIMETER
TOP
C9582
Borehole ID
B347T9
Sample Number
32.5-33.0
Depth from Chain-of-Custody


CENTIMETERS
MILLIMETERS
1 DECIMETER
C9582
Borehole ID
B347T7
Sample Number
33.0-33.5
Depth from Chain-of-Custody


CENTIMETERS
MILLIMETERS
1 DECIMETER
TOP
C9582
Borehole ID
B347T6
Sample Number
33.5-34.0
Depth from Chain-of-Custody

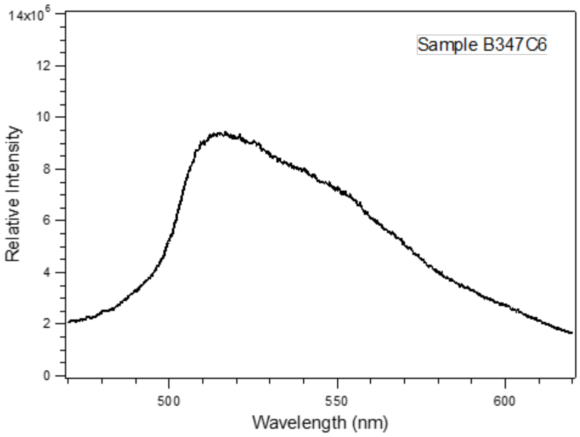

CENTIMETERS
MILLIMETERS
1 DECIMETER
~~TOP~~ bottom
C9582
Borehole ID
B347T6
Sample Number
33.5-34.0
Depth from Chain-of-Custody

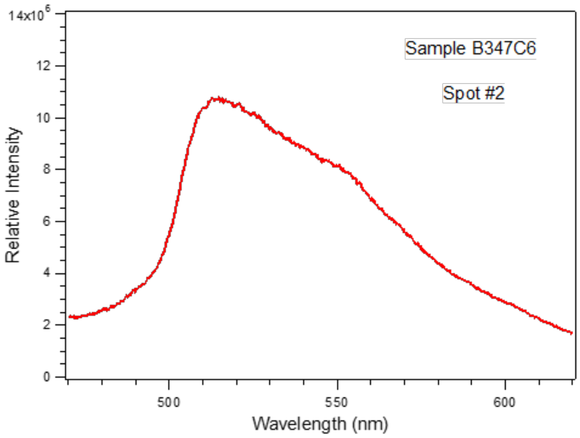

CENTIMETERS
MILLIMETERS
1 DECIMETER
C9582
Borehole ID
B347T5
Sample Number
TOP
34.0-34.5
Depth from Chain-of-Custody

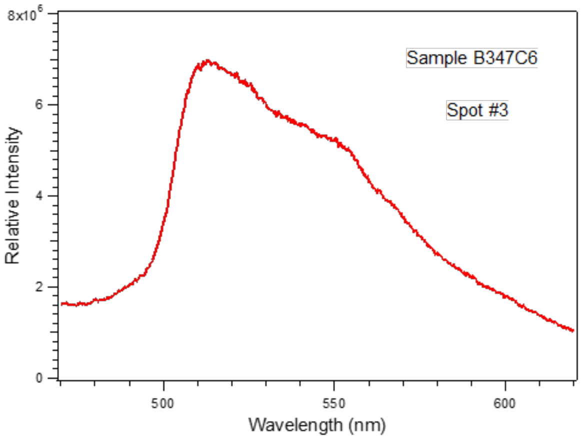
Appendix C

Cryogenic U(VI) Laser Fluorescence Spectroscopy

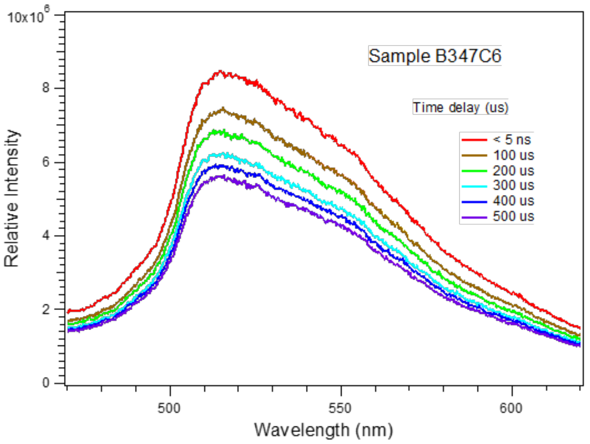
Sample B347C6 – Steady-state spectra (λ_{em}= 415 nm):

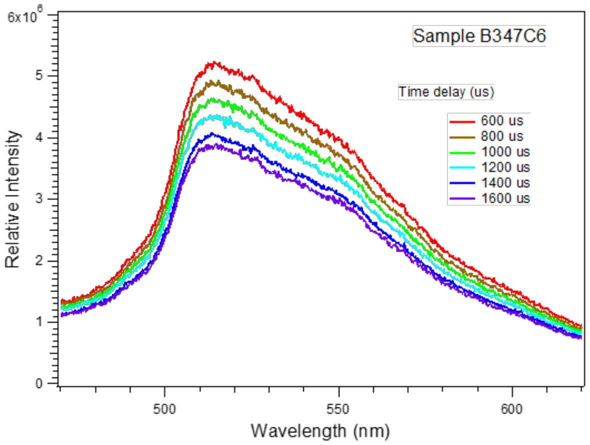


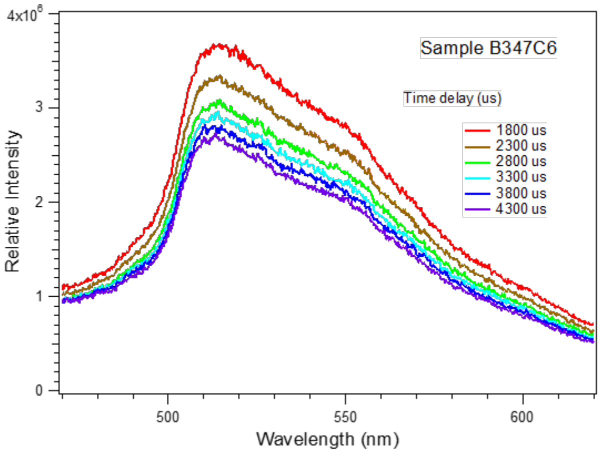




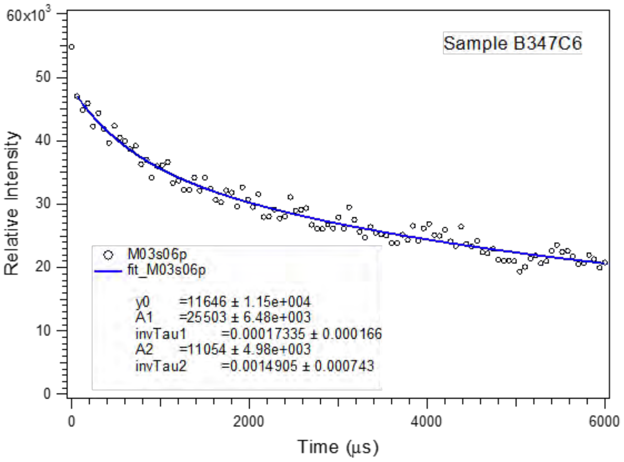
Sample B347C6 – Time-resolved spectra (λ_{em}= 415 nm):



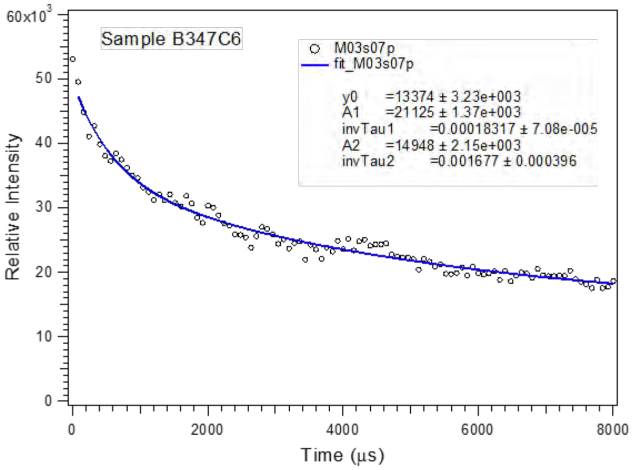




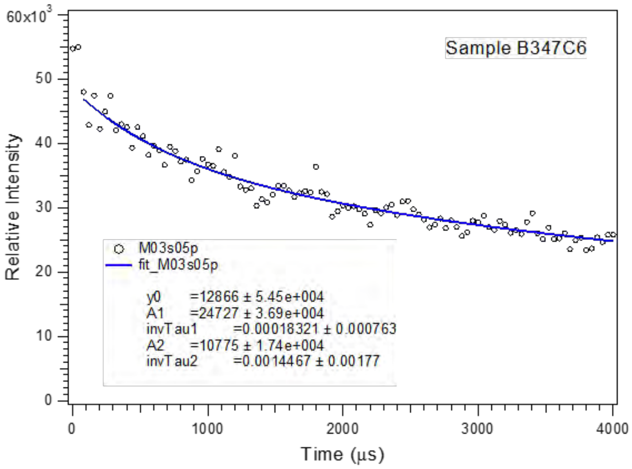
Sample B347C6 – Fluorescence decay curves (λ_{em}= 415 nm):



y0 =11646 ± 1.15e+004
A1 =25503 ± 6.48e+003
invTau1 =0.00017335 ± 0.000166
A2 =11054 ± 4.98e+003
invTau2 =0.0014905 ± 0.000743



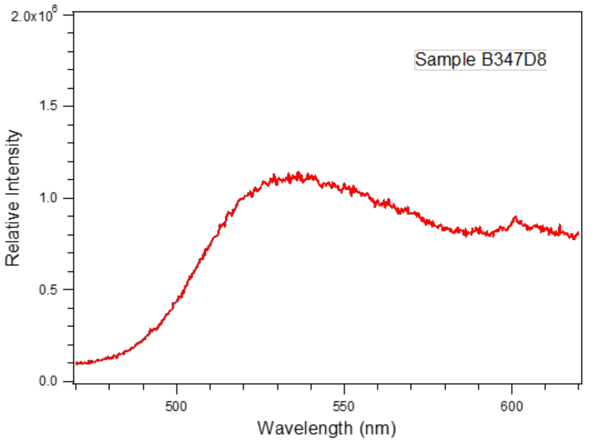
y0 =13374 ± 3.23e+003
A1 =21125 ± 1.37e+003
invTau1 =0.00018317 ± 7.08e-005
A2 =14948 ± 2.15e+003
invTau2 =0.001677 ± 0.000396

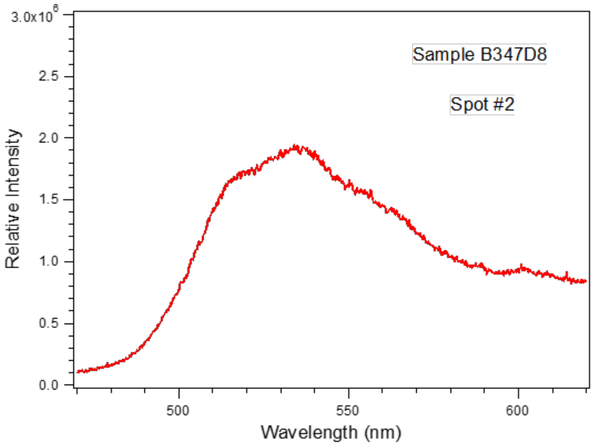


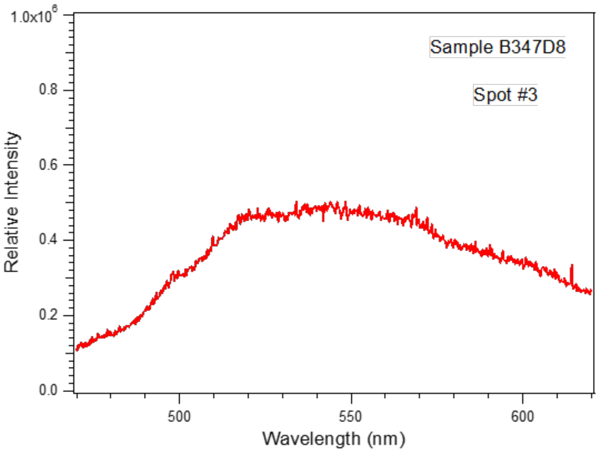
y0 =12866 ± 5.45e+004
A1 =24727 ± 3.69e+004
invTau1 =0.00018321 ± 0.000763
A2 =10775 ± 1.74e+004
invTau2 =0.0014467 ± 0.00177

C.3

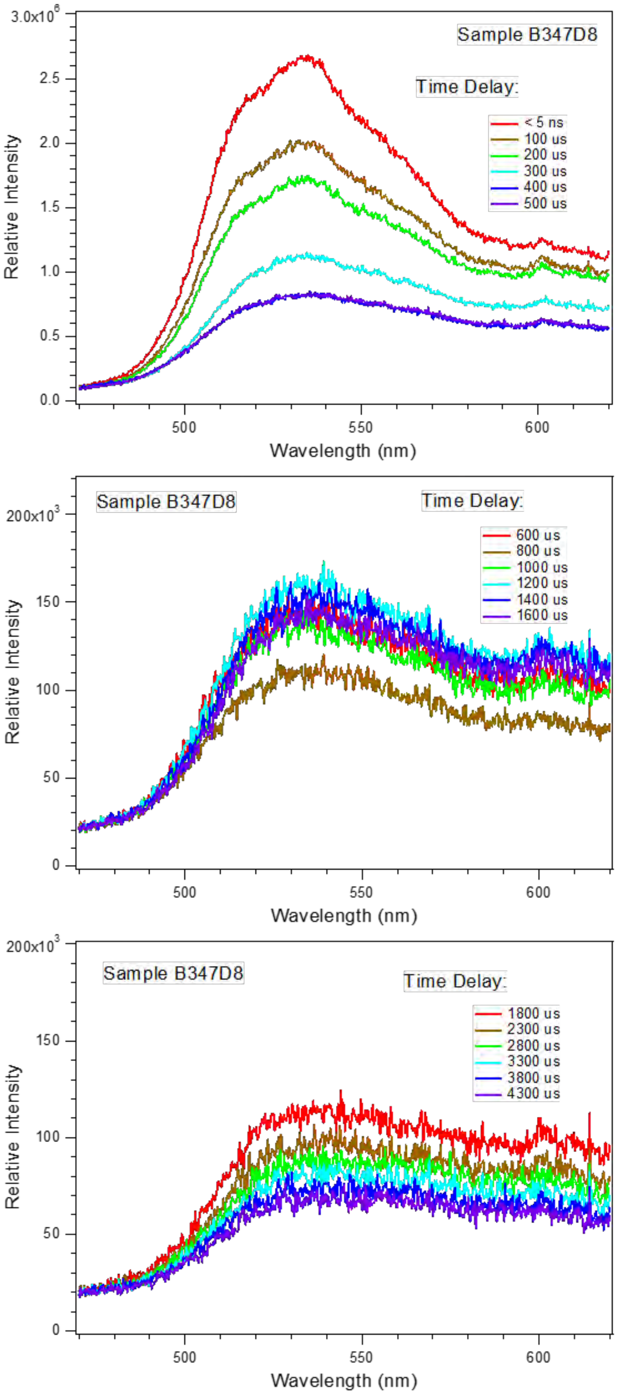
Sample B347D8 – Steady-state spectra (λ_{em}= 415 nm):



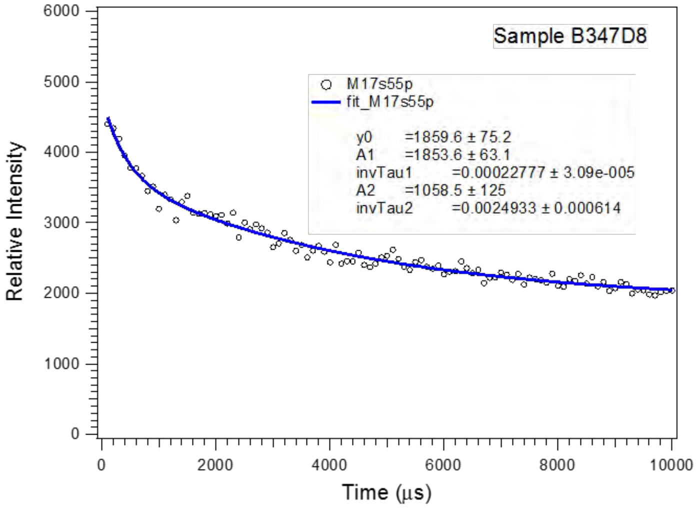


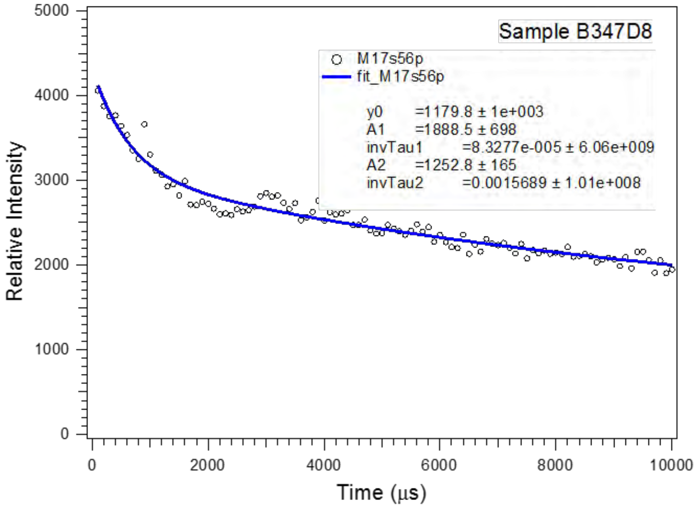


Sample B347D8 – Time-resolved spectra (λ_{em}= 415 nm):

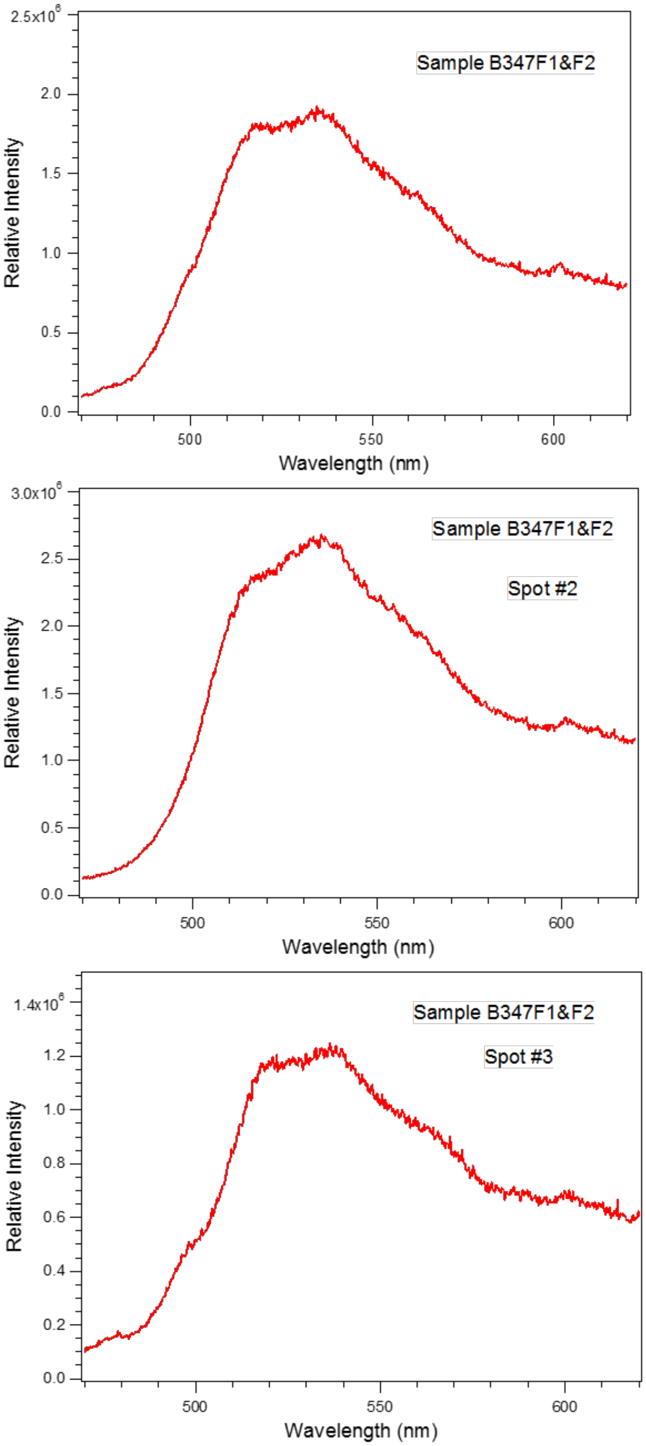


Sample B347D8 – Fluorescence decay curves (λ_{em}= 415 nm):

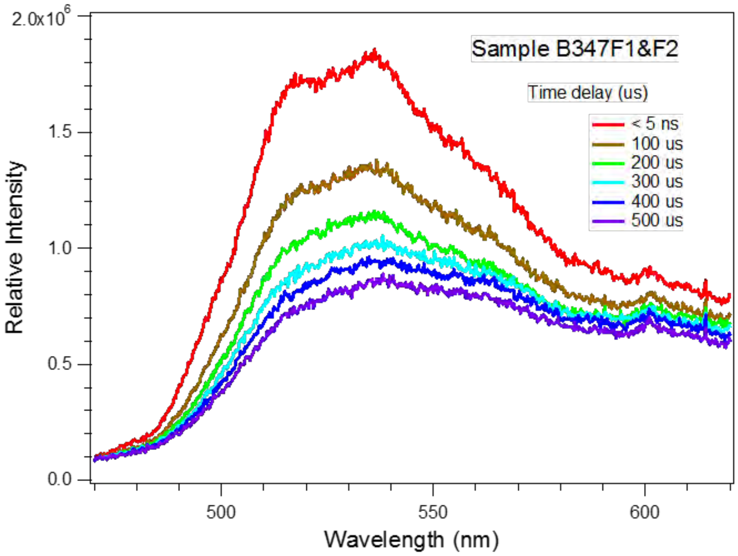




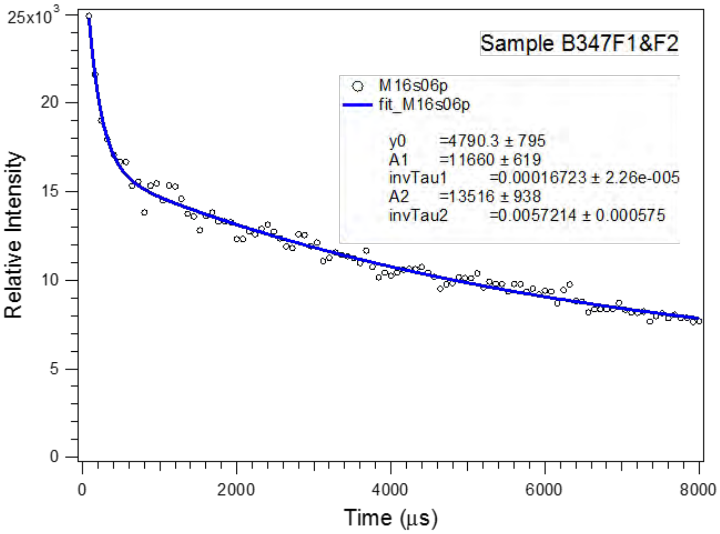
Sample B347F1 and F3 – Steady-state spectra (λ_{em}= 415 nm):

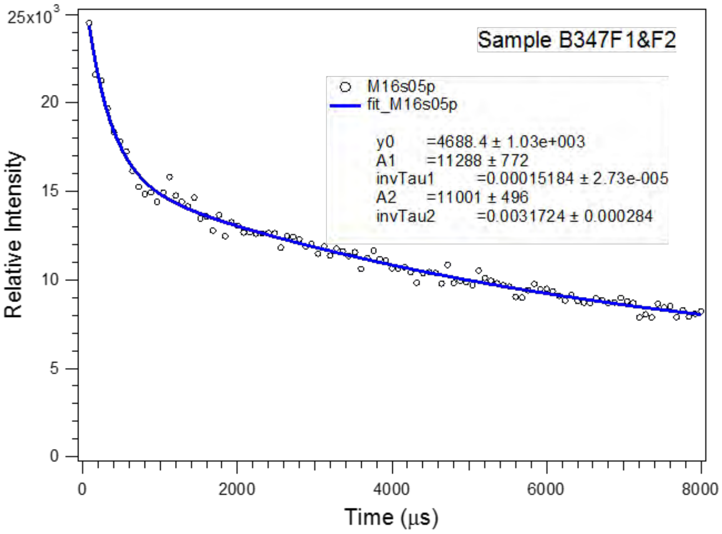


Sample B347F1 and F3 – Time-resolved spectra (λ_{em}= 415 nm):

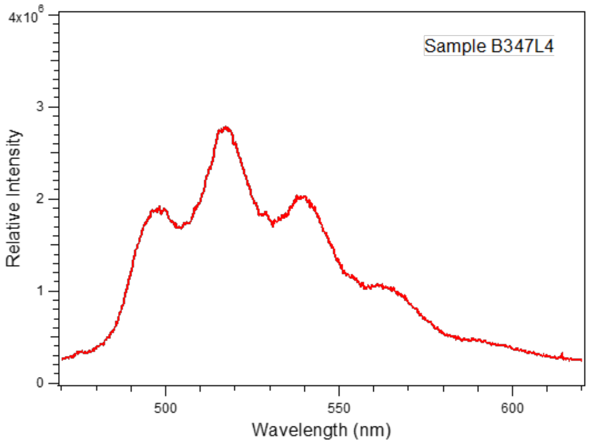


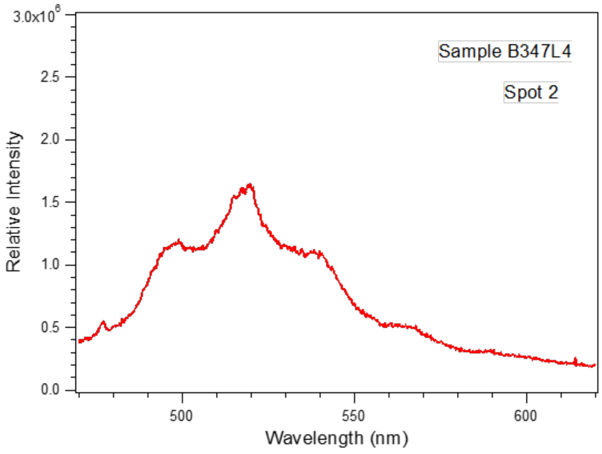
Sample B347F1 and F3 – Fluorescence decay curves (λ_{em}= 415 nm):

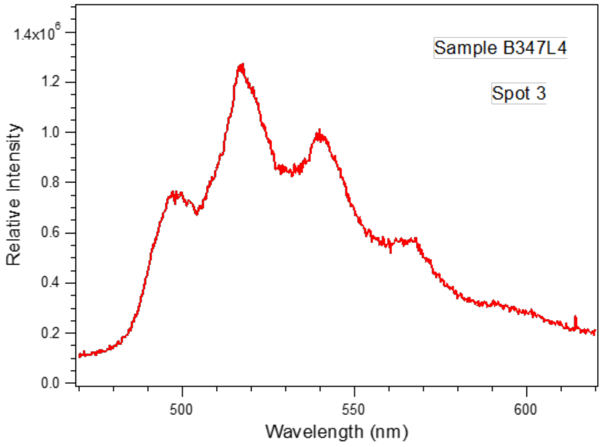




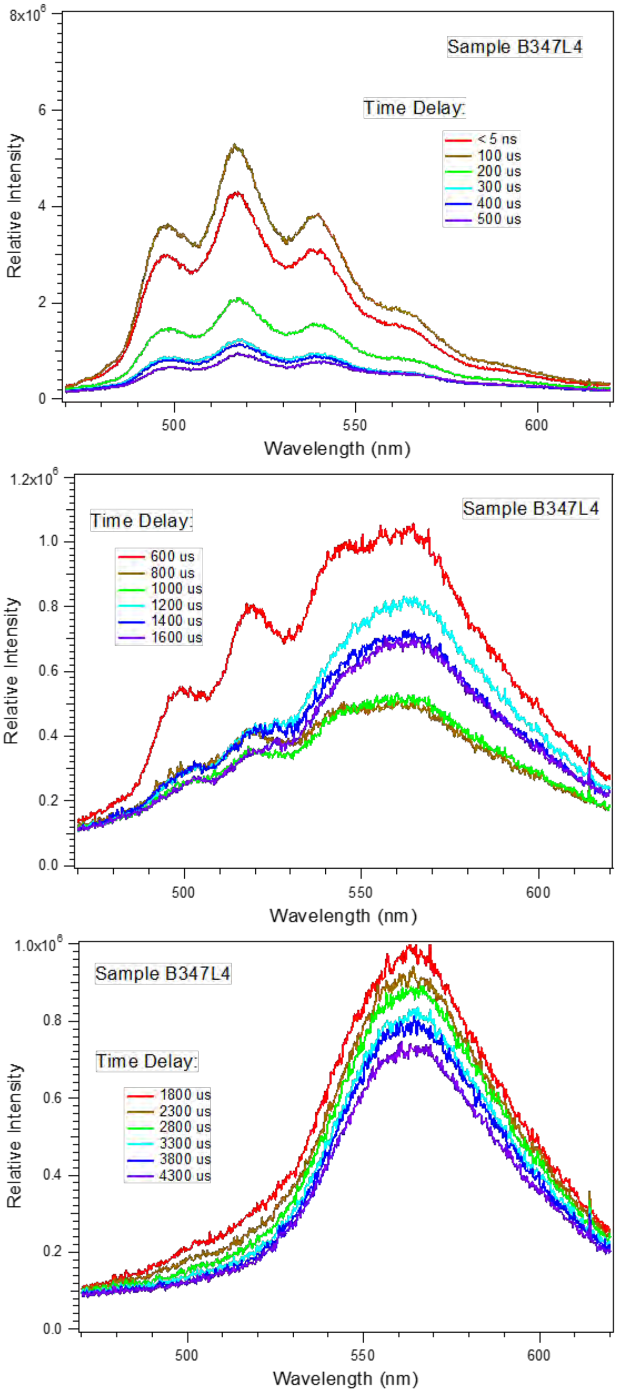
Sample B347L4 – Steady-state spectra (λ_{em}= 415 nm):



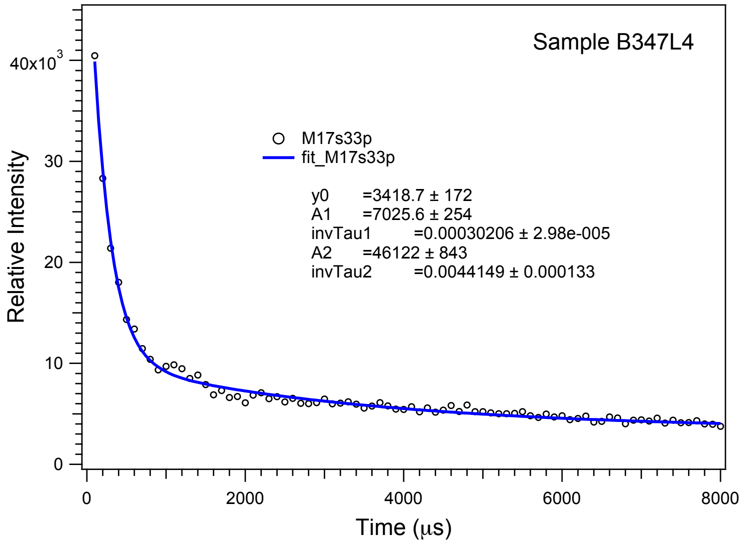


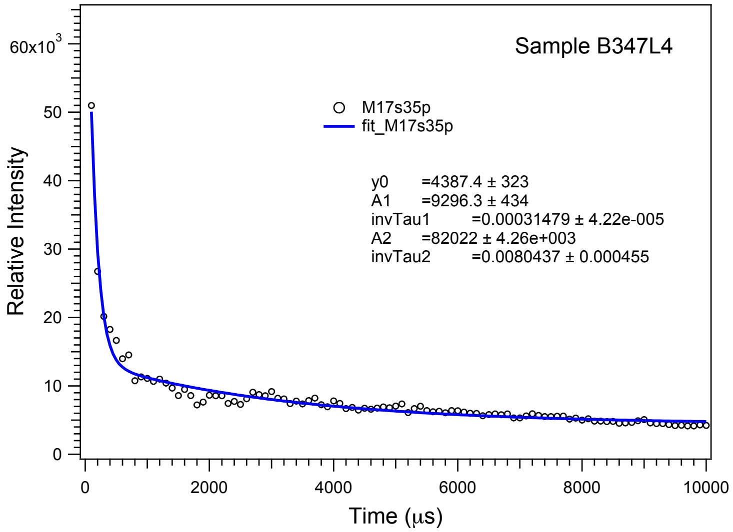


Sample B347L4 – Time-resolved spectra (λ_{em}= 415 nm):

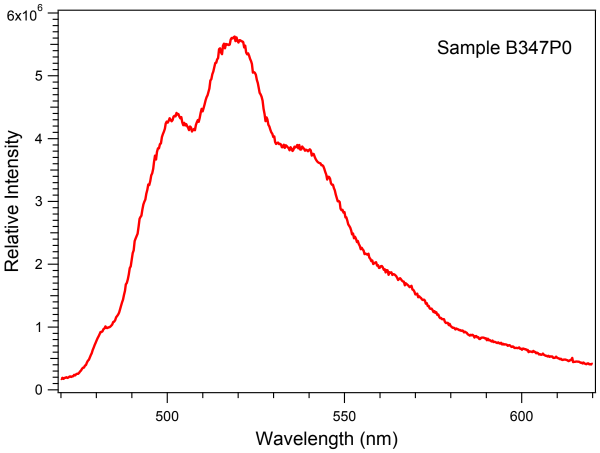


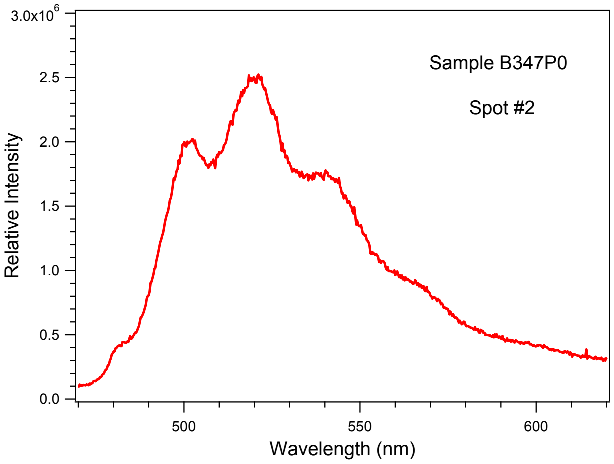
Sample B347L4 – Fluorescence decay curves (λ_{em}= 415 nm):

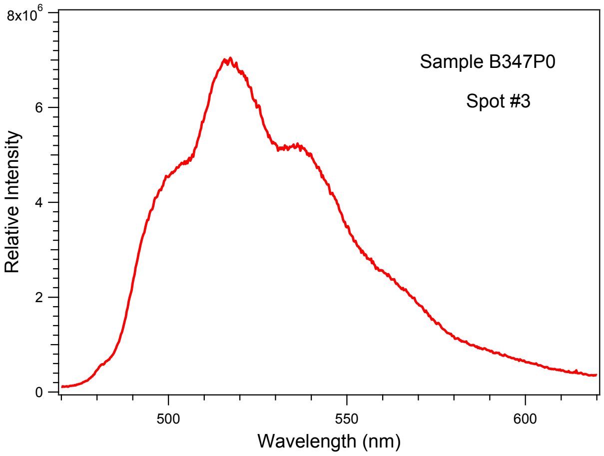




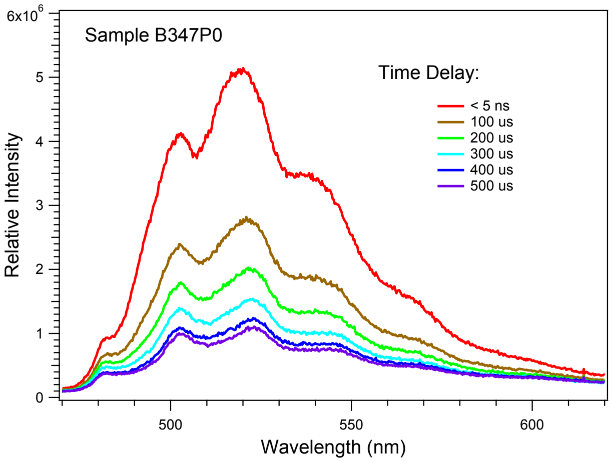
Sample B347P0 – Steady-state spectra (λ_{em}= 415 nm):

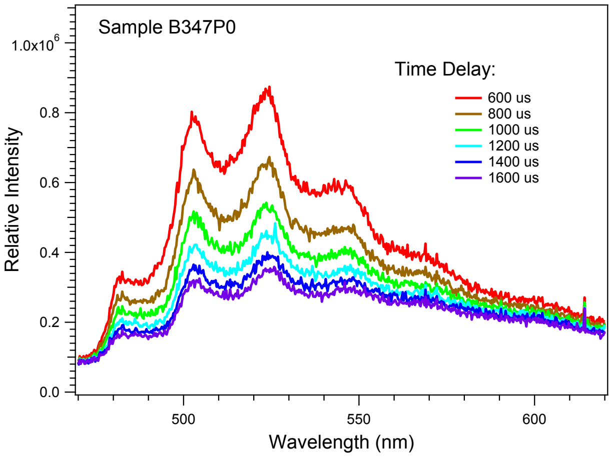


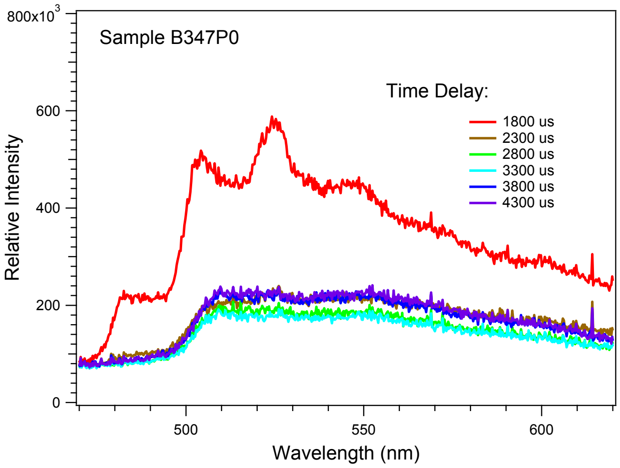




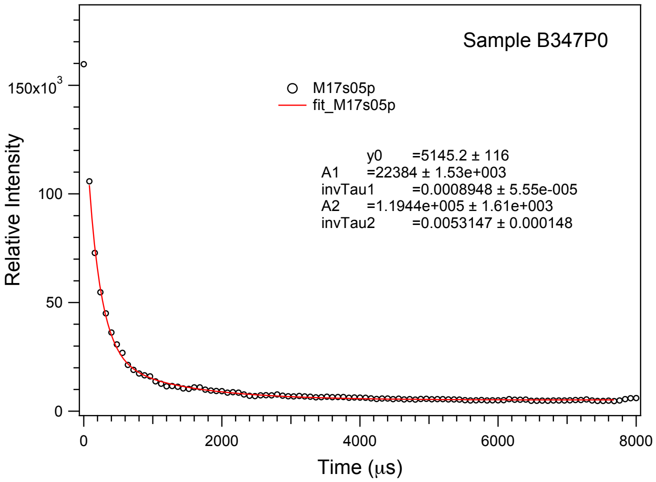
Sample B347P0 – Time-resolved spectra (λ_{em}= 415 nm):

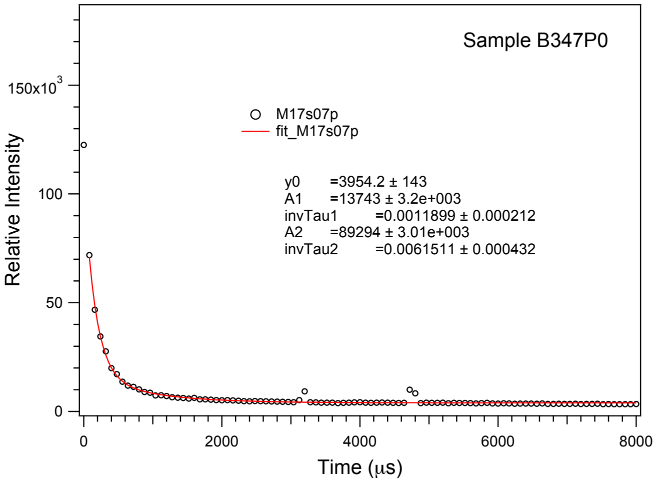




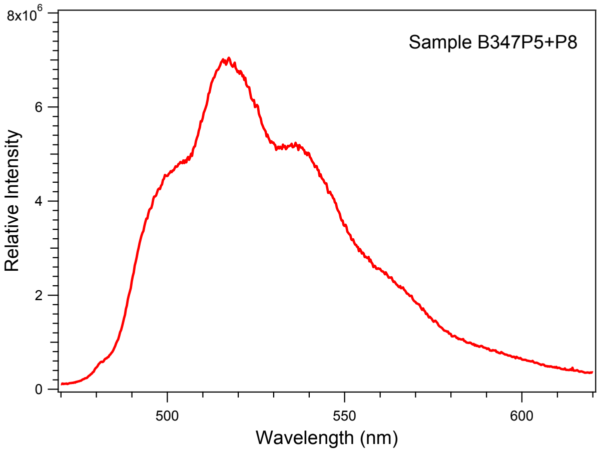


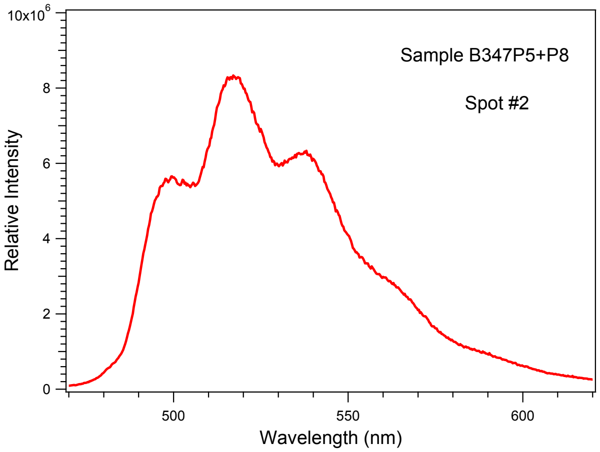
Sample B347P0 – Fluorescence decay curves (λ_{em}= 415 nm):

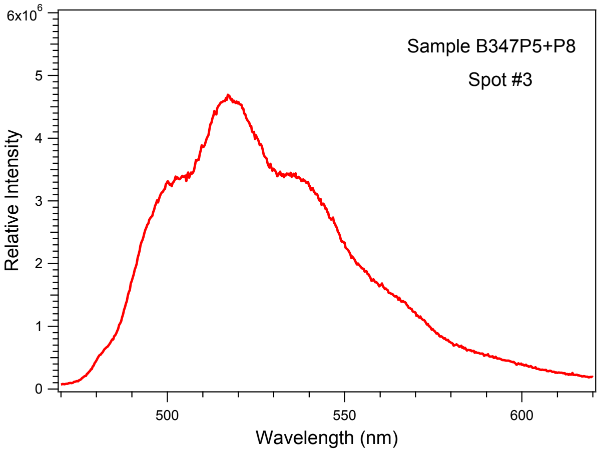




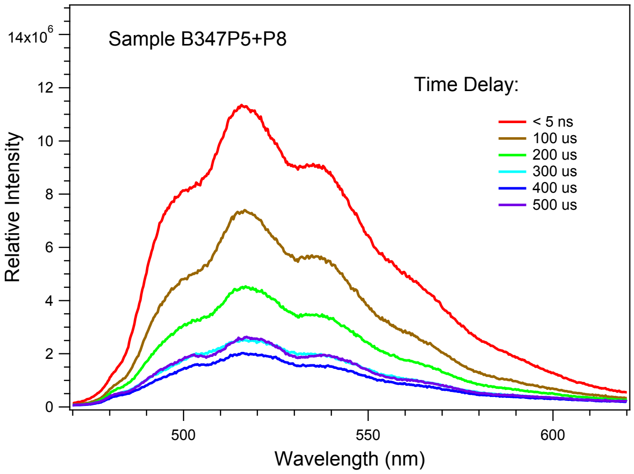
Sample B347P5 and P8 – Steady-state spectra (λ_{em}= 415 nm):

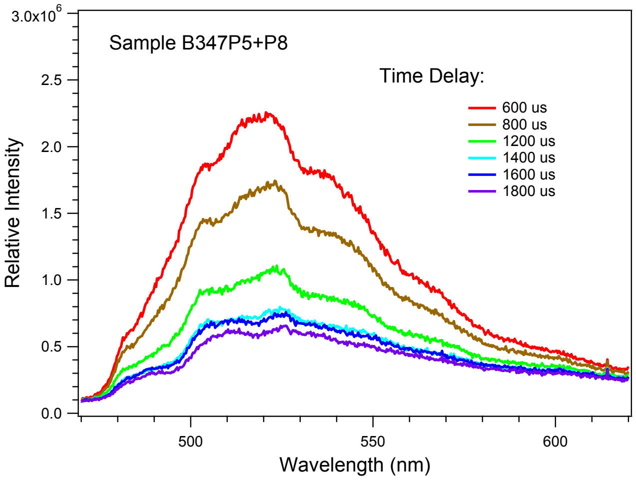


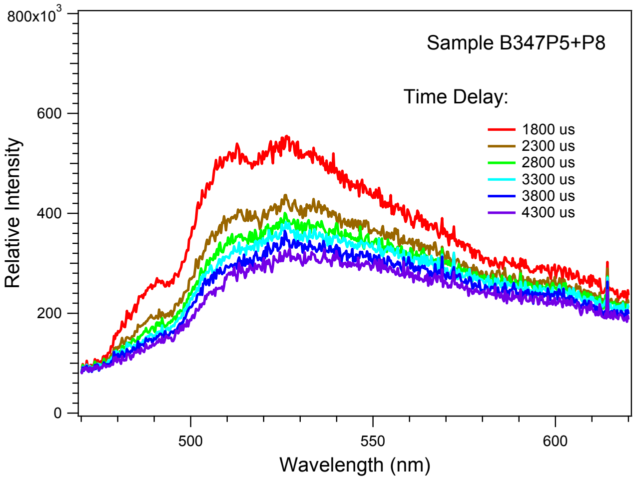




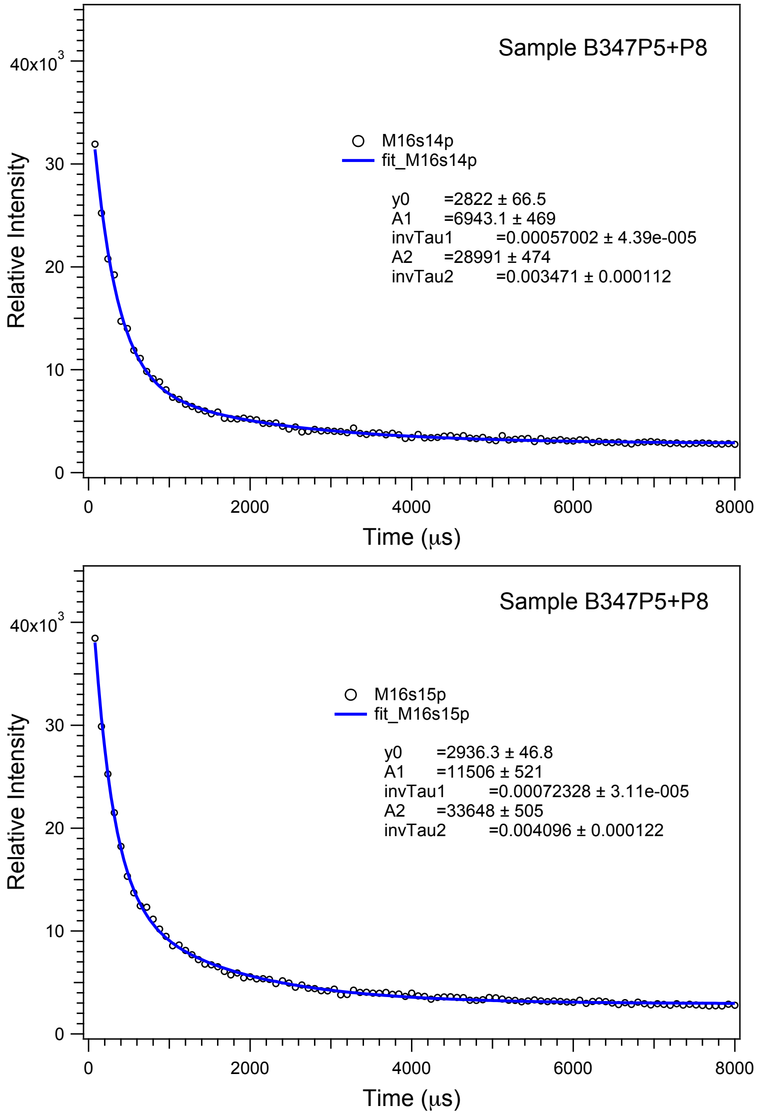
Sample B347P5 and P8 – Time-resolved spectra (λ_{em}= 415 nm):



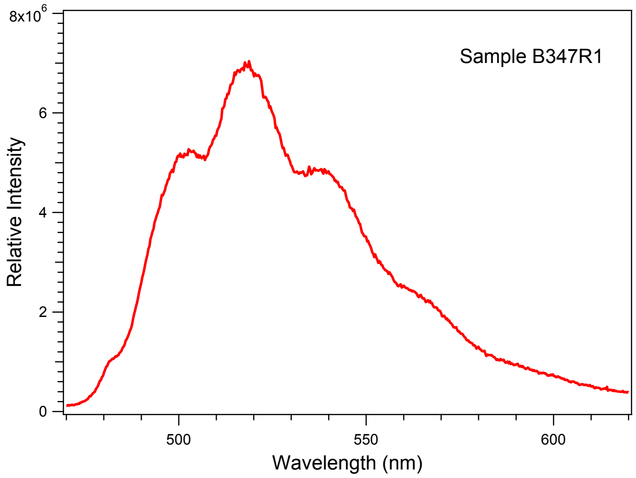


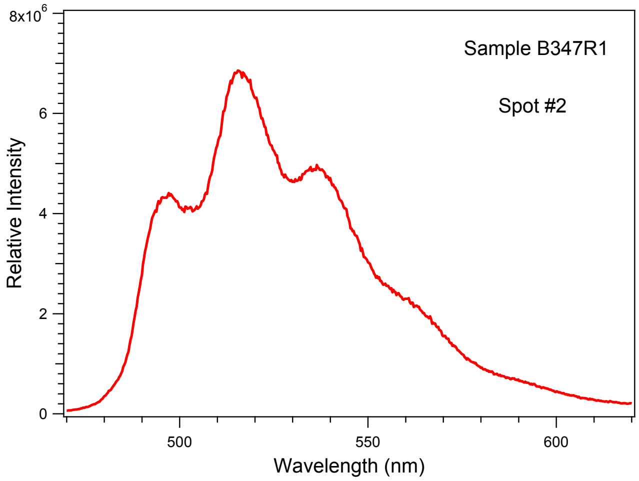


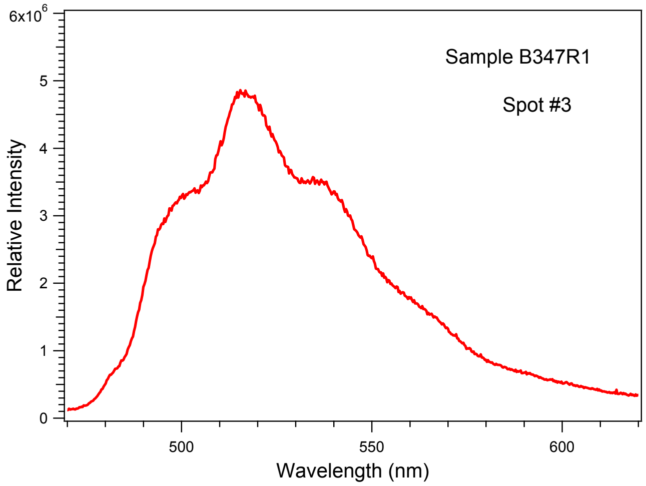
Sample B347P5 and P8 – Fluorescence decay curves (λ_{em}= 415 nm):



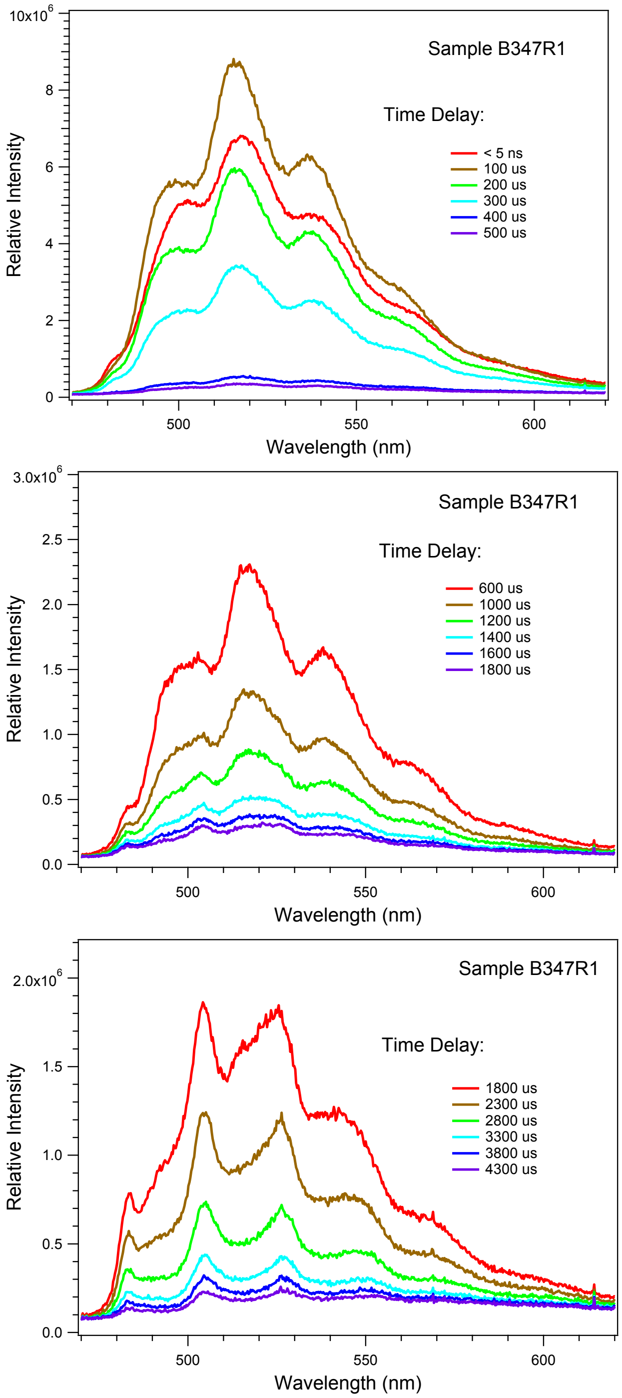
Sample B347R1 – Steady-state spectra (λ_{em}= 415 nm):





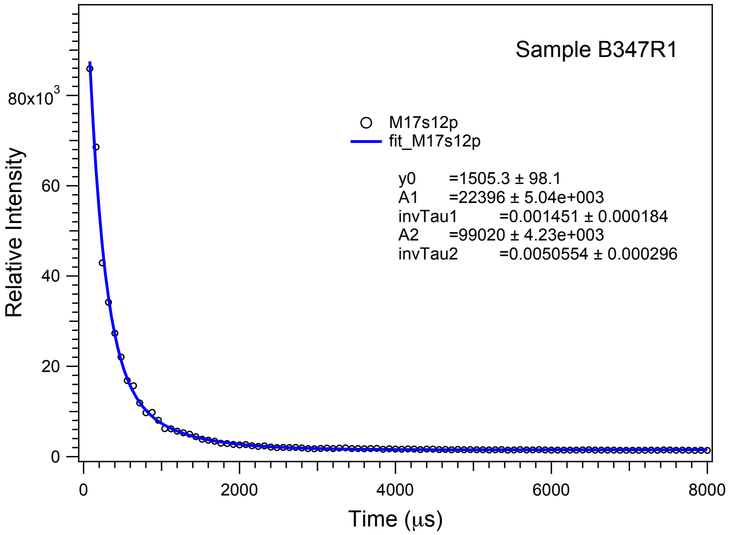


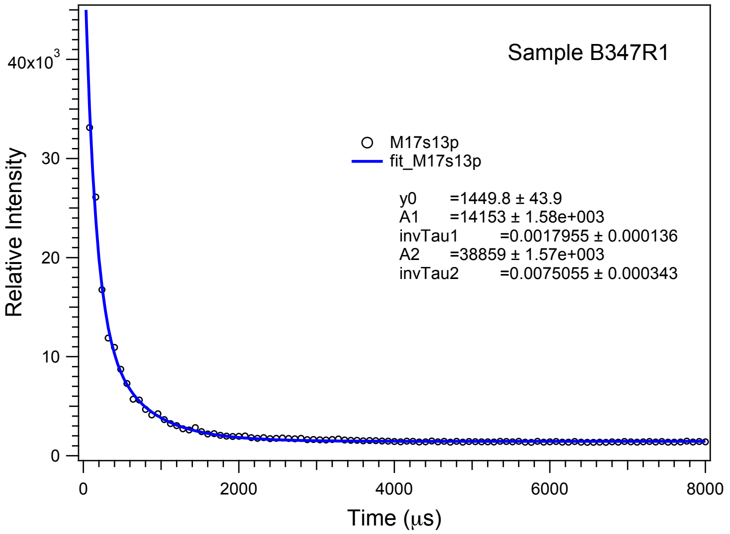
Sample B347R1 – Time-resolved spectra (λ_{em}= 415 nm):



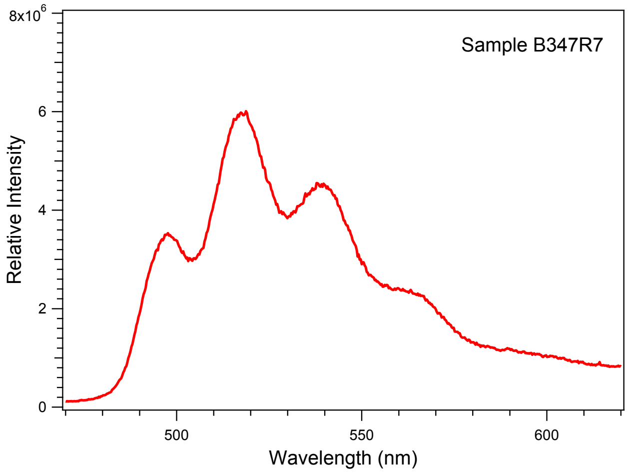
C.20

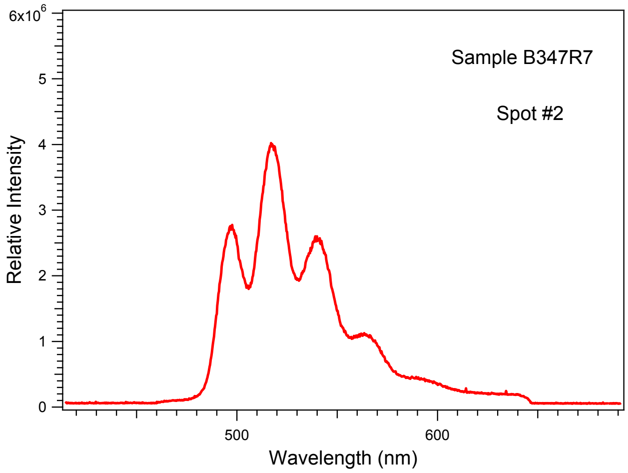
Sample B347R1 – Fluorescence decay curves (λ_{em}= 415 nm):

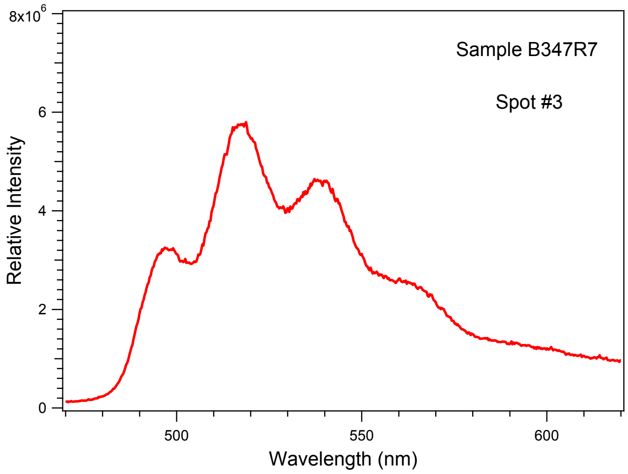




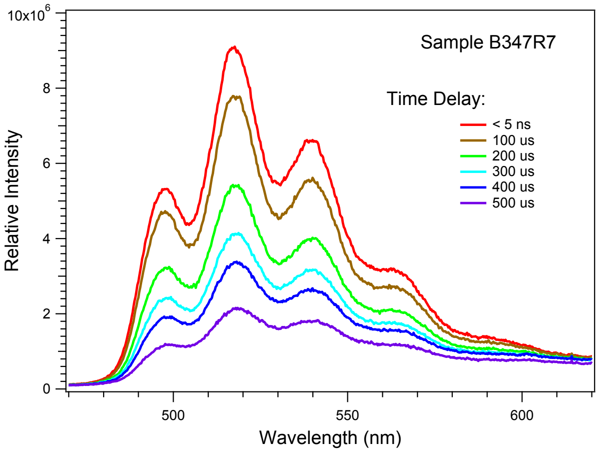
Sample B347R7 – Steady-state spectra (λ_{em}= 415 nm):

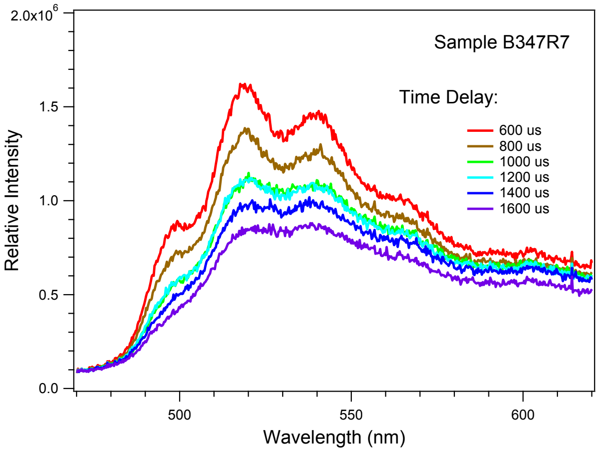


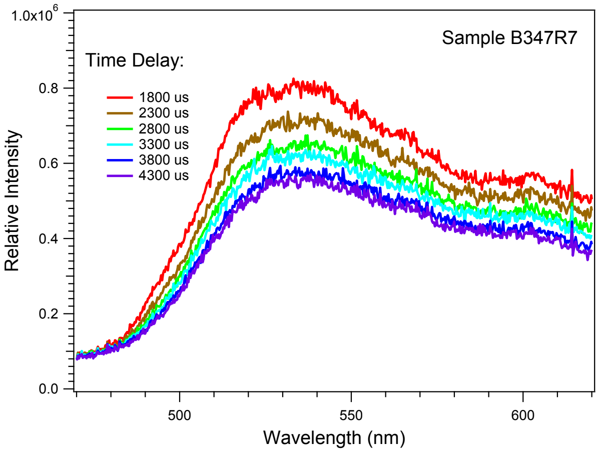




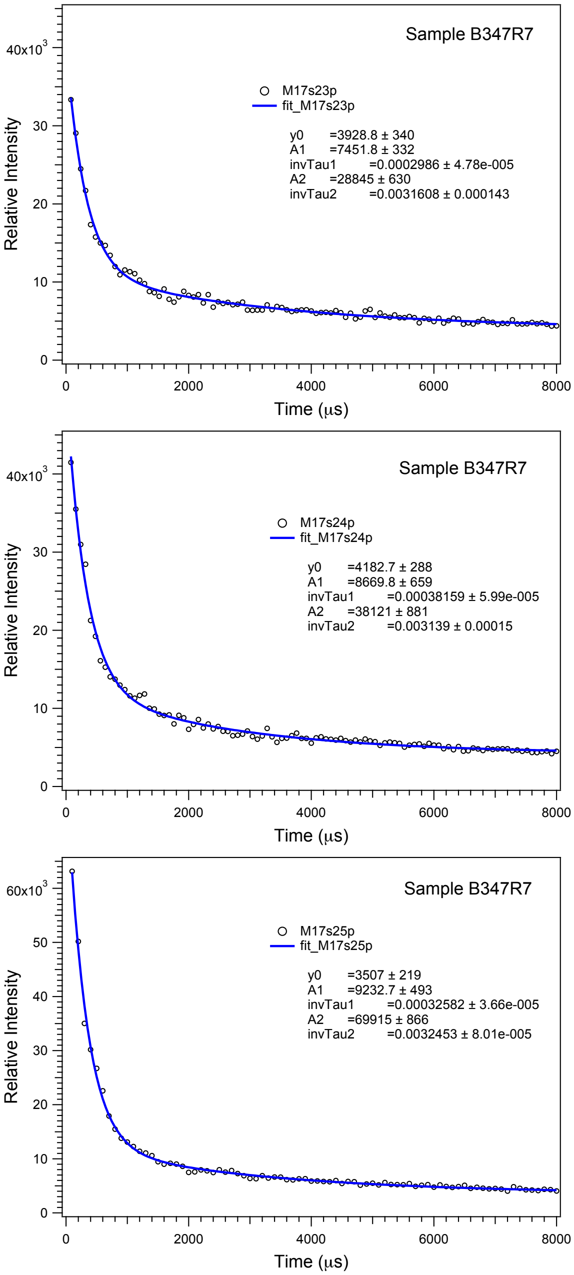
Sample B347R7 – Time-resolved spectra (λ_{em}= 415 nm):



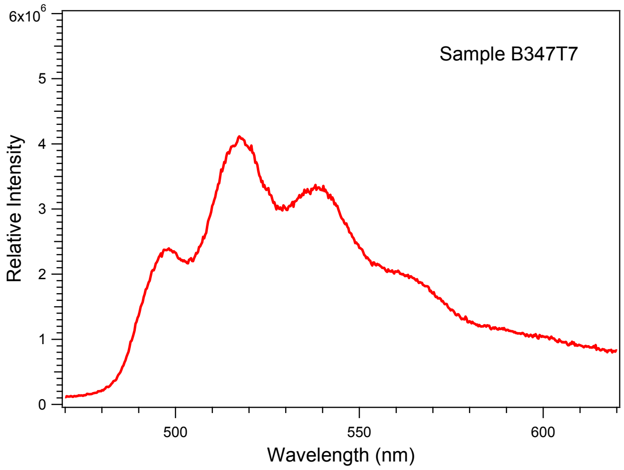


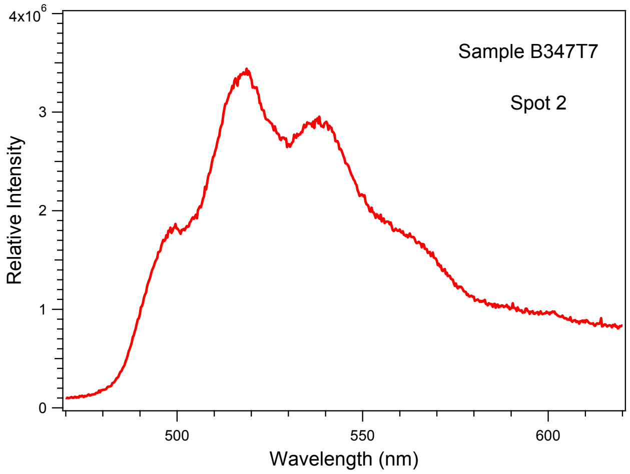


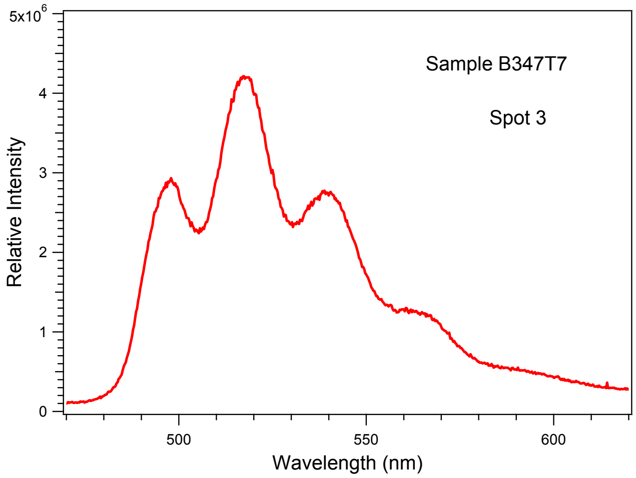
Sample B347R7 – Fluorescence decay curves (λ_{em}= 415 nm):



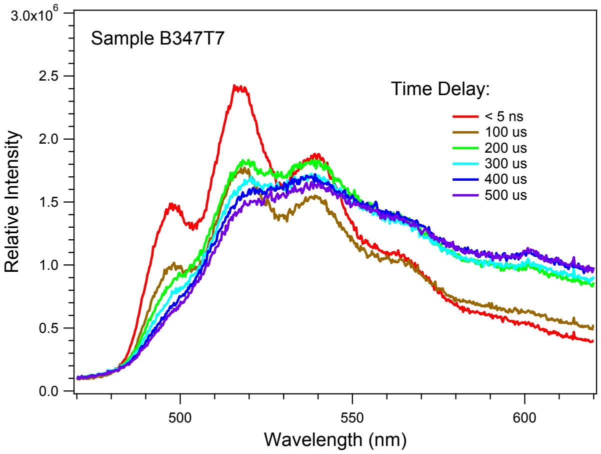
Sample B347T7 – Steady-state spectra (λ_{em}= 415 nm):

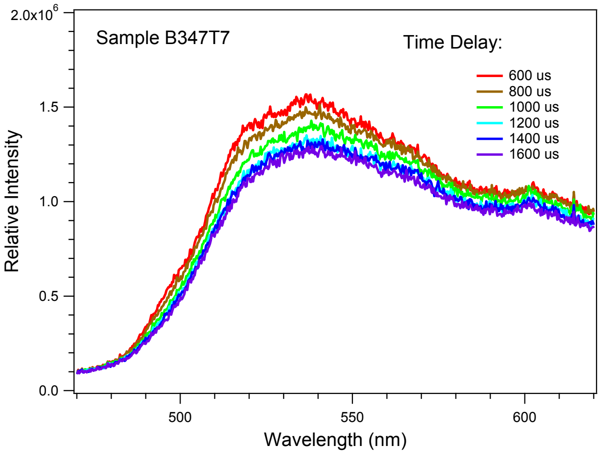


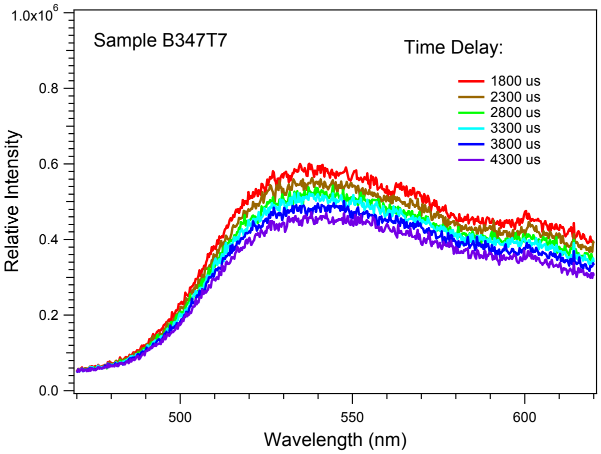




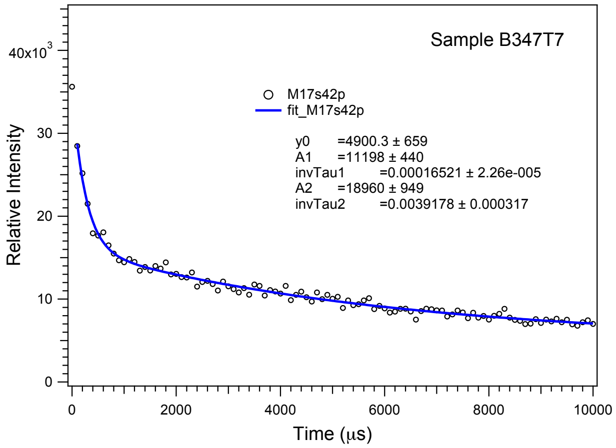
Sample B347T7 – Time-resolved spectra (λ_{em}= 415 nm):

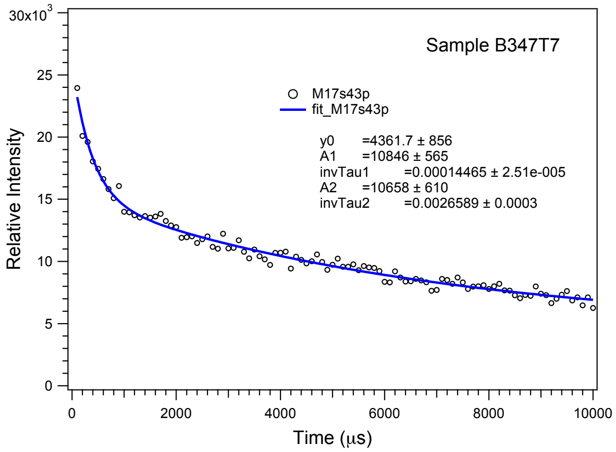


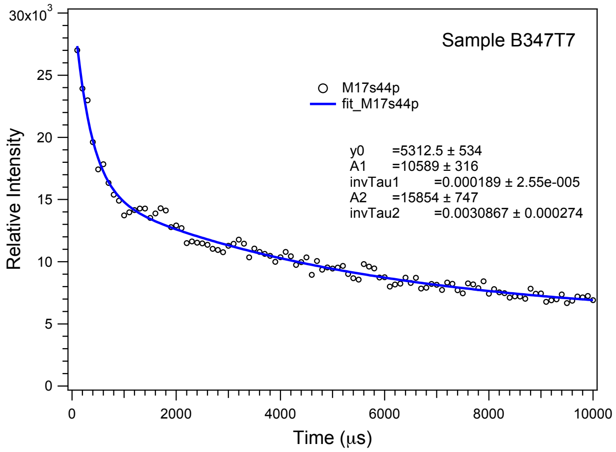




Sample B347T7 – Fluorescence decay curves (λ_{em}= 415 nm):







C.27

Table C.1. Sediment U(VI) fluorescence characteristics.

Sample ID		Spectral Positions (nm)			Lifetimes (ms)		
B347C6	Spot #1	512.2			5.57	±	0.18
					0.65	±	0.05
	Spot #2	514.6					
	Spot #3	512.7					
B347D8	Spot #1	536.2			8.04	±	6.31
					0.52	±	0.17
	Spot #2	534.8					
	Spot #3	534.0					
B347F1+F3	Spot #1	515.7(sh)	534.8		6.28	±	0.42
					0.25	±	0.10
	Spot #2	517.1	534.8				
	Spot #3	518.2	536.4				
B347L4	Spot #1	498.2	517.4	540	3.24	±	0.10
					0.18	±	0.07
	Spot #2	497.4	519.5	538.3			
	Spot #3	497.1	517.6	540			
B347P0	Spot #1	502.6	519	537.2	0.98	±	0.20
					0.18	±	0.02
	Spot #2	502.4	518.5	540.2			
	Spot #3	499.0 (sh)	517.4	536.2			
B347P5+P8	Spot #1	499.3 (sh)	517.1	536.2	1.57	±	0.26
					0.27	±	0.03
	Spot #2	499.3	517.1	538.1			
	Spot #3	500.1 (sh)	517.1	536.2			
B347R1	Spot #1	502.6	518.7	537.8	0.62	±	0.09
					0.17	±	0.05
	Spot #2	497.1	515.4	536.4			
	Spot #3	500.4(sh)	516.8	536.7			
B347R7	Spot #1	497.7	517.6	539.7	3.01	±	0.37
					0.31	±	0.01
	Spot #2	496.8	517.1	539.1			
	Spot #3	496.8	516.5	538.1			
B347T7	Spot #1	498.2	517.4	538.1	6.08	±	0.80
					0.32	±	0.06
	Spot #2	499.6	518.7	537.8			
	Spot #3	497.9	517.6	538.9			

Appendix D

Representative Scanning Electron Microscope/Energy Dispersive X-ray Spectroscopy and Electron Microprobe Results for Boreholes C9581 and C9582

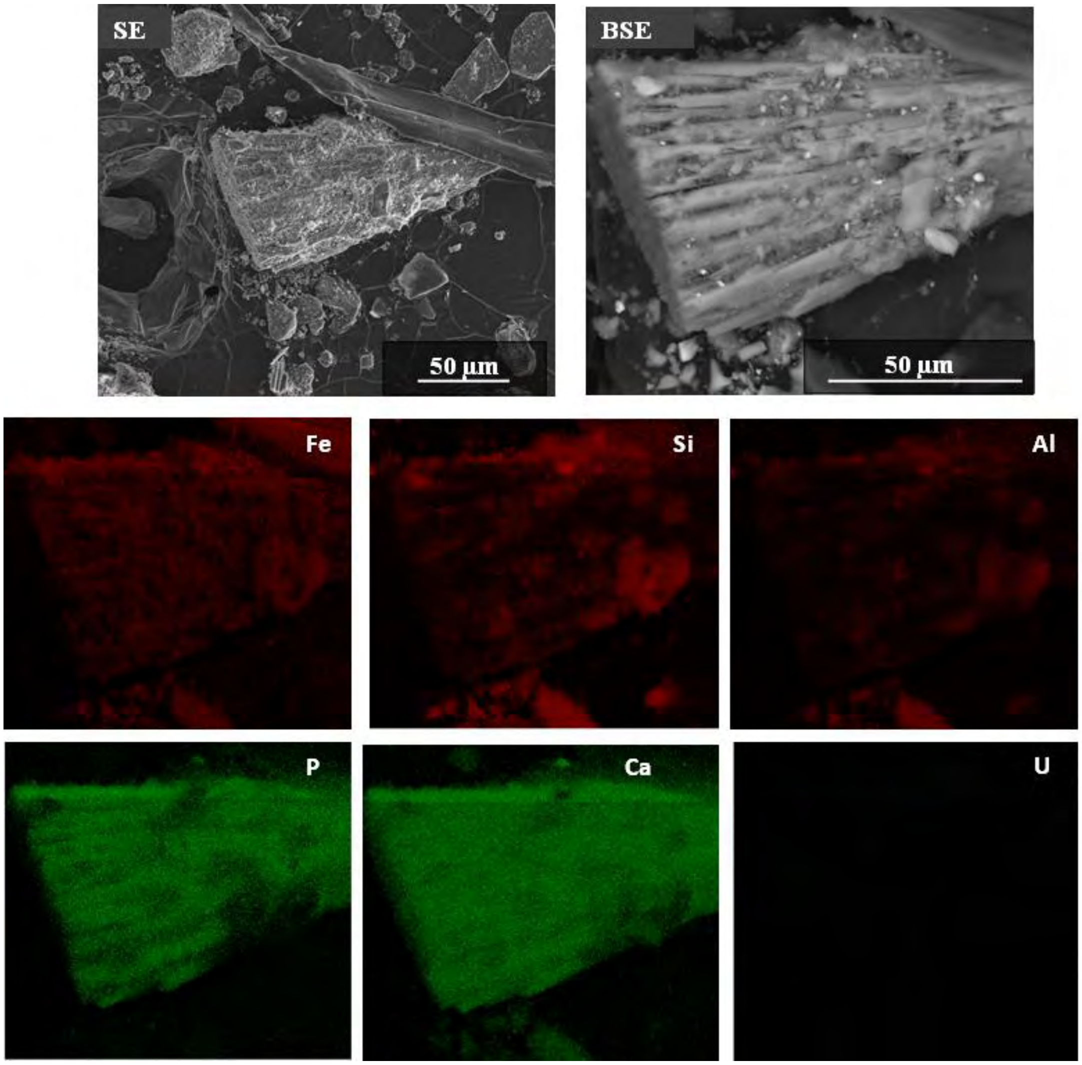
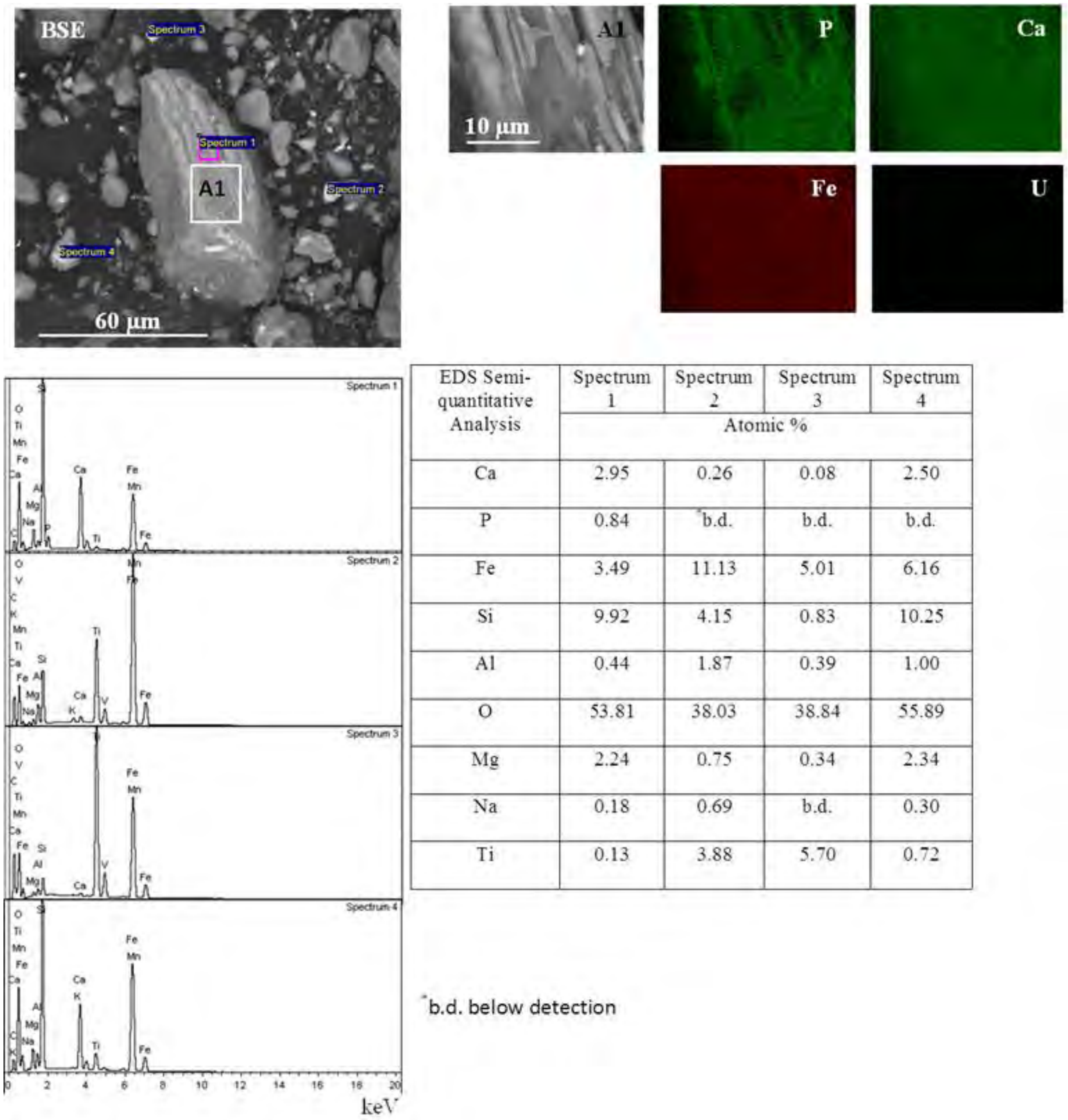


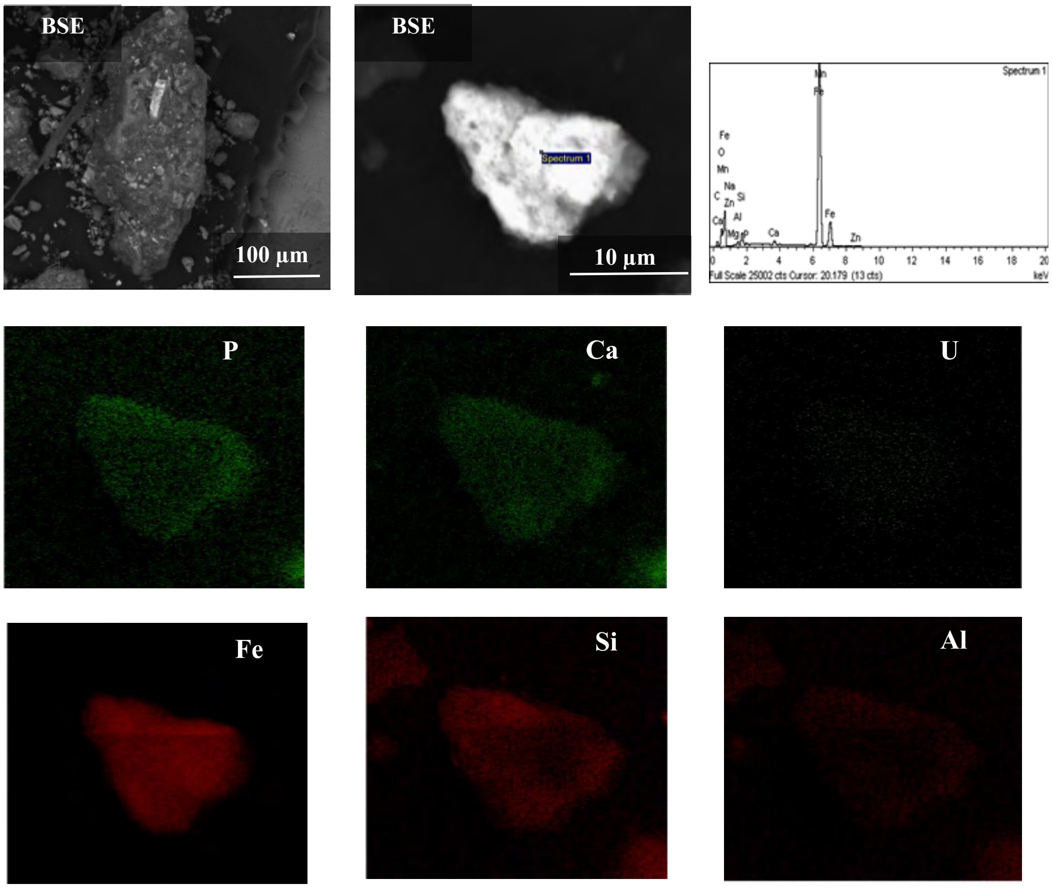
Figure D.1. Sample B347L4 (collected from borehole C9581, depth interval I-004, with at total uranium concentration of 4.3 mg/kg [ALS1601118, accessed via the Enterprise Application to IDMS]).



EDS Semi-quantitative Analysis	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4
	Atomic %			
Ca	2.95	0.26	0.08	2.50
P	0.84	*b.d.	b.d.	b.d.
Fe	3.49	11.13	5.01	6.16
Si	9.92	4.15	0.83	10.25
Al	0.44	1.87	0.39	1.00
O	53.81	38.03	38.84	55.89
Mg	2.24	0.75	0.34	2.34
Na	0.18	0.69	b.d.	0.30
Ti	0.13	3.88	5.70	0.72

*b.d. below detection

Figure D.2. Sample B347P0 (collected from borehole C9582, depth interval I-001, with at total uranium concentration of 71 mg/kg [ALS1601118, accessed via the Enterprise Application to IDMS]).



EDS Semi-quantitative Analysis	Ca	P	Fe	Si	Al
	Atomic %				
(Spectrum 1)	0.42	0.35	31.45	3.05	1.16

Figure D.3. Sample B347P5&8 (collected from borehole C9582, depth interval I-002, with at total uranium concentration of 100 mg/kg [ALS1601118, accessed via the Enterprise Application to IDMS]).

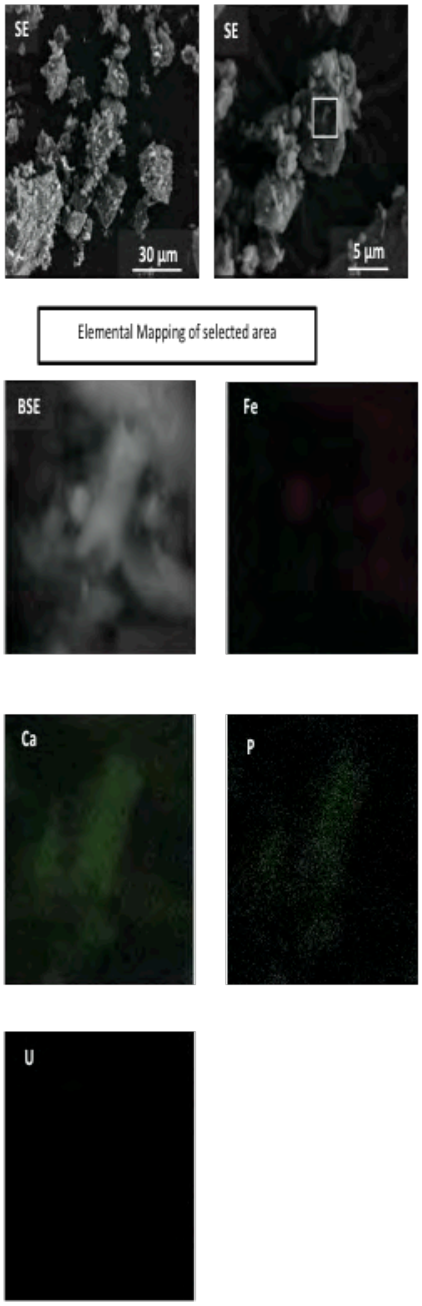


Figure D.4. Sample B347R1 (collected from borehole C9582, depth interval I-003, with at total uranium concentration of 31 mg/kg [ALS1601118, accessed via the Enterprise Application to IDMS]).

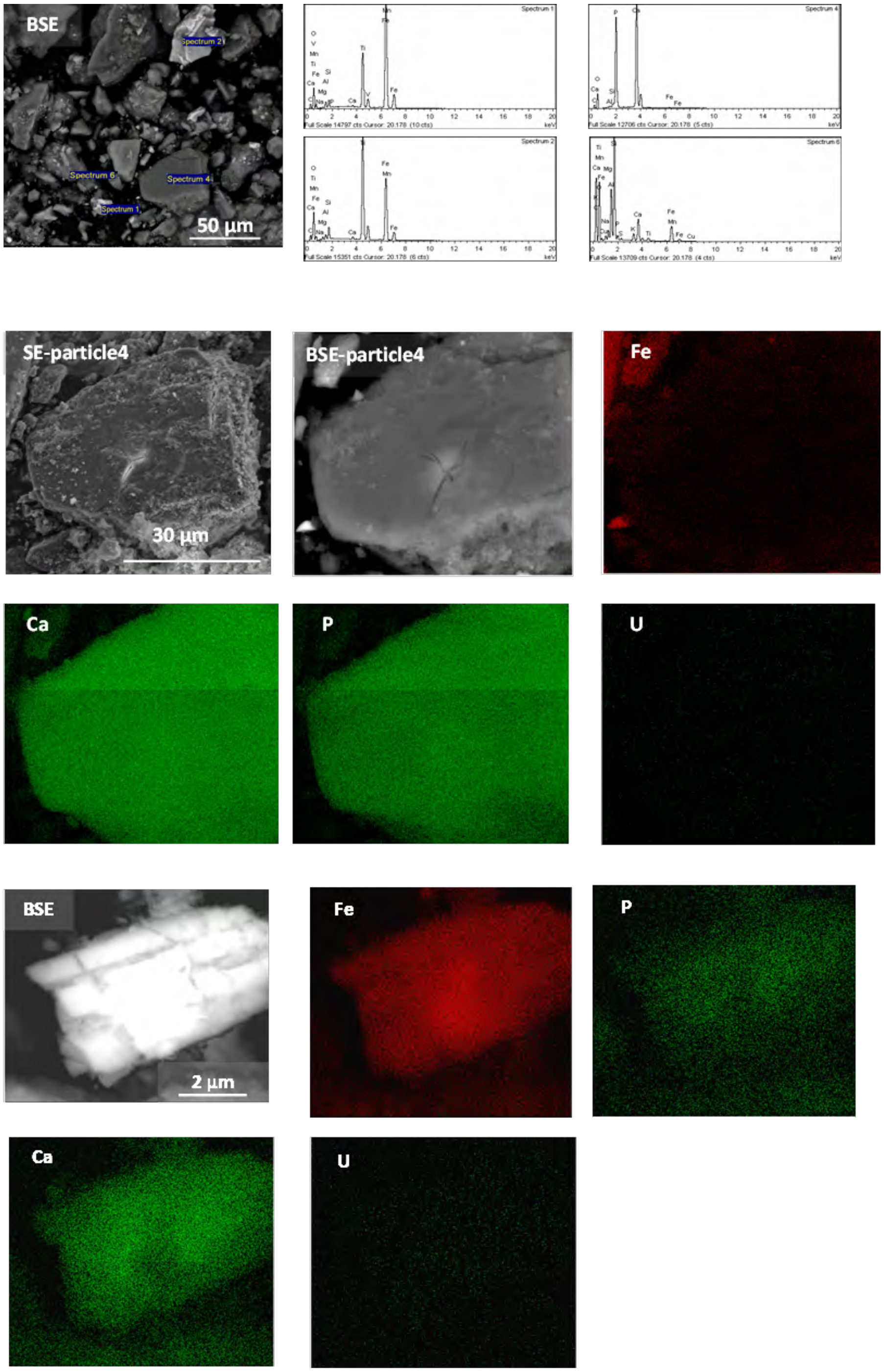


Figure D.5. Sample B347R7 (collected from borehole C9582, depth interval I-004, with at total uranium concentration of 31 mg/kg [ALS1601118, accessed via the Enterprise Application to IDMS]).

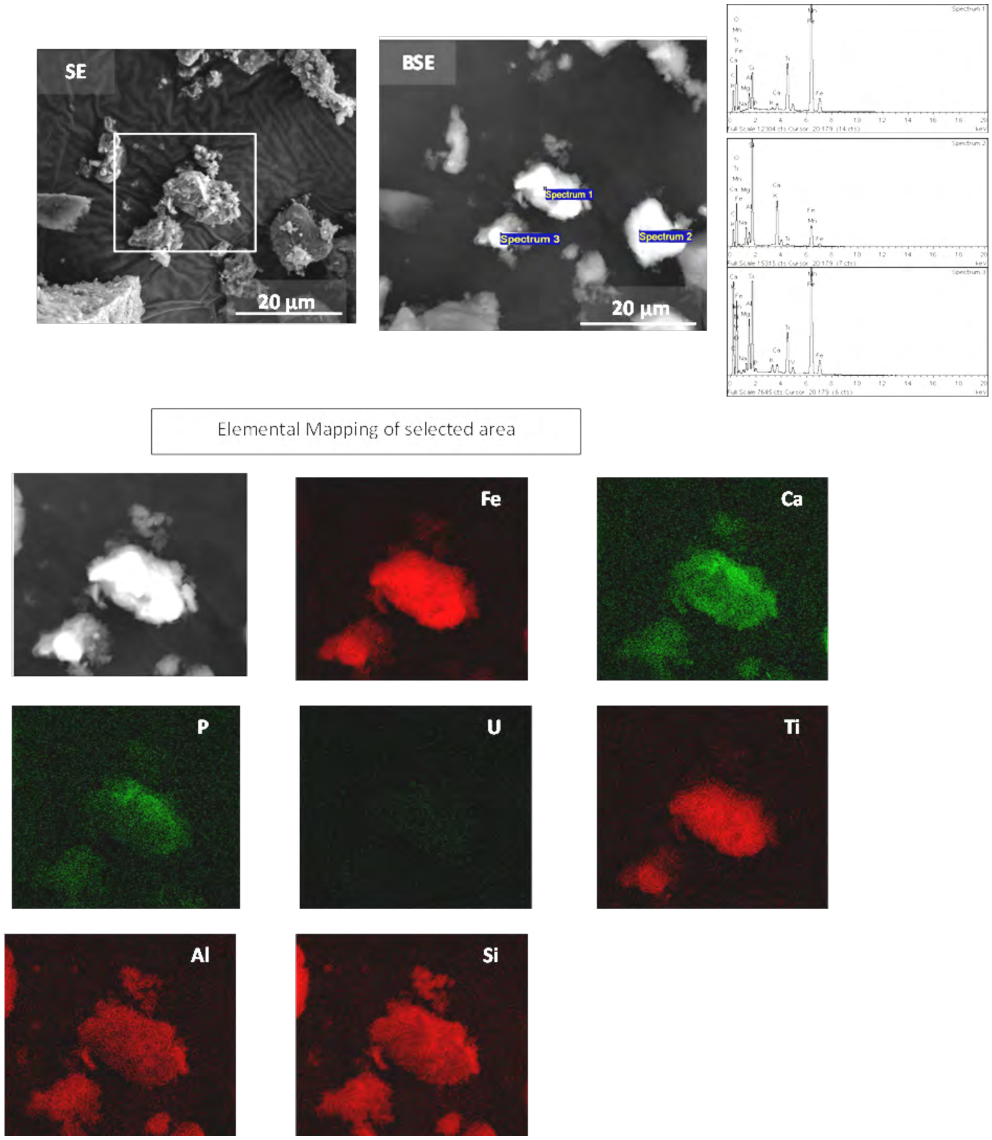
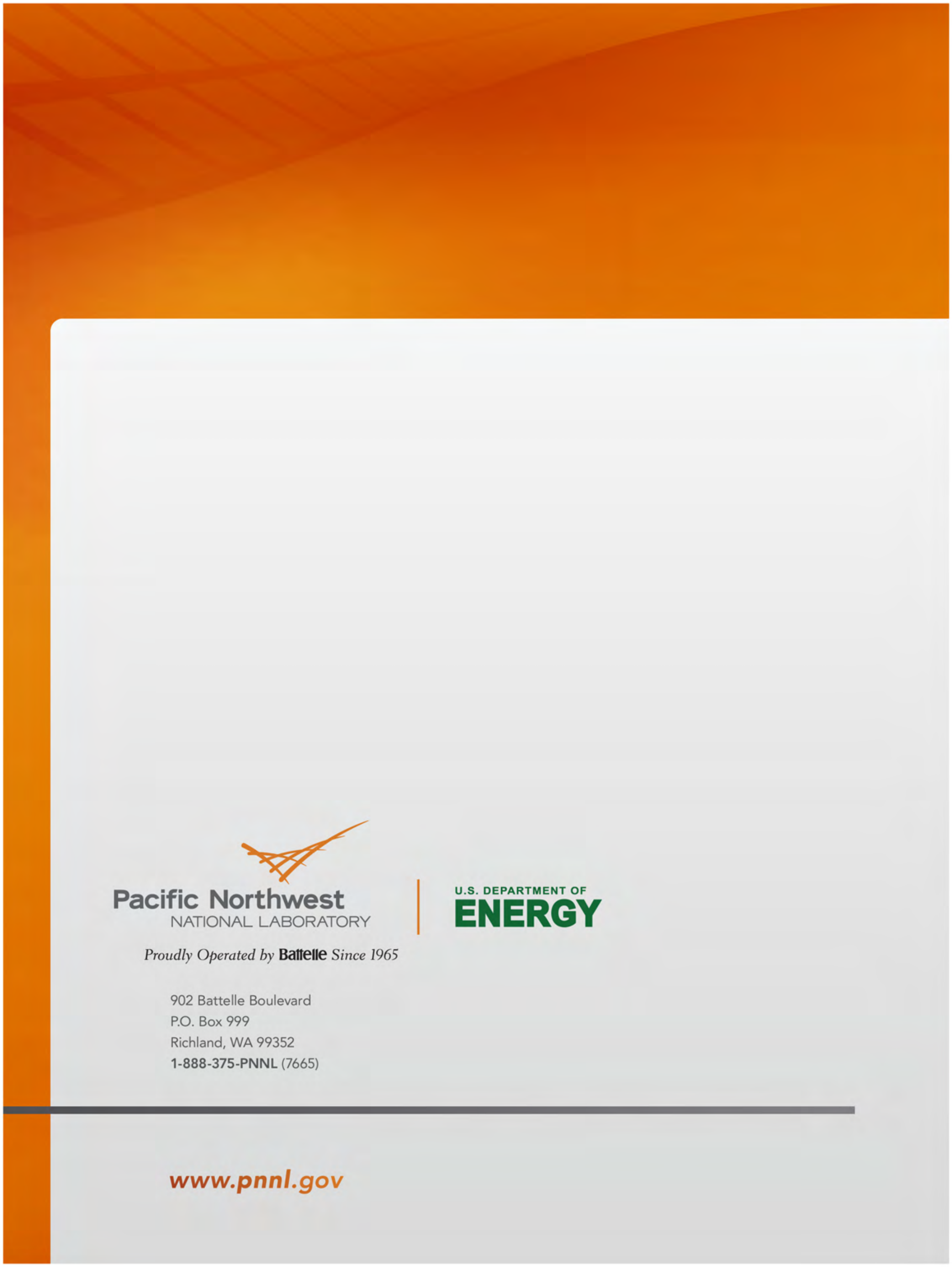


Figure D.6. Sample B347T7 (collected from borehole C9582, depth interval I-006, with at total uranium concentration of 19 mg/kg [ALS1601118, accessed via the Enterprise Application to IDMS]).



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** *Since 1965*

U.S. DEPARTMENT OF
ENERGY

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99352
1-888-375-PNNL (7665)

www.pnnl.gov

This page intentionally left blank.

Appendix B

Pre-Treatment Well Development Data

This page intentionally left blank.

Contents

Tables

This page intentionally left blank.

B1 Introduction

This appendix provides the pre-treatment well development data collected during installation of the injection and monitoring wells for the Stage A uranium sequestration operations.

B2 Pre-Treatment Well Development Data

Tables B-1 through B-5 summarize well completion and development data for the injection and monitoring wells used during Stage A of the enhanced attenuation remedy. Table B-1 summarizes completion and development information for the periodically rewetted zone/aquifer injection wells. Table B-2 summarizes completion and development information for the periodically rewetted zone monitoring wells installed to support Stage A treatment activities. Table B-3 summarizes completion information for existing wells that were used to monitor the periodically rewetted zone as part of the Stage A treatment activities. Table B-4 summarizes completion and development information for the aquifer monitoring wells installed to support Stage A treatment activities. Table B-5 summarizes completion information for existing wells that were used to monitor the aquifer as part of the Stage A treatment activities.

B3 References

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

SGW-59465, 2016, *Borehole Summary Report for the Installation of Nine Injection Wells, Twenty-One Monitoring Wells, and Three Boreholes in the 300-FF-5 Operable Unit*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0074320Hhttp://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078184H.

This page intentionally left blank.

Table B-1. Completion and Development Information for the Stage A Periodically Rewetted Zone/Aquifer Injection Wells

Well/Borehole Number	Construction Date	Horizontal Survey (NAD83)		Total Depth (m [ft] bgs)	PRZ Screened Interval (m [ft] bgs)		Aquifer Screened Interval (m [ft] bgs)		Date Developed	Initial Water Level (m [ft] bgs)	Duration Pumped (minutes)	Total Volume Pumped (liters [gallons])	Pumping Rate (L/min [gal/min])
		Northing (m)	Easting (m)		Top	Bottom	Top	Bottom					
399-1-89/C9460	07/16/2015	116467.59	594087.17	15.5 (50.5)	6.3 (20.4)	9.4 (30.4)	10.9 (35.4)	14 (45.4)	08/04/2015	9.6 (31.37)	69	~11,648 (3,077)	~169 (45)
399-1-90/C9461	07/20/2015	116478.21	594102.77	15.5 (50.3)	6.3 (20.4)	9.4 (30.4)	10.9 (35.4)	14 (45.4)	08/04/2015	9.6 (31.65)	32	~7,737 (2,044)	~242 (64)
399-1-91/C9462	07/21/2015	116489.07	594118.24	15.4 (50)	6.2 (20)	9.2 (30)	10.8 (35)	13.8 (45)	08/04/2015	9.7 (32.00)	42	~11,148 (2,945)	~265 (70)
399-1-92/C9463	07/22/2015	116466.66	594132.82	15.4 (50)	6.2 (20.3)	9.3 (30.3)	10.9 (35.3)	13.9 (45.3)	08/05/2015	9.8 (32.20)	54	~15,524 (4,101)	~287 (76)
399-1-93/C9464	07/15/2015	116470.77	594116.97	15.4 (50)	6.2 (20)	9.2 (30)	10.8 (35)	13.8 (45)	08/05/2015	9.8 (32.05)	20	~4,126 (1,090)	~206 (55)
399-1-94/C9465	07/22/2015	116479.65	594130.8	15.4 (50)	6.2 (20.2)	9.3 (30.2)	10.8 (35.2)	13.9 (45.2)	08/05/2015	9.8 (32.16)	47	~11,364 (3,002)	~242 (64)
399-1-95/C9466	07/27/2015	116488.32	594143.85	15.4 (50)	6.4 (20.9)	9.5 (30.9)	11 (35.9)	14.1 (45.9)	08/06/2015	9.5 (31.30)	30	~1,893 (500)	~63 (17)
399-1-96/C9467	07/23/2015	116473.85	594146.2	15.4 (50)	6.1 (19.9)	9.2 (29.9)	10.7 (34.9)	13.8 (44.9)	08/05/2015	9.6 (31.35)	59	~13,514 (3,570)	~229 (61)
399-1-97/C9468	07/28/2015	116480.09	594157.77	15.4 (50)	6.1 (19.9)	9.2 (29.9)	10.7 (34.9)	13.8 (44.9)	08/06/2015	9.5 (31.05)	35	~1,760 (465)	~50 (13)

References: NAD83, *North America Datum of 1983*.

SGW-59465, *Borehole Summary Report for the Installation of Nine Injection Wells, Twenty-One Monitoring Wells, and Three Boreholes in the 300-FF-5 Operable Unit*,.

bgs = below ground surface

PRZ = periodically rewetted zone

Table B-2. Completion and Development Information for the Stage A Periodically Rewetted Zone Monitoring Wells Installed to Support Stage A

Well/Borehole Number	Construction Date	Horizontal Survey (NAD83)		Total Depth (m [ft] bgs)	Screened Interval (m [ft] bgs)		Date Developed	Initial Water Level (m [ft] bgs)	Duration Pumped (minutes)	Total Volume Pumped (liters [gallons])
		Northing (m)	Easting (m)		Top	Bottom				
399-1-69/C8930	06/17/2015	116505.03	594169.73	12.3 (40)	9.4 (30.7)	11 (35.7)	07/16/2015	9.4 (30.70)	36	~136 (36)
399-1-71/C8932	06/16/2015	116508.84	594126.33	12.5 (40.5)	9.4 (30.4)	10.9 (35.4)	07/09/2015	9.5 (30.80)	37	~140 (37)
399-1-73/C8935	06/15/2015	116494.22	594081.69	12.5 (40.5)	8.7 (28.3)	10.2 (33.3)	07/16/2015	9.7 (31.74)	25	~95 (25)
399-1-75/C8939	06/29/2015	116475.62	594098.69	12.3 (40.1)	9.4 (30.6)	11 (35.6)	07/09/2015	9.2 (30.20)	39	~148 (39)
399-1-77/C8941	06/30/2015	116460.56	594118.72	12.4 (40.2)	9.4 (30.4)	10.9 (35.4)	07/15/2015	9.9 (32.65)	50	~189 (50)
399-1-79/C9450	06/18/2015	116463.09	594154.88	12.4 (40.2)	9.3 (30.3)	10.9 (35.3)	07/13/2015	9.8 (32.10)	31	~117 (31)
399-1-81/C9452	06/30/2015	116454.92	594090.9	12.5 (40.7)	9.4 (30.6)	11 (35.6)	07/09/2015	9.6 (31.50)	10	~38 (10)
399-1-83/C9454	06/24/2015	116427.4	594152.48	12.3 (40)	9.4 (30.4)	10.9 (35.4)	07/13/2015	10 (32.72)	21	~79 (21)
399-1-85/C9456	06/25/2015	116451.42	594175.5	12.3 (40)	9.4 (30.6)	11 (35.6)	07/14/2015	9.5 (31.80)	52	~197 (52)
399-1-87/C9458	06/23/2015	116478.8	594138.62	12.6 (41)	9.4 (30.6)	11 (35.6)	07/20/2015	9.6 (31.60)	39	~148 (39)

References: NAD83, *North America Datum of 1983*.

SGW-59465, *Borehole Summary Report for the Installation of Nine Injection Wells, Twenty-One Monitoring Wells, and Three Boreholes in the 300-FF-5 Operable Unit*,.

bgs = below ground surface

Table B-3. Completion Information for Existing Periodically Rewetted Zone Monitoring Wells Used in the Stage A Monitoring Network

Well/Borehole Number	Construction Date	Horizontal Survey (NAD83)		Total Depth (m [ft] bgs)	Screened Interval (m [ft] bgs)	
		Northing (m)	Easting (m)		Top	Bottom
399-1-67/C8936	01/26/2015	116481.59	594162.36	12.5 (40.7)	7.4 (24)	10.5 (34)
399-1-24/C5351	11/16/2006	116449.68	594116.45	12.9 (42)	9.8 (32)	11.4 (37)
399-1-37/C5630	06/01/2007	116438.15	594110.22	11.7 (37.9)	9.5 (31)	11.1 (36)

Reference: NAD83, *North America Datum of 1983*.

bgs = below ground surface

Table B-4. Completion and Development Information for the Stage A Aquifer Monitoring Wells Installed to Support Stage A

Well/Borehole Number	Construction Date	Horizontal Survey (NAD83)		Total Depth (m [ft] bgs)	Screened Interval (m [ft] bgs)		Date Developed	Initial Water Level (m [ft] bgs)	Duration Pumped (minutes)	Total Volume Pumped (liters [gallons])
		Northing (m)	Easting (m)		Top	Bottom				
399-1-65/C9408	07/18/2015	116481.19	594164.48	15.3 (49.7)	12.6 (40.9)	14.1 (45.9)	06/30/2015	9.2 (30.33)	72	~273 (72)
399-1-66/C9409	07/17/2015	116504.97	594168.41	15.4 (50.1)	12.2 (39.5)	13.7 (44.5)	07/13/2015	9.5 (31.15)	70	~265 (70)
399-1-70/C8931	06/16/2015	116508.83	594125.04	15.0 (48.9)	12.7 (41.3)	14.2 (46.3)	06/29/2015	9.4 (30.85)	17	~64 (17)
399-1-72/C8934	06/10/2015	116494.16	594080.16	14.8 (48.1)	12.2 (39.7)	13.8 (44.7)	07/16/2015	9.7 (31.69)	41	~155 (41)
399-1-74/C8937	06/29/2015	116475.26	594097.65	15.4 (50.1)	12.4 (40.2)	13.9 (45.2)	07/09/2015	9.2 (30.20)	44	~167 (44)
399-1-76/C8940	07/13/2015	116460.62	594117.79	15.7 (50.9)	12.4 (40.2)	13.9 (45.2)	07/15/2015	10 (32.7)	30	~114 (30)
399-1-78/C8942	06/22/2015	116463.17	594153.7	15.5 (50.3)	12.5 (40.5)	14 (45.5)	07/11/2015	9.5 (31.20)	36	~136 (36)
399-1-80/C9451	07/14/2015	116454.78	594089.52	15.5 (50.5)	12.5 (40.6)	14 (45.6)	07/15/2015	9.7 (31.78)	103	~390 (103)
399-1-82/C9453	06/24/2015	116427.47	594151.78	15.5 (50.5)	12.5 (40.5)	14 (45.5)	07/14/2015	9.9 (32.36)	29	~110 (29)
399-1-84/C9455	06/25/2015	116451.41	594174.47	18.5 (60)	14.8 (48)	16.3 (53)	07/14/2015	9.8 (32.00)	80	~303 (80)
399-1-86/C9457	06/23/2015	116478.66	594137.74	15.5 (50.5)	12.5 (40.4)	14 (45.4)	07/20/2015	8.9 (29.14)	58	~220 (58)

References: NAD83, *North America Datum of 1983*.

SGW-59465, *Borehole Summary Report for the Installation of Nine Injection Wells, Twenty-One Monitoring Wells, and Three Boreholes in the 300-FF-5 Operable Unit*.

bgs = below ground surface

Table B-5. Completion Information for Existing Aquifer Monitoring Wells Used in the Stage A Monitoring Network

Well/Borehole Number	Construction Date	Horizontal Survey (NAD83)		Total Depth (m [ft] bgs)	Screened Interval (m [ft] bgs)	
		Northing (m)	Easting (m)		Top	Bottom
399-1-25/C5352	11/17/2006	116450.35	594116.88	15.4 (50)	12.9 (42)	14.5 (47)
399-1-36/C5629	05/10/2007	116438.76	594108.45	15.4 (50)	12.6 (41)	14.2 (46)

Reference: NAD83, *North America Datum of 1983*.

bgs = below ground surface

Appendix C

Groundwater Analytical Data for Enhanced Attenuation Stage A Monitoring Wells

This page intentionally left blank.

Contents

Tables

This page intentionally left blank.

C1 Introduction

This appendix provides the analytical results for groundwater samples collected from 26 monitoring wells used to support implementation of the Stage A enhanced attenuation (EA) remedy. The wells were monitored before, during, and following application of polyphosphate solutions in the Stage A EA area; the results are presented in Sections C2, C3, and C4, respectively. The locations of the monitoring wells are shown on Figure 1-5. The data are stored in the Hanford Environmental Information System database, and users also may retrieve the data via the Internet through the U.S. Department of Energy Environmental Dashboard Application available at: https://ehs.hanford.gov/eda/.

This appendix also provides the analytical results for groundwater samples collected and analyzed by Pacific Northwest National Laboratory (PNNL) at groundwater monitoring wells downgradient of the Stage A EA area. The results are presented in Section C5. The locations of the monitoring wells are shown on Figure 3-3.

C2 Pre-Treatment Groundwater Samples

Pre-treatment (baseline) groundwater samples were collected from 26 monitoring wells located in the Stage A EA area. These baseline samples were collected from each well in August and September 2015, prior to application of polyphosphate solutions to the vadose zone, periodically rewetted zone (PRZ), and top of the aquifer. Table C-1 provides the analytical results for the groundwater characteristics of dissolved oxygen, oxidation-reduction potential, specific conductance, pH, temperature, and water level. Table C-2 provides the analytical results for carbonate and bicarbonate alkalinity, metals (calcium, magnesium, potassium, sodium, and uranium), and anions (chloride, phosphate, and sulfate).

Table C-1. Pre-Treatment Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Dissolved Oxygen[a] (µ/L)	Oxidation-Reduction Potential[b] (RmV)	Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (ºC)	Water Level Elevation[f] (m NAVD88)
Monitoring Well 399-1-24 (PRZ)							
8/28/2015	B32K88	9130	195.2	462	7.71	18	105.503
Monitoring Well 399-1-25 (Aquifer)							
8/28/2015	B32K82	9180	244	471	7.76	17.8	105.518
Monitoring Well 399-1-36 (Aquifer)							
8/28/2015	B32K91	8730	281.2	480	7.68	17.9	105.506
Monitoring Well 399-1-37 (PRZ)							
8/28/2015	B32K85	9120	291.3	474	7.7	18.1	105.508
Monitoring Well 399-1-65 (Aquifer)							
9/1/2015	B32K16	6470	223.4	486	7.54	17.9	105.227
Monitoring Well 399-1-66 (Aquifer)							
8/31/2015	B32K22	8910	162.9	460	7.52	18.1	105.296
Monitoring Well 399-1-67 (PRZ)							
9/1/2015	B32K19	6220	390.9	498	6.75	18	105.219
Monitoring Well 399-1-69 (PRZ)							
8/31/2015	B32K25	7630	176.5	526	7.23	18.3	105.283
Monitoring Well 399-1-70 (Aquifer)							
8/31/2015	B32K28	8120	164.2	458	7.7	17.7	105.308
Monitoring Well 399-1-71 (PRZ)							
8/31/2015	B32K31	9370	179.8	455	7.49	17.9	105.315
Monitoring Well 399-1-72 (Aquifer)							
8/31/2015	B32K34	9470	220	476	7.55	17.7	105.325

Table C-1. Pre-Treatment Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Dissolved Oxygen[a] (μ/L)	Oxidation-Reduction Potential[b] (RmV)	Specific Conductance[c] (μS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (ºC)	Water Level Elevation[f] (m NAVD88)
Monitoring Well 399-1-73 (PRZ)							
8/31/2015	B32K37	9200	195.2	480	7.43	17.9	105.324
Monitoring Well 399-1-74 (Aquifer)							
9/2/2015	B32K40	9120	127.1	479	7.65	18	105.232
Monitoring Well 399-1-75 (PRZ)							
9/2/2015	B32K43	8990	125.1	479	7.53	18	105.247
Monitoring Well 399-1-76 (Aquifer)							
9/2/2015	B32K46	9090	232.7	480	7.63	17.5	105.236
Monitoring Well 399-1-77 (PRZ)							
9/2/2015	B32K49	8880	181.7	468	7.52	17.6	105.236
Monitoring Well 399-1-78 (Aquifer)							
9/1/2015	B32K52	8460	298.2	482	7.25	18.1	105.203
Monitoring Well 399-1-79 (PRZ)							
9/1/2015	B32K55	8960	306.7	517	7.3	18.1	105.207
Monitoring Well 399-1-80 (Aquifer)							
9/2/2015	B32K58	6320	66.6	451	7.78	18	105.235
Monitoring Well 399-1-81 (PRZ)							
9/2/2015	B32K61	8980	118.4	472	7.56	17.9	105.238
Monitoring Well 399-1-82 (Aquifer)							
8/28/2015	B32K64	8730	319.3	472	7.7	18.2	105.49
Monitoring Well 399-1-83 (PRZ)							
8/28/2015	B32K67	9060	344.8	471	7.59	18.3	105.494
Monitoring Well 399-1-84 (Aquifer)							
8/28/2015	B32K70	470	63.2	584	8.21	20.5	105.501

Table C-1. Pre-Treatment Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Dissolved Oxygen[a] (µ/L)	Oxidation-Reduction Potential[b] (RmV)	Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
Monitoring Well 399-1-85 (PRZ)							
9/1/2015	B32K73	7460	396.4	499	6.91	18.3	105.197
Monitoring Well 399-1-86 (Aquifer)							
9/1/2015	B32K76	7720	152.7	462	8.23	20.1	105.212
Monitoring Well 399-1-87 (PRZ)							
9/1/2015	B32K79	9310	283.9	455	7.47	18	105.205

References: SESDPROC-113-R1, 2013, *Field Measurement of Oxidation-Reduction Potential (ORP)*, U.S. Environmental Protection Agency, Region 4, Science and Ecosystem Support Division, Athens, Georgia.

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

a. EPA Method 360.1. Dissolved oxygen using field probe.

b. EPA Method SESDPROC-113-R1, *Field Measurement of Oxidation-Reduction Potential (ORP)*. Oxidation-reduction potential using field probe.

c. EPA Method 120.1. Specific conductivity using field probe.

d. EPA Method 150.1. pH using field probe.

e. EPA Method 170.1. Temperature using field probe.

f. Water level measured using water level measurement tape.

EPA = U.S. Environmental Protection Agency

NAVD88 = North American Vertical Datum of 1988

PRZ = periodically rewetted zone

RmV = Relative milliVolt

Table C-2. Pre-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
Monitoring Well 399-1-24 (PRZ)											
8/28/2015	B32K89	--	--	--	--	--	--	--	19000 D	521 D	59000 D
	B32K90	540 U	124000	51800	11300	5630	24000	41.6	--	--	--
Monitoring Well 399-1-25 (Aquifer)											
8/28/2015	B32K83	--	--	--	--	--	--	--	19000 D	521 D	60000 D
	B32K84	540 U	128000	51400	11800	6130	23500	41.8	--	--	--
Monitoring Well 399-1-36 (Aquifer)											
8/28/2015	B32K92	--	--	--	--	--	--	--	23000 D	828 D	60000 D
	B32K93	540 U	127000	52700	11000	5680	24800	46.8	--	--	--
Monitoring Well 399-1-37 (PRZ)											
8/28/2015	B32K86	--	--	--	--	--	--	--	20000 D	521 D	60000 D
	B32K87	540 U	128000	55000	12000	5980	24300	39.7	--	--	--
Monitoring Well 399-1-65 (Aquifer)											
9/1/2015	B32K17	--	--	--	--	--	--	--	19000 D	251 U	61000 D
	B32K18	540 U	143000	48300	9580	4140 B	45800	291	--	--	--
	B32K96	--	--	--	--	--	--	--	19000 D	251 U	62000 D
	B32K97	540 U	144000	46800	9330	4230 B	46300	291	--	--	--
Monitoring Well 399-1-66 (Aquifer)											
8/31/2015	B32K23	--	--	--	--	--	--	--	19000 D	337 BD	59000 D
	B32K24	220 U	132000	52200	11700	5270	23700	50.3	--	--	--
Monitoring Well 399-1-67 (PRZ)											
9/1/2015	B32K20	--	--	--	--	--	--	--	18000 D	251 U	60000 D
	B32K21	540 U	147000	65600	12500	3800 B	24300	326	--	--	--

Table C-2. Pre-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
Monitoring Well 399-1-69 (PRZ)											
8/31/2015	B32K26	--	--	--	--	--	--	--	18000 D	251 U	59000 D
	B32K27	220 U	172000	73000	14600	4250 B	24400	150	--	--	--
Monitoring Well 399-1-70 (Aquifer)											
8/31/2015	B32K29	--	--	--	--	--	--	--	19000 D	337 BD	59000 D
	B32K30	220 U	125000	52100	11500	5680	24200	48.2	--	--	--
Monitoring Well 399-1-71 (PRZ)											
8/31/2015	B32K32	--	--	--	--	--	--	--	19000 D	399 BD	59000 D
	B32K33	220 U	128000	52100	11800	5350	23600	53.8	--	--	--
Monitoring Well 399-1-72 (Aquifer)											
8/31/2015	B32K35	--	--	--	--	--	--	--	26000 D	337 BD	59000 D
	B32K36	220 U	124000	53100	12500	6000	23600	30.9	--	--	--
Monitoring Well 399-1-73 (PRZ)											
8/31/2015	B32K38	--	--	--	--	--	--	--	27000 D	337 BD	59000 D
	B32K39	220 U	126000	54900	12100	5500	25500	91.1	--	--	--
Monitoring Well 399-1-74 (Aquifer)											
9/2/2015	B32K41	--	--	--	--	--	--	--	25000 D	251 U	59000 D
	B32K42	540 U	126000	55800	12100	5650	24100	26.8	--	--	--
Monitoring Well 399-1-75 (PRZ)											
9/2/2015	B32K44	--	--	--	--	--	--	--	25000 D	368 BD	59000 D
	B32K45	540 U	124000	55600	12100	5210	25100	84.6	--	--	--
Monitoring Well 399-1-76 (Aquifer)											
9/2/2015	B32K47	--	--	--	--	--	--	--	23000 D	251 U	59000 D
	B32K48	540 U	126000	56800	12400	5570	24000	32.2	--	--	--

Table C-2. Pre-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
detecMonitoring Well 399-1-77 (PRZ)											
9/2/2015	B32K50	--	--	--	--	--	--	--	21000 D	399 BD	60000 D
	B32K51	540 U	124000	55300	11700	4940 B	24300	52.3	--	--	--
Monitoring Well 399-1-78 (Aquifer)											
9/1/2015	B32K53	--	--	--	--	--	--	--	18000 D	251 U	59000 D
	B32K54	540 U	144000	60000	12000	3980 B	24700	230	--	--	--
Monitoring Well 399-1-79 (PRZ)											
9/1/2015	B32K56	--	--	--	--	--	--	--	23000 D	251 U	59000 D
	B32K57	540 U	142000	63000	13100	4070 B	25900	415	--	--	--
Monitoring Well 399-1-80 (Aquifer)											
9/2/2015	B32K59	--	--	--	--	--	--	--	25000 D	251 U	56000 D
	B32K60	540 U	119000	47100	9980	5550	32300	170	--	--	--
Monitoring Well 399-1-81 (PRZ)											
9/2/2015	B32K62	--	--	--	--	--	--	--	23000 D	368 BD	59000 D
	B32K63	540 U	128000	57000	12200	5310	25000	61.7	--	--	--
Monitoring Well 399-1-82 (Aquifer)											
8/28/2015	B32K65	--	--	--	--	--	--	--	19000 D	429 BD	59000 D
	B32K66	220 U	126000	52200	11700	5440	24500	61	--	--	--
Monitoring Well 399-1-83 (PRZ)											
8/28/2015	B32K68	--	--	--	--	--	--	--	19000 D	552 D	60000 D
	B32K69	220 U	125000	56400	11400	5330	24400	72	--	--	--
Monitoring Well 399-1-84 (Aquifer)											
8/28/2015	B32K71	--	--	--	--	--	--	--	34000 D	251 U	130000 D
	B32K72	220 U	126000	77300	18700	9290	23300	3.5	--	--	--

Table C-2. Pre-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	**Sample Number**	**Alkalinity[a] (µg/L)**		**Metals[b] (µg/L)**					**Anions[c] (µg/L)**		
		Carbonate	**Bicarbonate**	**Calcium**	**Magnesium**	**Potassium**	**Sodium**	**Uranium**	**Chloride**	**Phosphate**	**Sulfate**
Monitoring Well 399-1-85 (PRZ)											
9/1/2015	B32K74	--	--	--	--	--	--	--	18000 D	251 U	57000 D
	B32K75	540 U	156000	64300	12900	3610 B	25900	728	--	--	--
	B32KB0	--	--	--	--	--	--	--	18000 D	251 U	58000 D
	B32KB1	540 U	112000	67600	13000	3700 B	25800	719	--	--	--
Monitoring Well 399-1-86 (Aquifer)											
9/1/2015	B32K77	--	--	--	--	--	--	--	20000 D	399 BD	56000 D
	B32K78	540 U	130000	30800	6190	3670 B	63900	174	--	--	--
Monitoring Well 399-1-87 (PRZ)											
9/1/2015	B32K80	--	--	--	--	--	--	--	19000 D	368 BDN	59000 D
	B32K81	540 U	122000	55800	11600	4580 B	23800	57.9	--	--	--

Reference: DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079669H.

a. EPA Method 310.1.

b. EPA Method 6020. Results in this table are for unfiltered samples collected in accordance with Table A-6 in DOE/RL-2014-42.

c. EPA Method 300.

-- = not applicable

EPA = U.S. Environmental Protection Agency

PRZ = periodically rewetted zone

Laboratory Qualifiers:

B = The analyte was detected at a value less than the contract required detection limit, but greater than or equal to the instrument detection limit/maximum detection limit (as appropriate).

D = Analyte was reported at a secondary dilution factor.

N = Spike and/or spike duplicate sample recovery is outside control limits.

U = Undetected.

C3 Groundwater Samples Collected During Treatment

Groundwater samples were collected from two aquifer monitoring wells (399-1-65 and 399-1-74) and five PRZ monitoring wells (399-1-67, 399-1-75, 399-1-77, 399-1-81, and 399-1-87) in November 2015 during application of polyphosphate solutions to the vadose zone, PRZ, and top of the aquifer. Table C-3 provides the analytical results for the groundwater characteristics of dissolved oxygen, oxidation-reduction potential, specific conductance, pH, temperature, and water level. Table C-4 provides the analytical results for carbonate and bicarbonate alkalinity, metals (calcium, sodium, and uranium), and anions (phosphate).

Table C-3. Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b]		Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
			(mV)	(RmV)				
Monitoring Well 399-1-65 (Aquifer)								
11/6/2015	B32XM6	6910	--	364.6	481	7.36	18.4	105.119
11/7/2015	B32XR0	6890	--	188.4	479	7.33	18.5	105.136
11/8/2015	B32XW5	6880	--	377.7	480	7.36	18.8	105.11
11/9/2015	B32YH6	5970	372.5	--	481	7.41	18.1	105.187
11/10/2015	B32YL4	6180	--	329.9	538	7.61	17.9	105.05
11/11/2015	B32YP2	6410	--	337.1	642	7.49	18.2	105.139
11/12/2015	B32YV0	6390	339.1	--	772	7.38	17.5	105.114
11/14/2015	B32YX8	6390	379.1	--	1029	7.18	18.2	105.131
11/15/2015	B33016	6690	--	375.2	981	7.2	17.6	105.17
11/16/2015	B33044	6400	--	312.8	705	7.4	17.8	105.22
11/18/2015	B33L46	6970	--	412.2	2779	7.15	18.2	105.34
11/19/2015	B33L74	6840	253.1	--	2270	7.24	18	105.29
Monitoring Well 399-1-67 (PRZ)								
11/6/2015	B32XM9	4850	--	397.8	558	6.44	18.6	105.106
11/7/2015	B32XR3	4790	--	196.1	556	6.43	18.4	105.117
11/8/2015	B32XW9	4770	--	390.3	553	6.42	18.3	105.095
11/9/2015	B32YJ0	4980	404.2	--	663	6.41	17.9	105.127
11/10/2015	B32YL8	5080	--	383.9	2264	6.51	17.8	105.147
11/11/2015	B32YP6	5210	--	379.7	2610	6.63	17.8	105.144
11/12/2015	B32YV4	5380	375.3	--	2225	6.81	17.8	105.127
11/14/2015	B32YY2	5230	428.1	--	1918	6.88	18.8	105.151
11/15/2015	B33020	5270	--	415.5	1749	6.96	18.1	105.184
11/16/2015	B33048	5540	--	347.1	1746	7.12	18.9	105.244
11/18/2015	B33L50	8570	--	413.2	7050	7.19	16.4	105.619

Table C-3. Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b]		Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
			(mV)	(RmV)				
11/19/2015	B33L78	7780	287.5	--	5608	7.01	16.4	105.285
Monitoring Well 399-1-74 (Aquifer)								
11/6/2015	B32XN2	9280	--	368.2	1027	6.99	18.3	105.129
11/7/2015	B32XR6	9030	--	339.3	718	7.24	17.6	105.129
11/8/2015	B32XX3	9170	--	386.3	793	6.92	18.3	105.113
11/9/2015	B32YJ4	8930	391.5	--	1234	6.89	18.1	105.175
11/10/2015	B32YM2	8570	--	300.1	1157	6.79	17.7	105.186
11/11/2015	B32YR0	8870	--	405.5	901	7.11	17.6	105.131
11/12/2015	B32YV8	8690	192.1	--	909	6.88	17.4	105.118
11/14/2015	B32YY6	8810	392.3	--	882	7.15	18	105.135
11/15/2015	B33024	8890	--	387.7	792	7.18	17	105.159
11/16/2015	B33052	8460	--	347	1842	6.95	17.2	105.156
11/18/2015	B33L54	8120	--	379.1	3250	6.98	17.7	105.265
11/19/2015	B33L82	8100	189.5	--	2519	6.88	17.3	105.253
Monitoring Well 399-1-75 (PRZ)								
11/6/2015	B32XN5	9300	--	308.9	460	7.62	17.3	105.124
11/7/2015	B32XR9	9270	--	319.7	474	7.57	17.5	105.14
11/8/2015	B32XX7	9300	--	373.7	456	7.33	17.6	105.836[g]
11/9/2015	B32YJ8	9360	382.5	--	520	7.29	17.9	105.166
11/10/2015	B32YM6	8980	--	349.4	747	7.05	17.6	105.151
11/11/2015	B32YR4	9240	--	393.5	858	7.23	17.6	105.138
11/12/2015	B32YW2	9150	187.6	--	942	6.9	16.5	105.124
11/14/2015	B33000	8690	400	--	1126	6.69	19.2	105.139
11/15/2015	B33028	8630	--	395.2	1403	6.64	19	105.165
11/16/2015	B33056	9010	--	345	1609	6.55	18.7	105.205

Table C-3. Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b]		Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
			(mV)	(RmV)				
11/18/2015	B33L58	10280	--	368.6	9790	7.16	14.2	105.375
11/19/2015	B33L86	9170	266.9	--	5794	6.89	14.3	105.264
Monitoring Well 399-1-77 (PRZ)								
11/6/2015	B32XN8	9070	--	304.7	462	7.57	17.1	105.101
11/7/2015	B32XT2	8890	--	309.9	466	7.56	17.2	105.114
11/8/2015	B32XY1	8970	--	335.6	471	7.54	17.5	105.101
11/9/2015	B32YK2	8950	367.7	--	478	7.52	17.3	105.236
11/10/2015	B32YN0	8700	--	284	525	7.09	17.8	105.15
11/11/2015	B32YR8	8820	--	391.7	528	7.38	17.8	105.131
11/12/2015	B32YW6	8620	191.4	--	577	6.83	17.4	105.116
11/14/2015	B33004	8190	382	--	544	7.21	18.4	105.106
11/15/2015	B33032	8570	--	360.3	610	7.09	17.6	105.142
11/16/2015	B33060	8690	--	319	695	6.8	17.6	105.166
11/17/2015	B33L32	9180	--	359.7	3981	6.63	17.6	105.306
11/18/2015	B33L62	8870	--	424.4	4404	6.86	17.4	105.253
11/19/2015	B33L90	8690	33.2	--	3974	6.78	16.6	105.249
Monitoring Well 399-1-81 (PRZ)								
11/6/2015	B32XP1	9290	--	309.5	461	7.58	17.3	105.101
11/7/2015	B32XT5	9150	--	325.7	470	7.62	17.4	105.114
11/8/2015	B32XY5	9150	--	336.7	474	7.59	17.4	105.097
11/9/2015	B32YK6	9190	347.6	--	688	7.48	17.2	105.127
11/10/2015	B32YN4	8930	--	276.3	821	7.05	17.5	105.172
11/11/2015	B32YT2	9100	--	385.8	776	7.32	17.6	105.13
11/12/2015	B32YX0	8940	206.3	--	777	6.98	17.3	105.116
11/14/2015	B33008	8730	379.5	--	849	6.84	18.2	105.107

Table C-3. Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b] (mV)	Oxidation-Reduction Potential[b] (RmV)	Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
11/15/2015	B33036	8650	--	371.6	928	6.76	17.9	105.141
11/16/2015	B33064	8820	--	334	1024	6.53	18	105.15
11/18/2015	B33L66	8530	--	395.8	1014	6.65	18.3	105.246
11/19/2015	B33L94	8500	163	--	1111	6.52	18.4	105.247
Monitoring Well 399-1-87 (PRZ)								
11/6/2015	B32XP4	9120	--	360.3	455	7.25	17.8	105.06
11/7/2015	B32XT8	8830	--	168.9	563	7.18	17.8	105.09
11/8/2015	B32XY9	8630	--	403.2	573	7.14	17.8	105.077
11/9/2015	B32YL0	8650	389.1	--	569	7.11	17.8	105.102
11/10/2015	B32YN8	8110	--	333.3	1234	6.95	17.2	105.111
11/11/2015	B32YT6	7970	--	376.6	1190	6.93	17.4	105.105
11/12/2015	B32YX4	7870	358.6	--	1351	6.91	17.1	105.081
11/14/2015	B33012	7370	391.5	--	1336	6.93	17.8	105.1
11/15/2015	B33040	7380	--	374.2	1255	6.99	17.3	105.127
11/16/2015	B33068	7340	--	355.6	1203	7.12	17	105.157
11/17/2015	B33L40	9950	--	267.9	--	7.25	14.7	105.695
11/18/2015	B33L70	9470	--	416.4	7628	7.15	15.4	105.277
11/19/2015	B33L98	8040	276.9	--	3384	6.9	16.4	105.268

References: SESDPROC-113-R1, 2013, *Field Measurement of Oxidation-Reduction Potential (ORP)*, U.S. Environmental Protection Agency, Region 4, Science and Ecosystem Support Division, Athens, Georgia.

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

a. EPA Method 360.1. Dissolved oxygen using field probe.

b. EPA Method SESDPROC-113-R1, *Field Measurement of Oxidation-Reduction Potential (ORP)*. Oxidation-reduction potential using field probe.

c. EPA Method 120.1. Specific conductivity using field probe.

d. EPA Method 150.1. pH using field probe.

e. EPA Method 170.1. Temperature using field probe.

Table C-3. Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b]		Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (ºC)	Water Level Elevation[f] (m NAVD88)
			(mV)	(RmV)				

f. Water level measured using water level measurement tape.

g. Request for Data Review (RDR) submitted.

-- = not applicable

EPA = U.S. Environmental Protection Agency

NAVD88 = North American Vertical Datum of 1988

PRZ = periodically rewetted zone

RmV = Relative milliVolt

Table C-4. Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)			Anions[c] (µg/L)
		Carbonate	Bicarbonate	Calcium	Sodium	Uranium	Phosphate
Monitoring Well 399-1-65 (Aquifer)							
11/6/2015	B32XM7	--	--	--	--	--	251 U
	B32XM8	540 U	142000	48500	37600 N	194	--
11/7/2015	B32XR1	--	--	--	--	--	251 UN
	B32XR2	540 U	146000	54700	38100	116	--
11/8/2015	B32XW6	--	--	--	--	--	1500 D
	B32XW8	540 U	144000	47600	38200 N	190	--
11/9/2015	B32YH7	--	--	--	--	--	705 DN
	B32YH9	540 U	144000	47500	43400	189	--
11/10/2015	B32YL5	--	--	--	--	--	3680 DN
	B32YL7	540 U	148000	44500	59400	202	--
11/11/2015	B32YP3	--	--	--	--	--	1690 DN
	B32YP5	540 U	156000	55200	48400	295	--
11/12/2015	B32YV1	--	--	--	--	--	736 DN
	B32YV3	540 U	178000	80300	64600	721	--
11/14/2015	B32YX9	--	--	--	--	--	1290 DN
	B32YY1	540 U	222000	104000 D	64500 D	863	--
11/15/2015	B33017	--	--	--	--	--	1470 ND
	B33019	540 U	226000	95800	63700	1150	--
11/16/2015	B33045	--	--	--	--	--	2700 DN
	B33047	540 U	200000	71900	61900	831	--
11/18/2015	B33L47	--	--	--	--	--	1810000 D
	B33L49	2700 U	735000	39800 DN	599000 D	19.3 D	--

Table C-4. Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)			Anions[c] (µg/L)
		Carbonate	Bicarbonate	Calcium	Sodium	Uranium	Phosphate
11/19/2015	B33L75	--	--	--	--	--	1070000 D
	B33L77	2700 U	560000	15300	444000 D	8.9 BD	--
Monitoring Well 399-1-67 (PRZ)							
11/6/2015	B32XN0	--	--	--	--	--	251 U
	B32XN1	540 U	192000	66600	33300 N	462	--
11/7/2015	B32XR4	--	--	--	--	--	251 UN
	B32XR5	540 U	186000	76100	26500	269	--
11/8/2015	B32XX0	--	--	--	--	--	251 U
	B32XX2	540 U	184000	69100	26400 N	419	--
11/9/2015	B32YJ1	--	--	--	--	--	3680 DN
	B32YJ3	540 U	192000	83600	33900	575	--
11/10/2015	B32YL9	--	--	--	--	--	251 UN
	B32YM1	540 U	227000	272000 D	87800	1540	--
11/11/2015	B32YP7	--	--	--	--	--	251 UN
	B32YP9	540 U	370000	348000 D	181000 D	3620	--
11/12/2015	B32YV5	--	--	--	--	--	2210 D
	B32YV7	540 U	538000	250000 D	240000 D	5400 D	--
11/14/2015	B32YY3	--	--	--	--	--	42900 DN
	B32YY5	540 U	624000	163000 D	267000 D	5580 D	--
11/15/2015	B33021	--	--	--	--	--	156000 D
	B33023	540 U	644000	127000 D	301000 D	5310 D	-
11/16/2015	B33049	--	--	--	--	--	368000 D
	B33051	540 U	654000	86400 D	382000 D	3270	--

Table C-4. Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)			Anions[c] (µg/L)
		Carbonate	Bicarbonate	Calcium	Sodium	Uranium	Phosphate
11/18/2015	B33L51	--	--	--	--	--	5830000 D
	B33L53	2700 U	2000000	31400 DN	1640000 D	500 D	--
11/19/2015	B33L79	--	--	--	--	--	4290000 D
	B33L81	5400 U	1440000	24800	1240000 D	208 D	--
Monitoring Well 399-1-74 (Aquifer)							
11/6/2015	B32XN3	--	--	--	--	--	491000 D
	B32XN4	540 U	262000	59100	155000 D	10.2	--
11/7/2015	B32XR7	--	--	--	--	--	187000 D
	B32XR8	540 U	179000	52100	94100	14.6	--
11/8/2015	B32XX4	--	--	--	--	--	294000 D
	B32XX6	540 U	196000	40300	134000 DN	16.4	--
11/9/2015	B32YJ5	--	--	--	--	--	705000 D
	B32YJ7	540 U	307000	59000	231000 D	7.8	--
11/10/2015	B32YM3	--	--	--	--	--	552000 D
	B32YM5	540 U	276000	48900 D	230000 D	7.2	--
11/11/2015	B32YR1	--	--	--	--	--	368000 D
	B32YR3	540 U	217000	52100 D	163000 D	7.7	--
11/12/2015	B32YV9	--	--	--	--	--	368000 D
	B32YW1	540 U	213000	50100 D	158000 D	9.8	--
11/14/2015	B32YY7	--	--	--	--	--	224000 D
	B32YY9	540 U	197000	49100 D	116000 D	11.6	--
11/15/2015	B33025	--	--	--	--	--	212000 D
	B33027	540 U	192000	48300 D	105000 D	11.9	--

Table C-4. Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)			Anions[c] (µg/L)
		Carbonate	Bicarbonate	Calcium	Sodium	Uranium	Phosphate
11/16/2015	B33053	--	--	--	--	--	1200000 D
	B33055	540 U	425000	53000	301000 D	7.7	--
11/18/2015	B33L55	--	--	--	--	--	2540000 D
	B33L57	2700 U	705000	45200 DN	671000 D	2.3 U	--
11/19/2015	B33L83	--	--	--	--	--	1590000 D
	B33L85	2700 U	535000	32900	483000 D	2.3 U	--
Monitoring Well 399-1-75 (PRZ)							
11/6/2015	B32XN6	--	--	--	--	--	399 BD
	B32XN7	540 U	124000	56400	24800	60.4	--
11/7/2015	B32XT0	--	--	--	--	--	4600 DN
	B32XT1	540 U	116000	57800	28300	34.3	--
11/8/2015	B32XX8	--	--	--	--	--	2480 D
	B32XY0	540 U	126000	49700	25400 N	64.5	--
11/9/2015	B32YJ9	--	--	--	--	--	4290 DN
	B32YK1	540 U	126000	60400	33400	46.7	--
11/10/2015	B32YM7	--	--	--	--	--	2540 DN
	B32YM9	540 U	123000	71800	42400	99	--
11/11/2015	B32YR5	--	--	--	--	--	2760 DN
	B32YR7	540 U	124000	103000	53900	192	--
11/12/2015	B32YW3	--	--	--	--	--	8890 DN
	B32YW5	540 U	126000	99100	61800	182	--
11/14/2015	B33001	--	--	--	--	--	736000 D
	B33003	540 U	226000	92400 D	172000 D	53.2	--

Table C-4. Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)			Anions[c] (µg/L)
		Carbonate	Bicarbonate	Calcium	Sodium	Uranium	Phosphate
11/15/2015	B33029	--	--	--	--	--	1170000 D
	B33031	540 U	280000	86900 D	276000 D	20.1	--
11/16/2015	B33057	--	--	--	--	--	1440000 D
	B33059	540 U	322000	61800	348000 D	8.1	--
11/18/2015	B33L59	--	--	--	--	--	7970000 D
	B33L61	5400 U	2640000	29700 DN	1920000 D	19.5 D	--
11/19/2015	B33L87	--	--	--	--	--	4910000 D
	B33L89	5400 U	1320000	32000	1190000 D	32.5 D	--
Monitoring Well 399-1-77 (PRZ)							
11/6/2015	B32XN9	--	--	--	--	--	368 BD
	B32XP0	540 U	126000	55600	25300	52.8	--
11/7/2015	B32XT3	--	--	--	--	--	1590 DN
	B32XT4	540 U	128000	55000	25400	47.2	--
11/8/2015	B32XY2	--	--	--	--	--	3680 DN
	B32XY4	540 U	132000	51000	26800 N	51.6	--
11/9/2015	B32YK3	--	--	--	--	--	3990 DN
	B32YK5	540 U	132000	55600	26600	43	--
11/10/2015	B32YN1	--	--	--	--	--	4910 DN
	B32YN3	540 U	142000	52500	30900	47.1	--
11/11/2015	B32YR9	--	--	--	--	--	5830 DN
	B32YT1	540 U	147000	63400	33700	43.2	--
11/12/2015	B32YW7	--	--	--	--	--	33700 D
	B32YW9	540 U	164000	69200	46200	30.8	--

Table C-4. Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)			Anions[c] (µg/L)
		Carbonate	Bicarbonate	Calcium	Sodium	Uranium	Phosphate
11/14/2015	B33005	--	--	--	--	--	30700 DN
	B33007	540 U	162000	65100	38500	28.9	--
11/15/2015	B33033	--	--	--	--	--	76700 DN
	B33035	540 U	170000	67700	53500	21.9	--
11/16/2015	B33061	--	--	--	--	--	282000 DN
	B33063	540 U	198000	68700 D	99800 D	18.4	--
11/17/2015	B33L33	--	--	--	--	--	3990000 D
	B33L35	2700 U	890000	99300 DN	1040000 D	11 D	--
11/18/2015	B33L63	--	--	--	--	--	4290000 D
	B33L65	2700 U	1010000	43600 DN	1220000 D	9.2 BD	--
11/19/2015	B33L91	--	--	--	--	--	3370000 D
	B33L93	2700 U	820000	37500	880000 D	6.8 BD	--
Monitoring Well 399-1-81 (PRZ)							
11/6/2015	B32XP2	--	--	--	--	--	368 BD
	B32XP3	540 U	125000	56300	24700	56.4	--
11/7/2015	B32XT6	--	--	--	--	--	4600 DN
	B32XT7	540 U	128000	53700	25800	38.9	--
11/8/2015	B32XY6	--	--	--	--	--	3990 DN
	B32XY8	540 U	132000	50100	28200 N	41.2	--
11/9/2015	B32YK7	--	--	--	--	--	2610 DN
	B32YK9	540 U	125000	75100	32600	66.4	--
11/10/2015	B32YN5	--	--	--	--	--	3370 DN
	B32YN7	540 U	124000	79200	40700	112	--

Table C-4. Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)			Anions[c] (µg/L)
		Carbonate	Bicarbonate	Calcium	Sodium	Uranium	Phosphate
11/11/2015	B32YT3	--	--	--	--	--	2700 DN
	B32YT5	540 U	133000	92200	45800	120	--
11/12/2015	B32YX1	--	--	--	--	--	9510 D
	B32YX3	540 U	158000	89700	47500	97.1	--
11/14/2015	B33009	--	--	--	--	--	248000 D
	B33011	540 U	196000	90400 D	93500 D	15.2	--
11/15/2015	B33037	--	--	--	--	--	521000 D
	B33039	540 U	212000	95200 D	123000 D	8.6	--
11/16/2015	B33065	--	--	--	--	--	767000 DN
	B33067	540 U	226000	84000 D	190000 D	6	--
11/18/2015	B33L67	--	--	--	--	--	613000 D
	B33L69	540 U	202000	73600 DN	183000 D	2.3 U	--
11/19/2015	B33L95	--	--	--	--	--	736000 D
	B33L97	540 U	194000	70700	177000 D	2.3 U	--
Monitoring Well 399-1-87 (PRZ)							
11/6/2015	B32XP5	--	--	--	--	--	399 BD
	B32XP6	540 U	128000	49700	33900 N	59.8	--
11/7/2015	B32XT9	--	--	--	--	--	36800 DN
	B32XV0	540 U	163000	60000	55100	12.1	--
11/8/2015	B32Y00	--	--	--	--	--	46000 D
	B32Y02	540 U	168000	53300	58800 N	13.1	--
11/9/2015	B32YL1	--	--	--	--	--	--49100 DN
	B32YL3	540 U	162000	56800	59100	13.2	--

Table C-4. Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)			Anions[c] (µg/L)
		Carbonate	Bicarbonate	Calcium	Sodium	Uranium	Phosphate
11/10/2015	B32YN9	--	--	--	--	--	797000 D
	B32YP1	540 U	298000	306000 D	257000 D	171	--
11/11/2015	B32YT7	--	--	--	--	--	675000 D
	B32YT9	540 U	276000	75300 D	278000 D	274	--
11/12/2015	B32YX5	--	--	--	--	--	644000 D
	B32YX7	540 U	292000	90100 D	298000 D	364	--
11/14/2015	B33013	--	--	--	--	--	460000 D
	B33015	540 U	333000	87800 D	215000 D	599	--
11/15/2015	B33041	--	--	--	--	--	368000 D
	B33043	540 U	327000	77100 D	193000 D	519	--
11/16/2015	B33069	--	--	--	--	--	307000 DN
	B33071	540 U	310000	68900 D	205000 D	522	--
11/17/2015	B33L41	--	--	--	--	--	7670000 D
	B33L43	2700 U	2760000	26300 DN	2210000 D	137 D	--
11/18/2015	B33L71	--	--	--	--	--	6130000 D
	B33L73	5400 U	2050000	31800 DN	1780000 D	564 D	--
11/19/2015	B33L99	--	--	--	--	--	2640000 D
	B33LB1	2700 U	760000	34000	741000 D	29.2 D	--

Reference: DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079669H.

a. EPA Method 310.1.

b. EPA Method 6020. Results in this table are for unfiltered samples collected in accordance with Table A-6 in DOE/RL-2014-42.

c. EPA Method 300.

Table C-4. Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells During Treatment

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)			Anions[c] (µg/L)
		Carbonate	Bicarbonate	Calcium	Sodium	Uranium	Phosphate

Laboratory Qualifiers:

B = The analyte was detected at a value less than the contract required detection limit, but greater than or equal to the instrument detection limit/maximum detection limit (as appropriate).

D = Analyte was reported at a secondary dilution factor.

N = Spike and/or spike duplicate sample recovery is outside control limits.

U = Undetected.

C4 Post-Treatment Groundwater Samples

Groundwater samples were collected from 26 monitoring wells located in the Stage A EA area during November and December 2015 following application of polyphosphate solutions to the vadose zone, periodically rewetted zone, and top of the aquifer. Post-treatment samples were collected from each well at least four times within 1 month after completion of the polyphosphate infiltration and injection. Table C-5 provides the analytical results for the groundwater characteristics of dissolved oxygen, oxidation-reduction potential, specific conductance, pH, temperature, and water level. Table C-6 provides the analytical results for carbonate and bicarbonate alkalinity, metals (calcium, magnesium, potassium, sodium, and uranium), and anions (chloride, phosphate, and sulfate).

Table C-5. Post-Treatment Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b]		Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
			(mV)	(RmV)				
Monitoring Well 399-1-24 (PRZ)								
11/20/2015	B331Y4	8230	334	--	1235	6.65	16.6	105.264
12/3/2015	B33923	8260	--	303.4	911	7.01	16.4	105.209
12/11/2015	B339F3	8640	361.1	--	808	7.05	17.3	105.183
12/15/2015	B339W9	8830	327.7	--	775	7.21	16.7	105.076
Monitoring Well 399-1-25 (Aquifer)								
11/20/2015	B331X6	9330	339	--	398	7.19	15.7	105.273
12/3/2015	B33915	8120	--	321.9	1183	7.09	16.3	105.209
12/11/2015	B339D5	8290	368.9	--	1031	7.09	16.9	105.186
12/15/2015	B339W1	8670	331.7	--	882	7.27	16.9	105.079
Monitoring Well 399-1-36 (Aquifer)								
11/20/2015	B331Y8	6150	330	--	465	7.43	17.2	105.263
12/3/2015	B33927	7350	--	324.2	809	6.94	16.5	105.2
12/11/2015	B339F7	7310	356.3	--	766	6.99	17	105.177
12/15/2015	B339X3	8570	324.6	--	736	7.18	16.9	105.062
Monitoring Well 399-1-37 (PRZ)								
11/20/2015	B331Y0	8790	341	--	849	6.88	17.7	105.267
12/3/2015	B33919	8560	--	319.4	667	7.08	17	105.204
12/11/2015	B339D9	8500	359.6	--	657	7.01	17.5	105.18
12/15/2015	B339W5	9040	326.2	--	605	7.26	16.9	105.065
Monitoring Well 399-1-65 (Aquifer)								
11/30/2015	B331K8	8200	339.8	--	520	7.63	10.8	105.35
12/3/2015	B338N7	6680	--	224	813	7.58	15.5	105.147
12/11/2015	B33937	6410	282.5	--	692	7.66	17.6	105.184
12/15/2015	B339J3	6770	-181.4	--	679	7.74	17.3	105.086

Table C-5. Post-Treatment Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b] (mV)	Oxidation-Reduction Potential[b] (RmV)	Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
Monitoring Well 399-1-66 (Aquifer)								
11/20/2015	B331L6	8010	264	--	453	7.51	16.4	105.241
12/3/2015	B338P5	8240	--	210	469	7.59	17.1	Not recorded
12/11/2015	B33945	8890	316.9	--	464	7.61	17.7	105.23
12/15/2015	B339K1	8290	-37.7	--	495	7.53	17.3	105.105
Monitoring Well 399-1-67 (PRZ)								
11/30/2015	B331L2	8090	321.9	--	1445	7.15	8.8	105.361
12/3/2015	B338P1	5210	--	230	1214	7.07	14.8	105.208
12/11/2015	B33941	4400	330.3	--	1137	7.06	17.9	105.191
12/15/2015	B339J7	4180	45.7	--	1171	7.11	17.9	105.08
Monitoring Well 399-1-69 (PRZ)								
11/20/2015	B331M0	6190	273	--	577	6.94	17.2	105.241
12/3/2015	B338P9	6760	--	224	582	7.7	16.4	109.154
12/11/2015	B33949	7070	326.8	--	567	7.1	18.2	105.233
12/15/2015	B339K5	6590	180.6	--	6.13	7.14	17.6	105.094
Monitoring Well 399-1-70 (Aquifer)								
11/23/2015	B331M4	5210	216	--	481	7.55	16.3	105.298
12/2/2015	B338R3	6910	345	--	460	7.52	16.9	105.189
12/10/2015	B33953	6800	320.3	--	468	7.55	17.2	105.108
12/16/2015	B339K9	7110	55.3	--	506	7.52	17.3	105.065
Monitoring Well 399-1-71 (PRZ)								
11/23/2015	B331M8	8370	202.1	--	492	7.47	17.1	105.295
12/2/2015	B338R7	8860	361	--	474	7.44	17	105.206
12/10/2015	B33957	8970	329.2	--	462	7.51	17.3	105.11
12/16/2015	B339L3	8590	80.7	--	486	7.53	17.2	105.066

Table C-5. Post-Treatment Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b]		Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
			(mV)	(RmV)				
Monitoring Well 399-1-72 (Aquifer)								
11/20/2015	B331N2	8290	298	--	533	7.14	16.8	105.191
12/3/2015	B338T1	8940	--	323.3	473	7.5	16.7	105.221
12/11/2015	B33961	8970	389.4	--	502	7.43	17.4	105.194
12/15/2015	B339L7	9350	385.9	--	473	7.6	16.9	105.095
Monitoring Well 399-1-73 (PRZ)								
11/20/2015	B331N6	8970	274	--	463	7.32	16.4	105.221
12/3/2015	B338T5	8770	--	319.6	470	7.48	16.6	105.232
12/11/2015	B33965	8810	366.4	--	494	7.4	17.8	105.188
12/15/2015	B339M1	9220	354.6	--	474	7.55	17.1	105.096
Monitoring Well 399-1-74 (Aquifer)								
11/20/2015	B331P0	8450	307	--	1785	6.87	17	105.196
12/3/2015	B338T9	8790	--	332.6	654	7.22	16.5	105.224
12/11/2015	B33969	8830	430.4	--	597	7.21	17.2	105.181
12/15/2015	B339M5	9250	345.1	--	599	7.33	16.6	105.092
Monitoring Well 399-1-75 (PRZ)								
11/20/2015	B331P4	9460	312	--	4534	6.78	15.3	105.199
12/3/2015	B338V3	8650	--	334.4	1552	7.17	16	105.225
12/11/2015	B33973	8600	392.5	--	1297	7.16	17.2	105.195
12/15/2015	B339M9	8880	336.6	--	1260	7.31	17	105.099
Monitoring Well 399-1-76 (Aquifer)								
11/23/2015	B331P8	8350	307	--	1301	7.16	16.4	105.227
12/2/2015	B338V7	8760	391.2	--	906	7.14	16.1	105.255
12/10/2015	B33977	8650	242	--	702	7.24	17	105.108
12/16/2015	B339N3	8880	138	--	651	7.34	16.9	105.027

Table C-5. Post-Treatment Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b]		Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
			(mV)	(RmV)				
Monitoring Well 399-1-77 (PRZ)								
11/23/2015	B331R2	8680	327	--	2734	6.97	15.8	105.238
12/2/2015	B338W1	9320	858.4	--	2286	7	18.2	105.247
12/10/2015	B33981	8150	247.1	--	2003	7.07	16.5	105.096
12/16/2015	B339N7	7870	208	--	1986	7.15	16.4	105.04
Monitoring Well 399-1-78 (Aquifer)								
11/30/2015	B331R6	7170	293.1	--	3358	7.46	15.9	105.325
12/3/2015	B338W5	7380	--	205	3086	7.45	17.6	105.118
12/11/2015	B33985	6880	314.2	--	2734	7.57	16.8	105.162
12/15/2015	B339P1	6210	149.4	--	2709	7.62	16.3	105.062
Monitoring Well 399-1-79 (PRZ)								
11/30/2015	B331T0	6720	300.2	--	816	7.17	17	105.321
12/3/2015	B338W9	6630	--	204	935	7.27	16.7	105.141
12/11/2015	B33989	6830	320.1	--	740	7.25	18	105.169
12/15/2015	B339P5	6490	175.6	--	814	7.34	17.1	105.066
Monitoring Well 399-1-80 (Aquifer)								
11/23/2015	B331T4	6290	198	--	1013	6.8	15.6	105.213
12/2/2015	B338X3	7820	329.4	--	807	7.03	16.4	105.25
12/10/2015	B33993	6180	146.7	--	748	7.18	16.9	105.106
12/16/2015	B339P9	6200	33.1	--	781	7.27	16.9	105.054
Monitoring Well 399-1-81 (PRZ)								
11/23/2015	B331T8	8780	418	--	759	7.06	16.4	105.192
12/2/2015	B338X7	9060	331	--	635	7.23	15.6	105.197
12/10/2015	B33997	8770	246.2	--	615	7.28	17.1	105.097
12/16/2015	B339R3	8480	83.5	--	617	7.29	17.1	105.045

Table C-5. Post-Treatment Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b]		Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
			(mV)	(RmV)				
Monitoring Well 399-1-82 (Aquifer)								
11/23/2015	B331V2	6940	99.6	--	1203	6.83	17	105.252
12/2/2015	B338Y1	7580	465	--	1173	6.99	17.7	105.173
12/10/2015	B339B1	7760	342.1	--	1219	7.19	16.7	105.062
12/16/2015	B339R7	7570	201	--	1217	7.33	16.9	104.363
Monitoring Well 399-1-83 (PRZ)								
11/23/2015	B331V6	7920	60	--	705	7.12	17	105.261
12/2/2015	B338Y5	8300	422	--	692	7.02	17.6	105.167
12/10/2015	B339B5	8510	345.3	--	706	7.15	16.9	105.073
12/16/2015	B339T1	8380	224	--	683	7.25	16.9	105.013
Monitoring Well 399-1-84 (Aquifer)								
11/23/2015	B331W0	80	-79.5	--	611	8.04	17	105.278
12/2/2015	B338Y9	2290	106	--	584	7.99	18.2	105.159
12/10/2015	B339B9	100	97.7	--	587	8.11	17	105.071
12/16/2015	B339T5	240	46.7	--	579	8.16	16.8	105.001
Monitoring Well 399-1-85 (PRZ)								
11/23/2015	B331W4	5460	327.1	--	796	6.72	17.2	105.261
12/2/2015	B33903	6120	392	--	792	6.71	17.9	105.177
12/10/2015	B339C3	6080	359.9	--	745	6.88	17.1	105.059
12/16/2015	B339T9	5640	371	--	712	6.83	16.9	105.013
Monitoring Well 399-1-86 (Aquifer)								
11/23/2015	B331W8	7410	167	--	3707	7.12	17.1	105.268
12/2/2015	B33907	7300	320.6	--	2660	7.22	10.3	105.212
12/10/2015	B339C7	6730	158.8	--	2035	7.33	17.2	104.987
12/16/2015	B339V3	7440	17	--	1527	7.57	16.5	105.023

Table C-5. Post-Treatment Groundwater Characteristics Analytical Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Dissolved Oxygen[a] (µg/L)	Oxidation-Reduction Potential[b] (mV)	Oxidation-Reduction Potential[b] (RmV)	Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
Monitoring Well 399-1-87 (PRZ)								
11/23/2015	B331X2	7590	233.9	--	2532	7.02	16.4	105.264
12/3/2015	B33911	7710	--	190	1829	7.3	16.2	105.031
12/10/2015	B339D1	7800	237.2	--	1498	7.41	17.1	105.066
12/16/2015	B339V7	7590	45	--	1332	7.49	17	105.018

References: SESDPROC-113-R1, 2013, *Field Measurement of Oxidation-Reduction Potential (ORP)*, U.S. Environmental Protection Agency, Region 4, Science and Ecosystem Support Division, Athens, Georgia.

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

a. EPA Method 360.1. Dissolved oxygen using field probe.

b. EPA Method SESDPROC-113-R1, *Field Measurement of Oxidation-Reduction Potential (ORP)*. Oxidation-reduction potential using field probe.

c. EPA Method 120.1. Specific conductivity using field probe.

d. EPA Method 150.1. pH using field probe.

e. EPA Method 170.1. Temperature using field probe.

f. Water level measured by water level measurement tape.

-- = not applicable

NAVD88 = North American Vertical Datum of 1988

PRZ = periodically rewetted zone

RmV = Relative milliVolt.

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
Monitoring Well 399-1-24 (PRZ)											
11/20/2015	B331Y5	--	--	--	--	--	--	--	14000 D	889000 D	40000 D
	B331Y7	540 U	272000	32900	13200	7330	271000 D	7.4 D	--	--	--
12/3/2015	B33924	--	--	--	--	--	--	--	18000 D	429000 D	50000 D
	B33926	540 U	222000	38400 D	15800 D	17600 D	249000 D	1.2	--	--	--
12/11/2015	B339F4	--	--	--	--	--	--	--	20000 D	264000 D	56000 D
	B339F6	540 U	197000	28000 D	10100 D	14200 D	144000 D	2.7 BD	--	--	--
12/15/2015	B339X0	--	--	--	--	--	--	--	20000 D	270000 D	57000 D
	B339X2	540 U	198000	30100 D	11100 D	16400 D	150000 D	1.9 BD	--	--	--
Monitoring Well 399-1-25 (Aquifer)											
11/20/2015	B331X7	--	--	--	--	--	--	--	12000 D	21800 D	38000 D
	B331X9	540 U	114000	40200	8770	4300 B	28300	46.4	--	--	--
12/3/2015	B33916	--	--	--	--	--	--	--	17000 D	613000 D	47000 D
	B33918	540 U	290000	37900 D	16300 D	78000 D	340000 D	2.8	--	--	--
12/11/2015	B339D6	--	--	--	--	--	--	--	17000 D	429000 D	50000 D
	B339D8	540 U	248000	25300 D	9720 D	52800 D	185000 D	3.2 BD	--	--	--
12/15/2015	B339W2	--	--	--	--	--	--	--	19000 D	337000 D	55000 D
	B339W4	540 U	220000	23400 D	8750 D	38700 D	130000 D	2.6 BD	--	--	--
Monitoring Well 399-1-36 (Aquifer)											
11/20/2015	B331Y9	--	--	--	--	--	--	--	26000 D	3990 D	62000 D
	B33201	540 U	124000	56600	11600	4930 B	31000	148	--	--	--
12/3/2015	B33928	--	--	--	--	--	--	--	20000 D	337000 D	47000 D
	B33930	540 U	195000	52700 D	15700 D	10300 D	219000 D	17.8	--	--	--
12/11/2015	B339F8	--	--	--	--	--	--	--	22000 D	264000 D	55000 D
	B339H0	540 U	183000	42400 D	12200 D	8580 D	161000 D	25.3 D	--	--	--

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
12/15/2015	B339X4	--	--	--	--	--	--	--	22000 D	254000 D	55000 D
	B339X6	540 U	185000	45700 D	13700 D	10400 D	178000 D	14.6 D	--	--	--
Monitoring Well 399-1-37 (PRZ)											
11/20/2015	B331Y1	--	--	--	--	--	--	--	17000 D	491000 D	35000 D
	B331Y3	540 U	220000	83300	21200	8690	112000 D	7	--	--	--
12/3/2015	B33920	--	--	--	--	--	--	--	19000 D	193000 D	56000 D
	B33922	540 U	170000	48900 D	15100 D	12600 D	133000 D	7.1	--	--	--
12/11/2015	B339F0	--	--	--	--	--	--	--	21000 D	85900 D	58000 D
	B339F2	540 U	164000	49600	14800	13700	101000	8.9	--	--	--
12/15/2015	B339W6	--	--	--	--	--	--	--	21000 D	70500 D	58000 D
	B339W8	540 U	159000	37100	11500	10600	69000	6.5	--	--	--
Monitoring Well 399-1-65 (Aquifer)											
11/30/2015	B331K9	--	--	--	--	--	--	--	19000 D	163000 D	52000 D
	B331L1	540 U	237000	21100 D	7590 D	27700 ND	54100 D	7.6	--	--	--
12/3/2015	B338N8	--	--	--	--	--	--	--	21000 D	172000 D	53000 D
	B338P0	540 U	245000	33500	11100	19300	184000 D	20.8	--	--	--
12/11/2015	B33938	--	--	--	--	--	--	--	21000 D	79700 DN	60000 D
	B33940	540 U	206000	50400 D	13500 D	18000 D	144000 DN	47.4 D	--	--	--
	B339H1	--	--	--	--	--	--	--	21000 D	82800 DN	60000 D
	B339H3	540 U	210000	52600 D	14800 D	19300 D	158000 D	47.6 D	--	--	--
12/15/2015	B339J4	--	--	--	--	--	--	--	21000 D	58300 D	59000 D
	B339J6	540 U	190000	32700	9480	9050	94800	52.4	--	--	--

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
Monitoring Well 399-1-66 (Aquifer)											
11/20/2015	B331L7	--	--	--	--	--	--	--	20000 D	951 D	61000 D
	B331L9	540 U	129000	55600	12100	4970 B	25300	56.1	--	--	--
12/3/2015	B338P6	--	--	--	--	--	--	--	19000 D	368 BD	59000 D
	B338P8	540 U	134000	55600	13500	5030	28800	49.7	--	--	--
12/11/2015	B33946	--	--	--	--	--	--	--	19000 D	368 BD	59000 D
	B33948	540 U	128000	66700	16900	6650	33700	56.3	--	--	--
12/15/2015	B339K2	--	--	--	--	--	--	--	20000 D	251 U	60000 D
	B339K4	540 U	132000	44000	11800	4200	22400	43.2	--	--	--
Monitoring Well 399-1-67 (PRZ)											
11/30/2015	B331L3	--	--	--	--	--	--	--	34000 D	368000 D	66000 D
	B331L5	540 U	442000	18500 D	7320 BD	59800 ND	233000 D	145	--	--	--
12/3/2015	B338P2	--	--	--	--	--	--	--	29000 D	282000 ND	62000 D
	B338P4	540 U	396000	20600	8150	63400	333000 D	73.1	--	--	--
12/11/2015	B33942	--	--	--	--	--	--	--	27000 D	267000 DN	64000 D
	B33944	540 U	370000	35700 D	12800 D	81900 D	335000 D	59.2 D	--	--	--
12/15/2015	B339J8	--	--	--	--	--	--	--	25000 D	368000 D	63000 D
	B339K0	540 U	358000	21800 D	8050 D	45000 D	196000 D	37.7 D	--	--	--
Monitoring Well 399-1-69 (PRZ)											
11/20/2015	B331M1	--	--	--	--	--	--	--	19000 D	251 U	60000 D
	B331M3	540 U	204000	81000	16800	4780 B	26500	174	--	--	--
12/3/2015	B338R0	--	--	--	--	--	--	--	19000 D	251 U	59000 D
	B338R2	540 U	198000	87200	20100	5750	30900	187	--	--	--
12/11/2015	B33950	--	--	--	--	--	--	--	19000 D	251 U	59000 D
	B33952	540 U	192000	70800	15400	4450	24700 N	134	--	--	--

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
12/15/2015	B339K6	--	--	--	--	--	--	--	19000 D	251 U	61000 D
	B339K8	540 U	200000	85200	19100	5050	28300	183	--	--	--
Monitoring Well 399-1-70 (Aquifer)											
11/23/2015	B331M5	--	--	--	--	--	--	--	16000 D	10100 D	48000 D
	B331M7	540 U	144000	54000	13300	5370	26900	20.6	--	--	--
12/2/2015	B338R4	--	--	--	--	--	--	--	16000 D	7970 D	49000 D
	B338R6	540 U	140000	57100	15000	6240	30900	25.9	--	--	--
12/10/2015	B33954	--	--	--	--	--	--	--	15000 D	12600 DN	47000 D
	B33956	540 U	146000	57400	18900	6730	40500	16.3	--	--	--
12/16/2015	B339L0	--	--	--	--	--	--	--	16000 D	14700 DN	50000 D
	B339L2	540 U	146000	65200	17200	6830	38200	16.1	--	--	--
Monitoring Well 399-1-71 (PRZ)											
11/23/2015	B331M9	--	--	--	--	--	--	--	19000 D	429 BD	59000 D
	B331N1	540 U	132000	57900	12900	4960 B	25000	41.3	--	--	--
12/2/2015	B338R8	--	--	--	--	--	--	--	19000 D	429 BD	59000 D
	B338T0	540 U	128000	58000	14700	5870	28200	56.9	--	--	--
12/10/2015	B33958	--	--	--	--	--	--	--	19000 D	429 BD	59000 D
	B33960	540 U	128000	63100	16200	6120	30900	48.5	--	--	--
12/16/2015	B339L4	--	--	--	--	--	--	--	20000 D	644 D	59000 D
	B339L6	540 U	125000	49400	12100	4870	23800	41.8	--	--	--
Monitoring Well 399-1-72 (Aquifer)											
11/20/2015	B331N3	--	--	--	--	--	--	--	20000 D	39900 D	57000 D
	B331N5	540 U	148000	64800	15500	6080	46600	12.9	--	--	--
12/3/2015	B338T2	--	--	--	--	--	--	--	21000 D	4600 ND	59000 D
	B338T4	540 U	129000	55800	14500	6740	31900	26.4	--	--	--

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
12/11/2015	B33962	--	--	--	--	--	--	--	23000 D	4290 DN	59000 D
	B33964	540 U	127000	65900	16600	7510	36800	28.2	--	--	--
12/15/2015	B339L8	--	--	--	--	--	--	--	23000 D	1930 D	59000 D
	B339M0	540 U	126000	44000	12100	4910	24000	21.5	--	--	--
Monitoring Well 399-1-73 (PRZ)											
11/20/2015	B331N7	--	--	--	--	--	--	--	23000 D	251 U	61000 D
	B331N9	540 U	126000	57500	12600	4950 B	25300	99.6	--	--	--
12/3/2015	B338T6	--	--	--	--	--	--	--	23000 D	429 BD	59000 D
	B338T8	540 U	130000	54900	13200	5010	29000	72	--	--	--
12/11/2015	B33966	--	--	--	--	--	--	--	22000 D	399 BD	59000 D
	B33968	540 U	126000	66800	16600	6560	33200 N	74.4	--	--	--
12/15/2015	B339M2	--	--	--	--	--	--	--	24000 D	399 BD	60000 D
	B339M4	540 U	127000	46700	12400	4560	24000	51.3	--	--	--
Monitoring Well 399-1-74 (Aquifer)											
11/20/2015	B331P1	--	--	--	--	--	--	--	19000 BD	1290000 D	46000 D
	B331P3	540 U	416000	29500	15700	110000 D	344000 D	1.6	--	--	--
	B33202	--	--	--	--	--	--	--	20000 D	1290000 D	46000 D
	B33204	540 U	418000	29700	15900	107000 D	333000 D	1.5	--	--	--
12/3/2015	B338V0	--	--	--	--	--	--	--	19000 D	141000 ND	57000 D
	B338V2	540 U	172000	48200 D	15700 D	31900 D	112000 D	6.1	--	--	--
12/11/2015	B33970	--	--	--	--	--	--	--	21000 D	61300 DN	58000 D
	B33972	540 U	154000	56600 D	15000 D	25000 D	87800 DN	9.4 D	--	--	--
12/15/2015	B339M6	--	--	--	--	--	--	--	22000 D	58300 D	59000 D
	B339M8	540 U	156000	37500	11300	16500	61200	7.6	--	--	--

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
Monitoring Well 399-1-75 (PRZ)											
11/20/2015	B331P5	--	--	--	--	--	--	--	22000 BD	3990000 D	35000 BD
	B331P7	540 U	1030000	30400	26300	295000 D	931000 D	24	--	--	--
12/3/2015	B338V4	--	--	--	--	--	--	--	24000 D	797000 ND	49000 D
	B338V6	540 U	371000	24100 D	11500 D	137000 D	449000 D	10.6	--	--	--
12/11/2015	B33974	--	--	--	--	--	--	--	20000 D	583000 DN	50000 D
	B33976	540 U	312000	31100 D	11500 D	107000 D	333000 D	11 D	--	--	--
12/15/2015	B339N0	--	--	--	--	--	--	--	22000 D	583000 D	53000 D
	B339N2	540 U	309000	18200 D	7140 D	62900 D	219000 D	5.8 D	--	--	--
Monitoring Well 399-1-76 (Aquifer)											
11/23/2015	B331P9	--	--	--	--	--	--	--	16000 D	705000 DN	45000 D
	B331R1	540 U	302000	33100	13600	71300 D	240000 D	2.8 BD	--	--	--
12/2/2015	B338V8	--	--	--	--	--	--	--	17000 D	368000 D	49000 D
	B338W0	540 U	224000	45000 D	16400 D	56200 D	203000 D	7.6	--	--	--
12/10/2015	B33978	--	--	--	--	--	--	--	20000 D	199000 D	56000 D
	B33980	540 U	180000	48400	14900	34200	119000	14.1	--	--	--
12/16/2015	B339N4	--	--	--	--	--	--	--	21000 D	98100 D	58000 D
	B339N6	540 U	165000	52300 D	14800 D	35100 D	106000 D	18.1 D	--	--	--
Monitoring Well 399-1-77 (PRZ)											
11/23/2015	B331R3	--	--	--	--	--	--	--	15000 BD	2270000 DN	31000 D
	B331R5	540 U	622000	30600	21600	102000 D	680000 D	5.7 BD	--	--	--
12/2/2015	B338W2	--	--	--	--	--	--	--	22000 D	1470000 D	46000 D
	B338W4	540 U	528000	28100 D	19100 D	94600 D	724000 D	2.5	--	--	--
12/10/2015	B33982	--	--	--	--	--	--	--	20000 D	1350000 D	44000 D
	B33984	540 U	490000	19800 D	17800 D	82700 D	672000 D	2.1	--	--	--

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
12/16/2015	B339N8	--	--	--	--	--	--	--	20000 D	1350000 D	49000 D
	B339P0	540 U	486000	30000 D	18200 D	94000 D	675000 D	2.3 U	--	--	--
Monitoring Well 399-1-78 (Aquifer)											
11/30/2015	B331R7	--	--	--	--	--	--	--	24000 D	2090000 D	31000 D
	B331R9	540 U	958000	11000 BD	17900 BD	44500 BND	973000 D	1.2	--	--	--
12/3/2015	B338W6	--	--	--	--	--	--	--	22000 D	1960000 D	32000 D
	B338W8	540 U	892000	10700	16100	45000	1030000 D	0.85 B	--	--	--
12/3/2015	B33931	--	--	--	--	--	--	--	22000 D	1960000 D	32000 D
	B33933	540 U	888000	10900	16300	44900	1130000 D	0.86 B	--	--	--
12/11/2015	B33986	--	--	--	--	--	--	--	19000 BD	1720000 D	37000 D
	B33988	540 U	802000	126000 D	165000 D	600000 D	1110000 D	7.2 BD	--	--	--
12/15/2015	B339P2	--	--	--	--	--	--	--	20000 D	1530000 D	41000 D
	B339P4	540 U	745000	12400 D	16400 D	63600 D	936000 D	2.3 U	--	--	--
Monitoring Well 399-1-79 (PRZ)											
11/30/2015	B331T1	--	--	--	--	--	--	--	35000 D	15900 D	58000 D
	B331T3	540 U	289000	69200 D	17600 D	7640 BND	97500 D	1340	--	--	--
12/3/2015	B338X0	--	--	--	--	--	--	--	26000 D	107000 D	47000 D
	B338X2	540 U	334000	50500	14800	6710	192000 D	418	--	--	--
12/11/2015	B33990	--	--	--	--	--	--	--	27000 D	15300 D	58000 D
	B33992	540 U	263000	88400 D	22700 D	9220 D	120000 D	1050 D	--	--	--
12/15/2015	B339P6	--	--	--	--	--	--	--	25000 D	33700 D	55000 D
	B339P8	540 U	274000	71900 D	19700 D	8220 D	158000 D	527 D	--	--	--
Monitoring Well 399-1-80 (Aquifer)											
11/23/2015	B331T5	--	--	--	--	--	--	--	19000 D	644000 DN	36000 D
	B331T7	540 U	200000	43900	13000	6900 BD	194000 D	103 D	--	--	--

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
12/2/2015	B338X4	--	--	--	--	--	--	--	21000 D	337000 D	44000 D
	B338X6	540 U	190000	40100 D	12700 D	8530 D	196000 D	126	--	--	--
12/10/2015	B33994	--	--	--	--	--	--	--	22000 D	294000 D	46000 D
	B33996	540 U	188000	39700 D[d]	11900 D[d]	8800 D[d]	198000 D[d]	85.1[d]	--	--	--
12/16/2015	B339R0	--	--	--	--	--	--	--	23000 D	254000 D	49000 D
	B339R2	540 U	185000	27400 D	7820 D	6950 D	140000 D	76.8 D	--	--	--
Monitoring Well 399-1-81 (PRZ)											
11/23/2015	B331T9	--	--	--	--	--	--	--	27000 D	254000 DN	46000 D
	B331V1	540 U	174000	35500	9500	6070 BD	142000 D	1 BD	--	--	--
12/2/2015	B338X8	--	--	--	--	--	--	--	23000 D	92000 D	57000 D
	B338Y0	540 U	162000	46400 D	14600 D	8140 D	113000 D	5.7	--	--	--
12/10/2015	B33998	--	--	--	--	--	--	--	22000 D	79700 DN	57000 D
	B339B0	540 U	163000	61800 D	17100 D	10100 D	119000 D	6.4 D	--	--	--
12/16/2015	B339R4	--	--	--	--	--	--	--	23000 D	58300 D	57000 D
	B339R6	540 U	153000	50600	14400	8580	85900	5.8	--	--	--
Monitoring Well 399-1-82 (Aquifer)											
11/23/2015	B331V3	--	--	--	--	--	--	--	26000 D	583000 DN	36000 D
	B331V5	540 U	294000	63100 D	17500 D	7960 BD	216000 D	3.1	--	--	--
12/2/2015	B338Y2	--	--	--	--	--	--	--	13000 D	675000 D	36000 D
	B338Y4	540 U	310000	44800 D	15800 D	7580 D	366000 D	0.9 B	--	--	--
12/10/2015	B339B2	--	--	--	--	--	--	--	16000 D	644000 D	45000 D
	B339B4	540 U	309000	34900 D	13800 D	6340 D	369000 D	1	--	--	--
12/16/2015	B339R8	--	--	--	--	--	--	--	16000 D	613000 DN	48000 D
	B339T0	540 U	320000	23400 D	8800 D	4890 D	273000 D	1.2 U	--	--	--

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
Monitoring Well 399-1-83 (PRZ)											
11/23/2015	B331V7	--	--	--	--	--	--	--	25000 D	42900 DN	50000 D
	B331V9	540 U	207000	76900	18500	6160	60300	61.5	--	--	--
12/2/2015	B338Y6	--	--	--	--	--	--	--	18000 D	150000 D	53000 D
	B338Y8	540 U	198000	77000 D	22300 D	8130 D	114000 D	7.4	--	--	--
12/10/2015	B339B6	--	--	--	--	--	--	--	19000 D	218000 D	55000 D
	B339B8	540 U	184000	57500 D	16100 D	6630 D	138000 D	2	--	--	--
12/16/2015	B339T2	--	--	--	--	--	--	--	20000 D	193000 D	56000 D
	B339T4	540 U	177000	38900 D	10100 D	5140 D	104000 D	1.2 U	--	--	--
Monitoring Well 399-1-84 (Aquifer)											
11/23/2015	B331W1	--	--	--	--	--	--	--	34000 D	251 UN	130000 D
	B331W3	540 U	118000	73300	17600	6790	21300	0.23 U	--	--	--
12/2/2015	B33900	--	--	--	--	--	--	--	34000 D	251 UN	130000 D
	B33902	540 U	120000	77300	19600	7970	23100	0.23 U	--	--	--
12/10/2015	B339C0	--	--	--	--	--	--	--	32000 D	251 UN	120000 D
	B339C2	540 U	118000	78300	21200	7760	25000	0.23 B	--	--	--
12/16/2015	B339T6	--	--	--	--	--	--	--	34000 D	251 U	130000 D
	B339T8	540 U	117000	84000	21400	8410	25600	0.4 B	--	--	--
Monitoring Well 399-1-85 (PRZ)											
11/23/2015	B331W5	--	--	--	--	--	--	--	49000 D	6440 UN	53000 D
	B331W7	540 U	220000	108000 D	23300	4290 BD	31400 D	1270	--	--	--
12/2/2015	B33904	--	--	--	--	--	--	--	51000 D	6440 U	54000 D
	B33906	540 U	246000	97700	21500	4620	37600	1270	--	--	--
12/10/2015	B339C4	--	--	--	--	--	--	--	48000 D	2540 DN	58000 D
	B339C6	540 U	233000	109000	26100	5870	57800	777	--	--	--

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate
12/16/2015	B339V0	--	--	--	--	--	--	--	37000 D	3370 D	58000 D
	B339V2	540 U	222000	80300 D	18600 D	4340 D	41100 D	1070 D	--	--	--
Monitoring Well 399-1-86 (Aquifer)											
11/23/2015	B331W9	--	--	--	--	--	--	--	9500 BD	1010000 D	22000 D
	B331X1	540 U	794000	21300	29900	233000 D	1600000 D	14.8	--	--	--
12/2/2015	B33908	--	--	--	--	--	--	--	15000 BD	1870000 D	36000 D
	B33910	540 U	694000	18600 D	19900 D	164000 D	885000 D	8.5	--	--	--
12/10/2015	B339C8	--	--	--	--	--	--	--	16000 D	1230000 D	44000 D
	B339D0	540 U	530000	14800 D	12900 D	125000 D	679000 D	33.9 D	--	--	--
12/16/2015	B339V4	--	--	--	--	--	--	--	17000 D	1040000 D	49000 D
	B339V6	540 U	488000	13000 D	11600 D	109000 D	587000 D	8.5 BD	--	--	--
12/16/2015	B339X7	--	--	--	--	--	--	--	17000 D	1040000 D	49000 D
	B339X9	540 U	492000	12500 D	11000 D	105000 D	562000 D	15.4 D	--	--	--
Monitoring Well 399-1-87 (PRZ)											
11/23/2015	B331X3	--	--	--	--	--	--	--	19000 BD	1630000 D	44000 D
	B331X5	540 U	606000	27500	18600	103000 D	589000 D	12.6	--	--	--
12/3/2015	B33912	--	--	--	--	--	--	--	20000 D	951000 ND	52000 D
	B33914	540 U	466000	18100	11300	70900	566000 D	8.8	--	--	--
12/10/2015	B339D2	--	--	--	--	--	--	--	18000 D	736000 D	51000 D
	B339D4	540 U	390000	20100 D	12300 D	80400 D	443000 D	6.6	--	--	--
12/16/2015	B339V8	--	--	--	--	--	--	--	19000 D	583000 D	60000 D
	B339W0	540 U	344000	20700 D	11100 D	78600 D	363000 D	8.2 D	--	--	--

Reference: DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079669H.

Table C-6. Post-Treatment Groundwater Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Monitoring Wells

Sample Date	Sample Number	Alkalinity[a] (µg/L)		Metals[b] (µg/L)					Anions[c] (µg/L)		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Uranium	Chloride	Phosphate	Sulfate

a. EPA Method 310.1.

b. EPA Method 6020. Results in this table are for unfiltered samples collected in accordance with Table A-6 in DOE/RL-2014-42.

c. EPA Method 300.

d. Sample was filtered because of high turbidity measured during sampling.

-- = not applicable

PRZ = periodically rewetted zone

Laboratory Qualifiers:

B = The analyte was detected at a value less than the contract required detection limit, but greater than or equal to the instrument detection limit/maximum detection limit (as appropriate).

D = Analyte was reported at a secondary dilution factor.

N = Spike and/or spike duplicate sample recovery is outside control limits.

U = Undetected.

C5 Downgradient Groundwater Samples

Groundwater samples were collected from selected monitoring wells downgradient of the Stage A EA area (wells 399-1-7, 399-1-16A, 399-1-17A, 399-1-23, 399-2-1, 399-2-2, and 399-2-3) from September 2015 through June 2016. The samples were collected and analyzed by PNNL. Table C-7 provides the analytical results for the groundwater characteristics of dissolved oxygen, inorganic carbon, alkalinity, nonpurgable organic carbon, specific conductance, pH, temperature, and water level. Table C-8 provides the analytical results for metals (calcium, iron, magnesium, manganese, potassium, sodium, and uranium) and anions (chloride, fluoride, nitrite, nitrate, phosphate, and sulfate).

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
Well 399-1-23									
11/16/2015	8.66	44.7	223	1.20	574	7.20	16.3	11.11 (36.45)	105.20
11/19/2015	8.75	37.9	189	2.09	951	6.60	16.6	11.05 (36.25)	105.26
12/1/2015	9.43	35.5	178	1.16	741	6.98	16.4	11.02 (36.15)	105.29
12/9/2015	9.25	30.9	154	0.37	611	7.15	16.6	11.23 (36.84)	105.08
12/16/2015	9.57	29.7	148	0.33	578	7.20	15.9	11.26 (36.93)	105.05
12/22/2015	8.03	35.3	177	0.69	684	7.25	16.7	11.05 (36.25)	105.26
12/29/2015	8.26	31.6	158	0.29	572	7.38	15.9	11.21 (36.79)	105.09
1/6/2016	8.39	33.9	170	0.65	646	7.24	16.2	11.07 (36.31)	105.24
1/13/2016	8.22	33.6	168	0.42	634	7.23	16.6	11.09 (36.37)	105.22
2/10/2016	8.61	33.6	168	0.70	647	7.29	16.5	11.13 (36.51)	105.18
3/10/2016	8.63	35.2	176	0.48	603	7.30	17.1	10.73 (35.21)	105.58
4/7/2016	8.74	31.7	159	0.31	590	7.25	17.4	10.83 (35.52)	105.48
5/9/2016	9.18	32.6	163	0.52	556	7.33	16.9	10.25 (33.62)	106.06

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
6/14/2016	8.75	31.1	155	0.33	504	7.38	17.3	10.57 (34.69)	105.74
Well 399-1-16A (0.25 m Interval[h])									
9/23/2015	--	29.6	148	0.41	370	7.48	--	12.29 (40.31)	105.01
9/30/2015	9.06	32.8	164	0.23	389	7.33	16.4	12.26 (40.22)	105.04
10/8/2015	9.40	32.4	162	0.36	449	7.38	16.6	12.36 (40.54)	104.94
10/14/2015	9.27	31.8	159	0.51	443	7.47	16.6	12.46 (40.87)	104.84
11/6/2015	9.04	30.9	154	0.45	443	7.53	16.2	12.22 (40.09)	105.08
11/16/2015	8.98	30.3	151	0.51	452	7.49	16.2	12.10 (39.70)	105.20
11/19/2015	9.26	30.9	154	0.27	460	7.47	15.8	12.01 (39.40)	105.29
12/1/2015	9.17	30.3	152	0.33	447	7.29	15.8	12.08 (39.62)	105.22
12/9/2015	8.90	31.9	159	0.31	444	7.54	16.5	12.28 (40.29)	105.02
12/22/2015	8.26	32.5	162	0.45	454	7.63	15.8	12.09 (39.65)	105.21
12/29/2015	8.09	33.0	165	0.31	456	7.54	16.0	12.23 (40.14)	105.07
1/6/2016	9.05	32.2	161	0.32	459	7.51	15.8	12.13 (39.79)	105.17

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
1/13/2016	8.27	33.1	166	0.32	460	7.58	15.7	12.12 (39.78)	105.18
2/10/2016	8.38	34.0	170	0.33	458	7.48	16.5	12.15 (39.85)	105.15
3/10/2016	8.35	32.6	163	0.60	449	7.53	16.4	11.74 (38.51)	105.56
4/7/2016	8.60	29.9	149	0.64	447	7.40	17.6	11.82 (38.78)	105.48
5/9/2016	7.98	22.5	112	0.57	296	7.52	15.1	11.30 (37.07)	106.00
6/14/2016	8.22	25.2	126	0.39	322	7.52	16.6	11.63 (38.14)	105.67
Well 399-1-17A (0.25 m Interval[h])									
9/23/2015	--	29.7	148	0.39	408	7.50	--	11.05 (36.24)	105.02
9/30/2015	9.33	32.7	163	0.30	415	7.38	17.1	11.00 (36.10)	105.07
10/8/2015	9.43	33.2	166	0.28	458	7.39	17.1	11.07 (36.31)	105.01
10/14/2015	9.48	32.5	163	0.30	452	7.51	16.9	11.21 (36.79)	104.86
11/6/2015	9.25	30.8	154	0.32	448	7.51	16.5	10.99 (36.05)	105.08
11/16/2015	8.90	39.0	195	1.93	606	7.19	16.7	10.90 (35.75)	105.18
11/19/2015	8.94	31.7	158	1.80	711	7.02	16.5	10.83 (35.53)	105.24

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
12/1/2015	8.97	28.0	140	0.88	693	6.81	17.0	10.79 (35.41)	105.28
12/9/2015	8.89	29.9	149	0.58	605	7.01	17.1	11.00 (36.09)	105.07
12/16/2015	9.08	30.4	152	0.47	600	7.15	16.8	11.04 (36.21)	105.04
12/22/2015	8.15	30.2	151	0.41	607	7.22	16.6	10.82 (35.51)	105.25
12/29/2015	8.19	31.4	157	0.44	598	7.18	16.7	10.99 (36.05)	105.08
1/6/2016	8.39	30.7	153	0.39	570	7.18	16.6	10.84 (35.57)	105.23
1/13/2016	8.40	31.3	156	0.45	585	7.19	16.5	10.86 (35.63)	105.21
2/10/2016	8.53	30.8	154	0.40	562	7.24	16.3	10.90 (35.76)	105.17
3/10/2016	8.68	32.3	162	0.37	535	7.29	16.8	10.50 (34.46)	105.57
4/7/2016	8.68	31.0	155	0.31	533	7.26	17.9	10.60 (34.79)	105.47
5/9/2016	9.27	31.9	159	0.33	518	7.31	17.0	10.02 (32.88)	106.05
6/14/2016	8.90	29.9	150	1.60	480	7.38	17.1	10.35 (33.96)	105.72

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
Well 399-2-1 (0.25 m Interval[h])									
9/15/2015	6.60	28.7	143	0.43	413	7.11	16.6	10.42 (34.18)	104.98
9/23/2015	7.10	33.9	169	0.25	394	6.99	16.6	10.38 (34.06)	105.02
9/30/2015	8.92	32.5	163	0.45	406	7.41	16.5	10.34 (33.92)	105.06
10/8/2015	7.47	30.9	154	0.28	446	7.27	16.3	10.47 (34.36)	104.93
10/14/2015	8.70	30.6	153	0.28	449	7.48	16.3	10.56 (34.66)	104.83
11/6/2015	8.58	30.4	152	0.32	452	7.46	15.3	10.33 (33.90)	105.07
11/19/2015	8.65	30.1	151	0.31	424	7.50	15.8	10.10 (33.15)	105.29
12/1/2015	8.93	29.7	149	0.28	423	7.43	15.5	10.20 (33.45)	105.20
12/9/2015	8.26	31.4	157	0.37	455	7.49	16.5	10.41 (34.14)	104.99
12/22/2015	7.75	28.7	143	0.35	396	7.29	16.3	10.20 (33.45)	105.20
12/29/2015	7.72	31.6	158	0.29	448	7.40	16.3	10.34 (33.91)	105.06
1/7/2016	7.92	30.9	155	0.66	448	7.45	16.2	10.28 (33.72)	105.12
1/13/2016	7.82	32.3	161	0.35	460	7.34	16.3	10.24 (33.58)	105.16

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
2/10/2016	7.88	32.3	161	0.37	446	7.36	16.7	10.26 (33.65)	105.14
3/10/2016	8.12	26.1	131	0.48	346	7.35	16.7	9.84 (32.29)	105.56
4/7/2016	7.88	28.8	144	0.46	415	7.33	16.7	9.94 (32.60)	105.46
5/9/2016	7.70	19.6	98.0	0.76	217	7.39	14.0	9.43 (30.95)	105.97
6/14/2016	7.41	26.3	131	1.99	321	7.35	15.9	9.73 (31.92)	105.67
Well 399-2-1 (Bottom Interval[i])									
9/23/2015	7.06	30.7	154	0.26	401	7.19	15.8	10.38 (34.06)	105.02
9/30/2015	7.48	32.6	163	0.30	406	7.47	16.5	10.34 (33.92)	105.06
10/8/2015	8.67	30.4	152	0.23	448	7.37	16.3	10.47 (34.36)	104.93
10/14/2015	5.91	30.2	151	0.29	450	7.49	16.0	10.56 (34.66)	104.83
11/6/2015	7.13	29.9	150	0.27	454	7.51	15.4	10.33 (33.90)	105.07
11/19/2015	6.63	29.8	149	0.44	434	7.51	15.7	10.10 (33.15)	105.29
12/1/2015	6.74	29.8	149	0.28	424	7.31	15.8	10.20 (33.45)	105.20
12/9/2015	7.49	31.2	156	0.25	441	7.56	15.8	10.41 (34.14)	104.99

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
12/22/2015	6.18	29.6	148	0.53	421	7.38	16.0	10.20 (33.45)	105.20
12/29/2015	6.24	31.5	158	0.27	444	7.45	16.0	10.34 (33.91)	105.06
1/7/2016	7.12	31.4	157	0.36	451	7.50	15.9	10.28 (33.72)	105.12
1/13/2016	6.34	33.7	169	0.31	457	7.42	16.0	10.24 (33.58)	105.16
2/10/2016	6.22	32.5	162	0.34	453	7.35	16.6	10.26 (33.65)	105.14
3/10/2016	6.90	29.9	149	0.56	413	7.32	16.4	9.84 (32.29)	105.56
4/7/2016	6.65	30.4	152	0.28	423	7.37	16.5	9.94 (32.60)	105.46
5/9/2016	7.61	20.1	100	0.64	220	7.33	13.3	9.43 (30.95)	105.97
6/14/2016	7.31	25.3	127	0.86	318	7.41	15.2	9.73 (31.92)	105.67
Well 399-2-2 (0.25 m Interval[h])									
9/15/2015	8.10	29.9	149	0.22	415	7.29	18.1	11.09 (36.39)	105.00
9/23/2015	7.61	29.1	145	0.29	345	7.26	18.9	11.08 (36.34)	105.02
9/30/2015	2.88	26.8	134	0.51	347	7.51	17.1	11.06 (36.27)	105.04
10/8/2015	3.37	27.1	135	0.52	385	7.42	17.4	11.16 (36.61)	104.94

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
10/14/2015	3.93	27.3	137	0.33	406	7.45	17.1	11.25 (36.92)	104.84
11/6/2015	5.01	25.3	126	0.81	393	7.43	15.8	11.02 (36.15)	105.08
11/19/2015	3.62	27.1	135	0.35	405	7.64	16.1	10.79 (35.40)	105.31
12/1/2015	0.57	29.0	145	0.34	420	7.59	16.8	10.87 (35.67)	105.22
12/9/2015	3.06	29.1	146	0.32	417	7.66	16.9	11.08 (36.36)	105.01
12/18/2015	1.60	28.8	144	0.51	402	7.38	17.0	11.03 (36.18)	105.07
12/22/2015	3.91	30.6	153	0.37	456	7.47	16.8	10.88 (35.71)	105.21
12/29/2015	2.79	31.4	157	0.32	389	7.23	16.3	11.03 (36.19)	105.06
1/6/2016	2.87	30.5	153	0.41	395	7.77	16.4	10.30 (33.78)	105.80
1/13/2016	0.96	30.5	153	0.56	412	7.23	16.4	10.92 (35.82)	105.18
2/10/2016	2.03	32.5	163	0.47	443	7.19	16.3	10.95 (35.91)	105.15
3/10/2016	2.86	29.0	145	0.34	402	7.29	16.6	10.53 (34.56)	105.57
4/7/2016	5.46	28.4	142	0.44	438	7.10	17.2	10.62 (34.83)	105.48
5/9/2016	1.30	20.7	104	0.61	204	7.54	15.9	10.10 (33.15)	106.00

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
6/14/2016	1.68	22.9	114	0.47	265	7.33	17.3	10.42 (34.19)	105.68
Well 399-2-2 (2 m Interval[j])									
9/23/2015	7.21	31.5	157	0.33	389	7.30	17.7	11.08 (36.34)	105.02
9/30/2015	8.67	33.4	167	0.28	408	7.44	16.6	11.06 (36.27)	105.04
10/8/2015	8.89	32.1	160	0.39	446	7.39	16.1	11.16 (36.61)	104.94
10/14/2015	9.13	31.9	160	0.25	448	7.42	16.4	11.25 (36.92)	104.84
11/6/2015	8.77	30.9	155	0.46	450	7.41	16.2	11.02 (36.15)	105.08
11/19/2015	8.78	30.7	153	0.29	448	7.42	16.2	10.79 (35.40)	105.31
12/1/2015	8.47	30.4	152	0.27	433	7.49	16.6	10.87 (35.67)	105.22
12/9/2015	8.78	31.1	155	0.34	449	7.64	16.0	11.08 (36.36)	105.01
12/18/2015	8.53	34.8	174	0.38	473	7.29	16.3	11.03 (36.18)	105.07
12/22/2015	7.79	34.8	174	0.30	485	7.51	16.2	10.88 (35.71)	105.21
12/29/2015	7.53	37.4	187	0.39	510	7.47	16.1	11.03 (36.19)	105.06
1/6/2016	7.96	36.4	182	0.34	492	7.35	16.4	10.30 (33.78)	105.80

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
1/13/2016	7.81	36.5	183	0.41	496	7.37	16.0	10.92 (35.82)	105.18
2/10/2016	8.02	35.3	176	0.37	488	7.44	16.3	10.95 (35.91)	105.15
3/10/2016	8.08	29.4	147	0.34	411	7.46	15.9	10.53 (34.56)	105.57
4/7/2016	8.29	33.0	165	0.47	475	7.38	16.4	10.62 (34.83)	105.48
5/9/2016	7.39	21.5	108	0.52	224	7.44	12.4	10.10 (33.15)	106.00
6/14/2016	7.20	26.6	133	2.08	328	7.42	14.7	10.42 (34.19)	105.68
Well 399-2-3 (0.25 m Interval[h])									
9/15/2015	2.43	28.2	141	0.56	321	7.31	16.8	10.47 (34.34)	104.99
9/23/2015	3.61	32.1	161	0.65	352	7.39	18.5	10.44 (34.24)	105.02
9/30/2015	3.44	31.0	155	0.56	359	7.63	17.1	10.42 (34.18)	105.04
10/8/2015	9.03	27.2	136	0.74	368	7.58	17.3	10.52 (34.52)	104.93
10/14/2015	3.97	26.6	133	0.45	364	7.81	16.7	10.62 (34.84)	104.84
11/6/2015	2.90	25.0	125	0.58	370	7.66	16.3	10.38 (34.04)	105.08
11/19/2015	6.50	25.5	127	0.36	378	7.91	15.9	10.17 (33.35)	105.29

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
12/1/2015	2.29	23.4	117	0.33	348	7.60	16.2	10.24 (33.60)	105.21
12/9/2015	0.75	23.3	116	0.54	342	7.87	17.1	10.45 (34.28)	105.01
12/22/2015	2.72	25.2	126	0.32	390	7.98	16.3	10.25 (33.62)	105.21
12/29/2015	2.74	25.5	127	0.37	372	8.22	16.1	10.39 (34.10)	105.06
1/6/2016	1.95	25.6	128	0.42	404	7.52	16.4	10.93 (35.86)	104.53
1/13/2016	2.51	26.3	131	0.38	398	8.10	16.1	10.28 (33.74)	105.17
2/10/2016	5.14	26.7	133	0.36	435	7.65	16.5	10.31 (33.83)	105.15
3/10/2016	4.82	28.1	140	0.40	427	7.83	16.7	9.90 (32.47)	105.56
4/7/2016	5.48	27.1	136	0.41	452	7.55	17.3	9.98 (32.75)	105.48
5/9/2016	1.30	19.4	97.1	0.75	215	8.77	15.7	9.47 (31.08)	105.99
6/14/2016	2.55	23.2	116	2.46	317	8.41	16.9	9.78 (32.10)	105.68
Well 399-2-3 (2 m Interval[j])									
9/23/2015	3.60	32.7	163	0.33	371	7.31	19.2	10.44 (34.24)	105.02
9/30/2015	8.68	34.2	171	0.40	415	7.58	17.0	10.42 (34.18)	105.04

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
10/8/2015	4.77	32.5	162	0.28	430	7.51	16.7	10.52 (34.52)	104.93
10/14/2015	8.20	30.7	154	0.41	447	7.58	16.6	10.62 (34.84)	104.84
11/6/2015	3.85	30.5	153	0.28	442	7.53	16.5	10.38 (34.04)	105.08
11/19/2015	8.88	30.2	151	0.28	450	7.61	16.3	10.17 (33.35)	105.29
12/1/2015	8.55	30.6	153	0.25	441	7.56	16.2	10.24 (33.60)	105.21
12/9/2015	8.72	31.4	157	0.49	447	7.66	16.6	10.45 (34.28)	105.01
12/22/2015	7.54	32.6	163	0.26	473	7.48	16.4	10.25 (33.62)	105.21
12/29/2015	8.00	33.1	165	0.29	469	7.52	16.5	10.39 (34.10)	105.06
1/6/2016	7.61	35.3	176	0.34	493	7.40	15.9	10.93 (35.86)	104.53
1/13/2016	7.94	33.8	169	0.55	490	7.45	16.3	10.28 (33.74)	105.17
2/10/2016	8.03	32.6	163	0.33	481	7.46	16.5	10.31 (33.83)	105.15
3/10/2016	8.02	31.9	160	0.32	465	7.52	16.6	9.90 (32.47)	105.56
4/7/2016	8.21	32.2	161	0.29	490	7.44	16.9	9.98 (32.75)	105.48
5/9/2016	7.58	23.9	119	0.49	291	7.74	14.4	9.47 (31.08)	105.99

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
6/14/2016	7.46	28.6	143	0.83	370	7.51	16.0	9.78 (32.10)	105.68
Well 399-1-7 (0.25 m Interval[h])									
9/15/2015	6.40	28.9	144	1.02	403	7.33	17.2	13.55 (44.46)	105.01
9/23/2015	--	32.0	160	0.26	429	7.28	--	13.55 (44.44)	105.01
9/30/2015	9.26	32.6	163	0.33	411	7.59	17.8	13.52 (44.35)	105.04
10/8/2015	9.57	32.1	161	0.31	461	7.52	17.0	13.60 (44.62)	104.96
10/14/2015	9.50	30.5	152	0.30	457	7.59	17.2	13.71 (44.99)	104.85
11/6/2015	9.40	30.5	153	0.28	446	7.54	16.4	13.49 (44.25)	105.07
11/16/2015	9.29	29.6	148	0.25	455	7.55	16.5	13.37 (43.85)	105.19
11/19/2015	9.43	30.2	151	0.30	455	7.60	16.2	13.29 (43.60)	105.27
12/1/2015	9.34	30.3	151	0.27	456	7.42	16.6	13.32 (43.70)	105.24
12/9/2015	9.20	33.5	168	0.34	468	7.73	16.8	13.53 (44.39)	105.03
12/16/2015	9.34	33.5	167	0.41	481	7.66	16.6	13.56 (44.50)	104.99
12/22/2015	8.09	34.5	173	0.40	494	7.60	16.3	13.34 (43.76)	105.22

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
12/29/2015	8.25	33.7	169	0.42	489	7.58	16.4	13.49 (44.25)	105.07
1/6/2016	8.35	33.6	168	0.38	496	7.56	16.3	13.37 (43.88)	105.18
1/13/2016	8.14	33.3	166	0.42	497	7.52	16.3	13.37 (43.88)	105.18
2/10/2016	8.40	32.4	162	0.37	523	7.52	16.5	13.41 (43.98)	105.15
3/10/2016	8.57	32.4	162	0.35	512	7.50	16.6	13.00 (42.65)	105.56
4/7/2016	8.70	31.5	158	0.30	512	7.44	17.5	13.09 (42.94)	105.47
5/9/2016	8.76	34.3	172	0.35	531	7.40	17.0	12.55 (41.17)	106.01
6/14/2016	8.85	30.7	154	2.00	496	7.43	17.1	12.88 (42.26)	105.68
Well 399-1-7 (2 m Interval[j])									
9/23/2015	--	32.2	161	0.28	433	7.21	--	13.55 (44.44)	105.01
9/30/2015	9.13	33.4	167	0.25	418	7.58	17.6	13.52 (44.35)	105.04
10/8/2015	9.48	32.1	161	0.24	460	7.53	16.8	13.60 (44.62)	104.96
10/14/2015	9.64	30.8	154	0.23	456	7.60	17.1	13.71 (44.99)	104.85
11/6/2015	9.31	30.8	154	0.26	447	7.58	16.6	13.49 (44.25)	105.07

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)
11/16/2015	9.21	30.2	151	0.25	449	7.54	16.7	13.37 (43.85)	105.19
11/19/2015	9.31	30.8	154	0.23	454	7.67	16.7	13.29 (43.60)	105.27
12/1/2015	9.28	31.6	158	0.25	460	7.44	16.7	13.32 (43.70)	105.24
12/9/2015	9.20	33.0	165	0.38	467	7.82	16.8	13.53 (44.39)	105.03
12/16/2015	9.17	34.0	170	0.37	474	7.67	16.8	13.56 (44.50)	104.99
12/22/2015	8.07	34.4	172	0.37	486	7.59	16.7	13.34 (43.76)	105.22
12/29/2015	8.28	33.2	166	0.39	490	7.59	16.8	13.49 (44.25)	105.07
1/6/2016	8.43	33.1	166	0.37	497	7.53	16.7	13.37 (43.88)	105.18
1/13/2016	8.33	32.5	162	0.40	499	7.49	16.7	13.37 (43.88)	105.18
2/10/2016	8.46	32.7	163	0.51	517	7.50	16.7	13.41 (43.98)	105.15
3/10/2016	8.57	33.2	166	0.33	517	7.49	16.9	13.00 (42.65)	105.56
4/7/2016	8.70	32.4	162	0.26	516	7.44	17.1	13.09 (42.94)	105.47
5/9/2016	8.76	35.2	176	0.31	527	7.40	17.1	12.55 (41.17)	106.01
6/14/2016	8.80	30.4	152	0.49	493	7.44	17.2	12.88 (42.26)	105.68

Table C-7. Groundwater Characteristics Analytical Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Dissolved Oxygen[a] (mg/L)	Inorganic Carbon (mg/L)	HCO_3[b] (mg/L)	NPOC[c] (mg/L)	Specific Conductance[d] (µS/cm)	pH Measurement[e] (pH Units)	Temperature[f] (°C)	Depth to Water (m [ft])	Water Level Elevation[g] (m)

Data provided by Pacific Northwest National Laboratory. These data are preliminary, pending completion of the quality control process.

a. EPA Method 360.1. Dissolved oxygen using field probe.

b. Alkalinity calculated from inorganic carbon.

c. Nonpurgable organic carbon as carbon.

d. EPA Method 120.1. Specific conductivity using field probe.

e. EPA Method 150.1. pH using field probe.

f. EPA Method 170.1. Temperature using field probe.

g. Calculated by subtracting the depth to water from the elevation of the top of the well casing.

h. The 0.25 m interval is a sample collected 0.25 m below the top of the well screen.

i. The bottom interval is a sample collected at the bottom of the well screen.

j. The 2 m interval is a sample collected 2 m below the top of the well screen.

-- = not applicable
EPA = U.S. Environmental Protection Agency
HCO_3 = bicarbonate
NPOC = nonpurgable organic carbon

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]					
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
Well 399-1-23													
11/16/2015	71.8	< 0.04	16.6	< 0.01	9.83	29.7	122	16.7	0.30	< 0.05	31.4	11.2	74.4
11/19/2015	70.2	< 0.02	19.9	< 0.01	8.73	162	94.0	11.8	0.12	< 0.05	32.4	473	71.4
12/1/2015	51.5	< 0.02	14.4	< 0.01	9.07	109	2.19	18.5	0.23	< 0.05	26.6	248	53.6
12/9/2015	42.3	< 0.04	12.6	< 0.02	12.5	71.2	2.19	19.4	0.25	< 0.05	23.4	126	55.6
12/16/2015	42.4	< 0.04	12.7	< 0.01	12.7	63.7	3.54	20.1	0.25	< 0.05	23.7	106	57.0
12/22/2015	37.6	< 0.04	11.0	< 0.01	11.1	99.8	13.0	19.3	0.27	< 0.1	25.6	169	56.6
12/29/2015	45.9	< 0.04	11.9	< 0.01	12.3	49.5	8.65	21.3	0.29	< 0.1	24.1	83.9	58.7
1/6/2016	39.0	< 0.04	12.1	< 0.01	11.0	87.4	8.67	20.6	0.25	< 0.1	26.0	140	58.0
1/13/2016	38.2	< 0.04	11.5	< 0.01	14.8	83.6	6.31	20.3	0.15	< 0.1	25.3	130	53.9
2/10/2016	38.3	< 0.02	10.6	< 0.02	13.8	79.5	11.2	20.9	0.22	< 0.05	28.6	117	59.5
3/10/2016	45.2	< 0.02	11.0	< 0.01	8.10	68.2	26.4	20.3	0.22	< 0.05	26.3	82.8	58.1
4/7/2016	42.2	< 0.02	11.0	< 0.01	15.8	55.8	16.5	20.4	0.14	< 0.025	26.6	73.6	57.3
5/9/2016	42.9	0.016	11.5	< 0.01	14.5	58.2	22.5	18.7	0.16	< 0.025	25.8	73.5	54.5
6/14/2016	44.2	< 0.04	11.5	< 0.01	17.3	43.3	18.0	17.9	0.29	< 0.05	26.0	56.3	55.3
Well 399-1-16A (0.25 m Interval[d])													
9/23/2015	51.9	< 0.01	11.9	< 0.01	4.62	21.1	58.1	18.3	0.47	< 0.04	26.5	0.92	61.3
9/30/2015	51.3	< 0.01	12.2	< 0.01	4.70	21.2	53.7	18.2	0.40	< 0.04	26.1	1.04	61.1
10/8/2015	51.4	< 0.01	11.8	< 0.01	4.63	21.1	56.9	19.5	0.37	< 0.04	26.4	0.76	61.6
10/14/2015	51.8	< 0.01	11.7	< 0.01	4.52	20.4	58.7	17.9	0.33	< 0.04	25.7	0.64	60.0
11/6/2015	52.3	< 0.03	12.2	< 0.008	5.04	22.0	55.7	18.2	0.28	< 0.05	25.1	0.52	62.3
11/16/2015	50.4	< 0.04	11.8	< 0.01	8.86	22.4	51.4	18.3	0.31	< 0.05	24.4	< 0.20	60.7
11/19/2015	50.9	< 0.02	12.0	< 0.01	4.73	21.8	54.5	18.3	0.48	< 0.05	24.9	0.90	61.9

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]						
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
12/1/2015	52.2	< 0.02	12.0	< 0.01	4.85	23.8	51.8	18.2	0.51	< 0.05	25.0	0.60	62.4
12/9/2015	52.8	0.33	12.3	< 0.01	5.00	22.0	55.4	18.3	0.52	< 0.05	25.0	< 0.61	62.5
12/22/2015	53.2	< 0.04	12.1	< 0.01	4.87	21.4	58.4	18.5	0.69	< 0.1	25.2	< 0.61	65.4
12/29/2015	51.9	< 0.04	11.6	< 0.01	4.58	20.5	51.6	19.0	1.72	< 0.1	26.2	< 0.61	64.9
1/6/2016	50.9	< 0.04	12.2	< 0.01	5.09	23.6	48.9	18.8	0.59	< 0.1	24.0	< 0.61	66.2
1/13/2016	49.9	< 0.04	12.0	< 0.01	4.82	23.2	48.1	18.5	0.30	< 0.1	23.7	< 0.61	58.9
2/10/2016	51.7	< 0.02	11.8	< 0.02	4.85	22.2	50.0	18.7	0.42	< 0.05	23.9	< 0.61	61.1
3/10/2016	50.9	< 0.02	11.5	< 0.01	4.71	21.1	43.3	17.45	0.51	< 0.05	23.6	< 0.61	60.7
4/7/2016	48.7	< 0.02	11.7	< 0.01	4.89	21.4	43.8	15.7	0.47	< 0.025	21.9	< 1.23	54.1
5/9/2016	28.8	0.005	6.95	< 0.006	3.53	15.0	25.9	6.40	0.36	< 0.025	7.88	< 0.74	25.2
6/14/2016	36.5	< 0.024	8.31	< 0.006	3.94	16.8	32.4	9.99	0.38	< 0.05	14.1	< 0.70	34.8
Well 399-1-17A (0.25 m Interval[d])													
9/23/2015	51.6	0.02	12.1	< 0.01	5.35	22.4	46.8	22.0	0.42	< 0.04	24.8	0.879	61.9
9/30/2015	50.9	< 0.01	12.0	< 0.01	5.28	22.4	40.9	20.6	0.40	0.05	25.0	1.21	60.9
10/8/2015	50.6	< 0.01	12.1	< 0.01	5.19	22.2	42.2	22.1	0.38	< 0.04	24.3	0.76	61.6
10/14/2015	50.7	< 0.01	11.8	< 0.01	5.11	22.2	43.5	20.6	0.36	< 0.04	24.3	0.94	60.7
11/6/2015	51.9	< 0.03	12.3	< 0.008	5.61	23.3	37.5	21.0	0.32	< 0.05	23.2	0.50	62.0
11/16/2015	69.9	< 0.04	16.9	< 0.01	10.2	35.4	20.9	31.9	0.23	< 0.05	47.6	49.4	40.6
11/19/2015	78.2	< 0.02	20.0	< 0.01	7.11	59.9	5.04	19.4	0.18	< 0.05	29.3	238	38.6
12/1/2015	54.2	< 0.02	14.3	< 0.01	7.47	93.2	1.87	22.7	0.13	< 0.05	24.6	258	47.5
12/9/2015	46.0	< 0.04	12.6	< 0.01	6.62	77.9	1.68	22.5	0.26	< 0.05	24.6	161	52.2
12/16/2015	43.6	0.05	11.1	< 0.01	6.18	75.5	1.19	22.1	0.16	< 0.05	26.6	131	52.7
12/22/2015	40.3	< 0.04	10.3	< 0.01	6.11	77.8	4.17	21.2	0.18	< 0.1	23.4	129	55.1

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]					
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
12/29/2015	41.7	< 0.04	10.5	< 0.01	6.16	71.9	0.42	23.4	0.27	< 0.1	25.0	113	57.4
1/6/2016	39.6	< 0.04	10.5	< 0.01	6.36	67.5	1.50	21.7	0.18	< 0.1	23.2	95.2	56.6
1/13/2016	42.1	< 0.04	11.1	< 0.01	6.27	65.6	1.63	22.1	0.12	< 0.1	26.9	97.3	53.0
2/10/2016	46.6	< 0.02	11.8	< 0.02	6.73	50.2	2.71	23.4	0.22	< 0.05	27.2	69.0	56.3
3/10/2016	51.3	< 0.02	12.6	< 0.01	8.00	41.3	6.77	21.4	0.18	< 0.05	27.5	48.6	59.8
4/7/2016	49.6	< 0.02	12.7	< 0.01	8.62	37.4	9.73	22.8	0.15	< 0.025	26.2	39.3	58.3
5/9/2016	47.9	0.205	13.0	< 0.01	9.48	37.2	24.0	22.7	0.17	< 0.025	26.9	37.3	56.4
6/14/2016	49.9	< 0.04	12.0	< 0.01	9.42	31.2	17.2	21.0	0.27	< 0.05	27.1	26.4	57.4
Well 399-2-1 (0.25 m Interval[d])													
9/15/2015	51.5	0.03	11.2	< 0.01	3.85	20.5	119	19.6	0.34	< 0.04	24.0	1.02	57.5
9/23/2015	50.3	< 0.01	11.2	< 0.01	3.72	20.1	125	20.1	0.32	< 0.04	24.4	0.67	58.1
9/30/2015	51.8	0.01	11.3	< 0.01	3.83	20.5	113	19.3	0.33	< 0.04	23.5	1.02	56.7
10/8/2015	51.7	0.01	11.3	< 0.01	3.83	20.7	118	21.2	0.32	< 0.04	24.2	0.83	58.7
10/14/2015	53.8	0.02	11.4	< 0.01	8.02	20.6	127	20.8	0.26	< 0.04	24.2	0.75	58.5
11/6/2015	53.3	0.07	11.6	0.01	4.15	21.5	126	20.0	0.29	< 0.05	23.6	0.67	60.3
11/19/2015	50.2	0.03	10.8	< 0.01	3.88	20.0	109	18.5	0.42	< 0.05	22.3	0.97	57.1
12/1/2015	50.0	< 0.02	10.8	< 0.01	3.99	22.5	104	17.8	0.47	< 0.05	22.2	0.76	56.9
12/9/2015	52.3	< 0.04	11.5	< 0.01	4.16	21.9	104	18.7	0.44	< 0.05	23.9	0.71	60.1
12/22/2015	45.5	< 0.04	9.65	< 0.01	3.74	19.2	102	15.5	0.52	< 0.1	20.0	0.79	53.9
12/29/2015	49.9	< 0.04	10.5	< 0.01	3.75	19.4	106	19.7	0.53	< 0.1	24.8	0.67	63.3
1/7/2016	50.6	< 0.04	11.4	< 0.01	4.22	23.3	111	19.9	0.83	< 0.1	27.7	0.73	56.7
1/13/2016	52.4	< 0.04	11.6	< 0.01	4.16	22.7	110	20.4	0.39	< 0.1	24.8	< 0.61	56.7
2/10/2016	52.3	< 0.02	11.2	< 0.02	3.96	22.6	125	20.1	0.49	< 0.05	23.4	0.70	56.3

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]					
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
3/10/2016	39.0	< 0.02	8.23	< 0.01	3.43	17.8	72.4	12.2	0.48	< 0.05	14.4	0.70	39.7
4/7/2016	47.5	< 0.02	9.96	< 0.01	3.87	20.2	108	14.7	0.46	< 0.025	17.6	< 1.23	47.0
5/9/2016	24.5	0.008	5.66	< 0.004	2.59	11.0	41.9	4.67	0.88	< 0.025	4.46	0.61	20.5
6/14/2016	40.0	< 0.016	8.20	< 0.004	3.17	17.0	83.3	10.1	0.36	< 0.05	13.2	0.51	33.1
Well 399-2-1 (Bottom Interval[e])													
9/23/2015	49.0	0.03	11.0	0.01	3.68	19.9	125	19.6	0.31	< 0.04	22.2	0.42	55.8
9/30/2015	52.3	0.09	11.0	0.02	3.76	19.8	108	19.7	0.31	< 0.04	22.6	1.20	56.6
10/8/2015	50.4	0.03	11.1	0.02	17.62	20.6	122	20.0	0.29	< 0.04	23.9	0.72	58.9
10/14/2015	52.9	0.03	11.1	0.03	3.73	19.8	120	20.2	0.31	< 0.04	23.4	0.89	58.7
11/6/2015	52.0	0.05	11.3	0.02	4.06	20.4	125	20.0	0.28	< 0.05	23.1	< 0.49	59.3
11/19/2015	50.4	0.03	11.0	0.02	3.85	19.9	109	19.3	0.35	< 0.05	27.0	0.48	54.7
12/1/2015	50.8	< 0.02	10.9	0.00	3.89	21.8	104	18.4	0.37	< 0.05	25.8	0.44	53.3
12/9/2015	52.2	< 0.04	11.6	0.03	4.09	21.4	103	18.8	0.35	< 0.05	26.3	< 0.61	55.9
12/22/2015	50.6	< 0.04	10.6	0.03	3.85	19.8	112	17.3	0.30	< 0.1	21.5	< 0.61	54.1
12/29/2015	49.4	< 0.04	10.4	0.02	3.70	19.0	106	19.3	0.33	< 0.1	23.3	< 0.61	60.3
1/7/2016	50.9	< 0.04	11.4	0.02	4.06	22.3	115	20.1	0.33	< 0.1	23.3	< 0.61	57.8
1/13/2016	50.2	< 0.04	11.4	0.02	4.07	22.3	110	20.4	0.44	< 0.1	24.1	< 0.61	57.9
2/10/2016	53.6	< 0.02	11.4	0.044	3.96	22.3	121	20.7	0.48	< 0.05	22.9	< 0.61	57.4
3/10/2016	47.5	< 0.02	10.1	0.01	3.69	19.4	94.3	16.2	0.44	< 0.05	18.9	< 0.61	49.4
4/7/2016	48.8	< 0.02	10.4	0.011	3.94	20.4	105	15.5	0.45	< 0.025	18.4	< 1.23	47.8
5/9/2016	25.2	0.005	5.62	< 0.004	2.81	11.3	43.2	4.94	0.63	< 0.025	4.82	< 0.49	21.5
6/14/2016	40.6	< 0.016	8.06	0.011	3.06	15.7	73.2	10.8	0.35	< 0.05	13.6	< 0.50	34.1

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]					
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
Well 399-2-2 (0.25 m Interval[d])													
9/15/2015	52.4	< 0.01	11.7	< 0.01	4.34	22.8	91.7	20.4	0.40	< 0.04	25.1	1.36	60.8
9/23/2015	47.4	0.14	10.3	0.09	3.88	20.7	65.7	21.1	0.36	< 0.04	15.6	0.50	56.8
9/30/2015	39.6	0.27	9.73	0.13	3.63	20.6	37.5	21.7	0.34	0.05	6.32	0.59	55.8
10/8/2015	41.9	0.23	9.86	0.13	3.60	20.1	36.6	24.0	0.34	< 0.04	5.78	0.39	57.8
10/14/2015	46.3	0.10	9.97	0.09	3.37	19.3	44.9	22.9	0.34	< 0.04	10.6	0.51	58.5
11/6/2015	42.9	< 0.03	10.6	0.12	4.04	21.2	42.5	22.7	0.34	< 0.05	8.77	< 0.49	60.6
11/19/2015	44.9	< 0.02	11.0	0.11	3.96	20.6	41.7	23.0	0.47	< 0.05	8.68	0.16	59.3
12/1/2015	47.3	< 0.02	11.1	0.00	3.88	22.1	60.0	20.6	0.37	< 0.05	12.7	0.40	57.5
12/9/2015	47.8	< 0.04	11.4	0.04	4.29	21.5	58.8	20.7	0.40	< 0.05	13.0	< 0.61	56.8
12/18/2015	43.9	0.24	11.1	0.09	4.20	21.2	56.1	21.8	0.44	0.28	7.40	< 0.61	60.3
12/22/2015	48.0	< 0.04	12.2	0.05	4.46	22.3	74.3	22.9	0.31	0.11	14.0	< 0.61	57.7
12/29/2015	46.1	< 0.04	11.1	0.11	3.99	20.4	58.0	24.3	0.31	0.13	10.3	< 0.61	60.2
1/6/2016	42.3	< 0.04	12.1	0.08	4.37	24.0	50.9	23.2	0.35	0.63	5.34	< 0.61	56.5
1/13/2016	41.7	< 0.04	12.3	0.12	4.42	24.3	54.4	24.8	0.46	0.18	5.91	< 0.61	53.9
2/10/2016	47.9	< 0.02	11.4	0.063	4.19	26.0	50.0	22.7	0.47	< 0.05	14.0	3.29	60.7
3/10/2016	44.2	< 0.02	10.4	0.03	3.98	22.6	44.1	18.6	0.49	< 0.05	8.79	1.09	53.6
4/7/2016	41.5	< 0.02	10.1	0.37	3.93	22.7	35.9	18.9	0.44	< 0.025	6.91	< 1.23	50.0
5/9/2016	24.4	0.005	5.41	0.030	2.86	12.2	16.5	5.59	0.55	< 0.025	2.58	0.78	21.1
6/14/2016	30.6	< 0.016	6.14	0.007	3.17	19.6	20.7	9.73	0.36	< 0.05	5.65	4.30	28.1
Well 399-2-2 (2 m Interval[f])													
9/23/2015	52.2	0.02	11.6	< 0.01	4.14	21.9	98.5	20.3	0.37	< 0.04	25.0	0.80	59.7
9/30/2015	52.0	0.02	11.7	< 0.01	4.12	21.1	92.3	19.1	0.36	< 0.04	24.7	1.17	59.1

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]						
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
10/8/2015	51.8	< 0.01	11.2	< 0.01	3.86	19.8	94.4	19.9	0.33	< 0.04	25.0	0.77	59.4
10/14/2015	51.1	< 0.01	11.3	< 0.01	3.96	21.3	84.0	20.1	0.37	0.06	24.9	0.88	59.9
11/6/2015	53.2	< 0.03	12.1	< 0.008	4.48	23.0	93.2	19.7	0.35	< 0.05	24.4	0.64	61.8
11/19/2015	52.1	< 0.02	11.4	< 0.01	4.11	20.9	89.8	18.6	0.33	< 0.05	24.1	0.72	58.6
12/1/2015	50.8	< 0.02	11.2	< 0.01	3.92	21.7	90.5	17.5	0.49	< 0.05	24.6	0.32	56.2
12/9/2015	32.8	< 0.04	9.9	0.07	4.41	21.2	33.9	22.4	0.32	< 0.05	5.20	< 0.61	40.6
12/18/2015	59.3	< 0.04	12.7	< 0.01	4.50	22.3	123	22.1	0.47	< 0.1	27.9	< 0.61	61.9
12/22/2015	57.0	< 0.04	12.7	< 0.01	4.54	22.0	125	21.7	0.58	< 0.1	27.6	0.64	58.0
12/29/2015	57.1	< 0.04	12.3	< 0.01	4.21	21.9	116	23.7	0.43	< 0.1	28.1	< 0.61	59.0
1/6/2016	56.1	< 0.04	13.1	< 0.01	4.49	24.2	115	22.2	0.38	< 0.1	25.5	0.67	59.3
1/13/2016	52.2	< 0.04	12.4	< 0.01	4.24	23.6	111	21.9	0.38	< 0.1	24.9	< 0.61	57.2
2/10/2016	53.6	< 0.02	12.1	< 0.02	4.49	26.6	79.6	20.6	0.37	< 0.05	24.4	4.68	59.6
3/10/2016	47.5	< 0.02	10.5	< 0.01	4.00	21.1	58.8	15.7	0.46	< 0.05	19.1	2.87	52.5
4/7/2016	53.1	< 0.02	11.7	0.022	4.52	27.0	61.6	18.9	0.30	< 0.025	23.6	7.65	58.1
5/9/2016	29.8	0.006	6.88	0.005	3.00	13.0	30.9	6.68	0.48	< 0.025	7.73	2.54	28.1
6/14/2016	39.5	< 0.016	8.27	< 0.004	3.55	23.3	34.8	11.7	0.33	< 0.05	15.5	9.90	37.8
Well 399-2-3 (0.25 m Interval[d])													
9/15/2015	41.3	0.58	9.11	0.36	3.47	16.8	36.8	28.3	0.29	< 0.04	2.89	0.78	25.8
9/23/2015	46.5	< 0.008	10.0	0.18	3.73	18.6	52.4	25.7	0.27	< 0.04	9.40	0.52	38.0
9/30/2015	42.0	0.007	9.70	0.10	4.02	19.8	47.8	24.3	0.29	0.04	6.88	0.64	40.4
10/8/2015	39.2	< 0.008	9.68	0.04	4.03	20.1	48.0	24.5	0.28	0.04	6.63	0.63	42.6
10/14/2015	39.8	< 0.01	9.82	< 0.01	3.93	20.4	50.0	21.3	0.25	< 0.04	9.46	0.43	43.9
11/6/2015	37.0	< 0.03	9.85	0.02	4.31	21.2	47.7	20.8	0.22	< 0.05	10.5	< 0.49	45.2

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]					
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
11/19/2015	38.2	< 0.02	10.2	0.06	4.26	21.5	49.5	20.7	0.28	< 0.05	12.0	0.40	46.8
12/1/2015	32.7	< 0.02	9.24	0.004	3.89	21.6	39.8	21.4	0.29	< 0.05	7.03	0.24	42.8
12/9/2015	31.4	< 0.04	9.86	0.07	4.32	21.4	33.9	22.4	0.26	< 0.05	4.83	< 0.61	38.9
12/22/2015	38.7	< 0.04	10.1	0.05	4.38	21.0	45.6	22.9	0.33	< 0.1	10.1	< 0.61	46.2
12/29/2015	36.6	< 0.04	9.73	0.02	4.06	20.0	48.8	23.1	0.35	< 0.1	11.0	< 0.61	48.5
1/6/2016	35.6	< 0.04	10.36	0.08	4.52	23.2	42.1	23.7	0.34	< 0.1	9.86	< 0.61	48.8
1/13/2016	36.2	< 0.04	10.65	0.06	4.34	23.4	46.7	23.6	0.30	< 0.1	9.97	< 0.61	45.7
2/10/2016	38.9	< 0.02	10.5	0.030	4.41	23.5	51.5	22.8	0.42	< 0.05	12.4	< 0.61	48.3
3/10/2016	43.9	< 0.02	10.7	0.15	4.16	22.5	46.2	22.4	0.42	< 0.05	13.7	1.02	47.8
4/7/2016	39.8	< 0.02	10.4	0.13	4.11	22.9	37.4	23.7	0.49	< 0.025	8.65	< 1.23	40.5
5/9/2016	22.4	2.583	5.35	0.030	3.03	14.8	17.7	4.90	0.57	0.090	2.70	1.26	19.3
6/14/2016	31.4	< 0.016	6.49	< 0.004	3.45	18.7	22.2	9.68	0.33	< 0.05	6.91	3.00	25.5
Well 399-2-3 (2 m Interval[f])													
9/23/2015	52.2	< 0.01	11.5	< 0.01	4.42	22.3	77.9	21.3	0.36	< 0.04	23.1	0.84	58.8
9/30/2015	51.0	0.01	11.5	< 0.01	4.44	22.5	72.5	21.2	0.34	< 0.04	23.2	1.43	59.1
10/8/2015	50.8	< 0.01	11.4	< 0.01	4.31	21.9	76.3	22.4	0.34	< 0.04	23.5	0.99	59.5
10/14/2015	50.8	0.02	11.2	< 0.01	4.22	21.5	64.0	21.7	0.36	< 0.04	23.0	0.93	59.8
11/6/2015	52.2	< 0.03	11.9	< 0.008	4.75	22.9	78.2	21.2	0.29	< 0.05	22.6	0.78	60.5
11/19/2015	52.9	< 0.02	11.3	< 0.01	4.33	21.9	77.9	19.5	0.32	< 0.05	22.9	0.82	57.9
12/1/2015	51.3	< 0.02	11.4	< 0.01	4.20	22.7	81.1	19.2	0.39	< 0.05	22.8	0.84	57.7
12/9/2015	51.5	< 0.04	11.7	< 0.01	4.64	22.3	71.8	21.5	0.45	< 0.05	22.7	0.88	58.0
12/22/2015	55.9	< 0.04	12.1	< 0.01	4.67	22.7	81.6	21.1	0.36	< 0.1	24.9	0.82	59.2
12/29/2015	50.4	< 0.04	11.2	< 0.01	4.38	21.4	72.2	22.4	0.42	< 0.1	24.3	0.85	62.4

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]					
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
1/6/2016	53.6	< 0.04	12.5	< 0.01	4.79	25.0	95.5	23.3	0.41	< 0.1	25.4	0.85	58.7
1/13/2016	55.2	< 0.04	12.3	< 0.01	4.54	24.5	90.9	22.7	0.36	< 0.1	24.4	0.71	57.1
2/10/2016	52.6	< 0.02	11.8	< 0.02	4.56	24.7	79.3	22.7	0.51	< 0.05	23.2	1.11	59.2
3/10/2016	50.1	< 0.02	11.3	0.04	4.35	24.5	59.5	19.9	0.54	< 0.05	21.0	2.42	55.9
4/7/2016	51.8	< 0.02	11.6	0.015	4.71	27.6	52.7	21.6	0.31	< 0.025	22.2	5.84	57.6
5/9/2016	32.9	0.003	7.65	< 0.006	3.70	18.1	30.9	9.19	0.42	< 0.025	11.1	4.57	33.6
6/14/2016	43.2	< 0.024	9.03	< 0.006	3.76	26.4	35.9	15.7	0.36	< 0.05	18.9	9.62	44.2
Well 399-1-7 (0.25m Interval[d])													
9/15/2015	51.8	< 0.01	11.8	< 0.01	4.83	22.8	49.2	21.7	0.38	< 0.04	24.6	1.23	61.1
9/23/2015	50.5	< 0.01	11.7	< 0.01	4.77	22.5	56.6	21.7	0.36	< 0.04	24.4	1.06	60.3
9/30/2015	52.1	0.02	11.9	< 0.01	4.86	22.9	49.2	21.8	0.36	< 0.04	24.2	1.45	59.6
10/8/2015	51.8	< 0.01	11.8	< 0.01	4.90	22.1	50.4	23.3	0.36	< 0.04	24.5	0.82	60.7
10/14/2015	51.1	< 0.01	11.7	< 0.01	4.53	22.1	53.5	22.1	0.38	< 0.04	24.8	1.16	61.0
11/6/2015	51.2	< 0.03	11.9	< 0.008	5.07	23.0	52.4	21.2	0.31	< 0.05	23.9	0.84	62.9
11/16/2015	50.7	< 0.04	11.6	< 0.01	8.76	23.0	49.7	21.5	0.55	< 0.05	23.5	0.93	61.8
11/19/2015	51.4	< 0.02	11.6	< 0.01	4.84	22.2	50.5	20.5	0.35	< 0.05	23.6	0.82	60.2
12/1/2015	52.3	0.03	11.9	< 0.01	4.81	24.0	54.3	20.5	0.42	< 0.05	24.1	0.92	59.4
12/9/2015	55.2	< 0.04	12.7	< 0.01	5.18	23.7	50.3	23.4	0.44	< 0.05	25.5	1.07	56.7
12/16/2015	53.5	< 0.04	12.5	< 0.01	5.24	23.4	51.0	23.2	0.38	< 0.05	26.1	2.03	56.1
12/22/2015	56.9	< 0.04	12.7	< 0.01	5.12	24.4	45.2	22.8	0.40	< 0.1	26.6	4.92	58.0
12/29/2015	50.1	< 0.04	11.6	< 0.01	4.66	23.4	39.3	22.5	0.45	< 0.1	25.4	9.14	60.5
1/6/2016	54.8	< 0.04	12.9	< 0.01	5.28	28.8	30.1	22.6	0.42	< 0.1	24.2	12.6	60.5
1/13/2016	54.4	< 0.04	12.6	< 0.01	5.14	28.5	28.6	22.4	0.41	< 0.1	24.0	16.3	57.8

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]					
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
2/10/2016	53.6	< 0.02	12.3	< 0.02	5.30	35.6	20.1	22.2	0.29	< 0.05	23.3	31.2	58.4
3/10/2016	54.1	< 0.02	12.4	< 0.01	5.17	33.2	28.8	21.8	0.38	< 0.05	23.8	20.8	60.7
4/7/2016	52.4	< 0.02	11.9	< 0.01	5.24	35.0	21.5	22.1	0.23	< 0.025	24.2	25.0	57.5
5/9/2016	47.9	0.003	12.3	< 0.01	5.60	46.2	20.5	19.7	0.23	< 0.025	26.1	35.8	57.8
6/14/2016	48.4	< 0.04	10.4	< 0.01	4.87	43.0	15.1	23.0	0.34	< 0.05	26.8	28.4	57.1
Well 399-1-7 (2 m Interval[f])													
9/23/2015	53.2	< 0.01	11.9	< 0.01	4.84	22.7	56.2	21.8	0.39	< 0.04	24.5	1.10	60.5
9/30/2015	50.6	< 0.01	11.7	< 0.01	4.81	22.6	51.6	21.9	0.38	< 0.04	24.3	1.35	60.3
10/8/2015	51.1	< 0.01	12.0	< 0.01	4.68	22.5	49.4	23.3	0.37	< 0.04	24.6	1.05	60.3
10/14/2015	50.8	< 0.01	11.6	< 0.01	4.48	21.7	50.1	21.9	0.36	< 0.04	24.6	0.98	61.1
11/6/2015	52.1	< 0.03	12.1	< 0.008	5.12	23.2	51.3	21.1	0.33	< 0.05	23.5	0.82	62.3
11/16/2015	51.9	< 0.04	11.7	< 0.01	8.75	23.4	50.5	20.8	0.35	< 0.05	23.1	1.03	60.2
11/19/2015	53.3	< 0.02	11.7	< 0.01	4.77	22.4	50.5	20.7	0.34	< 0.05	23.8	0.94	60.1
12/1/2015	50.9	0.02	11.8	< 0.01	4.63	23.3	54.5	20.7	0.37	< 0.05	25.1	0.84	58.8
12/9/2015	55.6	< 0.04	12.7	< 0.01	5.20	23.8	49.5	23.4	0.48	< 0.05	25.9	1.08	57.3
12/16/2015	55.1	< 0.04	12.5	< 0.01	5.22	23.6	52.1	23.3	0.43	< 0.05	24.8	1.99	56.4
12/22/2015	56.3	< 0.04	12.6	< 0.01	5.09	24.4	45.6	22.9	0.41	< 0.1	26.6	4.78	57.6
12/29/2015	54.0	< 0.04	11.9	< 0.01	4.88	24.4	38.5	22.8	0.74	< 0.1	25.4	9.49	59.6
1/6/2016	54.9	< 0.04	12.6	< 0.01	5.14	28.2	30.1	22.1	0.41	< 0.1	23.5	12.4	54.6
1/13/2016	54.5	< 0.04	12.5	< 0.01	5.20	28.6	28.9	22.4	0.25	< 0.1	23.9	15.7	56.8
2/10/2016	53.9	< 0.02	12.4	< 0.02	5.29	36.4	19.5	22.2	0.28	< 0.05	26.2	32.3	57.8
3/10/2016	54.8	< 0.02	12.4	< 0.01	5.13	32.9	26.9	21.8	0.25	< 0.05	24.7	21.0	59.5
4/7/2016	52.7	0.17	12.0	< 0.01	5.26	35.6	22.1	21.9	0.26	< 0.025	25.1	25.1	59.5

Table C-8. Metals and Anion Results for Selected Monitoring Wells Downgradient of the 300-FF-5 Operable Unit Stage A Area

Sample Date	Metals[a]							Anions[b]						
	Ca (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	K (mg/L)	Na (mg/L)	U (µg/L)	Cl (mg/L	F (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4[c] (mg/L)	SO_4 (mg/L)
5/9/2016	48.9	0.014	12.3	< 0.01	5.48	46.6	19.4	19.7	0.23	< 0.025	26.1	37.7	58.6
6/14/2016	48.3	< 0.04	10.7	< 0.01	5.01	42.5	15.9	23.1	0.32	< 0.05	27.4	28.7	57.5

Data provided by Pacific Northwest National Laboratory. These data are preliminary, pending completion of the quality control process.

a. EPA Method 6020.

b. EPA Method 300.

c. Measured as total phosphorus using inductively coupled plasma optical emission spectrometry.

d. The 0.25 m interval is a sample collected 0.25 m below the top of the well screen.

e. The bottom interval is a sample collected at the bottom of the well screen.

f. The 2 m interval is a sample collected 2 m below the top of the well screen.

Ca = calcium
Cl = chloride
EPA = U.S. Environmental Protection Agency
F = fluoride
Fe = iron
K = potassium
Mg = magnesium
Mn = manganese
Na = sodium
NO_2 = nitrite
NO_3 = nitrate
PO_4 = phosphate
SO_4 = sulfate
U = uranium

Appendix D

Field Measurements for Enhanced Attenuation Stage A Monitoring Wells

This page intentionally left blank.

Contents

Figures

This page intentionally left blank.

D1 Data from Data Loggers

Automated groundwater measurements were collected using data loggers installed in six aquifer monitoring wells (399-1-70, 399-1-76, 399-1-80, 399-1-82, 399-1-84, and 399-1-86) at the Stage A enhanced attenuation area. The data loggers monitored water level and field parameters (specific conductivity, temperature, pH, and oxidation-reduction potential) every 30 minutes from September 11 to December 16, 2015 (Figures D-1 through D-30). The locations of the wells are shown on Figure 3-4. The data logger data presented in this appendix are provided on the accompanying CD as Supporting Information D-1.

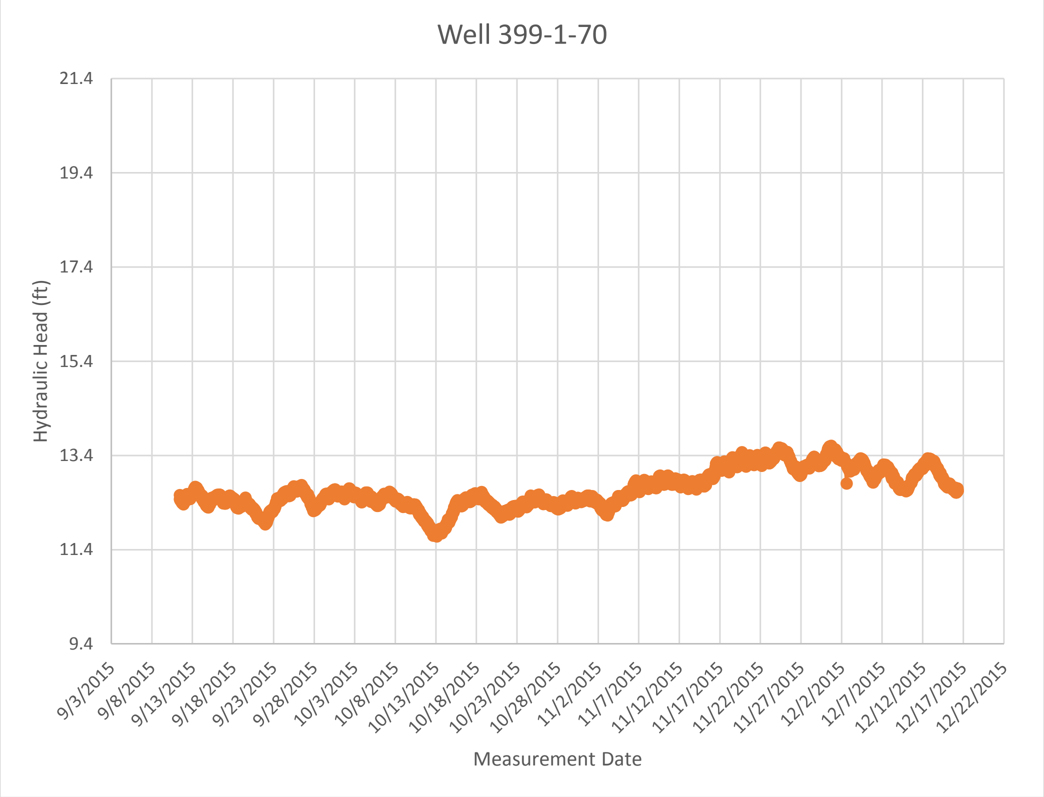


Figure D-1. Water Level Measurements for Well 399-1-70

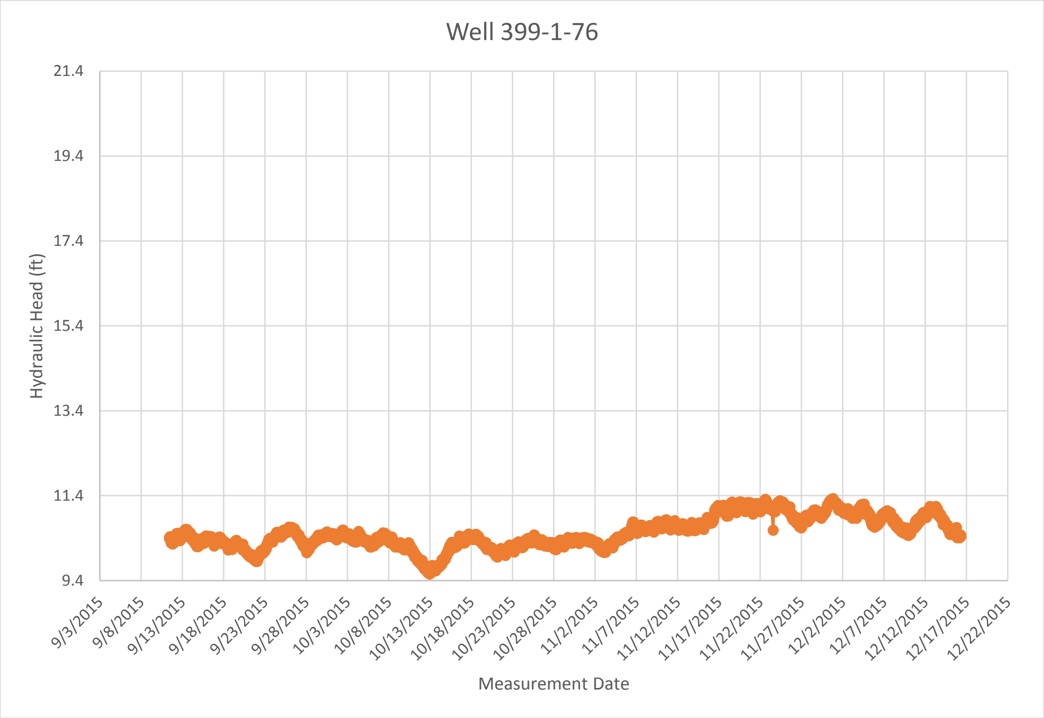


Figure D-2. Water Level Measurements for Well 399-1-76

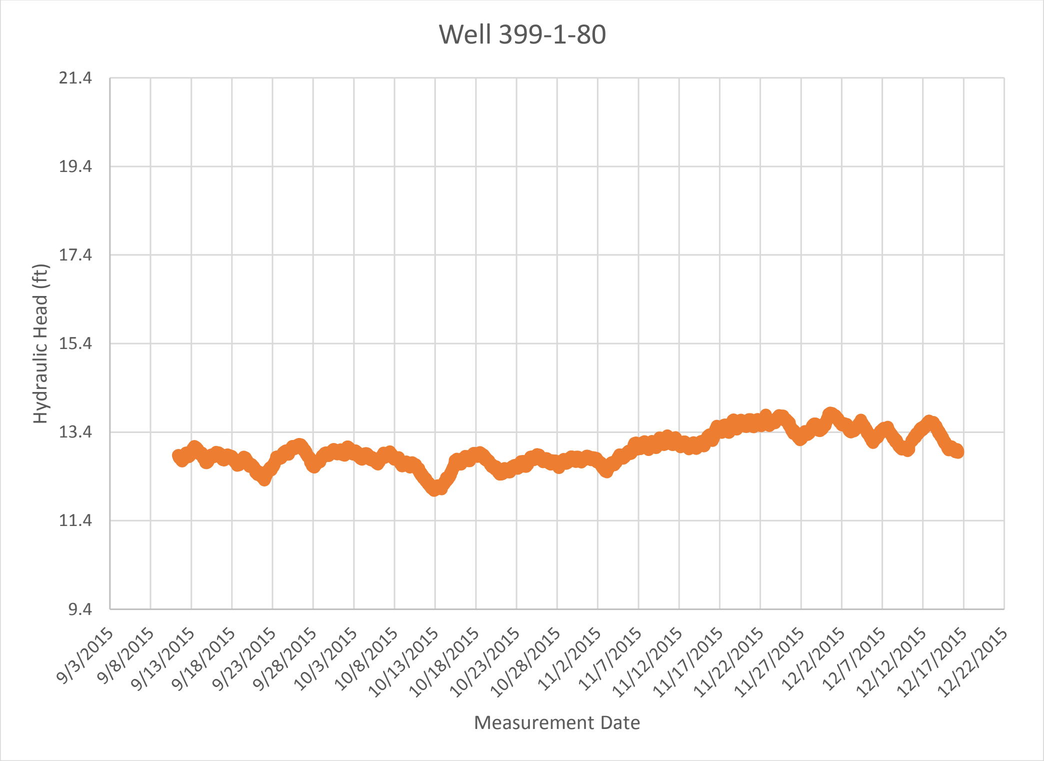


Figure D-3. Water Level Measurements for Well 399-1-80

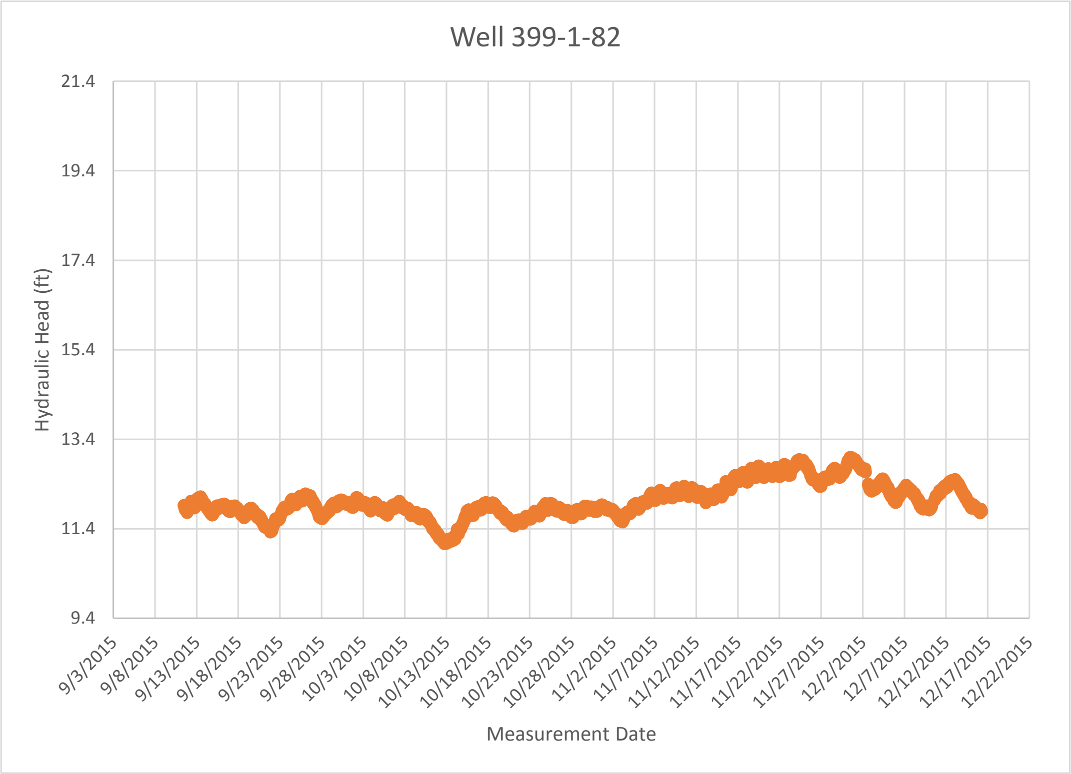


Figure D-4. Water Level Measurements for Well 399-1-82

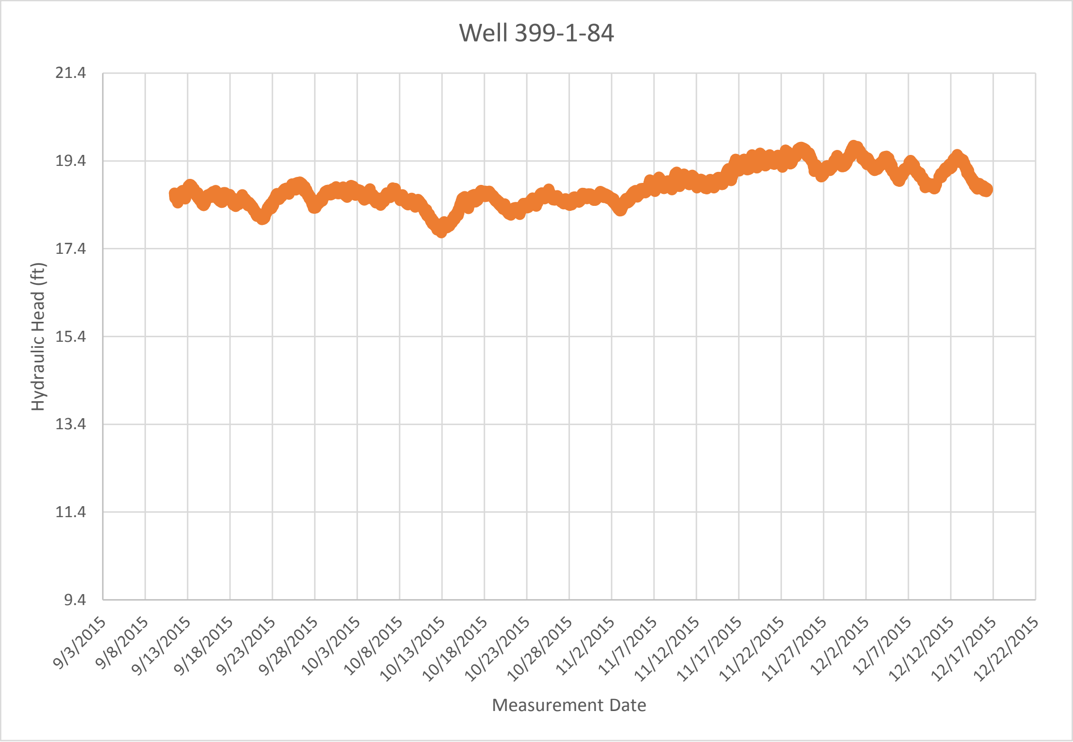


Figure D-5. Water Level Measurements for Well 399-1-84

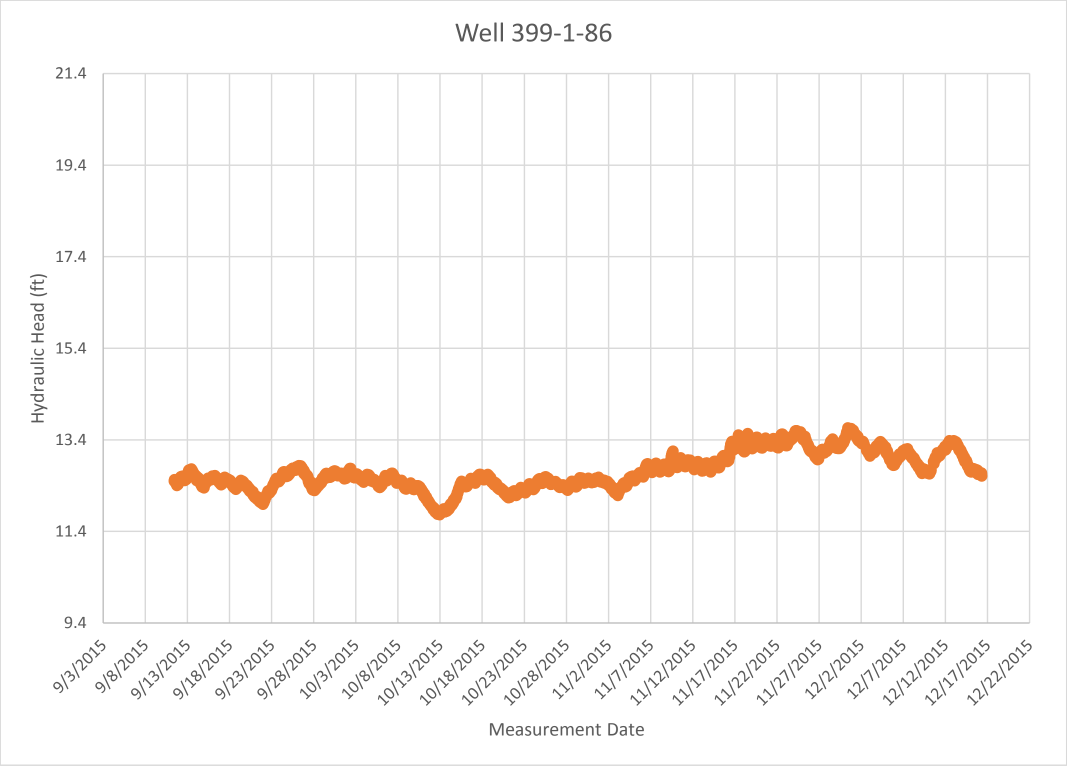


Figure D-6. Water Level Measurements for Well 399-1-86

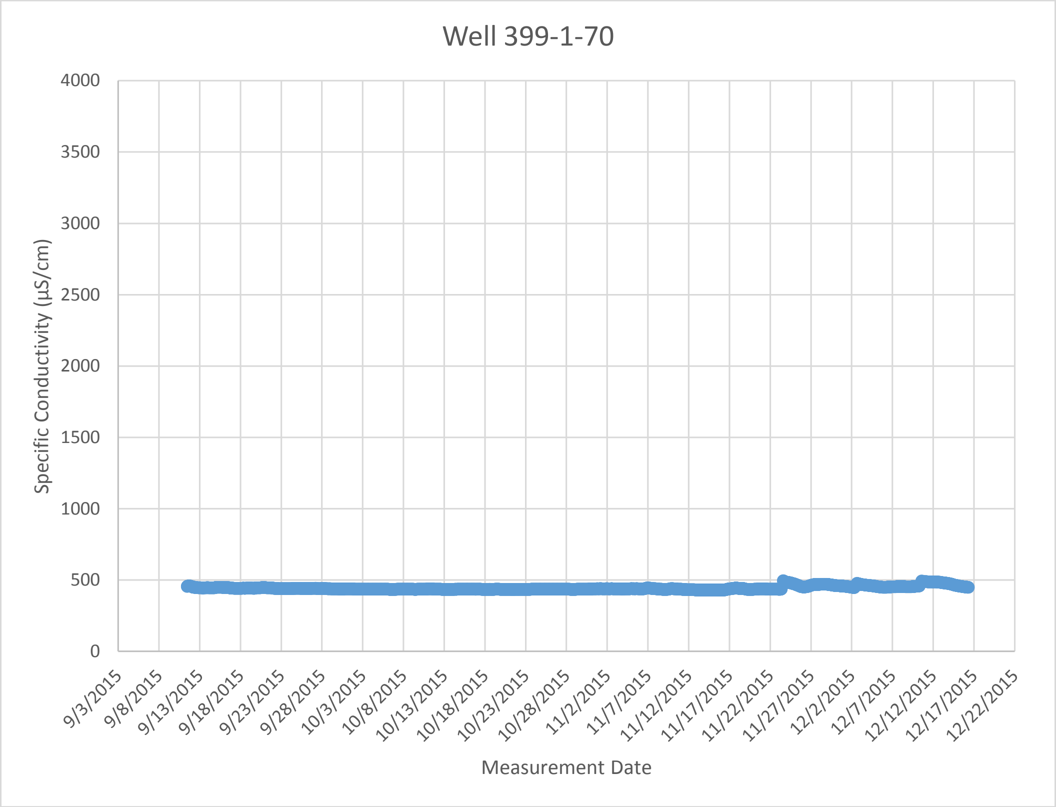


Figure D-7. Specific Conductivity Measurements for Well 399-1-70

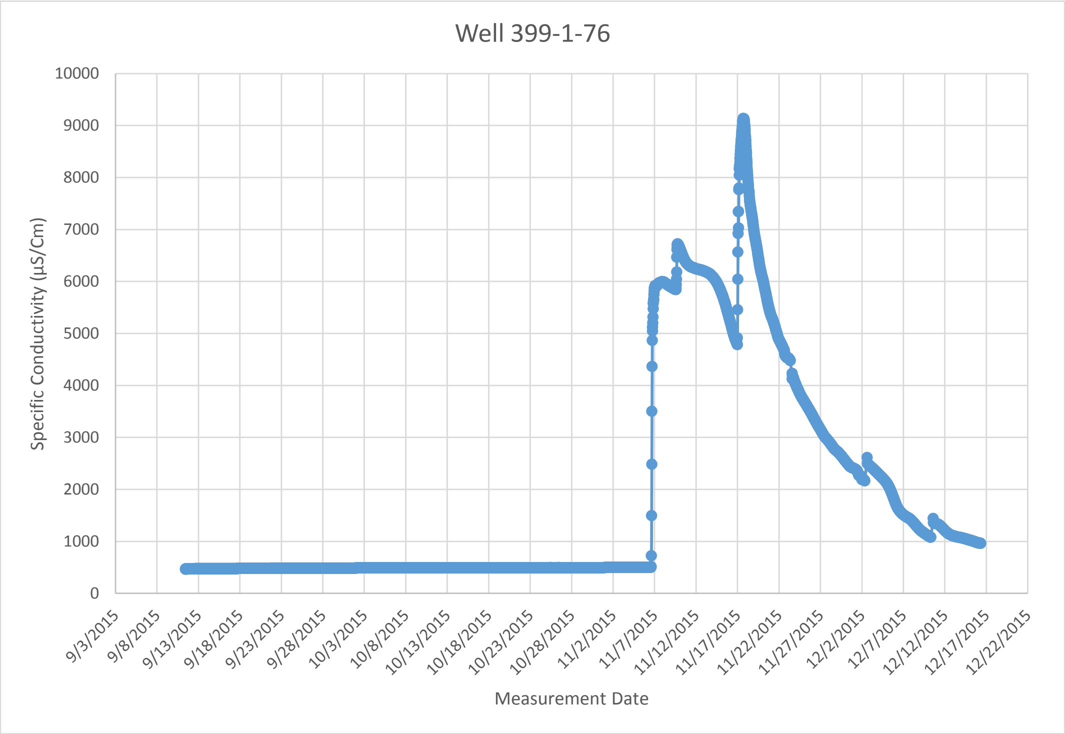


Figure D-8. Specific Conductivity Measurements for Well 399-1-76

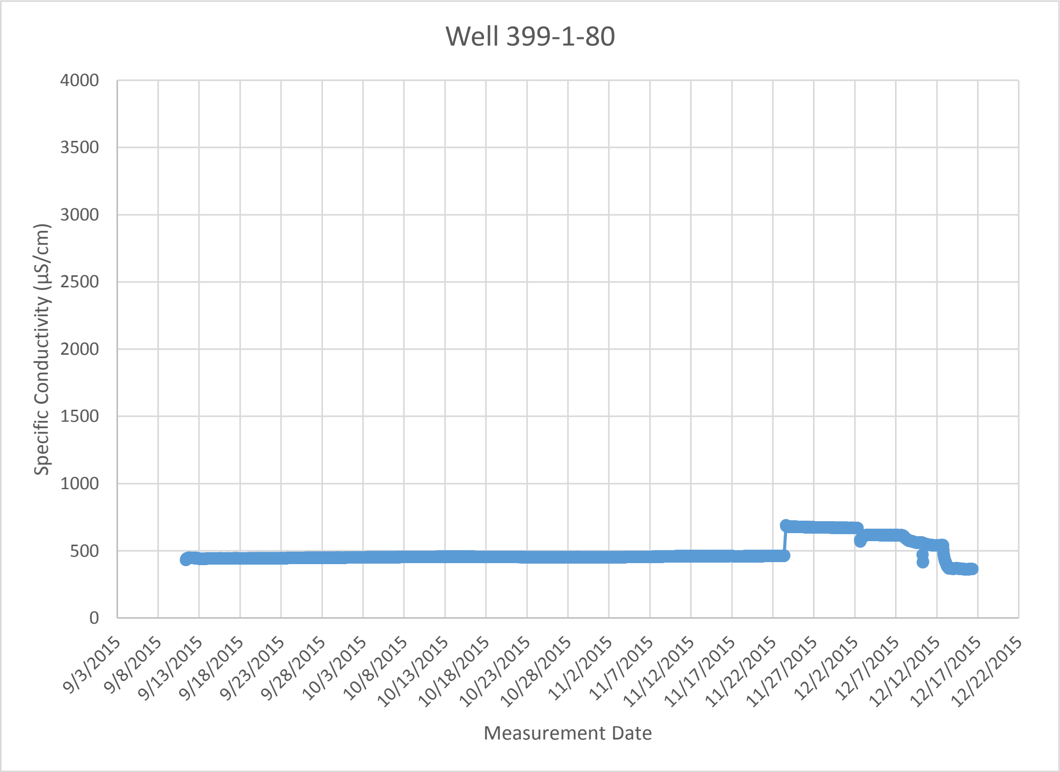


Figure D-9. Specific Conductivity Measurements for Well 399-1-80

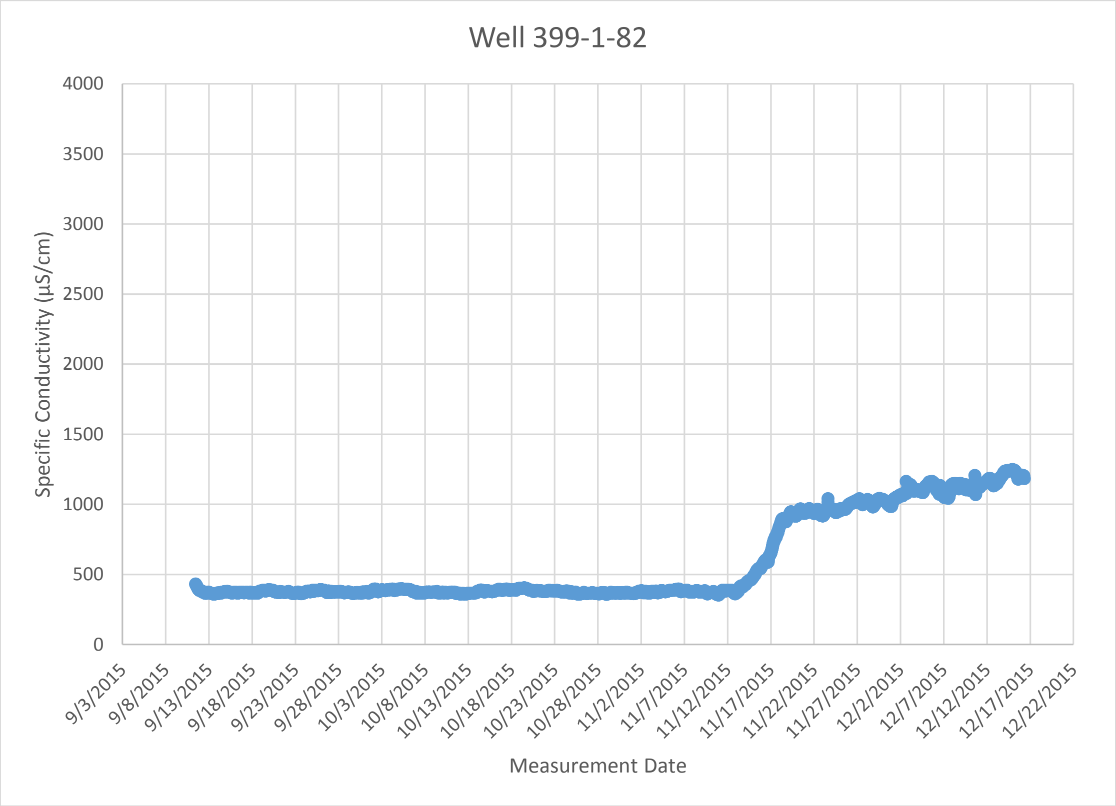


Figure D-10. Specific Conductivity Measurements for Well 399-1-82

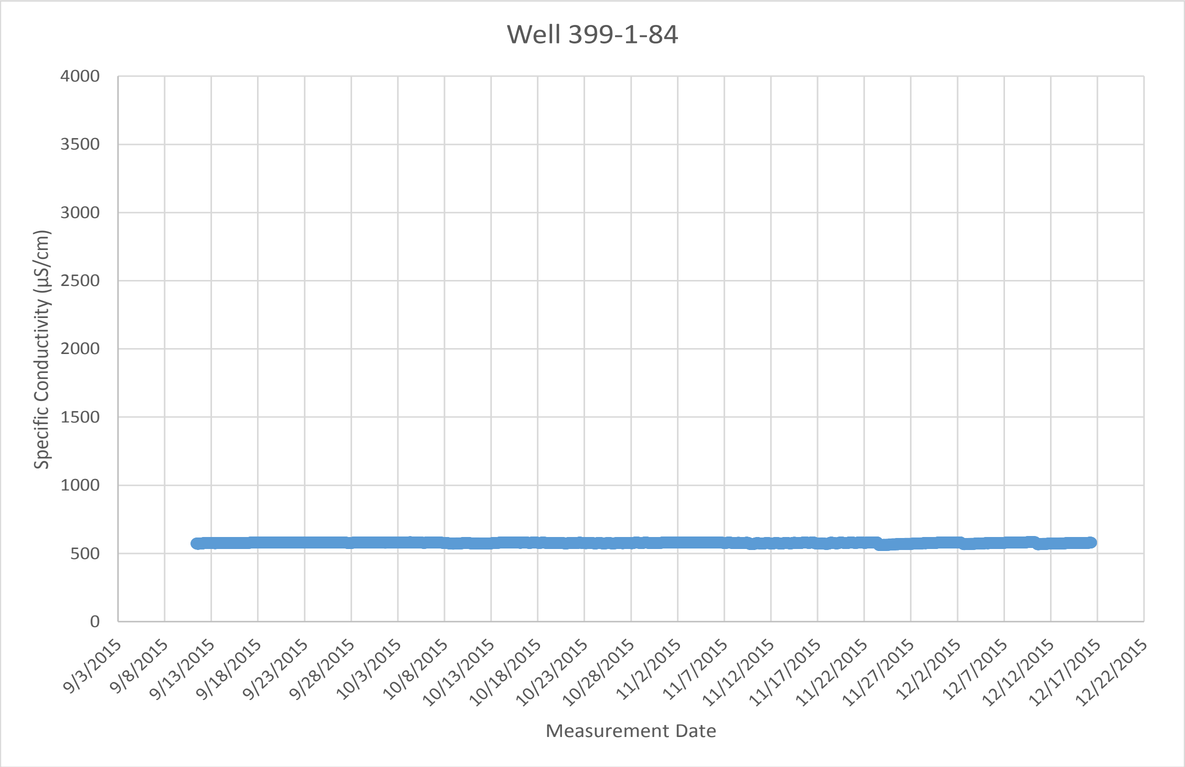


Figure D-11. Specific Conductivity Measurements for Well 399-1-84

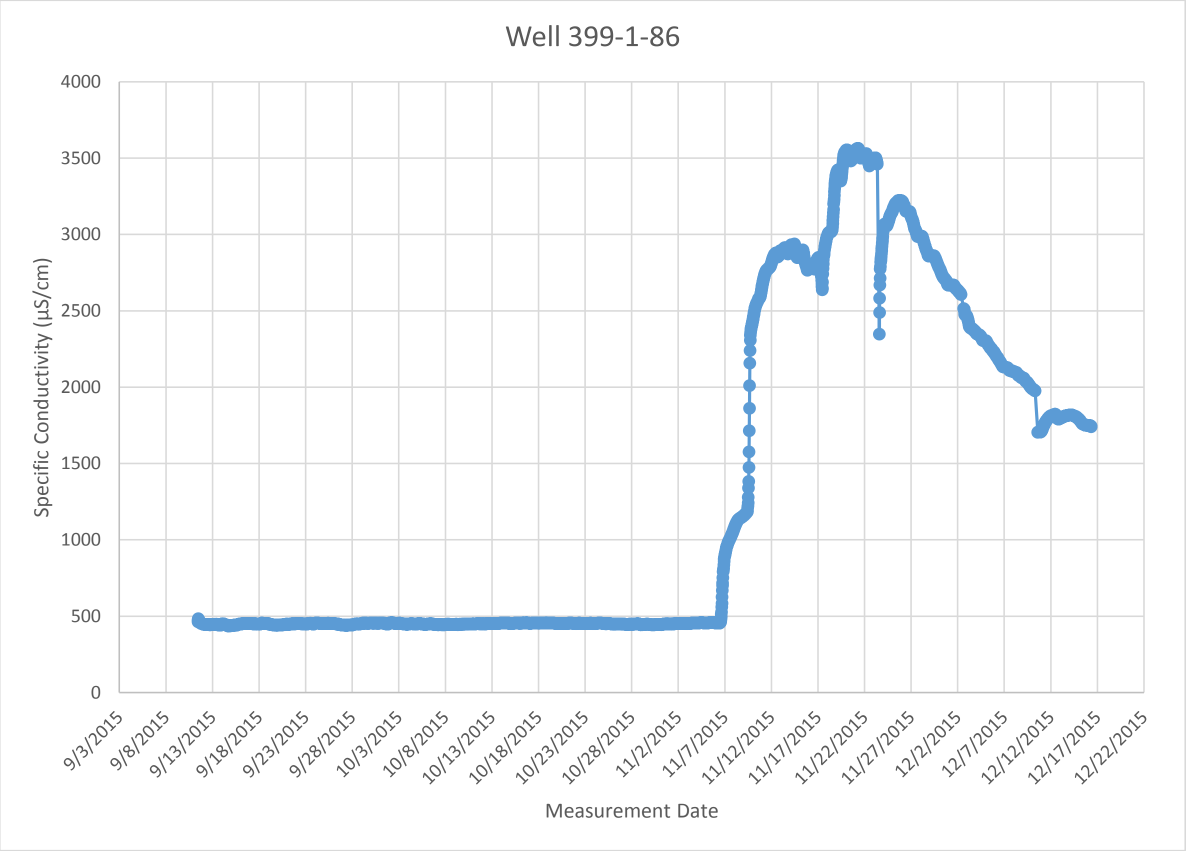


Figure D-12. Specific Conductivity Measurements for Well 399-1-86

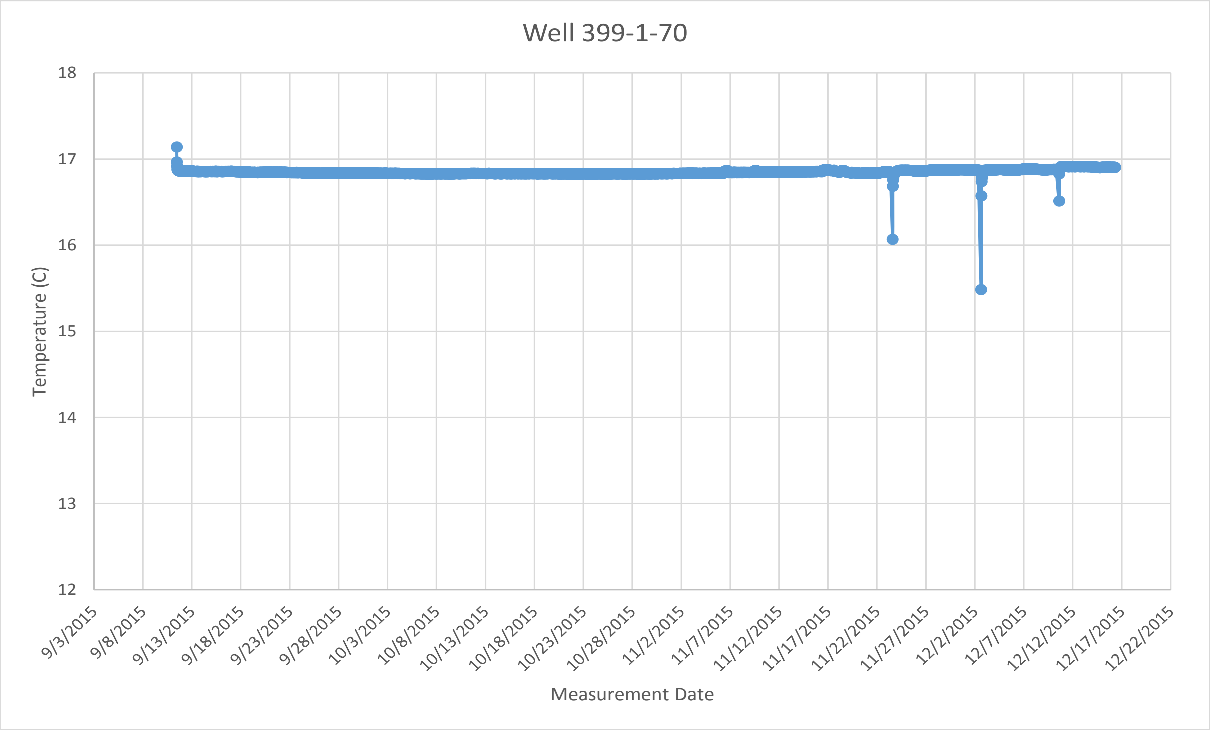


Figure D-13. Temperature Measurements for Well 399-1-70

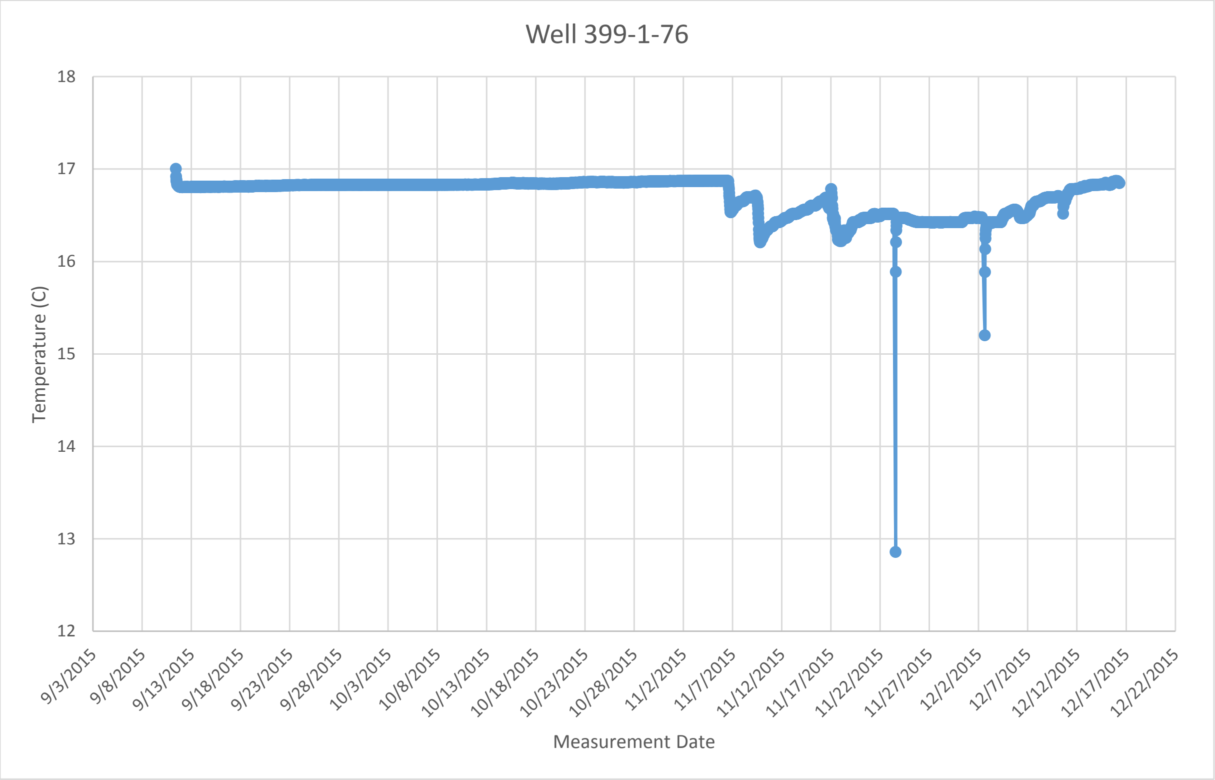


Figure D-14. Temperature Measurements for Well 399-1-76

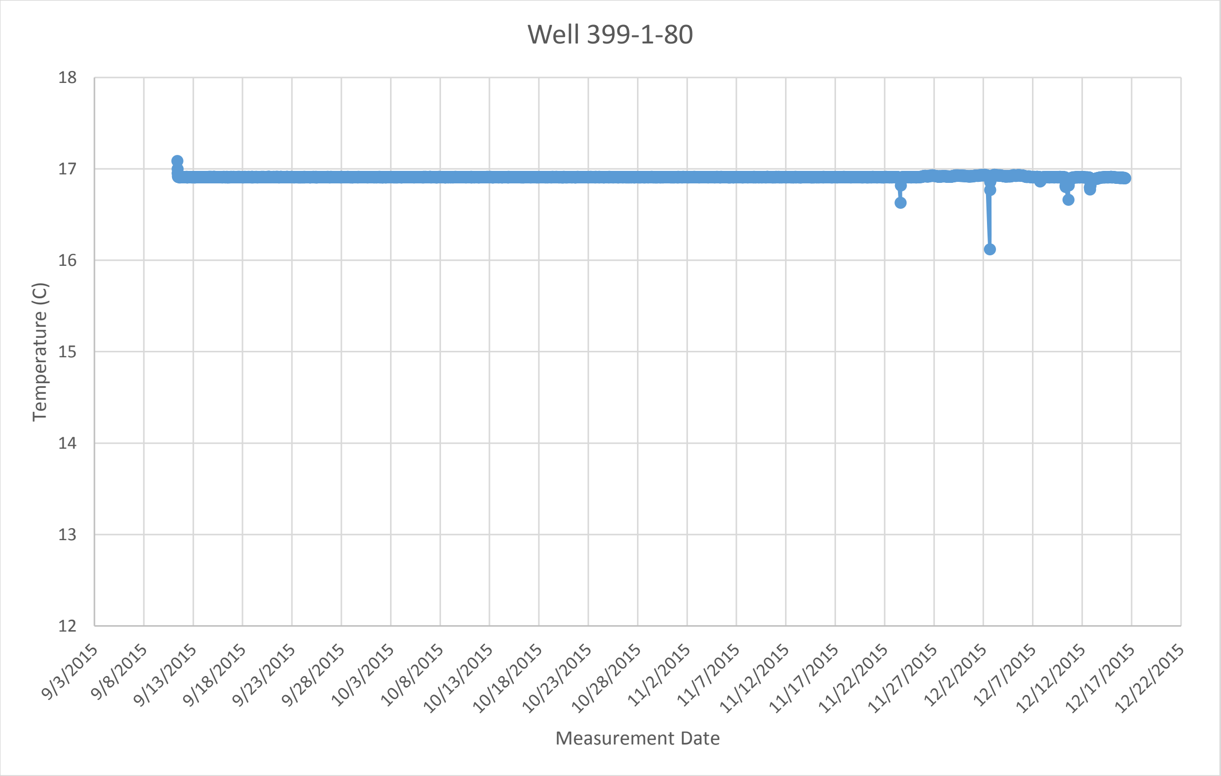


Figure D-15. Temperature Measurements for Well 399-1-80

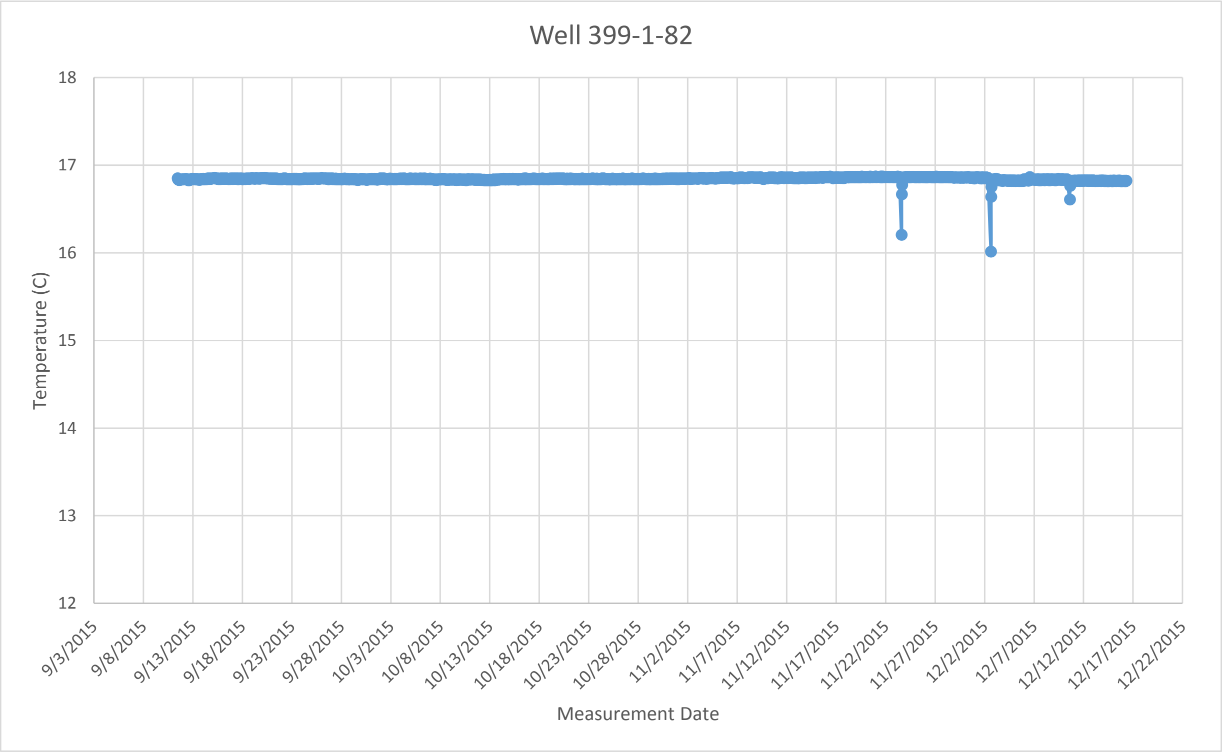


Figure D-16. Temperature Measurements for Well 399-1-82

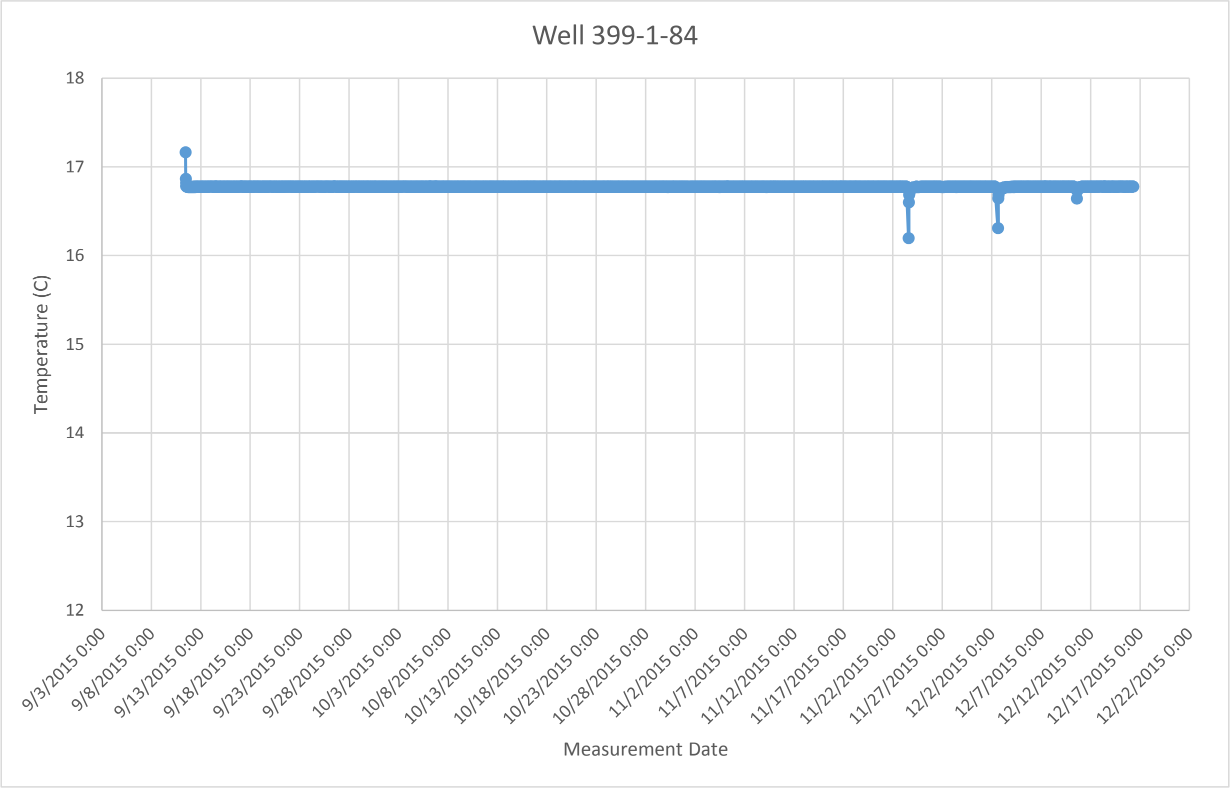


Figure D-17. Temperature Measurements for Well 399-1-84

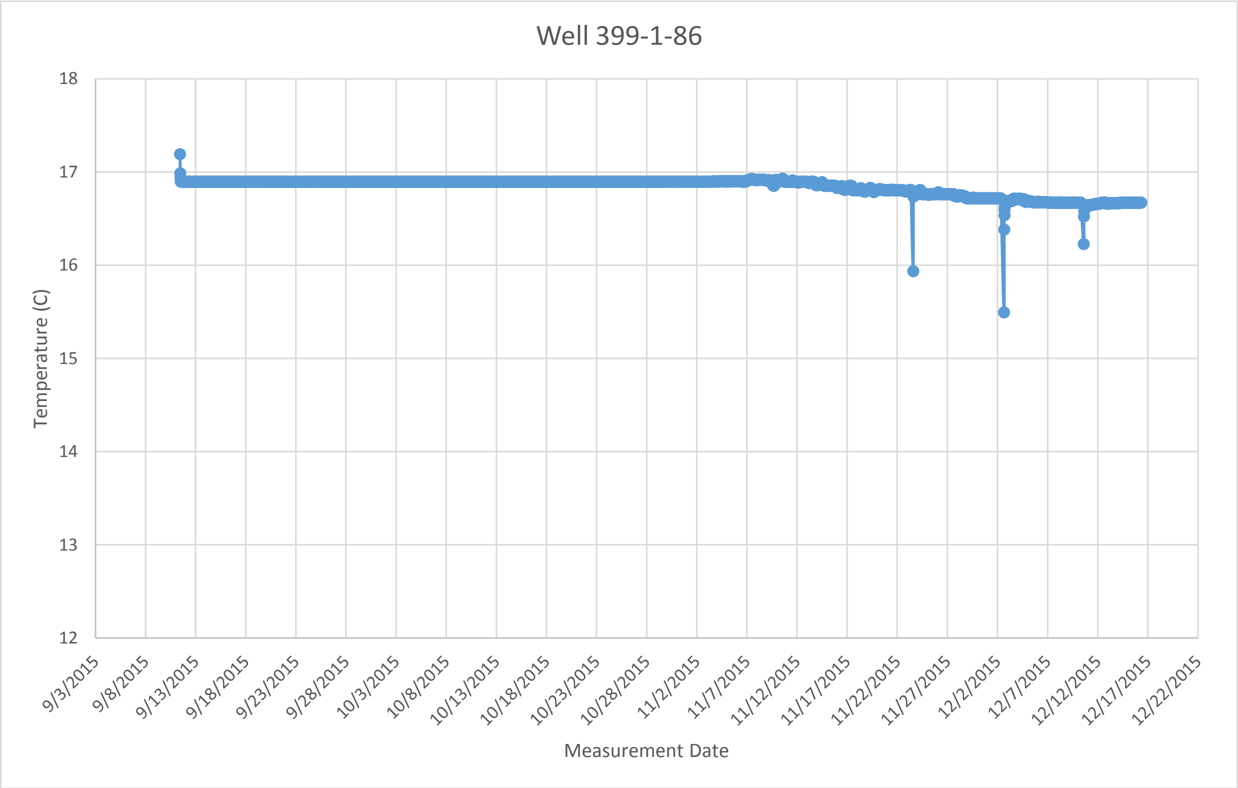


Figure D-18. Temperature Measurements for Well 399-1-86

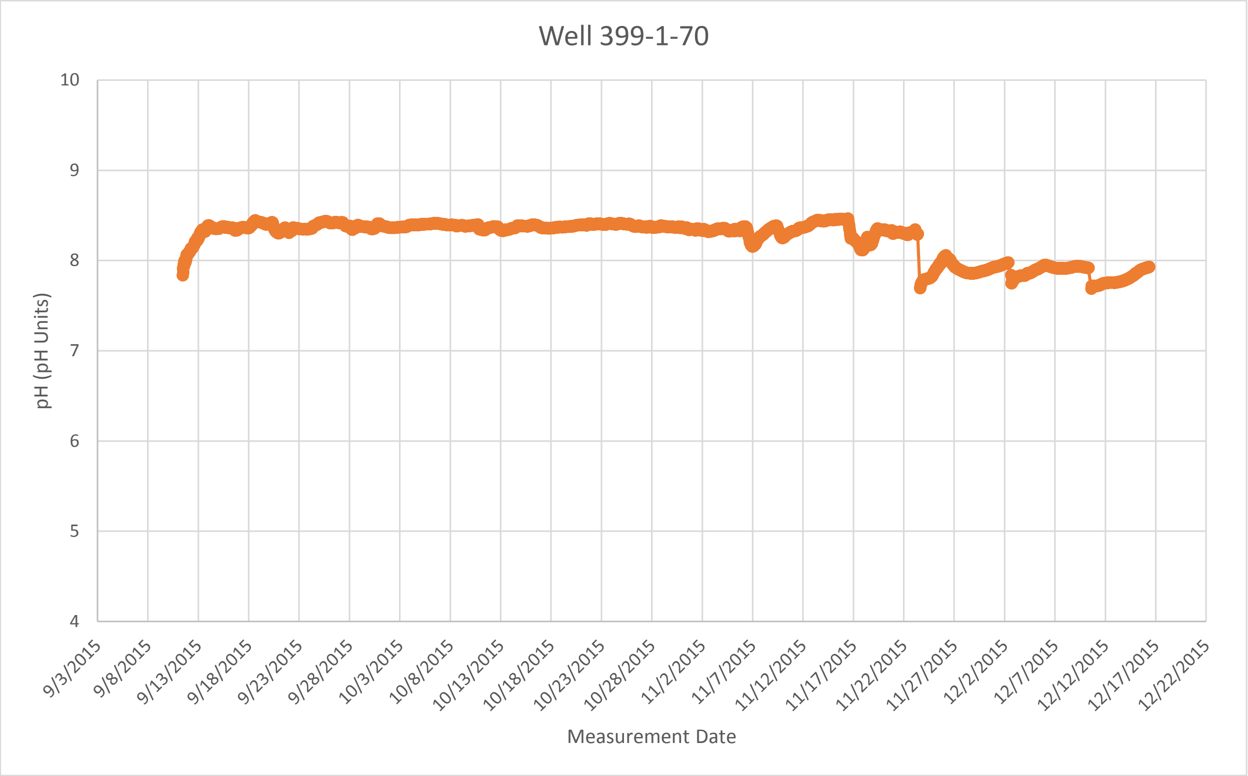


Figure D-19. pH Measurements for Well 399-1-70

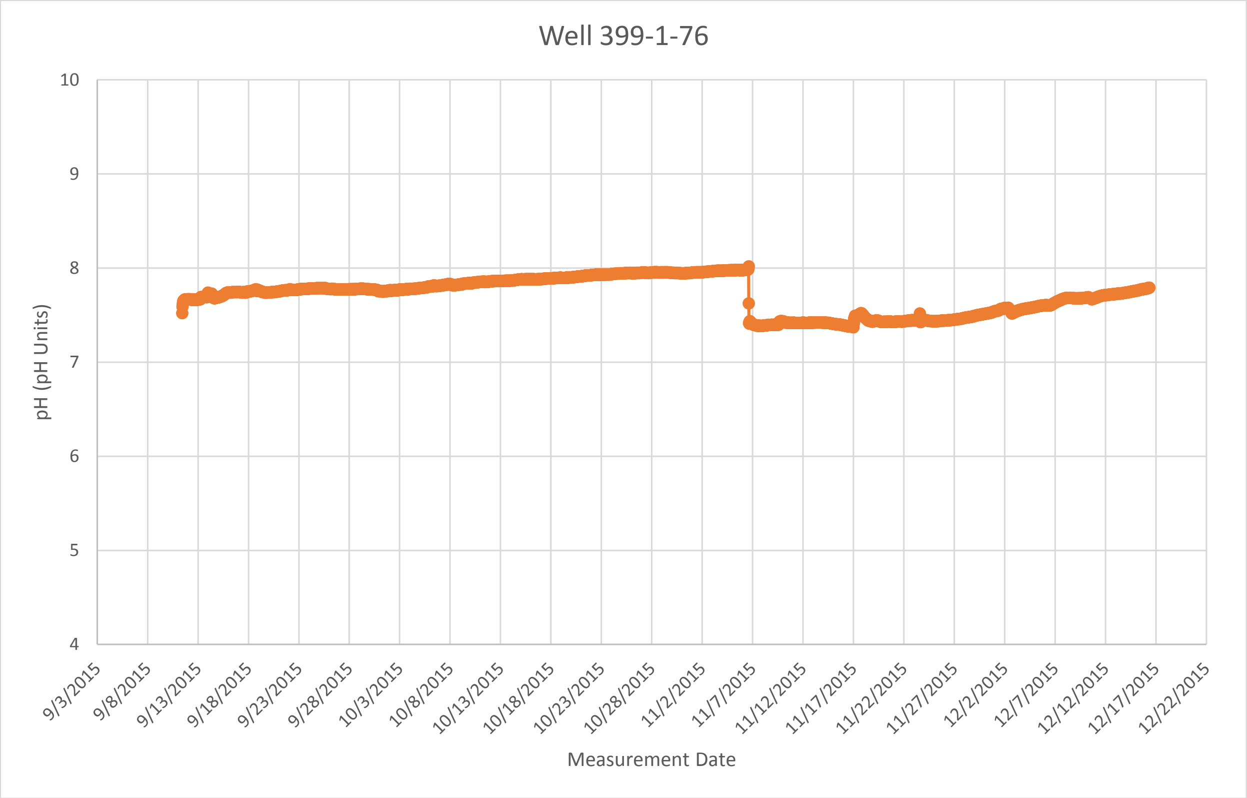


Figure D-20. pH Measurements for Well 399-1-76

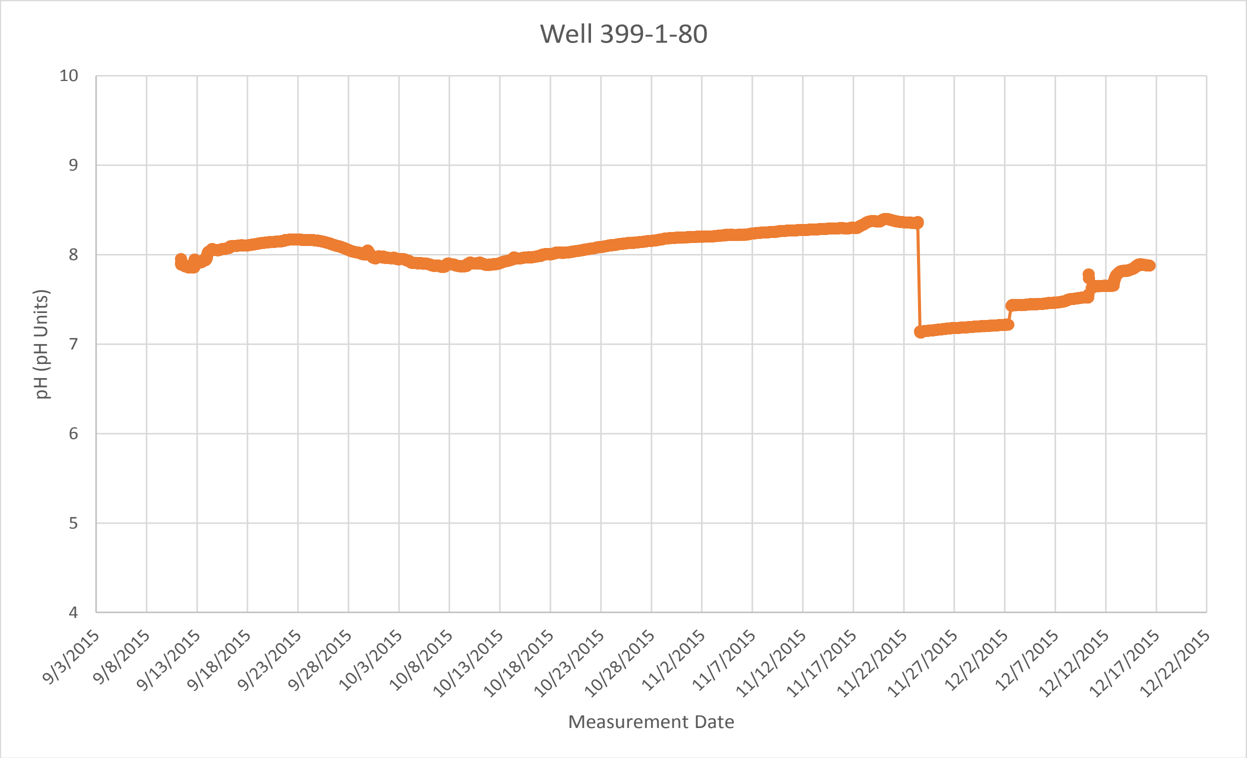


Figure D-21. pH Measurements for Well 399-1-80

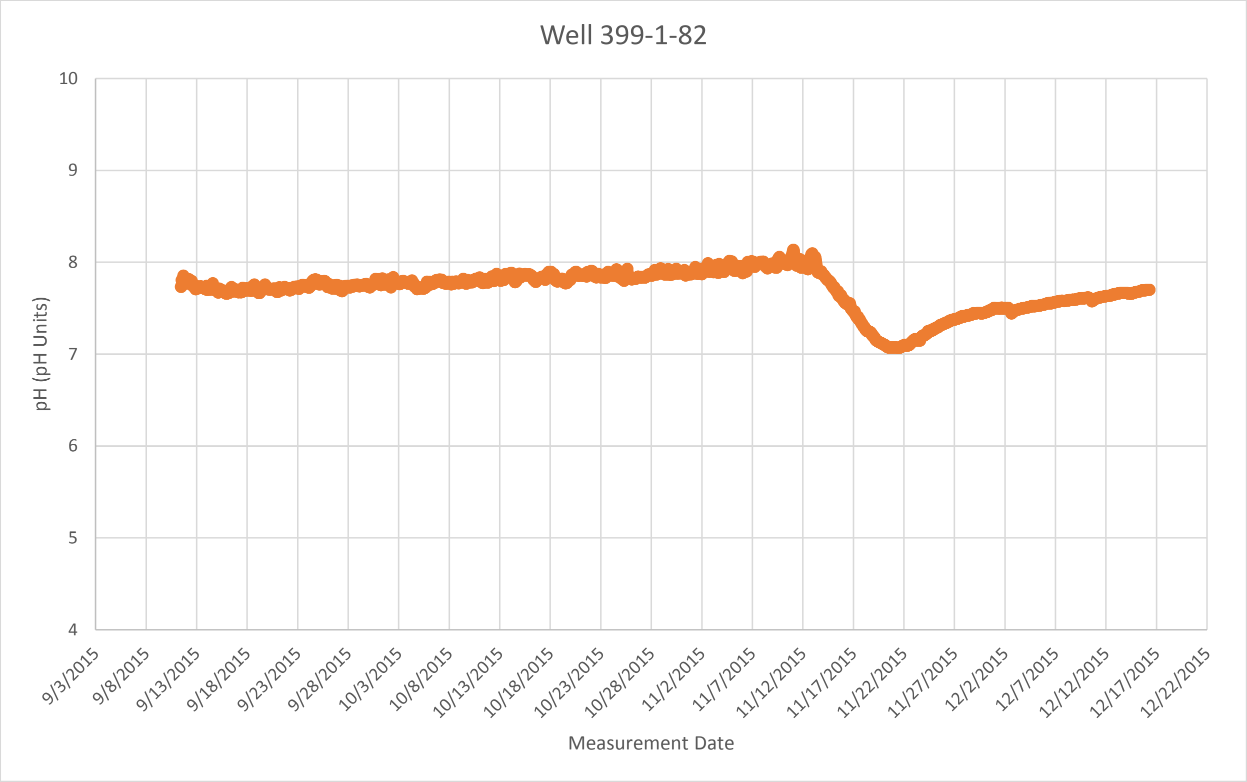


Figure D-22. pH Measurements for Well 399-1-82

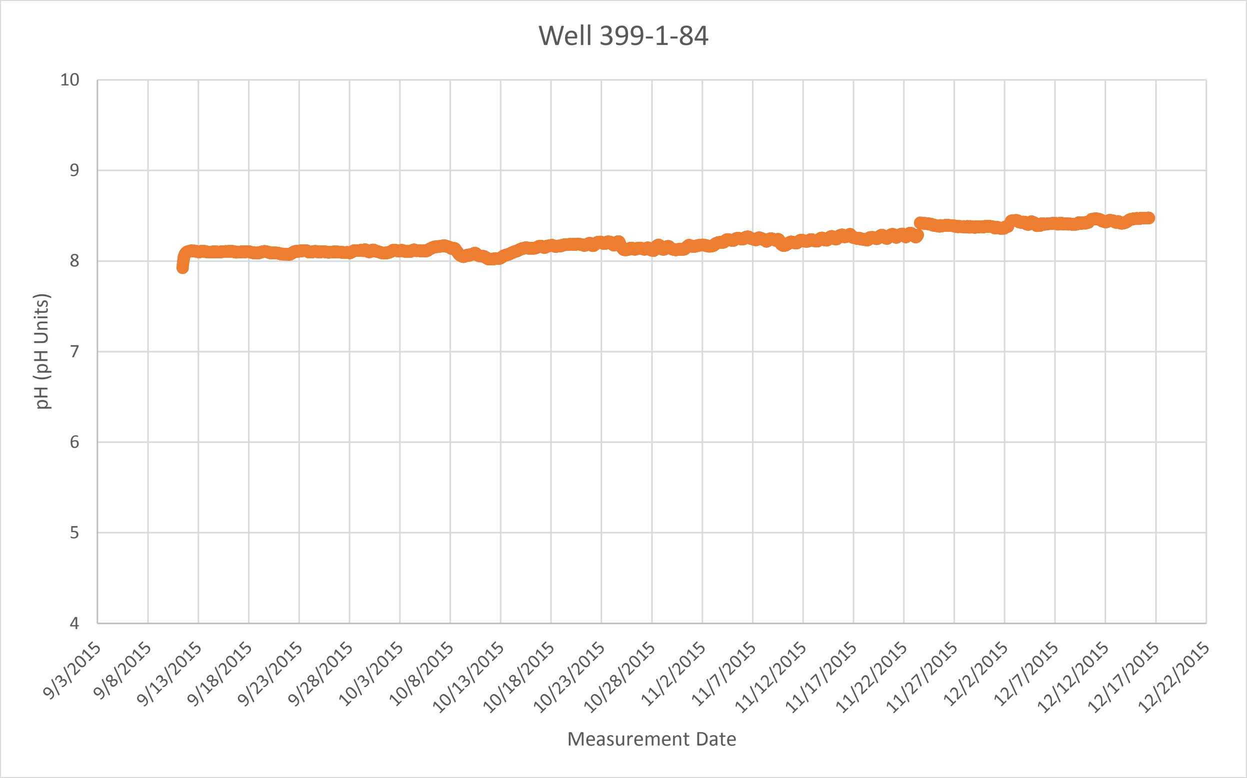


Figure D-23. pH Measurements for Well 399-1-84

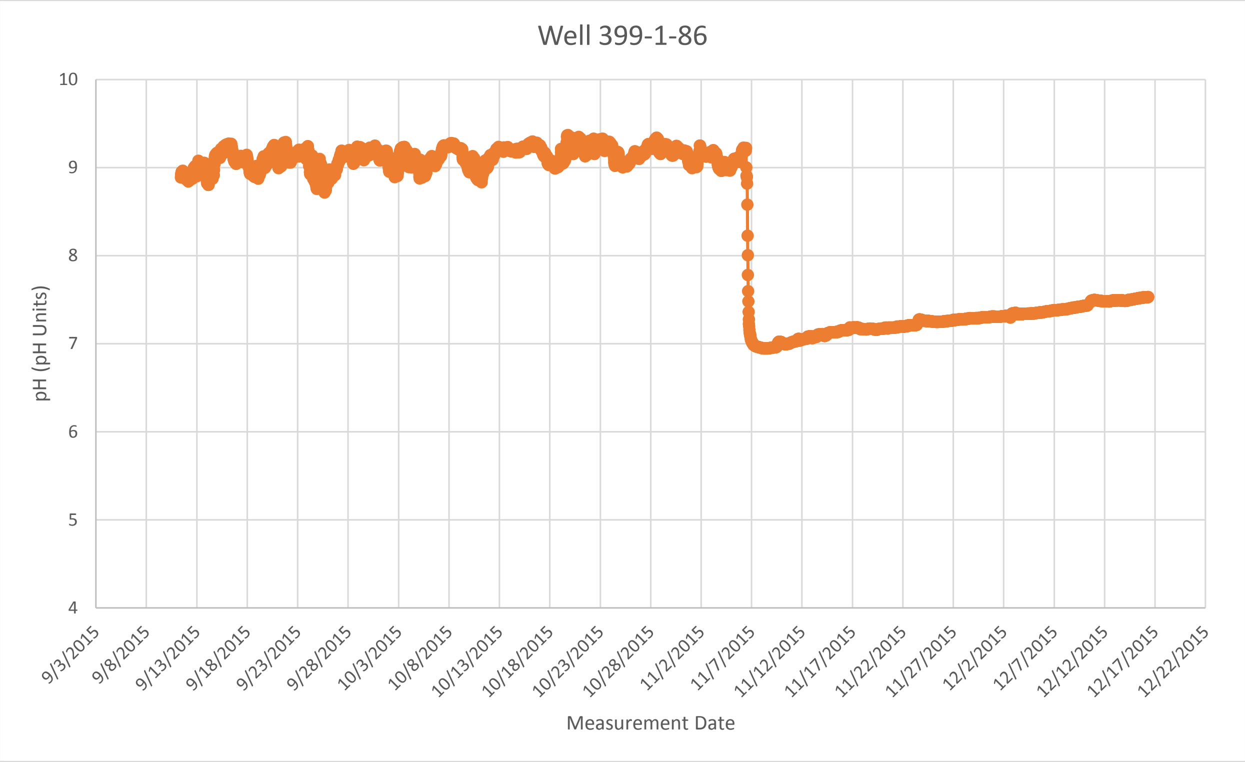


Figure D-24. pH Measurements for Well 399-1-86

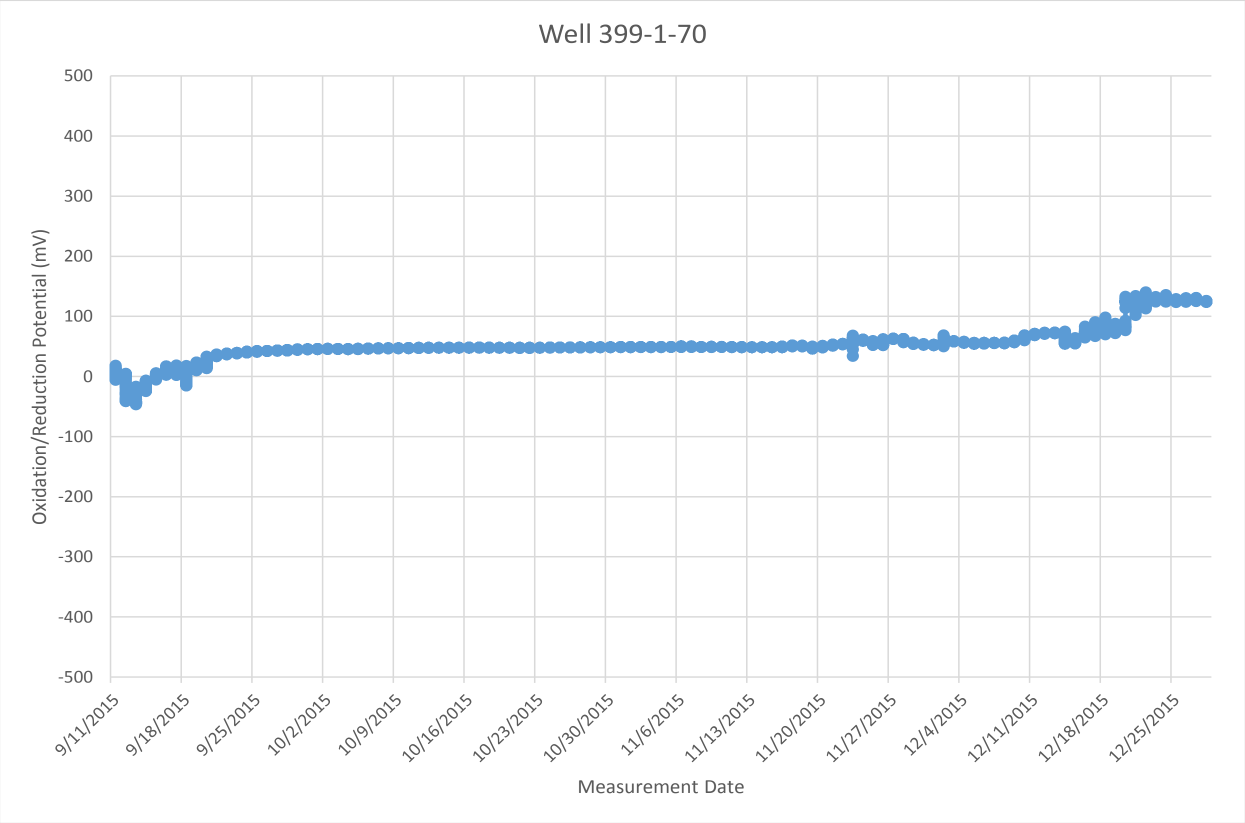


Figure D-25. Oxidation/Reduction Potential Measurements for Well 399-1-70

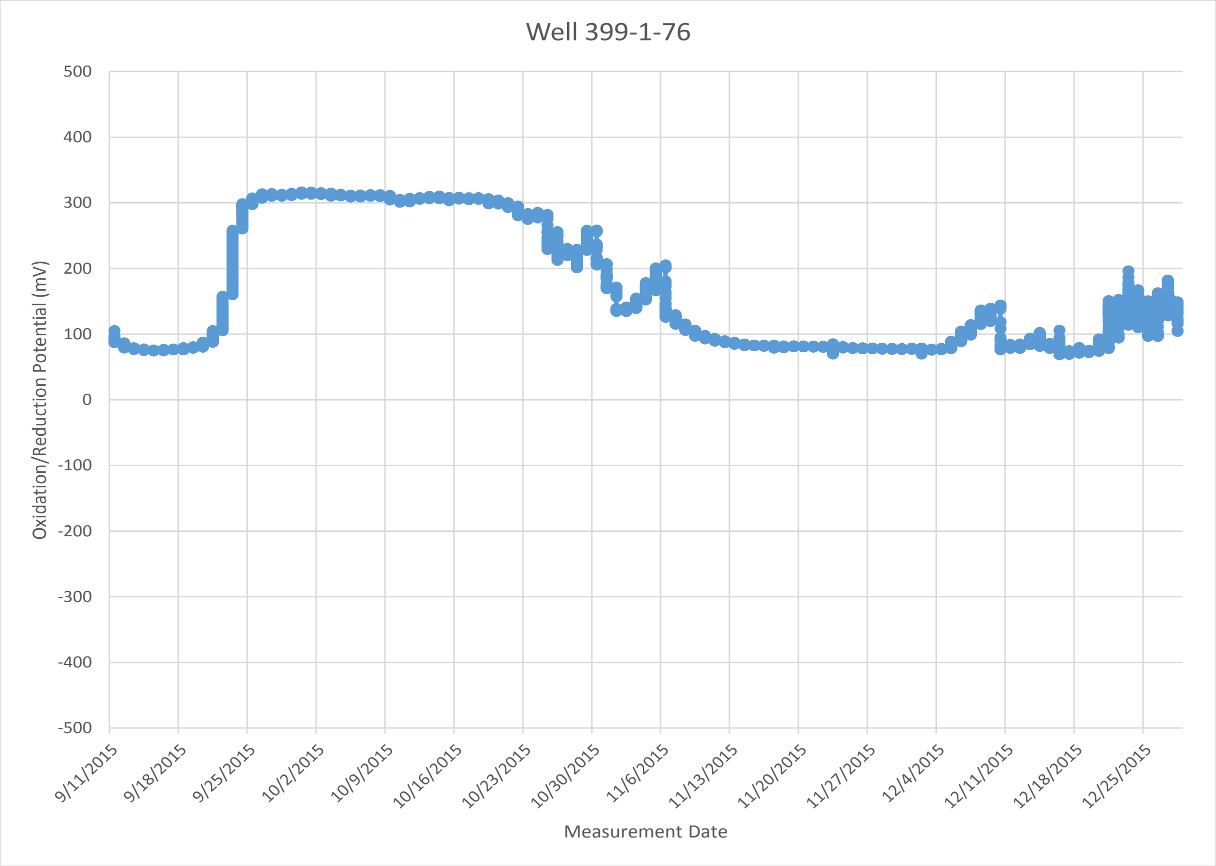


Figure D-26. Oxidation/Reduction Potential Measurements for Well 399-1-76

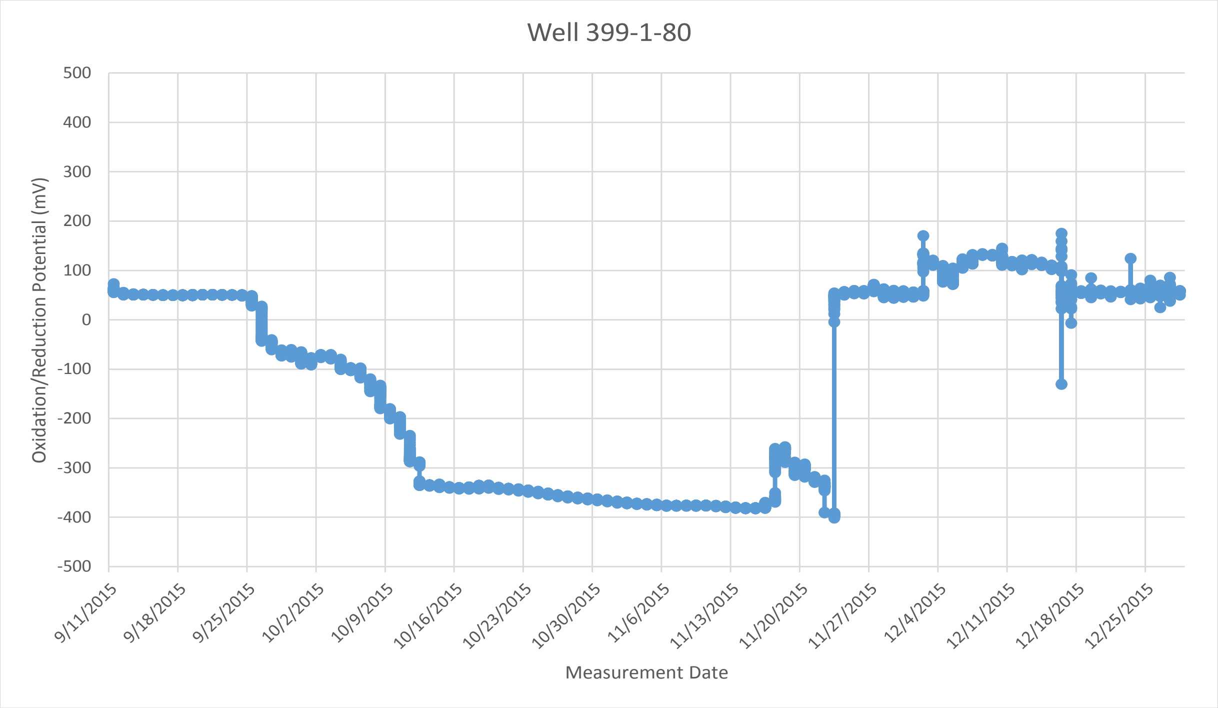


Figure D-27. Oxidation/Reduction Potential Measurements for Well 399-1-80

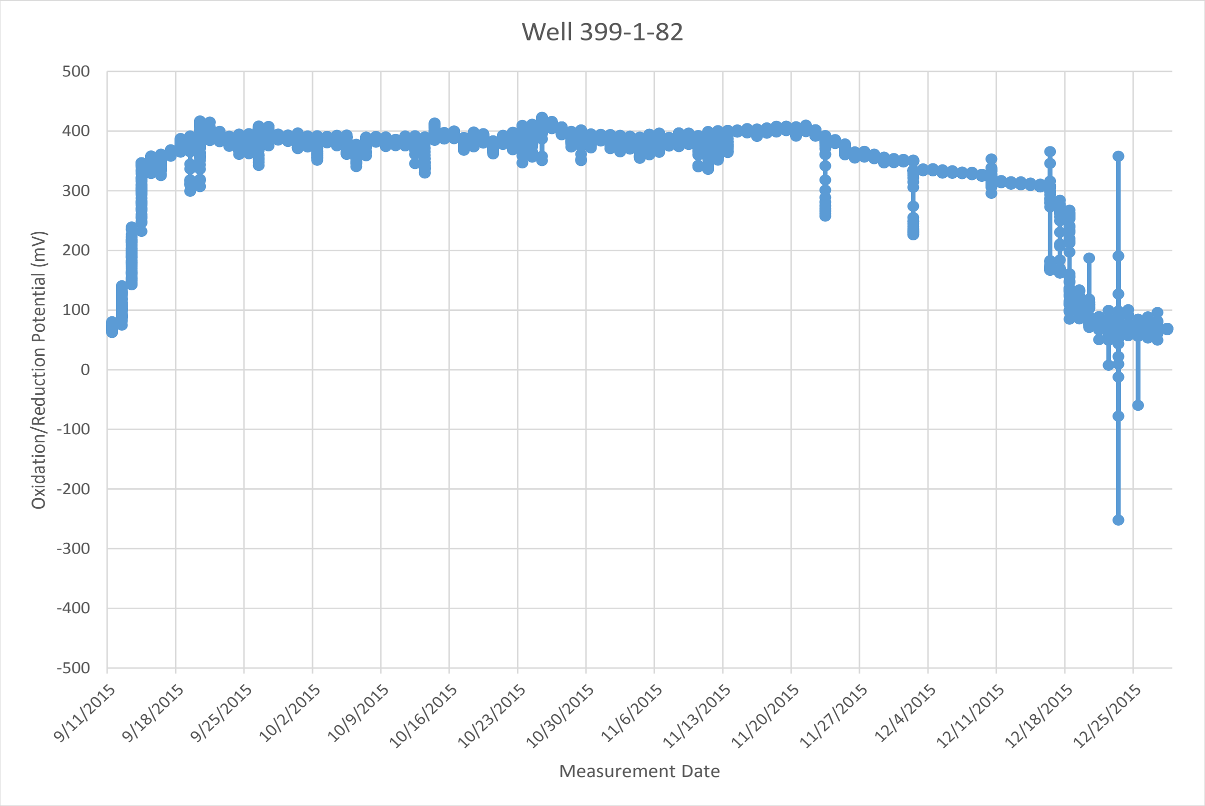


Figure D-28. Oxidation/Reduction Potential Measurements for Well 399-1-82

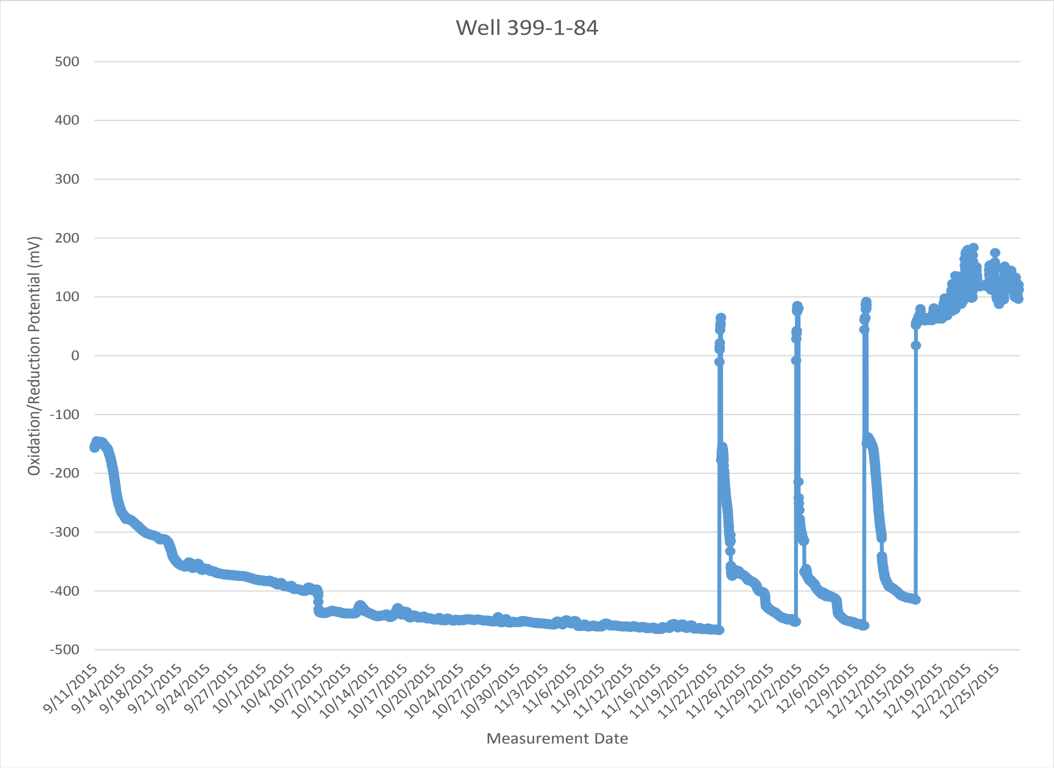


Figure D-29. Oxidation/Reduction Potential Measurements for Well 399-1-84

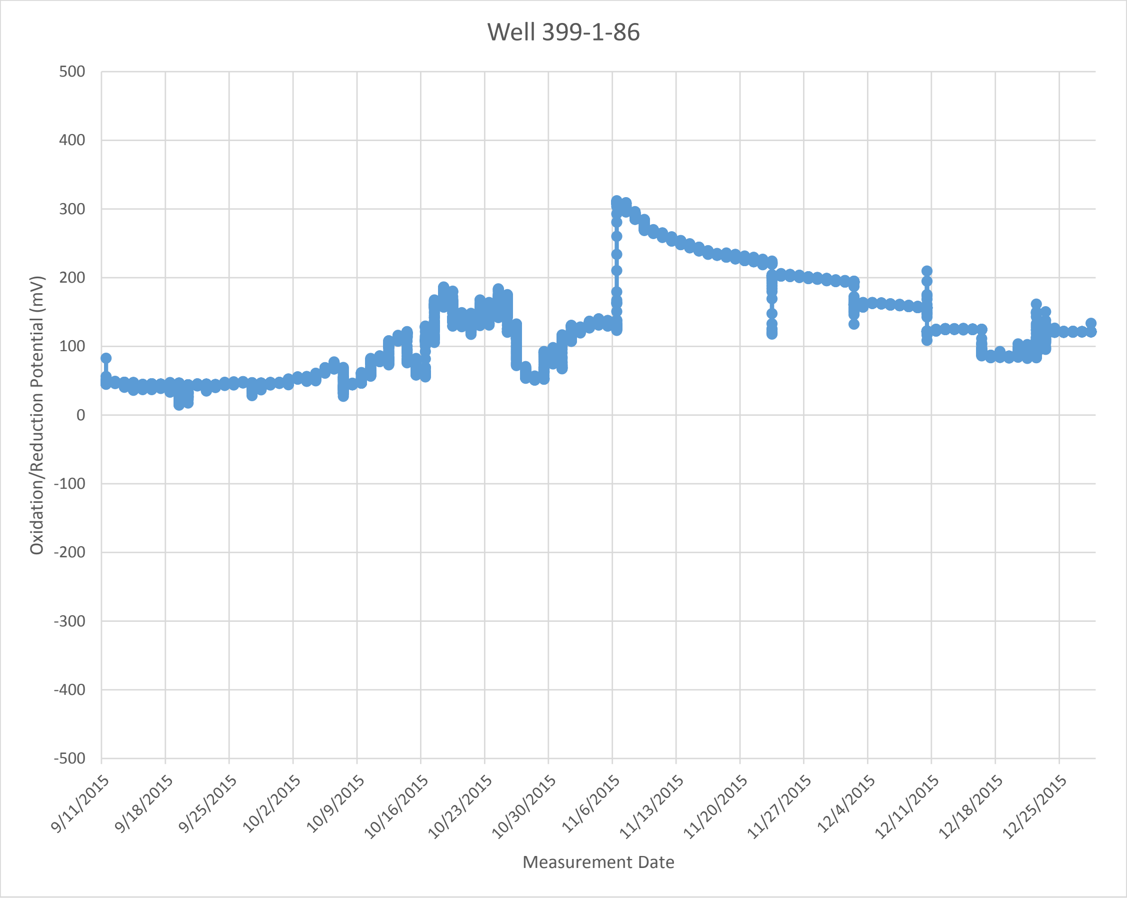


Figure D-30. Oxidation/Reduction Potential Measurements for Well 399-1-86

D2 Data from the Automated Water Level Network

Automated water level measurements were collected from six groundwater wells (399-1-7, 399-1-12, 399-1-16A, 399-1-23, 399-2-2, and 399-8-1) around the Stage A enhanced attenuation area that are part of the automated water level network (AWLN) in the 300 Area. The AWLN logs water levels every 15 minutes. During the Stage A enhanced attenuation operations, specific conductivity and temperature also were logged in these wells. The locations of the AWLN wells are shown on Figure 3-5. The AWLN data are provided on the accompanying CD as Supporting Information D-2.

Appendix E

Mixing Skid Analytical Data

This page intentionally left blank.

Contents

Tables

This page intentionally left blank.

E1 Infiltration Skid Analytical Data

Table E-1 contains the analytical results for a Columbia River sample collected prior to mixing with polyphosphate chemicals and for infiltration solution samples collected at the start of infiltration and once daily thereafter for each day of treatment. The samples were analyzed at an offsite laboratory for carbonate and bicarbonate alkalinity, calcium, magnesium, potassium, sodium, chloride, phosphate, and sulfate.

Table E-1. Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Infiltration Skid Samples

Sample Date	Sample Number	Alkalinity (EPA Method 310.1) in µg/L		Metals (EPA Method 6020) in µg/L				Anions (EPA Method 300) in µg/L		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Chloride	Phosphate	Sulfate
Filtered Columbia River Water (Mixing Water)										
11/7/2015	B32JN0	540 U	55,000	19,300	4,280	795 B	1700	--	--	--
	B32JN1	--	--	--	--	--	--	870 D	251 UN	10,000 D
Infiltration Solution (Daily Samples)										
11/7/2015	B32L04	5,400 U	3,780,000 D	15,300	3,950	2,380,000 D	2,780,000 D	--	--	--
	B32L05	--	--	--	--	--	--	50,000 U	12,300,000 D	63,000 U
11/8/2015	B32L07	5,400 U	1,780,000 D	15,900	3,990	1,110,000 D	1,440,000 D	--	--	--
	B32L08	--	--	--	--	--	--	50,000 U	4,910,000 D	63,000 U
	B32L54	5,400 U	1,800,000 D	15,200	3,970	981,000 D	1,270,000 D	--	--	--
	B32L55	--	--	--	--	--	--	50,000 U	4,910,000 D	63,000 U
11/9/2015	B32L10	5,400 U	1,640,000 D	16,500	4,070	879,000 D	1,170,000 D	--	--	--
	B32L11	--	--	--	--	--	--	50,000 U	4,600,000 D	63,000 U
11/10/2015	B32L13	5,400 U	1,760,000 D	15,200 BD	3,420 BD	1,020,000 D	1,380,000 D	--	--	--
	B32L14	--	--	--	--	--	--	50,000 U	4,910,000 D	63,000 U
11/11/2015	B32L16	5,400 U	1,690,000 D	17,800 BD	3,850 BD	1,150,000 D	1,420,000 D	--	--	--
	B32L17	--	--	--	--	--	--	50,000 U	4,910,000 D	63,000 U
11/12/2015	B33KX6	5,400 U	1,770,000 D	15,900 BD	3,480 BD	1,010,000 D	1,270,000 D	--	--	--
	B33KX7	--	--	--	--	--	--	50,000 U	4,910,000 D	63,000 U
11/14/2015	B33KX8	5,400 U	1,900,000	20,100 D	4,590 BD	1,350,000 D	1,620,000 D	--	--	--
	B33KX9	--	--	--	--	--	--	50,000 U	5,520,000 D	63,000 U

Table E-1. Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Infiltration Skid Samples

Sample Date	Sample Number	Alkalinity (EPA Method 310.1) in µg/L		Metals (EPA Method 6020) in µg/L				Anions (EPA Method 300) in µg/L		
		Carbonate	**Bicarbonate**	**Calcium**	**Magnesium**	**Potassium**	**Sodium**	**Chloride**	**Phosphate**	**Sulfate**
11/15/2015	B33KY0	5,400 U	1,770,000	29,400 D	4,550 BD	1,170,000 D	1,420,000 D	--	--	--
	B33KY1	--	--	--	--	--	--	50,000 U	5,210,000 D	63,000 U

-- = not applicable

EPA = U.S. Environmental Protection Agency

Laboratory Qualifiers:

B = The analyte was detected at a value less than the contract required detection limit, but greater than or equal to the instrument detection limit/maximum detection limit (as appropriate).

D = Analyte was reported at a secondary dilution factor.

N = Spike and/or spike duplicate sample recovery is outside control limits.

U = Undetected.

E2 Injection Skid Analytical Data

Table E-2 contains the analytical results for a Columbia River sample collected prior to mixing with polyphosphate chemicals and for injection solution samples collected at the start of injection and once daily thereafter for each day of treatment. The samples were analyzed at an offsite laboratory for carbonate and bicarbonate alkalinity, calcium, magnesium, potassium, sodium, chloride, phosphate, and sulfate.

Table E-2. Alkalinity, Metal, and Anion Results for 300-FF-5 Operable Unit Stage A Injection Skid Samples

Sample Date	Sample Number	Alkalinity (EPA Method 310.1) in µg/L		Metals (EPA Method 6020) in µg/L				Anions (EPA Method 300) in µg/L		
		Carbonate	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Chloride	Phosphate	Sulfate
Filtered Columbia River Water (Mixing Water)										
11/6/2015	B32JM7	540 U	58,000	22,100	4,730	2,530 B	3,160	--	--	--
	B32JM8	--	--	--	--	--	--	850 D	251 U	11,000 D
Aquifer Injection Solution (Daily Samples)										
11/6/2015	B32KX6	5,400 U	2,960,000 D	18,300	4,090	1,560,000 D	1,810,000 D	--	--	--
	B32KX7	--	--	--	--	--	--	50,000 U	8,590,000 D	63,000 U
11/9/2015	B32KX9	5,400 U	2,830,000 D	17,200	3,890	1,480,000 D	1,830,000 D	--	--	--
	B32KY0	--	--	--	--	--	--	50,000 U	8,280,000 D	63,000 U
11/16/2015*	B32L01	5,400 U	2,930,000	18,200 BD	4,070 BD	1,970,000 D	2,260,000 D	--	--	--
	B32L02	--	--	--	--	--	--	50,000 U	8,890,000 DN	63,000 U
Periodically Rewetted Zone Injection Solution (Daily Samples)										
11/17/2015	B33KY4	5,400 U	2,830,000	17,900 BD	4,060 BD	2,060,000 D	2,370,000 D	--	--	--
	B33KY5	--	--	--	--	--	--	50,000 U	8,280,000 DN	63,000 U
11/18/2015	B32L56	5,400 U	2,950,000	18,500 BD	4,010 BD	1,920,000 D	2,200,000 D	--	--	--
	B32L57	--	--	--	--	--	--	50,000 U	8,590,000 D	63,000 U

* The sample collected on November 16, 2015 represents both the aquifer injection and the periodically rewetted zone injection solution on that day of operation.

-- = not applicable

EPA = U.S. Environmental Protection Agency

Laboratory Qualifiers:

B = The analyte was detected at a value less than the contract required detection limit, but greater than or equal to the instrument detection limit/maximum detection limit (as appropriate).

D = Analyte was reported at a secondary dilution factor.

N = Spike and/or spike duplicate sample recovery is outside control limits.

U = Undetected.

This page intentionally left blank.

Appendix F

Electrical Resistivity Tomography Report

This page intentionally left blank.

F Electrical Resistivity Tomography Report

Electrical resistivity tomography (ERT) was used to evaluate the performance of polyphosphate solution infiltration during implementation of the Stage A enhanced attenuation (EA) remedy. The solution changes the electrical conductivity of the vadose zone as it migrates laterally and vertically. ERT was used to image the spatial and temporal distribution of the change in vadose zone electrical conductivity caused by solution migration. ERT monitoring was conducted by Pacific Northwest National Laboratory (PNNL) along two transects extending east-west and north-south across the Stage A EA area (Figure 2-5).

This appendix provides the report prepared by PNNL to document the ERT imaging operation and the interpretation of the imaging results: PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography*.

This page intentionally left blank.

PNNL-SA-25232

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** *Since 1965*

Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography

February 2016

TC Johnson
JN Thomle

U.S. DEPARTMENT OF
ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service
5301 Shawnee Rd., Alexandria, VA 22312
ph: (800) 553-NTIS (6847)
email: orders@ntis.gov <http://www.ntis.gov/about/form.aspx>
Online ordering: http://www.ntis.gov

PNNL-SA-25232

Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography

TC Johnson
JM Thomle

February 2016

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

The Hanford Site 300 Area lies adjacent to the Columbia River, approximately 5 km north of Richland, WA. Past waste disposal practices in the 300 Area resulted in vadose zone uranium contamination beneath former infiltration ponds and trenches. Stage-driven water table fluctuations and river water intrusion facilitate mobilization of uranium from contaminated sediments in the periodically rewetted zone (PRZ), thereby raising groundwater uranium concentrations above the maximum allowable contaminant level for uranium. On November 6 through December 18, 2015, CH2M Hill Plateau Remediation Company conducted an in situ uranium sequestration test by applying a phosphate amendment to a select region of the 300 Area vadose zone and PRZ. In addition to direct injections into the PRZ, amendment was infiltrated into the vadose zone using a near-surface infiltration system. Amendment application through the infiltration system occurred continuously over a 10-day period from November 6 through November 15, 2015. Real-time electrical resistivity tomography (ERT) was used to evaluate amendment delivery performance by imaging the spatial and temporal distribution of the change in vadose zone electrical conductivity caused by amendment migration. ERT imaging surveys were conducted at 12-minute intervals and reported via website in near real time. Monitoring was conducted along two transects extending 89.9 m (295 ft) and 70.1 m (230 ft) respectively within the treatment zone. This report documents the ERT imaging operations and interpretation of imaging results in terms of delivery system performance, amendment migration velocity, and overall amendment distribution within the treatment area. Based on the interpretation, vertical migration rates appear to have ranged from 0.75 to 3.00 m/d. Assuming conservative amendment transport, the image analysis shows amendment to have reached the water table throughout, and therefore infiltrated the vadose zone, in no more than 7 days after the start of infiltration, 3 days prior to the end of infiltration injections (Figure S.1). Although application rates through the infiltration system appear to have been variable, image results suggest complete amendment coverage throughout the vadose beneath each ERT transect, with the caveat that resolution limitations may have disabled the capability to detect small (less than ~ 1 m^3) regions that may not have been treated.

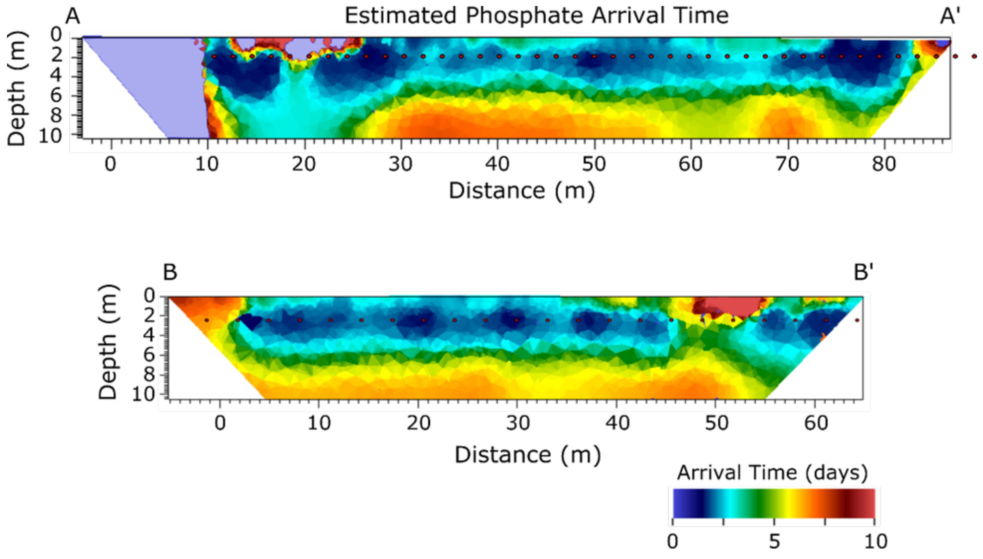


Figure S.1. ERT-based amendment arrival times beneath each of the two ERT imaging transects. The red dots indicate locations where amendment infiltration lines crossed the corresponding ERT transect. Infiltration operations commenced on Nov. 6th and ceased on Nov. 15th , 2015. The latest arrival times occur at the water table (i.e. ~10 m depth) in approximately 7 days.

Acknowledgments

This work was funded by the CH2M Hill Plateau Remediation Company under the 300-FF-5 Operable Unit Stage A Uranium Sequestration test.

Acronyms and Abbreviations

CHPRC	CH2M Hill Plateau Remediation Company
ERT	electrical resistivity tomography
MPT	Multiphase Technlogies, LLC
NQA	Nuclear Quality Assurance
PNNL	Pacific Northwest National Laboratory
PRZ	periodically rewetted zone
PVC	polyvinyl chloride

Nomenclature

$\sigma_{b,t}$	bulk electrical conductivity at time t
θ	porosity
m	Archie's cementation exponent
n	Archie's saturation exponent
$\sigma_{f,t}$	pore water fluid electrical conductivity at time t
S_t	saturation at time t
$\sigma_{s,t}$	pore/grain interface electrical conductivity at time t
$S_{pw,t}$	fraction of saturation attributed to pore water at time t
$S_{p,t}$	fraction of saturation attributed to phosphate amendment at time t
σ_{pw}	pore water conductivity
σ_p	phosphate amendment conductivity

Contents

Figures

Tables

---

[1] SGW-59455. 300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report, Rev. 0. CH2M Hill Plateau Remedation Company, Richland, WA (draft report) .

1.0 Introduction

1.1 Site Overview and Background

The Hanford Site is located in Washington State north of the city of Richland. From 1942 to 1988, the primary mission of the Hanford Site was weapons grade plutonium production. During production operations, waste disposal practices left many areas with vadose zone and groundwater contamination (Figure 1.1 and Figure 1.2). The 300 Area was the primary research center and housed fabrication facilities for the uranium fuel rods used in the plutonium production process. Between 1943 and 1975, liquid waste from research and fabrication operations in the 300 Area was disposed in process ponds (north and south). Additional waste from the 300 Area operations was discharged to the subsurface between 1975 and 1985. Much of the sediment contained in the 300 Area process ponds was excavated in the mid-90s and replaced with clean fill in 2004 (DOE-RL-2005-41 2005; Williams et al. 2007). However, uranium contamination persisted deeper in the vadose zone, and is now the primary contamination of concern. Leaching of uranium from contaminated sediments to the water table is largely driven by Columbia River stage levels. As river water enters the periodically rewetted zone (PRZ), uranium leaching from contaminated sediment within the PRZ elevates the aqueous uranium concentrations above the drinking water standard of 30 μg/L (Figure 1.2).

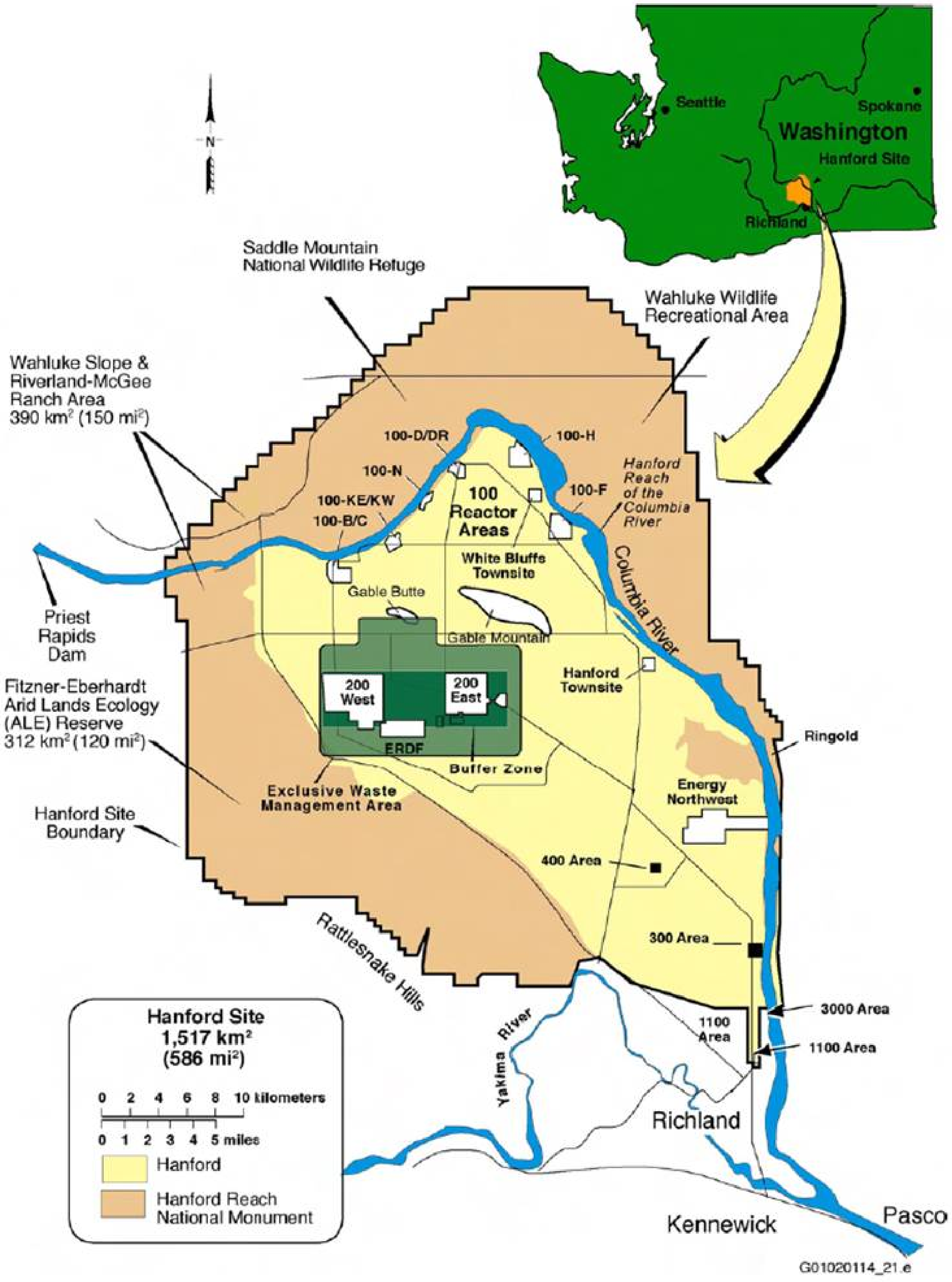


Figure 1.1. Hanford Site location (Peterson et al. 2008). The 300 Area is located in the southeast corner of the Hanford Site, north of Richland, WA.

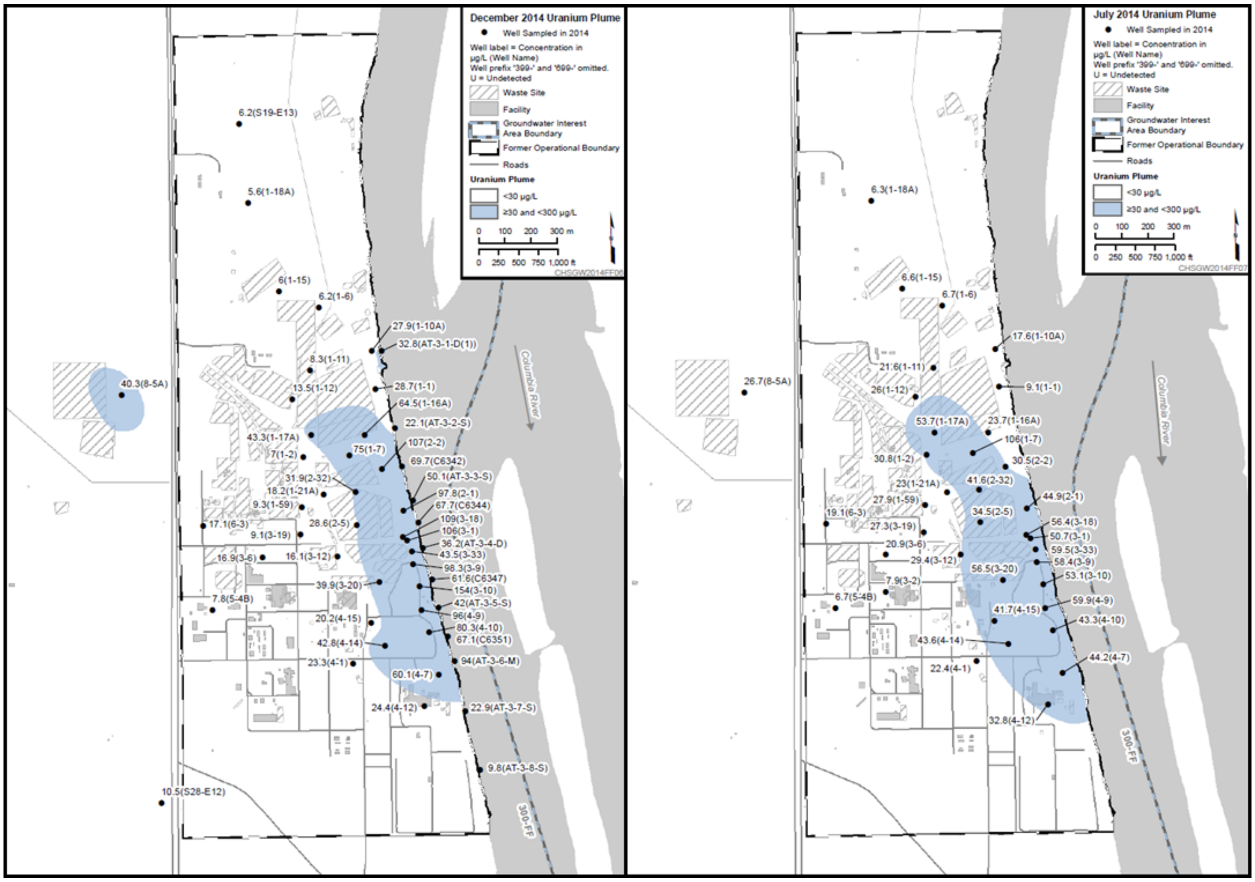


Figure 1.2. 300 Area uranium plume at low (December) and high (July) river stages DOE-RL 2015-07 2015.

In an effort to immobilize uranium contamination in the vadose zone and PRZ, a treatment method was developed using phosphate, which has been shown reduce uranium mobility by forming uranium phosphate precipitates and coating surface phases of uranium with stable mineral phases (Szecsody et al. 2012). On November 6 through November 18, 2015, CH2M Hill Plateau Remediation Company (CHPRC) treated a 0.3 ha (0.75 acre) area, within the 300 Area, which was thought to contain the highest mobile uranium concentrations. The phosphate amendment included a solution of monosodium phosphate and pyrophosphate that was injected directly into the PRZ and upper aquifer through wells, and infiltrated through the vadose zone using buried infiltration lines (see Section 2.1 for the well field and infiltration gallery layout).

Electrical resistivity tomography (ERT), a geophysical imaging method, was selected as one of the methods for monitoring phosphate amendment migration and assessing performance of the infiltration delivery system. ERT was selected because of its ability to remotely image changes in the bulk electrical conductivity caused by the presence of phosphate amendment. ERT uses an array of electrodes to induce electrical current flow within the subsurface, and to measure the resulting electrical potential. These measurements are then processed using a tomographic algorithm to recover, or image, the subsurface electrical conductivity distribution that gave rise to the measurements. Changes in electrical conductivity induced by phosphate amendment were monitored for the duration of treatment operations to help assess amendment delivery, migration, and overall coverage within the vadose zone. Two ERT electrode lines were installed to monitor two cross sections within infiltration gallery. This report describes the petrophysical underpinnings that connect changes in bulk electrical conductivity to amendment-induced changes in pore fluid conductivity and saturation, the layout of the ERT system within the treatment area, ERT operations, ERT imaging results during monitoring, and the interpretation of the resulting data.

1.2 ERT Imaging, Petrophysics, and Image Interpretation

1.2.1 Overview

The objective of ERT is to estimate the bulk electrical conductivity distribution of the subsurface through tomographic imaging. A single ERT measurement is collected by injecting current between a pair of electrodes, and measuring the resulting voltage across several other electrode pairs. Using an array of electrodes, many such measurements are strategically collected to optimize imaging resolution. This set of measurements, termed herein an "ERT survey," is processed using a computationally intensive tomographic inversion algorithm that approximates the subsurface conductivity distribution that gave rise to the measurements. When time-lapse imaging is conducted, surveys are continuously collected and processed to provide a chronological sequence of image frames that illustrate the change in bulk conductivity with time. Subtracting the baseline image (i.e., the pretreatment image in this case) from the time-lapse images reveals the change in bulk conductivity caused by the phosphate amendment, thereby revealing the distribution of amendment in space and time. The time-lapse images may then be analyzed to investigate amendment delivery performance and timing, subject to the resolution limitations of ERT imaging as described below.

1.2.2 Relationships between Amendment Concentration, Soil Properties, and Bulk Electrical Conductivity

In unsaturated sediments, bulk electrical conductivity is governed by porosity, saturation, pore fluid specific conductance, mineral surface conductivity, and pore-space tortuosity as described by Slater and Lesmes 2002:

$$\sigma_{b,t} = \theta^m \sigma_{f,t} S_t^n + \sigma_{s,t}, \tag{1.1}$$

where $\sigma_{b,t}$ is the bulk electrical conductivity at time t, θ is porosity, $\sigma_{f,t}$ is the pore fluid conductivity at time t, S_t^n is the saturation at time t, and $\sigma_{s,t}$ is the surface conductivity at time t, which accounts for conduction along the pore grain interface. For unconsolidated sediments, the cementation factor m is typically near 1.3 and the saturation exponent n is typically near 2.0 for 300 Area vadose zone sediments (Johnson et al. 2010). Introduction of phosphate amendment into the subsurface increases both saturation and pore fluid conductivity (due to the high ionic strength of the amendment), thereby increasing bulk conductivity and providing a target for time-lapse ERT imaging. In this report, it is assumed that the amendment electrical conductivity does not change with time, meaning the amendment transport is conservative over the time scale of the ERT imaging. Assuming that the change in $\sigma_{s,t}$ with time is insignificant, the change in bulk conductivity caused by the phosphate amendment from some baseline condition at time 0 to time t can be expressed as

$$\Delta\sigma_{b,t} = \theta^m (\sigma_{f,t} S_t^n - \sigma_{f,0} S_0^n). \tag{1.2}$$

Note here that the bulk conductivity distribution at time t, $\Delta\sigma_{b,t}$, is estimated through time-lapse ERT imaging. Equation (1.2) demonstrates that although the increase in pore fluid conductivity and saturation caused by the introduction of amendment causes a corresponding increase in bulk conductivity, the change in bulk conductivity alone cannot be used to uniquely determine pore fluid conductivity (and thus amendment concentration) or saturation at a given time without supporting information. However, time-lapse changes in bulk conductivity can be used to estimate the distribution of amendment, and the location and velocity of the amendment wetting front, thereby providing important information concerning the overall performance and timing of amendment delivery.

1.2.3 Image Interpretation in the Context of Limited Resolution

Valid assessment of time-lapse ERT images requires adequate accounting for the effects of limited imaging resolution. ERT data do not provide enough information to uniquely estimate the distribution of subsurface bulk conductivity. This problem is addressed by constraining the ERT imaging algorithm to provide only the spatial heterogeneity that is required to fit the survey data. Consequently, ERT images are a smoothed, or blurry, representation of the true subsurface bulk conductivity. Image smoothing increases, or resolution decreases, with distance from ERT electrodes.

The effects of limited resolution could be equivalently described in terms of the ERT sampling volume. That is, the bulk conductivity of a given point in the ERT image is a weighted average of the true bulk conductivity over some volume surrounding that point. The size of that volume increases with distance from the electrodes. This concept is shown schematically in Figure 1.3.

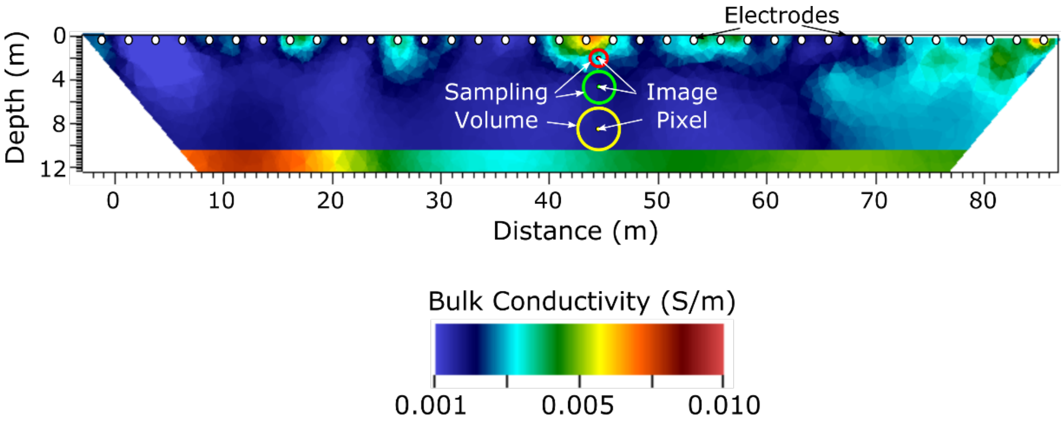


Figure 1.3. Conceptual diagram illustrating the effects of limited resolution. Each pixel in the ERT image is the weighted average of the true bulk conductivity over some sampling volume. The size of the sampling volume increases with distance from the electrodes, resulting in a loss of resolution with depth.

The spatial averaging caused by limited resolution generally causes high values to be under-predicted and low values to be over-predicted in the ERT image, thereby making quantitative analysis based on ERT images dubious. *Because of this, all observations, calculations, interpretations, and general conclusions derived from the ERT images must be understood in the context of limited image resolution. In this report, the general uncertainties arising from limited imaging resolution are discussed with each result.*

2.0 Site Layout

2.1 Infiltration Gallery and Wellfield Layout

Figure 2.1 shows a plan view of the phosphate treatment area. The site consisted of 9 injection wells, 13 pairs of monitoring wells, and 44 infiltration lines buried at a depth of 1.8 m (6 ft) to treat a 0.3 ha (0.75 acre) area (Figure 2.1). Injection wells were installed to approximately 50 feet below the ground surface and screened from 20 to 30 ft, and 35 to 45 ft deep. Each pair of monitoring wells consisted of one well for monitoring the PRZ and one for monitoring the aquifer. The wells for monitoring the PRZ were installed to approximately 40 ft below the ground surface and were screened between 30 and 35 ft. The wells for monitoring the aquifer were installed to approximately 50 ft and were screened between 40 and 45 ft.

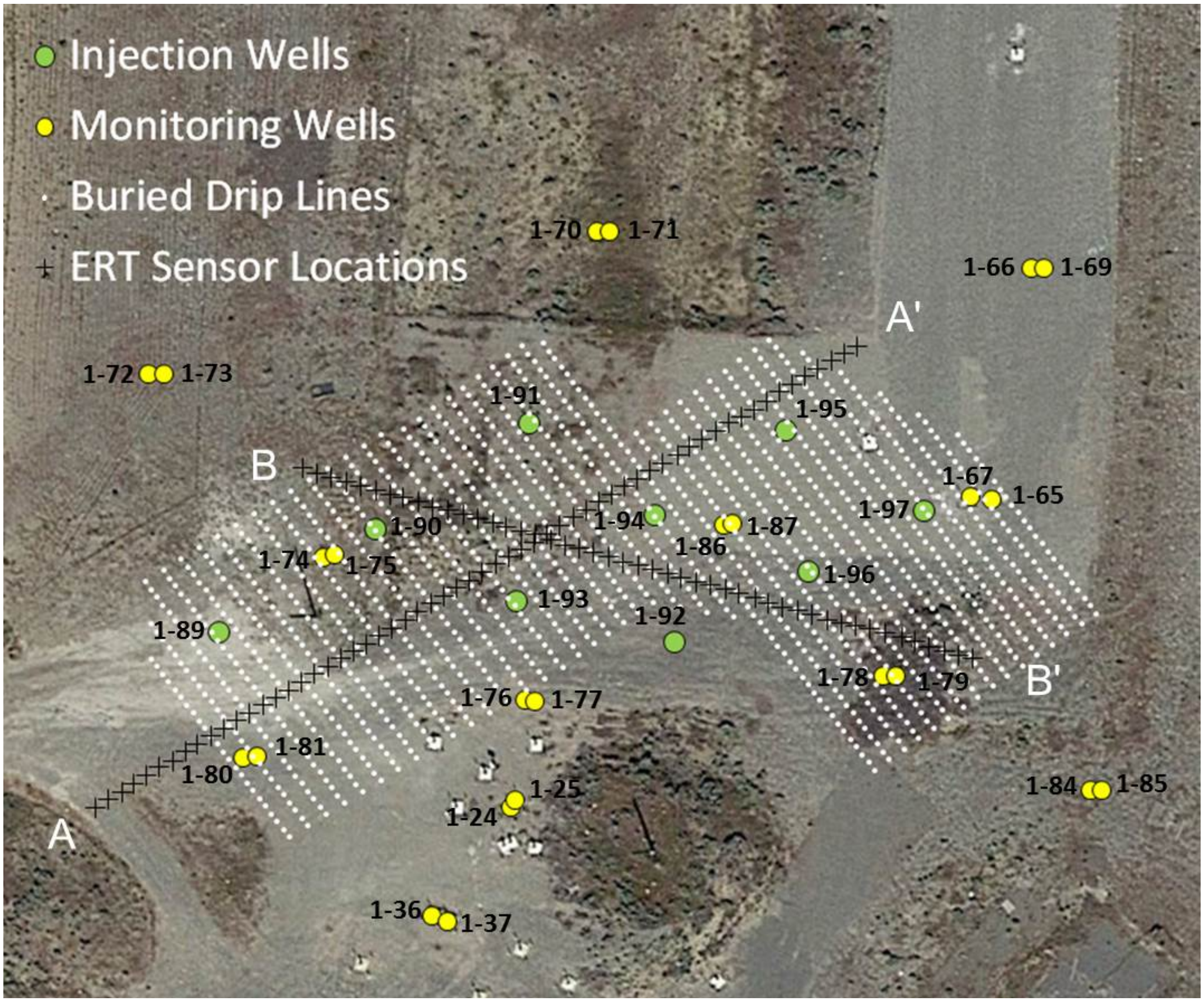


Figure 2.1. The 300 Area Stage-A treatment area layout.

Injection wells were cased with 6-inch schedule 80 polyvinyl chloride (PVC) pipe. Monitoring wells were cased with 2-inch schedule 40 PVC pipe except for wells 399-1-24, 399-1-25, 399-1-36, and 399-1-37, which were cased with stainless steel. The southern end of each of the 44 drip lines were attached to a feeder hose that supplied phosphate amendment to each line. Details concerning the infiltration system design and operation may be found in CHPRC report SGW-59455[a].

2.2 2D Electrical Resistivity Tomography (ERT) Lines

As shown in Figure 2.2, two ERT electrode lines were installed over the treatment area. Line 1, extending from A to A', consisted of 60 electrodes spaced at 1.5 m (5 ft), for a total line length of 89.9 m (295 ft). Line 2, extending from B to B', consisted of 47 electrodes spaced at 1.5, for a total line length of 70.1 m (230 ft). Each electrode consisted of a 1.88 cm (0.75 inch) diameter carbon steel rod, approximately 40.6 cm (16 inches) long.

Each ERT measurement required applying a voltage across a pair of electrodes to induce current flow within the subsurface. This in turn produced a potential distribution on the ground surface (Appendix A) that may have posed a shock hazard under certain circumstances. Two measures were taken to reduce the risk of electric shock to site operators. First, the electrode rods were buried so that the upper end of each electrode was 20 to 30 cm (8 to 12 in.) below ground surface (Figure 2.2). Burying the electrodes reduced the risk of electrical shock by direct contact. Second, a signed exclusion boundary was established around each electrode line, with a minimum distance of 1.8 m (6 ft) to any electrode. The exclusion boundary was administratively secured through Hanford Site lockout-tagout control, which was enforced during ERT operations. Figure 2.3 shows a photograph of line 1 and the exclusion boundary from A to A'.

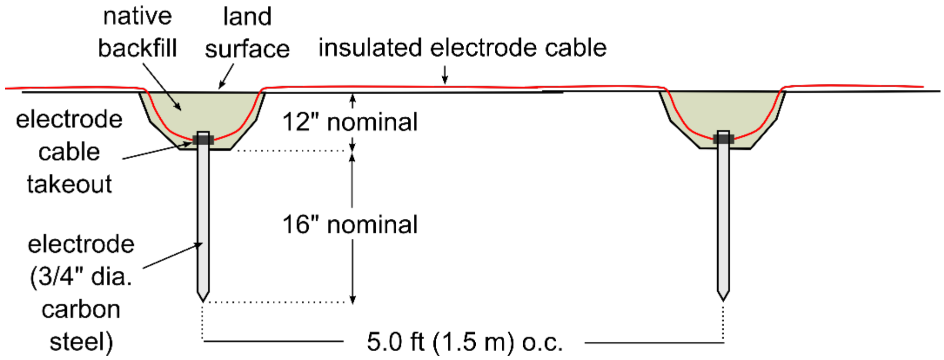


Figure 2.2. Diagram of buried electrode installation.

---

[a] SGW-59455. 300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report, Rev. 0. CH2M Hill Plateau Remedation Company, Richland, WA (draft report) .

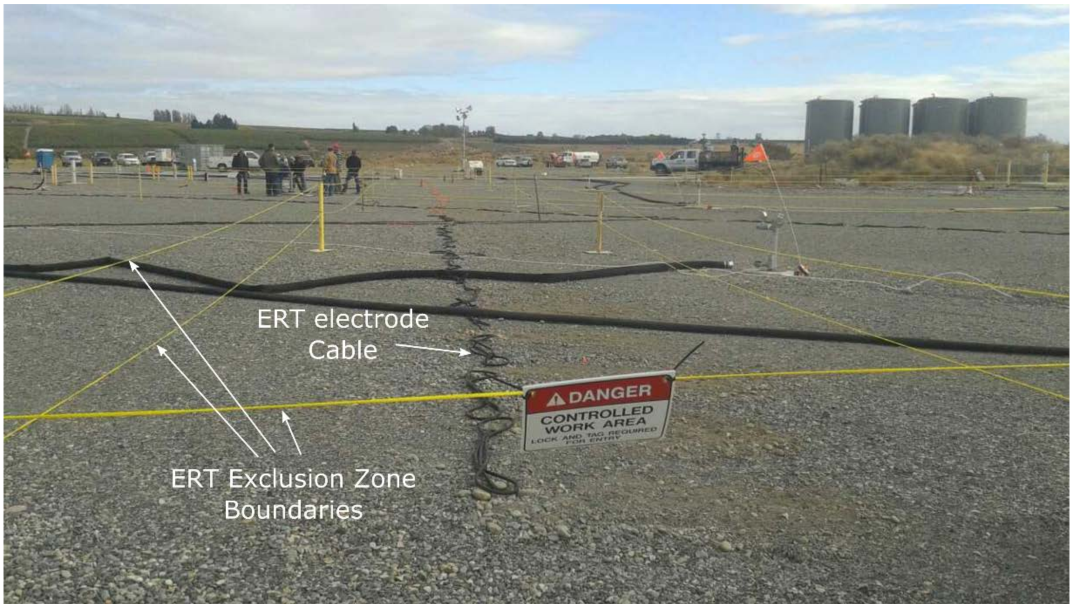


Figure 2.3. Photograph of ERT line 1 and associated exclusion boundary. The view is standing at the western end (A) and facing the eastern end (A') of line 1 (Figure 2.1).

3.0 ERT Operations

3.1 Phosphate Treatment Schedule

Three methods were used to deliver phosphate amendment to the subsurface: 1) direct injection into aquifer wells, 2) direct injection into PRZ wells, and 3) vadose zone infiltration through the infiltration network. Amendment application commenced on the morning of November 6, 2015, using the aquifer injection wells. Infiltration began the next day, November 7, and continued until November 15. The final application included PRZ well injections from November 16 to 18, 2015. Details concerning amendment injections, flow rates, and volumes are provided in Table 3.1.

Table 3.1. Uranium sequestration Stage A operational summary (SGW-59455[a]).

Operational Day	Date	Aquifer Injection (wells)[(a)]	PRZ Injection (wells)[(a)]	Infiltration Rate Achieved (gpm)	Injection Rate Achieved (gpm)
1	Nov. 6, 2015	1-89, 1-90, 1-91, 1-92, 1-93, 1-94	---	---	300
2	Nov. 7, 2015	---	---	56	---
3	Nov. 8, 2015	---	---	56	---
4	Nov. 9, 2015	1-92, 1-93, 1-94, 1-95, 1-96, 1-97	---	56	300
5	Nov. 10, 2015	---	---	56	---
6	Nov. 11, 2015	---	---	83	---

---

[a] SGW-59455. 300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report, Rev. 0. CH2M Hill Plateau Remedation Company, Richland, WA (draft report) .

Operational Day	Date	Aquifer Injection (wells)[a]	PRZ Injection (wells)[a]	Infiltration Rate Achieved (gpm)	Injection Rate Achieved (gpm)
7	Nov. 12, 2015	---	---	80	---
8	Nov. 13, 2015	---	---	80	---
9	Nov. 14, 2015	---	---	80	---
10	Nov. 15, 2015	---	---	80	---
11	Nov. 16, 2015	1-95, 1-96, 1-97, 1-89, 1-90, 1-91	1-89, 1-90, 1-91, 1-92, 1-93, 1-94	---	300
12	Nov. 17, 2015	---	1-92, 1-93, 1-94, 1-95, 1-96, 1-97	---	300
13	Nov. 18, 2015	---	1-95, 1-96, 1-97, 1-89, 1-90, 1-91	---	300

(a) All wells begin with “399-.”

3.2 ERT Data Collection Schedule

The ERT data collection schedule was chosen to balance the tradeoff between adequate spatial and temporal imaging resolution. Using a four-electrode measurement (two current electrodes and two potential electrodes) there are $N(N-1)(N-2)(N-3)/8$ unique measurements that may be collected during a given survey, where N is the number of electrodes. Collecting all unique measurements is impractical because doing so would require an excessive amount of time between time-lapse images. A subset of measurements was chosen that provided adequate imaging resolution and could be collected fast enough to capture phosphate migration during treatment. Each survey was composed of a set of Wenner and dipole-dipole measurements collected along each line, for a total of 1939 measurements per survey using each of the 108 electrodes comprising lines 1 and 2. An eight-channel Multiphase Technologies (MPT) DAS-1 (http://www.mpt3d.com/das1.html) electrical impedance tomography system was used to collect the data (see Figure 3.1). The measurement sequence was optimized to use each of the eight channels to the extent possible, resulting in a survey time of approximately 11 minutes per time-lapse survey. The data collection system was set to collect a new ERT survey every 12 minutes. Continuous surveying began on November 2, 2015, and continued until December 16, 2015, with the exception of three short periods caused by site power supply interruptions.

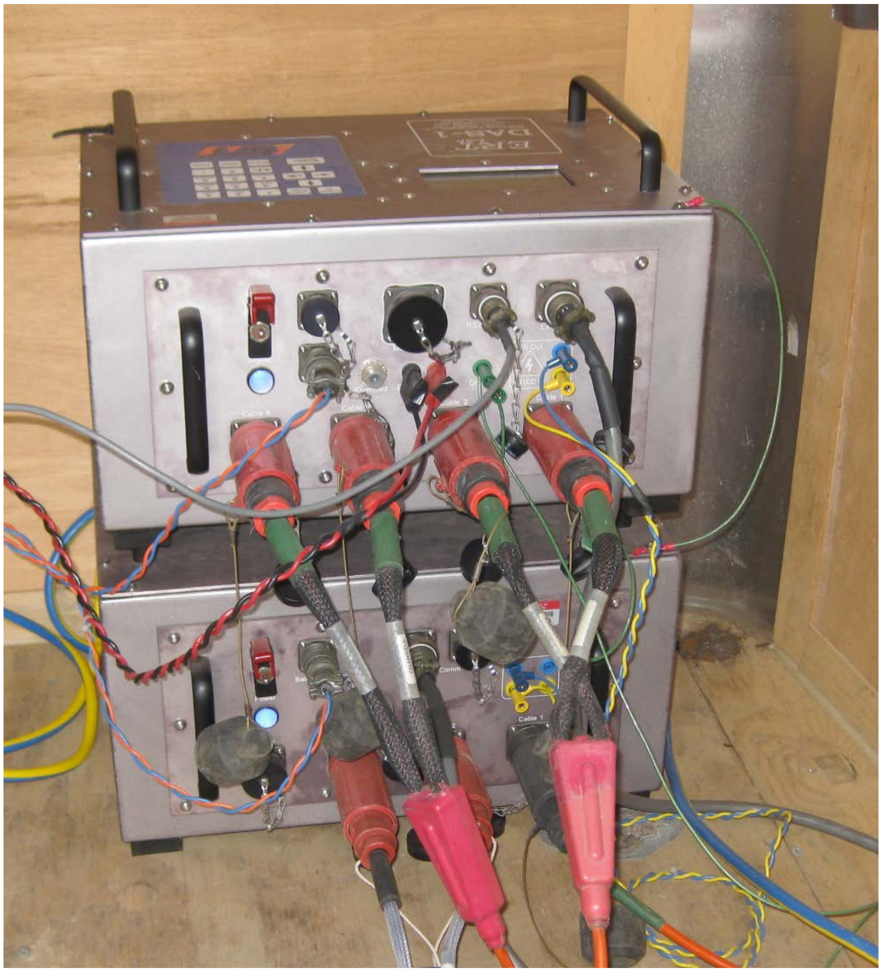


Figure 3.1. DAS-1 electrical impedance tomography system on top and Mux-1 on the bottom.

3.3 ERT Data Processing

ERT data processing was automated from data collection through database archiving and presentation on a secure website, with the exception of one remote data transfer step. A flow diagram of the processing sequence is shown in Figure 3.2. In the first step, time-lapse surveys were continuously collected on the field data collection system, as described in the previous section. As each survey was completed, that survey was filtered for quality, reformatted, and submitted to a parallel computing system for processing via secured wireless internet connection. This step was completed by the field laptop computer connected to the data collection system. After processing, each time-lapse survey was archived in a database, and each image was submitted to a webserver for visualization on a password protected website. This enabled site operators to visualize amendment distribution in near real time during the treatment operation. The processing time required from the completion of a survey to presentation on the website was a minimum of 3 minutes. The maximum time required for presentation was governed by the data transfer step, which was not automated due to communication issues between the field computer and the parallel computing system housed at Pacific Northwest National Laboratory (PNNL). This issue was not resolved during the monitoring period, and necessitated remote user intervention to complete a manual “drag and drop” data copy.

Rapid turnaround times were facilitated by using dedicated resources on the PNNL parallel computing system for the duration of the experiment. Although 2D measurements were collected (i.e., no cross-line measurements were acquired), the data were inverted in 3D to preserve consistency at the line 1/line 2 intersection. This also facilitated incorporating a metal cased well (399-1-55) into the imaging algorithm that may have influenced field measurements. That well was modeled using the approach described by Johnson and Wellman (2015). All processing was executed using E4D, a high performance ERT imaging code developed at the PNNL (https://e4d.pnnl.gov). E4D has been classified as safety software by PNNL, and is NQA-1 level B qualified for software safety.

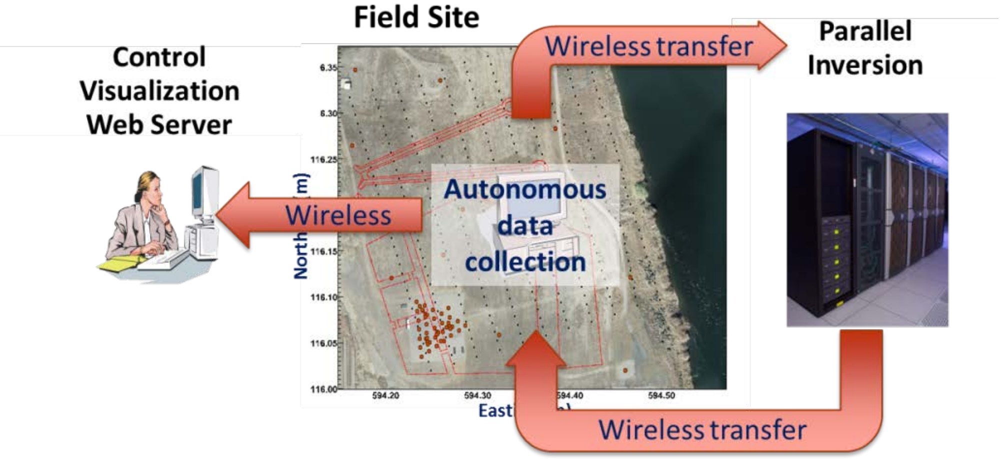


Figure 3.2. Autonomous ERT data control and processing flow diagram.

3.4 Website

To facilitate near real-time delivery of the ERT images, results were delivered to a password protected website. The website enabled users to animate the time-lapse images from the start of monitoring to the current time to view the estimated distribution of phosphate and the migration of phosphate with time. A screenshot of the website showing lines 1 and 2 at 4:04 p.m. on November 9, 2015, is shown in Figure 3.3. Users could view line 1 or line 2 individually, or view both lines together as shown in Figure 3.3. Users could also download the image frame for a given time step.

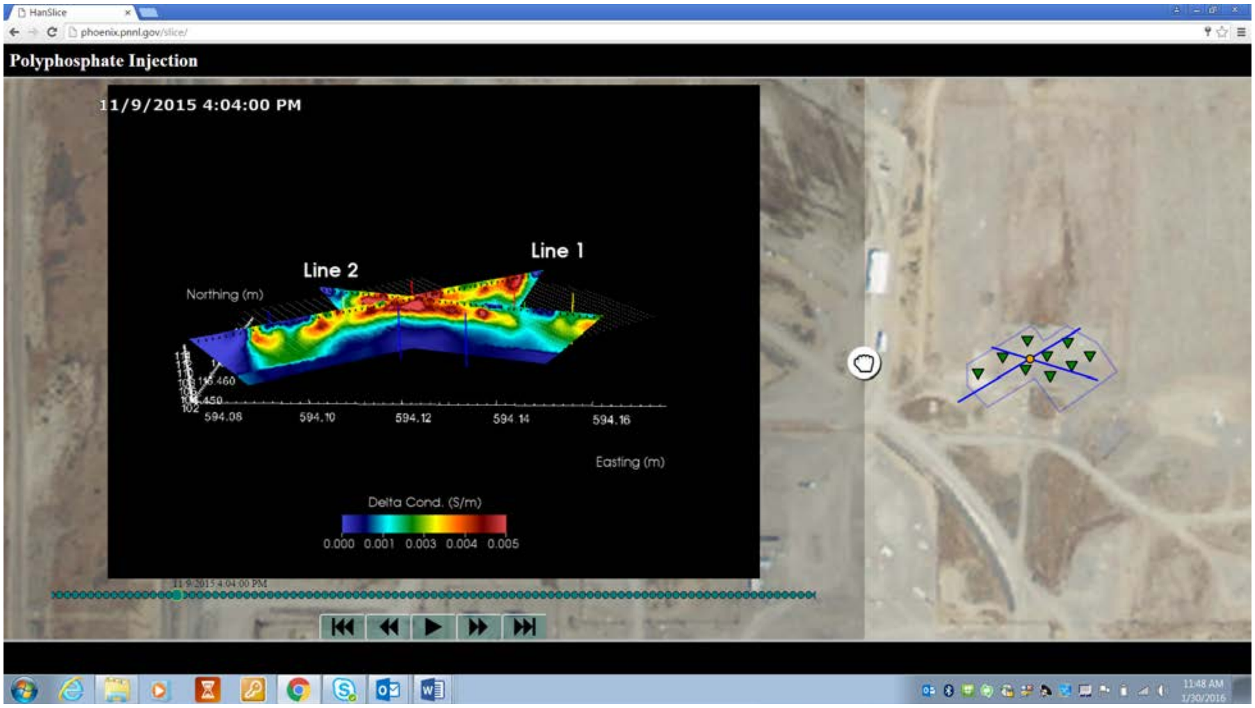


Figure 3.3. Example of the website used to monitor phosphate infiltration.

4.0 ERT Imaging Results

4.1 Baseline ERT Image

The baseline ERT image refers to the image that represents the bulk conductivity distribution prior to phosphate amendment injections. The baseline image is critical because it is subtracted from every time-lapse image to reveal only the change in bulk conductivity with time. In this case, that change in bulk conductivity is caused by the increase in saturation and pore fluid conductivity during phosphate application (see Eq. (1.2). The baseline image can also be used to infer geologic structure or other properties related to spatial variations in porosity, saturation, pore fluid conductivity, texture, and mineralogy (see Eq. (1.1).

The baseline image for the time-lapse imaging was collected at 6:00 a.m., November 6, 2015, just prior to the onset of phosphate injection into the saturated zone (Table 3.1). That image is shown in Figure 4.1. Note that prior to the acquisition of the baseline image, the phosphate infiltration system was performance tested by injecting river water into the infiltration lines. Due to the increase in saturation and the likely change in pore water specific conductance, the baseline image shown in Figure 4.1 does not represent native conditions, but does represent conditions well within the range caused by natural precipitation events for the period of September through November (SGW-59455[a]). Areas of elevated bulk conductivity likely result from the infiltration performance test. In Section 5.1, the baseline image is

---

[a] SGW-59455. 300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report, Rev. 0. CH2M Hill Plateau Remedation Company, Richland, WA (draft report) .

compared with a time-lapse image collected approximately 0.5 days after the onset of phosphate application through the infiltration system to provide insight into infiltration system performance.

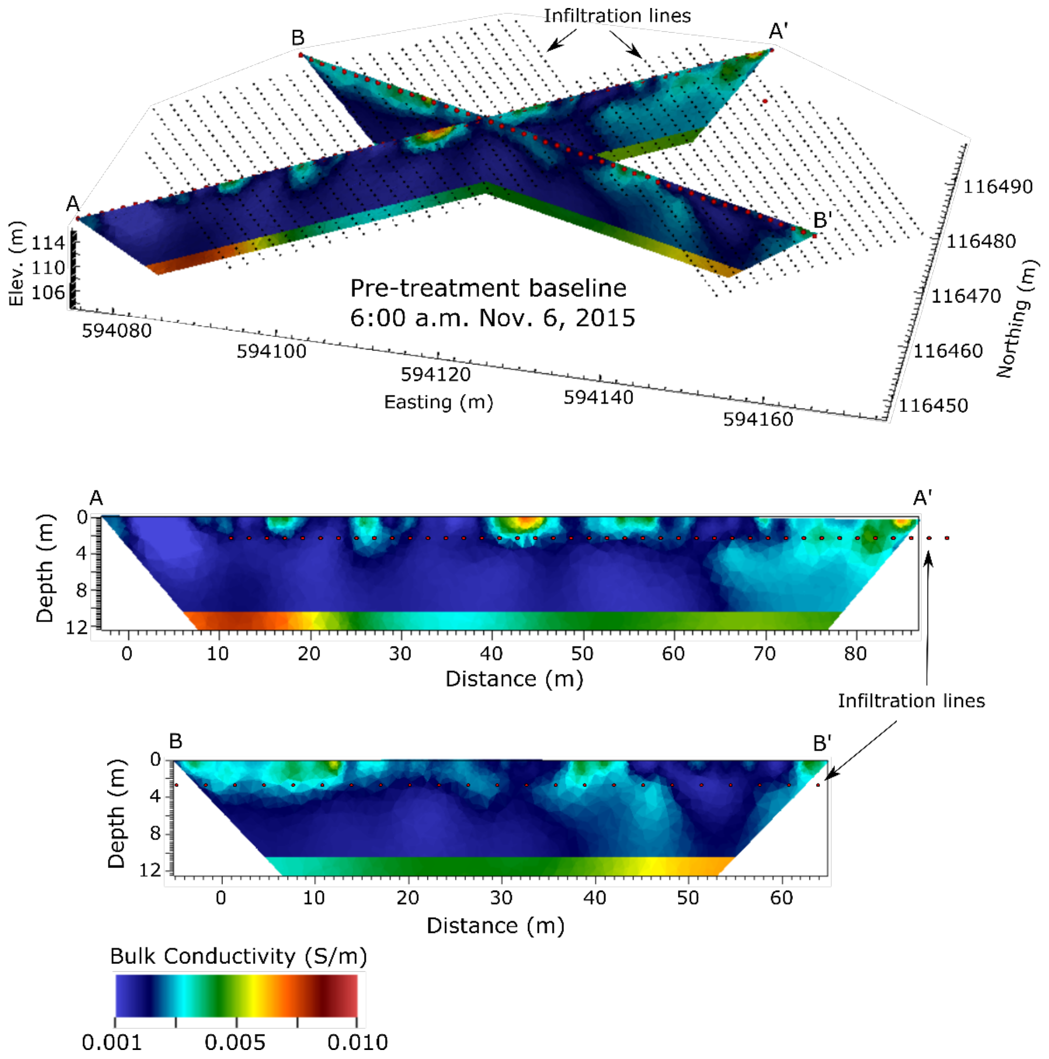


Figure 4.1. Baseline ERT image collected at 6:00 a.m., November 6, 2015: (top) oblique view of bulk conductivity beneath the ERT lines, (middle) cross-section of bulk conductivity beneath line 1 from A-A’, (bottom) cross section of bulk conductivity beneath line 2 from B-B’.

Figure 4.2 shows the data misfit histogram for the baseline inversion, which represents the difference between the field ERT measurements and those simulated by the ERT imaging algorithm given the conductivity distribution shown in Figure 4.1. The data misfit is indicative of both field data quality and the ability of the imaging algorithm to match those data and recover the subsurface conductivity distribution. The error distribution for the baseline inversion has a mean of -1.1% and a standard deviation of 2.5%. These values are indicative of high quality, relatively noise-free field data and accurate field data modeling and imaging. Similar results were obtained for each time-lapse inversion.

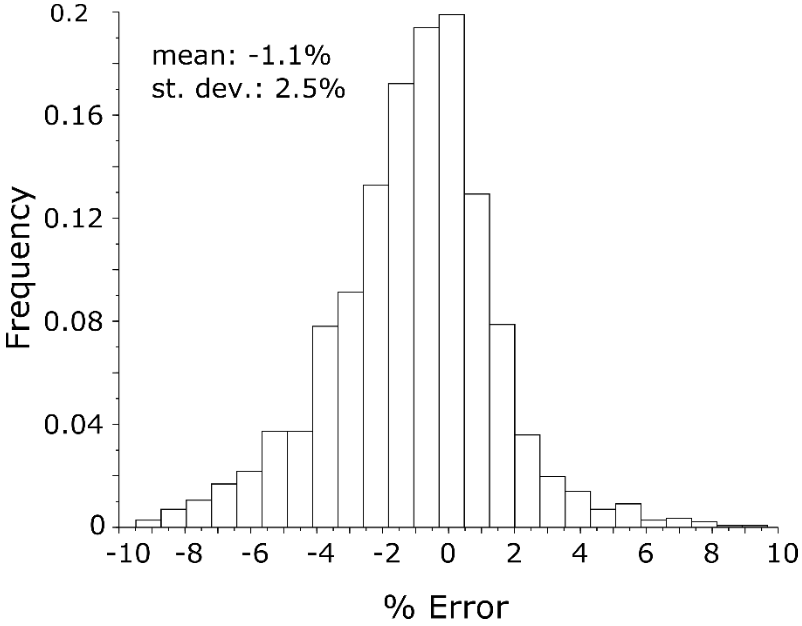


Figure 4.2. Observed vs. simulated data misfit histogram.

4.2 Time Lapse ERT Images

Figure 4.3 through Figure 4.6 show a daily subset of the time-lapse ERT images that were collected from November 6 through December 16, 2015. Figure 4.3 shows the first 5 days of treatment. On day 1, phosphate was injected into the aquifer wells (Table 3.1). Increases in conductivity are evident below the water table beneath both ERT lines. There also appears to be a slight increase in vadose zone conductivity during day 1, which may be an artifact of limited imaging resolution (i.e., image smoothing from the saturated zone).

Phosphate infiltration began on day 2 (November 7, 2015) at a rate of 56 gallons per minute. Figure 4.3 and Figure 4.4 show marked increases in bulk conductivity as the phosphate wetting front moves toward the water table from day 2 to day 10 (November 7 through 15). On day 10, the ERT images display increases in bulk conductivity throughout the unsaturated zone beneath each line, suggesting the presence of phosphate throughout, with the caveat that resolution limitations disable the capability to resolve small regions that may have been left untreated. With the exception of one region on the western end of line 1 and one on the southern end of line 2, the phosphate wetting front appears to have advanced relatively uniformly beneath both lines. There is no evidence of untreated regions beneath either line.

Figure 4.5 and Figure 4.6 show ERT images collected after completion of phosphate application through the infiltration system. These images show bulk conductivity decreasing with time as phosphate drains from the unsaturated zone, starting at the water table and progressing upward. By day 25, the unsaturated zone appears to have reached a relatively steady-state condition of elevated conductivity, suggesting the presence of phosphate in the residual pore water. Increases in conductivity after day 25, particularly near the surface, are likely associated with significant precipitation events that occurred during that period.

The western end line of 1, from approximately 15 to 22 m, displays characteristics diagnostic of coarser grained materials and elevated migration velocities. It is evident from Figure 4.3 that phosphate reached the water table relatively quickly within this region. The relatively low increase in conductivity suggests depressed saturation compared to the upper mid and eastern sections of line 1 from days 2 through 5. Conductivity in the same zone steadily increases from days 6 through 10. All of these observations are consistent with relatively coarse grained, higher porosity materials [Eq. (1.2)].

The southern end of line 2 from approximately 48 to 50 m exhibits relatively depressed increases in conductivity during infiltration, and relatively rapid decreases in conductivity after infiltration injections. The infiltration line performance analysis presented in Section 5.1 suggests phosphate application rates in this region may have been relatively low, resulting in the observed conductivity behavior. Furthermore, inspection of the time-lapse images suggests significant lateral flow in this region above approximately 5 m. These observations support the hypothesis that vertical flow may have been relatively depressed in this zone due to a reduced application rate, as opposed to being caused by geologic heterogeneity. Each of the images in Figure 4.3 through Figure 4.6 display white, gray, and black contour lines at conductivity increases of 0.002, 0.003, and 0.004 S/m, respectively. These are included to aid interpretation of the images in terms of phosphate migration velocity and phosphate arrival time presented in Section 5.

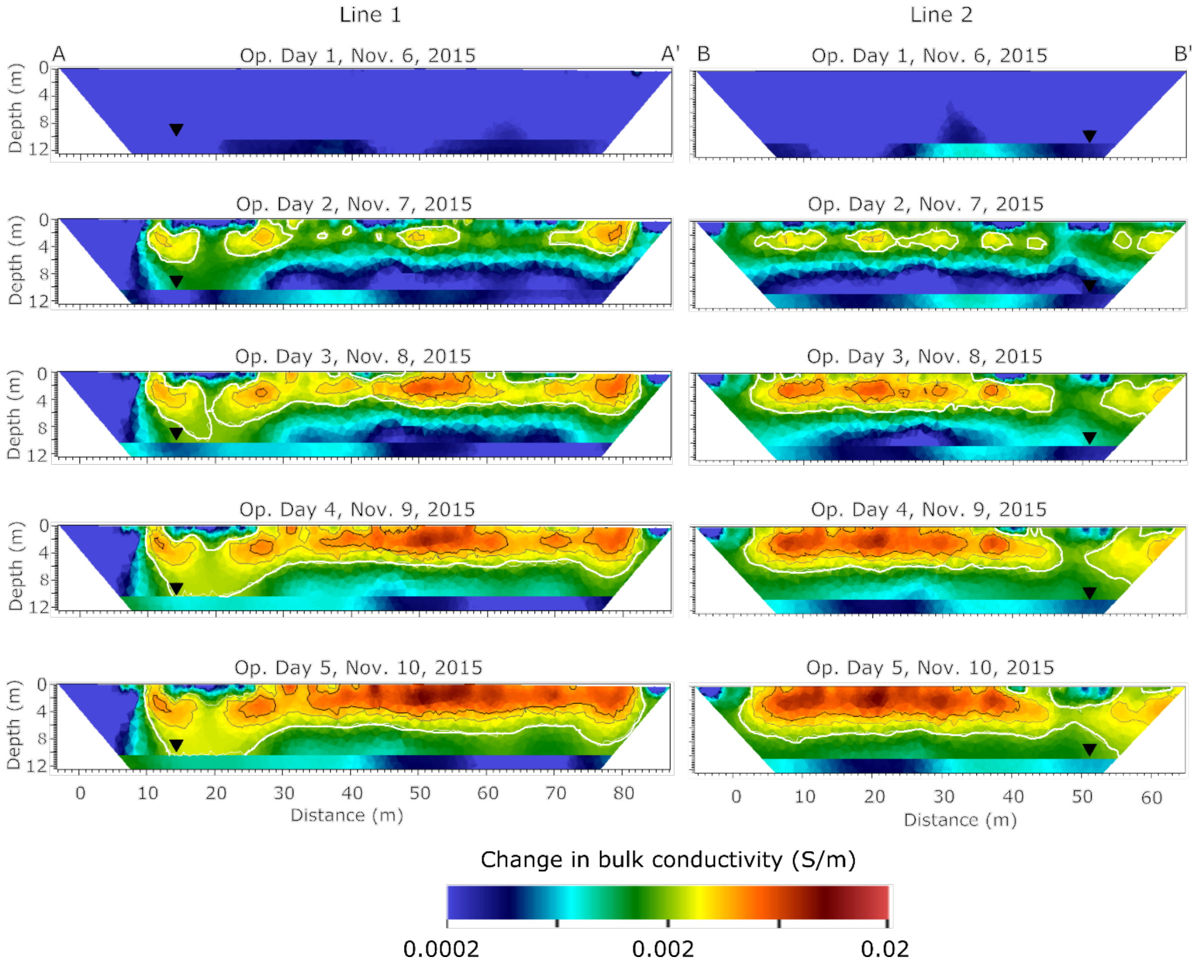


Figure 4.3. Change in bulk conductivity from baseline conditions on operational days 2 through 5. The white, gray, and black contour lines represent increases in conductivity of 0.002, 0.003, and 0.004 S/m, respectively.

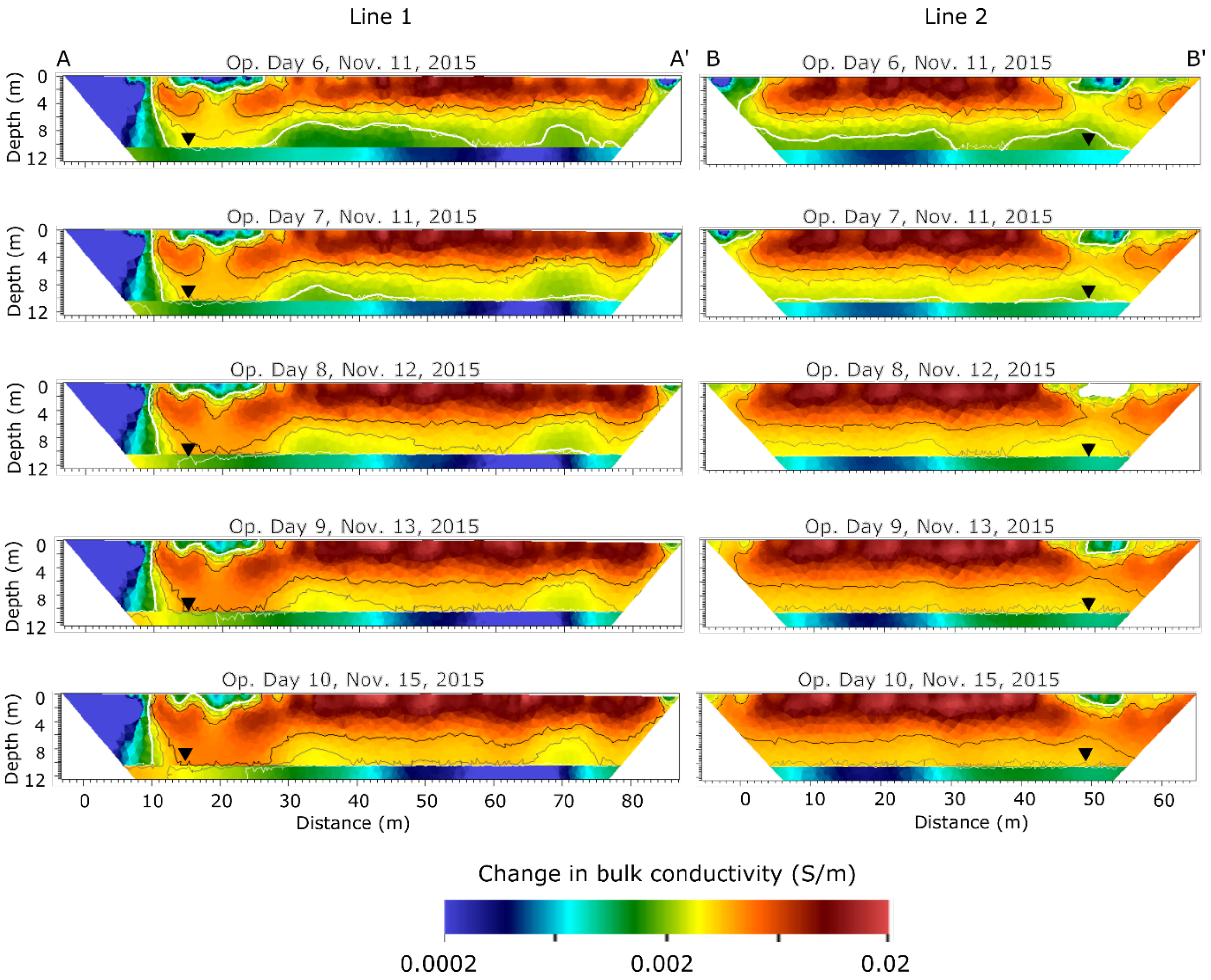


Figure 4.4. Change in bulk conductivity from baseline conditions on operational days 6 through 10. The white, gray, and black contour lines represent increases in conductivity of 0.002, 0.003, and 0.004 S/m, respectively. Day 10 was the last day of phosphate application through the infiltration system.

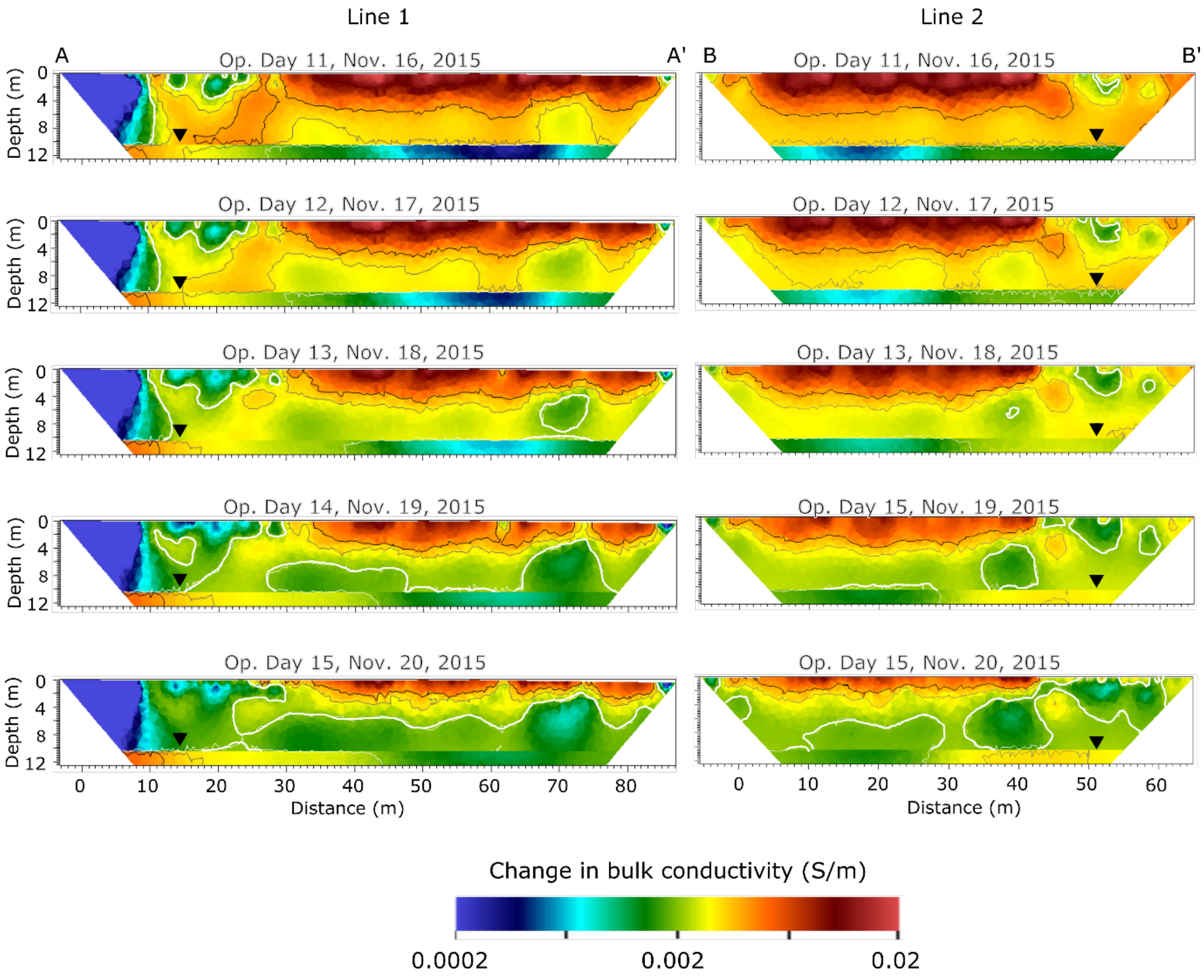


Figure 4.5. Change in bulk conductivity from baseline conditions on operational days 11 through 15, which are the first 5 days after terminating phosphate application through the infiltration system. The white, gray, and black contour lines represent increases in conductivity of 0.002, 0.003, and 0.004 S/m, respectively.

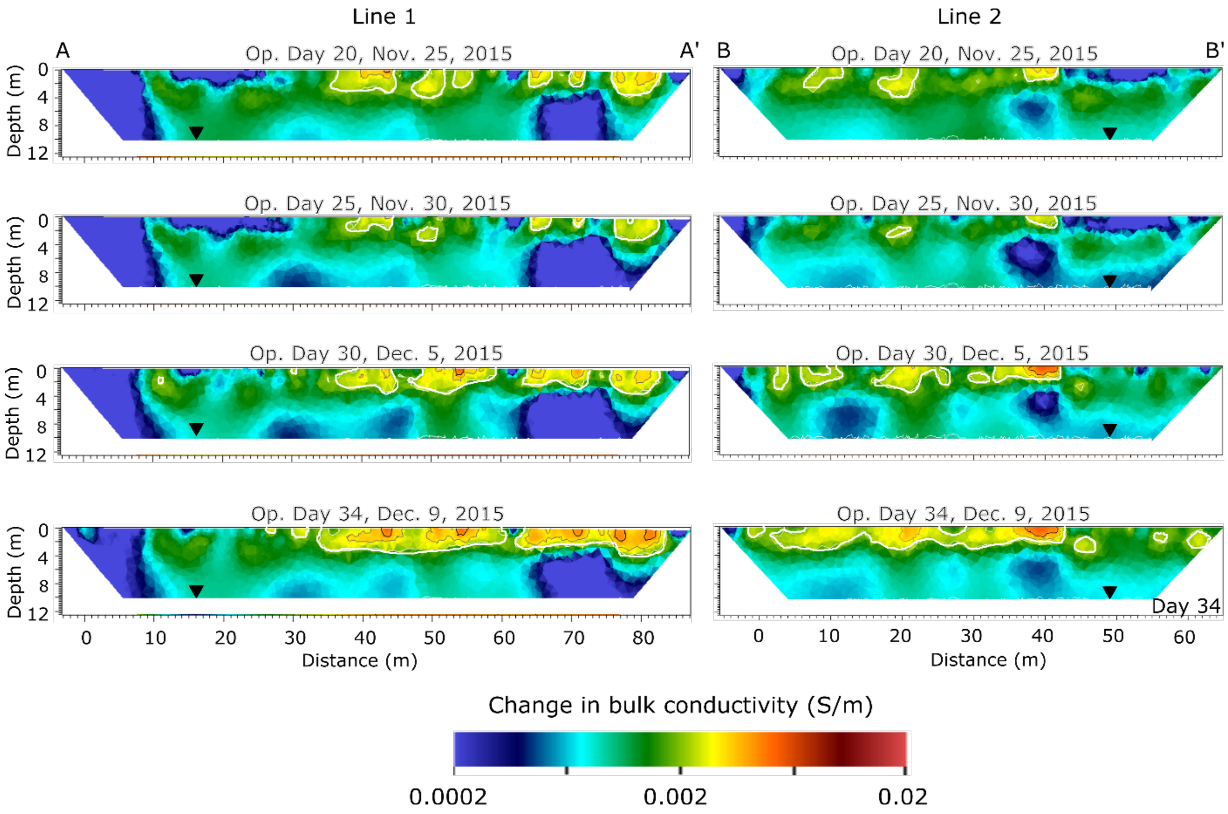


Figure 4.6. Change in bulk conductivity from baseline conditions on operational days 20, 25, 30, and 34. The white, gray, and black contour lines represent increases in conductivity of 0.002, 0.003, and 0.004 S/m, respectively.

5.0 Image Analysis and Interpretation

5.1 Infiltration Line Performance

Changes in conductivity near the infiltration lines, shortly after beginning phosphate application through the infiltration system, can be used to qualitatively investigate the relative application rates of infiltration lines passing beneath the ERT lines. Assuming relatively constant porosity, regions with larger phosphate release rates exhibit larger increases in bulk conductivity [Eq. (1.2)], thereby indicating where more phosphate is being released. Figure 5.1 shows the bulk conductivity beneath line 1 at baseline and at operational day 1.5, approximately 0.5 days after the onset of phosphate application through the infiltration system (Table 3.1). Locations of infiltration lines are shown as red dots on each panel. The baseline survey was collected after the infiltration system performance test. Regions of elevated conductivity in the baseline image suggest elevated saturation resulting from the test, and therefore indicate higher application rates. Those regions are consistent with the conductivity distribution after 0.5 days of infiltration shown in the lower panel of Figure 5.1. Infiltration lines circled in white exhibit lower bulk conductivities at baseline and after 0.5 days of application, and are therefore suspect of depressed flow rates in comparison to the other lines. However, from Figure 4.3 and Figure 4.4, it is apparent that flow rates in these zones were sufficient for adequate treatment, or that low flows in these zones were compensated by lateral flow from adjacent infiltration lines with higher flow rates.

Figure 5.2 shows bulk conductivity beneath line 2 at baseline and at day 1.5. In this case, there appears to be one infiltration line with low to zero application rate (circled in white). The conductivity beneath the suspect line does not increase after the performance test, or after 0.5 days of application, suggesting a reduced application rate beneath that line, at least where it passes beneath ERT line 2. Time-lapse imaging results collected during infiltration support that conclusion (Figure 4.3 and Figure 4.4). At approximately 48 to 50 m along ERT line 2, the increase in conductivity over time is notably less than the rest of line 2, suggesting lower phosphate saturation. Regardless, the same region does exhibit a significant increase in conductivity down to the water table on day 10. Careful investigation of the progression in conductivity over time shows that full treatment beneath this infiltration line was achieved by lateral flow from adjacent infiltration lines.

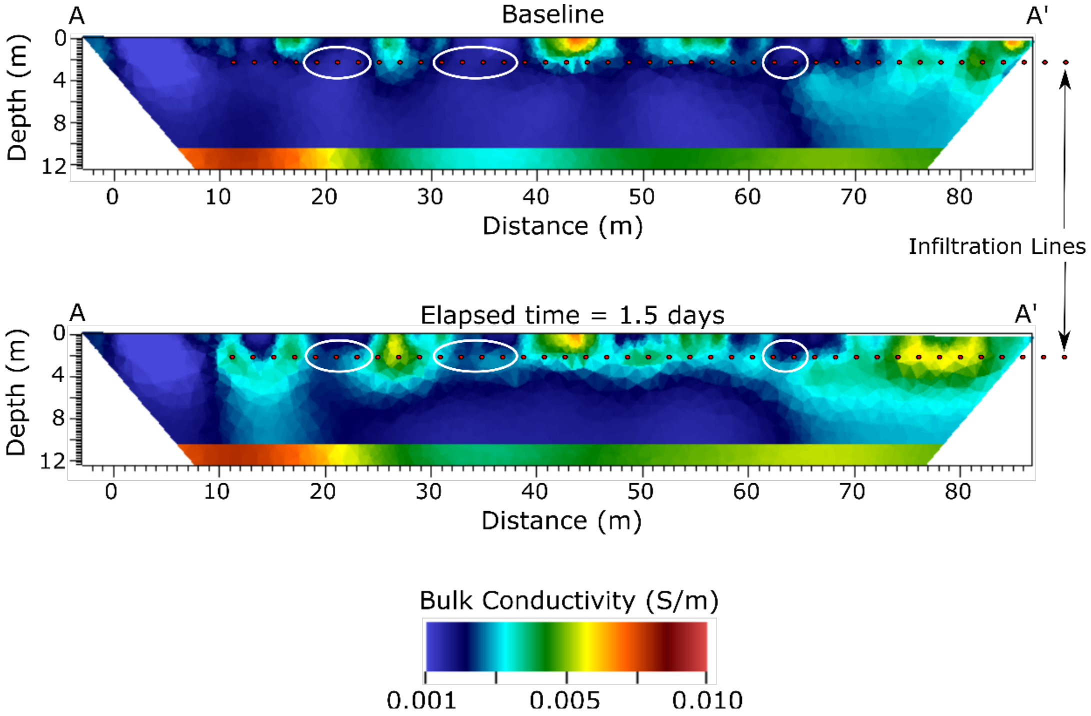


Figure 5.1. ERT images beneath line 1 at baseline and at operational day 1.5. Infiltration lines circled in white display smaller increases in conductivity, suggesting lower application rates.

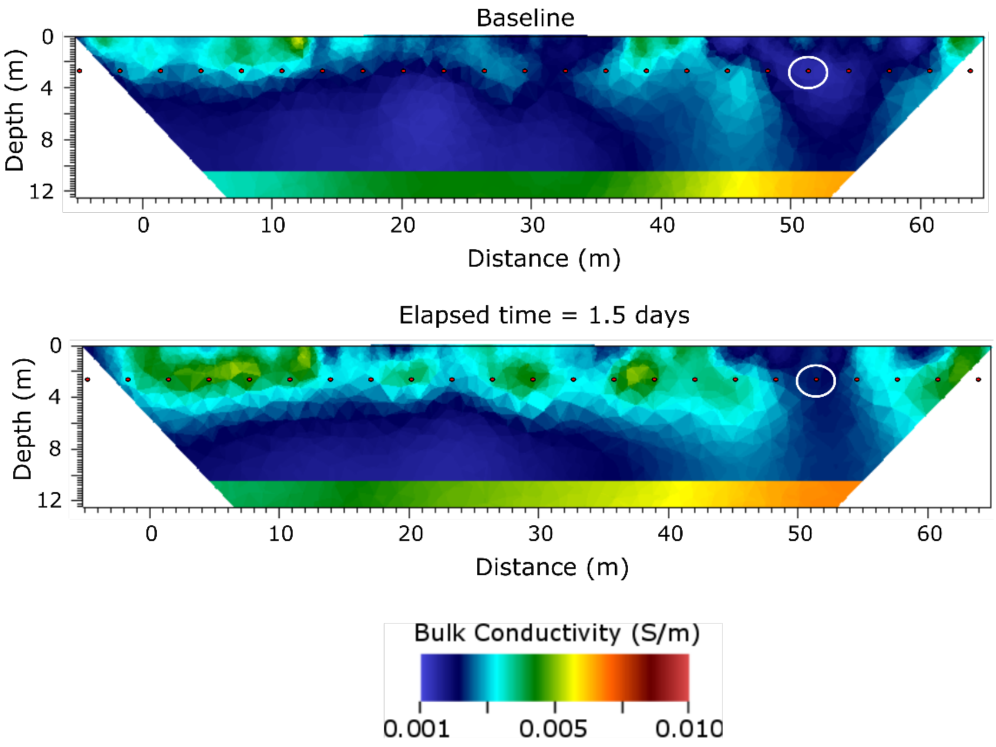


Figure 5.2. ERT images beneath line 1 at baseline and at operational day 1.5. Infiltration lines circled in white display smaller increases in conductivity, suggesting lower application rates.

5.2 Amendment Breakthrough

Time-lapse ERT imaging enables phosphate amendment breakthrough curves to be constructed at any point in the image in terms of the change in bulk conductivity. The change in bulk conductivity is related to the change in saturation and pore fluid conductivity induced by introducing phosphate as described by Eq. (1.1). Given the multivariate nature of the change in bulk conductivity, phosphate saturation and/or concentration cannot be uniquely determined from bulk conductivity without additional information. However, bulk conductivity breakthrough curves extracted from the time-lapse ERT images can be used to estimate the phosphate arrival time and migration velocity at a given point in the image. Furthermore, because the ERT images underestimate the true change in conductivity (see Section 1.2.3), they can be used with Eq. (1.2) and a few assumptions to estimate the minimum phosphate saturation at a given point in time.

For example, let total saturation at time *t* be defined by

$$S_t = S_{pw,t} + S_{p,t} \tag{5.1}$$

where $S_{pw,t}$ is the fraction of the pore space occupied by pore water and $S_{p,t}$ is the fraction of the pore space occupied by phosphate amendment. Assuming a linear mixing model between pore water and phosphate amendment in terms of fluid conductivity, the pore fluid conductivity at time *t* is defined by

$$\sigma_{f,t} = \sigma_{pw} \frac{S_{pw,t}}{S_{pw,t}+S_{p,t}} + \sigma_p \frac{S_{p,t}}{S_{pw,t}+S_{p,t}} \tag{5.2}$$

where σ_{pw} is the pore water conductivity and σ_p is the conductivity of the phosphate amendment. Substituting Eqs. (5.1) and (5.2) into Eq. (1.2) provides the change in bulk conductivity as a function of phosphate saturation ($S_{p,t}$), assuming all other parameters are known. Table 5.1 contains a list of assumed parameters, and the basis for those assumptions, used in the forthcoming discussion.

Table 5.1. Assumed parameters for Eq. (1.2).

Parameter	Value	Basis
Phosphate conductivity σ_{pw}	0.7 S/m	Approximate average observed from field measurements (CHPRC, personal comm.)
Pore water conductivity σ_p	0.045 S/m	Approximate groundwater conductivity (Wallin et al. 2013)
Pore water saturation $S_{pw,t}$	0.2 – 0.5	Typical range for coarse–grained Hanford Formation sediments (INTERA, personal comm.)
Porosity θ	0.18	Average value from FS (DOE-RL-2005-41 2005)
Cementation exponent m	1.3	(Johnson et al. 2010)
Saturation exponent n	2.0	(Johnson et al. 2010)

Using the values specified in Table 5.1 with Eq. (1.2) , augmented by Eqs. (5.1) and (5.2), phosphate saturation as a function of the change in bulk conductivity is shown in Table 5.1, for four different pore water fractions (0.2, 0.3, 0.4, and 0.5). Figure 4.3 through Figure 4.6 show the change in bulk conductivity beneath each ERT line on 19 different days. Each plot includes contour lines at conductivity increases of 0.002, 0.003, and 0.004 S/m. According to Figure 5.3, the phosphate saturation corresponding to an increase in conductivity of 0.002 S/m is between approximately 4% and 8%, depending on the pore water saturation. Similarly, for an increase of 0.003 S/m, the phosphate saturation is between approximately 6% and 12%. For an increase of 0.004 S/m, the phosphate saturation is between approximately 8% and 15%. However, due to resolution limitations in the ERT images, the change in bulk conductivity shown in each image underestimates the true change in bulk conductivity. Therefore, the phosphate saturations determined by applying Eq. (1.2) to the ERT images place a lower bound on the actual phosphate saturations. In other words, phosphate saturations are greater than what is suggested by applying Eq. (1.2) to the ERT images, *assuming the values specified in Table 5.1 are representative.*

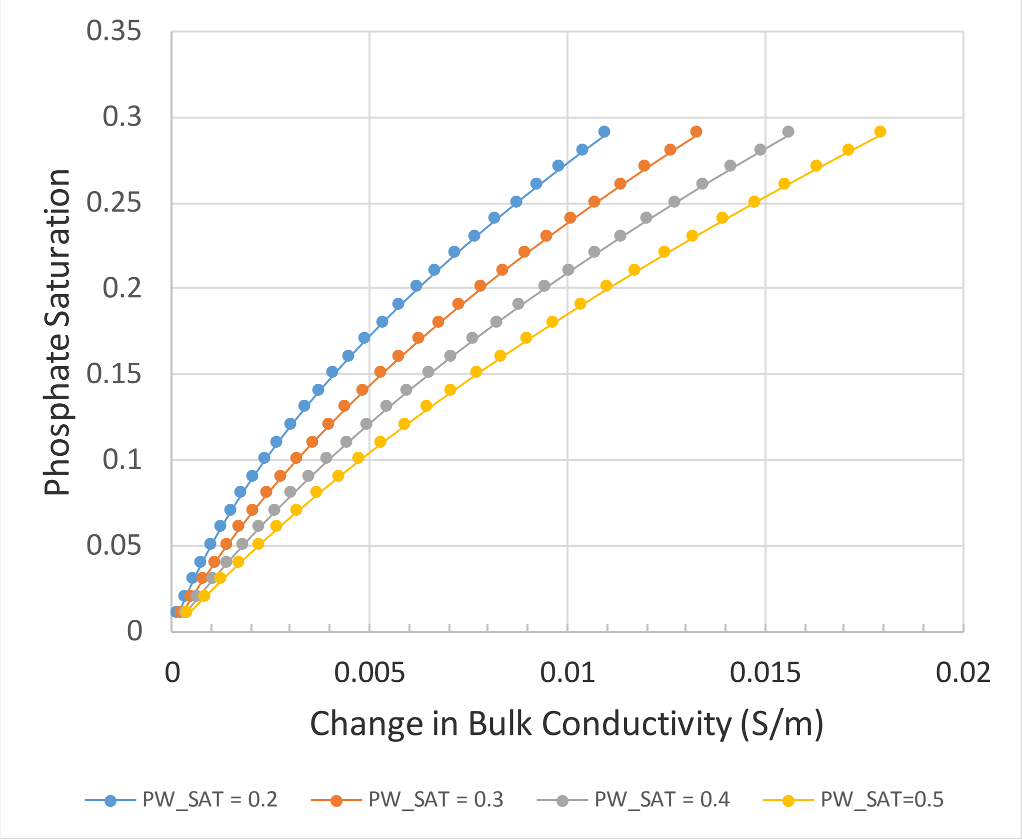


Figure 5.3. Phosphate saturation as a function of the change in bulk conductivity, at four pore water saturations, and given the values specified in Table 5.1.

The following analysis assumes that phosphate amendment has reached a point in space when the change in bulk conductivity at that point, as estimated from the ERT images, reaches 0.002 S/m. As discussed above, this corresponds to a minimum phosphate saturation of approximately 4%, contingent on the validity of the parameters specified in Table 5.1. The 0.002 S/m contour line is shown in white on Figure 4.3 through Figure 4.6.

Figure 5.4 shows two examples of bulk conductivity breakthrough curves extracted from the ERT image time series. The upper panel shows breakthrough curves at 10 depths, at 20 m along line 1 (Figure 4.3 through Figure 4.6), which is located within the anomalous fast-flow region at western end of line 1. The lower panel shows breakthrough curves at the same depths, but at 50 m along line 1, which is near the center of the line. Events E1-E3 in each panel denote the beginning of phosphate application through the infiltration system, the increase in phosphate application rate on day 6, November 11, 2015 (Table 3.1), and the conclusion of phosphate infiltration respectively (Table 3.1). The rapid breakthrough and depressed amplitude at 20 m in comparison to 50 m are diagnostic of relatively rapid transport to the water table, and lower saturation of phosphate. The decrease in breakthrough amplitude with depth is partially an artifact of limited imaging resolution. Peak amplitudes appear to decrease with depth, or with distance from the electrodes, because imaging resolution decreases with distance from the electrodes. It is also likely that amplitudes are decreasing with depth due in part to phosphate dilution with native pore water.

The horizontal line at 0.002 S/m in Figure 5.4 illustrates the position of the bulk conductivity threshold used to estimate phosphate arrival time. The arrival time at each depth is determined by identifying the time at which the corresponding curve intersects the 0.002 S/m threshold. As discussed previously, this determination is conservative, meaning that phosphate arrival time is likely sooner than estimated from the 0.002 S/m threshold. Investigation of Figure 5.4 shows the estimated breakthrough time at 20 m along line 1 is sooner than at 50 m for all depths except 9 and 10 m (i.e., near the water table).

Bulk conductivity time-series, such as those shown in Figure 5.4, were provided with this report in digital format for each ERT imaging mesh element, or "pixel," as described in Appendix B.

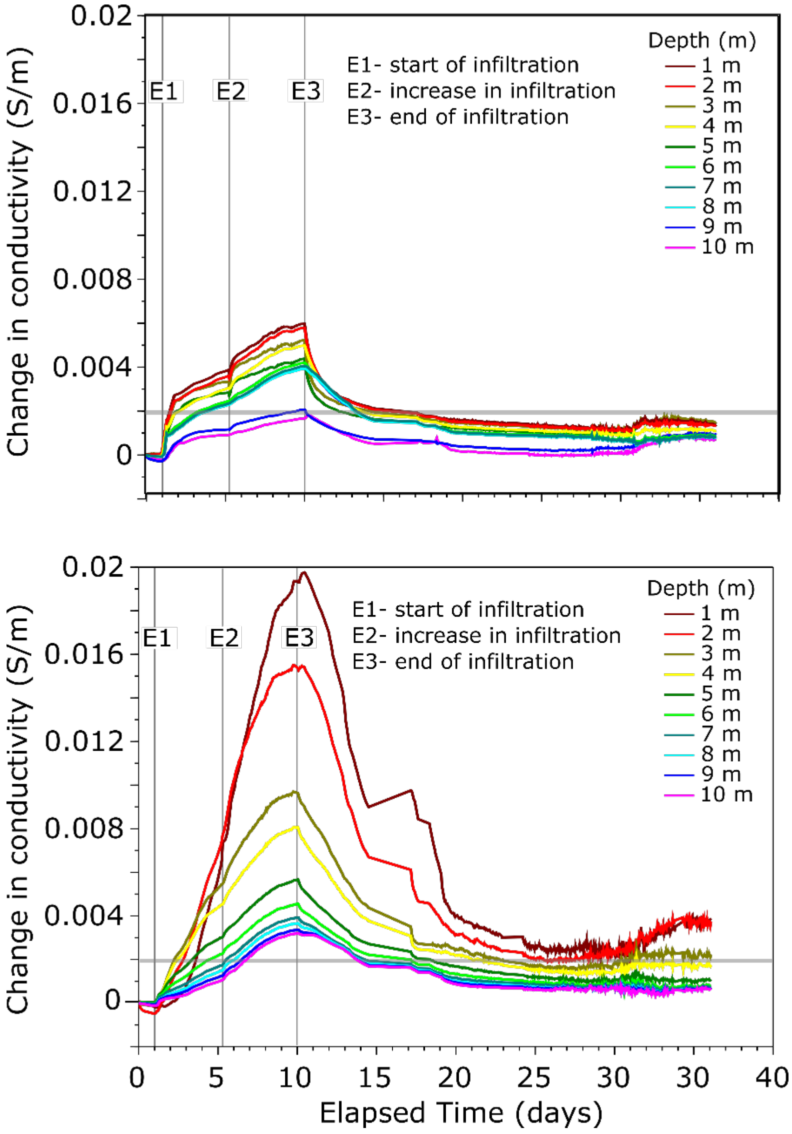


Figure 5.4. Example bulk conductivity breakthrough curves at 20 m (top) and 50 m (bottom) along line 1 (Figures 4.3-4.6).

5.3 Estimated Amendment Breakthrough Time

By conducting the breakthrough analysis described in the previous sections for each "pixel" in the ERT image sequence, a color-scale map of estimated phosphate arrival time was constructed for each line. The resulting phosphate arrival times are shown in Figure 5.5. This analysis suggests that arrival times at the water table occurred as soon as operational day 3 in the anomalous fast-flow region from 13 to 23 m along line 1. The latest arrival time at the water table is estimated to have occurred on operational day 7 at approximately 33 m along line 1, 3 days prior to the end of phosphate application through the infiltration lines. Along line 2, the breakthrough analysis suggests amendment reached the water table between days 6 and 7. The latest arrival time along line 2 occurs at approximately 48 m, beneath the infiltration identified as experiencing low flow in Section Figure 5.1. Overall, the breakthrough analysis suggests that, within the context of limited imaging resolution, phosphate appears to have reached the water table everywhere within the ERT imaging zone several days before the termination of phosphate application.

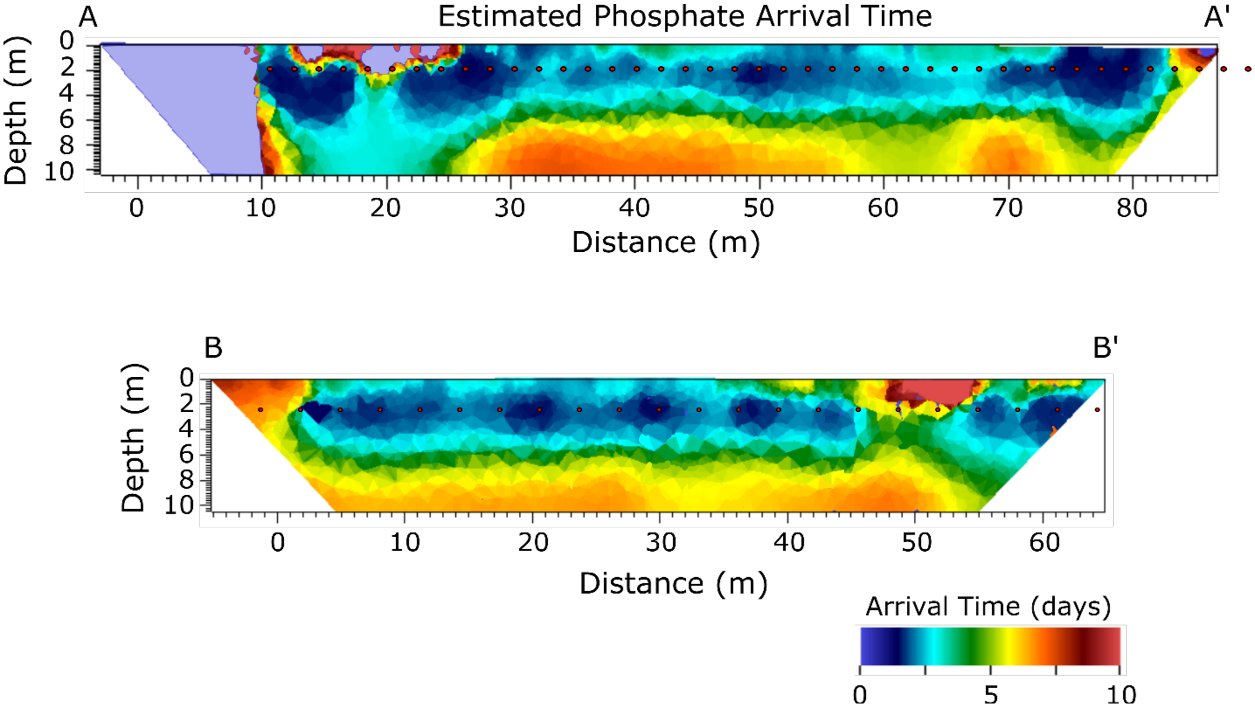


Figure 5.5. Estimated phosphate amendment arrival time beneath each ERT imaging line, based on a breakthrough magnitude of 0.002 S/m (see white contour line on Figure 4.3 and Figure 4.4).

5.4 Estimated Vertical Migration Rate

An estimate of the depth-averaged vertical migration rate at each "pixel" in the ERT images is obtained by dividing the vertical distance from each pixel to the infiltration line depth by the arrival times shown in Figure 5.5. The resulting migration rates are shown in Figure 5.6. With the exception of the western end of line 1, the migration rates infer a horizontally stratified structure. These include a lower migration velocity zone of approximately 0.75 to 1.0 m/d bounded above and below by higher velocity zones of approximately 1.5 to 1.75 m/d. Figure 5.6 should be interpreted with the understanding that the infiltration rate was increased on operational day 6, which according to Figure 5.5 is when amendment was near the water table in most areas. If the increased infiltration rate on day 6 caused the wetting front to advance more rapidly, then the higher velocity regions near the water table may be an artifact of the increased flow rate. Since the application rate was constant up to operational day 6, the relative migration velocities of all regions that experienced breakthrough before day 6 are governed primarily by variations in unsaturated hydraulic conductivity. With this in mind, Figure 5.5 suggests a decrease in hydraulic conductivity at approximately 5 m depth, which is consistent with patterns observed in the full ERT time series. For example, Figure 4.3 and Figure 4.4 show the highest increase in bulk conductivity above approximately 5 m, which may have been caused by elevated phosphate saturation above 5 m due to reduced downward flow rate at and below 5 m depth. Furthermore, close inspection of the ERT time series (not shown) displays significant lateral flow above 5 m depth, which could have been caused by the presumed low hydraulic conductivity zone at and below approximately 5 m depth. It appears that ultimately this low hydraulic conductivity zone may have aided the overall performance of the infiltration system by promoting lateral flow above 5 m, thereby creating an even horizontal distribution of amendment, and compensating for variable application rates that appear to have occurred within the infiltration system (Section 5.1).

Finally, as noted previously, the western end of line 1, from 13 to 23 m, exhibited elevated migration velocity, reaching 3 m/day. All aspects of the ERT monitoring show that this region of the treatment footprint exhibits significantly different flow properties than the rest of line 1 or line 2.

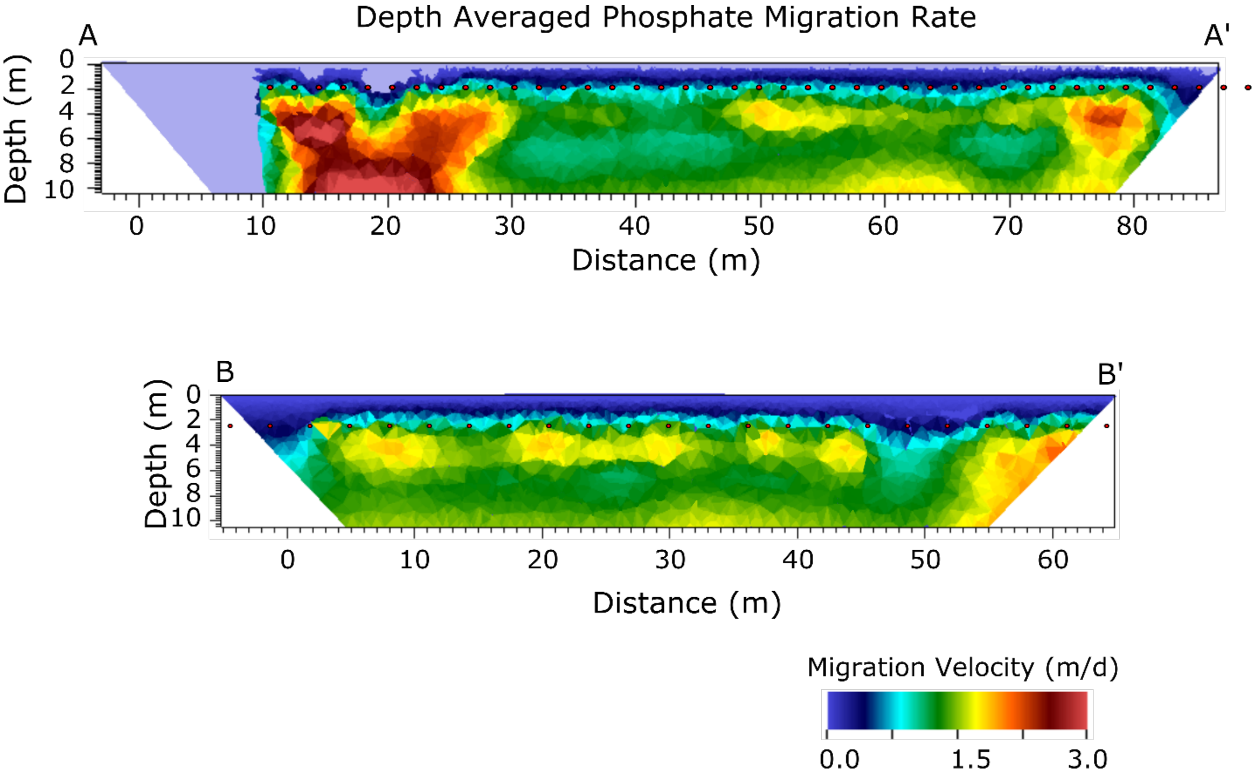


Figure 5.6. Depth-averaged migration rate estimation, based on the arrival times shown in Figure 5.5.

6.0 Recommendations for future ERT deployments

6.1 Electrical safety assessment procedures

The ERT survey system used for this project can apply up to 400 V across current electrodes to generate adequate current within the subsurface. The system self-regulates voltages, depending on the distance between electrodes, the bulk conductivity of the subsurface, and the contact resistance between the electrodes and the soil. Previous ERT surveys conducted in the 300 Area using similar electrode spacing exhibited 100 to 200 V applied across current electrodes. Based on this observation, electrical safety measures were taken to protect site personnel assuming voltages within the subsurface next to the current electrodes would achieve 200 V. The safety measures implemented based on this assumption, including ERT array exclusion boundaries and lockout-tagout procedures, placed a significant time and cost burden on the project.

Recent advancements in ERT modeling (Johnson and Wellman 2012) enable current electrodes to be modeled in true dimension, rather than as point sources of current used in commercially available codes. This enables the actual voltage within the soil next to the current electrodes to be accurately determined. Leveraging this capability, an assessment of actual soil surface voltages generated during monitoring was conducted at the termination of the project (Appendix A). The assessment revealed that although voltages applied to the current electrodes commonly approached 200 V, the maximum voltage experienced in the soil during monitoring was approximately 25 V, rather than the conservative 200 V assumed for safety evaluations. The discrepancy between the voltage across the current electrodes and the voltage within the soil next the current electrodes was caused by contact resistance. Imperfect contact between the soil and the electrode effectively acted as a resistor that decreased the soil voltage with respect to the electrode voltage.

It may have been possible to relax the safety measures applied to protect site personnel if the actual surface voltages generated during monitoring were known prior to the electrical safety evaluation. This information could have been determined by collecting a single ERT survey and conducting an analysis equivalent to that shown in Appendix A. Had such a survey and analysis been conducted prior to operations, the safety analysis may have determined that the ERT exclusion boundary was unnecessary, thereby increasing flexibility in electrode locations and reducing costs associate with establishing the ERT exclusion boundary and lockout-tagout procedures. However, measures taken to reduce the risk of direct contact with electrodes (i.e., burial) or the risk of electrical shock during hookup operations would have still been required.

To install the phosphate infiltration lines, approximately 6 ft of surface material was removed from the application area. The infiltration lines were then installed, and backfill was placed over the lines to the original grade. ERT electrodes could have been installed with the phosphate infiltration lines, which would have reduced the labor required for electrode installation, and would have addressed safety issues associated with surface voltages generated by the ERT system. Given the range of subsurface conductivity distributions during operations, the analysis in Appendix A shows a maximum surface voltage of 9 V if the electrodes are buried to a depth of 1 m, and a maximum surface voltage of 4 V if the electrodes are buried to a depth of 2 m. Furthermore, moving them deeper into the subsurface would have improved imaging resolution within the vadose zone.

6.2 Borehole electrodes for improved depth resolution

PVC phosphate injection and monitoring wells were installed within the application area. It is possible to install ERT electrodes on the outside of PVC casing, thereby providing the opportunity to improve ERT imaging depth resolution near the borehole. If two boreholes are close enough together, electrodes installed on the casings can be used for crosshole ERT imaging, which will significantly improve imaging resolution between boreholes compared to surface electrode deployments. Figure 6.1 shows an example of electrodes installed on 4 in. PVC casing being lowered into a borehole. The electrodes consist of stainless steel mesh attached to the casing using low-profile stainless steel clamps. Each electrode is attached to a single insulated conductor that extends to the surface through the annulus. If improved depth resolution is required or desired for future application, borehole electrodes such as those shown in Figure 6.1 should be considered for implementation.

Figure 6.1. (left) Close-up view of stainless steel borehole electrode attached to the outside of 4 in. PVC casing. The red conductors connect to the electrode and extend to the top of the casing. The other conductors attach to electrodes above and below the electrode shown here. (right) Bottom-up view of PVC casing with ERT electrodes being lowered into the borehole.

7.0 References

DOE-RL-2005-41. 2005. *Work Plan for Phase III Feasibility Study 300-FF-5 Operable Unit.* U.S. Department of Energy, Richland Operations Office, Richland, WA.

DOE-RL-2015-07 (2015). Hanford Site Groundwater Monitoring Report for 2014. Richland, WA, U.S. Department of Energy, Richland Operations Office.

Johnson TC and D Wellman. 2015. "Accurate modelling and inversion of electrical resistivity data in the presence of metallic infrastructure with known location and dimension." *Geophysical Journal International* 202(2):1096-1108.

Johnson TC et al. 2010. "Improved hydrogeophysical characterization and monitoring through parallel modeling and inversion of time-domain resistivity and induced-polarization data." *Geophysics* 75(4): Wa27-Wa41.

Peterson RE et al. 2008. *Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site, Washington.* PNNL-17034 Pacific Northest National Laboratory, Richland, WA.

Slater LD and D Lesmes. 2002. "IP interpretation in environmental investigations." *Geophysics* 67(1):77-88.

Szecsody JE et al. 2012. *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment*. PNNL-21733, Pacific Northwest National Laboratory, Richland, WA.

Wallin EL et al. 2013. "Imaging high stage river-water intrusion into a contaminated aquifer along a major river corridor using 2-D time-lapse surface electrical resistivity tomography." *Water Resources Research* 49(3):1693-1708.

Williams BA et al. 2007. *Limited Field Investigation Report for Uranium Contamination in the 300 Area, 300-FF-5 Operable Unit, Hanford Site, Washington.* PNNL-16435, Pacific Northwest National Laboratory, Richland, WA.

I

Surface Voltages Generated During ERT Operations

Appendix A

Surface Voltages Generated During ERT Operations

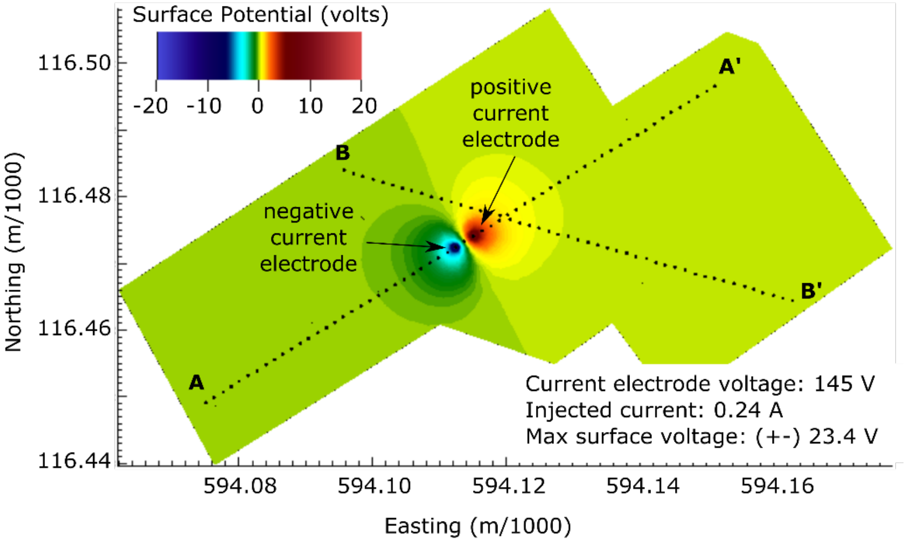
Electrical resistivity tomography (ERT) data collection operations involve applying voltages across electrodes to induce current flow within the subsurface. The resulting potential distribution generated on the ground surface may pose a safety risk to operators working near the ERT. Accurate surface potential measurements are necessary to prudently assess and manage this risk. However, it is generally not possible to determine induced surface potentials without first taking an ERT survey to estimate subsurface conductivity and determine the effects of electrode contact resistance. Contact resistance is the resistance to current flow caused by imperfect electrical couple at the soil-electrode interface. The ERT survey instrumentation must apply enough voltage across the current electrodes to overcome the combined effects of soil resistivity between the electrodes and contact resistance. If both the current injected between electrodes and the subsurface conductivity distribution are known, then the subsurface voltage distribution (including the surface boundary) may be accurately determined using the ERT forward modeling algorithm. The injected current is reported by the ERT measurement system, and the subsurface conductivity distribution is estimated during the ERT imaging process.

Most ERT imaging codes model electrodes using a point source (i.e., electrodes are modeled as infinitesimal points). Although this approximation is accurate at some distance from the electrode points, the simulated potential magnitudes near the current electrode are largely overestimated. This overestimation disables the capability to accurately estimate maximum soil potentials, which occur at the electrode/soil interface. E4D provides the capability to model electrodes in true dimension, thereby enabling potentials near the electrodes to be accurately approximated. This capability was used to simulate maximum surface potentials experienced during treatment operations, based on actual measurements and imaging results generated during ERT monitoring. Surface voltages were investigated at two times representing end member conditions: at baseline on November 6, 2015, when subsurface conditions were least conductive, and on November 20, 2015, just prior to cessation of infiltration, when subsurface conditions were most conductive. That analysis revealed a single measurement configuration that always induced the maximum surface potential during a given ERT survey. The same measurement configuration used the minimum separation between any two current electrodes, thereby providing the largest potential gradient, and the largest risk in terms of electrical safety.

Based on the ERT-estimated subsurface conductivity distribution and the injected currents reported by the ERT measurement system, the maximum surface voltages on November 6 and 20, 2015, are shown in Figure A.1. On November 6, the system applied 145 V across the current electrodes as indicated in Figure A.1, resulting in a current injection of 240 mA, a maximum surface potential magnitude of 23.4 V, and a maximum surface potential difference of 46.8 V. On November 15, the system applied 136 V across the current electrodes, resulting in a current injection of 970 mA, a maximum surface potential magnitude of 22.3 V, and a maximum surface potential difference of 44.6 V. Note that the potential across the soil adjacent to the current electrodes is less than the potential applied across the current electrodes due to contact resistance.

Figure A.2 shows the simulation maximum surface potential distribution at baseline conductivity conditions using electrodes buried at depths of 1 m and 2 m below ground surface. The simulation is included here to demonstrate the effects of burying the electrodes at depth in terms of reducing surface potentials and corresponding electrical hazards to site operators. The simulation shows maximum surface potential magnitudes to be 9.5 V (17 V differential) and 4.0 V (8.0 V differential) for electrodes buried at 1 m and 2 m depth, respectively.

Baseline Nov. 6, 2015



Operational day 15: Nov. 20, 2015

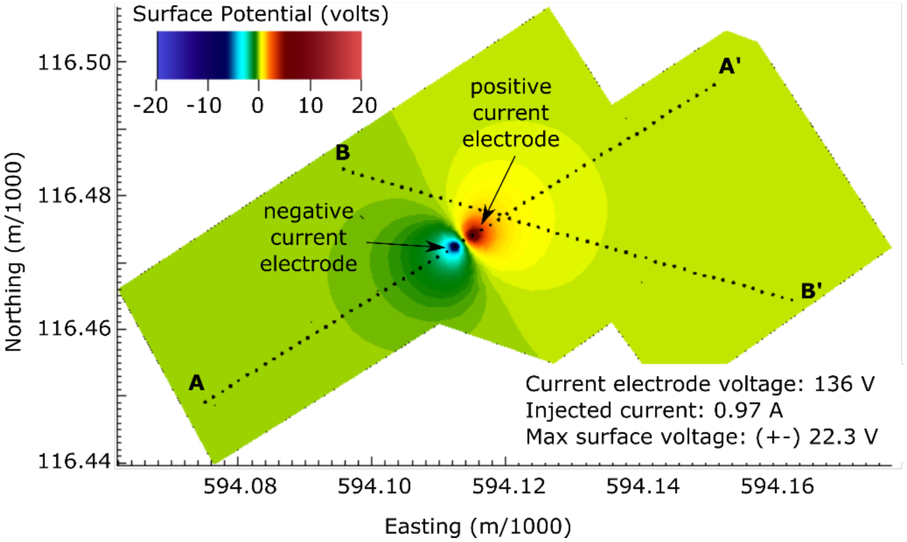
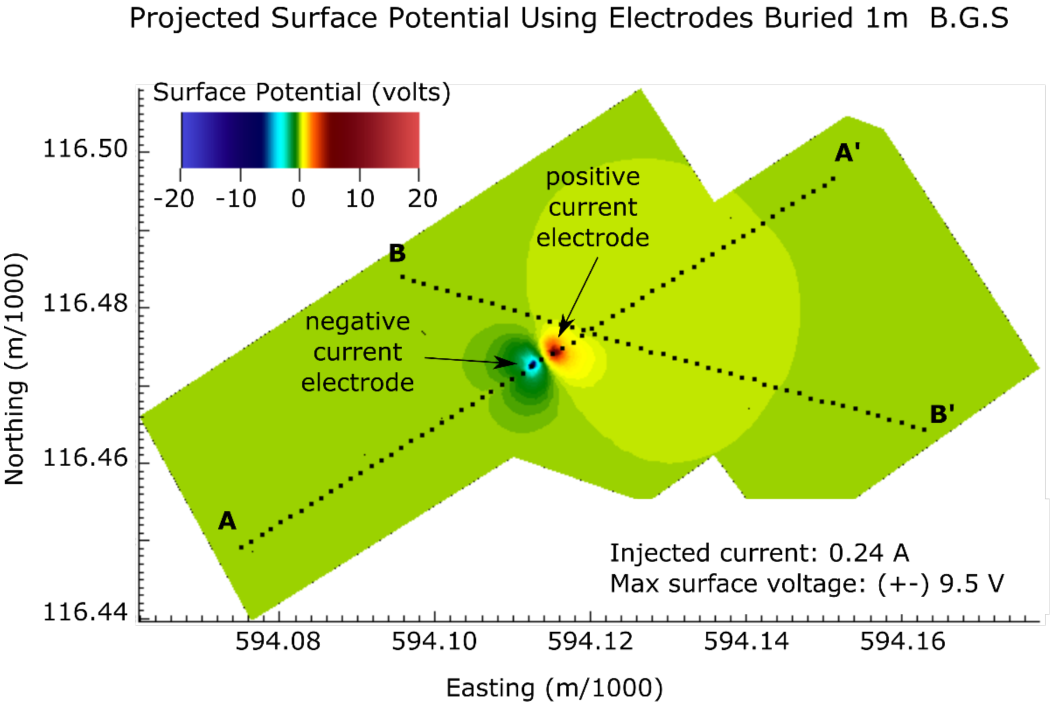


Figure A.1. (top) Maximum surface potential distribution observed prior to infiltration operations on Nov. 6, 2015. (bottom) Maximum surface potential distribution observed just prior to cessation of infiltration operations on November 20, 2015.



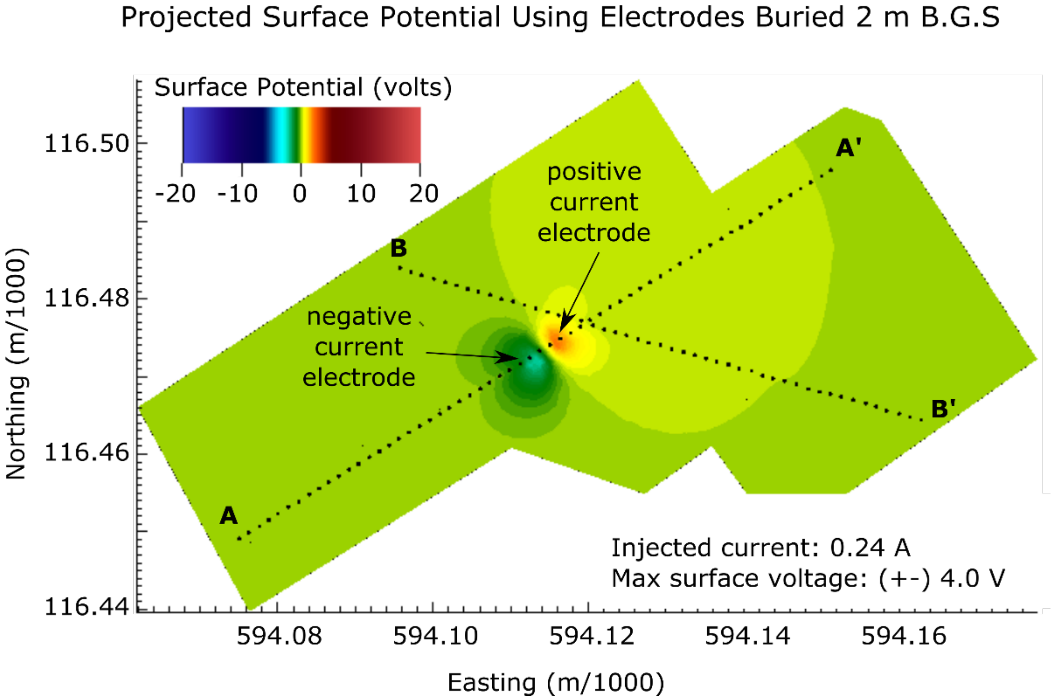


Figure A.2. Maximum surface potentials generated for electrodes deployed at (top) 1 m below ground surface and (bottom) 2 m below ground surface.

I

Bulk Conductivity Time-Series Data Format

Appendix B

Bulk Conductivity Time-Series Data Format

Bulk conductivity time series were extracted from the electrical resistivity tomography images at hourly intervals and provided digitally with the format and file names described in Table B.1.

Table B.1. Bulk conductivity time-series data file formats.

File Name	Content	Format
time_series_times.txt	Contains the time stamp for each date in the time series, one per row	Each row specifies the year, month, day, hour, and minute of each point in the time series
line_1_timeseries_positions.txt	Contains the location of the point in space along line 1 associated with each time series	Each row specifies a point in Washington State Plane coordinates
line_1_timeseries.txt	Contains the time-series of bulk conductivity values for every point beneath line 1	Each row provides the bulk conductivity time-series at the point given in the corresponding row of line_1_timeseries_positions.txt. Each column provides the bulk conductivity at the time specified in time_series_times.txt
line_2_timeseries_positions.txt	Contains the location of the point in space along line 2 associated with each time series	Each row specifies a point in Washington State Plane coordinates
line_2_timeseries.txt	Contains the time-series of bulk conductivity values for every point beneath line 2	Each row provides the bulk conductivity time-series at the point given in the corresponding row of line_2_timeseries_positions.txt. Each column provides the bulk conductivity at the time specified in time_series_times.txt

I

Raw Data and E4D-Formatted Files

Appendix C

Raw Data and E4D-Formatted Files

All of the raw electrical resistivity tomography (ERT) data files are provided in digital format with this report. In addition, all of the E4D input files are provided to enable reproducibility of the imaging results. Users should refer to Multiphase Technologies, LLC., documentation for the MPT-DAS 1 electrical impedance tomography system for details concerning the format of the raw ERT data files (although they are somewhat self-explanatory). E4D file formats are described in detail in the E4D User Guide, which is downloadable at https://e4d.pnnl.gov. The files provided are described in Table C.1.

Table C.1. Bulk conductivity time-series data file formats.

File	Content
POLY_A*.Data	Raw ERT data file in MPT format. The '*' indicates a time-stamp accurate to the second the ERT survey was initiated. These files are in the directory "Processed_Data" provided with this report.
POLY_A*.srv	E4D survey files. These contain the ERT data for each survey, and are located in the directory "Processed Surveys" provided with this report.
POLY_A*.sig	E4D sigma files. These contain the ERT inversion solutions on the E4D computational mesh, and are located in the "Solutions" directory provided with this report.
electrode_map.txt	Metadata file that maps electrode cable and pin numbers specified in the raw ert data files to the corresponding electrode position in Washington State Plane coordinates.
pp_2lines.1.node	E4D finite element mesh node file
pp_2lines.1.ele	E4D finite element mesh connections file
pp_2lines.1.neigh	E4D finite element mesh neighbor file
pp_2lines.1.face	E4D finite element mesh face file
pp_2lines.1.edge	E4D finite element mesh edge file
pp_2lines.trn	E4D finite element mesh translation file
pp_2lines_basline.inv	E4D inversion options file for baseline inversion
pp_2lines_timelapse.inv	E4D inversion options file for time-lapse inversions
baseline_field.sig	E4D sigma file containing baseline inversion solution
pp_2lines.out	E4D output options file

Pacific Northwest
NATIONAL LABORATORY

U.S. DEPARTMENT OF
ENERGY

Proudly Operated by **Battelle** *Since 1965*

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99352
1-888-375-PNNL (7665)

www.pnnl.gov

Appendix G

Environmental Calculation Files Documenting Numerical Model Development and Results

This page intentionally left blank.

G1 Introduction

A numerical model was developed to evaluate the fate and transport of uranium in the vadose zone and unconfined aquifer following the injection and infiltration of polyphosphate solutions within the Stage A Enhanced Attenuation area in the 300-FF-5 Operable Unit. Two environmental calculation files were prepared to document development of the model, as described below.

- ECF-300FF5-16-0087, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit, Hanford Washington*, documents the development of the three-dimensional geologic framework model and the distribution of uranium contamination in the vadose zone.
- ECF-300FF5-16-0091, *Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit*, summarizes the information gathered prior to, during, and after the polyphosphate treatment and synthesizes all of the relevant information for conducting fate and transport calculations. Results of the modeling are provided for the hypothetical No Action case (i.e., no remedy implemented) and for the Stage A remedy implemented in November 2015.

These environmental calculation files are provided in this appendix.

This page intentionally left blank.

ENVIRONMENTAL CALCULATION COVER PAGE

Section 1: **Completed by the Responsible Manager**

Project: 300-FF-5

Date: 05/17/2016

Calculation Title & Description: Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit, Hanford Washington

RELEASE / ISSUE

DATE:
Nov 01, 2016
HANFORD RELEASE

Section 2: **Completed by Preparer**

Calculation No.: ECF-300FF5-16-0087 **Revision No.:** 0

Revision History

Revision No.	Description	Date	Affected Pages ADD ROW
0	Initial issue		All

Section 3: **Completed by the Responsible Manager**

Document Control:

Is the document intended to be controlled within the Document Management Control System (DMCS)? ☒ Yes ☐ No

Does document contain scientific and technical information intended for public use? ☒ Yes ☐ No

Does document contain controlled-use information? ☐ Yes ☒ No

Section 4: **Document Review & Approval**

	Name /Position	Signature	Date
Preparer:	TB Hammond/Hydrogeologist		9/1/16
Checker:	Mary Weber/Hydrogeologist	Mary Weber	9/1/16
Senior Reviewer:	Raziuddin Khaleel/Sr. Hydrogeologist	R Khaleel	9/1/16
Responsible Manager:	Patrick Baynes Manager	Patrick A Baynes	9/15/16

Section 5: Applicable if calculation is a risk assessment or uses an environmental model

PRIOR TO INITIATING MODELING:

Required training for modelers completed:

	Name /Position	Signature	Date
Integration Lead	WE Nichols/Modeling Team Leader		1 SEP 2016

Safety Software Approved:

	Name /Position	Signature	Date
Integration Lead	WE Nichols/Modeling Team Leader		1 SEP 2016

CALCULATION APPROVED:

	Name /Position	Signature	Date
Risk/Modeling Integration Manager:	AH Aly/Risk & Model Integr. Manager		9/19/16

ECF-300FF5-16-0087
Revision 0

Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit, Hanford Washington

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

P.O. Box 1600
Richland, Washington 99352

ECF-300FF5-16-0087
Revision 0

Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit, Hanford Washington

Document Type: ENV Program/Project: EP&SP

T. B. Hammond
INTERA, Inc.

Date Published
October 2016

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

P.O. Box 1600
Richland, Washington 99352

APPROVED
By Julia Raymer at 8:41 am, Nov 01, 2016

Release Approval Date

ECF-300FF5-16-0087
Revision 0

Contents

Appendices

Figures

Tables

Terms

3D	three-dimensional
CHPRC	CH2M HILL Plateau Remediation Company
EAA	Enhanced Attenuation Area
ECF	environmental calculation file
EDA	Environmental Dashboard Application
EMMA	Environmental Model Management Archive
GIS	geographic information system
GFM	geologic framework model
HEIS	Hanford Environmental Information System
Hf	Hanford formation
LiDAR	light detection and ranging
PNNL	Pacific Northwest National Laboratory
PRZ	periodically rewetted zone
Rlm	Ringold Lower Mud
STOMP	Subsurface Transport Over Multiple Phases
WCH	Washington Closure Hanford

This page intentionally left blank.

1 Purpose

The objectives of this environmental calculation file (ECF) are to document development of the three-dimensional (3D) geologic framework model (GFM) and the extents of vadose zone uranium contamination distribution for the 300-FF-5 Groundwater Operable Unit (OU). Leapfrog® Geo (version 2.3.2) was used to develop the GFM and vadose zone uranium contamination distribution for the identical 3D domain. The primary area of focus for the vadose uranium contamination distribution encompasses the area of highest observed soil uranium concentrations at depth within a periodically rewetted zone (PRZ). The PRZ represents a region within the deep vadose zone beneath the 300 Area that becomes saturated during times of high river stage. When the PRZ is rewetted, the uranium contamination adsorbed to sediment particles within the PRZ sediments can become mobilized and transported to groundwater.

The following process was used for the modeling efforts described herein:

1. Compilation and conditioning of site soil uranium concentration data
2. Compilation and conditioning of site borehole geologic data
3. 3D modeling of site geology and soil uranium concentration distribution using the Leapfrog Geo (version 2.3.2) software

GFM and uranium soil concentration distributions developed in this ECF are intended for use in fate and transport modeling efforts for the 300 Area uranium contamination remediation by polyphosphate injection and infiltration (PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography*). Studies have shown that phosphate reduces uranium mobility by forming uranium phosphate precipitates and coating surface phases of uranium with stable mineral phases (PNNL-21733, *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment*). CH2M HILL Plateau Remediation Company (CHPRC) treated a 0.75 ac area, within the 300 Area, which was thought to contain the highest mobile uranium concentrations. The phosphate amendment included a solution of monosodium phosphate and pyrophosphate that was injected directly into the PRZ and upper aquifer through wells and infiltrated through the vadose zone using buried infiltration lines.

2 Background

This chapter describes the 300 Area geologic setting and geologic framework model.

2.1 Site Geologic Setting and Geologic Framework Model

Beneath the 300 Area, the Hanford formation (Hf) comprises the vadose zone that is made up of unconsolidated sandy gravels containing spatially (horizontally and vertically) variable amounts of silts and clays. Saturated Hf sediments are of the same materials as the vadose zone and are underlain by more consolidated materials of the Ringold formation unit E, hereinafter called Ringold E (WHC-EP-0500, *Geology and Hydrology of the 300 Area and Vicinity, Hanford Site, South-Central Washington*). Underlying Ringold E is the Ringold Lower Mud (Rlm) unit, consisting of predominately silts and clays, and underlying the Rlm is part of the Columbia River Basalt Group bedrock.

For the purposes of this ECF, the primary geologic unit of concern is the Hf. In the study area, the deep vadose zone and PRZ are located in the Hf; in these zones, uranium is periodically leached from and

---

® Leapfrog is a registered trademark of ARANZ Geo Limited, Christchurch, New Zealand.

reabsorbed to sediment particles during water table fluctuations. In the existing Hanford south GFM (ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*), the Hf is undifferentiated; however, variability in vertical and lateral distribution of fine materials in the vadose zone could affect the uranium contamination plume extents, as uranium has an affinity for the finer sediments (i.e., particles having <2mm size fraction (Shang et al., 2011, "Effect of Grain Size on Uranium(VI) Surface Complexation Kinetics and Adsorption Additivity"). In order to honor the effect that the geology has on uranium distribution, it was necessary to construct a GFM specific to the 300 Area complete with detailed, differentiated Hf subunits. The subunits were defined through observation of changes in composition and grain size, as well as through stratigraphic position and depositional order in the Hf through studying the borehole geologic and geophysical logs of the study area. These logs were obtained from the Hanford Site Well Environmental Dashboard Application (EDA) website and from CHPRC for newly drilled boreholes as part of the Stage A Enhanced Attenuation Area (EAA) (ECF-300FF5-15-0014, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Establishment of the Stage A Enhanced Attenuation Area for 300-FF-5*). The following specific Hf geologic subunits comprise the upper portion of the 300 Area GFM:

- The Hf is categorized into five subunits from land surface downward based on the observed sequence of deposition in the study area:
  - Hf sand unit 1—fine to coarse sand of mixed basaltic and felsic composition
  - Hf sandy gravel—unconsolidated mostly pebble to cobble gravels with sand
  - Hf sand unit 2—unconsolidated, fine to coarse sand (mostly basalt) with some silt
  - Hf Silt—100 percent silt unit identified in several wells drilled as part of the Stage A EAA uranium sequestration by polyphosphate remedy
  - Hf silty sandy gravel—unconsolidated mostly basalt pebble to cobble gravel with silt and sand
  - Hf gravel—unconsolidated predominantly basaltic pebble to cobble gravel with some sand and/or silt

These Hf subunits were interpreted, based on the following criteria:

- Hf sand unit 1—≥90 percent sand of mostly basaltic composition
- Hf sandy gravel—between 50 and 60 percent gravel with sand fraction ranging 50 to 40 percent (gravels are predominantly basaltic basaltic)
- Hf sand unit 2—80 to 90 percent sand with silt, sand, or gravel fraction ranging from 20 to 10 percent
- Hf silt—100 percent silt described in borehole geologic logs as being moderately plastic and grayish-brown in color
- Hf silty sandy gravel—50 to 70 percent gravels to cobbles, 20 to 10 percent sands, and 20 to 10 percent silt (gravel to cobble fraction is mostly basaltic; sand is moderately to poorly sorted)
- Hf gravel—85 percent to 90 percent gravels with 15 percent to 10 percent sand and/or silt fractions (gravels are at least 50 percent basaltic)

Much of the superficial sediments in the study area have been reworked due to excavation and the addition of clean fill material brought in from other areas of the Hanford Site. This material will have very little to no silt content and, therefore, will not likely contain uranium.

The lower portion of the 300 Area GFM was constructed using interpolated unit-top surfaces for Ringold E and Rlm. The surfaces were extracted from the Hanford south GFM (ECF-HANFORD-13-0029). Newly interpreted borehole information is not conformable with the current version of the Hanford south GFM and this does have implications on flow and transport modeling for the area. The next update of the Hanford south GFM will reflect the new borehole information, and this discrepancy will be resolved.

Information gained from the GFM efforts described in this section and Stage A EAA drilling and sampling activities laid the backdrop for the EAA determination. Previous geological and characterization studies were instrumental in providing information used in the geologic and uranium contamination distribution modeling discussed herein.

3 Methodology

This chapter discusses the data and methods used for the three-dimensional modeling.

3.1 Compilation and Conditioning of Site Soil Uranium Concentration Data

Input data consisted of spatially referenced soil concentrations with sample dates ranging from 1991 through 2015. Soil concentrations of uranium-238 in pCi/g or µg/g were compiled from the Hanford Environmental Information System (HEIS) with the exception of data from Peterson, 2010, "Uranium in Sediment from FS-2 Test Pit, 618-1 Burial Ground Excavation," which are based on the following primary reports for the 300 Area:

- DOE/RL-92-32, *Expedited Response Action Assessment for 316-5 Process Trenches* (Appendix A labels: Washington Closure Hanford [WCH]).
- BHI-01164, *300 Area Process Trenches Verification Package* (Appendix A labels: WCH)
- PNNL-17793, *Uranium Contamination in the 300 Area: Emergent Data and their Impact on the Source Term Conceptual Model* (Appendix A labels: PNNL-17793 Tables 5.11, 5.22, and 5.47)
- PNNL-16435, *Limited Field Investigation Report for Uranium Contamination in the 300 Area, 300-FF-5 Operable Unit, Hanford Site, Washington* (Appendix A labels PNNL-16435 Table D.2)
- PNNL-22032, *Uranium in Hanford Site 300 Area: Extraction Data on Borehole Sediments* (Appendix A labels: PNNL-22032)
- Unpublished post-record of decision field investigation sample data from borings C8933, 399-1-67, and 399-1-68 (Appendix A labels: Borehole Data Tracking Spreadsheet.xlsx)
- Data from Peterson (2010) in the form of a letter report (Appendix A labels: 618-1_BurialGroundExcavation)
- Unpublished data at the time of modeling (now available in HEIS) obtained from characterization sampling at wells 399-1-76 and 399-1-80 during drilling activities for the Stage A EAA (Appendix A labels: Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS)
- Additional data that were retrieved from HEIS based upon the proximity to the modeling area (may be documented in reports but for the purposes of this ECF, they are labeled according to the originator of the data; originators (WCH and CHPRC) have been labeled accordingly in Appendix A, and all data points pulled from HEIS that are not associated with the listed reports, WCH, or CHPRC have been labeled as HEIS)

The compiled data can be found in Table A-1 (Appendix A) of this document. Data from the Peterson (2010) letter report can be found in Appendix B.

The following process is used for compilation and conditioning of site soil uranium concentration data:

- Data downloaded from HEIS were selectively filtered by removing samples marked as duplicates and overburden/staging pile area measurements.
- Measurements from soil that were subsequently excavated after measurement were selectively removed from the data set.
- HEIS data that did not come with depth discrete measurements were assigned depths of 5 and 7.5 m for measurements and classified as shallow and deep, respectively. Sampling was performed at ground surface prior to excavation and given a depth of 0.3 m. The 5 and 7.5 m depths were sampled post-excavation within the trenches themselves (BHI-01164). Where a sampling depth range was given, the sampling depth was taken as the midpoint of the range. These depth assignments were done to estimate sampling depths more accurately during the cleanup excavation (BHI-01164).
- Soil sample results based on one laboratory analytical method (described in HEIS as UISO_Plate_AEA) were used for consistency and comparability of data. This method detects the isotopes of uranium using alpha spectroscopy.
- All data for soil that were below the detectable limit were set to zero.
- The newest data from boreholes C8933, 399-1-67, 399-1-68, 399-1-76, and 399-1-80 were received as total uranium soil concentration (µg/kg). Soil concentration results for the uranium-238 isotope were used in the calculations for uranium modeling as 99.3 percent of existing uranium is composed of uranium-238 (IUPAC, 1998, "Isotopic Compositions of the Elements"); therefore, the total uranium data were assumed to be a proxy for uranium-238 concentrations.
- All data were converted to µg/g if not received in those units.
- The data were then compiled into the worksheet U238_soil_updated0915.csv for use in Leapfrog Geo.

3.2 Compilation and Conditioning of Site Borehole Geologic Data

Before entering the uranium concentration data into Leapfrog Geo for plume interpolation, Hf detailed vadose zone and lower suprabasalt sediment geologic models of the suprabasalt sediments underlying the 300 Area were constructed. Data interpolation by Leapfrog Geo is carried out using radial basin functions (Buhmann, 2000, "Radial basis functions"). The Hf detailed vadose zone geologic model was developed using three sets of data:

- Current data sets from the existing GFM representing the entire Hanford site south of Gable Mountain and Gable Butte (ECF-HANFORD-13-0029)
- Interpretations of recently received borehole geologic logs from the area (PNNL-22032 and CHPRC geologic field logs from Stage A EAA)
- Interpretations of borehole and geophysical logs from EDA

The following steps were involved in GFM data compilation and conditioning:

1. Identify a model domain within the 300 Area section of the Hanford South model, and extract the boreholes from this section. Locate additional boreholes not used in the Hanford south GFM by querying HEIS. Plot the additional boreholes in a geographic information system (GIS).
2. Obtain available borehole geologic and geophysical logs from EDA for selected locations of the GFM borehole data.
3. Interpret borehole geologic and geophysical logs for Hf subunits. Geophysical logs were used to look for consistency between the Hf subunits interpreted from the borehole logs and were especially helpful for matching up siltier units because their contacts are indicated by distinct count spikes.
4. Format borehole location and geologic data into Excel® comma separated value files for import into Leapfrog Geo. Details and examples of these formats can be found in ECF-HANFORD-13-0029.

Not all wells or borings within the selected Hf detailed vadose zone model domain were used in the GFM data set because the omitted well logs lacked sufficient detail for an accurate interpretation of the geologic units. A list of wells and boreholes with information deemed unsuitable for the aforementioned reason can be found in Table C-4 (Appendix C). However, some of the omitted wells were suitable enough for interpretation of major units (i.e. top of Ringold E) and, therefore, were used in Hanford South model interpolation. Thus, some wells in the collars and Hanford South lithology tables (Tables C-1 and C-3) will be included in Table C-4.

The lower suprabasalt sediment geologic model was constructed using borehole geologic data instead from existing surfaces from geologic unit volumes interpolated within the Hanford south GFM (ECF-HANFORD-13-0029). However, boreholes used in the Hanford south GFM interpolation were imported into the 300 Area lower suprabasalt sediment GFM to assign lithologies to the geologic unit volumes.

3.3 Three-Dimensional Modeling of Site Geology and Soil Uranium Concentration Distribution

Construction of the 300 Area GFM and soil uranium concentration distribution models first involved development of the site geology and then interpolation of the conditioned soil uranium concentration data all using the Leapfrog Geo 3D modeling software.

The 300 Area GFM construction used interpreted borehole data and pre-existing geologic unit surface grids to define geologic unit contacts as subsurface elevations. These data inputs are interpolated within the Leapfrog Geo framework to define geologic unit surfaces that form the upper (i.e., top of the geologic unit surface) and lower bounding model surfaces of the geologic unit intervals that, when combined together, represent the solid model.

Soil uranium concentration distribution modeling involved interpolating the data in Appendix A (including control points) within the boundary of the GFM, resulting in volumes correlating to the defined contamination concentration ranges of >30, >90, and >157 µg/g. The concentration ranges represent values of 10 times background, 30 times background, and preliminary remediation goal values, respectively (ECF-300FF5-11-0151, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS*).

® Excel is a registered trademark of Microsoft Corporation, Redmond, Washington.

3.3.1 Geologic Framework Model Construction

This subsection provides the sequence of steps (and the input files required in each step) for the user to construct or recreate the 300 Area GFM. A detailed explanation of the input file times, formatting, and general model boundary determination is outlined in ECF-HANFORD-13-0029. Appendix C contains GFM input data formatted for import into Leapfrog Geo.

1. Open Leapfrog Geo software, and create a new project.
2. Import borehole data by right clicking on the folder titled Drillhole Data and from the import data dialogue box navigate to “Vds_collars_300Area.csv”. In the import data dialogue box, there will also be sections to import well alignment survey information (included in the collars table so also import “Vds_collars_300Area.csv” in this slot), well intervals, and screens. In this area, browse to the comma separated value tables entitled “Vds_lithology_300Area.csv”, “HS_062614_lithology.csv”, and “Area_Screens.csv”. The collars file contains the location information for both lithology files. The lithology file “Vds_lithology_300Area.csv” will be used in the construction of the detailed vadose zone model (see Step 7), and “HS_062614_lithology.csv” will be used to assign lithology to the volumes created in the construction of the lower suprabasalt sediment model but not used in any interpolation.
3. Follow the prompts in the Leapfrog Borehole Data dialogue box entering the well name column from the .csv file as Hole Id, the X coordinates column from the table as X data, the Y coordinates as Y data, the elevation as Z, borehole dip and azimuth information as the dip and azimuth, and the constructed depth as MAX DEPTH in the Leapfrog dialogue boxes. Follow prompts to import the screen top and bottom depths.
4. To add the upper surface of the model right click on the folder entitled Topographies, then New Topography, then Import Elevation Grid. Browse to the light detection and ranging (LiDAR) bath_new.asc file (Aero-Metric LiDAR, 2008, *RCCC-Hanford Battelle/PNNL/DOE, Digital Orthophotography & LiDAR Surveys Photogrammetric Report*), and import it. (Note: Leapfrog will not accept the native 0.5 resolution due to the size of the file. Input 10 for the grid spacing.) In the import pop-up window, import the file so it is clipped to the model clipping boundary to import only the necessary extents of the raster. The model clipping boundary is as follows: X minimum and maximum of 593846.00 and 594683.19 respectively, and Y minimum and maximum of 115954.03 and 116815.54 (Washington State Plane [NAD83 *North American Datum of 1983*]), respectively.
5. To add the lower surface of the model, right click on the Meshes folder and import elevation grid, navigate to Sitewide_tob_ThompsenC (top of basalt surface [SGW-48478, *Interpretation and Integration of Seismic Data in the Gable Gap*]), and import the file. In the import pop-up window, import the file so is clipped to the model clipping boundary.
6. To add the Ringold E and Rlm surfaces of the model, right click on the Meshes folder and import elevation grid, then navigate to Rwie_062614 and Rlm_062614 (ECF-HANFORD-13-0029) and import both files.
7. Create Hf vadose model:
   a. To create a new geological model, define a region that encompasses the boundary coordinates of the model. Right click on the folder entitled Geological Model, and click New Geological Model. In the Base Lithology dropdown, navigate to the lithology (which should appear by default). Set the X minimum and maximum to 593846.00 and 594683.19, respectively; and set the Y minimum and maximum to 115954.03 and 116815.54, respectively. Set the surface resolution

to 10, and click OK. These are the predefined model coordinates. Be sure to check the box to use the topography for the upper model extent.

b. For the eastern model boundary, right click on the folder entitled GIS Data, Maps, and Photos and click Import Vector Data. Navigate to “River_vds_bdry.shp”. Use this feature as a new boundary lateral extent. This shape file was created specifically for this calculation as a model boundary element. All polylines created for this modeling effort can be found with this ECF in the Environmental Model Management Archive (EMMA).

c. Expand the new geological model, and right click Surface Chronology then drop down to New Deposit and select From Base Lithology. In the dropdown menu beneath Select primary lithology, select Hf sand unit 1. Click the radio button Use contacts below, and the Contacting/Avoided lithologies box should automatically populate with Hf sandy gravel and Hf sandy silty gravel. Double click on Hf sand unit 2 in order to move it from the Ignored lithologies to the Contacting/Avoided lithologies box. Click OK to add the Hf sandy gravel solids model geometry to the existing model.

d. Right click on Surface Chronology then drop down to New Deposit, and select From Base Lithology. In the dropdown menu beneath Select primary lithology, select Hf sandy gravel. Click the radio button Contacts Below and Hf sand unit 2 and Hf silty sandy gravel. Click OK.

e. The Hf sand unit 2 is not continuous throughout the model domain; therefore, this unit had to be modeled in several separate volumes representing the same lithology. Separate, localized pockets of Hf sand unit 2 were labeled in the input file “Vds_lithology_300Area.csv” as Hf sand units 3 and 4. Interpolation of the additional Hf sand units, as described for deposits listed, was unrealistic; therefore, an alternative approach was taken:

    i. Right click on Surface Chronology then drop down to New Vein, and select From Base Lithology.

    ii. In the pop-up window, select Hf sand unit 3 lithology. In the Surfacing tab, make sure that the Inherit resolution from GM and Include points at the ends of holes boxes are clicked. Click OK to add the Hf sand unit 3 solids model vein geometry to the existing model. Under the surface chronology, a vein surface icon for Hf sand unit 3 will be created.

    iii. Refine the vein morphology by clicking the dropdown arrow next to the vein surface icon for Hf sand unit 3 and then right clicking on “Hangingwall”. Next select “Add polyline”. Navigate to the “Hf S3 Hangingwall 3” curved polyline in the project tree and add it. All polylines created for this modeling effort can be found with this ECF in EMMA. No additional editing objects are required for the footwall.

    iv. Repeat steps i through iii for Hf sand unit 4 but add the curved polylines “Hf S4 Hangingwall 2” to the hangingwall and “Hf S4 Footwall 2” to the footwall:

    v. Right click Surface Chronology, then drop down to New Deposit and select From Base Lithology. In the dropdown menu, beneath Select primary lithology, select Hf sand unit 2. Click the radio button Contacts Below, and check Hf silty sandy gravel. Click OK to add the Hf sand unit 2 solids model geometry to the existing model. Since the bottom unit is Hf silty sandy gravel and only the top of basalt boundary surface is below it, Leapfrog automatically creates the volume for Hf silty sandy gravel. Therefore, it is automatically added to the surface chronology.

8. Create lower suprabasalt sediment model:
    a. Right click on the folder entitled Geological Models, and click New geological model. In the Base Lithology dropdown, navigate to the lithology (HS_062614_lithology.csv). Set the X minimum and maximum to 593,180.55 and 594844.84, respectively; set the Y minimum and maximum to 114,496.49 and 117,830.16, respectively. Set the surface resolution to 100, and click OK. These are the predefined model coordinates. Be sure to check the box to use the topography for the upper model extent.
    b. For the eastern model boundary, use “River_vds_bdry” as for the Hf vadose zone model.
    c. Expand the new Geological Model and right click Surface Chronology, then drop down to New Deposit from Surface. Navigate to Rwie_062614 and select it. Click OK to add the Ringold E solids model geometry to the existing model.
    d. Continue constructing the Geologic Model by right clicking Surface Chronology, then drop down to New Deposit and select From Surface. Navigate to Rlm_062614 and select it. Click OK to add Rlm solids model geometry to the existing model.
    e. Add an additional lateral extent to include “HS Saturated Geology Volume Only 2.msh”. This volume mesh was created in Leapfrog Geo by subtracting the Hf vadose model boundary mesh from the Lower Suprabasalt Sediment Model volume mesh using the Clip Volume tool.

3.3.2 Soil Uranium Concentration Distribution Modeling

This subsection provides the sequence of steps for the user to construct or recreate the 300 Area uranium vadose plume. A detailed explanation of the input file types, formatting, and general model boundary determination is provided in ECF-200UP1-14-0019, *Initial Groundwater Plume Development (Uranium, Technetium-99, Nitrate, and Iodine-129) to Support Fate and Transport Modeling for Remedial Design in the 200- UP-1 Groundwater Operable Unit*. Interpolation was carried out using the inbuilt interpolation utility in Leapfrog Geo. Leapfrog Geo carries out 3D interpolation using the ALGLIB® Fast RBF algorithm (Carr et al., 2001, “Reconstruction and Representation of 3D Objects with Radial Basis Functions”). The following steps are taken to construct or recreate the 300 Area uranium vadose zone plume:

1. In the same Leapfrog project containing the GFMs created in Section 3.2, import the soil uranium contamination data in Table A-1 by right clicking the Points folder and then clicking Import Points. Navigate to the .csv file “U238_soil_updated090115” (Section 3.1), and import it.
2. Begin the plume construction process by right clicking the Interpolants folder and then clicking New Interpolant. Set the X minimum and maximum to 593180.6 and 594844.8, respectively; set the Y minimum and maximum to 114887.8 and 117830.2, respectively. Set the surface resolution to 1.0 m.
3. Change the base of the interpolant to the top of basalt by expanding the interpolant. Right click on Boundary, and select New Lateral Extent then scroll down to From Surface, select Sitewide_tob_ThompsenC, the same top of basalt mesh used in the geologic model.
4. Default values for trends, sill and range were used. The plumes were not found to be sensitive to these parameters (the parameters were varied above and below the default values to evaluate this sensitivity). Model parameters are listed in Table 2.

® ALGLIB is a registered trademark of the ALGLIB Project, Russian Federation.

5. Volume control is added to the model with control points included in the "U238_soil_updated090115" data set when it is imported. No additional control other than points imported with the uranium concentration data set we used in the current interpolation.
6. In order to portray the uranium distribution more accurately in the PRZ at approximate 7.5 m below land surface, an upper bounding surface was used. This surface (plmcttr.asc) was created by exporting the topography (Lidar_bath_new.tif) from the model (constrained to the clipping boundary extents) and then subtracting 7.5 from the exported topography raster in GIS. However, this surface was not used to constrain the uranium distribution in the final interpolant.

4 Assumptions and Inputs

The following assumptions apply to the 3D vadose zone uranium distribution interpolations:

1. All data used in interpolation are correct and accurate.
2. All uranium concentrations are for the isotope uranium-238 because it is overwhelmingly abundant in proportion to other uranium isotopes in nature.

4.1 Geologic Framework Model Uncertainty

The principal source of uncertainty for identification of geologic units and their contacts is the quality of the descriptions and records of the drilling, sampling, and logging techniques used during borehole drilling, as well as the methods and materials used in well construction. The variable quality or lack of availability of borehole geophysical logs and laboratory data from borehole samples also contribute to this uncertainty. Many boreholes installed prior to the 1980s were drilled without a well site geologist present to describe the drill cuttings and samples. For these boreholes, only drillers' logs are available, and their quality varies greatly. Furthermore, varying quality of descriptions of subtle differences and gradational changes among geologic facies and across stratigraphic units can hamper reliable spatial correlation of sediment packages and individual facies.

As a result of the variability of data and the experience and professional judgment of the different investigators, many of the same geologic contacts have been picked at slightly different locations by different investigators. Different investigators may use different criteria for choosing contacts, depending on the objectives of the specific project (e.g., geologic or hydrologic in nature). Therefore, contact selection can be subjective and inconsistent. In some cases, the difference in contact elevation may be attributable to differences in the ground-surface elevations used by the different investigators

4.2 Inputs

Input data (U238_soil_updated090115.csv) for vadose uranium distribution interpolation are included in Appendices A and B. Input data (Vds_lithology_300Area.csv, HS_062614_lithology.csv, and Area_Screens.csv) for the GFM are included in Appendix C. All uranium concentration data from wells 399-1-33, 399-1-35 through 37, C8933, and 399-1-23 (except for one value from 399-1-23) were ultimately omitted in interpolation because the low values in these locations resulted in unrealistic holes within the uranium distribution. One anomalously high value data point (316-5-TP4) was omitted because the duplicate point in its location, as well as several data points from different sampling depths within the same borehole, had much lower uranium concentrations.

Table 1. Data from U238_soil_updated090115.csv Omitted from Interpolation

Data Point	X Coordinate[a,b]	Y Coordinate[a,b]	Z Coordinate[a,c]	HEIS Number	Constituent	Value (µg/g)
300-18	593808.3	117042.1	112.85	J036W6	Uranium-238	0
399-1-21B	594157.2	116176.8	92.9	B014W3	Uranium-238	0
618-7	593212.6	116509.2	116.61	J17R55	Uranium-238	0
618-7	593208	116518	116.78	J17R59	Uranium-238	0
618-8	593821.1	116477.9	115.43	J11274	Uranium-238	0
316-5-TP4	594090	116455	111.5	B01033	Uranium-238	1080.3

a. All coordinates are in meters.

b. Horizontal datum is Washington State Plane (NAD83, *North American Datum of 1983*).

c. Vertical datum is NAVD88, *North American Vertical Datum of 1988*.

5 Software Applications

Leapfrog Geo, Microsoft Excel and Access®, and ArcGIS[1] software programs were used for this calculation. These are CHPRC approved software, managed and used in compliance with the requirements of PRC-PRO-IRM-309, *Controlled Software Management*. Leapfrog Geo is approved calculation software; approval is documented in CHPRC-01755, *Leapfrog-Hydro and Leapfrog-Geo Acceptance Test Report*. Microsoft Excel and ArcGIS software programs were used as spreadsheet software for this calculation.

5.1 Approved Software

For approved software used in this calculation, the required descriptions are provided in the following subsections.

5.1.1 Description

The following information has been identified for the software package used in the calculation:

- Software Title: Leapfrog Geo
- Software Version: 3.0.0
- Hanford Information System Inventory Identification Number: 2874 (Safety Software, Level C)
- Workstation type and property number: Dell Work Station INTERA #00771

5.1.2 Software Installation and Checkout

Copies of the Software Installation and Checkout Forms for the authorized users and authorized workstations for software used that requires this documentation are provided in Appendix D to this ECF.

® Microsoft and Access are registered trademarks of Microsoft Corporation, Redmond, Washington.

[1] ArcGIS is a product of Esri, Redlands, California.

5.2 Statement of Valid Software Application

The preparers of this calculation attest that the software identified and used for this calculation is appropriate for the application and has been within the range of intended uses for which it was tested and accepted by CHPRC.

6 Calculation

3D interpolation was carried out for soil uranium data contained in Appendices A and B. The overall approach was kept consistent with the steps defined in Chapter 3. Interpolation parameters were selected to interpolate the data to provide the best correlation to existing information (i.e., location of high depth discrete data values, nondetects, and uranium groundwater plume contours). Table 2 shows the interpolation parameters used for soil uranium.

Table 2. Interpolation Parameters Used for Uranium Plume Interpolation in Leapfrog Geo

Trend				
Directions			**Ellipsoid Ratio**	
Dip	Degree	0	Maximum	1
Dip Azimuth	Degree	0	Intermediate	1
Pitch	Degree	0	Minimum	1
Interpolant				
Sill	Meters	600	Drift	None
Range	Meters	50	Nugget	0
Accuracy	Meters	0.1	Interpolant	Spheroidal
			Alpha	3
Isosurface and Volumes				
Intervals	µg/g	<1.5; 3.0; 10; 30; 90; 157	--	--
Isosurface and Volumes				
Resolution	Meter	1.0	--	--

7 Results/Conclusions

Figure 1 shows the results of the 3D vadose zone uranium distribution interpolation. The interpolated soil uranium concentrations along with other details are presented in a plan view. The interpolated vadose zone uranium concentration and isoconcentration contours are shown for the 7.5 m depth (below ground surface), which is the approximate target depth for the polyphosphate injection located in the PRZ. Figures 2 through 5 show the interpolated model geology and 3D uranium plumes to provide additional information.

Figures 6 and 7 illustrate the location of the Hf silt unit. It is important to note that since uranium contamination has an adsorption affinity for particles sized <2 mm (Shang et al., 2011), the location of silt beneath the highest concentrations (>157 µg/g) of the uranium vadose zone contamination distribution is significant.

Figures 8 and 9 show representations of a sandy gravel zone that appears to be excised through Hf silty, sandy gravel beneath the 300 Area. This feature was evident from the GFM interpretation of the detailed vadose zone borehole geologic data (Appendices C and D) assembled for the modeling efforts presented in this ECF (Figure 8). Table 3 lists interpreted borehole log locations containing evidence suggestive of the paleochannel outline, and no borehole locations contain unit information for Hf silty sandy gravel. The zone is filled with highly permeable Hf sandy gravel sediments and is underlain by low-permeability, silty sediments of the Ringold Formation. The significance of the excised zone is that it might contain less uranium due its slightly lower silt content than adjacent sediments. However, hydraulic properties of the excision fill material (Hf sandy gravel) and Hf silty sandy gravel are similar (Appendix E).

Figure 10 is a representation of the modeled geology and vadose zone uranium distribution in cross-section. The cross-section follows along the site direction of groundwater flow towards the Columbia River.

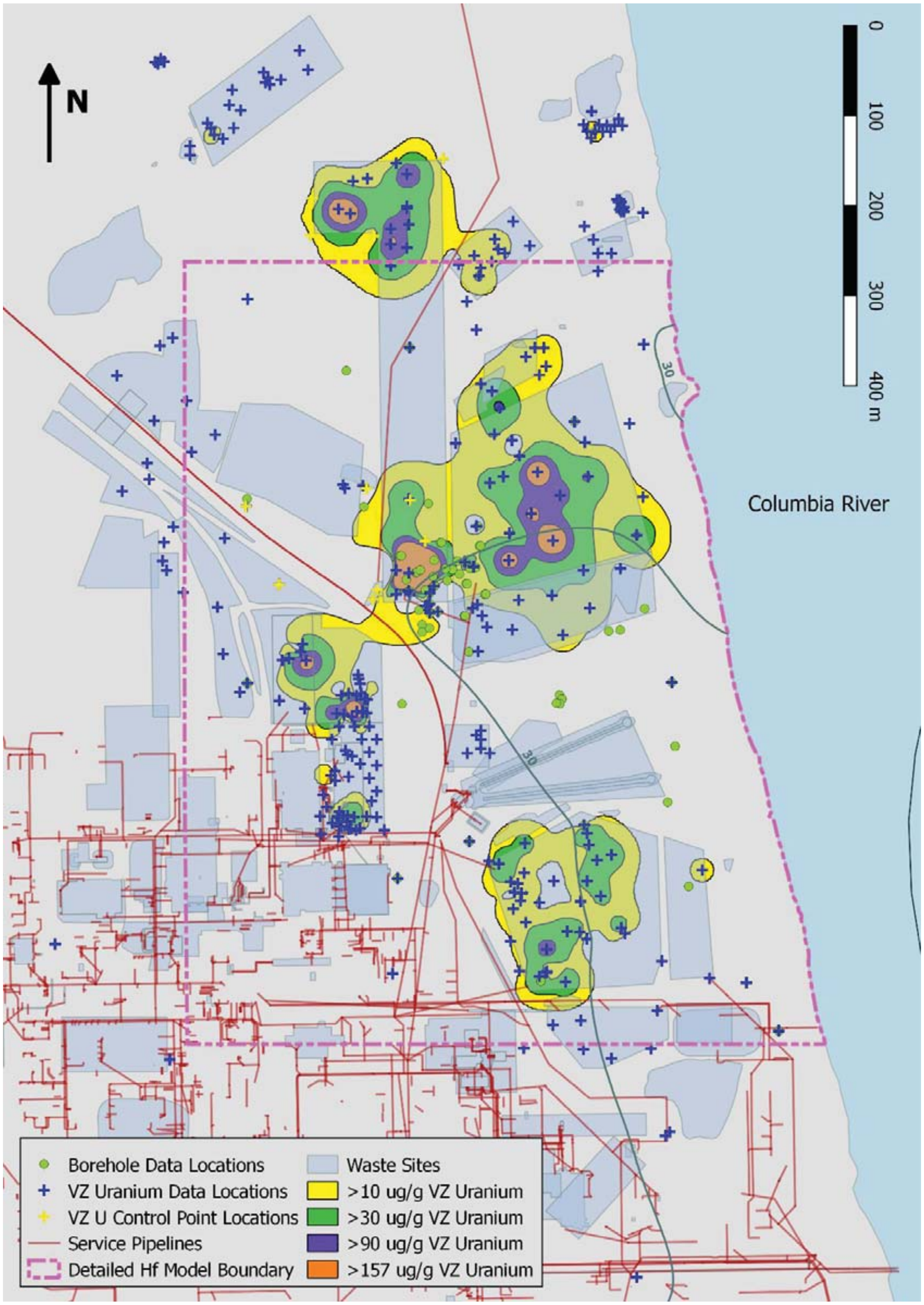
After completion of the Stage A remedy operations, three post-treatment borings were made to collect samples for comparing pre-remedy and post-remedy soil uranium conditions. Total uranium and borehole geology results were used as a validation data set to compare with the model results. Similarity between model and post remedy total uranium concentration results upon initial comparison showed confidence in the data set used to model the vadose zone uranium distribution discussed in this document. This was also the case when borehole geologies were compared. A detailed discussion of the model and post-remedy results can be found in Appendix E.

Table 3. Hf Sandy Gravel Zone Borehole Locations and Lithologic Information

Well Name	From	To	Lithology	Total Depth	X Coordinate	Y Coordinate	Z Coordinate*
399-1-57	0	11.5824	Hf SG	36.1188	594382	116353.7	114.6343
399-1-7	0	24.86	Hf SG	24.86	594260.1	116335.1	117.7757
399-1-8	0	34.6136	Hf SG	34.6136	594257.8	116329.6	117.7526
399-1-9	0	57.1688	Hf SG	35.052	594254	116330.4	117.728
399-2-3	0	21.812	Hf SG	35.052	594377.4	116220.5	115.0428
399-1-2	0	2.1336	Hf S	54.7304	594082.4	116329.5	117.9911
399-1-2	2.1336	30.7848	Hf SG	54.7304	594082.4	116329.5	117.9911
399-1-5	0	1.8288	Hf S	15.716	594111.7	116552.1	114.6323
399-1-5	1.8288	14.3256	Hf SG	15.716	594111.7	116552.1	114.6323
399-1-20	0	56.9976	Hf SG	54.7304	594257.3	116339.6	117.7588
399-1-68	0	12.5882	Hf SG	12.5882	594166.8	116527	114.4458

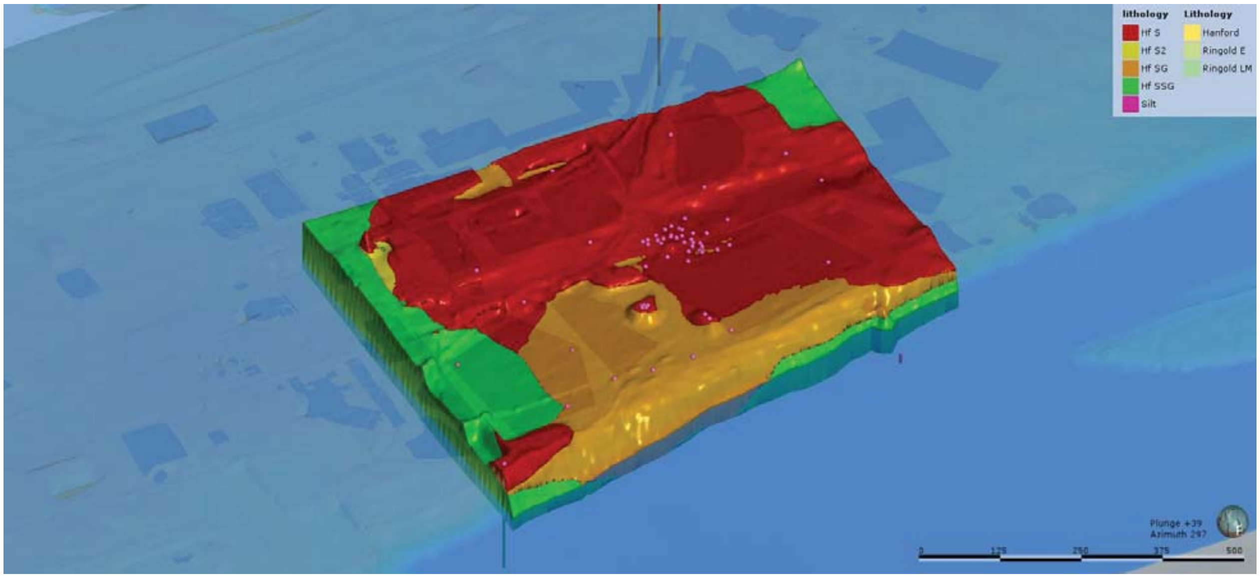
* Z coordinate represents surveyed top elevation of well or borehole.

S = Sand; SG = Sandy Gravel



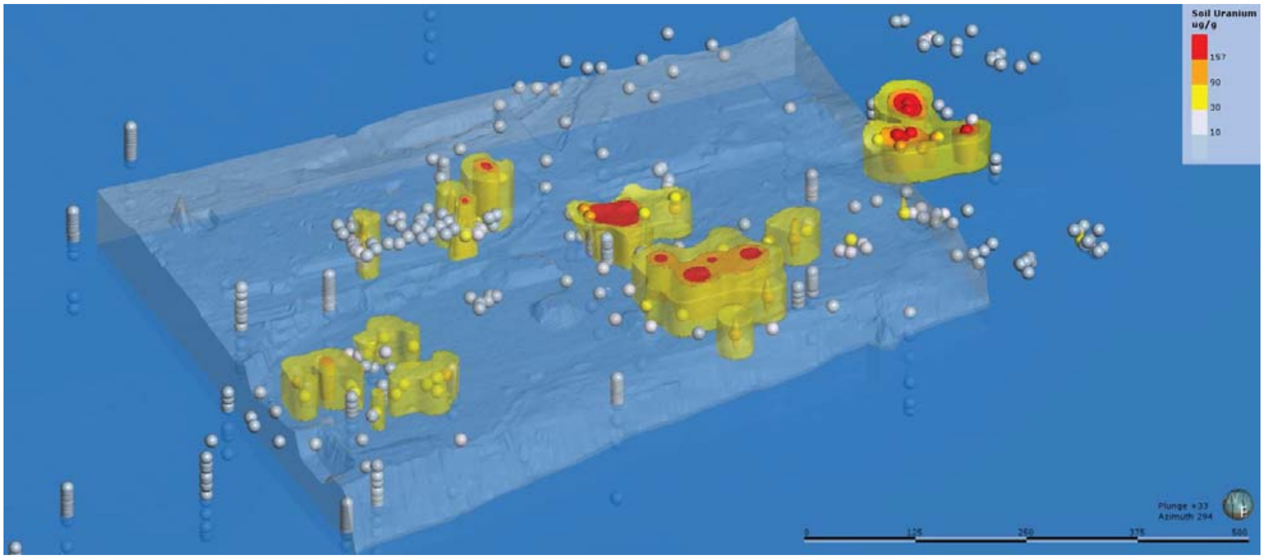
Note: Plume extents presented are from a depth of 7.5 m below ground surface.

Figure 1. Uranium Concentration Distribution



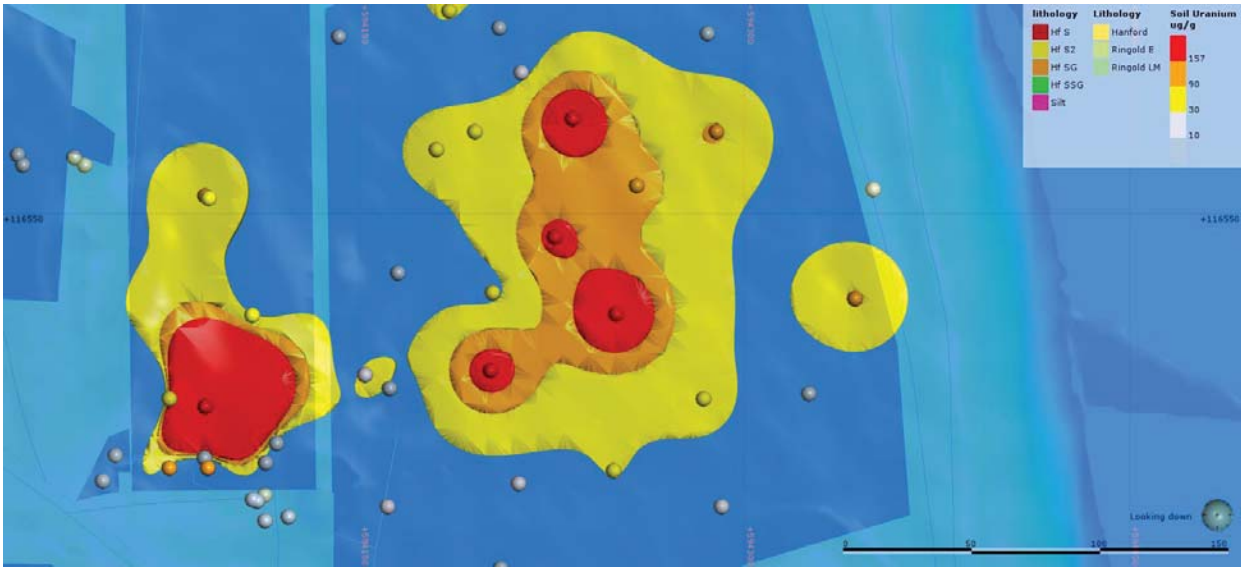
Note: Geologic units: red = Hf sand unit 1, orange = Hf sandy gravel, yellow = Hf sand unit 2, and green = Hf silty sandy gravel. Pink dots represent detailed vadose model well locations. Blue semitransparent shading represents the water table surface.

Figure 2. 300 Area Geologic Framework Model



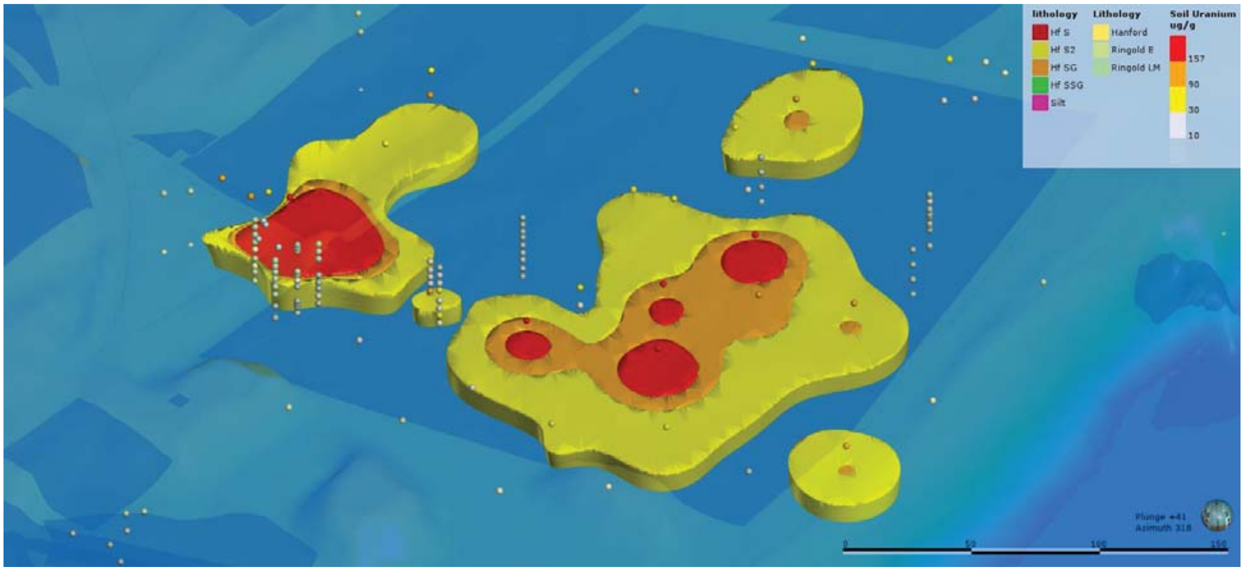
Note: Detailed plan view plume concentrations (µg/g) are yellow = >30, orange = >90, and red = >157.

Figure 3. 300 Area Uranium Concentration Distribution Plume Model



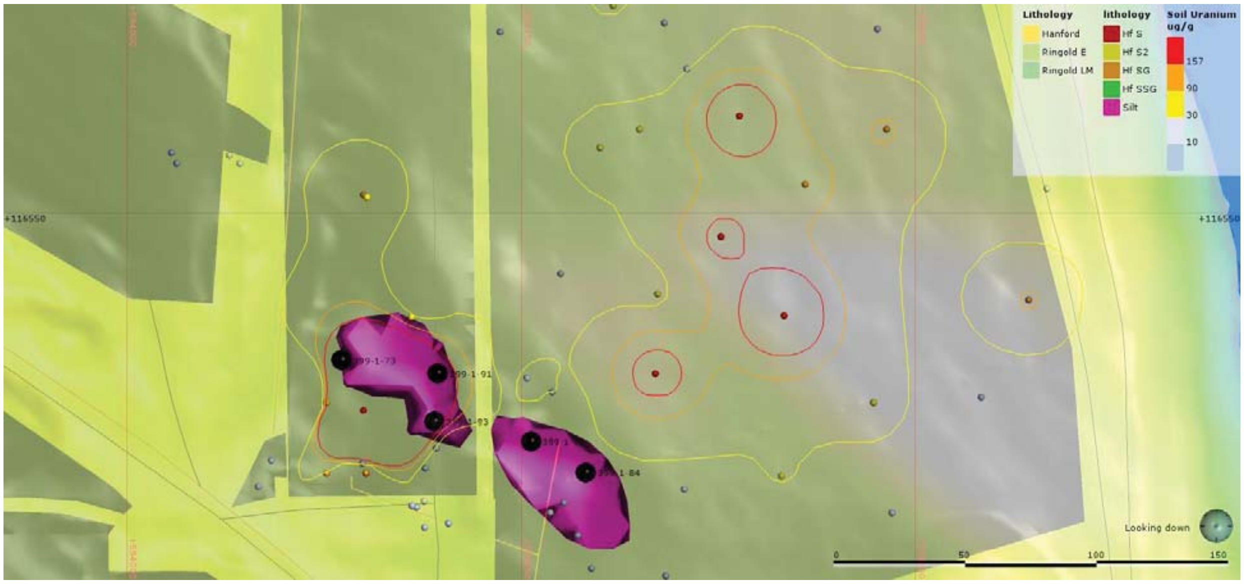
Note: Detailed plan view plume concentrations (µg/g) are yellow = >30, orange = >90, and red = >157.

Figure 4. 300 Area Uranium Concentration Distribution Plume Model



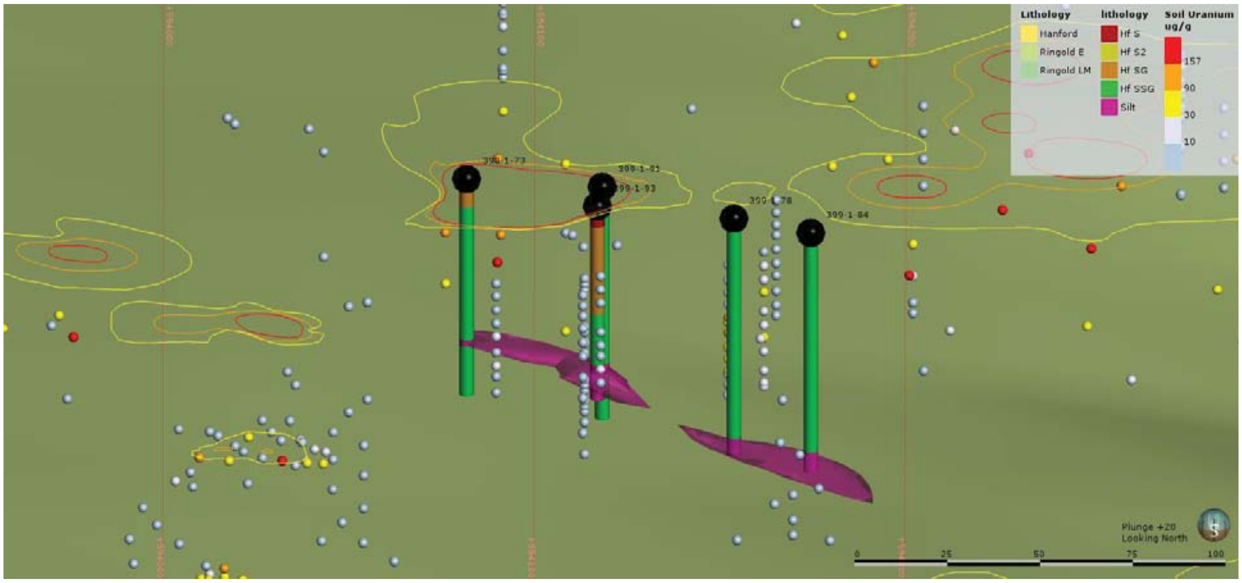
Note: Plume concentrations (µg/g) are yellow = >30, orange = >90, and red = >157.

Figure 5. 300 Area Uranium Concentration Distribution Plume Model Detailed Orthogonal View



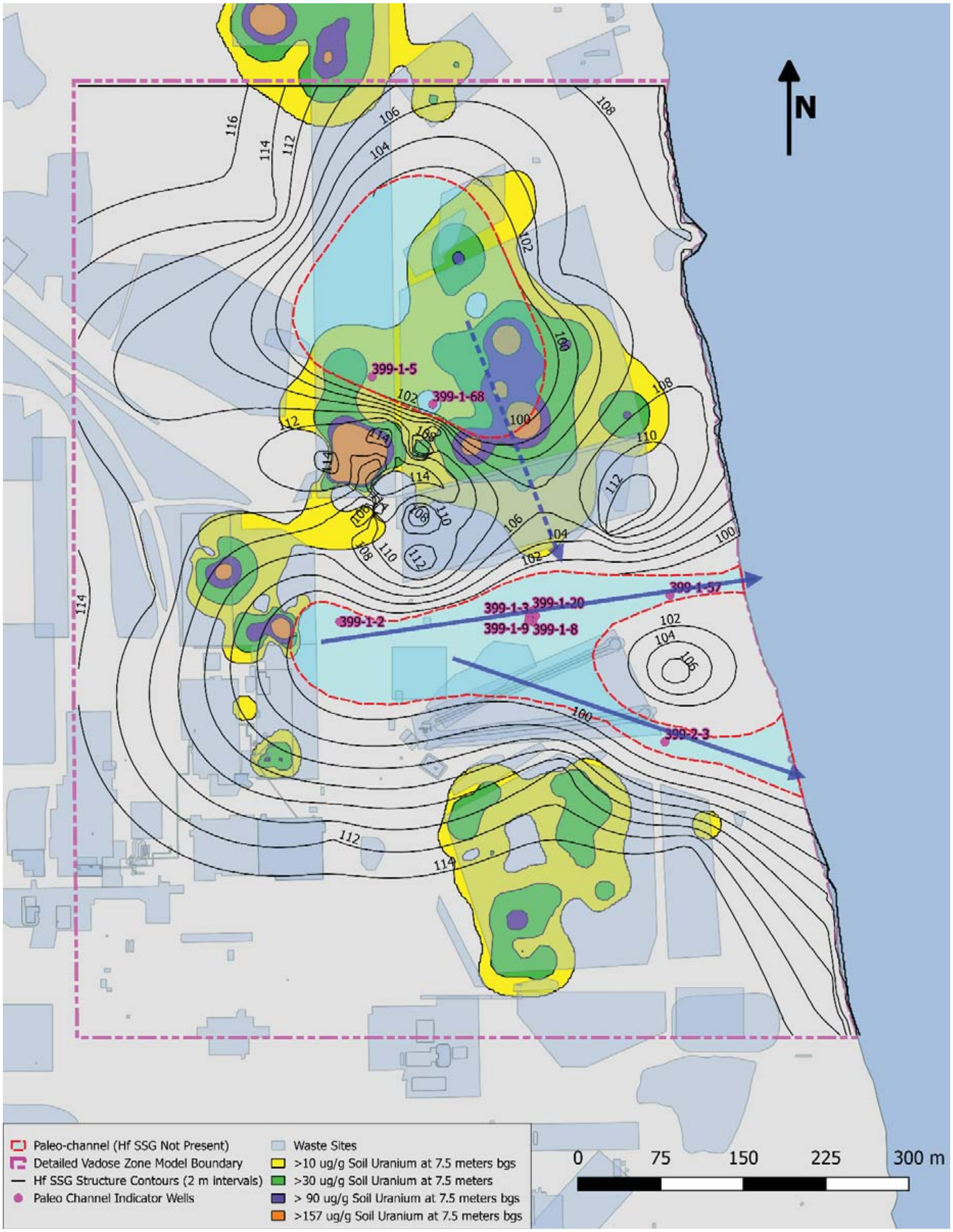
Note: The five wells with Hf silt contact data are shown (black dots). Uranium plume concentration outlines (µg/g) are yellow = >30, orange = >90, and red = >157. Waste sites are shaded in gray. Notice that the northwestern plume portion lies with the >157 µg/g contour.

Figure 6. Hf Silt Location Plan View



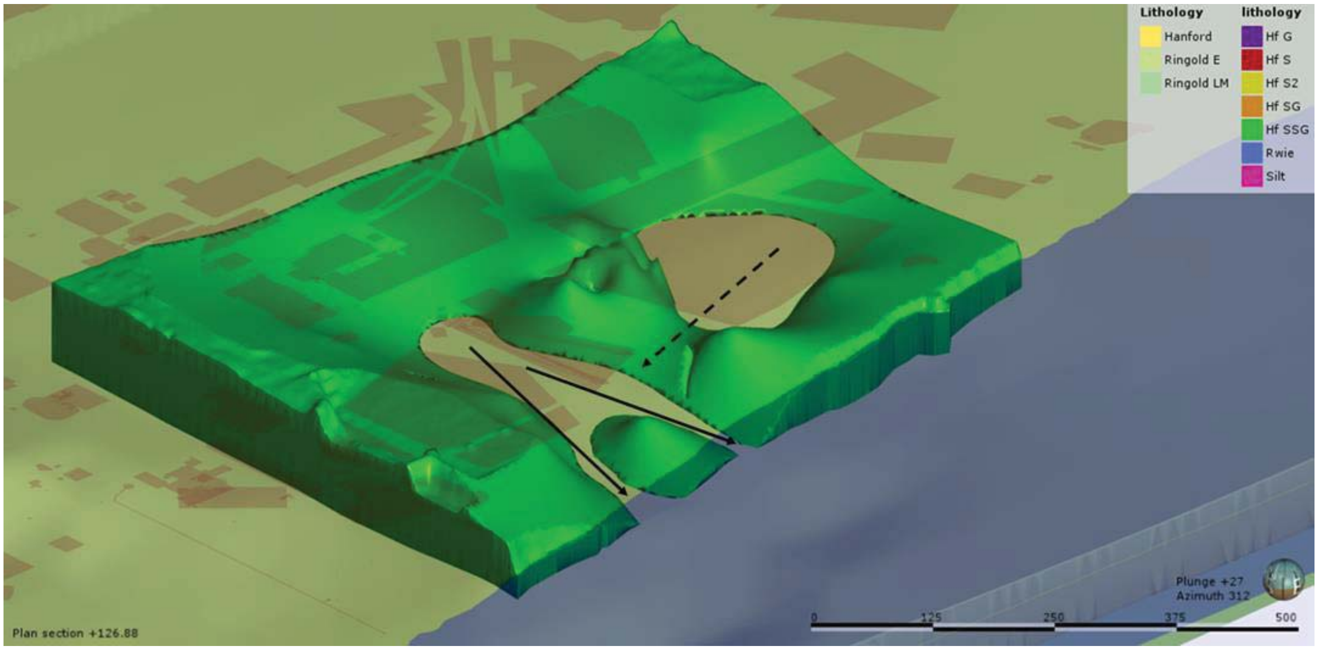
Note: The five wells with Hf silt contact data are shown (black dots). Uranium plume concentration outlines (µg/g) are yellow = >30, orange = >90, and red = >157. Vadose zone uranium data points are also shown with their values corresponding to the values of the plume concentration outlines except for lower values with light blue = <10 and white = >10 µg/g.

Figure 7. Hf Silt Location from the West



Note: The solid blue arrows indicate likely flow direction during HF silty sandy gravel excision. The dashed blue arrow indicates a possible scour flow direction, based on the current geologic model interpretation.

Figure 8. Hf Sandy Gravel Zone Features Excised into Hanford Formation Silty, Sandy Gravel



Note: The solid arrows indicate possible flow direction during HF silty sandy gravel excision. The dashed arrow indicates a possible excision direction as evidenced from interpretation of new borehole data. Model image shows 5 times vertical exaggeration.

Figure 9. View of Hanford Formation Silty, Sandy Gravel Unit Showing Hf Sandy Gravel Zone

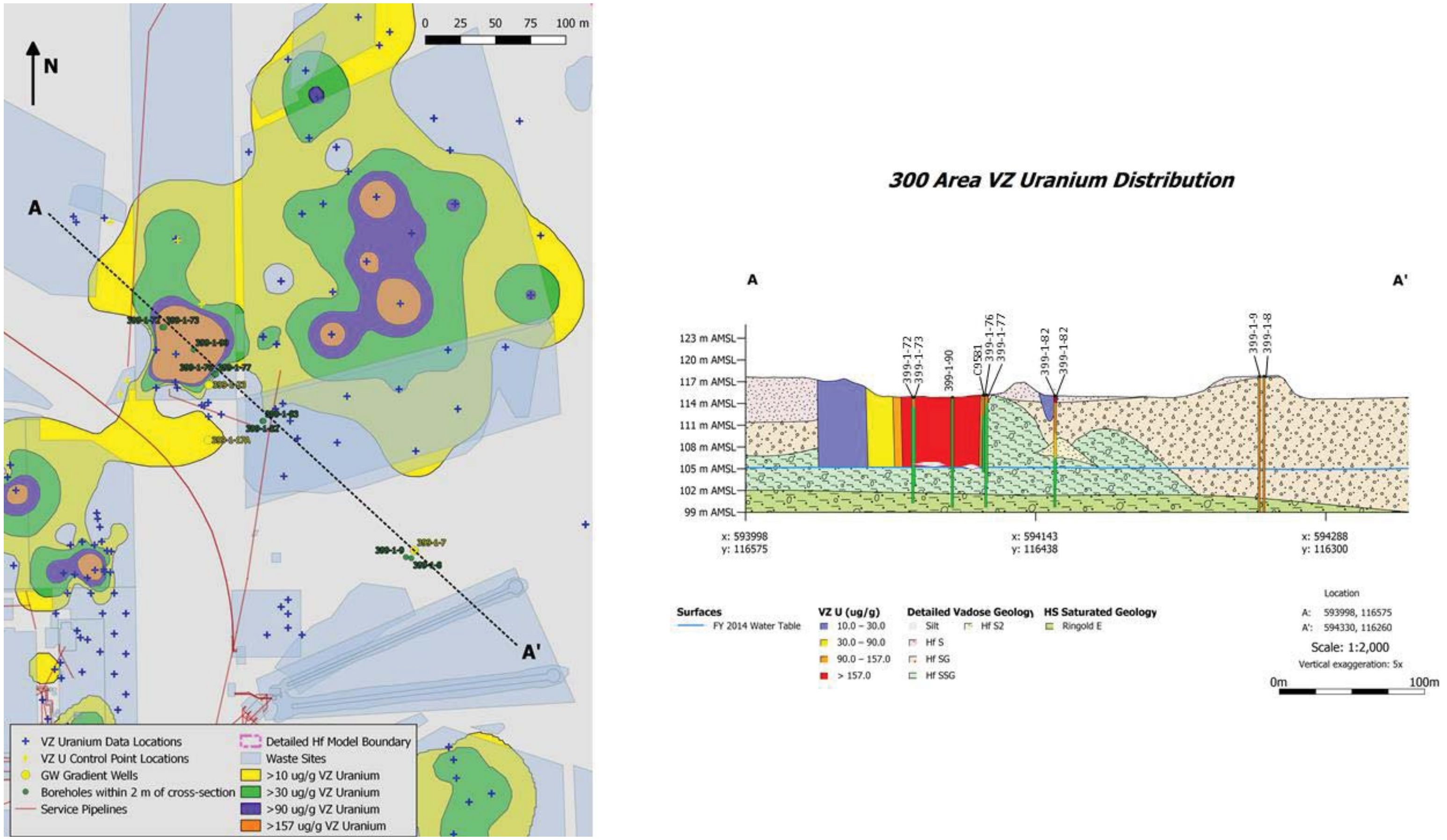


Figure 10. Cross-Section through 300 Area GFM and Vadose Zone Uranium Distribution

8 References

Aero-Metric LiDAR, 2008, *RCCC-Hanford Battelle/PNNL/DOE, Digital Orthophotography & LiDAR Surveys Photogrammetric Report*, prepared by Aero-metric, Seattle, Washington.

BHI-01164, 1998, *300 Area Process Trenches Verification Package*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D198200905.

Buhmann, M.D., 2000, "Radial basis functions," *Acta Numerica* 9:1-38. Available at: https://www.math.ucdavis.edu/~saito/data/jim/buhmann-actanumerica.pdf.

Carr, J.C., R.K. Beatson, J.B. Cherrie, T.J. Mitchell, W.R. Fright, B.C. McCallum, and T.R. Evans, 2001, "Reconstruction and Representation of 3D Objects with Radial Basis Functions," in SIGGRAPH 2001: Proceedings of the 28th annual conference on Computer graphics and interactive techniques, ACM Press, New York, New York, 67-76. Available at: http://www-lb.cs.umd.edu/class/spring2005/cmsc828v/papers/siggraph01.pdf.

CHPRC-01755, 2016, *Leapfrog-Hydro and Leapfrog-Geo Acceptance Test Report*, Leapfrog-Hydro Version 2.3.2 and Leapfrog-Geo Version 3.0.0, Rev. 4, CH2M HILL Plateau Remediation Company, Richland, Washington.

DOE/RL-92-32, 1992, *Expedited Response Action Assessment for 316-5 Process Trenches*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

ECF-200UP1-14-0019, 2014, *Initial Groundwater Plume Development (Uranium, Technetium-99, Nitrate, and Iodine-129) to Support Fate and Transport Modeling for Remedial Design in the 200- UP-1 Groundwater Operable Unit*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-300FF5-11-0151, 2012, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS*, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078650H.

ECF-300FF5-15-0014, 2015, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Establishment of the Stage A Enhanced Attenuation Area for 300-FF-5*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-HANFORD-13-0029, 2015, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*, Rev. 2, CH2M HILL Plateau Remediation Company, Richland, Washington.

IUPAC, 1998, "Isotopic Compositions of the Elements," International Union of Pure and Applied Chemistry, *Pure and Applied Chemistry* 70(1):217.

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

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

Peterson, R.E., 2010, “Uranium in Sediment from FS-2 Test Pit, 618-1 Burial Ground Excavation,” Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16435, 2007, *Limited Field Investigation Report for Uranium Contamination in the 300 Area, 300-FF-5 Operable Unit, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA06586011.

PNNL-17793, 2008, *Uranium Contamination in the 300 Area: Emergent Data and Their Impact on the Source Term Conceptual Model*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17793.pdf.

PNNL-22032, 2012, *Uranium in Hanford Site 300 Area: Extraction Data on Borehole Sediments*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22032.pdf.

PNNL-21733, 2012 *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21733.pdf.

PNNL-SA-25232, 2016, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography*, Pacific Northwest National Laboratory, Richland, Washington.

PRC-PRO-IRM-309, 2014, *Controlled Software Management*, Revision 5, Change 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

Shang, Jianying, Liu Chongxuan, Zheming Wang, and John M. Zachara, 2011, “Effect of Grain Size on Uranium (VI) Surface Complexation Kinetics and Adsorption Additivity,” *Environmental Science & Technology* 45(14):6025-6031. Available at: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1239&context=usdoepub.

SGW-48478, 2012, *Interpretation and Integration of Seismic Data in the Gable Gap*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0082286H.

WHC-EP-0500, 1991, *Geology and Hydrology of the 300 Area and Vicinity, Hanford Site, South-Central Washington*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0017495.

This page intentionally left blank.

Appendix A

Compiled Data for Uranium Soil Concentration Distribution Modeling

This page intentionally left blank.

A1 Introduction

Table A-1 lists only the uranium concentration values that were used directly in the interpolation of the vadose zone uranium concentration distribution. Some values originally imported into Leapfrog Geo (described in Section 4.2 of the main text) may have been omitted from the interpolation because they were duplicate locations or caused unrealistic features within the interpolant. Therefore, these omitted values are not included in Table A-1. For example, multiple values imported for the exact same location result in an error in Leapfrog Geo so in these cases, only the highest values among the duplicates were retained. In the Data Source column of Table A-1, all data (except from Peterson, 2010, "Uranium in Sediment from FS-2 Test Pit, 618-1 Burial Ground Excavation") can be found in the Hanford Environmental Information System (HEIS). This column is intended to point out the particular entity (Washington Closure Hanford [WCH] or CH2M HILL Plateau Remediation Company [CHPRC]) or report from which the data can be referenced.

Soil concentrations of uranium-238 in pCi/g or µg/g were compiled from HEIS (accessed 02/15/2015), with the exception of the data from Peterson (2010), which are based on the following primary reports for the 300 Area:

- DOE/RL-92-32, *Expedited Response Action Assessment for 316-5 Process Trenches* (Table A-1 labels: WCH).
- BHI-01164, *300 Area Process Trenches Verification Package* (Table A-1 labels: WCH).
- PNNL-17793, *Uranium Contamination in the 300 Area: Emergent Data and their Impact on the Source Term Conceptual Model* (Table A-1 labels: PNNL-17793 Tables 5.11, 5.22 and 5.47).
- PNNL-16435, *Limited Field Investigation Report for Uranium Contamination in the 300 Area, 300-FF-5 Operable Unit, Hanford Site, Washington* (Table A-1 labels PNNL-16435 Table D.2).
- PNNL-22032, *Uranium in Hanford Site 300 Area: Extraction Data on Borehole Sediments* (Table A-1 labels: PNNL-22032).
- Unpublished post-record of decision field investigation sample data from borings C8933, 399-1-67, and 399-1-68 (Table A-1 labels: Borehole Data Tracking Spreadsheet.xlsx).
- Data from Peterson (2010) in the form of a letter report (Table A-1 labels: 618-1_BurialGroundExcavation).
- Unpublished data at the time of modeling (now available in HEIS) obtained from characterization sampling at wells 399-1-76 and 399-1-80 during drilling activities for the Stage A Enhanced Attenuation Area (Table A-1 labels: Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS).
- Additional data were retrieved from HEIS based upon the proximity to the modeling area. These data may be documented in reports but for the purposes of this calculation, they are labeled according to the originator of the data. The originators are WCH and CHPRC, as labeled in Table A-1. All data points pulled from HEIS that are not associated with the reports listed in this appendix, WCH, or CHPRC have been labeled as HEIS.

A2 References

BHI-01164, 1998, *300 Area Process Trenches Verification Package*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D198200905.

DOE/RL-92-32, 1992, *Expedited Response Action Assessment for 316-5 Process Trenches*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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

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

Peterson, R.E., 2010, "Uranium in Sediment from FS-2 Test Pit, 618-1 Burial Ground Excavation," Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16435, 2007, *Limited Field Investigation Report for Uranium Contamination in the 300 Area, 300-FF-5 Operable Unit, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA06586011.

PNNL-17793, 2008, *Uranium Contamination in the 300 Area: Emergent Data and Their Impact on the Source Term Conceptual Model*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17793.pdf.

PNNL-22032, 2012, *Uranium in Hanford Site 300 Area: Extraction Data on Borehole Sediments*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22032.pdf.

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
300 ASH PITS	B0L704	594366	115989	110.72	Uranium-238	0.45	pCi/g	8/13/1997	WCH	5	1.36	µg/g
300 ASH PITS	B0L705	594359	115947	112.8	Uranium-238	0.77	pCi/g	8/14/1997	WCH	5	2.33	µg/g
300 ASH PITS	B0L706	594315	115936	112.5	Uranium-238	0.73	pCi/g	8/14/1997	WCH	5	2.21	µg/g
300 ASH PITS	B0L707	594284	115946	110.54	Uranium-238	0.78	pCi/g	8/14/1997	WCH	5	2.36	µg/g
300 ASH PITS	B0L708	594250	115973	111.82	Uranium-238	0.82	pCi/g	8/14/1997	WCH	5	2.48	µg/g
300 ASH PITS	B0L709	594281	115978	110.06	Uranium-238	0.77	pCi/g	8/14/1997	WCH	5	2.33	µg/g
300-10	B0L944	594043	116569	111.02	Uranium-238	0.82	pCi/g	8/26/1997	WCH	5	2.48	µg/g
300-10	B0L945	594019	116569	112.62	Uranium-238	1.37	pCi/g	8/26/1997	WCH	5	4.15	µg/g
300-10	B0L959	594039	116572	112.12	Uranium-238	1.26	pCi/g	10/3/1997	WCH	5	3.82	µg/g
300-10	B0L961	594017	116573	112.67	Uranium-238	1.13	pCi/g	10/3/1997	WCH	5	3.42	µg/g
300-18	J036W6	593808.3	117042.1	112.85	Uranium-238	0	pCi/g	5/25/2005	WCH	5	0	µg/g
300-18	J036W7	593811.5	117039.9	112.45	Uranium-238	0.34	pCi/g	5/25/2005	WCH	5	1.03	µg/g
300-18	J036W8	593814.7	117046.3	112.66	Uranium-238	0.31	pCi/g	5/25/2005	WCH	5	0.94	µg/g
300-18	J036W9	593818.3	117042.8	112.6	Uranium-238	0.34	pCi/g	5/25/2005	WCH	5	1.03	µg/g
300-259	J19C15	594062.8	116189.4	115.01	Uranium-238	1.31	pCi/g	10/19/2009	WCH	5	3.97	µg/g
300-259	J19C16	594054.4	116203.8	115.03	Uranium-238	1.37	pCi/g	10/19/2009	WCH	5	4.15	µg/g
300-259	J19C17	594054.4	116232.7	114.91	Uranium-238	0.57	pCi/g	10/19/2009	WCH	5	1.73	µg/g
300-259	J19C18	594046.1	116247.1	114.95	Uranium-238	1.19	pCi/g	10/19/2009	WCH	5	3.61	µg/g
300-259	J19C19	594054.4	116261.5	114.71	Uranium-238	0.78	pCi/g	10/19/2009	WCH	5	2.36	µg/g
300-259	J19C20	594046.1	116275.9	114.58	Uranium-238	1.04	pCi/g	10/19/2009	WCH	5	3.15	µg/g
300-259	J19C21	594004.5	116290.3	115.27	Uranium-238	0.79	pCi/g	10/19/2009	WCH	5	2.39	µg/g
300-259	J19C22	594037.8	116290.3	114.52	Uranium-238	1.2	pCi/g	10/19/2009	WCH	5	3.64	µg/g
300-259	J19C23	594054.4	116290.3	114.36	Uranium-238	1.35	pCi/g	10/19/2009	WCH	5	4.09	µg/g
300-259	J19C24	594012.8	116304.7	114.09	Uranium-238	2.1	pCi/g	10/19/2009	WCH	5	6.36	µg/g
300-259	J19C25	594029.5	116304.7	114.08	Uranium-238	1.17	pCi/g	10/19/2009	WCH	5	3.55	µg/g
300-259	J19C26	594046.1	116304.7	114.06	Uranium-238	0.83	pCi/g	10/19/2009	WCH	5	2.52	µg/g
300-275	J17XW5	594293	116987.6	106.65	Uranium-238	0.4	pCi/g	11/19/2008	WCH	5	1.21	µg/g
300-275	J17XW6	594284.1	116972.9	107.42	Uranium-238	0.83	pCi/g	11/19/2008	WCH	5	2.52	µg/g
300-275	J17XW7	594288.2	116965.4	107.05	Uranium-238	1.71	pCi/g	11/19/2008	WCH	5	5.18	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
300-275	J17XW8	594301.3	116972.5	105.68	Uranium-238	1.33	pCi/g	11/19/2008	WCH	5	4.03	μg/g
300-275	J17XX0	594296.8	116965.2	105.27	Uranium-238	15.5	pCi/g	11/19/2008	WCH	5	46.97	μg/g
300-275	J17XX1	594292.3	116957.8	108.02	Uranium-238	0.96	pCi/g	11/19/2008	WCH	5	2.91	μg/g
300-275	J17XX2	594309.9	116972.3	104.24	Uranium-238	0.49	pCi/g	11/19/2008	WCH	5	1.48	μg/g
300-275	J17XX3	594305.4	116964.9	105.14	Uranium-238	0.39	pCi/g	11/19/2008	WCH	5	1.18	μg/g
300-275	J17XX4	594323	116979.4	105.75	Uranium-238	0.47	pCi/g	11/19/2008	WCH	5	1.42	μg/g
300-275	J17XX5	594318.5	116972.1	104.32	Uranium-238	0.63	pCi/g	11/19/2008	WCH	5	1.91	μg/g
300-275	J17XX6	594314	116964.7	107.19	Uranium-238	0.47	pCi/g	11/19/2008	WCH	5	1.42	μg/g
300-275	J17XX7	594327.1	116971.8	105.61	Uranium-238	1	pCi/g	11/19/2008	WCH	5	3.03	μg/g
300-275	J17XX8	594325.7	116875.9	107.32	Uranium-238	0.47	pCi/g	11/20/2008	WCH	5	1.42	μg/g
300-275	J17XX9	594328.9	116875.9	107.56	Uranium-238	0.76	pCi/g	11/20/2008	WCH	5	2.3	μg/g
300-275	J17XY0	594324.1	116878.6	107.24	Uranium-238	0.54	pCi/g	11/20/2008	WCH	5	1.64	μg/g
300-275	J17XY1	594327.3	116878.6	107.04	Uranium-238	0.63	pCi/g	11/20/2008	WCH	5	1.91	μg/g
300-275	J17XY2	594325.7	116881.3	107.65	Uranium-238	1.59	pCi/g	11/20/2008	WCH	5	4.82	μg/g
300-275	J17XY3	594328.9	116881.3	107.94	Uranium-238	1.79	pCi/g	11/20/2008	WCH	5	5.42	μg/g
300-275	J17XY4	594322.6	116886.8	107.32	Uranium-238	0.66	pCi/g	11/20/2008	WCH	5	2	μg/g
300-275	J17XY5	594325.7	116886.8	107.62	Uranium-238	1.35	pCi/g	11/20/2008	WCH	5	4.09	μg/g
300-275	J17XY6	594321	116889.6	107.61	Uranium-238	1.09	pCi/g	11/20/2008	WCH	5	3.3	μg/g
300-275	J17XY7	594324.1	116889.6	106.64	Uranium-238	0.89	pCi/g	11/20/2008	WCH	5	2.7	μg/g
300-44	B0M1V6	593847	116939	112.64	Uranium-238	0.24	pCi/g	9/25/1997	WCH	5	0.73	μg/g
300-44	B0M1V9	593847	116949	112.36	Uranium-238	0.29	pCi/g	9/25/1997	WCH	5	0.88	μg/g
300-45	B0L946	594050	116446	111.06	Uranium-238	1.18	pCi/g	9/22/1997	WCH	5	3.58	μg/g
300-45	B0L947	594055	116456	110.58	Uranium-238	1.2	pCi/g	9/22/1997	WCH	5	3.64	μg/g
300-49	B0Y6M6	594300	116810	109.96	Uranium-238	0.44	pCi/g	6/28/2000	WCH	5	1.33	μg/g
300-49	B0Y6M7	594300	116830	109.34	Uranium-238	0.64	pCi/g	6/28/2000	WCH	5	1.94	μg/g
300-49	B0Y6M8	594315	116830	108.69	Uranium-238	0.99	pCi/g	6/28/2000	WCH	5	3	μg/g
300-49	B0Y6M9	594295	116845	108.76	Uranium-238	1.32	pCi/g	6/28/2000	WCH	5	4	μg/g
300-49	B0Y6P0	594285	116860	108.75	Uranium-238	0.36	pCi/g	6/28/2000	WCH	5	1.09	μg/g
300-49	B0Y6P1	594350	116875	107.76	Uranium-238	0.86	pCi/g	6/28/2000	WCH	5	2.61	μg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
300-50	B0Y756	594230	116725	109.36	Uranium-238	4.76	pCi/g	7/5/2000	WCH	5	14.42	µg/g
300-50	B0Y758	594240	116725	109.38	Uranium-238	7.2	pCi/g	7/5/2000	WCH	5	21.82	µg/g
300-50	B0Y759	594170	116685	110.02	Uranium-238	6	pCi/g	7/5/2000	WCH	5	18.18	µg/g
300-50	B0Y770	594235	116695	109.81	Uranium-238	5.45	pCi/g	7/5/2000	WCH	5	16.52	µg/g
300-50	B0Y771	594220	116715	109.8	Uranium-238	10.5	pCi/g	7/5/2000	WCH	5	31.82	µg/g
300-50	B0Y772	594165	116745	110.65	Uranium-238	0.58	pCi/g	7/5/2000	WCH	5	1.76	µg/g
300-8	J03VD4	593875	116628.6	112.32	Uranium-238	0.77	pCi/g	7/27/2005	WCH	5	2.33	µg/g
300-8	J03VD5	593848.9	116609.4	112.51	Uranium-238	0.53	pCi/g	7/27/2005	WCH	5	1.61	µg/g
300-8	J03VD6	593807.2	116644.2	113.36	Uranium-238	0.38	pCi/g	7/27/2005	WCH	5	1.15	µg/g
300-8	J03VD7	593843.3	116666.1	113.26	Uranium-238	0.53	pCi/g	7/27/2005	WCH	5	1.61	µg/g
300-8	J03VD8	593827.9	116736	112.07	Uranium-238	0.65	pCi/g	7/27/2005	WCH	5	1.97	µg/g
300-8	J03VD9	593813.7	116727.2	113.6	Uranium-238	0.6	pCi/g	7/27/2005	WCH	5	1.82	µg/g
300-8	J03VF0	593765.8	116694.3	112.85	Uranium-238	0.62	pCi/g	7/27/2005	WCH	5	1.88	µg/g
300-8	J03VF1	593799.4	116597	112.8	Uranium-238	0.69	pCi/g	7/27/2005	WCH	5	2.09	µg/g
300-8	J03VF2	593801.7	116578.9	113.94	Uranium-238	0.42	pCi/g	7/28/2005	WCH	5	1.27	µg/g
300-8	J03VF3	593771.8	116565.7	112.97	Uranium-238	0.62	pCi/g	7/28/2005	WCH	5	1.88	µg/g
300-8	J03VF4	593828.6	116526.1	114.18	Uranium-238	0.31	pCi/g	7/28/2005	WCH	5	0.94	µg/g
300-8	J03VF5	593877.5	116437	114.79	Uranium-238	1.19	pCi/g	7/28/2005	WCH	5	3.61	µg/g
300-8	J03VF6	593883.7	116385	112.21	Uranium-238	0.99	pCi/g	7/28/2005	WCH	5	3	µg/g
300-8	J03VF7	593902.4	116342.7	113.89	Uranium-238	1.47	pCi/g	7/28/2005	WCH	5	4.45	µg/g
300-8	J03VF8	593885.5	116513.6	112.72	Uranium-238	0.84	pCi/g	7/28/2005	WCH	5	2.55	µg/g
300-8	J03VF9	593946.3	116462.5	112.29	Uranium-238	0.29	pCi/g	7/28/2005	WCH	5	0.88	µg/g
300-FF-1 RI|B00H44	B00H44	594211	116130	105.5	Uranium-238	2.9	pCi/g	12/6/1991	HEIS	9.45	8.79	µg/g
300-FF-1 RI|B00H44	B00H46	594211	116130	104.28	Uranium-238	1.6	pCi/g	12/6/1991	HEIS	10.67	4.85	µg/g
300-FF-1 RI|B00H44	B00H48	594211	116130	102.76	Uranium-238	1.1	pCi/g	12/6/1991	HEIS	12.19	3.33	µg/g
316-1	B0R3R1	594243	116057	109.98	Uranium-238	48	pCi/g	12/17/1998	WCH	5	145.45	µg/g
316-1	B0R3R4	594242	116031	110	Uranium-238	16	pCi/g	12/17/1998	WCH	5	48.48	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
316-1	B0R3R5	594235	116027	109.93	Uranium-238	31	pCi/g	12/17/1998	WCH	5	93.94	µg/g
316-1	B0R3R6	594264	116021	109.84	Uranium-238	23	pCi/g	12/17/1998	WCH	5	69.7	µg/g
316-1	B0R3R7	594303	116116	109.95	Uranium-238	15	pCi/g	12/17/1998	WCH	5	45.45	µg/g
316-1	B0R3R8	594288	116133	109.87	Uranium-238	16	pCi/g	12/17/1998	WCH	5	48.48	µg/g
316-1	B0R3R9	594299	116156	109.91	Uranium-238	20	pCi/g	12/17/1998	WCH	5	60.61	µg/g
316-1	B0R3T0	594315	116162	109.79	Uranium-238	22	pCi/g	12/17/1998	WCH	5	66.67	µg/g
316-1	B0R3T1	594290	116173	109.83	Uranium-238	12	pCi/g	12/17/1998	WCH	5	36.36	µg/g
316-1	B0YNM1	594266	116077	109.92	Uranium-238	21.7	pCi/g	7/13/2000	WCH	5	65.76	µg/g
316-1	B0YNM2	594288	116186	109.76	Uranium-238	31.1	pCi/g	7/13/2000	WCH	5	94.24	µg/g
316-1	B0YNM3	594251	116133	109.85	Uranium-238	1.04	pCi/g	7/13/2000	WCH	5	3.15	µg/g
316-1	B0YNM4	594213	116033	110.03	Uranium-238	2.25	pCi/g	7/13/2000	WCH	5	6.82	µg/g
316-1	B0YNM5	594330	116075	109.66	Uranium-238	3.17	pCi/g	7/13/2000	WCH	5	9.61	µg/g
316-1	B0YNM6	594326	116081	109.72	Uranium-238	15.5	pCi/g	7/13/2000	WCH	5	46.97	µg/g
316-1	B0YNM7	594371	116044	109.59	Uranium-238	2.11	pCi/g	7/13/2000	WCH	5	6.39	µg/g
316-1	B0YNM8	594424	116025	109.6	Uranium-238	2.57	pCi/g	7/13/2000	WCH	5	7.79	µg/g
316-1	B0YNM9	594280	116076	109.91	Uranium-238	14.5	pCi/g	7/13/2000	WCH	5	43.94	µg/g
316-1	B0YNN0	594416	116145	109.49	Uranium-238	6.49	pCi/g	7/13/2000	WCH	5	19.67	µg/g
316-1	B0YNN1	594203	116066	109.99	Uranium-238	3.12	pCi/g	7/14/2000	WCH	5	9.45	µg/g
316-1	B0YNN2	594203	116132	109.97	Uranium-238	11.9	pCi/g	7/14/2000	WCH	5	36.06	µg/g
316-1	B0YNN3	594235	116109	109.89	Uranium-238	2.21	pCi/g	7/14/2000	WCH	5	6.7	µg/g
316-1	B0YNN4	594218	116142	109.88	Uranium-238	4.94	pCi/g	7/14/2000	WCH	5	14.97	µg/g
316-1	B0YNN5	594219	116175	109.8	Uranium-238	15.5	pCi/g	7/14/2000	WCH	5	46.97	µg/g
316-1	B0YNN6	594190	116152	109.96	Uranium-238	28.9	pCi/g	7/14/2000	WCH	5	87.58	µg/g
316-1	B0YNN7	594179	116155	109.9	Uranium-238	1.72	pCi/g	7/14/2000	WCH	5	5.21	µg/g
316-1	B0YNN8	594206	116102	110.07	Uranium-238	9.33	pCi/g	7/14/2000	WCH	5	28.27	µg/g
316-1	B0YNN9	594220	116087	110.07	Uranium-238	8.85	pCi/g	7/14/2000	WCH	5	26.82	µg/g
316-1	B0YNP0	594214	116111	110.15	Uranium-238	8.72	pCi/g	7/14/2000	WCH	5	26.42	µg/g
316-1-TP1	B00H52	594280.8	116110.2	109.99	Uranium-238	1	pCi/g	11/21/1991	HEIS	4.88	3.03	µg/g
316-1-TP1	B00H53	594280.8	116110.2	108.47	Uranium-238	2.7	pCi/g	11/21/1991	HEIS	6.4	8.18	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
316-1-TP1	B00H54	594280.8	116110.2	106.94	Uranium-238	1.4	pCi/g	11/21/1991	HEIS	7.93	4.24	µg/g
316-1-TP1	B00H55	594280.8	116110.2	105.73	Uranium-238	1.9	pCi/g	11/21/1991	HEIS	9.14	5.76	µg/g
316-1-TP1	B00H56	594280.8	116110.2	104.2	Uranium-238	3.1	pCi/g	11/21/1991	HEIS	10.67	9.39	µg/g
316-1-TP2	B00H68	594243.4	116032.2	110.14	Uranium-238	1.5	pCi/g	12/3/1991	HEIS	4.88	4.55	µg/g
316-1-TP2	B00H69	594243.4	116032.2	108.62	Uranium-238	1.2	pCi/g	12/3/1991	HEIS	6.4	3.64	µg/g
316-1-TP2	B00H70	594243.4	116032.2	107.09	Uranium-238	1.6	pCi/g	12/3/1991	HEIS	7.93	4.85	µg/g
316-1-TP2	B00H71	594243.4	116032.2	105.57	Uranium-238	0.9	pCi/g	12/3/1991	HEIS	9.45	2.73	µg/g
316-1-TP2	B00H72	594243.4	116032.2	104.05	Uranium-238	2.9	pCi/g	12/3/1991	HEIS	10.97	8.79	µg/g
316-1-TP2	B00H73	594243.4	116032.2	102.52	Uranium-238	1	pCi/g	12/3/1991	HEIS	12.5	3.03	µg/g
316-1-TP3	B00H84	594215.2	116119.4	110.15	Uranium-238	26.2	pCi/g	12/6/1991	HEIS	4.88	79.39	µg/g
316-1-TP3	B00H86	594215.2	116119.4	108.63	Uranium-238	1.9	pCi/g	12/6/1991	HEIS	6.4	5.76	µg/g
316-1-TP3	B00H88	594215.2	116119.4	107.1	Uranium-238	6.8	pCi/g	12/6/1991	HEIS	7.93	20.61	µg/g
316-2	B0L633	594182.5	116677	109.9	Uranium-238	23.8	pCi/g	6/26/1997	WCH	5	72.12	µg/g
316-2	B0L635	594191	116658	109.72	Uranium-238	36.8	pCi/g	6/26/1997	WCH	5	111.52	µg/g
316-2	B0L636	594242.5	116704.5	109.64	Uranium-238	7.21	pCi/g	7/2/1997	WCH	5	21.85	µg/g
316-2	B0L649	594335	116641	109.54	Uranium-238	0.92	pCi/g	7/30/1997	WCH	5	2.79	µg/g
316-2	B0L650	594350	116559.5	109.54	Uranium-238	4.24	pCi/g	7/31/1997	WCH	5	12.85	µg/g
316-2	B0L648	594325	116480	109.59	Uranium-238	1.52	pCi/g	8/8/1997	WCH	5	4.61	µg/g
316-2	B0V024	594195	116582	109.66	Uranium-238	15	pCi/g	3/12/1999	WCH	5	45.45	µg/g
316-2	B0V025	594180	116575	109.77	Uranium-238	17.8	pCi/g	3/12/1999	WCH	5	53.94	µg/g
316-2	B0V026	594213	116605	109.68	Uranium-238	4.09	pCi/g	3/12/1999	WCH	5	12.39	µg/g
316-2	B0V027	594201	116489	109.76	Uranium-238	79	pCi/g	3/12/1999	WCH	5	239.39	µg/g
316-2	B0V028	594142	116619	109.9	Uranium-238	2.98	pCi/g	3/12/1999	WCH	5	9.03	µg/g
316-2	B0V029	594185	116629	109.83	Uranium-238	11.9	pCi/g	3/12/1999	WCH	5	36.06	µg/g
316-2	B0V030	594233	116587	109.66	Uranium-238	101	pCi/g	3/12/1999	WCH	5	306.06	µg/g
316-2	B0V031	594258	116561	109.69	Uranium-238	43.7	pCi/g	3/12/1999	WCH	5	132.42	µg/g
316-2	B0V032	594289	116582	109.71	Uranium-238	34.9	pCi/g	3/12/1999	WCH	5	105.76	µg/g
316-2	B0V033	594343	116517	109.54	Uranium-238	35.2	pCi/g	3/12/1999	WCH	5	106.67	µg/g
316-2	B0V034	594250	116511	109.7	Uranium-238	119	pCi/g	3/12/1999	WCH	5	360.61	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
316-2	B0V035	594226	116541	109.74	Uranium-238	66.1	pCi/g	3/12/1999	WCH	5	200.3	µg/g
316-2-TP2	B01GG2	594204.4	116622.4	109.81	Uranium-238	0.9	pCi/g	12/14/1991	HEIS	4.88	2.73	µg/g
316-2-TP2	B01GG3	594204.4	116622.4	108.29	Uranium-238	1	pCi/g	12/14/1991	HEIS	6.4	3.03	µg/g
316-2-TP2	B01GG4	594204.4	116622.4	106.76	Uranium-238	1.4	pCi/g	12/14/1991	HEIS	7.93	4.24	µg/g
316-2-TP2	B01GG5	594204.4	116622.4	105.24	Uranium-238	1.2	pCi/g	12/14/1991	HEIS	9.45	3.64	µg/g
316-2-TP3	B01GJ7	594285.5	116620.2	109.87	Uranium-238	2.1	pCi/g	12/16/1991	HEIS	4.88	6.36	µg/g
316-2-TP3	B01GJ8	594285.5	116620.2	108.35	Uranium-238	2.2	pCi/g	12/16/1991	HEIS	6.4	6.67	µg/g
316-2-TP3	B01GJ9	594285.5	116620.2	106.82	Uranium-238	2.7	pCi/g	12/16/1991	HEIS	7.93	8.18	µg/g
316-2-TP3	B01GK0	594285.5	116620.2	105.3	Uranium-238	1.6	pCi/g	12/16/1991	HEIS	9.45	4.85	µg/g
316-5	B0M4N1	594091	116451	114.8	Uranium-238	45.2	pCi/g	10/7/1997	WCH	0.3	136.97	µg/g
316-5	B0M4N4	594076	116451	114.93	Uranium-238	32.3	pCi/g	10/7/1997	WCH	0.3	97.88	µg/g
316-5	B0L950	594076	116930	113.56	Uranium-238	5.38	pCi/g	11/12/1997	WCH	0.3	16.3	µg/g
316-5	B0L952	594044	116913	112.57	Uranium-238	3.28	pCi/g	11/12/1997	WCH	0.3	9.94	µg/g
316-5	B0L953	594028	116910	112.96	Uranium-238	0.71	pCi/g	11/12/1997	WCH	0.3	2.15	µg/g
316-5	B0L954	594012	116879	113.06	Uranium-238	119	pCi/g	11/12/1997	WCH	0.3	360.61	µg/g
316-5	B0L955	594025	116874	113.05	Uranium-238	103	pCi/g	11/12/1997	WCH	0.3	312.12	µg/g
316-5	B0L956	594088	116880	112.78	Uranium-238	41.2	pCi/g	11/12/1997	WCH	0.3	124.85	µg/g
316-5	B0L963	594070	116816	113.52	Uranium-238	27.2	pCi/g	11/13/1997	WCH	0.3	82.42	µg/g
316-5	B0MD75	594088	116918	112.68	Uranium-238	74.7	pCi/g	11/13/1997	WCH	0.3	226.36	µg/g
316-5	B0MD78	594070	116840	113.52	Uranium-238	74.7	pCi/g	11/13/1997	WCH	0.3	226.36	µg/g
316-5	B0MDK0	594088	116836	112.85	Uranium-238	34.8	pCi/g	11/13/1997	WCH	0.3	105.45	µg/g
316-5	B0MDK3	594088	116882	112.79	Uranium-238	22	pCi/g	11/13/1997	WCH	0.3	66.67	µg/g
316-5	B0N1R4	594070	116857	113.09	Uranium-238	55.6	pCi/g	2/3/1998	WCH	0.3	168.48	µg/g
316-5-TP1	B01045	594090	116862	111.5	Uranium-238	4.29	pCi/g	7/30/1991	HEIS	3.5	13	µg/g
316-5-TP1	B01044	594090	116862	111.5	Uranium-238	30.14	pCi/g	7/30/1991	HEIS	3.5	91.33	µg/g
316-5-TP10	B014Q8	594076	116478	110.06	Uranium-238	18.62	pCi/g	9/20/1991	HEIS	5.03	56.42	µg/g
316-5-TP2	B01042	594090	116557	111.5	Uranium-238	32.88	pCi/g	7/30/1991	HEIS	3.5	99.64	µg/g
316-5-TP2	B01041	594090	116557	111.5	Uranium-238	8.64	pCi/g	7/30/1991	HEIS	3.5	26.18	µg/g
316-5-TP3	B01036	594090	116475	111.5	Uranium-238	1072	pCi/g	7/31/1991	HEIS	3.5	3248.48	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
316-5-TP3	B01035	594090	116475	111.5	Uranium-238	49.83	pCi/g	7/31/1991	HEIS	3.5	151	µg/g
316-5-TP4	B01033	594090	116455	111.5	Uranium-238	356.5	pCi/g	7/31/1991	HEIS	3.5	1080.3	µg/g
316-5-TP4	B01032	594090	116455	111.5	Uranium-238	9.19	pCi/g	7/31/1991	HEIS	3.5	27.85	µg/g
331 LSLDF	J134V6	594640	115369	110.65	Uranium-238	0.46	pCi/g	4/18/2007	WCH	5	1.39	µg/g
331 LSLDF	J134V8	594640	115359	110.83	Uranium-238	0.47	pCi/g	4/19/2007	WCH	5	1.42	µg/g
399-1-10B	B010S4	594350.9	116728.8	104.88	Uranium-238	1.1	pCi/g	9/10/1991	HEIS	9.6	3.33	µg/g
399-1-10B	B010T4	594350.9	116728.8	99.05	Uranium-238	0.28	pCi/g	9/12/1991	HEIS	15.43	0.85	µg/g
399-1-10B	B014V1	594350.9	116728.8	93.08	Uranium-238	0.31	pCi/g	9/25/1991	HEIS	21.4	0.94	µg/g
399-1-10B	B014V5	594350.9	116728.8	86.35	Uranium-238	0.25	pCi/g	9/28/1991	HEIS	28.13	0.76	µg/g
399-1-10B	B014V6	594350.9	116728.8	80.86	Uranium-238	0.33	pCi/g	9/30/1991	HEIS	33.62	1	µg/g
399-1-10B	B014V7	594350.9	116728.8	79.12	Uranium-238	0.51	pCi/g	10/1/1991	HEIS	35.36	1.55	µg/g
399-1-13B	B010S2	593909.6	116549.2	105.19	Uranium-238	0.22	pCi/g	9/5/1991	HEIS	13.52	0.67	µg/g
399-1-13B	B010S8	593909.6	116549.2	99.2	Uranium-238	0.51	pCi/g	9/11/1991	HEIS	19.51	1.55	µg/g
399-1-13B	B014T7	593909.6	116549.2	94.02	Uranium-238	0.62	pCi/g	9/13/1991	HEIS	24.69	1.88	µg/g
399-1-13B	B014T9	593909.6	116549.2	87.92	Uranium-238	0.54	pCi/g	9/17/1991	HEIS	30.79	1.64	µg/g
399-1-13B	B014V0	593909.6	116549.2	82.74	Uranium-238	0.24	pCi/g	9/20/1991	HEIS	35.97	0.73	µg/g
399-1-14B	B010R8	593910.9	116779.1	105.42	Uranium-238	0.23	pCi/g	9/3/1991	HEIS	11.36	0.7	µg/g
399-1-14B	B010R9	593910.9	116779.1	100.32	Uranium-238	0.33	pCi/g	9/5/1991	HEIS	16.46	1	µg/g
399-1-14B	B010S3	593910.9	116779.1	93.77	Uranium-238	0.47	pCi/g	9/10/1991	HEIS	23.01	1.42	µg/g
399-1-14B	B010T3	593910.9	116779.1	87.79	Uranium-238	0.61	pCi/g	9/12/1991	HEIS	28.99	1.85	µg/g
399-1-14B	B014V9	593910.9	116779.1	82.2	Uranium-238	0.25	pCi/g	9/18/1991	HEIS	34.58	0.76	µg/g
399-1-21B	B014W0	594157.2	116176.8	105.03	Uranium-238	0.42	pCi/g	10/30/1991	HEIS	11.95	1.27	µg/g
399-1-21B	B014W1	594157.2	116176.8	98.99	Uranium-238	0.37	pCi/g	11/1/1991	HEIS	17.99	1.12	µg/g
399-1-21B	B014W3	594157.2	116176.8	92.9	Uranium-238	0	pCi/g	11/5/1991	HEIS	24.08	0	µg/g
399-1-21B	B014W5	594157.2	116176.8	86.38	Uranium-238	0.8	pCi/g	11/8/1991	HEIS	30.6	2.42	µg/g
399-1-22	B014N1	594201.9	116519.3	109.35	Uranium-238	10.84	pCi/g	10/9/1991	HEIS	5.49	32.85	µg/g
399-1-22	B014N2	594201.9	116519.3	107.52	Uranium-238	7.81	pCi/g	10/11/1991	HEIS	7.32	23.67	µg/g
399-1-22	B014N7	594201.9	116519.3	106	Uranium-238	2.4	pCi/g	10/11/1991	HEIS	8.84	7.27	µg/g
399-1-22	B014N3	594201.9	116519.3	105.39	Uranium-238	1.5	pCi/g	10/11/1991	HEIS	9.45	4.55	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-23	B1JXM7	594113.5	116453.2	86.04	Uranium-238	0.26	pCi/g	7/26/2006	HEIS	29.41	0.79	µg/g
399-1-23	C5000-36A	594113.5	116453	112.15	N/A	0.64	pCi/g	N/A	PNNL-16435 Table D.2	3.35	1.94	µg/g
399-1-23	C5000-36E	594113.5	116453	111.84	N/A	0.7	pCi/g	N/A	PNNL-16435 Table D.2	3.66	2.12	µg/g
399-1-23	C5000-37A	594113.5	116453	111.54	N/A	0.63	pCi/g	N/A	PNNL-16435 Table D.2	3.96	1.91	µg/g
399-1-23	C5000-38B	594113.5	116453	109.4	N/A	1.12	pCi/g	N/A	PNNL-16435 Table D.2	6.1	3.39	µg/g
399-1-23	C5000-38C	594113.5	116453	109.1	N/A	2.24	pCi/g	N/A	PNNL-16435 Table D.2	6.4	6.79	µg/g
399-1-23	C5000-39B	594113.5	116453	108.49	N/A	5.03	pCi/g	N/A	PNNL-16435 Table D.2	7.01	15.24	µg/g
399-1-23	C5000-39D	594113.5	116453	107.88	N/A	1.48	pCi/g	N/A	PNNL-16435 Table D.2	7.62	4.48	µg/g
399-1-23	C5000-40A	594113.5	116453	106.36	N/A	2.31	pCi/g	N/A	PNNL-16435 Table D.2	9.14	7	µg/g
399-1-23	C5000-40B	594113.5	116453	106.05	N/A	0.83	pCi/g	N/A	PNNL-16435 Table D.2	9.45	2.52	µg/g
399-1-23	C5000-40C	594113.5	116453	105.75	N/A	1.19	pCi/g	N/A	PNNL-16435 Table D.2	9.75	3.61	µg/g
399-1-23	C5000-40E	594113.5	116453	105.14	N/A	0.38	pCi/g	N/A	PNNL-16435 Table D.2	10.36	1.15	µg/g
399-1-23	C5000-41B	594113.5	116453	104.83	N/A	1	pCi/g	N/A	PNNL-16435 Table D.2	10.67	3.03	µg/g
399-1-23	C5000-41C	594113.5	116453	104.53	N/A	1.05	pCi/g	N/A	PNNL-16435 Table D.2	10.97	3.18	µg/g
399-1-23	C5000-41E	594113.5	116453	103.92	N/A	1.18	pCi/g	N/A	PNNL-16435 Table D.2	11.58	3.58	µg/g
399-1-23	C5000-43A	594113.5	116453	102.09	N/A	0.89	pCi/g	N/A	PNNL-16435 Table D.2	13.41	2.7	µg/g
399-1-23	C5000-44E	594113.5	116453	100.26	N/A	1.19	pCi/g	N/A	PNNL-16435 Table D.2	15.24	3.61	µg/g
399-1-23	C5000-45B	594113.5	116453	99.35	N/A	1.15	pCi/g	N/A	PNNL-16435 Table D.2	16.15	3.48	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-23	C5000-45C	594113.5	116453	99.04	N/A	1.47	pCi/g	N/A	PNNL-16435 Table D.2	16.46	4.45	µg/g
399-1-23	C5000-45D	594113.5	116453	98.74	N/A	1.23	pCi/g	N/A	PNNL-16435 Table D.2	16.76	3.73	µg/g
399-1-23	C5000-46D	594113.5	116453	97.52	N/A	0.46	pCi/g	N/A	PNNL-16435 Table D.2	17.98	1.39	µg/g
399-1-23	C5000-47C	594113.5	116453	96.75	N/A	0.59	pCi/g	N/A	PNNL-16435 Table D.2	18.75	1.79	µg/g
399-1-23	C5000-48E	594113.5	116453	95.38	N/A	0.7	pCi/g	N/A	PNNL-16435 Table D.2	20.12	2.12	µg/g
399-1-23	C5000-50B	594113.5	116453	93.86	N/A	0.88	pCi/g	N/A	PNNL-16435 Table D.2	21.64	2.67	µg/g
399-1-23	C5000-51E	594113.5	116453	92.03	N/A	0.5	pCi/g	N/A	PNNL-16435 Table D.2	23.47	1.52	µg/g
399-1-33	B1PD60	594113.3	116430.5	115.61	Uranium-238	0.72	pCi/g	8/20/2007	HEIS	0	2.18	µg/g
399-1-35	B1PD68	594122.3	116432.1	115.59	Uranium-238	0.93	pCi/g	8/20/2007	HEIS	0	2.82	µg/g
399-1-36	B1PD72	594108.5	116438.8	115.81	Uranium-238	0.15	pCi/g	8/20/2007	HEIS	0	0.45	µg/g
399-1-37	B1PD76	594110.2	116438.2	115.73	Uranium-238	0.51	pCi/g	8/20/2007	HEIS	0	1.55	µg/g
399-1-41	B207H4	594166.2	116439.9	103.71	Uranium-238	3.1	pCi/g	4/15/2009	HEIS	11.28	9.39	µg/g
399-1-46	B207H8	594171.5	116427.4	103.92	Uranium-238	0.92	pCi/g	4/22/2009	HEIS	11.05	2.79	µg/g
399-1-51	B207J2	594176.7	116414.9	102.89	Uranium-238	0.66	pCi/g	4/28/2009	HEIS	12.04	2	µg/g
399-1-54	B25C44	594273.9	116643	111.3085	Uranium-238	2.65	pCi/g	9/21/2010	WCH	3.2615	8.030303	µg/g
399-1-54	B25C45	594273.9	116643	110.608	Uranium-238	3.91	pCi/g	9/21/2010	WCH	3.962	11.84848	µg/g
399-1-54	B25C46	594273.9	116643	109.7845	Uranium-238	2.04	pCi/g	9/21/2010	WCH	4.7855	6.181818	µg/g
399-1-54	B25C47	594273.9	116643	109.0985	Uranium-238	2.51	pCi/g	9/21/2010	WCH	5.4715	7.606061	µg/g
399-1-54	B25C48	594273.9	116643	108.291	Uranium-238	1.5	pCi/g	9/21/2010	WCH	6.279	4.545455	µg/g
399-1-54	B25C49	594273.9	116643	107.6665	Uranium-238	1.72	pCi/g	9/22/2010	WCH	6.9035	5.212121	µg/g
399-1-54	B25C51	594273.9	116643	105.9445	Uranium-238	0.809	pCi/g	11/10/2010	WCH	8.6255	2.451515	µg/g
399-1-54	B28302	594273.9	116643	103.22	Uranium-238	0.95	pCi/g	11/10/2010	CHPRC	11.35	2.878788	µg/g
399-1-54	B28305	594273.9	116643	93.4	Uranium-238	0.14	pCi/g	11/12/2010	CHPRC	21.17	0.424242	µg/g
399-1-54	B28302	594273.9	116643	103.295	U-238	0.95	pCi/g	N/A	HEIS	11.35	2.88	µg/g
399-1-54	B28305	594273.9	116643	93.475	U-238	0.14	pCi/g	N/A	HEIS	21.17	0.42	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-54	N/A	594273.9	116643	111.1562	Uranium-238	N/A	µg/g	N/A	PNNL-22032	3.41376	7.88	µg/g
399-1-54	N/A	594273.9	116643	110.5466	Uranium-238	N/A	µg/g	N/A	PNNL-22032	4.02336	11.63	µg/g
399-1-54	N/A	594273.9	116643	109.6932	Uranium-238	N/A	µg/g	N/A	PNNL-22032	4.8768	6.07	µg/g
399-1-54	N/A	594273.9	116643	109.236	Uranium-238	N/A	µg/g	N/A	PNNL-22032	5.334	1.43	µg/g
399-1-54	N/A	594273.9	116643	108.9312	Uranium-238	N/A	µg/g	N/A	PNNL-22032	5.6388	7.47	µg/g
399-1-54	N/A	594273.9	116643	108.1082	Uranium-238	N/A	µg/g	N/A	PNNL-22032	6.46176	4.46	µg/g
399-1-54	N/A	594273.9	116643	106.0356	Uranium-238	N/A	µg/g	N/A	PNNL-22032	8.5344	1.11	µg/g
399-1-55	B27F39	594152.3	116487.3	111.1855	Uranium-238	0.605	pCi/g	8/20/2010	WCH	3.4445	1.833333	µg/g
399-1-55	B27F40	594152.3	116487.3	110.469	Uranium-238	5.45	pCi/g	8/20/2010	WCH	4.161	16.51515	µg/g
399-1-55	B27F41	594152.3	116487.3	109.5855	Uranium-238	7.15	pCi/g	8/20/2010	WCH	5.0445	21.66667	µg/g
399-1-55	B27F42	594152.3	116487.3	108.885	Uranium-238	9.26	pCi/g	8/20/2010	WCH	5.745	28.06061	µg/g
399-1-55	B27F43	594152.3	116487.3	108.214	Uranium-238	9.2	pCi/g	8/20/2010	WCH	6.416	27.87879	µg/g
399-1-55	B27F44	594152.3	116487.3	107.421	Uranium-238	38.6	pCi/g	8/20/2010	WCH	7.209	116.9697	µg/g
399-1-55	B27F46	594152.3	116487.3	106.568	Uranium-238	33.2	pCi/g	8/20/2010	WCH	8.062	100.6061	µg/g
399-1-55	B27F47	594152.3	116487.3	105.806	Uranium-238	21	pCi/g	8/23/2010	WCH	8.824	63.63636	µg/g
399-1-55	B27F48	594152.3	116487.3	105.0895	Uranium-238	13.5	pCi/g	8/23/2010	WCH	9.5405	40.90909	µg/g
399-1-55	B27F45	594152.3	116487.3	104.372	Uranium-238	16.7	pCi/g	8/23/2010	WCH	10.258	50.60606	µg/g
399-1-55	B27F50	594152.3	116487.3	103.61	Uranium-238	9.25	pCi/g	8/23/2010	WCH	11.02	28.0303	µg/g
399-1-55	B27DL7	594152.3	116487.3	97.485	Uranium-238	0.44	pCi/g	8/24/2010	CHPRC	17.145	1.333333	µg/g
399-1-55	B27DL5	594152.3	116487.3	93.77	Uranium-238	0.29	pCi/g	8/24/2010	CHPRC	20.86	0.878788	µg/g
399-1-55	B27DL6	594152.3	116487.3	80.57	Uranium-238	0.43	pCi/g	8/26/2010	CHPRC	34.06	1.30303	µg/g
399-1-55	B27DL7	594152.1	116487.4	97.74	U-238	0.44	pCi/g	N/A	HEIS	17.145	1.33	µg/g
399-1-55	B27DL5	594152.1	116487.4	94.025	U-238	0.29	pCi/g	N/A	HEIS	20.86	0.88	µg/g
399-1-55	B27DL6	594152.1	116487.4	80.825	U-238	0.43	pCi/g	N/A	HEIS	34.06	1.3	µg/g
399-1-55	N/A	594152.1	116487.4	107.204	Uranium-238	N/A	µg/g	N/A	PNNL-22032	7.68096	74.8	µg/g
399-1-55	N/A	594152.1	116487.4	105.741	Uranium-239	N/A	µg/g	N/A	PNNL-22032	9.144	38.1	µg/g
399-1-55	N/A	594152.1	116487.4	104.217	Uranium-240	N/A	µg/g	N/A	PNNL-22032	10.668	28	µg/g
399-1-55	N/A	594152.1	116487.4	102.9978	Uranium-241	N/A	µg/g	N/A	PNNL-22032	11.8872	13.3	µg/g
399-1-56	B27KN6	594090.9	116725.3	111.5075	Uranium-238	1.1	pCi/g	9/13/2010	WCH	3.3225	3.333333	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-56	B27KN7	594090.9	116725.3	110.7605	Uranium-238	0.741	pCi/g	9/13/2010	WCH	4.0695	2.245455	µg/g
399-1-56	B27KN8	594090.9	116725.3	110.0755	Uranium-238	0.822	pCi/g	9/13/2010	WCH	4.7545	2.490909	µg/g
399-1-56	B27KN9	594090.9	116725.3	109.176	Uranium-238	4.58	pCi/g	9/13/2010	WCH	5.654	13.87879	µg/g
399-1-56	B27KP1	594090.9	116725.3	108.292	Uranium-238	4.51	pCi/g	9/13/2010	WCH	6.538	13.66667	µg/g
399-1-56	B27KP3	594090.9	116725.3	107.5755	Uranium-238	3.7	pCi/g	9/13/2010	WCH	7.2545	11.21212	µg/g
399-1-56	B27KP4	594090.9	116725.3	106.905	Uranium-238	3.52	pCi/g	9/13/2010	WCH	7.925	10.66667	µg/g
399-1-56	B27K66	594090.9	116725.3	104.512	Uranium-238	0.54	pCi/g	9/14/2010	CHPRC	10.318	1.636364	µg/g
399-1-56	B27K69	594090.9	116725.3	97.32	Uranium-238	0.62	pCi/g	9/17/2010	CHPRC	17.51	1.878788	µg/g
399-1-56	B27K66	594090.9	116725.3	104.361	U-238	0.54	pCi/g	N/A	HEIS	10.318	1.64	µg/g
399-1-56	B27K69	594090.9	116725.3	97.169	U-238	0.62	pCi/g	N/A	HEIS	17.51	1.88	µg/g
399-1-56	N/A	594090.9	116725.3	103.9805	Uranium-238	N/A	µg/g	N/A	PNNL-22032	10.69848	1.8	µg/g
399-1-56	N/A	594090.9	116725.3	109.4974	Uranium-239	N/A	µg/g	N/A	PNNL-22032	5.1816	3.9	µg/g
399-1-56	N/A	594090.9	116725.3	108.644	Uranium-240	N/A	µg/g	N/A	PNNL-22032	6.03504	12.48	µg/g
399-1-56	N/A	594090.9	116725.3	107.6686	Uranium-241	N/A	µg/g	N/A	PNNL-22032	7.0104	4.74	µg/g
399-1-56	N/A	594090.9	116725.3	105.535	Uranium-242	N/A	µg/g	N/A	PNNL-22032	9.144	3.57	µg/g
399-1-57	B25DM5	594382	116353.7	110.896	Uranium-238	0.377	pCi/g	8/9/2010	WCH	3.734	1.142424	µg/g
399-1-57	B25DM6	594382	116353.7	110.134	Uranium-238	0.423	pCi/g	8/9/2010	WCH	4.496	1.281818	µg/g
399-1-57	B25DM7	594382	116353.7	109.372	Uranium-238	0.239	pCi/g	8/9/2010	WCH	5.258	0.724242	µg/g
399-1-57	B25DM8	594382	116353.7	108.61	Uranium-238	0.546	pCi/g	8/9/2010	WCH	6.02	1.654545	µg/g
399-1-57	B25DM9	594382	116353.7	107.848	Uranium-238	0.37	pCi/g	8/9/2010	WCH	6.782	1.121212	µg/g
399-1-57	B25DN0	594382	116353.7	107.086	Uranium-238	0.678	pCi/g	8/10/2010	WCH	7.544	2.054545	µg/g
399-1-57	B25DN1	594382	116353.7	106.324	Uranium-238	0.564	pCi/g	8/10/2010	WCH	8.306	1.709091	µg/g
399-1-57	B25DN2	594382	116353.7	105.7145	Uranium-238	0.823	pCi/g	8/10/2010	WCH	8.9155	2.493939	µg/g
399-1-57	B25DN3	594382	116353.7	105.0285	Uranium-238	0.638	pCi/g	8/10/2010	WCH	9.6015	1.933333	µg/g
399-1-57	B261D6	594382	116353.7	104.19	Uranium-238	0.32	pCi/g	8/10/2010	CHPRC	10.44	0.969697	µg/g
399-1-57	B261D7	594382	116353.7	99.47	Uranium-238	0.36	pCi/g	8/11/2010	CHPRC	15.16	1.090909	µg/g
399-1-57	B261D8	594382	116353.7	93.43	Uranium-238	0.57	pCi/g	8/12/2010	CHPRC	21.2	1.727273	µg/g
399-1-57	B276T9	594382	116353.7	78.8905	Uranium-238	0.31	pCi/g	8/18/2010	CHPRC	35.7395	0.939394	µg/g
399-1-57	B261D6	594382	116353.7	104.307	U-238	0.32	pCi/g	N/A	HEIS	10.44	0.97	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-57	B261D7	594382	116353.7	99.587	U-238	0.36	pCi/g	N/A	HEIS	15.16	1.09	µg/g
399-1-57	B261D8	594382	116353.7	93.547	U-238	0.57	pCi/g	N/A	HEIS	21.2	1.73	µg/g
399-1-57	B276T9	594382	116353.7	79.0075	U-238	0.31	pCi/g	N/A	HEIS	35.7395	0.94	µg/g
399-1-57	N/A	594382	116353.7	110.937	Uranium-238	N/A	µg/g	N/A	PNNL-22032	3.81	1.18	µg/g
399-1-57	N/A	594382	116353.7	109.8702	Uranium-238	N/A	µg/g	N/A	PNNL-22032	4.8768	1.26	µg/g
399-1-57	N/A	594382	116353.7	108.3462	Uranium-238	N/A	µg/g	N/A	PNNL-22032	6.4008	1.62	µg/g
399-1-57	N/A	594382	116353.7	106.8222	Uranium-238	N/A	µg/g	N/A	PNNL-22032	7.9248	2.02	µg/g
399-1-57	N/A	594382	116353.7	105.603	Uranium-238	N/A	µg/g	N/A	PNNL-22032	9.144	2.45	µg/g
399-1-57	N/A	594382	116353.7	104.9934	Uranium-238	N/A	µg/g	N/A	PNNL-22032	9.7536	1.9	µg/g
399-1-57	N/A	594382	116353.7	104.079	Uranium-238	N/A	µg/g	N/A	PNNL-22032	10.668	1.44	µg/g
399-1-58	B27K77	593910.8	116352.6	113.4455	Uranium-238	0.694	pCi/g	8/27/2010	WCH	6.3245	2.10303	µg/g
399-1-58	B27K78	593910.8	116352.6	112.47	Uranium-238	0.81	pCi/g	8/30/2010	WCH	7.3	2.454545	µg/g
399-1-58	B27K79	593910.8	116352.6	111.86	Uranium-238	0.552	pCi/g	8/30/2010	WCH	7.91	1.672727	µg/g
399-1-58	B27K80	593910.8	116352.6	110.8695	Uranium-238	0.392	pCi/g	8/30/2010	WCH	8.9005	1.187879	µg/g
399-1-58	B27K81	593910.8	116352.6	109.8805	Uranium-238	0.444	pCi/g	8/30/2010	WCH	9.8895	1.345455	µg/g
399-1-58	B27K82	593910.8	116352.6	109.85	Uranium-238	0.336	pCi/g	8/30/2010	WCH	9.92	1.018182	µg/g
399-1-58	B27K83	593910.8	116352.6	109.09	Uranium-238	0.512	pCi/g	8/30/2010	WCH	10.68	1.551515	µg/g
399-1-58	B27K84	593910.8	116352.6	108.355	Uranium-238	0.331	pCi/g	8/30/2010	WCH	11.415	1.00303	µg/g
399-1-58	B27K86	593910.8	116352.6	107.59	Uranium-238	0.293	pCi/g	8/30/2010	WCH	12.18	0.887879	µg/g
399-1-58	B27K87	593910.8	116352.6	106.83	Uranium-238	0.345	pCi/g	8/30/2010	WCH	12.94	1.045455	µg/g
399-1-58	B27K88	593910.8	116352.6	106.07	Uranium-238	0.37	pCi/g	8/30/2010	WCH	13.7	1.121212	µg/g
399-1-58	B27K89	593910.8	116352.6	105.37	Uranium-238	0.434	pCi/g	8/31/2010	WCH	14.4	1.315152	µg/g
399-1-58	B27M31	593910.8	116352.6	97.75	Uranium-238	0.76	pCi/g	8/31/2010	CHPRC	22.02	2.30303	µg/g
399-1-58	B27JT2	593910.8	116352.6	93.18	Uranium-238	0.13	pCi/g	9/1/2010	CHPRC	26.59	0.393939	µg/g
399-1-58	B27M31	593910.8	116352.6	97.831	U-238	0.76	pCi/g	N/A	HEIS	22.02	2.3	µg/g
399-1-58	B27JT2	593910.8	116352.6	93.261	U-238	0.13	pCi/g	N/A	HEIS	26.59	0.39	µg/g
399-1-58	N/A	593910.8	116352.6	106.7446	N/A	N/A	N/A	N/A	PNNL-22032	13.1064	0.343	µg/g
399-1-59	B27PY2	594077.4	116135.9	114.298	Uranium-238	0.649	pCi/g	12/9/2010	WCH	6.477	1.966667	µg/g
399-1-59	B27PY3	594077.4	116135.9	113.445	Uranium-238	0.501	pCi/g	12/9/2010	WCH	7.33	1.518182	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-59	B27PY4	594077.4	116135.9	112.683	Uranium-238	0.757	pCi/g	12/9/2010	WCH	8.092	2.293939	µg/g
399-1-59	B27PY5	594077.4	116135.9	111.951	Uranium-238	0.552	pCi/g	12/9/2010	WCH	8.824	1.672727	µg/g
399-1-59	B27R02	594077.4	116135.9	111.189	Uranium-238	0.674	pCi/g	12/9/2010	WCH	9.586	2.042424	µg/g
399-1-59	B27R06	594077.4	116135.9	110.457	Uranium-238	0.399	pCi/g	12/9/2010	WCH	10.318	1.209091	µg/g
399-1-59	B27R07	594077.4	116135.9	109.695	Uranium-238	0.698	pCi/g	12/9/2010	WCH	11.08	2.115152	µg/g
399-1-59	B27R08	594077.4	116135.9	108.905	Uranium-238	0.79	pCi/g	12/10/2010	WCH	11.87	2.393939	µg/g
399-1-59	B27R09	594077.4	116135.9	108.205	Uranium-238	0.628	pCi/g	12/10/2010	WCH	12.57	1.90303	µg/g
399-1-59	B27R10	594077.4	116135.9	107.38	Uranium-238	5.47	pCi/g	12/10/2010	WCH	13.395	16.57576	µg/g
399-1-59	B27R11	594077.4	116135.9	106.615	Uranium-238	0.531	pCi/g	12/10/2010	WCH	14.16	1.609091	µg/g
399-1-59	B27R12	594077.4	116135.9	105.975	Uranium-238	0.515	pCi/g	12/10/2010	WCH	14.8	1.560606	µg/g
399-1-59	B2B1K0	594077.4	116135.9	104.335	Uranium-238	0.625	pCi/g	12/13/2010	WCH	16.44	1.893939	µg/g
399-1-59	B27JW6	594077.4	116135.9	95.585	Uranium-238	0.78	pCi/g	12/13/2010	CHPRC	25.19	2.363636	µg/g
399-1-59	B27JW2	594077.4	116135.9	94.09	Uranium-238	0.68	pCi/g	12/14/2010	CHPRC	26.685	2.060606	µg/g
399-1-59	B27JW3	594077.4	116135.9	84.793	Uranium-238	0.22	pCi/g	12/15/2010	CHPRC	35.982	0.666667	µg/g
399-1-59	B27JW5	594077.4	116135.9	75.832	Uranium-238	0.35	pCi/g	12/15/2010	CHPRC	44.943	1.060606	µg/g
399-1-59	B27JW6	594077.4	116135.9	95.585	U-238	0.78	pCi/g	N/A	HEIS	25.19	2.36	µg/g
399-1-59	B27JW2	594077.4	116135.9	94.09	U-238	0.68	pCi/g	N/A	HEIS	26.685	2.06	µg/g
399-1-59	B27JW3	594077.4	116135.9	84.793	U-238	0.22	pCi/g	N/A	HEIS	35.982	0.67	µg/g
399-1-59	B27JW5	594077.4	116135.9	75.832	U-238	0.35	pCi/g	N/A	HEIS	44.943	1.06	µg/g
399-1-59	N/A	594077.4	116135.9	107.9734	Uranium-238	N/A	µg/g	N/A	PNNL-22032	12.8016	0.722	µg/g
399-1-59	N/A	594077.4	116135.9	106.4494	Uranium-238	N/A	µg/g	N/A	PNNL-22032	14.3256	0.685	µg/g
399-1-67	N/A	594161.8	116482	111.6	Total U	408	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	3.05	0.408	µg/g
399-1-67	N/A	594161.8	116482	110.8	Total U	14,700	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	3.81	14.7	µg/g
399-1-67	N/A	594161.8	116482	110	Total U	16,800	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	4.57	16.8	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-67	N/A	594161.8	116482	109.3	Total U	34,800	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	5.33	34.8	µg/g
399-1-67	N/A	594161.8	116482	108.2	Total U	26,100	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	6.4	26.1	µg/g
399-1-67	N/A	594161.8	116482	107.4	Total U	16,900	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	7.16	16.9	µg/g
399-1-67	N/A	594161.8	116482	107.4	Total U	20,600	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	7.16	20.6	µg/g
399-1-67	N/A	594161.8	116482	106.7	Total U	41,400	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	7.92	41.4	µg/g
399-1-67	N/A	594161.8	116482	105.9	Total U	20,800	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	8.69	20.8	µg/g
399-1-67	N/A	594161.8	116482	104.8	Total U	25,800	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	9.75	25.8	µg/g
399-1-67	N/A	594161.8	116482	104.1	Total U	12,300	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	10.52	12.3	µg/g
399-1-67	N/A	594161.8	116482	103.9	Total U	19,900	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	10.67	19.9	µg/g
399-1-68	N/A	594165	116527	111.3	Total U	6,590	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	3.05	6.59	µg/g
399-1-68	N/A	594165	116527	111.3	Total U	6,520	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	3.05	6.52	µg/g
399-1-68	N/A	594165	116527	110.6	Total U	3,120	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	3.66	3.12	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-68	N/A	594165	116527	109.9	Total U	3,390	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	4.42	3.39	µg/g
399-1-68	N/A	594165	116527	109.3	Total U	4,210	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	5.03	4.21	µg/g
399-1-68	N/A	594165	116527	108.5	Total U	4,420	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	5.79	4.42	µg/g
399-1-68	N/A	594165	116527	107.7	Total U	2,010	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	6.55	2.01	µg/g
399-1-68	N/A	594165	116527	107	Total U	4,390	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	7.32	4.39	µg/g
399-1-68	N/A	594165	116527	106.1	Total U	3,090	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	8.23	3.09	µg/g
399-1-68	N/A	594165	116527	105.3	Total U	3,200	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	8.99	3.2	µg/g
399-1-68	N/A	594165	116527	104.7	Total U	2,030	µg/Kg	N/A	Borehole Data Tracking Spreadsheet.xlsx	9.6	2.03	µg/g
399-2-32	B27PB4	594284.6	116195.1	110.407	Uranium-238	8.06	pCi/g	11/2/2010	WCH	4.343	24.42424	µg/g
399-2-32	B27PB5	594284.6	116195.1	109.645	Uranium-238	9.09	pCi/g	11/2/2010	WCH	5.105	27.54545	µg/g
399-2-32	B27PB6	594284.6	116195.1	108.883	Uranium-238	2.16	pCi/g	11/2/2010	WCH	5.867	6.545455	µg/g
399-2-32	B27PB7	594284.6	116195.1	108.121	Uranium-238	1.72	pCi/g	11/2/2010	WCH	6.629	5.212121	µg/g
399-2-32	B27PB9	594284.6	116195.1	107.359	Uranium-238	2.56	pCi/g	11/2/2010	WCH	7.391	7.757576	µg/g
399-2-32	B27PC0	594284.6	116195.1	106.597	Uranium-238	1.15	pCi/g	11/2/2010	WCH	8.153	3.484848	µg/g
399-2-32	B27PC1	594284.6	116195.1	105.835	Uranium-238	1.08	pCi/g	11/3/2010	WCH	8.915	3.272727	µg/g
399-2-32	B27PC5	594284.6	116195.1	105.072	Uranium-238	1.04	pCi/g	11/3/2010	WCH	9.678	3.151515	µg/g
399-2-32	B27PC2	594284.6	116195.1	104.31	Uranium-238	1.41	pCi/g	11/3/2010	WCH	10.44	4.272727	µg/g
399-2-32	B27JV3	594284.6	116195.1	102.025	Uranium-238	0.38	pCi/g	11/4/2010	CHPRC	12.725	1.151515	µg/g
399-2-32	B28PN2	594284.6	116195.1	98.215	Uranium-238	1.5	pCi/g	11/5/2010	CHPRC	16.535	4.545455	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-2-32	B27JV4	594284.6	116195.1	77.4885	Uranium-238	0.57	pCi/g	11/9/2010	CHPRC	37.2615	1.727273	µg/g
399-2-32	B27JV3	594284.6	116195.1	102.122	U-238	0.38	pCi/g	N/A	HEIS	12.725	1.15	µg/g
399-2-32	B28PN2	594284.6	116195.1	98.312	U-238	1.5	pCi/g	N/A	HEIS	16.535	4.55	µg/g
399-2-32	B27JV4	594284.6	116195.1	77.5855	U-238	0.57	pCi/g	N/A	HEIS	37.2615	1.73	µg/g
399-2-32	N/A	594284.6	116195.1	110.1226	Uranium-238	N/A	µg/g	N/A	PNNL-22032	4.7244	22.44	µg/g
399-2-32	N/A	594284.6	116195.1	109.3606	Uranium-238	N/A	µg/g	N/A	PNNL-22032	5.4864	27.04	µg/g
399-2-32	N/A	594284.6	116195.1	108.751	Uranium-238	N/A	µg/g	N/A	PNNL-22032	6.096	5.59	µg/g
399-2-32	N/A	594284.6	116195.1	108.5986	Uranium-238	N/A	µg/g	N/A	PNNL-22032	6.2484	6.43	µg/g
399-2-32	N/A	594284.6	116195.1	107.8366	Uranium-238	N/A	µg/g	N/A	PNNL-22032	7.0104	5.14	µg/g
399-2-32	N/A	594284.6	116195.1	107.227	Uranium-238	N/A	µg/g	N/A	PNNL-22032	7.62	3.13	µg/g
399-2-32	N/A	594284.6	116195.1	107.0746	Uranium-238	N/A	µg/g	N/A	PNNL-22032	7.7724	7.62	µg/g
399-2-32	N/A	594284.6	116195.1	106.3126	Uranium-238	N/A	µg/g	N/A	PNNL-22032	8.5344	3.42	µg/g
399-2-32	N/A	594284.6	116195.1	106.0078	Uranium-238	N/A	µg/g	N/A	PNNL-22032	8.8392	2.19	µg/g
399-2-32	N/A	594284.6	116195.1	105.5506	Uranium-238	N/A	µg/g	N/A	PNNL-22032	9.2964	5.3	µg/g
399-2-32	N/A	594284.6	116195.1	105.2458	Uranium-238	N/A	µg/g	N/A	PNNL-22032	9.6012	2.27	µg/g
399-2-32	N/A	594284.6	116195.1	104.4838	Uranium-238	N/A	µg/g	N/A	PNNL-22032	10.3632	1.81	µg/g
399-2-32	N/A	594284.6	116195.1	104.0266	Uranium-238	N/A	µg/g	N/A	PNNL-22032	10.8204	4.2	µg/g
399-2-32	N/A	594284.6	116195.1	103.2646	Uranium-238	N/A	µg/g	N/A	PNNL-22032	11.5824	4.2	µg/g
399-2-4	B014M1	594207.2	116120.4	108.54	Uranium-238	2.7	pCi/g	9/26/1991	HEIS	6.4	8.18	µg/g
399-2-4	B014M2	594207.2	116120.4	107.01	Uranium-238	1.1	pCi/g	9/26/1991	HEIS	7.93	3.33	µg/g
399-2-4	B014M3	594207.2	116120.4	105.49	Uranium-238	0.8	pCi/g	9/27/1991	HEIS	9.45	2.42	µg/g
399-2-4	B014M4	594207.2	116120.4	104.57	Uranium-238	0.8	pCi/g	9/27/1991	HEIS	10.37	2.42	µg/g
399-2-5	B1PL46-1	594287.8	116068.8	109.88	Uranium-238	0.65	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.11	5.12	1.97	µg/g
399-2-5	B1PL47-1	594287.8	116068.8	108.26	Uranium-238	0.75	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.11	6.74	2.27	µg/g
399-2-5	B1PL48-1	594287.8	116068.8	106.89	Uranium-238	1.35	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.11	8.11	4.09	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-2-5	B1PL49-1	594287.8	116068.8	105.79	Uranium-238	1.82	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.11	9.21	5.52	µg/g
399-2-5	B1PL50-2	594287.8	116068.8	104.24	Uranium-238	0.67	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.11	10.76	2.03	µg/g
399-2-5	B1PL51-1	594287.8	116068.8	101.8	Uranium-238	0.55	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.11	13.2	1.67	µg/g
399-2-5	C5708-56.5	594287.8	116068.8	97.78	Uranium-238	0.85	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.11	17.22	2.58	µg/g
399-2-5	C5708-67	594287.8	116068.8	94.58	Uranium-238	0.4	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.11	20.42	1.21	µg/g
399-2-5	B1PL54-1	594287.8	116068.8	92.2	Uranium-238	0.61	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.11	22.8	1.85	µg/g
399-3-18	B1JXM3	594464.7	116020	106.75	Uranium-238	0.41	pCi/g	7/26/2006	HEIS	10.98	1.24	µg/g
399-3-18	C4999-3B	594465	116020	114.94	N/A	0.96	pCi/g	N/A	PNNL-16435 Table D.2	2.74	2.91	µg/g
399-3-18	C4999-5D	594465	116020	112.19	N/A	0.54	pCi/g	N/A	PNNL-16435 Table D.2	5.49	1.64	µg/g
399-3-18	C4999-6D	594465	116020	110.67	N/A	0.71	pCi/g	N/A	PNNL-16435 Table D.2	7.01	2.15	µg/g
399-3-18	C4999-9B	594465	116020	108.38	N/A	0.84	pCi/g	N/A	PNNL-16435 Table D.2	9.3	2.55	µg/g
399-3-18	C4999-9C	594465	116020	108.08	N/A	1.23	pCi/g	N/A	PNNL-16435 Table D.2	9.6	3.73	µg/g
399-3-18	C4999-10C	594465	116020	106.86	N/A	1.04	pCi/g	N/A	PNNL-16435 Table D.2	10.82	3.15	µg/g
399-3-18	C4999-10D	594465	116020	106.55	N/A	1.2	pCi/g	N/A	PNNL-16435 Table D.2	11.13	3.64	µg/g
399-3-18	C4999-11B	594465	116020	105.64	N/A	0.82	pCi/g	N/A	PNNL-16435 Table D.2	12.04	2.48	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-3-18	C4999-11D	594465	116020	105.03	N/A	3.54	pCi/g	N/A	PNNL-16435 Table D.2	12.65	10.73	µg/g
399-3-18	C4999-12C	594465	116020	103.66	N/A	2.18	pCi/g	N/A	PNNL-16435 Table D.2	14.02	6.61	µg/g
399-3-18	C4999-12D	594465	116020	103.35	N/A	0.91	pCi/g	N/A	PNNL-16435 Table D.2	14.33	2.76	µg/g
399-3-18	C4999-15A	594465	116020	100	N/A	1.19	pCi/g	N/A	PNNL-16435 Table D.2	17.68	3.61	µg/g
399-3-18	C4999-17B	594465	116020	97.26	N/A	3.06	pCi/g	N/A	PNNL-16435 Table D.2	20.42	9.27	µg/g
399-3-18	C4999-21C	594465	116020	91.47	N/A	0.68	pCi/g	N/A	PNNL-16435 Table D.2	26.21	2.06	µg/g
399-3-18	C4999-22E	594465	116020	90.1	N/A	0.91	pCi/g	N/A	PNNL-16435 Table D.2	27.58	2.76	µg/g
399-3-18	C4999-25B	594465	116020	87.35	N/A	0.64	pCi/g	N/A	PNNL-16435 Table D.2	30.33	1.94	µg/g
399-3-18	C4999-27B	594465	116020	84.76	N/A	0.53	pCi/g	N/A	PNNL-16435 Table D.2	32.92	1.61	µg/g
399-3-18	C4999-31E	594465	116020	78.97	N/A	1.19	pCi/g	N/A	PNNL-16435 Table D.2	38.71	3.61	µg/g
399-3-19	B1JXN1	594071.9	116030.2	95.46	Uranium-238	0.35	pCi/g	7/26/2006	HEIS	25.15	1.06	µg/g
399-3-19	C5001-64E	594072	116030	116.08	N/A	0.44	pCi/g	N/A	PNNL-16435 Table D.2	4.57	1.33	µg/g
399-3-19	C5001-66A	594072	116030	114.25	N/A	0.4	pCi/g	N/A	PNNL-16435 Table D.2	6.4	1.21	µg/g
399-3-19	C5001-68B	594072	116030	111.81	N/A	0.43	pCi/g	N/A	PNNL-16435 Table D.2	8.84	1.3	µg/g
399-3-19	C5001-69C	594072	116030	110.59	N/A	0.48	pCi/g	N/A	PNNL-16435 Table D.2	10.06	1.45	µg/g
399-3-19	C5001-69D	594072	116030	110.29	N/A	0.48	pCi/g	N/A	PNNL-16435 Table D.2	10.36	1.45	µg/g
399-3-19	C5001-70C	594072	116030	108.92	N/A	0.49	pCi/g	N/A	PNNL-16435 Table D.2	11.73	1.48	µg/g
399-3-19	C5001-70D	594072	116030	108.61	N/A	0.57	pCi/g	N/A	PNNL-16435 Table D.2	12.04	1.73	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-3-19	C5001-70E	594072	116030	108.31	N/A	0.44	pCi/g	N/A	PNNL-16435 Table D.2	12.34	1.33	µg/g
399-3-19	C5001-71E	594072	116030	108	N/A	0.5	pCi/g	N/A	PNNL-16435 Table D.2	12.65	1.52	µg/g
399-3-19	C5001-73B	594072	116030	105.47	N/A	0.5	pCi/g	N/A	PNNL-16435 Table D.2	15.18	1.52	µg/g
399-3-19	C5001-74B	594072	116030	104.34	N/A	0.46	pCi/g	N/A	PNNL-16435 Table D.2	16.31	1.39	µg/g
399-3-19	C5001-76C	594072	116030	100.99	N/A	0.49	pCi/g	N/A	PNNL-16435 Table D.2	19.66	1.48	µg/g
399-3-19	C5001-76D	594072	116030	100.69	N/A	0.54	pCi/g	N/A	PNNL-16435 Table D.2	19.96	1.64	µg/g
399-3-19	C5001-78A	594072	116030	97.94	N/A	0.52	pCi/g	N/A	PNNL-16435 Table D.2	22.71	1.58	µg/g
399-3-19	C5001-79A	594072	116030	95.81	N/A	0.86	pCi/g	N/A	PNNL-16435 Table D.2	24.84	2.61	µg/g
399-3-19	C5001-80A	594072	116030	94.59	N/A	0.92	pCi/g	N/A	PNNL-16435 Table D.2	26.06	2.79	µg/g
399-3-20	B1JXN5	594375.4	115849.7	97.06	Uranium-238	0.38	pCi/g	7/26/2006	HEIS	23.4	1.15	µg/g
399-3-20	C5002-84C	594375	115850	115.57	N/A	0.37	pCi/g	N/A	PNNL-16435 Table D.2	4.88	1.12	µg/g
399-3-20	C5002-86E	594375	115850	113.9	N/A	0.55	pCi/g	N/A	PNNL-16435 Table D.2	6.55	1.67	µg/g
399-3-20	C5002-87D	594375	115850	112.98	N/A	0.5	pCi/g	N/A	PNNL-16435 Table D.2	7.47	1.52	µg/g
399-3-20	C5002-90A	594375	115850	110.54	N/A	0.59	pCi/g	N/A	PNNL-16435 Table D.2	9.91	1.79	µg/g
399-3-20	C5002-90C	594375	115850	109.93	N/A	0.58	pCi/g	N/A	PNNL-16435 Table D.2	10.52	1.76	µg/g
399-3-20	C5002-91C	594375	115850	108.41	N/A	0.47	pCi/g	N/A	PNNL-16435 Table D.2	12.04	1.42	µg/g
399-3-20	C5002-91D	594375	115850	108.11	N/A	0.49	pCi/g	N/A	PNNL-16435 Table D.2	12.34	1.48	µg/g
399-3-20	C5002-92D	594375	115850	105.67	N/A	0.47	pCi/g	N/A	PNNL-16435 Table D.2	14.78	1.42	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-3-20	C5002-93E	594375	115850	103.99	N/A	0.65	pCi/g	N/A	PNNL-16435 Table D.2	16.46	1.97	µg/g
399-3-20	C5002-94D	594375	115850	100.49	N/A	0.57	pCi/g	N/A	PNNL-16435 Table D.2	19.96	1.73	µg/g
399-3-20	C5002-98E	594375	115850	95.73	N/A	0.4	pCi/g	N/A	PNNL-16435 Table D.2	24.72	1.21	µg/g
399-3-20	C5002-99D	594375	115850	95.46	N/A	0.8	pCi/g	N/A	PNNL-16435 Table D.2	24.99	2.42	µg/g
399-3-20	C5002-100A	594375	115850	94.85	N/A	0.71	pCi/g	N/A	PNNL-16435 Table D.2	25.6	2.15	µg/g
399-3-21	B1PD84	594379.8	115854.3	120.37	Uranium-238	0.25	pCi/g	8/20/2007	HEIS	0	0.76	µg/g
399-3-22	B1PL37	594217.7	115947.5	109.33	Uranium-238	0.38	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.22	9.14	1.15	µg/g
399-3-22	B1PL38	594217.7	115947.5	107.8	Uranium-238	0.38	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.22	10.67	1.15	µg/g
399-3-22	B1PL56-2	594217.7	115947.5	105.91	Uranium-238	0.49	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.22	12.56	1.48	µg/g
399-3-22	B1PL57-2	594217.7	115947.5	105.18	Uranium-238	1.2	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.22	13.29	3.64	µg/g
399-3-22	B1PL58-2	594217.7	115947.5	99.88	Uranium-238	0.41	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.22	18.59	1.24	µg/g
399-3-22	B1PL59-3	594217.7	115947.5	99.15	Uranium-238	0.56	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.22	19.32	1.7	µg/g
399-3-22	B1PL60-1	594217.7	115947.5	97.9	Uranium-238	0.93	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.22	20.57	2.82	µg/g
399-3-22	B1PL61-1	594217.7	115947.5	92.96	Uranium-238	0.91	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.22	25.51	2.76	µg/g
399-3-33	B25F13	594500.7	115966.5	111.863	Uranium-238	0.746	pCi/g	11/18/2010	WCH	6.477	2.260606	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-3-33	B25F14	594500.7	115966.5	111.101	Uranium-238	0.325	pCi/g	11/18/2010	WCH	7.239	0.984848	µg/g
399-3-33	B25F15	594500.7	115966.5	110.339	Uranium-238	0.988	pCi/g	11/18/2010	WCH	8.001	2.993939	µg/g
399-3-33	B25F16	594500.7	115966.5	109.577	Uranium-238	0.651	pCi/g	11/18/2010	WCH	8.763	1.972727	µg/g
399-3-33	B25F17	594500.7	115966.5	108.815	Uranium-238	1.04	pCi/g	11/19/2010	WCH	9.525	3.151515	µg/g
399-3-33	B25F18	594500.7	115966.5	108.052	Uranium-238	0.571	pCi/g	11/19/2010	WCH	10.288	1.730303	µg/g
399-3-33	B25F19	594500.7	115966.5	107.29	Uranium-238	2.81	pCi/g	11/19/2010	WCH	11.05	8.515152	µg/g
399-3-33	B25F20	594500.7	115966.5	106.53	Uranium-238	2.14	pCi/g	11/19/2010	WCH	11.81	6.484848	µg/g
399-3-33	B25F21	594500.7	115966.5	105.16	Uranium-238	4.06	pCi/g	11/19/2010	WCH	13.18	12.30303	µg/g
399-3-33	B28J86	594500.7	115966.5	104.395	Uranium-238	2.94	pCi/g	12/1/2010	WCH	13.945	8.909091	µg/g
399-3-33	B282Y1	594500.7	115966.5	103.63	Uranium-238	1.2	pCi/g	12/1/2010	CHPRC	14.71	3.636364	µg/g
399-3-33	B28PY0	594500.7	115966.5	100.735	Uranium-238	0.27	pCi/g	12/3/2010	CHPRC	17.605	0.818182	µg/g
399-3-33	B282Y1	594500.7	115966.5	103.66	Uranium-238	1.2	pCi/g	N/A	HEIS	14.71	3.64	µg/g
399-3-33	B28PY0	594500.7	115966.5	100.765	Uranium-238	0.27	pCi/g	N/A	HEIS	17.605	0.82	µg/g
399-3-33	N/A	594500.7	115966.5	111.482	Uranium-238	N/A	µg/g	N/A	PNNL-22032	6.858	2.22	µg/g
399-3-33	N/A	594500.7	115966.5	110.72	Uranium-239	N/A	µg/g	N/A	PNNL-22032	7.62	0.97	µg/g
399-3-33	N/A	594500.7	115966.5	109.958	Uranium-240	N/A	µg/g	N/A	PNNL-22032	8.382	2.94	µg/g
399-3-33	N/A	594500.7	115966.5	109.196	Uranium-241	N/A	µg/g	N/A	PNNL-22032	9.144	1.94	µg/g
399-3-33	N/A	594500.7	115966.5	108.434	Uranium-242	N/A	µg/g	N/A	PNNL-22032	9.906	3.09	µg/g
399-3-33	N/A	594500.7	115966.5	107.672	Uranium-243	N/A	µg/g	N/A	PNNL-22032	10.668	1.2	µg/g
399-3-33	N/A	594500.7	115966.5	106.91	Uranium-244	N/A	µg/g	N/A	PNNL-22032	11.43	8.36	µg/g
399-3-33	N/A	594500.7	115966.5	106.148	Uranium-245	N/A	µg/g	N/A	PNNL-22032	12.192	6.37	µg/g
399-3-33	N/A	594500.7	115966.5	104.7764	Uranium-246	N/A	µg/g	N/A	PNNL-22032	13.5636	12.08	µg/g
399-3-33	N/A	594500.7	115966.5	109.8056	Uranium-247	N/A	µg/g	N/A	PNNL-22032	8.5344	0.617	µg/g
399-3-33	N/A	594500.7	115966.5	107.672	Uranium-248	N/A	µg/g	N/A	PNNL-22032	10.668	1.7	µg/g
399-3-33	N/A	594500.7	115966.5	106.4528	Uranium-249	N/A	µg/g	N/A	PNNL-22032	11.8872	8.76	µg/g
399-3-33	N/A	594500.7	115966.5	105.5384	Uranium-250	N/A	µg/g	N/A	PNNL-22032	12.8016	0.722	µg/g
399-4-14	B1PL64-2	594396.2	115604.7	106.86	Uranium-238	1	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.47	11.13	3.03	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituentc	Valued	Units	Sample Date	Data Source	Sample Depth (m)	Valuee	Units
399-4-14	B1PL65-2	594396.2	115604.7	105.34	Uranium-238	0.51	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.47	12.65	1.55	µg/g
399-4-14	C5707-43	594396.2	115604.7	104.88	Uranium-238	0.65	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.47	13.11	1.97	µg/g
399-4-14	B1PL66-1	594396.2	115604.7	93.51	Uranium-238	0.28	pCi/g	N/A	PNNL-17793: Emergent Data Table 5.47	24.48	0.85	µg/g
399-4-15	B2B8N6	594343	115692.9	112.015	Uranium-238	0.653	pCi/g	1/26/2011	WCH	6.325	1.978788	µg/g
399-4-15	B2B8N7	594343	115692.9	111.2075	Uranium-238	0.438	pCi/g	1/26/2011	WCH	7.1325	1.327273	µg/g
399-4-15	B2B8N8	594343	115692.9	110.491	Uranium-238	0.579	pCi/g	1/26/2011	WCH	7.849	1.754545	µg/g
399-4-15	B2B8N9	594343	115692.9	109.897	Uranium-238	0.359	pCi/g	1/26/2011	WCH	8.443	1.087879	µg/g
399-4-15	B2B8P0	594343	115692.9	108.692	Uranium-238	0.366	pCi/g	1/26/2011	WCH	9.648	1.109091	µg/g
399-4-15	B2B8P1	594343	115692.9	108.2225	Uranium-238	0.402	pCi/g	1/27/2011	WCH	10.1175	1.218182	µg/g
399-4-15	B2B8P2	594343	115692.9	107.29	Uranium-238	0.216	pCi/g	1/27/2011	WCH	11.05	0.654545	µg/g
399-4-15	B2B8P3	594343	115692.9	106.44	Uranium-238	0.396	pCi/g	1/27/2011	WCH	11.9	1.2	µg/g
399-4-15	B2B8P6	594343	115692.9	105.83	Uranium-238	0.47	pCi/g	1/27/2011	WCH	12.51	1.424242	µg/g
399-4-15	B2B8P7	594343	115692.9	105.08	Uranium-238	0.404	pCi/g	1/28/2011	WCH	13.26	1.224242	µg/g
399-4-15	B2B8P8	594343	115692.9	104.06	Uranium-238	0.516	pCi/g	1/28/2011	WCH	14.28	1.563636	µg/g
399-4-15	B2B919	594343	115692.9	103.39	Uranium-238	0.18	pCi/g	1/28/2011	CHPRC	14.95	0.545455	µg/g
399-4-15	B2B920	594343	115692.9	96.32	Uranium-238	0.19	pCi/g	2/1/2011	CHPRC	22.02	0.575758	µg/g
399-4-15	B2B922	594343	115692.9	91.59	Uranium-238	0.7	pCi/g	2/1/2011	CHPRC	26.75	2.121212	µg/g
399-4-15	B2B921	594343	115692.9	86.8235	Uranium-238	0.38	pCi/g	2/3/2011	CHPRC	31.5165	1.151515	µg/g
399-6-3	B29FV7	593697.4	116062.8	113.217	Uranium-238	0.469	pCi/g	12/17/2010	WCH	5.563	1.421212	µg/g
399-6-3	B29FT3	593697.4	116062.8	112.379	Uranium-238	0.446	pCi/g	12/20/2010	WCH	6.401	1.351515	µg/g
399-6-3	B29FT4	593697.4	116062.8	111.617	Uranium-238	0.544	pCi/g	12/20/2010	WCH	7.163	1.648485	µg/g
399-6-3	B29FT5	593697.4	116062.8	110.855	Uranium-238	0.379	pCi/g	12/20/2010	WCH	7.925	1.148485	µg/g
399-6-3	B29FT6	593697.4	116062.8	110.1695	Uranium-238	0.363	pCi/g	12/20/2010	WCH	8.6105	1.1	µg/g
399-6-3	B29FT7	593697.4	116062.8	109.255	Uranium-238	0.53	pCi/g	12/20/2010	WCH	9.525	1.606061	µg/g
399-6-3	B29FT8	593697.4	116062.8	108.492	Uranium-238	0.632	pCi/g	12/20/2010	WCH	10.288	1.915152	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-6-3	B29FT9	593697.4	116062.8	107.73	Uranium-238	0.484	pCi/g	12/20/2010	WCH	11.05	1.466667	µg/g
399-6-3	B29FV0	593697.4	116062.8	106.97	Uranium-238	0.528	pCi/g	12/20/2010	WCH	11.81	1.6	µg/g
399-6-3	B29FV2	593697.4	116062.8	106.285	Uranium-238	0.557	pCi/g	12/21/2010	WCH	12.495	1.687879	µg/g
399-6-3	B29FV4	593697.4	116062.8	105.445	Uranium-238	0.594	pCi/g	12/21/2010	WCH	13.335	1.8	µg/g
399-6-3	B29FV5	593697.4	116062.8	104.68	Uranium-238	0.685	pCi/g	12/21/2010	WCH	14.1	2.075758	µg/g
399-6-3	B29FJ0	593697.4	116062.8	103.845	Uranium-238	0.11	pCi/g	12/21/2010	CHPRC	14.935	0.333333	µg/g
399-6-3	B29FJ3	593697.4	116062.8	97.06	Uranium-238	0.28	pCi/g	12/27/2010	CHPRC	21.72	0.848485	µg/g
399-6-3	B29FJ2	593697.4	116062.8	92.705	Uranium-238	0.39	pCi/g	12/28/2010	CHPRC	26.075	1.181818	µg/g
399-6-3	B29FJ0	593697.4	116062.8	103.869	U-238	0.11	pCi/g	N/A	HEIS	14.935	0.33	µg/g
399-6-3	B29FJ3	593697.4	116062.8	97.084	U-238	0.28	pCi/g	N/A	HEIS	21.72	0.85	µg/g
399-6-3	B29FJ2	593697.4	116062.8	92.729	U-238	0.39	pCi/g	N/A	HEIS	26.075	1.18	µg/g
399-6-4	B29DX1	593824.6	115934.2	112.364	Uranium-238	0.382	pCi/g	12/30/2010	WCH	6.416	1.157576	µg/g
399-6-4	B29DX2	593824.6	115934.2	111.571	Uranium-238	0.523	pCi/g	12/30/2010	WCH	7.209	1.584848	µg/g
399-6-4	B29DX3	593824.6	115934.2	110.962	Uranium-238	0.546	pCi/g	12/30/2010	WCH	7.818	1.654545	µg/g
399-6-4	B29DX4	593824.6	115934.2	110.0935	Uranium-238	0.316	pCi/g	12/30/2010	WCH	8.6865	0.957576	µg/g
399-6-4	B29DX5	593824.6	115934.2	109.132	Uranium-238	0.525	pCi/g	12/30/2010	WCH	9.648	1.590909	µg/g
399-6-4	B29DX6	593824.6	115934.2	108.4465	Uranium-238	0.67	pCi/g	12/30/2010	WCH	10.3335	2.030303	µg/g
399-6-4	B29DX7	593824.6	115934.2	107.84	Uranium-238	0.329	pCi/g	1/3/2011	WCH	10.94	0.99697	µg/g
399-6-4	B29DX8	593824.6	115934.2	106.88	Uranium-238	0.421	pCi/g	1/3/2011	WCH	11.9	1.275758	µg/g
399-6-5	B29DY1	593824.6	115935	106.677	Uranium-238	0.435	pCi/g	1/5/2011	WCH	12.665	1.318182	µg/g
399-6-5	B29DY2	593824.6	115935	105.977	Uranium-238	0.307	pCi/g	1/5/2011	WCH	13.365	0.930303	µg/g
399-6-5	B29DY4	593824.6	115935	105.212	Uranium-238	0.642	pCi/g	1/5/2011	WCH	14.13	1.945455	µg/g
399-6-5	B29DY5	593824.6	115935	104.392	Uranium-238	0.442	pCi/g	1/6/2011	WCH	14.95	1.339394	µg/g
399-6-5	B29DR4	593824.6	115935	103.022	Uranium-238	0.084	pCi/g	1/6/2011	CHPRC	16.32	0.254545	µg/g
399-6-5	B29DR5	593824.6	115935	101.042	Uranium-238	0.086	pCi/g	1/7/2011	CHPRC	18.3	0.260606	µg/g
399-6-5	B29DR7	593824.6	115935	89.582	Uranium-238	0.4	pCi/g	1/10/2011	CHPRC	29.76	1.212121	µg/g
399-6-5	B29DR6	593824.6	115935	86.5015	Uranium-238	0.3	pCi/g	1/10/2011	CHPRC	32.8405	0.909091	µg/g
399-8-5B	B010J8	593392	116567.3	116.04	Uranium-238	0.1	pCi/g	8/6/1991	HEIS	6.1	0.3	µg/g
399-8-5B	B010K1	593392	116567.3	114.21	Uranium-238	0.08	pCi/g	8/6/1991	HEIS	7.93	0.24	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-8-5B	B010K3	593392	116567.3	113.07	Uranium-238	0.01	pCi/g	8/7/1991	HEIS	9.07	0.03	µg/g
399-8-5B	B010K7	593392	116567.3	111.16	Uranium-238	0.1	pCi/g	8/7/1991	HEIS	10.98	0.3	µg/g
399-8-5B	B010L0	593392	116567.3	109.94	Uranium-238	0.1	pCi/g	8/7/1991	HEIS	12.2	0.3	µg/g
399-8-5B	B010L2	593392	116567.3	108.27	Uranium-238	0.16	pCi/g	8/8/1991	HEIS	13.87	0.48	µg/g
399-8-5B	B010L4	593392	116567.3	106.2	Uranium-238	0.1	pCi/g	8/8/1991	HEIS	15.94	0.3	µg/g
399-8-5B	B010L6	593392	116567.3	104.88	Uranium-238	0.18	pCi/g	8/8/1991	HEIS	17.26	0.55	µg/g
399-8-5C	B00YM6	593386.1	116573.6	104.45	Uranium-238	0.08	pCi/g	7/8/1991	HEIS	17.68	0.24	µg/g
399-8-5C	B00YM7	593386.1	116573.6	97.74	Uranium-238	0.38	pCi/g	7/10/1991	HEIS	24.39	1.15	µg/g
399-8-5C	B00YM9	593386.1	116573.6	92.41	Uranium-238	0.4	pCi/g	7/12/1991	HEIS	29.72	1.21	µg/g
399-8-5C	B00YN2	593386.1	116573.6	79.76	Uranium-238	0.13	pCi/g	7/26/1991	HEIS	42.37	0.39	µg/g
399-8-5C	B00YN5	593386.1	116573.6	74.12	Uranium-238	0.17	pCi/g	7/31/1991	HEIS	48.01	0.52	µg/g
399-8-5C	B00YN6	593386.1	116573.6	68.48	Uranium-238	1	pCi/g	8/8/1991	HEIS	53.65	3.03	µg/g
600-47	J036X2	594137.2	117635.5	111.06	Uranium-238	0.67	pCi/g	5/25/2005	WCH	5	2.03	µg/g
600-47	J036X3	594237.3	117620.3	110.92	Uranium-238	0.75	pCi/g	5/25/2005	WCH	5	2.27	µg/g
600-47	J036X4	594266.8	117603.5	110.3	Uranium-238	1.29	pCi/g	5/25/2005	WCH	5	3.91	µg/g
600-47	J036X5	594224.3	117418.8	108.24	Uranium-238	1.58	pCi/g	5/25/2005	WCH	5	4.79	µg/g
618-1	J19HP6	594022	116273.1	115.23	Uranium-238	1.47	pCi/g	1/26/2010	WCH	5	4.45	µg/g
618-1	J19HP7	594019.7	116278	115.2	Uranium-238	1.27	pCi/g	1/26/2010	WCH	5	3.85	µg/g
618-1	J19HP8	594023.2	116248.6	115.18	Uranium-238	1.5	pCi/g	1/26/2010	WCH	5	4.55	µg/g
618-1	J19HP9	594048.7	116221.6	114.91	Uranium-238	0.75	pCi/g	1/26/2010	WCH	5	2.27	µg/g
618-1	J19HR0	594012.1	116182.1	115.27	Uranium-238	2.17	pCi/g	1/26/2010	WCH	5	6.58	µg/g
618-1	J19J25	593991.4	116204.9	115.15	Uranium-238	0.99	pCi/g	1/26/2010	WCH	5	3	µg/g
618-1	J19J28	594003.7	116250.4	115.19	Uranium-238	8.23	pCi/g	1/26/2010	WCH	5	24.94	µg/g
618-1	J19J29	594008.4	116244.2	115.31	Uranium-238	0.97	pCi/g	1/26/2010	WCH	5	2.94	µg/g
618-1	J19J30	593995	116228.7	115.23	Uranium-238	0.88	pCi/g	1/26/2010	WCH	5	2.67	µg/g
618-1	J19J31	593998.8	116215.1	115.23	Uranium-238	1.46	pCi/g	1/26/2010	WCH	5	4.42	µg/g
618-1	J19J32	593992.6	116185	115.18	Uranium-238	0.81	pCi/g	1/26/2010	WCH	5	2.45	µg/g
618-1	J19J34	594036	116263	115.17	Uranium-238	0.93	pCi/g	1/26/2010	WCH	5	2.82	µg/g
618-1	J19HP2	594013	116210	112.76	Uranium-238	3.75	pCi/g	1/26/2010	WCH	7.5	11.36	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
618-1	J19HP3	594017	116204.5	112.82	Uranium-238	65.2	pCi/g	1/26/2010	WCH	7.5	197.58	µg/g
618-1	J19HP4	594021	116199	112.77	Uranium-238	9	pCi/g	1/26/2010	WCH	7.5	27.27	µg/g
618-1	J19HP5	594025.7	116191.4	112.68	Uranium-238	3.11	pCi/g	1/26/2010	WCH	7.5	9.42	µg/g
618-1	J19HR1	594021.9	116205.6	112.76	Uranium-238	26.2	pCi/g	1/26/2010	WCH	7.5	79.39	µg/g
618-1	J19HR2	594010.7	116204.9	112.87	Uranium-238	11.8	pCi/g	1/26/2010	WCH	7.5	35.76	µg/g
618-1	J19J26	594023.4	116190.2	112.77	Uranium-238	2.31	pCi/g	1/26/2010	WCH	7.5	7	µg/g
618-1	J19J27	594035.7	116191.6	112.73	Uranium-238	5.37	pCi/g	1/26/2010	WCH	7.5	16.27	µg/g
618-1	J19J33	594013	116194	112.81	Uranium-238	3.68	pCi/g	1/26/2010	WCH	7.5	11.15	µg/g
618-1	J19HH7	594007.8	116255.3	115.34	Uranium-238	1.19	pCi/g	1/27/2010	WCH	5	3.61	µg/g
618-1	J19HH8	594004.9	116197.2	115.44	Uranium-238	0.9	pCi/g	1/27/2010	WCH	5	2.73	µg/g
618-1	J19HH9	594027.1	116271.6	114.97	Uranium-238	1.45	pCi/g	1/27/2010	WCH	5	4.39	µg/g
618-1	J19HJ0	594043.2	116204.7	115.06	Uranium-238	0.81	pCi/g	1/27/2010	WCH	5	2.45	µg/g
618-1	J19HN3	594012.7	116203.7	112.88	Uranium-238	29.1	pCi/g	1/27/2010	WCH	7.5	88.18	µg/g
618-1	J19HN4	594015	116193.2	112.85	Uranium-238	2.98	pCi/g	1/27/2010	WCH	7.5	9.03	µg/g
618-1	J19HN5	594029.3	116203.9	112.64	Uranium-238	32	pCi/g	1/27/2010	WCH	7.5	96.97	µg/g
618-1	J19HN6	594031.4	116189.2	112.73	Uranium-238	2.84	pCi/g	1/27/2010	WCH	7.5	8.61	µg/g
618-1	J19XD1	594017	116204.5	113.5	Uranium-238	43.3	pCi/g	N/A	618-1_BurialGround Excavation	0.61	131.21	µg/g
618-1	J19XD2	594017	116204.5	113	Uranium-238	25.3	pCi/g	N/A	618-1_BurialGround Excavation	1.22	76.67	µg/g
618-1	J19XD3	594017	116204.5	112	Uranium-238	20.3	pCi/g	N/A	618-1_BurialGround Excavation	1.83	61.52	µg/g
618-1	J19XD4	594017	116204.5	111.5	Uranium-238	5.79	pCi/g	N/A	618-1_BurialGround Excavation	2.44	17.55	µg/g
618-1	J19XD5	594017	116204.5	111	Uranium-238	21.7	pCi/g	N/A	618-1_BurialGround Excavation	3.05	65.76	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
618-1	J19XD6	594017	116204.5	110	Uranium-238	17.6	pCi/g	N/A	618-1_BurialGround Excavation	3.66	53.33	µg/g
618-1	J19XD7	594017	116204.5	109.5	Uranium-238	9.84	pCi/g	N/A	618-1_BurialGround Excavation	4.27	29.82	µg/g
618-1	J19XD8	594017	116204.5	109	Uranium-238	8.49	pCi/g	N/A	618-1_BurialGround Excavation	4.88	25.73	µg/g
618-1	J19XD9	594017	116204.5	108	Uranium-238	6.17	pCi/g	N/A	618-1_BurialGround Excavation	5.49	18.7	µg/g
618-1	J19FX0	594017	116204.5	107.5	Uranium-238	5.46	pCi/g	N/A	618-1_BurialGround Excavation	6.1	16.55	µg/g
618-1	J19FX1	594017	116204.5	107	Uranium-238	7.4	pCi/g	N/A	618-1_BurialGround Excavation	6.71	22.42	µg/g
618-1	J19FX2	594017	116204.5	106	Uranium-238	8.68	pCi/g	N/A	618-1_BurialGround Excavation	7.32	26.3	µg/g
618-1	J19FX3	594017	116204.5	105.5	Uranium-238	20.7	pCi/g	N/A	618-1_BurialGround Excavation	7.92	62.73	µg/g
618-1	J19FX4	594017	116204.5	105	Uranium-238	22	pCi/g	N/A	618-1_BurialGround Excavation	8.23	66.67	µg/g
618-12	B0L651	594291	116436	109.77	Uranium-238	8.59	pCi/g	8/11/1997	WCH	5	26.03	µg/g
618-12	B0L653	594249	116450	109.66	Uranium-238	10.8	pCi/g	8/11/1997	WCH	5	32.73	µg/g
618-12	B0L654	594212	116445	109.77	Uranium-238	4.84	pCi/g	8/12/1997	WCH	5	14.67	µg/g
618-12	B0L655	594205	116412	109.85	Uranium-238	1.83	pCi/g	8/12/1997	WCH	5	5.55	µg/g
618-12	B0L656	594161	116436	109.95	Uranium-238	3.73	pCi/g	8/12/1997	WCH	5	11.3	µg/g
618-12	B0L657	594167	116388	109.91	Uranium-238	2.32	pCi/g	8/12/1997	WCH	5	7.03	µg/g
618-12	B0L658	594261	116406	109.77	Uranium-238	8.01	pCi/g	8/13/1997	WCH	5	24.27	µg/g
618-12	B0L659	594284	116478	109.74	Uranium-238	17.5	pCi/g	8/13/1997	WCH	5	53.03	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
618-13	J18PX0	592856.7	116243.9	115.79	Uranium-238	0.63	pCi/g	4/28/2009	WCH	5	1.91	µg/g
618-13	J18PX1	592878.9	116248	120.13	Uranium-238	1.7	pCi/g	4/28/2009	WCH	5	5.15	µg/g
618-13	J18PX2	592856	116236	116.14	Uranium-238	0.65	pCi/g	4/28/2009	WCH	5	1.97	µg/g
618-13	J18PX3	592877.9	116222.5	118.95	Uranium-238	0.73	pCi/g	4/28/2009	WCH	5	2.21	µg/g
618-13	J18R00	592861	116248	115.11	Uranium-238	0.68	pCi/g	4/28/2009	WCH	5	2.06	µg/g
618-13	J18R01	592880	116240	120.33	Uranium-238	0.96	pCi/g	4/28/2009	WCH	5	2.91	µg/g
618-2	J13DJ6	594033.6	116361.8	113.39	Uranium-238	1.9	pCi/g	9/7/2006	WCH	5	5.76	µg/g
618-2	J13DJ7	594035.9	116351.8	113.37	Uranium-238	1.77	pCi/g	9/7/2006	WCH	5	5.36	µg/g
618-2	J13DJ9	591502.9	116331.3	120.73	Uranium-238	2.2	pCi/g	9/7/2006	WCH	5	6.67	µg/g
618-2	J13DK0	594027	116315.6	113.96	Uranium-238	2.14	pCi/g	9/7/2006	WCH	5	6.48	µg/g
618-2	J13DJ0	594023.2	116341.4	111.12	Uranium-238	14.8	pCi/g	9/7/2006	WCH	7.5	44.85	µg/g
618-2	J13DJ2	594037.2	116341.5	110.95	Uranium-238	5.22	pCi/g	9/7/2006	WCH	7.5	15.82	µg/g
618-2	J13DJ3	594032.4	116321.2	111.24	Uranium-238	165	pCi/g	9/7/2006	WCH	7.5	500	µg/g
618-2	J13DJ4	594034.3	116357.7	110.88	Uranium-238	2.87	pCi/g	9/7/2006	WCH	7.5	8.7	µg/g
618-2	J13DH9	594043.4	116319.6	111.18	Uranium-238	10.7	pCi/g	9/7/2006	WCH	7.5	32.42	µg/g
618-2	J13DJ5	594038.7	116321.8	111.16	Uranium-238	3.52	pCi/g	9/7/2006	WCH	7.5	10.67	µg/g
618-2	J13DN0	594010	116319	111.58	Uranium-238	50.1	pCi/g	9/26/2006	WCH	7.5	151.82	µg/g
618-2	J13DN1	594018	116318	111.46	Uranium-238	10.3	pCi/g	9/26/2006	WCH	7.5	31.21	µg/g
618-2	J13DN2	594039	116320	111.2	Uranium-238	13.4	pCi/g	9/26/2006	WCH	7.5	40.61	µg/g
618-2	J13DN3	594015	116339	111.37	Uranium-238	0.49	pCi/g	9/26/2006	WCH	7.5	1.48	µg/g
618-2	J13DN4	594032	116339	111.11	Uranium-238	0.5	pCi/g	9/26/2006	WCH	7.5	1.52	µg/g
618-2	J13H86	594041	116335	110.89	Uranium-238	6.28	pCi/g	9/28/2006	WCH	7.5	19.03	µg/g
618-2	J13H87	594044	116334.4	110.79	Uranium-238	6.71	pCi/g	9/28/2006	WCH	7.5	20.33	µg/g
618-3	J10TX0	593976	116378	114.2	Uranium-238	79.4	pCi/g	11/30/2005	WCH	5	240.61	µg/g
618-3	J10TX1	593957	116380	114.53	Uranium-238	25.4	pCi/g	11/30/2005	WCH	5	76.97	µg/g
618-3	J10TX2	593972	116396	114.14	Uranium-238	11.9	pCi/g	11/30/2005	WCH	5	36.06	µg/g
618-3	J11264	593949.7	116378.2	114.67	Uranium-238	0.75	pCi/g	1/31/2006	WCH	5	2.27	µg/g
618-3	J11266	593970	116387.4	114.19	Uranium-238	0.75	pCi/g	1/31/2006	WCH	5	2.27	µg/g
618-3	J11267	593946.2	116333.1	114.43	Uranium-238	0.55	pCi/g	1/31/2006	WCH	5	1.67	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituentc	Valued	Units	Sample Date	Data Source	Sample Depth (m)	Valuee	Units
618-3	J11268	593974.4	116324.4	114.55	Uranium-238	0.45	pCi/g	1/31/2006	WCH	5	1.36	µg/g
618-4	J00H62	593930.9	117019.6	108.63	Uranium-238	1.08	pCi/g	2/12/2003	WCH	7.5	3.27	µg/g
618-4	J00WT8	593890.6	116994.6	108.97	Uranium-238	2.14	pCi/g	8/25/2003	WCH	7.5	6.48	µg/g
618-4	J00WT9	593903.2	116988.7	108.78	Uranium-238	1.54	pCi/g	8/25/2003	WCH	7.5	4.67	µg/g
618-4	J00WV0	593928.7	117030.9	108.61	Uranium-238	0.51	pCi/g	8/25/2003	WCH	7.5	1.55	µg/g
618-4	J00WV1	593948	117022.6	108.52	Uranium-238	2.05	pCi/g	8/25/2003	WCH	7.5	6.21	µg/g
618-4	J00WX2	593866.4	116974.7	109	Uranium-238	1.18	pCi/g	8/25/2003	WCH	7.5	3.58	µg/g
618-4	J00WX3	593870.2	116968.9	109	Uranium-238	3.38	pCi/g	8/25/2003	WCH	7.5	10.24	µg/g
618-4	J00WX4	593874	116961.4	109.28	Uranium-238	6.9	pCi/g	8/25/2003	WCH	7.5	20.91	µg/g
618-4	J00WX5	593883.6	116957	109.51	Uranium-238	0.43	pCi/g	8/25/2003	WCH	7.5	1.3	µg/g
618-4	J00WX8	593933.8	117025	108.51	Uranium-238	1.15	pCi/g	8/25/2003	WCH	7.5	3.48	µg/g
618-4	J00WX9	593935.6	117017.3	108.56	Uranium-238	0.51	pCi/g	8/25/2003	WCH	7.5	1.55	µg/g
618-4	J00WV3	593893.9	117011.4	111.85	Uranium-238	0.68	pCi/g	8/26/2003	WCH	5	2.06	µg/g
618-4	J00WV4	593895.6	116969.2	111.71	Uranium-238	1.23	pCi/g	8/26/2003	WCH	5	3.73	µg/g
618-4	J00WV5	593978.1	117033.6	110.88	Uranium-238	3.07	pCi/g	8/26/2003	WCH	5	9.3	µg/g
618-4	J00WV6	593968.7	117055.1	111.08	Uranium-238	1.91	pCi/g	8/26/2003	WCH	5	5.79	µg/g
618-5	J00HM5	594167.9	116804.8	105.97	Uranium-238	12.2	pCi/g	2/26/2003	WCH	7.5	36.97	µg/g
618-5	J00HM8	594182.1	116820.9	105.63	Uranium-238	3.06	pCi/g	2/26/2003	WCH	7.5	9.27	µg/g
618-5	J00YK3	594205.9	116865.4	108.05	Uranium-238	0.56	pCi/g	9/24/2003	WCH	5	1.7	µg/g
618-5	J00YK4	594145.3	116817.6	108.33	Uranium-238	0.85	pCi/g	9/24/2003	WCH	5	2.58	µg/g
618-5	J00YK5	594154.5	116776.5	109.3	Uranium-238	0.75	pCi/g	9/24/2003	WCH	5	2.27	µg/g
618-5	J00YK6	594224.3	116838.4	108.24	Uranium-238	1.05	pCi/g	9/24/2003	WCH	5	3.18	µg/g
618-5	J00YJ8	594185.5	116845.7	105.68	Uranium-238	5.86	pCi/g	9/24/2003	WCH	7.5	17.76	µg/g
618-5	J00YJ9	594162.6	116827.3	105.67	Uranium-238	8.87	pCi/g	9/24/2003	WCH	7.5	26.88	µg/g
618-5	J00YK0	594169.9	116813.9	105.79	Uranium-238	6.28	pCi/g	9/24/2003	WCH	7.5	19.03	µg/g
618-5	J00YK1	594196.7	116830.2	105.48	Uranium-238	1.74	pCi/g	9/24/2003	WCH	7.5	5.27	µg/g
618-5-TP2	B01GK8	594189.4	116834.4	106.79	Uranium-238	3	pCi/g	1/27/1992	HEIS	6.1	9.09	µg/g
618-5-TP2	B01GN3	594189.4	116834.4	105.27	Uranium-238	11.66	pCi/g	1/27/1992	HEIS	7.62	35.33	µg/g
618-7	J17J15	593288	116578	116.85	Uranium-238	0.85	pCi/g	9/10/2008	WCH	5	2.58	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
618-7	J17J17	593298	116618	116.68	Uranium-238	1.03	pCi/g	9/10/2008	WCH	5	3.12	µg/g
618-7	J17J18	593243	116611	116.25	Uranium-238	1.7	pCi/g	9/10/2008	WCH	5	5.15	µg/g
618-7	J17J19	593146	116631	117.23	Uranium-238	0.99	pCi/g	10/6/2008	WCH	5	3	µg/g
618-7	J17J21	593192	116630	116.81	Uranium-238	0.54	pCi/g	10/6/2008	WCH	5	1.64	µg/g
618-7	J17J22	593246	116572	116.54	Uranium-238	0.73	pCi/g	10/6/2008	WCH	5	2.21	µg/g
618-7	J17J27	593296	116600	116.66	Uranium-238	0.44	pCi/g	10/6/2008	WCH	5	1.33	µg/g
618-7	J17J28	593241	116630	116.4	Uranium-238	4.24	pCi/g	10/6/2008	WCH	5	12.85	µg/g
618-7	J17J29	593194	116596	116.14	Uranium-238	0.77	pCi/g	10/6/2008	WCH	5	2.33	µg/g
618-7	J17J23	593193	116589	116.33	Uranium-238	4.26	pCi/g	10/13/2008	WCH	5	12.91	µg/g
618-7	J17J24	593193	116610	114.22	Uranium-238	5.05	pCi/g	10/13/2008	WCH	5	15.3	µg/g
618-7	J17J25	593146	116609	116.33	Uranium-238	1.23	pCi/g	10/13/2008	WCH	5	3.73	µg/g
618-7	J17J26	593243	116592	116.23	Uranium-238	2.03	pCi/g	10/13/2008	WCH	5	6.15	µg/g
618-7	J17J31	593142	116590	116.3	Uranium-238	0.59	pCi/g	10/15/2008	WCH	5	1.79	µg/g
618-7	J17J32	593143	116570	116.55	Uranium-238	0.31	pCi/g	10/15/2008	WCH	5	0.94	µg/g
618-7	J17R51	593298	116635	116.83	Uranium-238	7.9	pCi/g	10/15/2008	WCH	5	23.94	µg/g
618-7	J17R29	593172.1	116568	116.77	Uranium-238	0.36	pCi/g	10/15/2008	WCH	5	1.09	µg/g
618-7	J17R30	593207.4	116602.1	116.17	Uranium-238	0.68	pCi/g	10/15/2008	WCH	5	2.06	µg/g
618-7	J17R31	593262	116507	116.71	Uranium-238	6.42	pCi/g	10/15/2008	WCH	5	19.45	µg/g
618-7	J17R32	593308	116614	116.81	Uranium-238	0.32	pCi/g	10/15/2008	WCH	5	0.97	µg/g
618-7	J17R33	593231	116619	116.19	Uranium-238	1.25	pCi/g	10/15/2008	WCH	5	3.79	µg/g
618-7	J17R34	593150.6	116571.9	116.44	Uranium-238	1.23	pCi/g	10/15/2008	WCH	5	3.73	µg/g
618-7	J17R35	593234.2	116577	116.62	Uranium-238	1.47	pCi/g	10/15/2008	WCH	5	4.45	µg/g
618-7	J17R36	593253.8	116577	116.64	Uranium-238	2.89	pCi/g	10/15/2008	WCH	5	8.76	µg/g
618-7	J17R55	593212.6	116509.2	116.61	Uranium-238	0	pCi/g	10/16/2008	WCH	5	0	µg/g
618-7	J17R54	593174.2	116506.4	116.23	Uranium-238	0.4	pCi/g	10/16/2008	WCH	5	1.21	µg/g
618-7	J17R56	593244.7	116511.2	116.75	Uranium-238	0.53	pCi/g	10/16/2008	WCH	5	1.61	µg/g
618-7	J17R57	593286	116503.5	116.36	Uranium-238	0.39	pCi/g	10/16/2008	WCH	5	1.18	µg/g
618-7	J17R59	593208	116518	116.78	Uranium-238	0	pCi/g	10/16/2008	WCH	5	0	µg/g
618-7	J17R60	593237.2	116514.1	116.75	Uranium-238	0.21	pCi/g	10/16/2008	WCH	5	0.64	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
618-7	J17RK1	593180	116715	117.88	Uranium-238	0.53	pCi/g	10/21/2008	WCH	5	1.61	µg/g
618-7	J17RK3	593203	116681	117.97	Uranium-238	0.54	pCi/g	10/21/2008	WCH	5	1.64	µg/g
618-7	J17RK4	593185	116681	118.19	Uranium-238	0.54	pCi/g	10/21/2008	WCH	5	1.64	µg/g
618-7	J17WL0	593214	116715	117.61	Uranium-238	0.18	pCi/g	11/14/2008	WCH	5	0.55	µg/g
618-7	J17WL1	593215	116702	117.72	Uranium-238	0.45	pCi/g	11/14/2008	WCH	5	1.36	µg/g
618-7	J17XN3	593320	116599	117.05	Uranium-238	0.93	pCi/g	11/15/2008	WCH	5	2.82	µg/g
618-7	J17XN4	593317	116582	117.16	Uranium-238	0.89	pCi/g	11/15/2008	WCH	5	2.7	µg/g
618-7	J17XV9	593309	116594	116.87	Uranium-238	0.24	pCi/g	11/18/2008	WCH	5	0.73	µg/g
618-7	J17XW0	593318	116599	117	Uranium-238	0.87	pCi/g	11/18/2008	WCH	5	2.64	µg/g
618-7	J17XW1	593303	116579	116.92	Uranium-238	0.95	pCi/g	11/18/2008	WCH	5	2.88	µg/g
618-7	J17XW3	593312	116573	117.21	Uranium-238	0.39	pCi/g	11/18/2008	WCH	5	1.18	µg/g
618-8	J11274	593821.1	116477.9	115.43	Uranium-238	0	pCi/g	1/31/2006	WCH	5	0	µg/g
618-8	J11271	593818.2	116509.1	114.22	Uranium-238	0.44	pCi/g	1/31/2006	WCH	5	1.33	µg/g
618-8	J11273	593816.6	116488.3	115.41	Uranium-238	0.73	pCi/g	1/31/2006	WCH	5	2.21	µg/g
618-8	J11275	593839.5	116453.3	115.08	Uranium-238	0.52	pCi/g	1/31/2006	WCH	5	1.58	µg/g
628-4	B0Y9W1	594155	116275	110.05	Uranium-238	0.82	pCi/g	7/13/2000	WCH	5	2.48	µg/g
628-4	B0Y9W2	594170	116290	110.12	Uranium-238	0.72	pCi/g	7/13/2000	WCH	5	2.18	µg/g
628-4	B0Y9W3	594165	116295	110.67	Uranium-238	0.63	pCi/g	7/13/2000	WCH	5	1.91	µg/g
628-4	B0Y9W4	594170	116300	110.83	Uranium-238	0.89	pCi/g	7/13/2000	WCH	5	2.7	µg/g
628-4	B0Y9W5	594170	116280	109.97	Uranium-238	1.24	pCi/g	7/13/2000	WCH	5	3.76	µg/g
628-4	B0Y9W6	594180	116275	110.02	Uranium-238	0.94	pCi/g	7/13/2000	WCH	5	2.85	µg/g
699-S19-E14	B010R0	594249.9	117716.2	107.72	Uranium-238	0.12	pCi/g	8/19/1991	HEIS	6.34	0.36	µg/g
699-S19-E14	B010R3	594249.9	117716.2	106.29	Uranium-238	0.11	pCi/g	8/19/1991	HEIS	7.77	0.33	µg/g
699-S19-E14	B010R5	594249.9	117716.2	104.85	Uranium-238	0.13	pCi/g	8/20/1991	HEIS	9.21	0.39	µg/g
699-S22-E9B	B010H5	592696.1	116756.4	107.74	Uranium-238	0.09	pCi/g	7/26/1991	HEIS	6.37	0.27	µg/g
699-S22-E9B	B010H8	592696.1	116756.4	106.11	Uranium-238	0.09	pCi/g	7/29/1991	HEIS	8	0.27	µg/g
699-S22-E9C	B00YK0	592689	116752.6	105.61	Uranium-238	0.06	pCi/g	6/10/1991	HEIS	8.53	0.18	µg/g
699-S22-E9C	B00YK2	592689	116752.6	99.5	Uranium-238	0.38	pCi/g	6/19/1991	HEIS	14.64	1.15	µg/g
699-S22-E9C	B00YK4	592689	116752.6	93.41	Uranium-238	0.31	pCi/g	6/21/1991	HEIS	20.73	0.94	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
699-S22-E9C	B00YK6	592689	116752.6	87.31	Uranium-238	0.33	pCi/g	6/26/1991	HEIS	26.83	1	µg/g
699-S22-E9C	B00YK8	592689	116752.6	81.86	Uranium-238	0.14	pCi/g	7/2/1991	HEIS	32.28	0.42	µg/g
699-S22-E9C	B00YK9	592689	116752.6	76.04	Uranium-238	0.18	pCi/g	7/11/1991	HEIS	38.1	0.55	µg/g
699-S22-E9C	B00YL1	592689	116752.6	63.95	Uranium-238	1	pCi/g	8/1/1991	HEIS	50.19	3.03	µg/g
699-S27-E9B	B00YP6	592727.3	115328.7	112.8	Uranium-238	0.1	pCi/g	7/24/1991	HEIS	6.4	0.3	µg/g
699-S27-E9B	B00YP8	592727.3	115328.7	110.97	Uranium-238	0.16	pCi/g	7/25/1991	HEIS	8.23	0.48	µg/g
699-S27-E9B	B00YQ0	592727.3	115328.7	109.75	Uranium-238	0.1	pCi/g	7/25/1991	HEIS	9.45	0.3	µg/g
699-S27-E9B	B00YQ4	592727.3	115328.7	108.22	Uranium-238	0.08	pCi/g	7/26/1991	HEIS	10.98	0.24	µg/g
699-S27-E9B	B00YQ7	592727.3	115328.7	106.7	Uranium-238	0.1	pCi/g	7/26/1991	HEIS	12.5	0.3	µg/g
699-S27-E9C	B00VS1	592720.9	115324.8	106.41	Uranium-238	0.14	pCi/g	6/3/1991	HEIS	12.84	0.42	µg/g
699-S27-E9C	B00YJ1	592720.9	115324.8	100.76	Uranium-238	0.04	pCi/g	6/11/1991	HEIS	18.49	0.12	µg/g
699-S27-E9C	B00YJ2	592720.9	115324.8	94.55	Uranium-238	0.23	pCi/g	6/14/1991	HEIS	24.7	0.7	µg/g
699-S27-E9C	B00YJ4	592720.9	115324.8	88.65	Uranium-238	0.32	pCi/g	6/20/1991	HEIS	30.6	0.97	µg/g
699-S27-E9C	B00YJ6	592720.9	115324.8	83.74	Uranium-238	0.14	pCi/g	6/28/1991	HEIS	35.51	0.42	µg/g
699-S27-E9C	B00YJ7	592720.9	115324.8	77.58	Uranium-238	0.01	pCi/g	7/16/1991	HEIS	41.67	0.03	µg/g
699-S27-E9C	B00YJ9	592720.9	115324.8	69.49	Uranium-238	0.15	pCi/g	8/7/1991	HEIS	49.76	0.45	µg/g
699-S27-E9C	B010M2	592720.9	115324.8	64.31	Uranium-238	0.93	pCi/g	8/12/1991	HEIS	54.94	2.82	µg/g
699-S29-E16B	B010P3	594746.9	114738.8	109.69	Uranium-238	0.17	pCi/g	8/14/1991	HEIS	6.26	0.52	µg/g
699-S29-E16B	B010P6	594746.9	114738.8	108.24	Uranium-238	0.13	pCi/g	8/15/1991	HEIS	7.71	0.39	µg/g
699-S29-E16B	B010P9	594746.9	114738.8	104.9	Uranium-238	0.19	pCi/g	8/15/1991	HEIS	11.05	0.58	µg/g
699-S29-E16C	B00YL5	594742.4	114730.5	103.88	Uranium-238	0.09	pCi/g	6/26/1991	HEIS	12.04	0.27	µg/g
699-S29-E16C	B00YL7	594742.4	114730.5	98.69	Uranium-238	0.08	pCi/g	7/2/1991	HEIS	17.23	0.24	µg/g
699-S29-E16C	B00YL8	594742.4	114730.5	92.68	Uranium-238	0.06	pCi/g	7/9/1991	HEIS	23.24	0.18	µg/g
699-S29-E16C	B00YM0	594742.4	114730.5	86.76	Uranium-238	0.19	pCi/g	7/12/1991	HEIS	29.16	0.58	µg/g
699-S29-E16C	B00YM1	594742.4	114730.5	80.61	Uranium-238	1.5	pCi/g	7/26/1991	HEIS	35.31	4.55	µg/g
699-S29-E16C	B00YM3	594742.4	114730.5	74.46	Uranium-238	0.78	pCi/g	7/31/1991	HEIS	41.46	2.36	µg/g
699-S29-E16C	B00YM4	594742.4	114730.5	68.6	Uranium-238	0.93	pCi/g	8/5/1991	HEIS	47.32	2.82	µg/g
699-S29-E16C	B010M0	594742.4	114730.5	62.58	Uranium-238	0.13	pCi/g	8/12/1991	HEIS	53.34	0.39	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
C8933	N/A	594113.1	116440.5	112.1	Total U	460	µg/Kg	12/31/2014	Borehole Data Tracking Spreadsheet.xlsx	3.35	0.46	µg/g
C8933	N/A	594113.1	116440.5	111.5	Total U	688	µg/Kg	12/31/2014	Borehole Data Tracking Spreadsheet.xlsx	3.96	0.688	µg/g
C8933	N/A	594113.1	116440.5	110.9	Total U	540	µg/Kg	12/31/2014	Borehole Data Tracking Spreadsheet.xlsx	4.57	0.54	µg/g
C8933	N/A	594113.1	116440.5	110.2	Total U	508	µg/Kg	12/31/2014	Borehole Data Tracking Spreadsheet.xlsx	5.33	0.508	µg/g
C8933	N/A	594113.1	116440.5	110.2	Total U	622	µg/Kg	12/31/2014	Borehole Data Tracking Spreadsheet.xlsx	5.33	0.622	µg/g
C8933	N/A	594113.1	116440.5	109.4	Total U	726	µg/Kg	12/31/2014	Borehole Data Tracking Spreadsheet.xlsx	6.1	0.726	µg/g
C8933	N/A	594113.1	116440.5	108.6	Total U	739	µg/Kg	12/31/2014	Borehole Data Tracking Spreadsheet.xlsx	6.86	0.739	µg/g
C8933	N/A	594113.1	116440.5	107.4	Total U	8,180	µg/Kg	1/6/2015	Borehole Data Tracking Spreadsheet.xlsx	8.08	8.18	µg/g
C8933	N/A	594113.1	116440.5	106.2	Total U	7,130	µg/Kg	1/6/2015	Borehole Data Tracking Spreadsheet.xlsx	9.3	7.13	µg/g
C8933	N/A	594113.1	116440.5	104.2	Total U	2,030	µg/Kg	1/7/2015	Borehole Data Tracking Spreadsheet.xlsx	11.28	2.03	µg/g
N/A	N/A	594108.3	116510.5	114.5657	N/A	N/A	N/A	N/A	control	0	31	µg/g
N/A	N/A	594108.3	116510.5	104.9647	N/A	N/A	N/A	N/A	control	1	31	µg/g
N/A	N/A	594104.7	116409.2	115.2667	Ur	N/A	N/A	N/A	control	0	31	µg/g
N/A	N/A	594104.7	116409.2	105.4905	N/A	N/A	N/A	N/A	control	1	31	µg/g
N/A	N/A	594091.4	116556	114.2829	N/A	N/A	N/A	N/A	control	0	31	µg/g
N/A	N/A	593981	116850	111	N/A	1	N/A	N/A	control	0	3.030303	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
N/A	N/A	593983	116891	111	N/A	1	N/A	N/A	control	0	3.030303	µg/g
N/A	N/A	594051	116849	110	N/A	1	N/A	N/A	control	0	3.030303	µg/g
N/A	N/A	594128	116935	109	N/A	1	N/A	N/A	control	0	3.030303	µg/g
N/A	N/A	594128	116935	106.5	N/A	1	N/A	N/A	control	2.5	3.030303	µg/g
N/A	N/A	593981	116850	108.5	N/A	1	N/A	N/A	control	2.5	3.030303	µg/g
N/A	N/A	593983	116891	108.5	N/A	1	N/A	N/A	control	2.5	3.030303	µg/g
N/A	N/A	594051	116849	107.5	N/A	1	N/A	N/A	control	2.5	3.030303	µg/g
N/A	N/A	593981	116850	106	N/A	1	N/A	N/A	control	5	3.030303	µg/g
N/A	N/A	593983	116891	106	N/A	1	N/A	N/A	control	5	3.030303	µg/g
N/A	N/A	594051	116849	105	N/A	1	N/A	N/A	control	5	3.030303	µg/g
N/A	N/A	594128	116935	104	N/A	1	N/A	N/A	control	5	3.030303	µg/g
N/A	N/A	594055	116456	105	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
N/A	N/A	594050	116446	105	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
N/A	N/A	594043	116569	105	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
N/A	N/A	593946	116462	105	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
N/A	N/A	593909	116549	105	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
N/A	N/A	594055	116456	100	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
N/A	N/A	594050	116446	100	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
N/A	N/A	594043	116569	100	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
N/A	N/A	593946	116462	100	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
N/A	N/A	593909	116549	100	N/A	1	N/A	N/A	control	N/A	3.030303	µg/g
399-1-76	B31MY3	594117.8	116460.6	111.7365	Uranium	987	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	3.429	0.987	µg/g
399-1-76	B31MY8	594117.8	116460.6	110.9745	Uranium	1,300	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	4.191	1.3	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-76	B31MY9	594117.8	116460.6	NA	Uranium	141	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	NA	0.141	µg/g
399-1-76	B31N04	594117.8	116460.6	110.2125	Uranium	1,180	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	4.953	1.18	µg/g
399-1-76	B31N14	594117.8	116460.6	108.5361	Uranium	2,540	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	6.6294	2.54	µg/g
399-1-76	B31N15	594117.8	116460.6	108.5361	Uranium	2,140	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	6.6294	2.14	µg/g
399-1-76	B31N20	594117.8	116460.6	107.7741	Uranium	2,500	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	7.3914	2.5	µg/g
399-1-76	B31N25	594117.8	116460.6	107.1645	Uranium	5,900	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	8.001	5.9	µg/g
399-1-76	B31N30	594117.8	116460.6	106.4025	Uranium	11,500	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	8.763	11.5	µg/g
399-1-76	B31N35	594117.8	116460.6	105.6405	Uranium	4,490	µg/Kg	7/13/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	9.525	4.49	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituentc	Valued	Units	Sample Date	Data Source	Sample Depth (m)	Valuee	Units
399-1-80	B31N65	594089.7	116454.9	111.7365	Uranium	1,440	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	3.429	1.44	µg/g
399-1-80	B31N70	594089.7	116454.9	111.005	Uranium	1180	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	4.16052	1.18	µg/g
399-1-80	B31N75	594089.7	116454.9	110.2125	Uranium	1,270	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	4.953	1.27	µg/g
399-1-80	B31N76	594089.7	116454.9	110.2125	Uranium	1,030	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	4.953	1.03	µg/g
399-1-80	B31N81	594089.7	116454.9	109.4505	Uranium	1,100	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	5.715	1.1	µg/g
399-1-80	B31N86	594089.7	116454.9	108.6885	Uranium	12,000	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	6.477	12	µg/g
399-1-80	B31N91	594089.7	116454.9	107.7741	Uranium	5,440	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	7.3914	5.44	µg/g
399-1-80	B31N92	594089.7	116454.9	NA	Uranium	248	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	NA	0.248	µg/g

Table A-1. 300 Area Uranium Soil Concentration Data

Sampling Location Name[a]	HEIS Number	X Coordinate (m)[b]	Y Coordinate (m)[b]	Z Coordinate (m)[b]	Constituent[c]	Value[d]	Units	Sample Date	Data Source	Sample Depth (m)	Value[e]	Units
399-1-80	B31N97	594089.7	116454.9	107.0121	Uranium	10,600	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	8.1534	10.6	µg/g
399-1-80	B31NB2	594089.7	116454.9	106.4025	Uranium	9,290	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	8.763	9.29	µg/g
399-1-80	B31NB7	594089.7	116454.9	105.4881	Uranium	6,500	µg/Kg	7/14/2015	Borehole_Data_Tracking_Spreadsheet_399-1-76_&_80.xlsx and HEIS	9.6774	6.5	µg/g

a. See Figure 1 for sampling locations.

b. All coordinates are in meters. Horizontal coordinates (X and Y) use Washington State Plane (NAD83, North American Datum of 1983), and vertical coordinates (Z) use NAVD88, North American Vertical Datum of 1988.

c. Constituent name or indicator, as listed in the corresponding Data Source column.

d. Value is unaltered straight from its source.

e. Value is converted from source units (pCi/L) to model units (µg/g).

CHPRC = CH2M HILL Plateau Remediation Company

HEIS = Hanford Environmental Information System

N/A = not applicable

WCH = Washington Closure Hanford

Appendix B

Uranium Soil Concentration Data

This page intentionally left blank.

Table B-1. Uranium Soil Concentration Data

Sample No.	Sample Depth (ft below ground surface)	Field Record: Estimated Elevation in m (NAVD88)	Adjusted Elevation in m (NAVD88)	pH	Total Uranium (µg/g)	U-233/234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Total Uranium Calculated from Isotopes (µg/g)
J19XD1	2	111.5	113.5	4.39	143.0	46.2	3.4	43.3	130.3
J19XD2	4	111.0	113.0	3.84	77.7	23.5	1.9	25.3	76.1
J19XD3	6	110.0	112.0	4.42	71.0	21.3	1.2	20.3	60.9
J19XD4	8	109.5	111.5	3.99	16.2	5.2	0.4	5.8	17.4
J19XD5	10	109.0	111.0	4.51	72.0	21.8	1.2	21.7	65.0
J19XD6	12	108.0	110.0	4.57	58.4	18.1	1.2	17.6	52.9
J19XD7	14	107.5	109.5	4.07	32.6	10.7	0.6	9.8	29.5
J19XD8	16	107.0	109.0	4.08	30.2	9.1	0.6	8.5	25.5
J19XD9	18	106.0	108.0	3.91	18.2	6.1	0.6	6.2	18.6
J19FX0	20	105.5	107.5	4.12	16.7	5.3	0.3	5.5	16.4
J19FX1	22	105.0	107.0	3.99	22.4	6.9	0.4	7.4	22.2
J19FX2	24	104.0	106.0	4.00	31.6	9.8	0.3	8.7	25.9
J19FX3	26	103.5	105.5	4.04	76.5	22.1	1.7	20.7	62.3
J19FX4	27	103.0	105.0	3.97	73.7	22.2	1.9	22.0	66.3

Reference: NAVD88 = North America Vertical Datum of 1988.

Notes: Table data are from Peterson, 2010, “Uranium in Sediment from FS-2 Test Pit, 618-1 Burial Ground Excavation.”

Total uranium in solids was measured by method UTOT_KPA; isotopic uranium was measured by method UISO_PLATE_AEA and included uranium-233/234, uranium-235, and uranium-238; pH was measured using SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V, method 9045.

This page intentionally left blank.

Appendix C

Well Information and Geologic Contacts Data Tables

This page intentionally left blank.

Table C-1. Geologic Framework Model Well Names, Locations, Maximum Drill Depths, and Surface Elevations

Well Name	X Coordinate	Y Coordinate	Z Coordinate	Depth	Dip	Azimuth
399-1-1	594360	116588.8	114.9648	25.4696	90	0
399-1-10A	594346.5	116734	114.202	15.716	90	0
399-1-10B	594350.8	116728.8	114.4801	38.2712	90	0
399-1-11	594109.8	116660.2	115.2807	16.41704	90	0
399-1-12	594040.2	116548.5	117.3435	21.812	90	0
399-1-13A	593910.4	116557.3	118.5868	19.0688	90	0
399-1-13B	593909.6	116549.2	118.6545	39.73424	90	0
399-1-14A	593901.1	116778.2	116.8506	17.24	90	0
399-1-14B	593910.9	116779.1	116.782	38.4236	90	0
399-1-16A	594318.1	116414.2	116.8101	16.478	90	0
399-1-16B	594324.7	116411.6	116.8682	37.9664	90	0
399-1-16C	594312	116410.4	116.9818	56.2544	90	0
399-1-16D	594315.5	116404.6	117.0962	57.4736	90	0
399-1-17A	594112.9	116413.8	115.2667	14.4968	90	0
399-1-17B	594104.8	116417.7	115.5572	37.052	90	0
399-1-17C	594104.7	116409.2	115.5987	54.7304	90	0
399-1-2	594082.4	116329.5	117.9911	32.7848	90	0
399-1-20	594257.3	116339.6	117.7588	58.9976	90	0
399-1-21B	594157.2	116176.8	116.6382	37.052	90	0
399-1-23	594113.5	116453.2	115.3971	37.3568	90	0
399-1-26	594108.3	116456.2	115.1657	17.3924	90	0
399-1-3	594254.2	116334.9	117.7332	33.242	90	0
399-1-33	594113.3	116430.5	115.6783	15.0208	90	0
399-1-34	594101.2	116433.8	115.6977	17.3924	90	0
399-1-35	594122.3	116432.1	115.6916	16.9352	90	0
399-1-38	594117.4	116435.4	115.5915	16.84376	90	0
399-1-4	594020.6	116699.6	116.6163	32.7848	90	0
399-1-5	594111.7	116552.1	114.6323	15.716	90	0
399-1-54	594273.9	116643	114.5853	36.1188	90	0
399-1-55	594152.3	116487.3	114.6316	34.4424	90	0
399-1-56	594090.9	116725.3	114.2395	37.6428	90	0
399-1-57	594382	116353.7	114.6343	36.1188	90	0
399-1-58	593910.8	116352.6	119.5085	38.4048	90	0
399-1-59	594077.4	116135.9	120.5487	45.32376	90	0
399-1-65	594164.3	116481.2	114.6368	15.14856	90	0
399-1-66	594168.5	116505	114.6305	15.24	90	0
399-1-67	594162.4	116481.6	114.5984	12.4054	90	0

Table C-1. Geologic Framework Model Well Names, Locations, Maximum Drill Depths, and Surface Elevations

Well Name	X Coordinate	Y Coordinate	Z Coordinate	Depth	Dip	Azimuth
399-1-68	594166.8	116527	114.4458	12.58824	90	0
399-1-69	594169.7	116505.1	114.6575	12.3444	90	0
399-1-7	594260.1	116335.1	117.7757	24.86	90	0
399-1-70	594125.1	116508.9	114.5195	14.9047	90	0
399-1-71	594126.3	116508.9	114.51	35.052	90	0
399-1-72	594080.3	116494.2	114.8809	14.66088	90	0
399-1-73	594081.7	116494.2	114.889	12.3444	90	0
399-1-74	594097.7	116475.3	114.8288	15.3924	90	0
399-1-75	594098.7	116475.6	114.8446	12.3444	90	0
399-1-76	594117.8	116460.6	115.1655	15.49908	90	0
399-1-77	594118.7	116460.5	115.174	12.24382	90	0
399-1-78	594153.8	116463.2	114.8702	15.27048	90	0
399-1-79	594154.8	116463.1	114.8595	12.192	90	0
399-1-8	594257.8	116329.6	117.7526	34.6136	90	0
399-1-80	594089.7	116454.9	114.8724	15.3924	90	0
399-1-81	594090.9	116454.9	114.8952	12.40536	90	0
399-1-82	594151.8	116427.4	115.06	15.3924	90	0
399-1-83	594152.5	116427.4	115.06	12.1859	90	0
399-1-84	594174.5	116451.4	114.9117	18.288	90	0
399-1-85	594175.5	116451.4	114.9033	12.3444	90	0
399-1-86	594137.8	116478.7	114.8187	15.17904	90	0
399-1-87	594138.6	116478.8	114.8394	12.192	90	0
399-1-89	594087.2	116467.5	114.8606	15.24	90	0
399-1-9	594254	116330.4	117.728	57.1688	90	0
399-1-90	594102.7	116478.2	114.8546	15.24	90	0
399-1-91	594118.2	116489.1	114.8083	15.29182	90	0
399-1-92	594132.8	116466.6	115.0367	15.10284	90	0
399-1-93	594117	116470.8	115.0163	15.3924	90	0
399-1-94	594130.8	116479.7	114.9393	15.29182	90	0
399-1-95	594143.9	116488.4	114.7328	15.3924	90	0
399-1-96	594146.2	116473.8	114.8872	15.05102	90	0
399-1-97	594157.9	116480.2	114.4927	15.24	90	0
399-2-1	594467.2	116121.2	114.4859	25.4696	90	0
399-2-10	594234.6	116094.5	115.0018	22.574	90	0
399-2-11	594236.3	116074.5	115.0198	21.23288	90	0
399-2-12	594252.5	116086	114.9006	21.812	90	0
399-2-13	594237.2	116064.6	115.0427	21.08048	90	0

Table C-1. Geologic Framework Model Well Names, Locations, Maximum Drill Depths, and Surface Elevations

Well Name	X Coordinate	Y Coordinate	Z Coordinate	Depth	Dip	Azimuth
399-2-14	594245.3	116070.2	114.9721	20.288	90	0
399-2-15	594253.3	116076	114.8933	20.7452	90	0
399-2-16	594261.6	116081.9	114.8862	20.8976	90	0
399-2-17	594245.1	116060.3	115.0073	21.2024	90	0
399-2-18	594254.2	116066.1	114.9096	21.812	90	0
399-2-19	594262.7	116071.8	114.8948	20.53184	90	0
399-2-2	594385.7	116282.6	114.987	21.812	90	0
399-2-20	594270.6	116077.6	114.8935	20.8976	90	0
399-2-21	594263.3	116061.9	114.9121	20.80616	90	0
399-2-22	594279.7	116073.4	114.9422	21.812	90	0
399-2-23	594272.3	116057.6	114.9105	20.288	90	0
399-2-24	594280.7	116063.3	114.9038	22.574	90	0
399-2-25	594269.2	116088.1	114.8715	54.1208	90	0
399-2-26	594244	116081	114.952	20.92808	90	0
399-2-27	594244.1	116078.2	114.9676	21.3548	90	0
399-2-28	594246.4	116080	114.9319	21.812	90	0
399-2-29	594270.8	116068.1	114.9064	20.7452	90	0
399-2-3	594377.4	116220.5	115.0428	21.812	90	0
399-2-30	594271.2	116065.5	114.9072	21.5072	90	0
399-2-31	594273.6	116067.2	114.91	21.2024	90	0
399-2-32	594284.6	116195.1	114.7519	36.8808	90	0
399-2-5	594287.7	116068.8	114.9128	41.9288	90	0
399-2-7	594235.2	116084.5	115.0642	20.8976	90	0
399-2-8	594243.5	116090.3	114.9766	20.288	90	0
399-2-9	594237.7	116089.7	115.0128	21.812	90	0
399-3-1	594481.3	116008	117.8439	25.7744	90	0
399-3-18	594464.7	116020	117.6155	41.9288	90	0
399-3-19	594071.9	116030.2	120.7012	33.5468	90	0
399-3-23	594237.9	116054.7	115.0415	21.812	90	0
399-3-24	594238.8	116044.6	115.0263	21.812	90	0
399-3-25	594255.1	116056	114.925	21.812	90	0
399-3-26	594239.8	116034.8	114.9963	22.1168	90	0
399-3-27	594247.9	116040.7	115.0011	20.8976	90	0
399-3-28	594256.1	116046	114.9311	21.6596	90	0
399-3-29	594264.3	116052	114.9796	21.5072	90	0
399-3-30	594246.3	116051.4	115.0074	20.7452	90	0
399-3-31	594246.7	116048.3	115.0085	21.2024	90	0

Table C-1. Geologic Framework Model Well Names, Locations, Maximum Drill Depths, and Surface Elevations

Well Name	X Coordinate	Y Coordinate	Z Coordinate	Depth	Dip	Azimuth
399-3-32	594249.1	116050.1	114.9859	21.2024	90	0
399-3-33	594500.7	115966.5	118.3221	41.148	90	0
399-8-3	593626.1	116683.6	120.4763	33.0896	90	0
C8933	594113.1	116440.5	115.6402	12.10056	90	0
C9580	594088.7	116456.4	114.8352	10.668	90	0
C9581	594116.8	116462.1	115.1454	10.668	90	0
C9582	594161.1	116484	114.5966	10.668	90	0
North Pond Pit 1	594351.8	116435.4	114.4814	6.7056	90	0
North Pond Pit 2	594156.8	116387.4	114.8828	3.6576	90	0
South Pond Pit 1	594400.8	116127	114.5267	6.7056	90	0
South Pond Pit 2	594236.7	116021.7	114.9242	6.7056	90	0

Note: All coordinates, elevations, and depths in this table are in meters. The vertical datum is from NAVD88, *North American Vertical Datum of 1988*, and the horizontal coordinate system Washington State Plane (NAD83, *North American Datum of 1983*). Geologic units (indicated in Appendix D [Tables D-3 and D-3]) are explained in Section 2.1 in the main text of this calculation.

Table C-2. Detailed Vadose Zone Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-1-17B	0	1.524	Hf S	37.052
399-1-17B	1.524	16.764	Hf SG	37.052
399-1-17B	16.764	37.052	Hf SSG	37.052
399-1-17C	0	1.2192	Hf S	54.7304
399-1-17C	1.2192	6.096	Hf SG	54.7304
399-1-17C	6.096	54.7304	Hf SSG	54.7304
399-1-23	0	0.9144	Hf S	37.3568
399-1-26	0	1.2192	Hf S	17.3924
399-1-26	1.2192	5.6388	Hf SG	17.3924
399-1-26	5.6388	17.3924	Hf SSG	17.3924
399-1-33	0	1.3716	Hf S	14.02
399-1-33	1.3716	7.0104	Hf SSG	14.02
399-1-33	7.0104	16.0208	Hf G	16.0208
399-1-34	0	1.92024	Hf S	17.3924

Table C-2. Detailed Vadose Zone Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-1-34	1.92024	8.9916	Hf SG	17.3924
399-1-34	8.9916	17.3924	Hf SSG	17.3924
399-1-35	0	1.524	Hf S	16.9352
399-1-54	0	8.8392	Hf SG	36.1188
399-1-55	0	11.2776	Hf SG	34.4424
399-1-55	11.2776	12.4968	Hf SSG	34.4424
399-1-55	12.4968	34.4324	Hf G	34.4424
399-1-56	0	5.0292	Hf S	37.6428
399-1-56	5.0292	12.192	Hf SG	37.6428
399-1-57	0	11.5824	Hf SG	36.1188
399-1-57	11.5824	36.1088	Hf G	36.1188
399-1-58	0	1.8288	Hf S	38.4048
399-1-58	1.8288	7.0104	Hf SG	38.4048
399-1-7	0	24.86	Hf SG	24.86
399-1-8	0	34.6136	Hf SG	34.6136
399-1-9	0	57.1688	Hf SG	35.052
399-2-2	0	7.62	Hf SG	35.052
399-2-2	7.62	21.812	Hf SSG	35.052
399-2-3	0	21.812	Hf SG	35.052
399-1-59	0	5.1816	Hf SSG	38.4048
399-2-32	0	4.2672	Hf SG	35.052
399-2-32	4.2672	36.8808	Hf SSG	35.052
399-3-33	0	5.4864	Hf S	35.052
399-3-33	5.4864	41.148	Hf SSG	35.052
399-8-3	0	3.3528	Hf S	33.0896
399-8-3	3.3528	33.0896	Hf SG	33.0896
North Pond Pit-1	0	6.7056	Hf SSG	35.052
North Pond Pit-2	0	3.6576	Hf SSG	35.052
South Pond Pit-1	0	6.7056	Hf SSG	35.052
South Pond Pit-2	0	6.7056	Hf SSG	35.052
399-1-2	0	2.1336	Hf S	54.7304
399-1-2	2.1336	30.7848	Hf SG	54.7304
399-1-5	0	1.8288	Hf S	15.716
399-1-5	1.8288	14.3256	Hf SG	15.716
399-1-12	0	6.096	Hf S	19.812
399-1-12	6.096	9.144	Hf SG	19.812

Table C-2. Detailed Vadose Zone Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-1-12	9.144	10.668	Hf S2	19.812
399-1-12	10.668	19.812	Hf SSG	19.812
399-1-20	0	56.9976	Hf SG	54.7304
399-1-16B	10.668	13.716	Hf S3	35.2044
399-1-16B	13.716	35.2044	Hf SSG	35.2044
399-1-16C	9.144	12.192	Hf S3	54.2544
399-1-13A	0	4.2672	Hf S	17.0688
399-1-13A	4.2672	10.3632	Hf SG	17.0688
399-1-13A	10.3632	17.0688	Hf SSG	17.0688
399-1-21B	0	2.7432	Hf S	35.052
399-1-54	8.8392	36.1088	Hf SSG	36.1188
399-1-56	12.192	37.6328	Hf SSG	37.6428
399-1-58	7.0104	38.3948	Hf SSG	38.4048
399-1-65	0	3.47472	Hf SG	15.14856
399-1-65	3.47472	13.5636	Hf SSG	15.14856
399-1-65	13.5636	15.14856	Hf S2	15.14856
399-1-66	0	15.24	Hf SSG	15.24
399-1-69	0	3.6576	Hf SG	12.3444
399-1-69	3.6576	10.42416	Hf SSG	12.3444
399-1-69	10.42416	12.3444	Hf G	12.3444
399-1-70	0	14.9047	Hf SSG	14.9047
399-1-71	0	12.192	Hf SSG	12.192
399-1-72	0	1.2192	Hf SG	14.66088
399-1-72	1.2192	14.66088	Hf SSG	14.66088
399-1-73	0	1.524	Hf SG	12.3444
399-1-73	1.524	9.144	Hf SSG	12.3444
399-1-73	9.144	9.4488	Silt	12.3444
399-1-73	9.4488	12.3444	Hf SSG	12.3444
399-1-74	0	4.2672	Hf SG	15.3924
399-1-74	4.2672	15.3924	Hf SSG	15.3924
399-1-75	0	4.2672	Hf SG	12.3444
399-1-75	4.2672	12.3444	Hf SSG	12.3444
399-1-76	0	2.5908	Hf SG	15.49908
399-1-76	2.5908	15.49908	Hf SSG	15.49908
399-1-77	0	1.2192	Hf SG	12.24382
399-1-77	1.2192	12.24382	Hf SSG	12.24382
399-1-78	0	12.4968	Hf SSG	15.27048

Table C-2. Detailed Vadose Zone Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-1-78	12.4968	14.0208	Silt	15.27048
399-1-78	14.0208	15.27048	Hf SSG	15.27048
399-1-79	0	12.192	Hf SSG	12.192
399-1-80	0	2.98704	Hf SG	15.3924
399-1-80	2.98704	15.3924	Hf SSG	15.3924
399-1-81	0	2.7432	Hf SG	12.40536
399-1-81	2.7432	12.40536	Hf SSG	12.40536
399-1-82	0	0.9144	Hf S	15.3924
399-1-83	0	0.97536	Hf S	12.1859
399-1-83	0.97536	5.1816	Hf SG	12.1859
399-1-83	5.1816	8.5344	Hf S4	12.1859
399-1-83	8.5344	12.1859	Hf SSG	12.1859
399-1-84	0	12.4968	Hf SSG	18.288
399-1-84	12.4968	14.0208	Silt	18.288
399-1-84	14.0208	16.1544	Hf SSG	18.288
399-1-84	16.1544	18.288	Ringold Formation Member of Wooded Island, unit E	18.288
399-1-86	0	15.17904	Hf SSG	15.17904
399-1-87	0	12.192	Hf SSG	12.192
399-1-89	0	15.24	Hf SSG	15.24
399-1-90	0	15.24	Hf SSG	15.24
399-1-91	0	10.0584	Hf SSG	15.29182
399-1-91	10.0584	10.668	Silt	15.29182
399-1-91	10.668	15.29182	Hf SSG	15.29182
399-1-92	0	0.97536	Hf S	15.10284
399-1-92	0.97536	15.10284	Hf SSG	15.10284
399-1-93	0	1.0668	Hf S	15.3924
399-1-93	1.0668	6.096	Hf SG	15.3924
399-1-93	6.096	9	Hf SSG	15.3924
399-1-93	9	11	Silt	15.3924
399-1-93	11	15.3924	Hf G	15.3924
399-1-94	0	1.09728	Hf S	15.29182
399-1-94	1.09728	15.29182	Hf SSG	15.29182
399-1-95	0	15.3924	Hf SSG	15.3924
399-1-96	0	14.6304	Hf SSG	15.05102
399-1-96	14.6304	15.05102	Hf S2	15.05102
399-1-97	0	15.24	Hf SSG	15.24

Table C-2. Detailed Vadose Zone Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-1-85	0	12.3444	Hf SSG	12.3444
399-1-59	23.5	38.4048	Ringold Formation Member of Wooded Island, unit E	38.4048
399-1-17A	0	6.096	Hf SG	14.4968
399-1-33	7.0104	11.8872	Hf SG	14.02
399-1-33	11.8872	13.8684	Hf SSG	14.02
399-1-4	0	1.8288	Hf S	32.7848
399-1-4	1.8288	32.7848	Hf SSG	32.7848
399-1-59	8.8392	23.5	Hf SSG	38.4048
399-1-67	0	8.2296	Hf SG	12.4054
399-1-16B	0	3.048	Hf SG	35.2044
399-1-16B	3.048	10.668	Hf SSG	35.2044
399-1-21B	2.7432	6.096	Hf SG	35.052
399-1-21B	6.096	7.4676	Hf S2	35.052
399-1-59	5.1816	8.8392	Hf S2	38.4048
399-1-23	0.9144	9.7536	Hf SSG	37.3568
399-1-35	1.524	6.096	Hf SSG	16.9352
C8933	0	10.88136	Hf SG	12.10056
399-1-16C	0	4.572	Hf S	54.2544
399-1-16C	4.572	9.144	Hf SG	54.2544
399-1-16C	12.192	13.716	Hf SSG	54.2544
399-1-67	8.2296	12.4054	Hf SSG	12.4054
399-1-68	0	12.5882	Hf SG	12.5882
399-1-17A	6.096	8.8392	Hf SSG	14.4968
399-1-17A	8.8392	12.192	Hf S4	14.4968
399-1-82	0.9144	6.03504	Hf SG	15.3924
399-1-82	6.03504	8.6868	Hf S4	15.3924
399-1-82	8.6868	15.3924	Hf SSG	15.3924

Hf = Hanford formation; S = Sand, SG = Sandy Gravel; SSG = Silty Sandy Gravel

Note: All coordinates, elevations, and depths in this table are in meters. The vertical datum is from NAVD88, *North American Vertical Datum of 1988*, and the horizontal coordinate system Washington State Plane (NAD83, *North American Datum of 1983*). Geologic units (indicated in Appendix D [Tables D-3 and D-3]) are explained in Section 2.1 in the main text of this calculation.

Table C-3. Lower Suprabasalt Sediment Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-1-10B	0	16.9672	Hanford	36.2712

Table C-3. Lower Suprabasalt Sediment Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-1-10B	16.972	34.437	Ringold E	36.2712
399-1-10B	34.437	35.437	Ringold LM	36.2712
399-1-13A	0	15.84	Hanford	17.0688
399-1-13B	0	18.82	Hanford	37.73424
399-1-13B	18.82	35.351	Ringold E	37.73424
399-1-16B	0	15.844	Hanford	35.9664
399-1-16B	15.844	34.741	Ringold E	35.9664
399-1-16C	0	16.453	Hanford	54.2544
399-1-16C	16.453	35.046	Ringold E	54.2544
399-1-16C	35.046	53.334	Ringold LM	54.2544
399-1-16C	53.334	54.334	Basalt	54.2544
399-1-16D	0	16.453	Hanford	55.4736
399-1-16D	16.453	33.522	Ringold E	55.4736
399-1-16D	33.522	54.858	Ringold LM	55.4736
399-1-16D	54.858	55.858	Basalt	55.4736
399-1-17B	0	15.539	Hanford	35.052
399-1-17B	15.539	32.913	Ringold E	35.052
399-1-17C	0	15.539	Hanford	52.7304
399-1-17C	15.539	35.046	Ringold E	52.7304
399-1-17C	35.046	50.591	Ringold LM	52.7304
399-1-17C	50.591	51.591	Basalt	52.7304
399-1-2	0	18.343	Hanford	30.7848
399-1-20	0	15.234	Hanford	56.9976
399-1-20	15.234	36.113	Ringold E	56.9976
399-1-20	36.113	53.639	Ringold LM	56.9976
399-1-20	53.639	54.639	Basalt	56.9976
399-1-21B	0	20.873	Hanford	35.052
399-1-21B	20.873	32.913	Ringold E	35.052
399-1-23	16.149	30.474	Ringold E	35.3568
399-1-8	0	14.015	Hanford	32.6136
399-1-8	14.015	31.998	Ringold E	32.6136
399-1-9	0	15.234	Hanford	55.1688
399-1-9	15.234	35.046	Ringold E	55.1688
399-1-9	35.046	51.81	Ringold LM	55.1688
399-1-9	51.81	54.553	Ringold A	55.1688
399-1-9	54.553	55.553	Basalt	55.1688
399-2-1	0	14.32	Hanford	23.4696
399-2-11	0	17.063	Hanford	19.23288

Table C-3. Lower Suprabasalt Sediment Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-2-12	0	19.806	Hanford	19.812
399-2-13	0	16.911	Hanford	19.08048
399-2-15	0	16.758	Hanford	18.7452
399-2-16	0	16.606	Hanford	18.8976
399-2-18	0	17.368	Hanford	19.812
399-2-19	0	16.454	Hanford	18.53184
399-2-2	0	18.282	Hanford	19.812
399-2-20	0	17.063	Hanford	18.8976
399-2-21	0	16.758	Hanford	18.80616
399-2-22	0	17.52	Hanford	19.812
399-2-24	0	17.673	Hanford	20.574
399-2-25	0	17.673	Hanford	52.1208
399-2-25	17.673	37.18	Ringold E	52.1208
399-2-25	37.18	49.677	Ringold LM	52.1208
399-2-25	49.677	50.677	Basalt	52.1208
399-2-26	0	17.673	Hanford	18.92808
399-2-29	0	16.911	Hanford	18.7452
399-2-30	0	16.911	Hanford	19.5072
399-2-31	0	17.063	Hanford	19.2024
399-2-5	0	17.063	Hanford	39.9288
399-2-5	17.063	38.094	Ringold E	39.9288
399-2-7	0	16.454	Hanford	18.8976
399-3-18	0	14.015	Hanford	39.9288
399-3-18	14.015	38.399	Ringold E	39.9288
399-3-23	0	16.454	Hanford	19.812
399-3-24	0	16.149	Hanford	19.812
399-3-25	0	17.368	Hanford	19.812
399-3-26	0	15.844	Hanford	20.1168
399-3-27	0	15.539	Hanford	18.8976
399-3-28	0	17.063	Hanford	19.6596
399-3-29	0	15.996	Hanford	19.5072
399-3-30	0	16.911	Hanford	18.7452
399-3-31	0	16.911	Hanford	19.2024
399-8-3	17.977	26.817	Ringold E	31.0896
399-1-14B	0	14.325	Hanford	36.4236
399-1-14B	14.325	33.069	Ringold E	36.4236
399-1-14B	33.069	36.4236	Ringold LM	36.4236
399-1-4	0	13.715	Hanford	30.7848

Table C-3. Lower Suprabasalt Sediment Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-1-4	13.715	30.7848	Ringold E	30.7848
399-1-1	0	23.4696	Hanford	23.4696
399-1-1	23.4696	24.4696	Ringold E	23.4696
399-1-10A	0	1.524	Fill	13.716
399-1-10A	1.524	13.716	Hanford	13.716
399-1-10A	13.716	14.716	Ringold E	13.716
399-1-11	0	12.8016	Hanford	14.41704
399-1-11	12.8016	15.41704	Ringold E	14.41704
399-1-12	0	3.3528	Fill	19.812
399-1-12	3.3528	14.05128	Hanford	19.812
399-1-12	14.05128	20.812	Ringold E	19.812
399-1-14A	0	0.762	Fill	15.24
399-1-14A	0.762	14.3256	Hanford	15.24
399-1-16A	0	1.2192	Fill	14.478
399-1-16A	1.2192	14.478	Hanford	14.478
399-1-16A	14.478	15.478	Ringold E	14.478
399-1-17A	0	12.4968	Hanford	12.4968
399-1-17A	12.4968	13.4968	Ringold E	12.4968
399-1-26	0	14.7828	Hanford	15.3924
399-1-26	14.7828	16.3924	Ringold E	15.3924
399-1-33	0	13.1064	Hanford	14.0208
399-1-33	13.1064	15.0208	Ringold E	14.0208
399-1-34	0	11.8872	Hanford	15.3924
399-1-34	11.8872	16.3924	Ringold E	15.3924
399-1-35	0	11.8872	Hanford	14.9352
399-1-35	11.8872	15.9352	Ringold E	14.9352
399-1-38	0	15.84376	Hanford	14.84376
399-3-1	0	2.4384	Fill	23.7744
399-3-1	2.4384	14.3256	Hanford	23.7744
399-3-1	14.3256	24.7744	Ringold E	23.7744
399-1-14A	14.3256	16.24	Ringold E	15.24
399-1-5	0	1.83	Fill	13.716
399-1-5	1.83	13.11	Hanford	13.716
399-1-5	13.11	13.716	Ringold E	13.716
399-3-32	0	3.01	Fill	19.2024
399-3-32	3.01	17.063	Hanford	19.2024
399-3-32	17.063	19.2024	Ringold E	19.2024
399-2-23	0	4.88	Fill	18.288

Table C-3. Lower Suprabasalt Sediment Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-2-23	4.88	16.46	Hanford	18.288
399-2-23	16.46	18.288	Ringold E	18.288
399-2-27	0	3.05	Fill	19.3548
399-2-27	3.05	15.54	Hanford	19.3548
399-2-27	15.54	19.3548	Ringold E	19.3548
399-3-19	0	3.96	Fill	31.5468
399-3-19	3.96	25.3	Hanford	31.5468
399-1-13B	35.351	37.73424	Ringold LM	37.73424
399-1-2	18.343	30.7848	Ringold E	30.7848
399-1-21B	32.913	35.052	Ringold LM	35.052
399-1-23	0	0.304	Fill	35.3568
399-1-23	0.304	16.149	Hanford	35.3568
399-1-23	30.474	35.3568	Ringold LM	35.3568
399-1-3	0	3.35	Fill	31.242
399-1-3	3.35	13.405	Hanford	31.242
399-1-3	13.405	32.242	Ringold E	31.242
399-1-7	0	15.85	Hanford	22.86
399-1-7	15.85	22.86	Ringold E	22.86
399-2-1	14.33	23.4696	Ringold E	23.4696
399-2-10	0	3.05	Fill	20.574
399-2-10	3.05	18.13	Hanford	20.574
399-2-10	18.13	20.574	Ringold E	20.574
399-2-14	0	3.05	Fill	18.288
399-2-14	3.05	16.606	Hanford	18.288
399-2-14	16.606	18.288	Ringold E	18.288
399-2-17	0	3.05	Fill	19.2024
399-2-17	3.05	16.911	Hanford	19.2024
399-2-17	16.911	19.2024	Ringold E	19.2024
399-2-2	18.282	19.812	Ringold E	19.812
399-2-28	0	2.44	Fill	19.812
399-2-28	2.44	17.216	Hanford	19.812
399-2-28	17.216	19.812	Ringold E	19.812
399-2-3	0	18.29	Hanford	19.812
399-2-3	18.29	19.812	Ringold E	19.812
399-2-8	0	2.74	Fill	18.288
399-2-8	2.74	16.149	Hanford	18.288
399-2-8	16.149	18.288	Ringold E	18.288
399-2-9	0	2.74	Fill	19.812

Table C-3. Lower Suprabasalt Sediment Geologic Framework Model Lithology

Well Name	From Depth	To Depth	Lithology	Total Depth
399-2-9	2.74	18.13	Hanford	19.812
399-2-9	18.13	19.812	Ringold E	19.812
399-8-3	0	2.13	Fill	31.0896
399-8-3	26.817	31.0896	Ringold LM	31.0896
399-3-19	25.3	31.5468	Ringold E	31.5468
399-8-3	2.13	17.977	Hanford	31.0896

Note: All coordinates, elevations, and depths in this table are in meters. The vertical datum is from NAVD88, North American Vertical Datum of 1988, and the horizontal coordinate system Washington State Plane (NAD83, North American Datum of 1983). Geologic units (indicated in Appendix D [Tables D-3 and D-3]) are explained in Section 2.1 in the main text of this calculation.

Table C-4. Wells within Hanford Formation Detailed Vadose Geologic Framework Model Domain Omitted from Interpolation

Wells Not in Hanford Formation Detailed Vadose Model			
B8765	399-1-19	399-1-14A	399-1-1
399-1-63	399-1-11	399-1-21A	399-2-19
399-2-27	399-3-1	399-3-30	399-2-39
399-2-25	399-2-5	399-3-31	399-2-40
399-2-26	399-1-42	399-1-29	399-3-35
399-2-29	399-1-43	399-1-51	
399-2-31	399-1-44	399-1-52	
399-3-29	399-1-24	399-1-10B	
399-2-24	399-2-37	399-1-13B	
C5387	399-3-36	399-1-14B	
C5388	B8767	399-1-16D	
399-2-10	B8768	399-2-20	
399-2-11	399-1-22	399-3-24	
399-2-16	399-3-32	399-3-25	
399-3-23	399-2-30	399-1-40	
399-1-31	399-3-18	399-2-38	
399-3-34	399-1-27	B8761	
C6341	399-1-28	B8766	
C6342	399-1-37	399-2-28	
C6343	399-3-19	399-1-39	
C6345	399-1-3	399-1-41	
C6346	399-1-45	399-2-23	
399-2-18	399-2-4	C3961	
399-2-21	399-2-12	B8762	

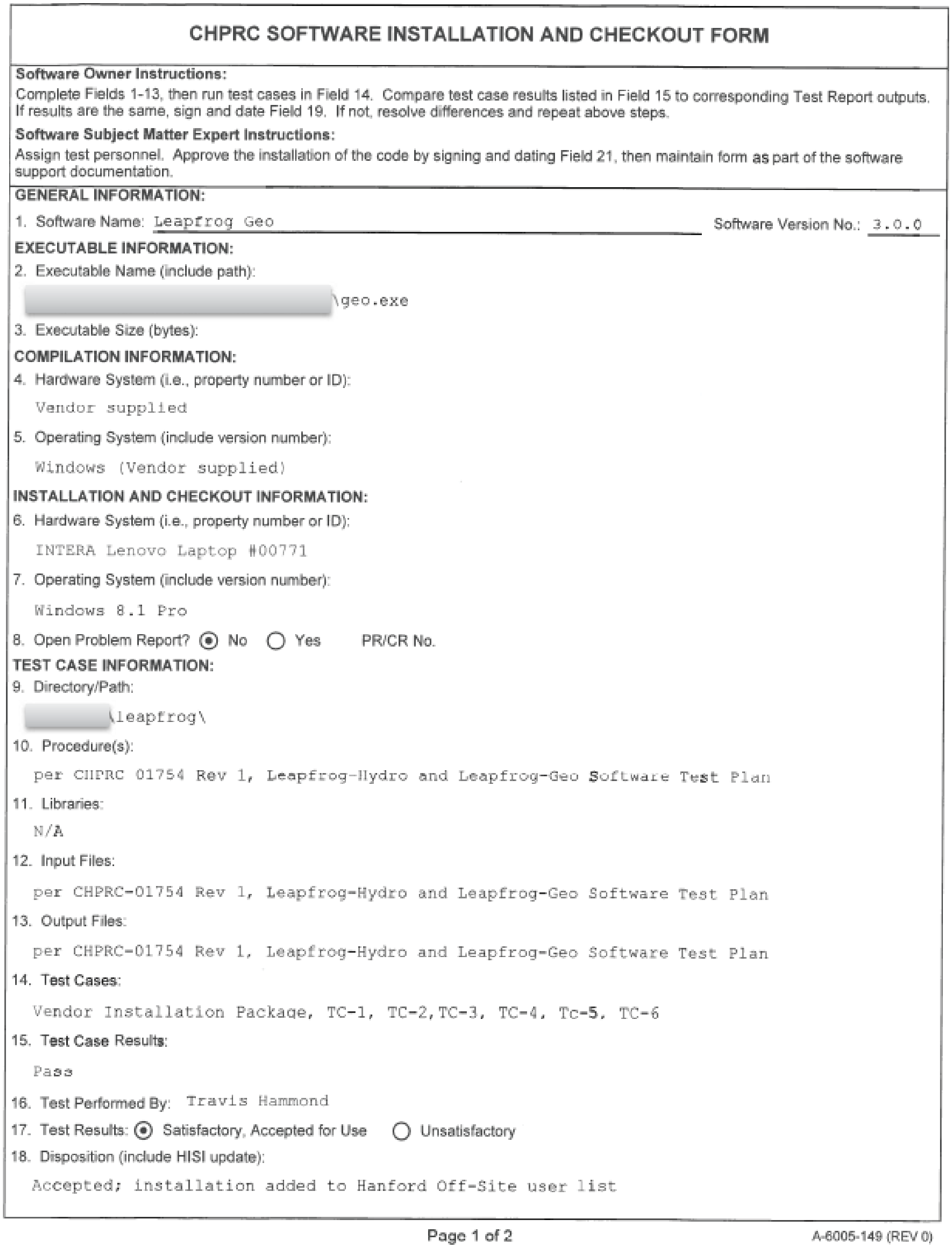
Table C-4. Wells within Hanford Formation Detailed Vadose Geologic Framework Model Domain Omitted from Interpolation

Wells Not in Hanford Formation Detailed Vadose Model		
399-2-22	399-2-13	B8763
399-1-61	399-2-14	B8764
399-1-62	399-2-15	B8769
399-1-46	399-1-38	B8770
399-1-47	399-2-1	C6344
399-1-48	399-1-60	399-3-37
399-1-49	399-2-33	399-1-36
399-1-50	399-1-53	399-1-64
399-2-34	C3962	C9581
399-2-36	399-2-6	C9580
399-2-35	399-2-7	C9582
399-3-26	399-2-8	C5389
399-3-27	399-2-9	399-2-17
399-3-28	399-1-25	399-1-30
399-1-16A	399-1-10A	399-1-32

Appendix D

Software Installation and Checkout Forms

This page intentionally left blank.



CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

Software Owner Instructions:

Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

Software Subject Matter Expert Instructions:

Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

GENERAL INFORMATION:

1. Software Name: Leapfrog Geo Software Version No.: 3.0.0

EXECUTABLE INFORMATION:

2. Executable Name (include path):

[redacted]\geo.exe

3. Executable Size (bytes):

COMPILATION INFORMATION:

4. Hardware System (i.e., property number or ID):

Vendor supplied

5. Operating System (include version number):

Windows (Vendor supplied)

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):

INTERA Lenovo Laptop #00771

7. Operating System (include version number):

Windows 8.1 Pro

8. Open Problem Report? ● No ○ Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:

[redacted]\leapfrog\

10. Procedure(s):

per CHPRC 01754 Rev 1, Leapfrog-Hydro and Leapfrog-Geo Software Test Plan

11. Libraries:

N/A

12. Input Files:

per CHPRC-01754 Rev 1, Leapfrog-Hydro and Leapfrog-Geo Software Test Plan

13. Output Files:

per CHPRC-01754 Rev 1, Leapfrog-Hydro and Leapfrog-Geo Software Test Plan

14. Test Cases:

Vendor Installation Package, TC-1, TC-2,TC-3, TC-4, Tc-5, TC-6

15. Test Case Results:

Pass

16. Test Performed By: Travis Hammond

17. Test Results: ● Satisfactory, Accepted for Use ○ Unsatisfactory

18. Disposition (include HISI update):

Accepted; installation added to Hanford Off-Site user list

Page 1 of 2 A-6005-149 (REV 0)

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: Leapfrog Geo Software Version No.: 3.0.0

Prepared By:

19. Software Owner (Signature) — WE Nichols (Print) — 4 JAN 2016 (Date)

20. Test Personnel:

Sign	Print	Date
	TB Hammond	12/16/15

Approved By:

21. Software SME (Signature) — N/R per SMP (Print) — Date

Page 2 of 2

A-6005-149 (REV 0)

Appendix E

Comparison of Model and Post-Remedy Results for Validation of Geologic Framework Model and Vadose Zone Uranium Distribution

This page intentionally left blank.

Terms

EAA	Enhanced Attenuation Area
GFM	geologic framework model
Hf	Hanford formation
S	Sand
SG	Sandy Gravel
SSG	Silty Sandy Gravel

This page intentionally left blank.

E1 Introduction

The existing geologic framework model (GFM) and vadose zone uranium models were completed using data from before the Stage A Enhanced Attenuation Area (EAA) polyphosphate remedy. In order to demonstrate that existing models perform in a manner that does not require alterations, comparisons were examined between the models and data from three boreholes drilled after the Stage A EAA polyphosphate remedy. The post-remedy boreholes were located next to pre-remedy borehole locations in an effort to obtain data at approximately the same locations as the pre-remedy samples were taken.

E1.1 Comparison of Geologic Sections

A comparison was made between data derived from the geologic logging in three boreholes drilled after the Stage A EAA remedy (PNNL-25420, *Analytical Data Report for Sediment Samples Collected from 300-FF-5: Boreholes C9580, C9581, and C9582*) and the elevations of geologic unit surfaces interpolated by the current GFM, which utilizes pre-remedy information. Table E-1 lists the elevations of the differentiated Hanford formation (Hf) units at the locations of the post-remedy boreholes for the GFM (modeled) versus the unit elevations as interpreted from borehole geologic logs. The following significant differences were encountered (also outlined in Table E-1):

- Hf S (sand) is present at two borehole locations (C9580 and C9582) in the GFM but is absent in post-remedy geologic logs.
- Hf SG (sandy gravel) is present in the GFM at the location of C9581 but is absent in the C9581 geologic log.
- A thin silt lens is present in the C9580 geologic log but is absent in the GFM at that location.
- The presence of significant differences between the elevation of the Hf SSG (silty sandy gravel) surface in the GFM at the locations of C9580 and C9582 and elevations of the Hf SSG in the geologic logs.

These differences do not warrant alteration of the GFM for the following reasons:

- Hf S unit present in the GFM at locations C9580 and C9582 is very thin (0.18 and 0.04 m, respectively), and its hydraulic properties are very similar to the underlying Hf SG. For example, Hf S has a hydraulic conductivity of 3.20 m/day, while Hf SG has a hydraulic conductivity of 2.85 m/day (PNNL-18564, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses: Fiscal Year 2008 Status Report*).
- Similarity in hydraulic properties of Hf S and Hf SG at C9581 do warrant updating the GFM.
- The silt lens, which is absent in the GFM at the location of C9580 but present in its geologic log, is too thin and its extents are too uncertain to have a significant impact in the site numerical model.
- Saturated hydraulic conductivities of Hf SG and underlying Hf SSG are the same (2.85 m/day [PNNL-18564]) in the site numerical model. Therefore, the differences in elevations of the Hf SSG surface in the GFM at the locations of C9580 and C9582 between elevations of that unit in the geologic logs do warrant alteration of the GFM.

The significance of the excised zone is that it might contain less uranium due its slightly lower silt content than adjacent sediments. However, hydraulic properties of the excision fill material (Hf sandy gravel) and Hf silty sandy gravel are similar.

Table E-1. Differences between Geologic Framework Model Surfaces and Post-Remedy Borehole Geologic Interpretation

Borehole	Evaluation	Hf S	Hf SG	Silt	Hf SSG	Total Depth
C9580	Modeled	114.86	114.68	--	112.43	101.47
	Interpreted	--	114.86	109.98	109.68	104.19
C9581	Modeled	115.09	114.28	--	111.54	101.41
	Interpreted	115.09	--	--	112.35	104.42
C9582	Modeled	114.59	114.55	--	104.64	101.46
	Interpreted	--	114.59	--	108.80	103.92

Note: Unit elevations are in meters above mean sea level, based on NAVD88 *North American Vertical Datum of 1988*.

E1.2 Vadose Zone Uranium Distribution Comparison

Depth discrete sampling for uranium analysis at one post-remedy borehole was compared to the uranium distribution modeled from the Stage A EAA pre-remedy information at the same location (Figure E-1).Comparison of the modeled uranium distribution and observed post-remedy total uranium concentrations at the post-remedy borehole locations showed significant differences at C9580 and C9581 and more similar results at C9852 (Figures E-2 through E-4).

At borehole locations C9580 and C9581, modeled uranium concentrations are considerably higher than observed concentrations. The reason for these large differences stem back to the data set used in the pre-remedy vadose zone uranium contamination distribution interpolation. To capture the full extent of the contamination, the use of pre-excavation data from samples dating back to 1991 collection from 300 Area cleanup verification packages was required. Pre-excavation Sample B01036, with total uranium value of 3,248.48 µg/g (converted from pCi/g), had a large impact on the model interpolation that resulted in the high concentration (>30 µg/g) uranium distribution to extend beyond the locations of C9580 and C9581 (Figures E-5 and E-6), which resulted in modeled concentrations largely exceeding post-remedy concentrations. The argument can be made that these results do not warrant altering the vadose uranium concentration distribution because the extents of the current pre-remedy distribution are a conservative estimate that lie well within the uncertainties of the model considering the relatively small uranium data set used for interpolation. Pre-remedy depth discrete sampling results from wells 399-1-80 and 399-1-76 that were used in the model also had low uranium concentrations similar to C9580 and C9581, respectively. Thus, it is unlikely that incorporating the post-remedy uranium sample data would have a significant impact on the vadose uranium contamination distribution extents (Figures E-2 through E-4).

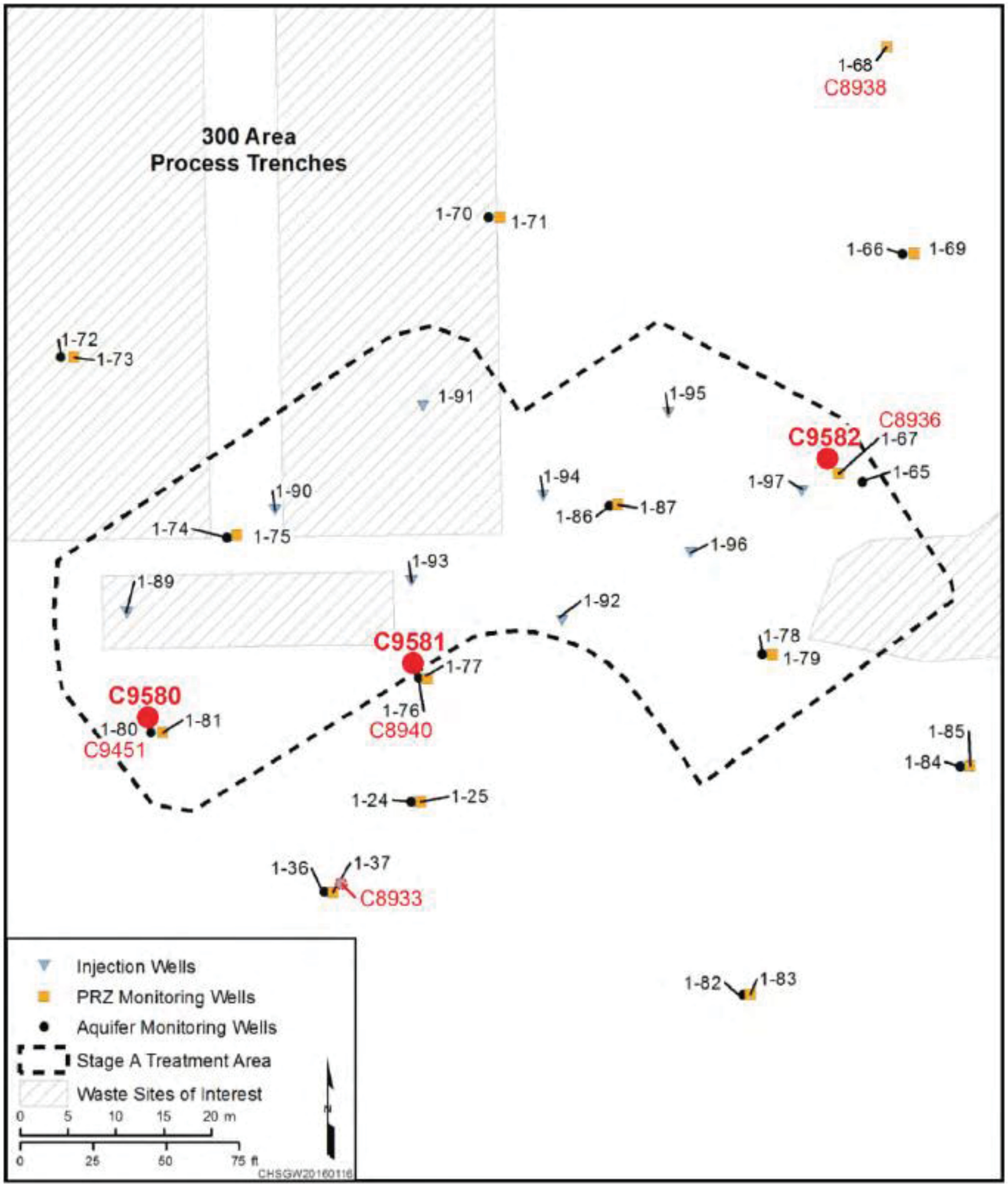
E2 References

DOE/RL-92-32, 1992, *Expedited Response Action Assessment for 316-5 Process Trenches*, Rev. 1, United States Department of Energy, Richland Operations Office, Richland, Washington.

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

PNNL-18564, 2009, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses: Fiscal Year 2008 Status Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18564.pdf.

PNNL-25420, 2016, *Analytical Data Report for Sediment Samples Collected from 300-FF-5: Boreholes C9580, C9581, and C9582*, Pacific Northwest National Laboratory, Richland, Washington.



Note: The post-remedy boreholes indicated include C9580, C9581, and C9582 (from PNNL-25420, *Analytical Data Report for Sediment Samples Collected from 300-FF-5: Boreholes C9580, C9581, and C9582*).

Figure E-1. Locations of Post Stage A EAA Remedy Boreholes

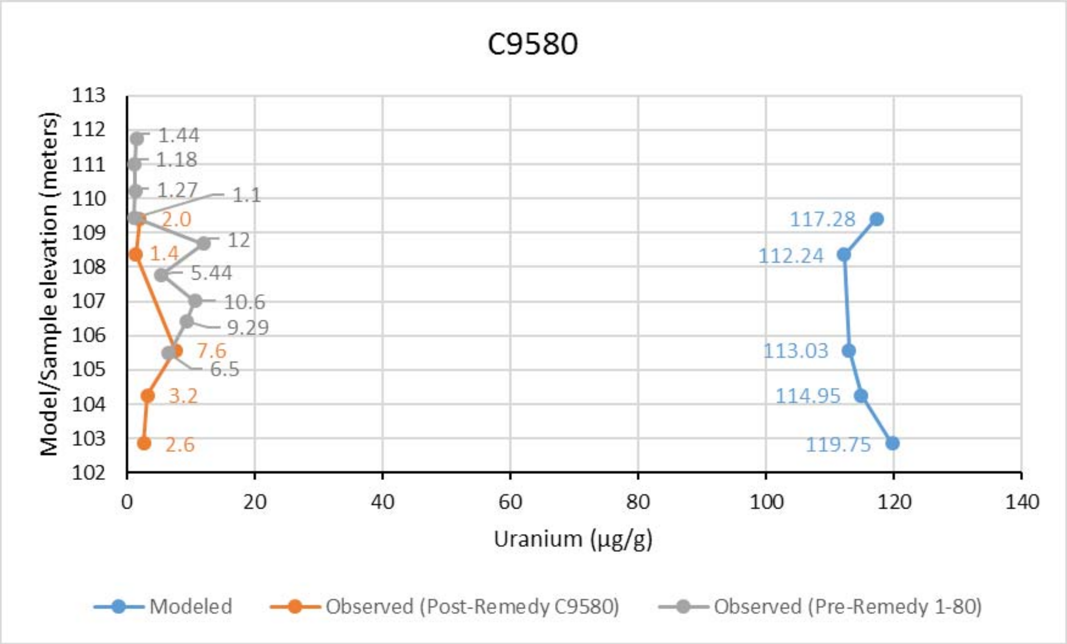


Figure E-2. Modeled and Observed Results Comparison at the Location of C9580

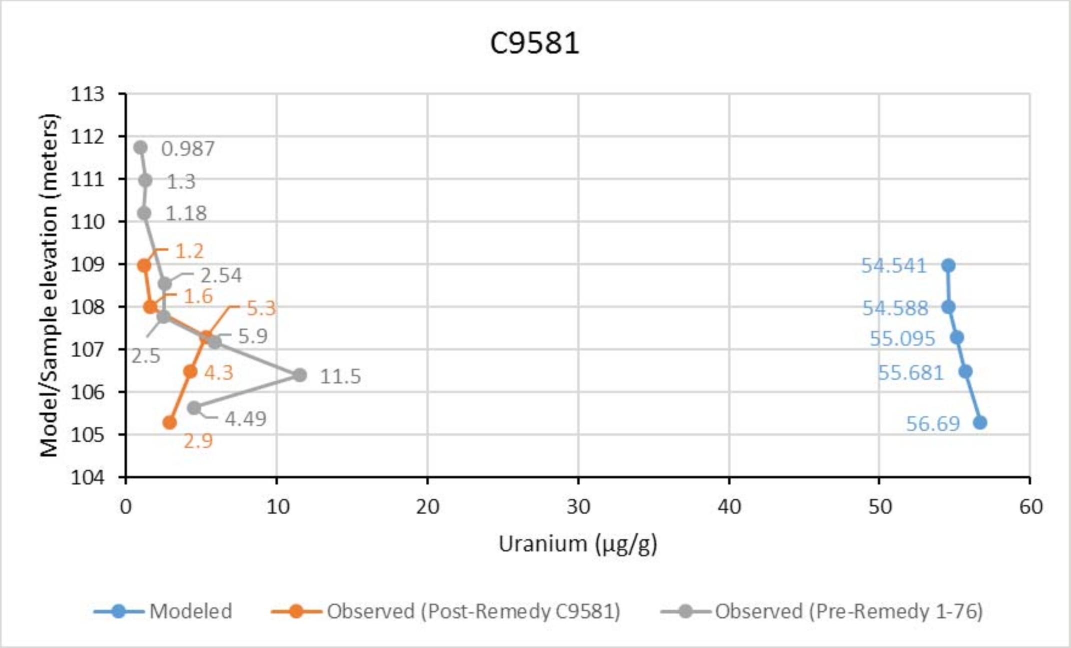


Figure E-3. Modeled and Observed Results Comparison at the Location of C9581

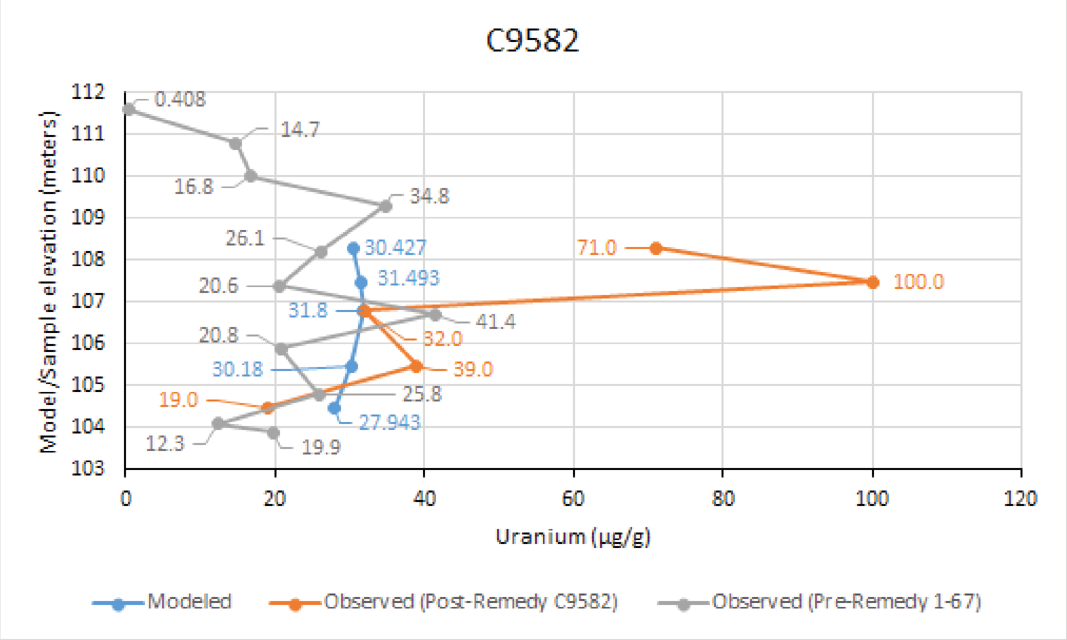
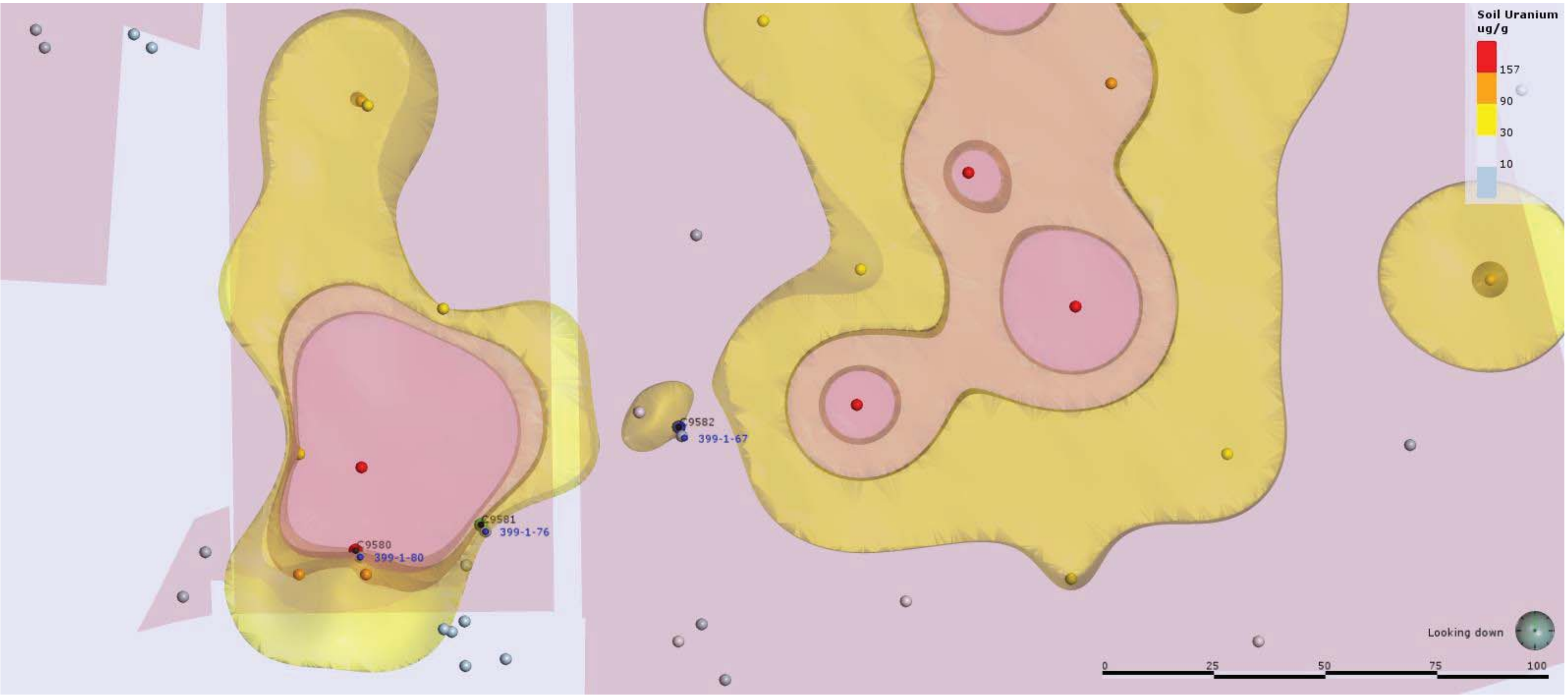
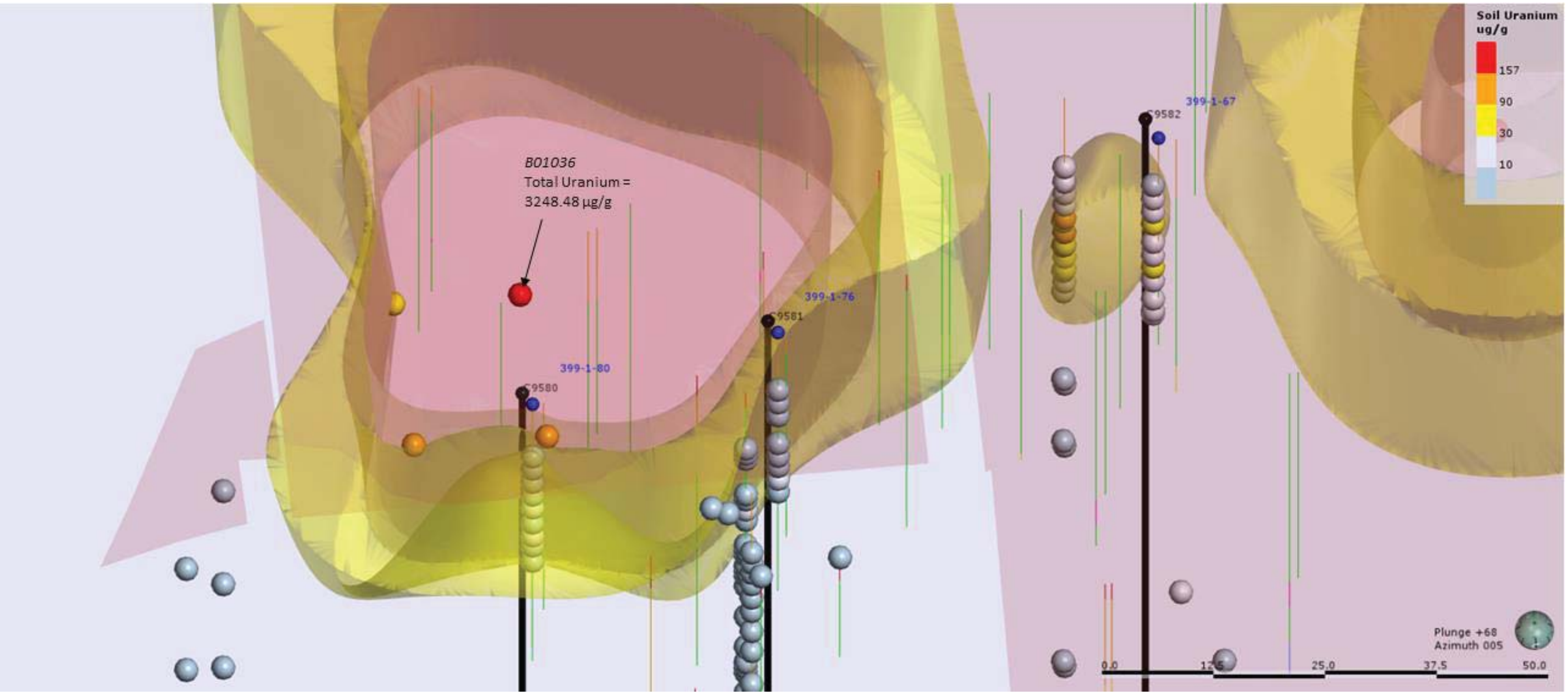


Figure E-4. Modeled and Observed Results Comparison at the Location of C9582



Note: Pre-remedy boreholes are blue points with blue labels, and post-remedy boreholes are black points with black labels.

Figure E-5. Plan View of Vadose Zone Uranium Distribution Showing the Pre-Remedy and Post-Remedy Comparison Borehole Locations



Note: Pre-remedy boreholes are blue points with blue labels, and post-remedy boreholes are black points with black labels.

Figure E-6. Oblique View of Vadose Zone Uranium Distribution Showing Pre-Remedy and Post-Remedy Comparison Borehole Locations

ENVIRONMENTAL CALCULATION COVER PAGE

Section 1: Completed by the Responsible Manager

Project: 300-FF-5

Date: 09/01/2016

Calculation Title & Description: Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit

RELEASE / ISSUE

DATE:
Nov 01, 2016
HANFORD RELEASE

Section 2: Completed by Preparer

Calculation No.: ECF-300FF5-16-0091 **Revision No.:** 0

Revision History

Revision No.	Description	Date	Affected Pages ADD ROW
0	Initial issue		

Section 3: Completed by the Responsible Manager

Document Control:

Is the document intended to be controlled within the Document Management Control System (DMCS)? ☒ Yes ☐ No

Does document contain scientific and technical information intended for public use? ☒ Yes ☐ No

Does document contain controlled-use information? ☐ Yes ☒ No

Section 4: Document Review & Approval

	Name /Position	Signature	Date
Preparer:	S. Mehta A. Mayenna/Modeler		9/1/2016
Checker:	P. Allena/Modeler		9/1/2016
Senior Reviewer:	R. Khaleel/Senior Scientist	RKhaleel	9/1/2016
Responsible Manager:	P. Baynes/Project Manager	Patrick A. Baynes	9/15/2016

Section 5: Applicable if calculation is a risk assessment or uses an environmental model

PRIOR TO INITIATING MODELING:

Required training for modelers completed:

	Name /Position	Signature	Date
Integration Lead	WE Nichols/Modeling Team Leader		1 Sep 2016

Safety Software Approved:

	Name /Position	Signature	Date
Integration Lead	WE Nichols/Modeling Team Leader		1 SEP 2016

CALCULATION APPROVED:

	Name /Position	Signature	Date
Risk/Modeling Integration Manager:	AH Aly/Risk & Model Integr. Manager		1 Sep 2016

ECF-300FF5-16-0091
Revision 0

Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit

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

P.O. Box 1600
Richland, Washington 99352

ECF-300FF5-16-0091
Revision 0

Uranium Transport Modeling in Support of the Stage A Enhanced Attenuation Remedy at 300-FF-5 Operable Unit

Document Type: ENV Program/Project: EP&SP

S. Mehta
CH2M HILL Plateau Remediation Company

A. Mayenna
INTERA, Inc.

Date Published
October 2016

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

P.O. Box 1600
Richland, Washington 99352

APPROVED
By Julia Raymer at 9:24 am, Nov 01, 2016

Release Approval Date

ECF-300FF5-16-0091
Revision 0

Contents

Appendices

Figures

Tables

This page intentionally left blank.

Terms

3D	three-dimensional
AWLN	automated water level network
bgs	below ground surface
CHPRC	CH2M HILL Plateau Remediation Company
COC	contaminant of concern
DOE	U.S. Department of Energy
EA	enhanced attenuation
EAA	Enhanced Attenuation Area
EC	electrical conductivity
ECF	environmental calculation file
EPA	U.S. Environmental Protection Agency
ERT	electrical resistivity tomography
GFM	geologic framework model
GWB	Geochemist's Workbench
HEIS	Hanford Environmental Information System
Hf	Hanford formation
IC	ion chromatography
ICP-AES	inductively coupled plasma-atomic emission spectroscopy
ICP-OES	inductively coupled plasma-optical emission spectroscopy
ID	identification
OU	operable unit
PNNL	Pacific Northwest National Laboratory
PRZ	periodically rewetted zone
RLM	Ringold Lower Mud
ROD	record of decision
SAP	sampling and analysis plan
SEM/EDX	scanning electron microscope/energy dispersive x-ray
STOMP	Subsurface Transport Over Multiple Phases

This page intentionally left blank.

1 Purpose

Completion of 300 Area cleanup on the Hanford Site is being accomplished under the 2013 U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) record of decision (ROD) and amendment (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* [hereafter referred to as the 300 Area ROD/ROD Amendment]), which identifies uranium as a contaminant of concern (COC). Part of the selected remedy for uranium contamination in groundwater is enhanced attenuation (EA) of uranium over a 12,140 m^2 (3 ac) area using phosphate solutions to reduce the uranium concentrations in the aquifer. The desired goal of injection and infiltration is to deliver phosphate in high concentrations to the vadose zone (and top of the aquifer), where uranium is present in the sediments, to precipitate phosphate bearing mineral phases that can bind labile uranium and sequester it. The EA remedy is being implemented in two sequential stages: Stage A and Stage B; Stage A covers an area of 3,035 m^2 (0.75 ac), and Stage B covers the remaining portion (9,105 m^2 [2.25 ac]).

The objectives of this report are two-fold: first, present monitoring data and observations on uranium and phosphate concentrations in the PRZ and aquifer following injections and infiltration; second, using numerical modeling, evaluate the fate and transport of uranium following the remedial action. During Stage A treatment, which occurred from November 6 through 18, 2015, high concentration polyphosphate amended solutions were injected into the aquifer and into the periodically rewetted zone (PRZ) along with surficial infiltration (below the root zone) into the vadose zone.

This report synthesizes relevant information for conducting fate and transport modeling to evaluate uranium concentrations in the aquifer in the vicinity of Stage A Enhanced Attenuation Area (EAA). Information gathered from geochemical evaluations of pretreatment and post-treatment soil samples, sequential extraction tests, batch desorption and flow-through column tests, mineral phase analysis, and observations made in the field regarding uranium and phosphate concentrations in groundwater are all used in developing parameters and conceptual models for conducting fate and transport calculations. For forward (predictive) modeling, an understanding of the processes governing uranium sequestration is needed so that proof-of-principle can be sufficiently justified. For this purpose, reactive transport modeling was conducted to understand the complex geochemical reactions. Based on that understanding, predictive fate and transport modeling was conducted to estimate uranium concentrations in the future.

This page intentionally left blank.

2 Background

The sampling and analysis plan (SAP) (DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*) presents the plans for the 300-FF-5 Groundwater Operable Unit (OU) remedy implementations, performance monitoring, and groundwater monitoring. The SAP is prepared in accordance with the groundwater remedial actions presented in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013). The SAP supplements information provided in DOE/RL-2014-13, *Integrated Remedial Design Report/Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units)*, and DOE/RL-2014-13-ADD2, *Remedial Design Report/Remedial Action Work Plan for the 300 Area Groundwater*. The 300-FF-5 OU comprises groundwater contaminated by releases from facilities and waste sites associated with past operation of uranium fuel production, research, and development in the 300 Area Industrial Complex. The 300 Area ROD/ROD Amendment identifies uranium, gross alpha, nitrate, tritium, trichloroethene, and *cis*-1,2-dichloroethene as groundwater COCs.

A key part of the groundwater remedy selected in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013) was EA of uranium using sequestration by phosphate application in the vadose zone and PRZ. Uranium sequestration will be implemented using a staged approach. Stage A will consist of performing infiltration/injection in one section of the EAA, covering approximately 0.3 ha (0.75 ac). The treatment effectiveness of the Stage A phosphate application will be evaluated by comparing the overall decrease in uranium leachability in vadose zone and PRZ soil samples, taking into consideration a fate and transport model assumption that 50 percent of mobile uranium will be reduced from phosphate treatment. Treatment effectiveness will also be evaluated based on other factors from Stage A implementation, such as phosphate distribution efficiency, the degree of uranium mobilization to groundwater, and changes to hydraulic conductivity of the aquifer due to precipitation of phosphate minerals. The EA remedial action for the 300 Area is considered complete upon implementation of Stage A and Stage B infiltration and injection in the EAA unless otherwise agreed to by DOE and EPA following the Stage A delivery performance report. Stage B will be performed if a high likelihood of treatment effectiveness can be expected, based upon all the considerations from the Stage A evaluation. If Stage B is performed, Stage A results will be used to refine the Stage B approach for the remaining untreated portions of the EAA.

This report is structured in the following manner. Chapter 3 discusses the general methodology followed for evaluation of data towards building the fate and transport model for uranium, while Chapter 4 summarizes the approach regarding assumptions and inputs. Chapter 5 describes the software applications used, and Chapter 6 provides a discussion of key observations from monitoring along with development of a conceptual model. Chapter 7 discusses the development and results from the fate and transport model. Appendix A provides additional details based on monitoring of wells during treatment operations and post-treatment time period. Appendix B provides the details on reactive transport modeling that help in the development of parameter values for fate and transport modeling. Appendix C provide details on deriving kinetic sorption-desorption parameters based on leaching test results. Appendix D provides details regarding implementation of the numerical model described in Appendix C. Appendix E provides the results that help in the evaluation of any changes in hydraulic properties in the aquifer following treatment.

This page intentionally left blank.

3 Methodology

The following steps were undertaken to simulate post-treatment uranium concentrations in groundwater:

1. Obtain detailed information on the operational parameters and outcomes of the injections and infiltration conducted in Stage A.
    a. Evaluate concentrations of phosphate, sodium, and potassium in the amended solutions prior to injection and infiltration.
    b. Evaluate temporal changes in injection and infiltration rates, along with field sampled pH during the operations.
2. Evaluate data from 26 groundwater monitoring wells used in Stage A.
    a. Evaluate uranium and phosphate concentrations before, during, and after treatment in the seven wells monitored daily during treatment.
    b. Evaluate information collected from continuous electrical conductivity (EC) values from the six wells with data loggers in relation to the timing of injection/infiltration.
    c. Correlate specific conductance values and phosphate concentrations in the dilute solutions at the mixing skids.
    d. Evaluate the results available from electrical resistivity tomography (ERT) surveying regarding distribution of infiltrated phosphate bearing solutions. Review results related to breakthrough times and average velocity of the wetted front.
3. Evaluate data from sediment samples obtained from three pretreatment and three post-treatment boreholes.
    a. Compare pretreatment and post-treatment concentrations of uranium in the sediment.
    b. Evaluate the concentration of precipitated phosphate and compare data from water extracts, acid extracts, and total digestion of pretreatment and post-treatment samples and their concentrations relative to depth within the borehole and to the PRZ.
    c. Compare the data (phosphorous [P], calcium [Ca], aluminum [Al], iron [Fe], manganese [Mn], and uranium [U]) from sequential extraction tests conducted on pretreatment and post-treatment sediment samples, and interpret the data in terms of geochemical processes to explain the results.
    d. Compare the leaching behavior of the sediments subjected to flow-through column leach tests. Compare pretreatment and post-treatment leaching behavior of sediments in relation to uranium concentrations and proximity to the PRZ.
    e. Review the results from batch tests and surface analyses on post-treatment samples.
4. Develop conceptual model of possible geochemical reactions that occurred within the host rock as a result of treatment that led to sequestration of uranium. Perform detailed reactive transport modeling.
5. Simulate the fate and transport of uranium in the vadose zone and unconfined groundwater aquifer to evaluate the effectiveness of the Stage A remedy by predicting groundwater uranium concentrations in the near future.

This page intentionally left blank.

4 Assumptions and Inputs

Assumptions and inputs related to fate and transport modeling are discussed in Chapters 6 and 7, where details are presented. Appendix A provides additional information, based on monitoring data, to support fate and transport modeling.

Sections 6.3 and 6.4 provide assumptions and inputs information related to reactive transport modeling discussed in Appendix B; Chapter 7 provides information regarding development of three-dimensional (3D) flow and transport modeling for evaluating the uranium concentrations. Appendix C provides information on determination of desorption parameters based on column leach tests.

This page intentionally left blank.

5 Software Applications

The following software products were used in the development of this report:

- Subsurface Transport Over Multiple Phases (STOMP©[1]) was the primary software used for this environmental calculation file (ECF). Tecplot®, a commercial graphics software package, was used for graphical display of results.
- The Geochemist's Workbench® (GWB) software was used for performing reactive transport modeling.
- MATLAB® software was used for estimating kinetic sorption-desorption parameters, based on leaching test results.

5.1 Software Details

STOMP (PNNL-12030, *STOMP Subsurface Transport Over Multiple Phases Version 2.0 Theory Guide*; PNNL-15782, *STOMP Subsurface Transport Over Multiple Phases Version 4.0 User's Guide*; PNNL-11216, *STOMP Subsurface Transport Over Multiple Phases Application Guide*) was the software used for this calculation; as approved software, the information required is provided in this section.

The fate and transport calculations are performed using CH2M HILL Plateau Remediation Company (CHPRC) Build 4 of the STOMP software, registered in the Hanford Information System Inventory under identification (ID) number 2471. STOMP use by CHPRC is managed under the following software lifecycle documents: CHPRC-00222, *STOMP Functional Requirements Document*; CHPRC-00176, *STOMP Software Management Plan*; CHPRC-00211, *STOMP Software Test Plan*; CHPRC-00515, *STOMP Acceptance Test Report*; and CHPRC-00269, *STOMP Requirements Traceability Matrix*. STOMP was executed on the Green Linux cluster (owned and operated by INTERA, Inc. at its Richland, Washington office).

GWB (Version 11.0.3) is used for conducting geochemical evaluations and reactive transport modeling (presented in Appendix B). The GWB software is registered in the Hanford Information System Inventory under identification (ID) number 3845. Use of GWB by CHPRC is managed under CHPRC-01874, *The Geochemist's Workbench Integrated Software Management Plan Version 11.0.3*. The software was executed on the Blue Windows 2008 server (owned and operated by INTERA, Inc. at its Richland, Washington office).

Kinetic and equilibrium sorption models were solved using MATLAB R2011b 7.13.0.564 software. In this ECF, MATLAB was used analogously with a flat-file spreadsheet in which the calculation is wholly incorporated into this ECF and where the calculations, mathematical formulas, and input data were verified by the technical review of this ECF. Appendix D provides details regarding the calculations for one column using the single-site kinetic sorption model. The entire input file used in MATLAB is

---

[1] Battelle Memorial Institute (Battelle) retains copyright on all versions, revisions, and operational modes of the Subsurface Transport Over Multiple Phases (STOMP) software simulator, as permitted by the U.S. Department of Energy. STOMP is used here under a limited government use license.

® Tecplot is a registered trademark of TecPlot, Inc., Bellevue, Washington.

® Geochemist's Workbench is a registered trademark of Aqueous Solutions LLC, Champaign, Illinois.

® MATLAB is a registered trademark of The MathWorks, Inc., Natick, Massachusetts.

documented in Appendix D and verified by comparison to the mathematical formulation presented in Appendix C.

5.2 Software Installation and Checkout

A copy of the Software Installation and Checkout Form for STOMP and GWB installation used in this ECF is provided in Appendix F.

6 Observations and Conceptual Model Development

This chapter discusses observations made during Stage A treatment operations and the post-treatment time period that are relevant to fate and transport modeling. A conceptual model is also developed, based on evaluation of field-scale and lab-scale data.

6.1 Stage A Phosphate Injection and Infiltration

The operational period for Stage A infiltration and injections toward the goal of uranium sequestration was November 6 through 18, 2015. Treatment of the vadose zone, PRZ, and aquifer was conducted using a mixed effort of surface infiltration, direct injection to the PRZ, and chemical injection to the top of the aquifer. The polyphosphate solution injection and infiltration schedule for Stage A is summarized in Table 6-1. Beginning on November 6, 2015, application of the phosphate solutions mixed with river water was injected into the aquifer via groundwater wells configured with inflatable packers set at the interface point between the PRZ and the aquifer. The location of the injection wells within the Stage A area along with monitoring wells is shown in Figure 6-1. The rate of injection was approximately 189 L/min (50 gal/min) per well with simultaneous injections conducted in six wells, as shown in Table 6-1. The duration of various injections ranged from about 8 hours.

Table 6-1. Summary of Polyphosphate Solution Injection and Infiltration Schedule

Operation Day (Date)	Aquifer Injection Wells*	PRZ Injection Wells*	Average Infiltration Rate Achieved (L/min [gal/min])	Total Injection Rate Achieved (L/min [gal/min])
1 (Nov. 6)	1-89, 1-90, 1-91, 1-92, 1-93, 1-94	---	---	1,136 (300)
2 (Nov. 7)	---	---	212 (56)	---
3 (Nov. 8)	---	---	198 (52)	---
4 (Nov. 9)	1-92, 1-93, 1-94, 1-95, 1-96, 1-97	---	197 (52)	1,136 (300)
5 (Nov. 10)	---	---	202(53)	---
6 (Nov. 11)	---	---	254 (67)	---
7 (Nov. 12)	---	---	316 (84)	---
8 (Nov. 13)	---	---	311 (82)	---
9 (Nov. 14)	---	---	303 (80)	---
10 (Nov. 15)	---	---	298 (79)	---
11 (Nov. 16)	1-95, 1-96, 1-97, 1-89, 1-90, 1-91		---	1,136 (300)
	---	1-89, 1-90, 1-91, 1-92, 1-93, 1-94	---	1,136 (300)
12 (Nov. 17)	---	1-92, 1-93, 1-94, 1-95, 1-96, 1-97	---	1,136 (300)
13 (Nov. 18)	---	1-95, 1-96, 1-97, 1-89, 1-90, 1-91	---	1,136 (300)

* All well names begin with 399-.

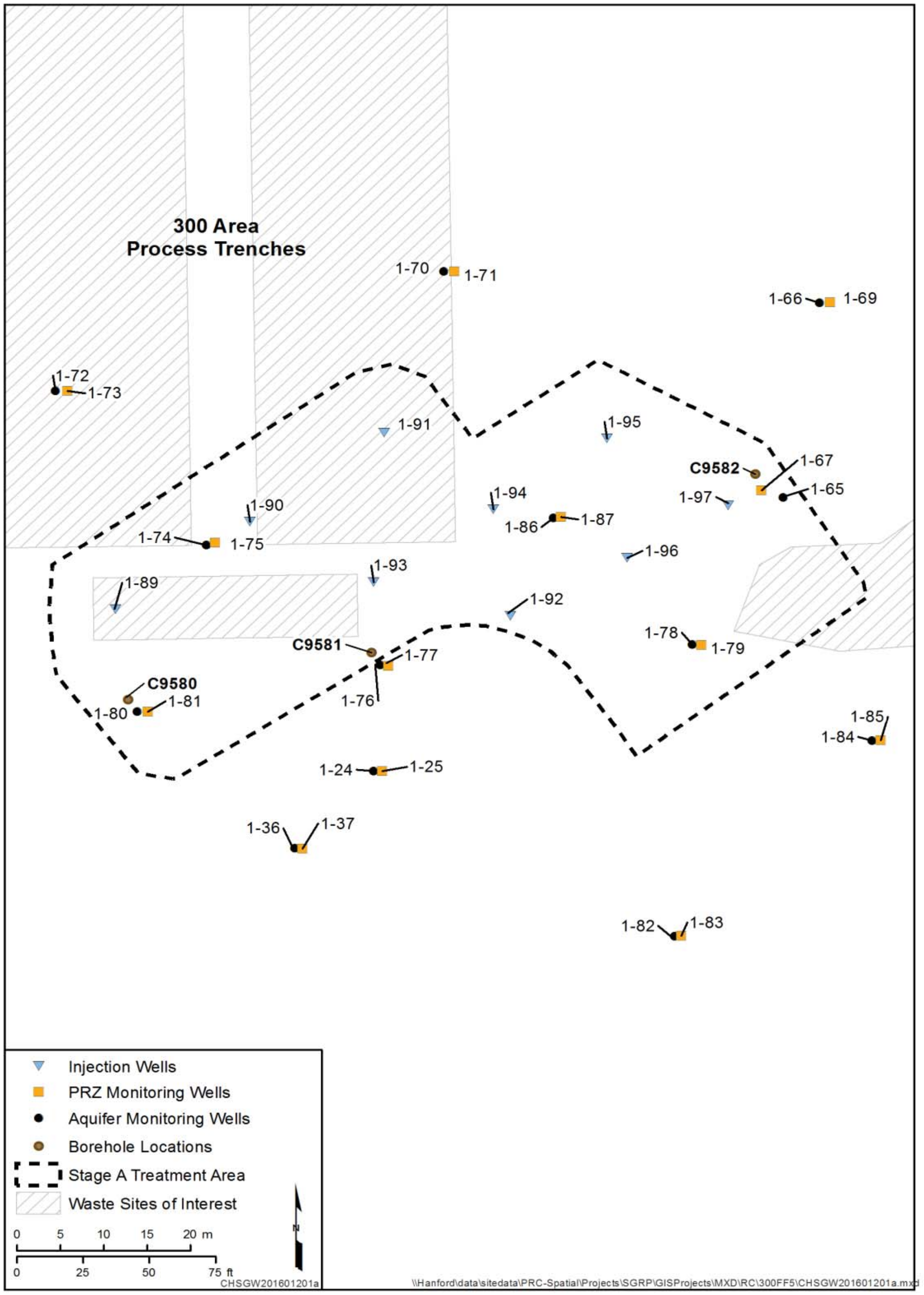


Figure 6-1. Location of Injection Wells Along with Monitoring Wells and Soil Sampling Locations for Stage A Area

Infiltration was initiated the following day (November 7, 2015) and concluded on November 15, 2015. A single mixing skid was used to mix concentrated phosphate solutions with Columbia River water and deliver it to a main distribution header and then through 44 buried drip lines (Figure 6-2). Once infiltration commenced, the system was operated continually (24 hr/day) for 9 days. During the first 4 days of infiltration, the mixed chemical solution was delivered at an approximate flow rate of about 212 L/min (56 gal/min). After the 15 psi pressure regulators connecting the header to the drip lines were replaced with 20 psi pressure regulators, flows increased to approximately 303 L/min (80 gal/min) for the remaining 5 days of infiltration. Some temporal variability in flow rates were observed during infiltration due to adjustments made to the mixing pumps during operations.

During the third day of infiltration, a second injection to the aquifer was conducted (Table 6-1). A final injection into the aquifer occurred on November 16, 2015 after infiltration had ended. The first of three injections to the PRZ also occurred on November 16, 2015 where phosphate solutions mixed with river water were injected into the same groundwater wells configured with packers, but only the solution was delivered to the top of the packer, which forced fluids out through a well interval screened in the PRZ.

Each injection well had two screened intervals: one in the aquifer, and the other in the PRZ. The screened intervals were about 3.1 m (10 ft) each, with approximate depths of 10.9 to 14 m (35.8 to 45.9 ft) below ground surface (bgs) for the aquifer and 6.2 to 9.3 m (20.3 to 30.5 ft) bgs for the PRZ. Minor depth variations occurred during construction; additional details are provided in SGW-59455, *300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report*.

The objective of injection and infiltration was to deliver phosphate in high concentrations to the vadose zone (and top of the aquifer), where uranium is present in the sediments, to precipitate phosphate-bearing mineral phases that can bind labile uranium and sequester it. Based on a number of past experimental studies conducted with polyphosphate solutions to bind uranium, such as PNNL-17818, 300 *Area Treatability Test: Laboratory Development of Polyphosphate Remediation Technology for In Situ Treatment of Uranium Contamination in the Vadose Zone and Capillary Fringe*, and PNNL-21733, *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment*, it was determined that polyphosphate solutions of high concentrations should be injected/infiltrated. Since most experiments were conducted using a phosphate concentration of about 50 mM, this concentration was initially selected as a target concentration with minor adjustment to account for polyphosphate solution (mixture of orthophosphate and pyrophosphate). However, to account for dilution within the PRZ and aquifer during injection, the target concentrations were raised higher for the injected solutions compared to the infiltrated solutions.

The polyphosphate solutions were composed of a mixture of 90 percent orthophosphate (mixture of NaH_2PO_4-Na_2HPO_4-KH_2PO_4-K_2HPO_4) and 10 percent pyrophosphate ($Na_4P_2O_7$). The orthophosphate solutions were prepared by mixing sodium hydroxide and potassium hydroxide with the phosphoric acid. The initial solutions were prepared at high concentrations, and then they were mixed with river water (using mixing skids) prior to injection and infiltration. The composition of the injected and infiltrated solutions for the three primary components (sodium, potassium, and phosphate) are shown in Figure 6-3 (a, b) based on daily samples collected following mixing in the skids. Concentrations are higher on the days when solutions were being injected, and lower when they were infiltrated, as per the design objectives. During injection, phosphate concentrations varied from about 8,000 mg/L to 9,000 mg/L (84 to 95 mM), reflecting variability in the manufacturing of the concentrated solution and mixing with the river water in the mixing skids. During infiltration, phosphate concentrations were generally maintained around 5,000 mg/L (53 mM) except for the first day of infiltration when the concentrations were around 12,000 mg/L (126 mM) due to operational issues related to mixing with river water. Sodium and potassium concentrations varied in proportion to the phosphate concentrations, with the sodium concentrations being slightly greater than potassium concentrations.

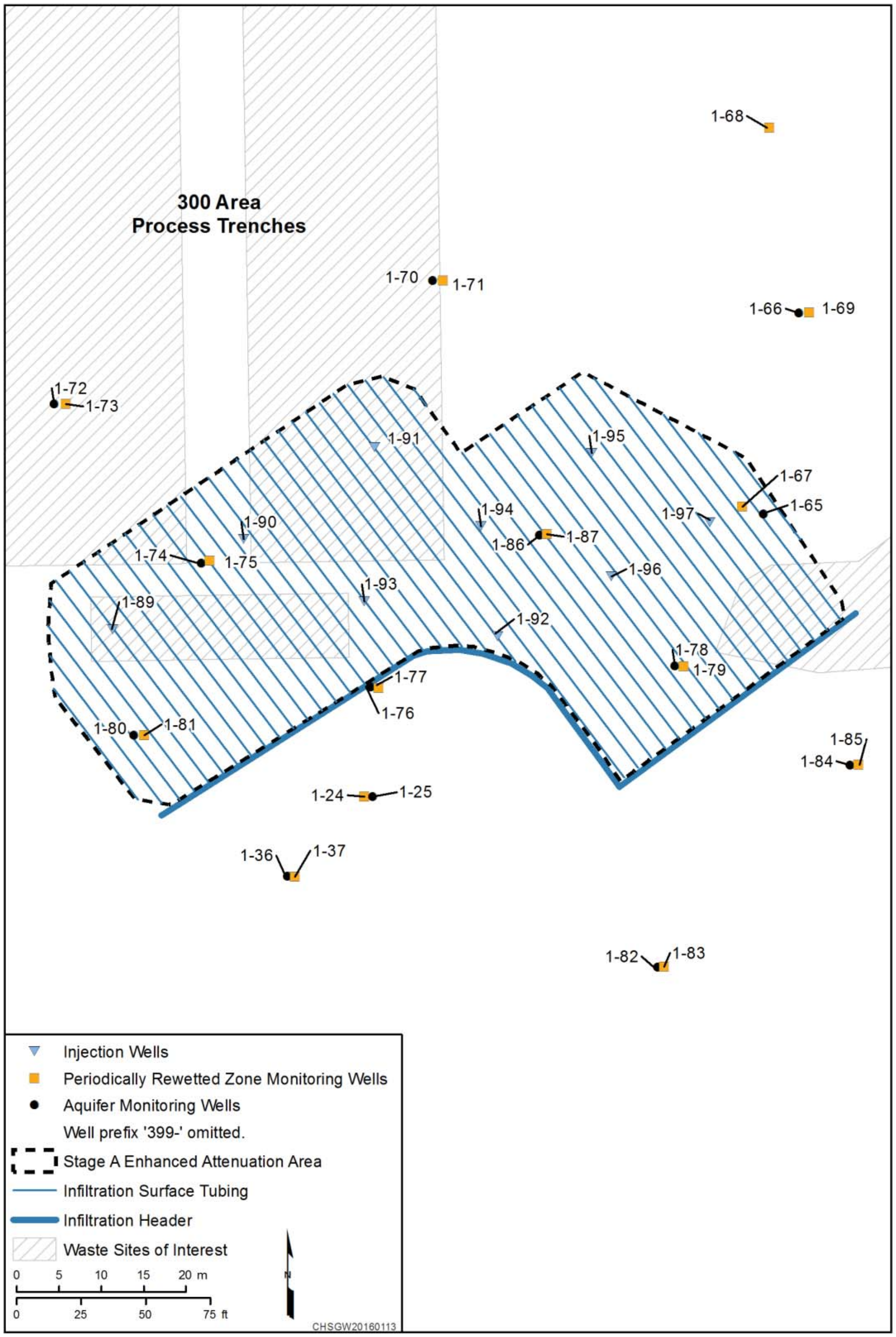
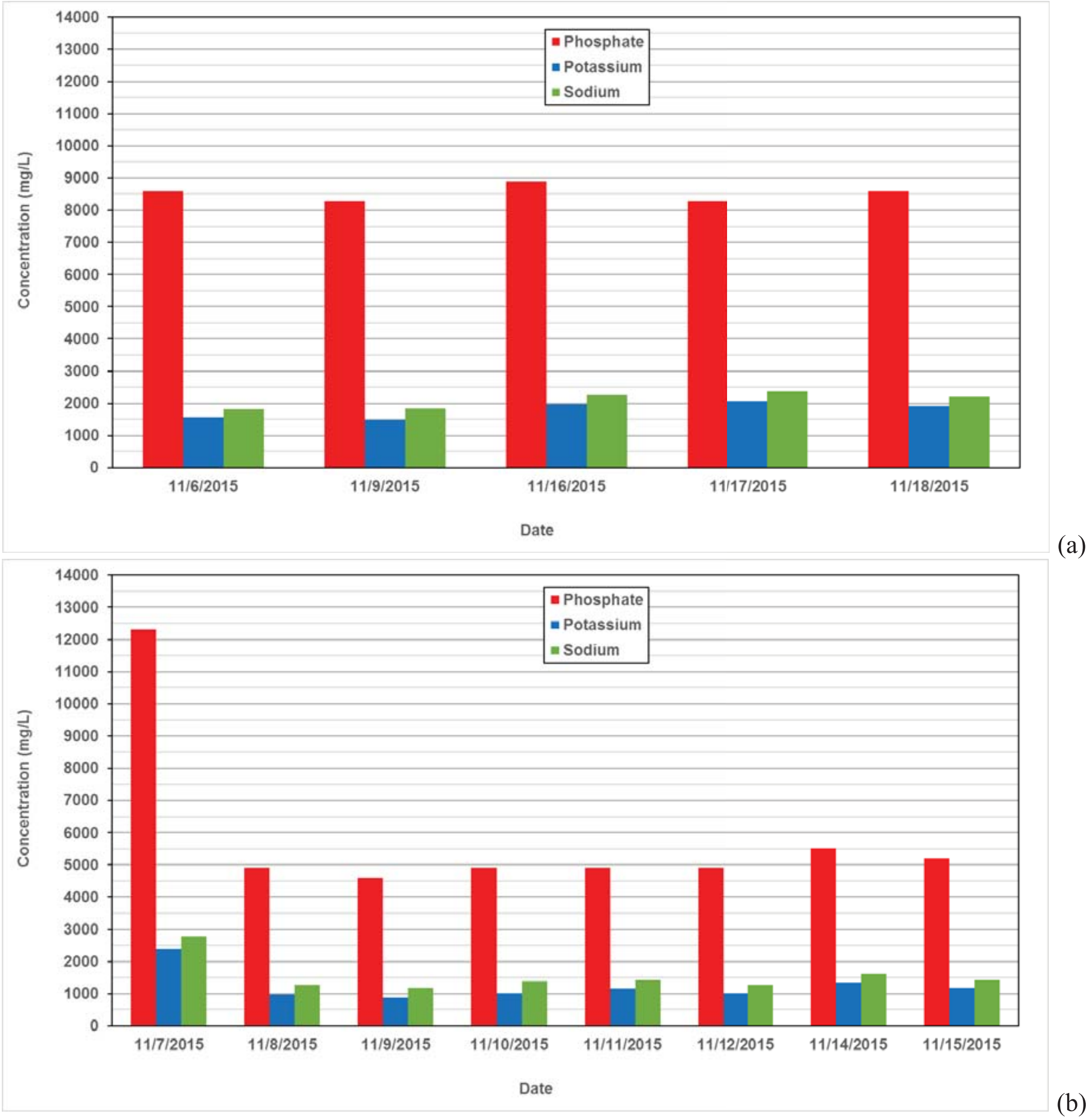


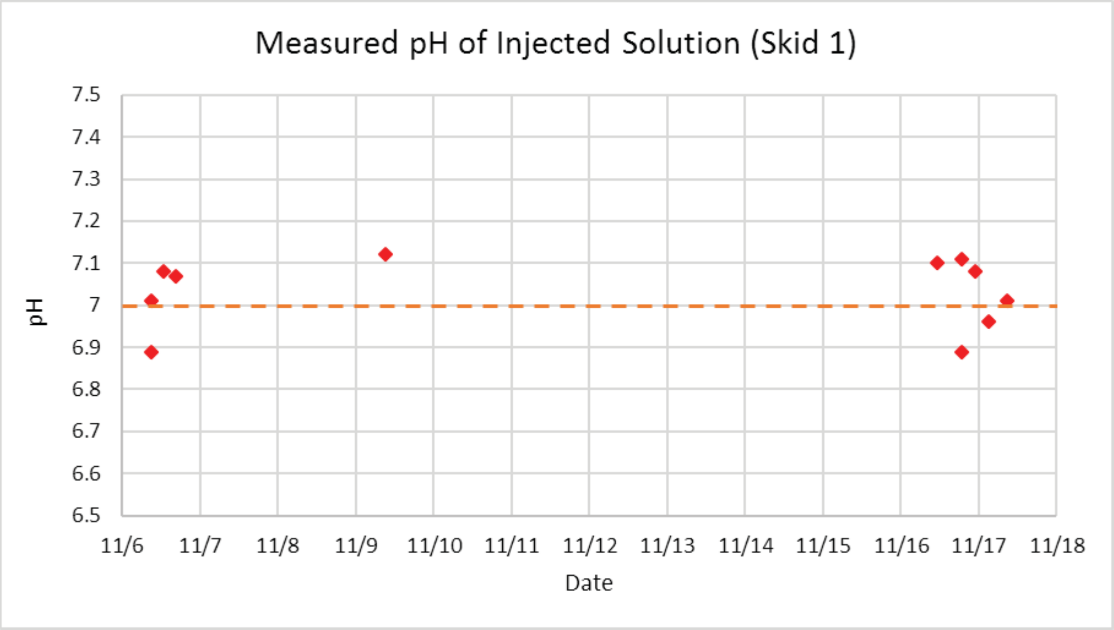
Figure 6-2. Infiltration System in the Stage A Treatment Area



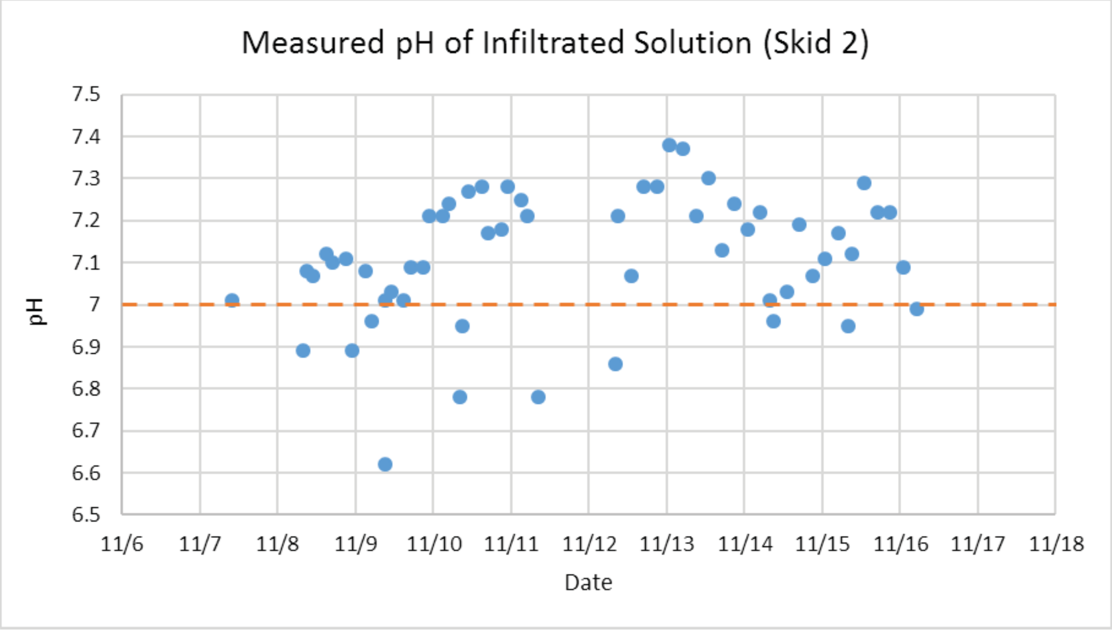
Note: No sample taken on November 13, 2015.

Figure 6-3. Daily Sampled Concentrations at the Mixing Skid During (a) Injection Period and (b) Infiltration Period

Figure 6-4 (a and b) shows the field sampled pH of the solution during the infiltration and injection period. The pH of the final mixed solution remained above 7 for most of the time period, typically in the range of 7 to 7.3, with short-term fluctuations outside this range. The intraday sharp declines in pH, followed by rises noticeable on November 9 and 10, 2015, likely reflect instrument error rather than changes in composition of the solution.



(a)



(b)

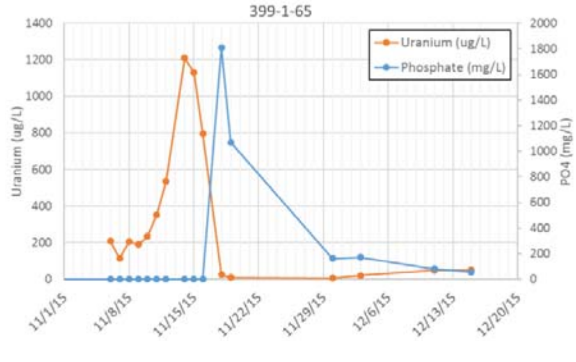
Figure 6-4. Measured pH of the Solution Following Mixing at the Skids Prior to (a) Injection and (b) Infiltration

6.2 Monitoring Results from Stage A Treatment

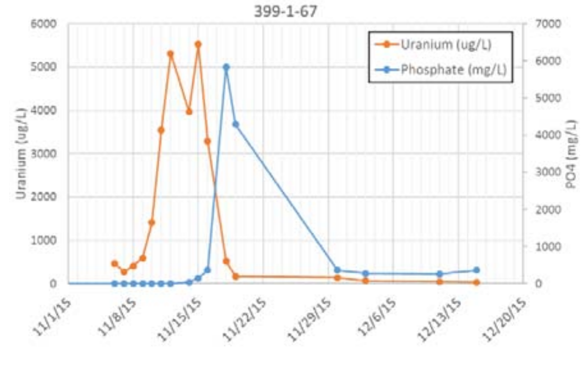
There are 26 individual monitoring wells, consisting of 13 collocated well pairs (including 2 existing well pairs and 1 well from the post-ROD investigation). For each well pair, one well is screened in the PRZ, and one well is screened in the aquifer to enable monitoring of each zone. As shown in Figure 6-1, the monitoring well system includes three monitoring well pairs upgradient (north and west) of the Stage A area, six monitoring well pairs within the Stage A area, and four monitoring well pairs downgradient (south and east) of the Stage A area (SGW-59455). The aquifer monitoring wells are generally screened from 10.9 m to 14 m (35.8 to 45.9 ft) bgs, while the PRZ monitoring wells are generally screened from 6.2 to 9.3 m (20.3 to 30.5 ft) bgs. Additional details are presented in SGW-59455.

Seven of these monitoring wells (a combination of PRZ and aquifer monitoring wells) were sampled daily, during and following Stage A, while other wells were sampled intermittently. Data loggers were also placed in six monitoring wells that were screened in the aquifer to provide continuous monitoring of water level fluctuations and EC. Details of the sampling plan are provided in SGW-58976, Field Instructions for Uranium Sequestration in the 300 Area. Data were also evaluated from groundwater monitoring wells being monitored by Pacific Northwest National Laboratory (PNNL) that were located away from the Stage A area.

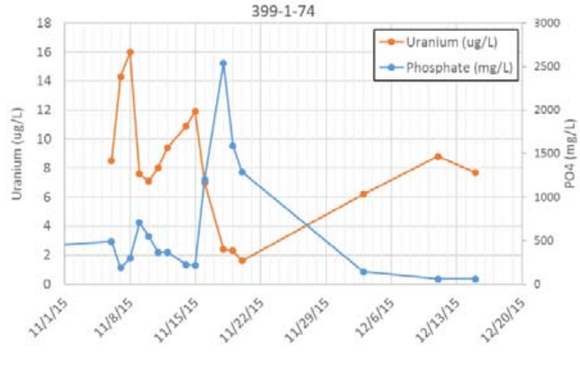
The seven monitoring wells where daily sampling was conducted included two aquifer/PRZ well pairs (399-1-65/399-1-67 and 399-1-74/399-1-75) and three PRZ wells (399-1-77, 399-1-81, and 399-1-87). The uranium versus phosphate concentrations from the seven daily monitoring wells are presented in Figure 6-5. Uranium concentrations are shown in µg/L, while phosphate concentrations (total phosphorus as phosphate) are shown in mg/L. Results of the two aquifer/PRZ well pairs show that uranium and phosphate concentrations are higher in wells screened in the PRZ compared to wells screened in the aquifer. The observed peak in uranium concentrations precedes the peak in phosphate concentration because the labile fraction of uranium travels as an aqueous complex with the infiltrated water, while the phosphate undergoes chemical reactions with the sediment and is retarded in the vadose zone. The sharp increase in phosphate after November 16, 2015 occurs from PRZ injections that peak on November 18, 2015 (the last day of PRZ injection). A gradual decline in phosphate concentration is observed following the PRZ injection. While the phosphate concentrations are increasing, the uranium concentrations show a steep decline resulting likely from uranium-phosphate-calcium aqueous complexation and co-precipitation of amorphous monocalcium phosphate (PNNL-21733) with structural incorporation of uranium under circumneutral pH conditions (Mehta et al., 2016, “Effect of Reaction Pathway on the Extent and Mechanism of Uranium(VI) Immobilization with Calcium and Phosphate”). The uranium concentrations continue to remain low following treatment (ended on November 18, 2015), indicating that aqueous complexation, surface complexation, and mineral phase precipitation processes continue to sequester uranium from the phosphate that is still retained in the vadose zone. Other monitoring wells, within and around the Stage A area, that were sampled (usually on a weekly basis) also show similar trends. Additional monitoring results are presented in Appendix A.



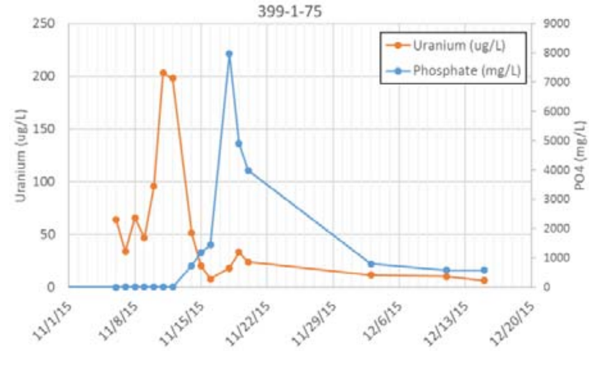
Aquifer Well



PRZ Well

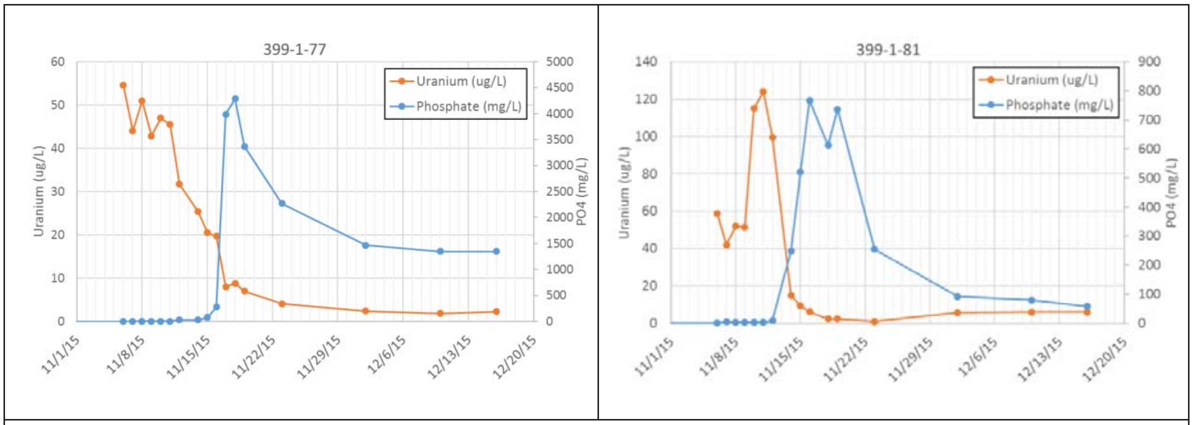


Aquifer Well

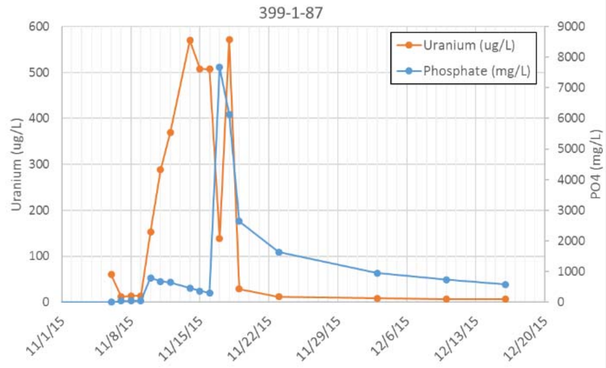


PRZ Well

Figure 6-5. Uranium and Phosphate Trends from Daily Sampling of Wells¶(page 1 of 2)



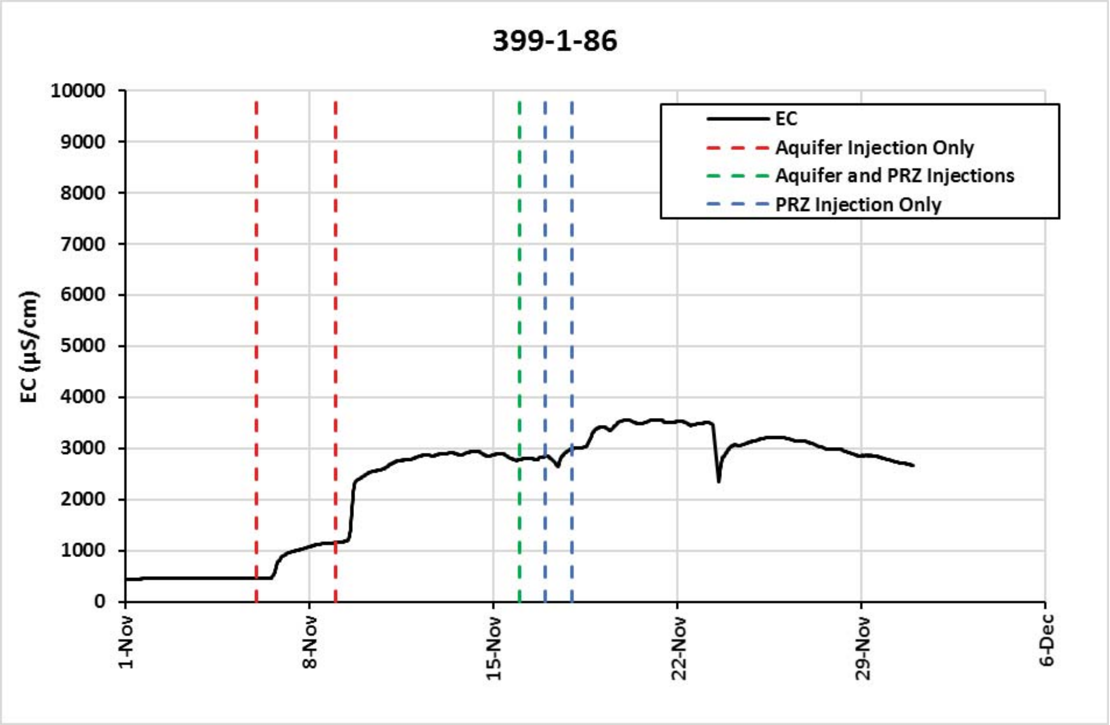
PRZ Well



PRZ Well

Figure 6-5. Uranium and Phosphate Trends from Daily Sampling of Wells (page 2 of 2)

The six aquifer monitoring wells where data loggers were installed are 399-1-70, 399-1-76, 399-1-80, 399-1-82, 399-1-84, and 399-1-86. Of these, EC results are shown for wells 399-1-86 and 399-1-76 in Figure 6-6 because they are located close to the injection wells or just at the edge of the Stage A area (Figure 6-1). All others are located either outside the Stage A area or away from injection wells, leading to either negligible or no change in EC from injection/infiltration. The time periods of injections are indicated as vertical lines along with EC measurements. EC increases from background of about 500 µS/cm following injection events, but the increase is greatest from PRZ injections. EC results for 399-1-86 indicate that high concentrations (~3,000 µS/cm) were being maintained in the aquifer even after 2 weeks had passed since the injections ended. The sharp temporary decline in EC after November 22, 2015 is attributed to a data logger disturbance during post-treatment deactivation activities undertaken at the site. EC in 399-1-76 shows a gradual decline following injection after peaking at 9,000 µS/cm. Since this well is located at the downgradient edge of Stage A area, it received higher concentrations due to injections at multiple locations and mixing of waters; in comparison, 399-1-86 was probably only affected by one or two nearby injection wells.



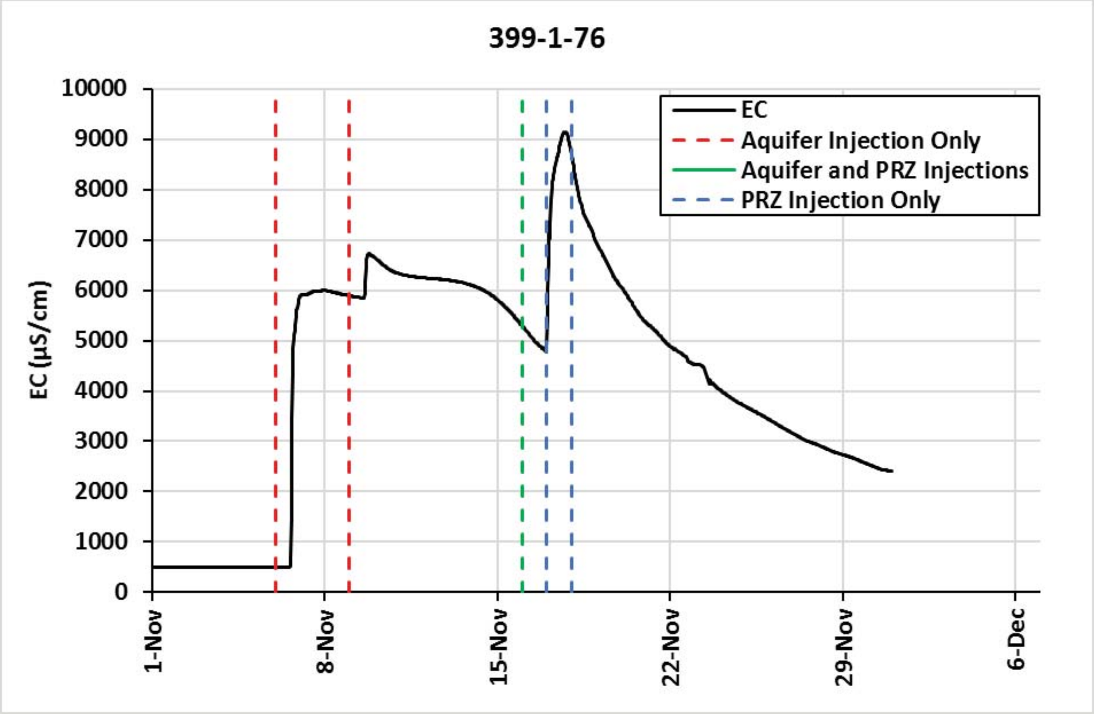
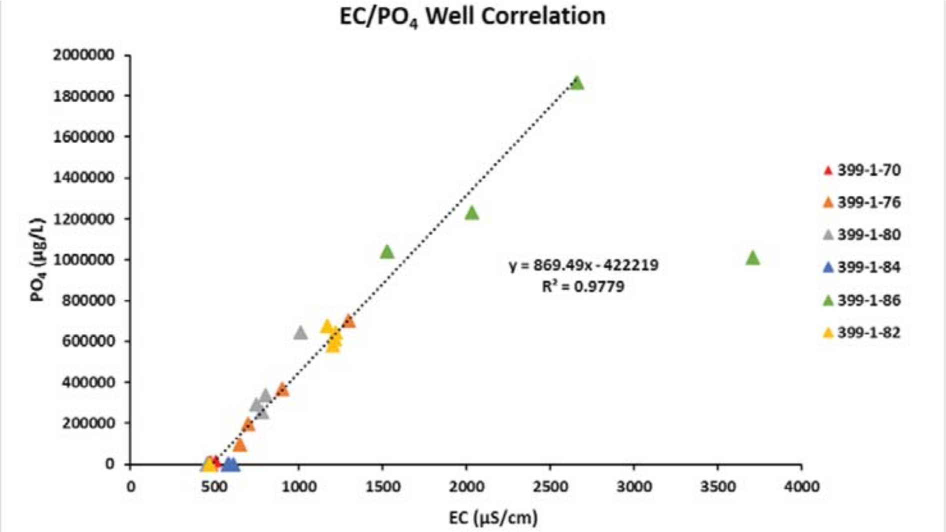


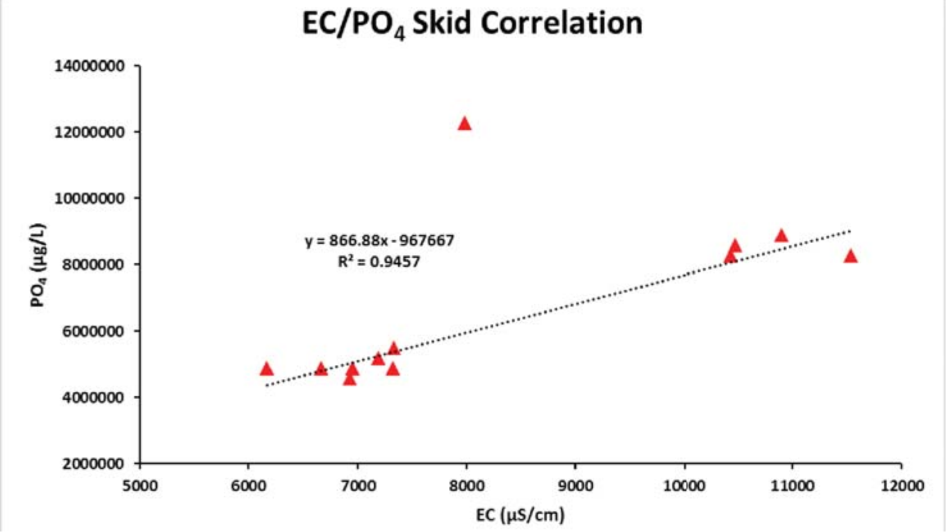
Figure 6-6. Electrical Conductivity in Selected Monitoring Wells Fitted with Data Loggers

Figure 6-7 presents the correlation between EC and measured phosphate concentrations (total phosphorus reported as phosphate). Based on this correlation, the EC value of 3,000 µS/cm approximates to about 2,190 mg/L of phosphate, while 9,000 µS/cm (peak value) is approximately equal to 7,400 mg/L of phosphate, which is close to the peak concentrations observed in the PRZ wells during injection (Figure 6-5). Figure 6-8 presents the correlation between EC and measured phosphate concentrations at the mixing skids prior to injection and infiltration. It indicates a similar strong correlation based on which 9,000 µS/cm is approximately equal to 6,800 mg/L phosphate. These results indicate that high phosphate concentrations were delivered to the PRZ (and aquifer), and the concentrations remained high in the aquifer for at least 2 weeks (duration of monitoring using data loggers) following injection.



Note: Total P is reported as phosphate.

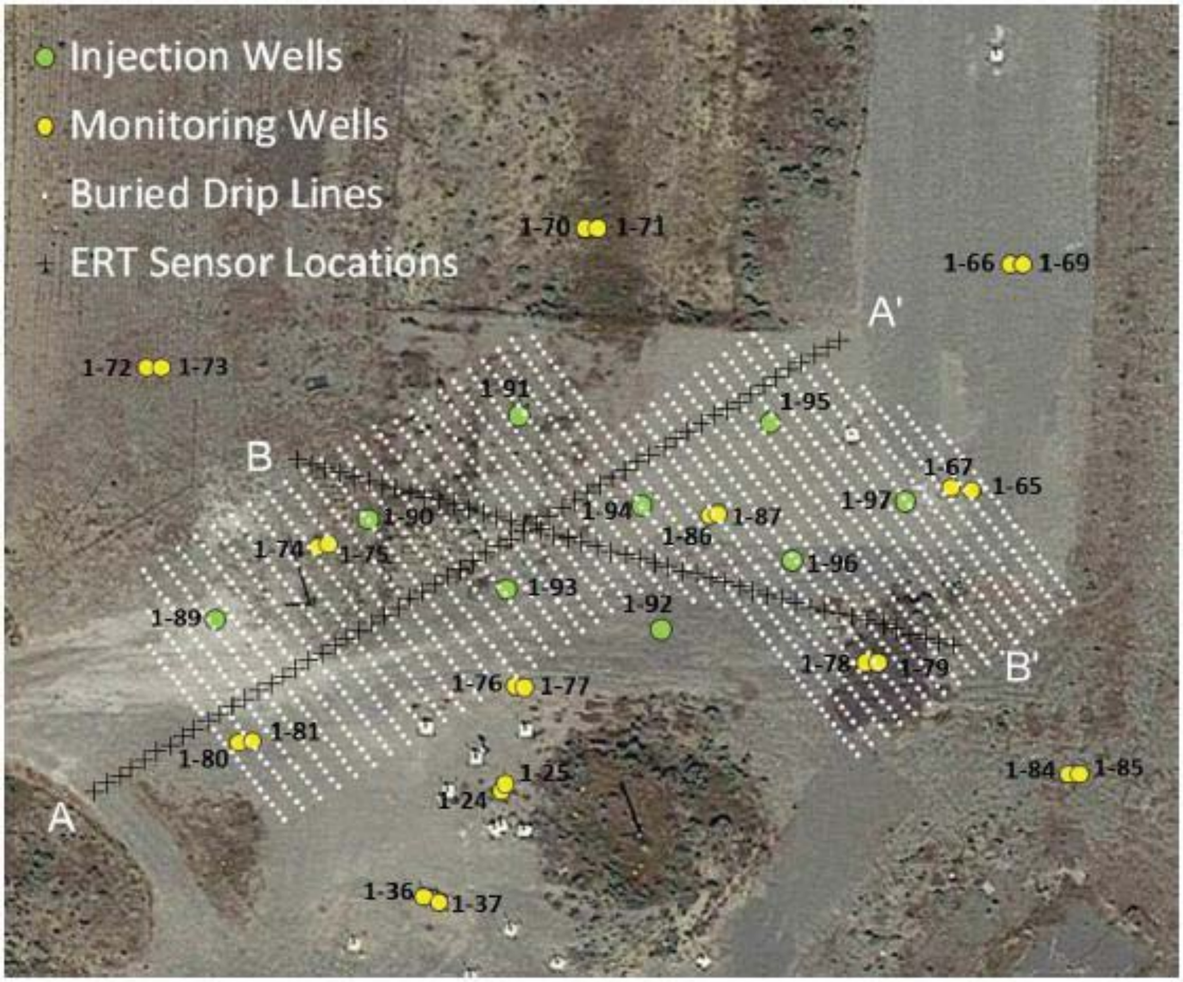
Figure 6-7. Correlation between Electrical Conductivity and Phosphate Concentration in Monitoring Wells



Note: Total P is reported as phosphate.

Figure 6-8. Correlation between Electrical Conductivity and Phosphate Concentration at the Mixing Skids Prior to Injection and Infiltration

During the injection and infiltration period, continuous imaging was performed in real time, using time-lapse ERT, to evaluate amendment delivery performance in the subsurface (PNNL-SA-25232, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography*). ERT monitoring was conducted along two transects extending 89.9 m (295 ft) (transect A-A’) and 70.1 m (230 ft) (transect B-B’) within the treatment zone, as shown in Figure 6-9. A single ERT measurement is conducted by injecting current between a pair of electrodes and measuring the resulting voltage across several other electrode pairs. Using an array of electrodes, many such measurements are strategically collected to optimize imaging resolution. This set of measurements, termed ERT survey, is processed using a computationally intensive tomographic inversion algorithm that approximates the subsurface conductivity distribution that gave rise to the measurements. When time-lapse imaging is conducted, surveys are continuously collected and processed to provide a chronological sequence of image frames that illustrate the change in bulk conductivity with time. Subtracting the baseline image (in this case, pretreatment image) from the time-lapse images reveals the change in bulk conductivity caused by the phosphate amendment, thereby revealing the distribution of amendment in space and time. Additional details are presented in PNNL-SA-25232.



Note: White, gray, and black contour lines represent increases in bulk conductivity of 0.002, 0.003, and 0.004 S/m, respectively.

Figure 6-9. Location of ERT Sensors (Electrodes) Along Two Cross-Sections (A-A’ and B-B’) Relative to Stage A Treatment Area

Results of the ERT survey are presented in Figure 6-10 for 5 selected days of operations, from November 11 (sixth day of operation) through November 15, 2015 (tenth day of operation). The results show variable concentrations of phosphate solutions, with increased change in bulk conductivity correlating with higher concentration of phosphate (the primary ion in the solution). The variable concentrations indicate that the heterogeneities in the subsurface (variable permeability layers) lead to variable distribution of phosphate. The contour of 0.002 S/m and 0.003 S/m (white and gray contours) gets to the water table located at about 10 m depth by the tenth day of operation (November 15, 2015), while the contour of 0.004 S/m gets to a depth of about 6 m in most of the cross-section. Although earlier arrival is observed in cross-section A-A' for the location on the west side, most cross-section lengths of the contour lines are fairly uniform, indicating that the effect of heterogeneities leads to establishment of uniform distribution of infiltrated phosphate solution. Using the breakthrough times of 0.002 S/m contour at the water table, the average migration velocity is estimated in Figure 6-11. It ranges from about 0.5 m/day to 3 m/day, with most of the area experiencing migration velocity of about 1 to 1.5 m/day.

Results from monitoring wells located downgradient of the Stage A treatment area are presented in Figures 6-12 and 6-13. Figure 6-12(a) presents the location of monitoring wells downgradient of the Stage A treatment area, while Figure 6-12(b) shows EC measurements at 399-1-23. This well is located downgradient of Stage A and received injected and infiltrated solutions, as indicated by the changes in EC corresponding to various injections. Based on elevated EC values (greater than the background value that ranges from 450 to 500 μS/cm), it can be inferred that phosphate concentrations at 399-1-23 continued to remain high for 2 weeks after the treatment period. Figure 6-13 presents uranium and phosphate concentrations, based on sampling of wells 399-1-23, 399-1-17A, and 399-1-7, which are located approximately along the groundwater flow path downgradient of the Stage A treatment area. The decline in uranium concentrations correlates with the increase in phosphate concentrations, reflecting changes that have occurred in the Stage A treatment area. As the phosphate pulse moves downgradient, it gets retarded and dispersed. Uranium concentrations declined in all downgradient wells and have remained low over the 6 months of monitoring following treatment. A small rebound in uranium concentrations is noticeable in the wells, but concentrations have remained substantially lower than those prior to the treatment. This indicates that prior to treatment, uranium concentrations in this part of the aquifer were derived largely from the Stage A area.

6.3 Comparison of Post-Treatment and Pretreatment Samples

To evaluate performance of the remedy within the Stage A treatment area, three boreholes were drilled to collect post-treatment sediment samples for further analysis. Locations of the three boreholes (C9580, C9581, and C9582) are shown in bold red color (Figure 6-14). These boreholes were drilled adjacent to three boreholes where pretreatment samples were collected (shown in light red color in Figure 6-14), so a comparison can be made. Details of the analysis of post-treatment borehole samples are provided in PNNL-25420, *Analytical Data Report for Sediment Samples Collected from 300-FF-5: Boreholes C9580, C9581, and C9582*; results of similar analyses conducted on pretreatment samples are provided in PNNL-24911, *Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8940 and C9451*, and SGW-58830, *300-FF-5 Supplemental Post-ROD Field Investigation Summary*.

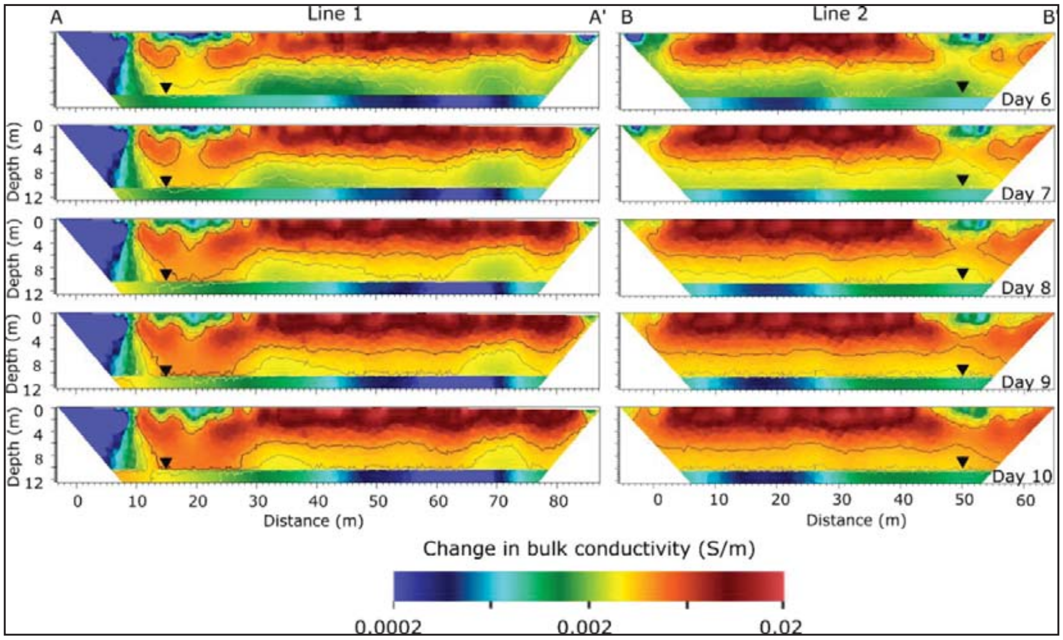


Figure 6-10. Changes in Bulk Conductivity Observed Using ERT Imaging Along Two Lines for Selected Time Periods

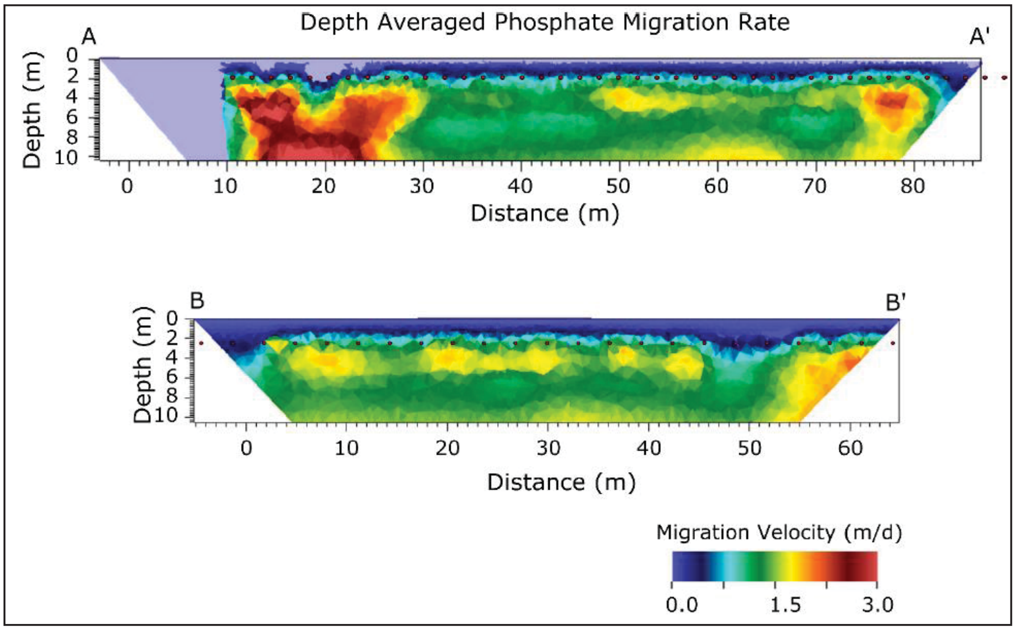
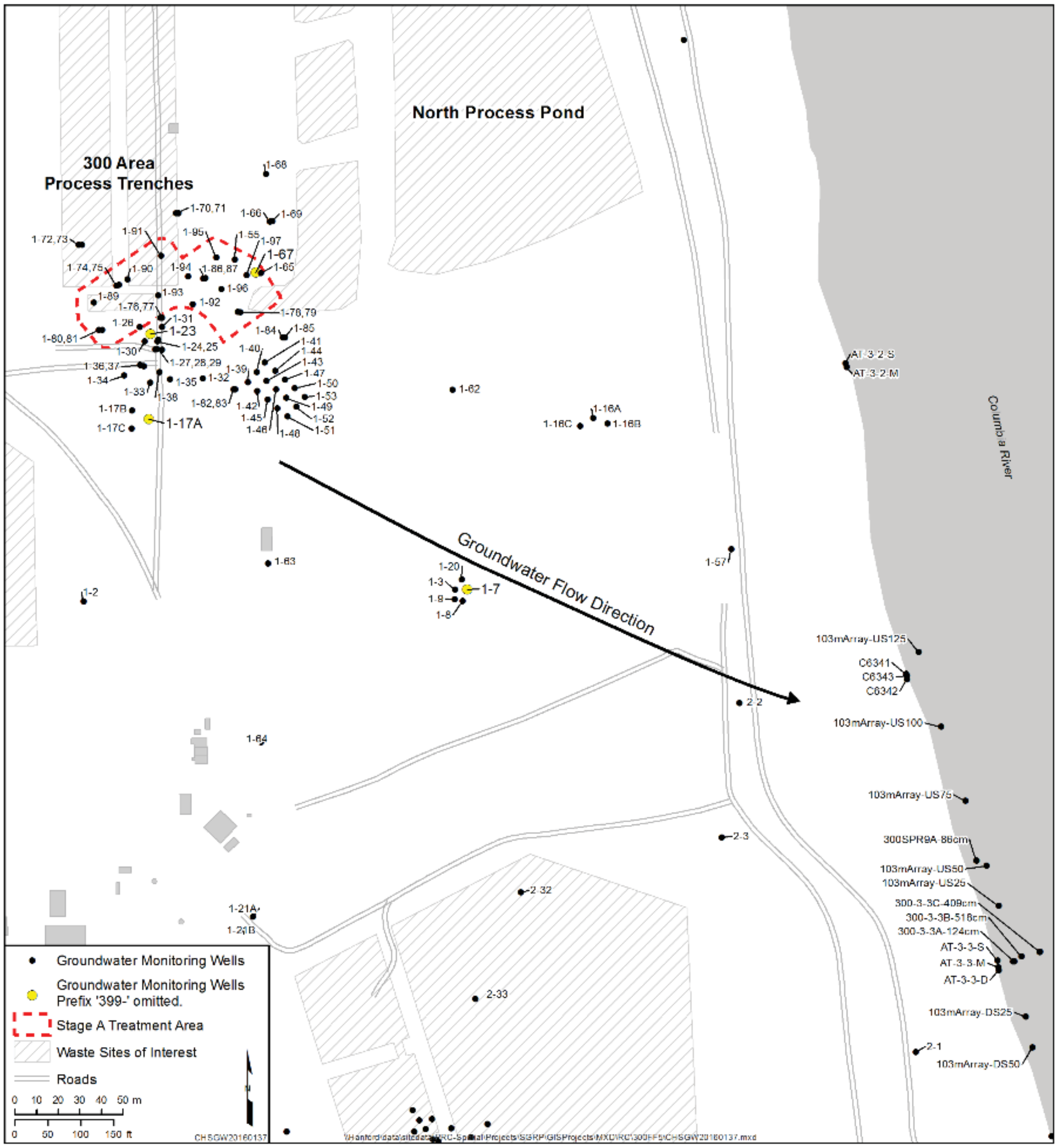
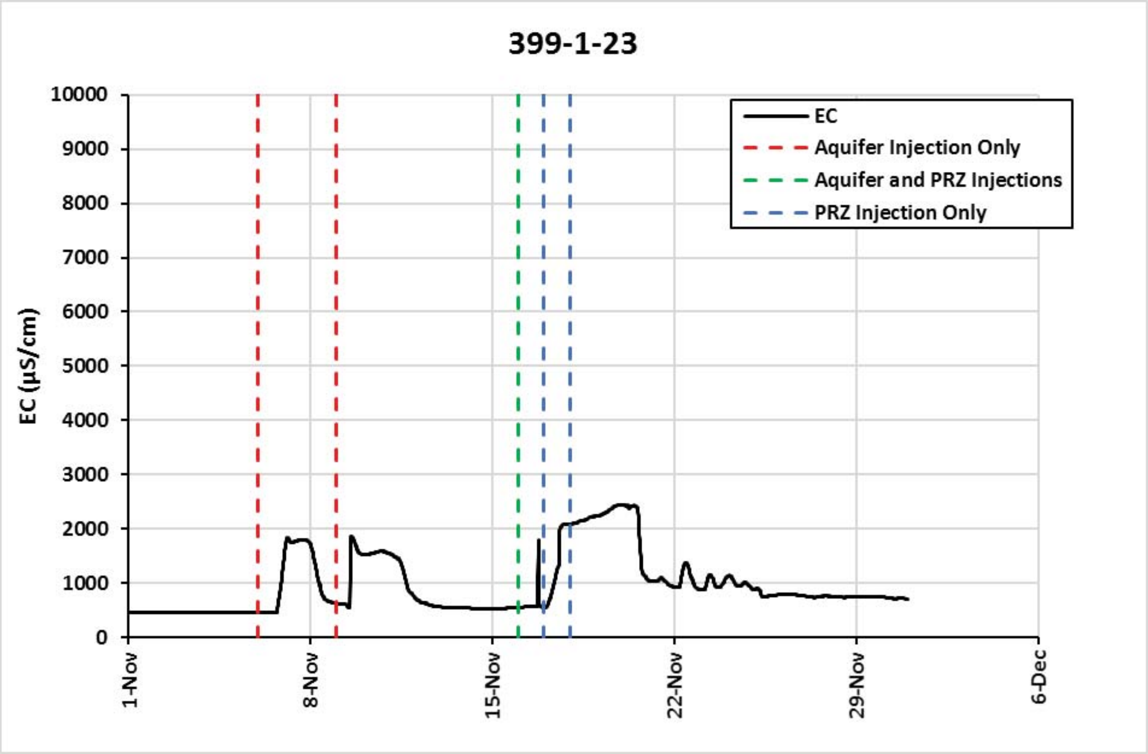


Figure 6-11. Depth Averaged Phosphate Migration Rate Estimated from ERT Imaging Based on Breakthrough Magnitude Change in Bulk Conductivity of 0.002 S/m



(a)

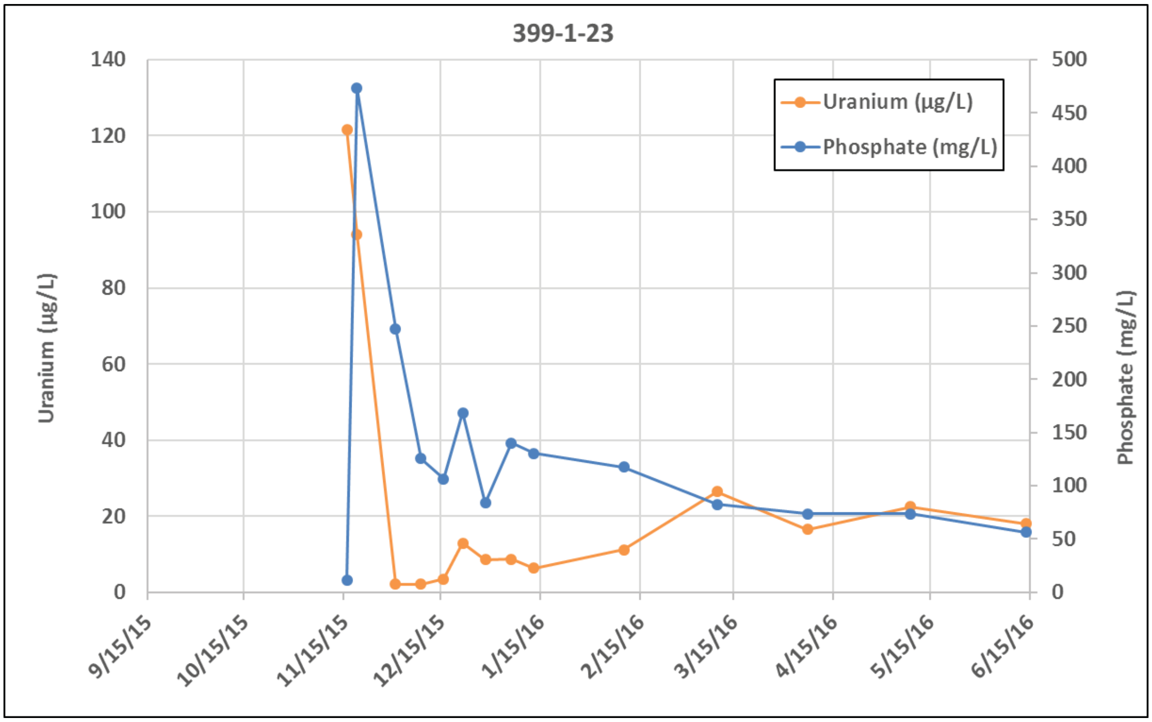
Figure 6-12. Results from Monitoring Wells Located Away from the Stage A Treatment Area¶(page 1 of 2)



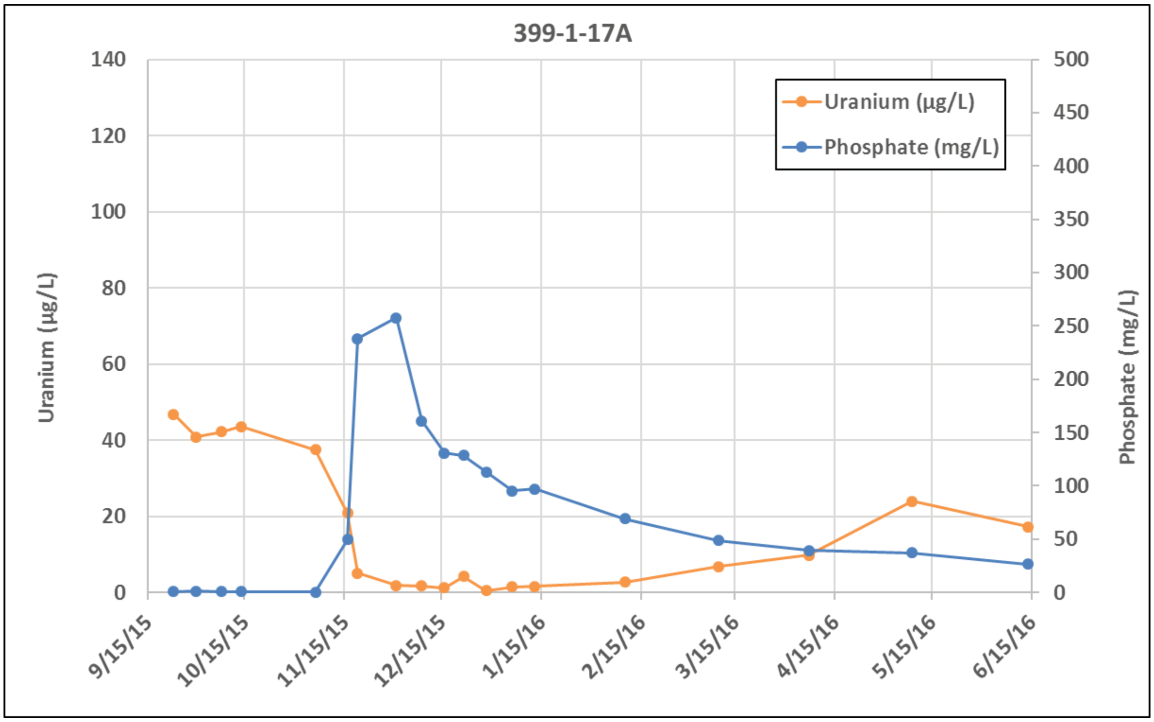
(b)

Note: The location map (a) and continuous EC measurements (b) are shown.

Figure 6-12. Results from Monitoring Wells Located Away from the Stage A Treatment Area (page 2 of 2)

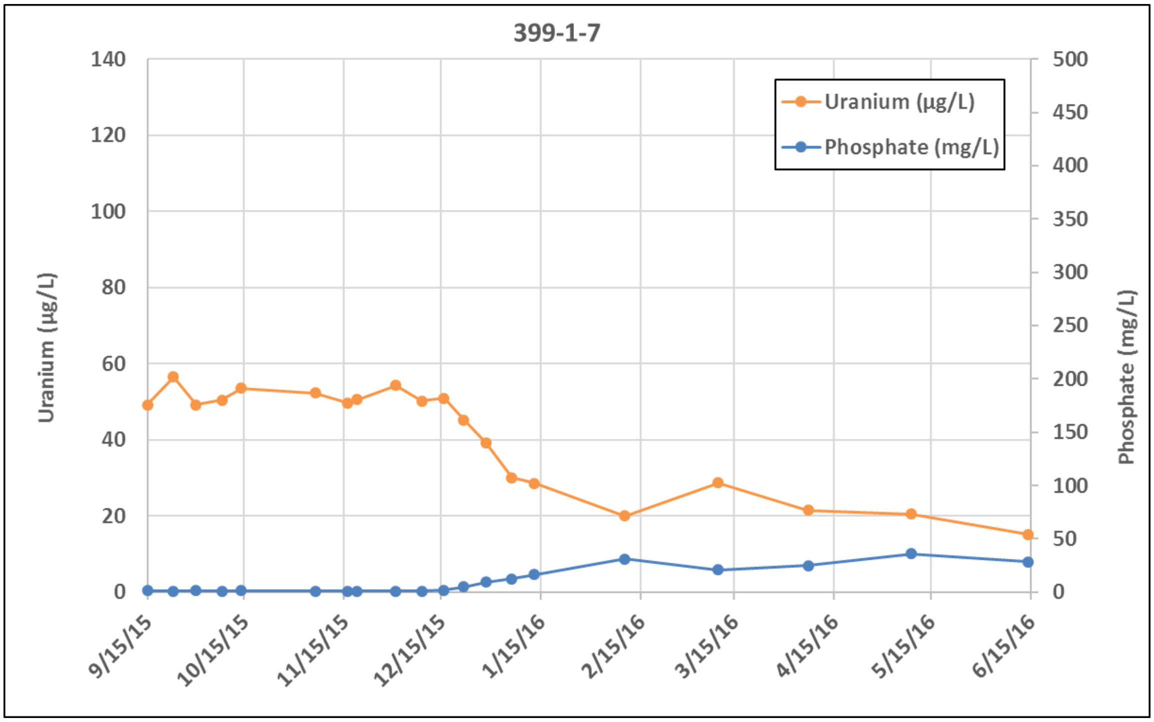


(a)



(b)

Figure 6-13. Phosphate and Uranium Concentrations Observed in Wells¶(page 1 of 2)



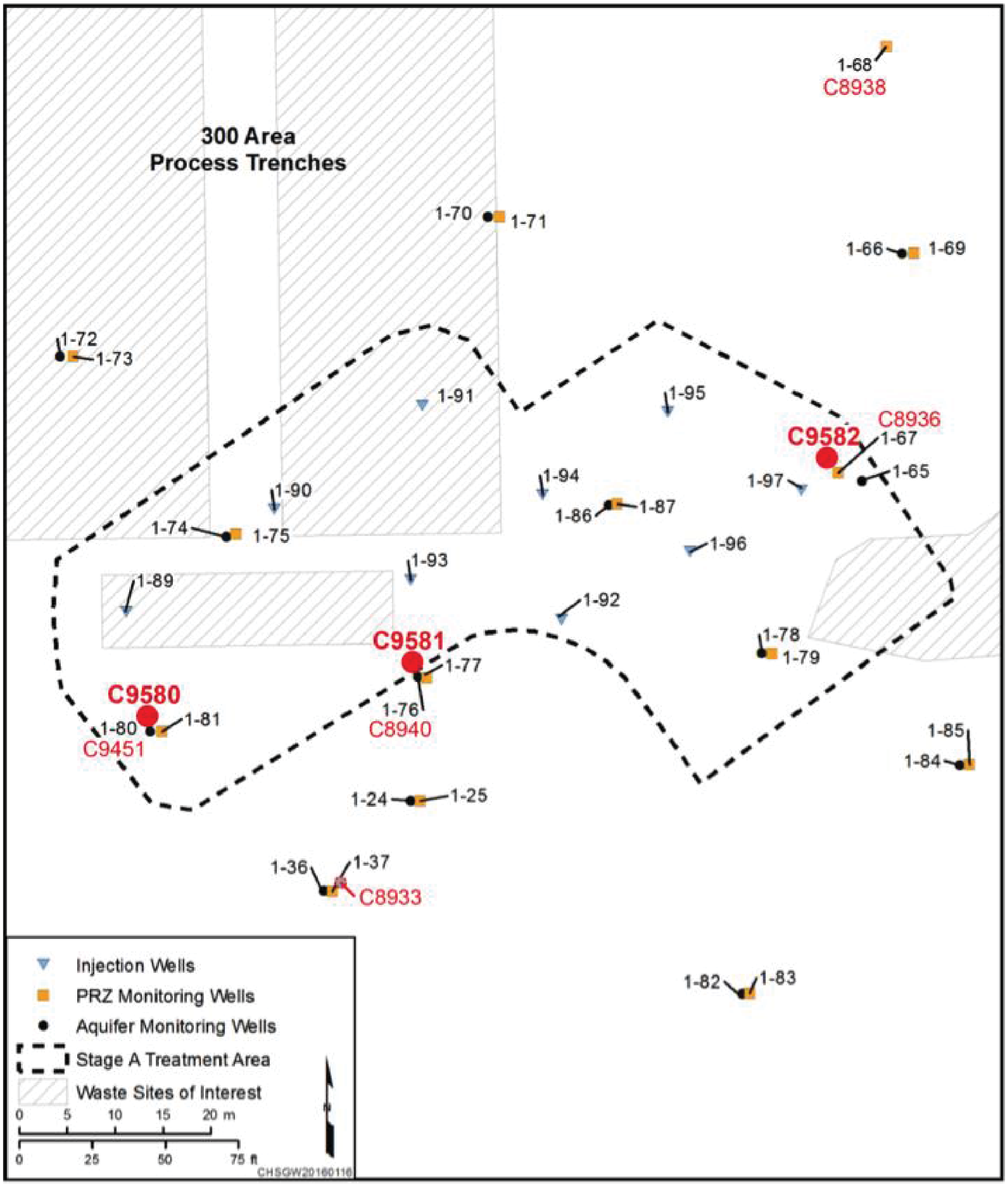
(c)

Note: 399-1-23 (a), 399-1-17A (b), and 399-1-7(c) are located downgradient of the Stage A treatment zone.

Figure 6-13. Phosphate and Uranium Concentrations Observed in Wells (page 2 of 2)

Three pretreatment boreholes of interest (Figure 6-14) are C8940 (399-1-76), C9451 (399-1-80), and C9451 (399-1-67). Sediment samples collected from various depths were analyzed for total uranium concentration using a contract (e.g., GEL or ALS) laboratory, and then specific sampling depths were selected for detailed laboratory evaluations performed at PNNL. The detailed laboratory tests consisted of sequential uranium extraction tests, labile uranium leach tests, flow-through column tests on both intact (field-texture) split-spoon liner samples and <2-mm repacked columns, and identification of uranium mineral phase(s) and surface coating(s). Total uranium analysis results for the pretreatment samples are presented in Table 6-2. GEL was the contract laboratory used for this evaluation. Later, when selected samples were sent to PNNL for detailed analyses, total uranium concentrations were recalculated based on the results of sequential extraction. These are also presented in Table 6-2 for comparison purposes. The results indicate that where total uranium concentrations were low, the GEL and PNNL results matched but, where total uranium concentrations were high, the GEL analysis consistently resulted in lower concentrations compared to PNNL results. Since detailed laboratory evaluations were conducted by PNNL, to be internally consistent, the total uranium concentrations from PNNL are used in further analysis. Figure 6-15 (part a) shows the vertical profiles of total uranium concentrations based on sampled depth intervals from the pretreatment boreholes.

Total uranium analyses results for post-treatment samples collected from C9580, C9581, and C9582 are presented in Table 6-3. Samples from various depth intervals were sent to the contract laboratory (ALS). Based on uranium concentrations, a subset of samples was selected for detailed laboratory analyses conducted at PNNL. Total uranium results from both labs, presented in Table 6-3, indicate reasonable comparisons between the two labs. Figure 6-15 (part b) shows the vertical profiles of total uranium concentrations based on sampled depth intervals from the post-treatment boreholes.



Note: Bold red represents post-treatment boreholes, while pretreatment sampling locations are shown in light red.

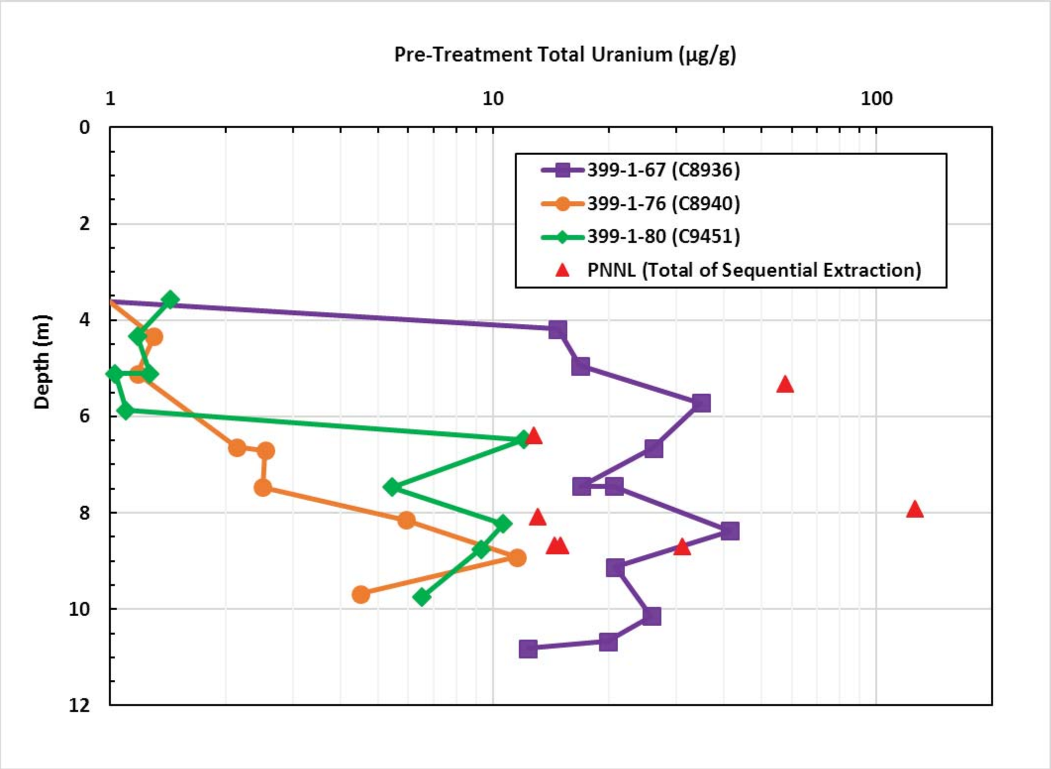
Figure 6-14. Borehole Locations to Evaluate Analyte Concentrations in Sediment

Table 6-2. Pretreatment Sediment Analysis for Total Uranium by the GEL Laboratory and PNNL for Samples Located Greater Than 6 m (20 ft) in Depth Below Ground Surface

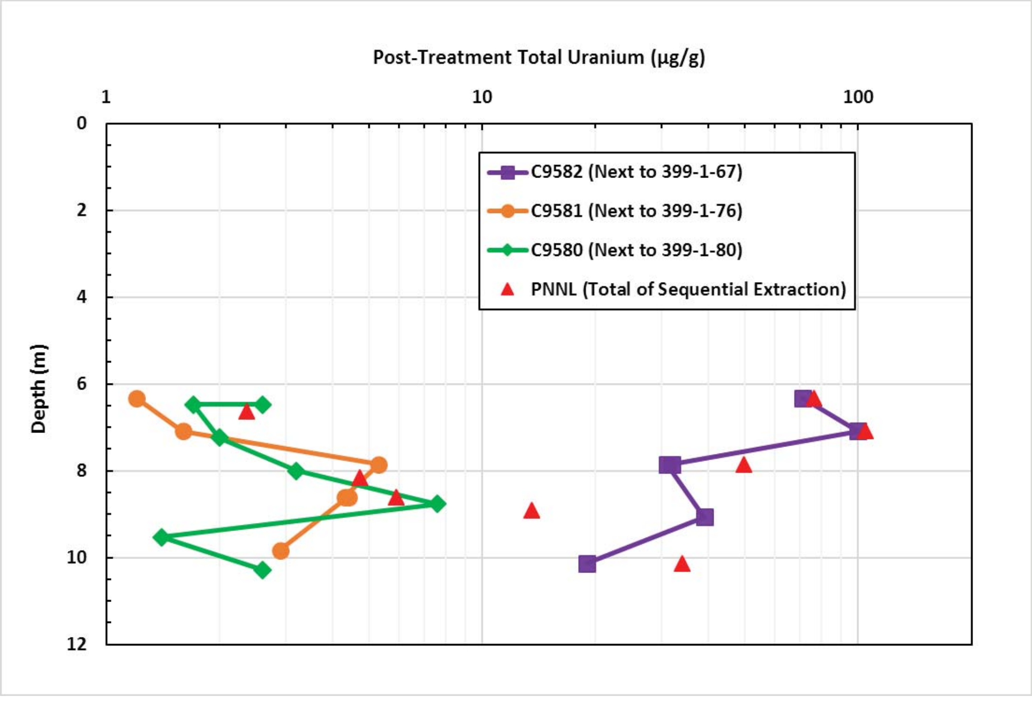
Well ID	Sample ID (GEL Lab)	Borehole, Sampling Interval	Depth Below Ground in m (ft)	GEL Lab Based Total Uranium in Sediment Sample (µg/g)	PNNL Lab Based Total Uranium (µg/g) (Total from Sequential Extraction)	Sample ID (PNNL Leach)
C8940 (399-1-76)	B31N14	I-005B	6.6 to 6.7 (21.5 to 22)	2.54	--	--
	B31N15	I-005B (Duplicate)	6.6 to 6.7 (21.5 to 22)	2.14	--	--
	B31N20	I-006B	7.3 to 7.5 (24 to 24.5)	2.50	--	--
	B31N25	I-007B	7.9 to 8.1 (26 to 26.5)	5.90	--	--
	B31N30	I-008B	8.7 to 8.8 (28.5 to 29)	11.50	14.4	B31N29
	B31N35	I-009B	9.4 to 9.6 (31 to 31.5)	4.49	--	--
C9451 (399-1-80)	B31N86	I-005B	6.4 to 6.6 (21 to 21.5)	12.0	12.72	B31N85
	B31N91	I-006B	7.3 to 7.5 (24 to 24.5)	5.44	--	--
	B31N97	I-007B	8.1 to 8.2 (26.5 to 27)	10.6	13.02	B31N96
	B31NB2	I-008B	8.7 to 8.8 (28.5 to 29)	9.29	14.96	B31NB1
	B31NB7	I-009B	9.6 to 9.8 (31.5 to 32)	6.5	--	--
C8936 (399-1-67)	B30524	I-004B	5.3 to 6.1 (17.5 to 20)	34.8	57.66	B30525
	B30529	I-005B	6.4 to 7 (21 to 23)	26.1	--	--
	B30534	I-006B	7.2 to 7.8 (23.5 to 25.5)	16.9	--	--
	B30535	I-006B (Duplicate)	7.2 to 7.8 (23.5 to 25.5)	20.6	--	--
	B30540	I-007B	7.9 to 8.7 (26-28.5)	41.4	125.79	B30538
	B30545	I-008B	8.7 to 9.4 (28.5 to 31)	20.8	31.0	B30546

Table 6-2. Pretreatment Sediment Analysis for Total Uranium by the GEL Laboratory and PNNL for Samples Located Greater Than 6 m (20 ft) in Depth Below Ground Surface

Well ID	Sample ID (GEL Lab)	Borehole, Sampling Interval	Depth Below Ground in m (ft)	GEL Lab Based Total Uranium in Sediment Sample (µg/g)	PNNL Lab Based Total Uranium (µg/g) (Total from Sequential Extraction)	Sample ID (PNNL Leach)
	B30550	I-009B	9.8 to 10.5 (32 to 34.5)	25.8	--	--
	B309C9	(Contingency)	10.5 to 11.1 (34.5 to 36.5)	12.3	--	--
	B30552	I-0010	10.7 (35)	19.9	--	--



(a)



(b)

Figure 6-15. Total Uranium Concentration Profiles based on (a) Pre-Treatment Borehole Samples and (b) Collocated Post-Treatment Borehole Samples

Table 6-3. Post-Treatment Sediment Analysis for Total Uranium by the ALS Lab and PNNL for Samples Located Greater Than 20 ft in Depth Below Ground Surface

Well ID	Sample ID (GEL Lab)	Borehole, Sampling Interval	Depth (ft below ground surface)	ALS Lab Based Total Uranium in Sediment Sample (µg/g)	PNNL Lab Based Total Uranium (µg/g) (Total from Sequential Extraction)	Sample ID (PNNL Leach)
C9581	B347J9	I-001	6.1 to 6.9 (20 to 22.5)	1.2	--	--
	B347K5	I-002	6.9 to 7.6 (22.5 to 25)	1.6	--	--
	B347L0	I-003	7.6 to 8.4 (25 to 27.5)	5.3	--	--
	B347L5	I-004	8.4 to 9.1 (27.5 to 30)	4.3	5.8	B347L4
	B347L6	--	--	4.4	--	--
	B347M1	I-005	9.1 to 9.9 (30 to 32.5)	2.9	--	--
C9580	B347C7	I-001	6.1 to 6.9 (20 to 22.5)	2.6	2.3	B347C6
	B3347C9	--	--	1.7	--	--
	B347D3	I-002	6.9 to 7.6 (22.5 to 25)	2.0	--	--
	B347D9	I-003	7.6 to 8.4 (25 to 27.5)	3.2	4.7	B347D8
	B347F4	I-004	8.4 to 9.1 (27.5 to 30)	7.6	13.3	B347F1, B347F3
	B347F9	I-005	9.1 to 9.9 (30 to 32.5)	1.4	--	--
	B347H4	I-006	9.9 to 10.7 (32.5 to 35)	2.6	--	--
C9582	B347P1	I-001	6.1 to 6.9 (20 to 22.5)	71.0	74.8	B347P0
	B347P6	I-002	6.9 to 7.6 (22.5 to 25)	100.0	102.3	B347P4, B347P5, B347P8
	B347R2	I-003	7.6 to 8.4 (25 to 27.5)	32.0	48.1	B347R0, B347R1
	B347R3	--	--	31.0	--	--
	B347R8	I-004	8.4 to 9.1 (27.5 to 30)	39.0	--	--
	B347T8	I-006	9.9 to 10.7 (32.5 to 35)	19.0	33.4	B347T6, B347T7

Comparing total uranium concentrations between the collocated pretreatment and post-treatment boreholes (Figure 6-15) indicates that uranium concentrations remained largely unchanged in the sediment following treatment. (NOTE: For the purpose of comparison, the pretreatment borehole profile for 399-1-67 [C8936] has been used based on PNNL data instead of GEL data.) This shows that most of the uranium present in the sediment remained in place, and only a limited amount was displaced during injection and infiltration.

Acid extractions using 0.5 M nitric acid were conducted on selected post-treatment samples (boreholes C9580, C9581, and C9582) as well as pretreatment samples from boreholes C8940 (399-1-76) and C9451 (399-1-80) to evaluate the precipitated phosphate concentration by etching the sediments without digesting the sample (PNNL-25420). For each sample, 0.5 M nitric acid was added at a solid-to-solution ratio of 1 g/2 mL. The sample was then agitated on an orbital shaker for 15 minutes, centrifuged, decanted, and filtered. The results in terms of phosphate concentration (total P as phosphate) are presented in Figure 6-16 (pretreatment samples are shown in part a, and post-treatment samples [prior to any leaching] are shown in part b). Results from pretreatment samples provide an average phosphate concentration of 1,750 mg/kg, indicating that some residual phosphate existed prior to injection/infiltration from past discharge activities in this area. Results from post-treatment samples (Figure 6-16, b) show that phosphate concentrations are typically higher than 2,000 mg/kg for C9580 and for deeper samples at C9582, indicating that these resulted from Stage A treatment. Borehole C9580 shows high phosphate concentrations throughout its depth profile, consistent with the ERT data, where faster migration of infiltrated solutions was observed resulting in higher bulk conductance (Figures 6-10 and 6-11). Higher phosphate concentrations observed at a deeper depth at C9582 indicate that injections conducted in the PRZ were instrumental in precipitating phosphate. Higher phosphate concentration is also observed for the deeper sample collected at C9581, which confirms the effect of injection in delivering high concentrations of phosphate.

Sediment samples collected from post-treatment boreholes were also analyzed for phosphate concentration (at the ALS laboratory) by performing water extraction (analyzed using ion chromatography) and total digestion (analyzed using inductively coupled plasma-optical emission spectroscopy [ICP-OES]; SW6010B). Vertical profiles, based on water extraction and total digestion of the sample, are shown in Figure 6-17. Phosphate concentrations derived from total digestion performed in the ALS laboratory are compared to the total phosphate, based on sequential extraction performed by PNNL. They show values of similar magnitude with depth. The concentration shows a marked increase in the PRZ, indicating that injections performed in the PRZ led to formation of phosphate precipitate, and they are considerably greater than the background phosphate concentration of about 3,600 mg/kg, which is inferred for the 300 Area samples (for total digestion) based on evaluation of results. A similar increase in phosphate concentration is also noticeable for the water extracted profiles within the PRZ. Above the PRZ, phosphate concentrations are controlled by the infiltrated solutions. Concentrations above the PRZ vary by location indicating variable depths to which highly concentrated phosphate solutions reached. The infiltrated solutions at C9580 appear to have influenced phosphate precipitation throughout the vadose zone (down to PRZ), while only high concentrations are noticeable in the shallow portion (<4 m depth) above the PRZ at C9581. The sharp increase in phosphate concentration at about 5 m depth at C9580 is due to presence of a silt lens indicating enhanced reaction with phosphate. At C9582, the amount of phosphate precipitation above the PRZ does not appear to be appreciable, and they may be impacted by local heterogeneities in permeability that could have precluded uniform distribution of phosphate in the upper vadose zone.

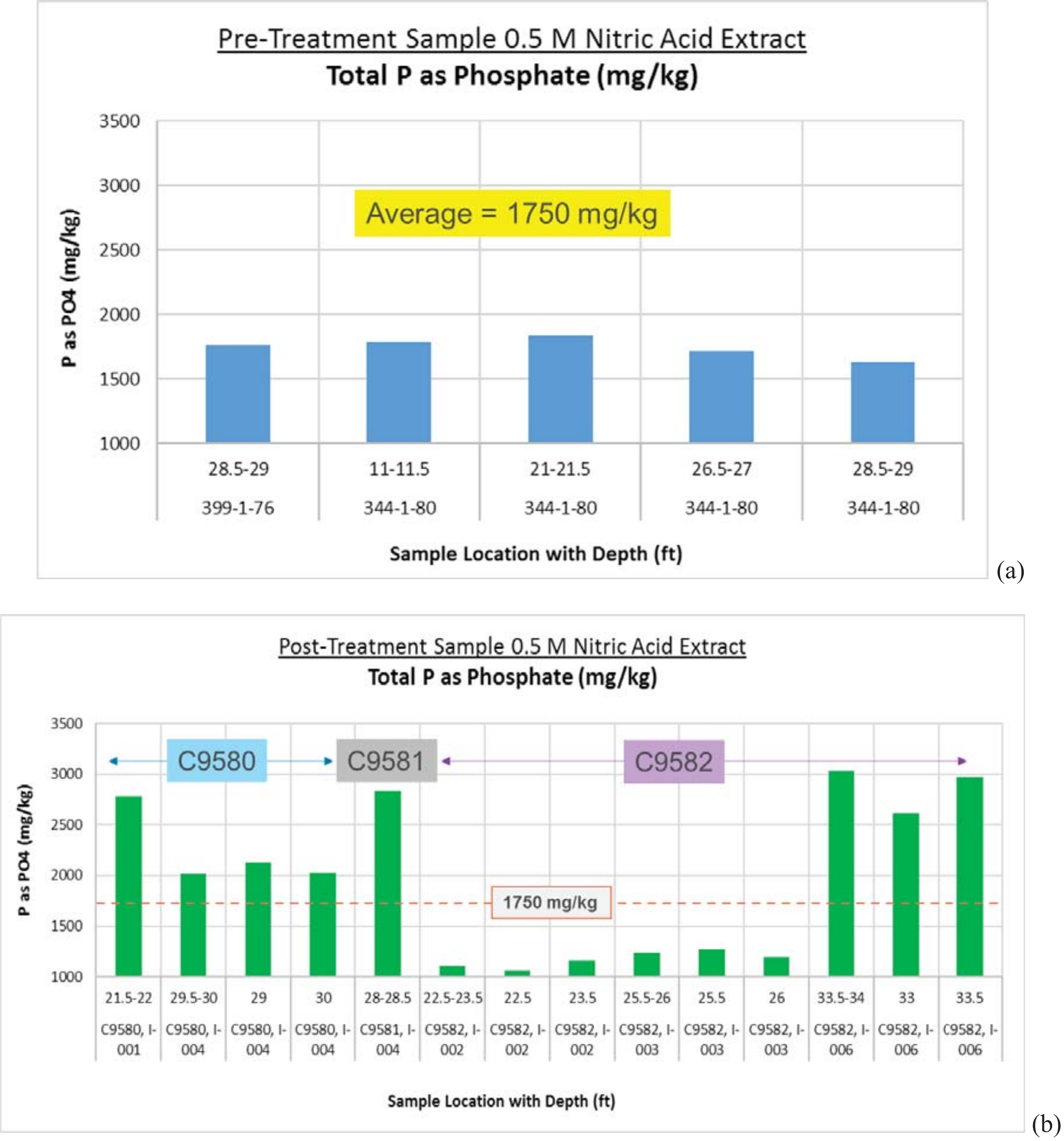
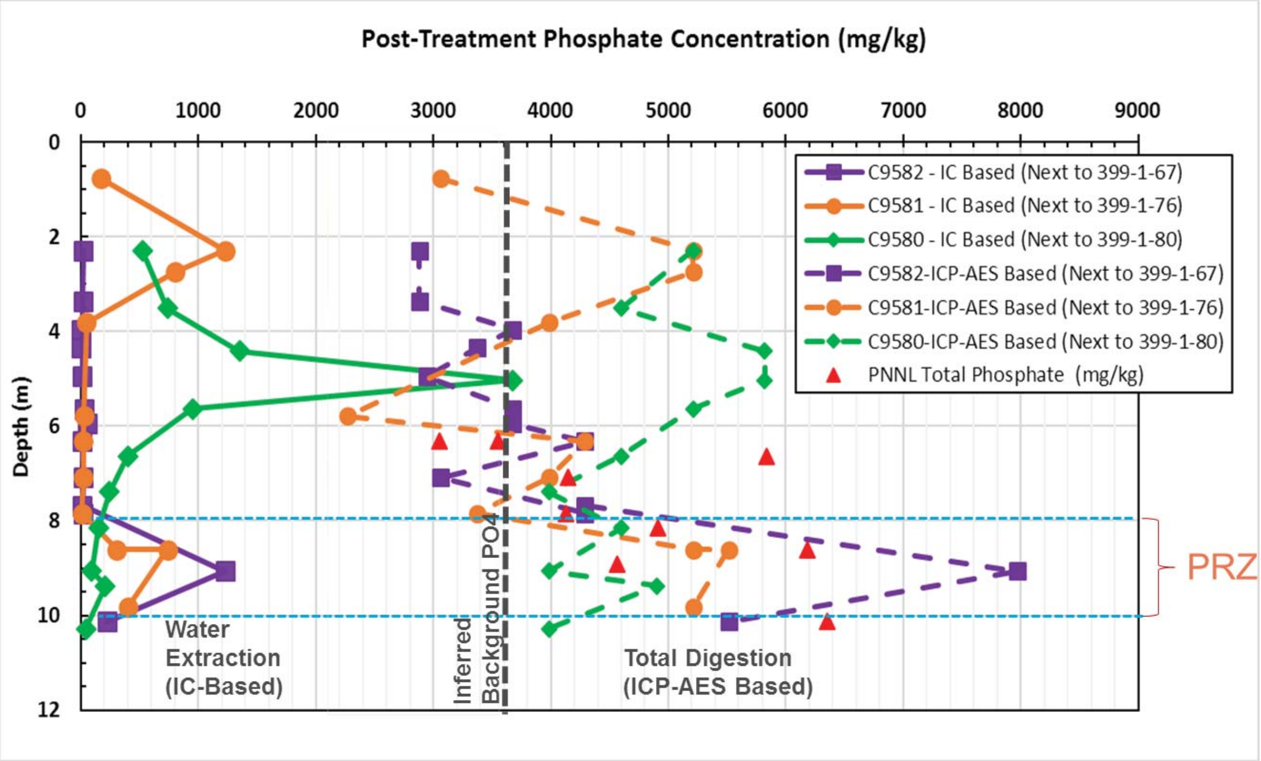


Figure 6-16. Concentration of Phosphate (Total P as Phosphate) Based on 0.5 M Nitric Acid Extraction on (a) Pretreatment Samples and (b) Post-Treatment Samples



Note: Vertical line of background phosphate concentration is inferred for the samples undergoing total digestion.

Figure 6-17. Phosphate Concentrations (total P as Phosphate) in Post-Treatment Samples Analyzed Using Water Extraction (Ion Chromatography [IC]) and Total Digestion (ICP-Atomic Emission Spectroscopy [ICP-AES; same as ICP-OES])

6.3.1 Sequential Extraction

Sequential extraction tests were performed on both the pretreatment and post-treatment samples. Aliquots of air dried <2 mm size fraction are used in the analysis. These tests use a sequential chemical extraction technique described in PNNL-14022, *300 Area Uranium Leach and Adsorption Project*, and PNNL-21733. The tests can provide information on the relative amount of uranium (or other elements) present in extractable phases of carbonate coatings, carbonate solid-bearing compounds, amorphous hydrous oxides, crystalline iron oxides, and strong acid leachable compounds. The following extractions were undertaken in sequence:

1. Weak Acetic Acid Extraction: This involved contacting the sediment with a weak acetic acid consisting of 1 mol/L sodium acetate with a final pH of ~5. The solid-to-solution ratio is kept at 1 g/2 mL, and the sample is agitated in an orbital shaker for 1 hour. The solution is removed, decanted, and filtered. Target uranium phases for this extraction are the adsorbed (weakly bound) uranium and some of the uranium associated with carbonate minerals.

2. Strong Acetic Acid Extraction: The sample from the previous extraction is contacted with a strong acetic acid (concentrated glacial acetic acid) at a pH of 2.3 for 5 days. The sample is centrifuged, and the solution is decanted and filtered. The target phase for the strong acetic acid is the strongly bound uranium associated with carbonate minerals.

3. Ammonium Oxalate Extraction: The third extraction used a solution consisting of 0.1 mol/L ammonium oxalate with 0.1 mol/L oxalic acid. After 1 hour of contact time, the samples are centrifuged, decanted, and filtered. Target phases for the oxalate solution are the amorphous Fe, Al, Mn, and Si oxides.

4. Nitric Acid Extraction: The final extraction involved contacting the sample from the previous step with 8 mol/L of nitric acid and heating at 95°C for 2 hours on a hot plate. Target phases for the nitric acid extraction included clays and crystalline oxides of Fe, Al, and Mn.

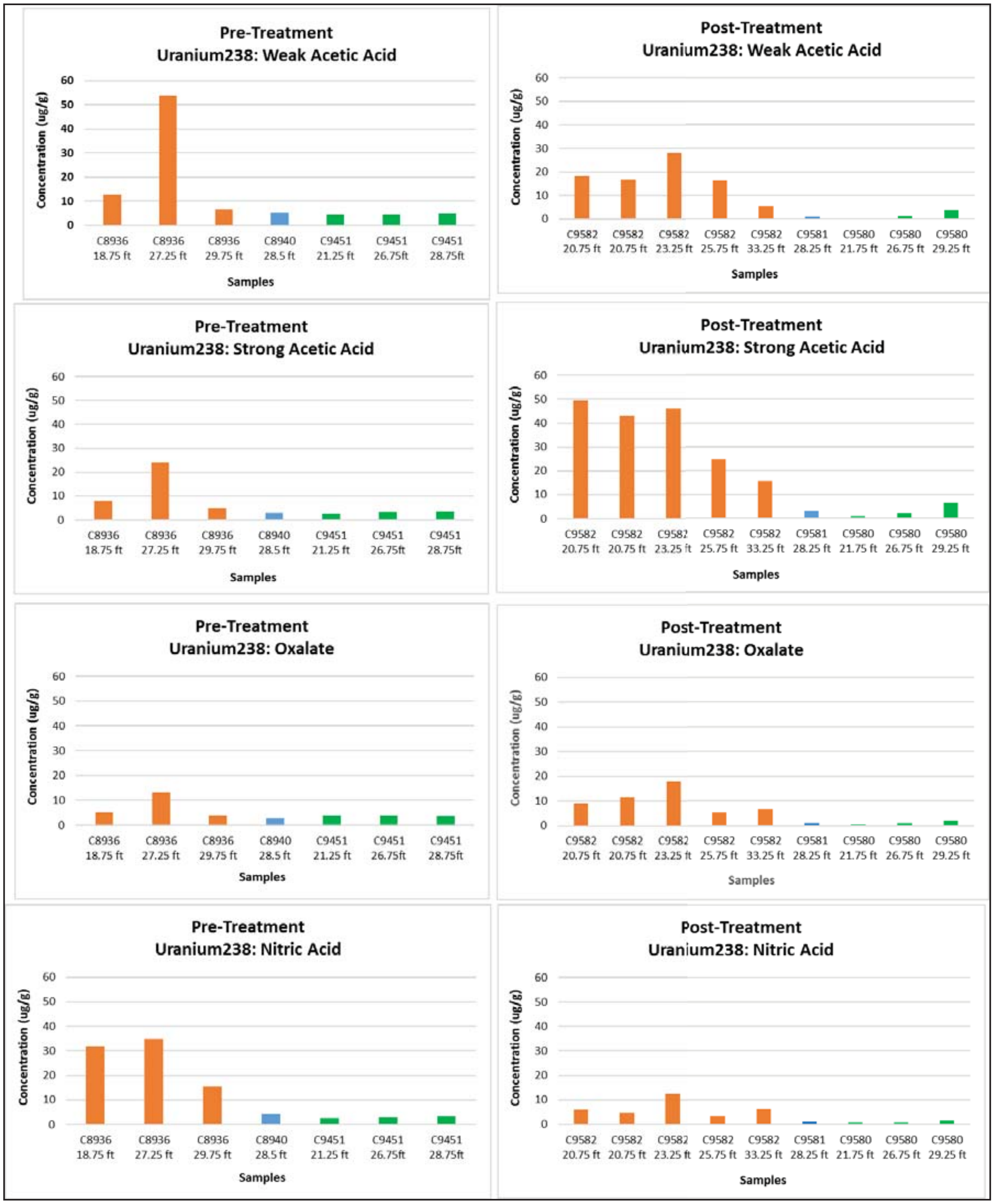
Each extractant solution was collected and analyzed for P, Ca, Al, Fe, Mn via ICP-OES, and uranium content via inductively coupled plasma-mass spectroscopy. Results are presented in Figures 6-18 through 6-22 for each analyzed element by comparing pretreatment borehole samples with post-treatment borehole samples (same colors used for collocated boreholes). The following observations are based on the results presented for uranium (Figure 6-18):

1. In the pretreatment samples, uranium is associated primarily with two different mineral phases: the majority of the uranium is associated with crystalline oxides of Fe (including Al and Mn) and with clay minerals (based on extraction using nitric acid), while a significant yet somewhat lower amount is weakly adsorbed on sediment surface or weakly complexed with carbonate minerals (based on extraction using weak acetic acid).

2. In the post-treatment samples, uranium is primarily present as strongly bound with carbonate minerals (based on extraction using strong acetic acid) and as weakly complexed with carbonate mineral phases (based on weak acetic acid extraction). According to PNNL-20004, *Remediation of Uranium in the Hanford Vadose Zone Using Ammonia Gas: FY 2010 Laboratory-Scale Experiments*, Na-boltwoodite (uranium bearing silicate) is also predominantly dissolved (85 percent) in the acetic acid extraction. Therefore, it is possible that some of the uranium fraction is present as silicate in addition to being associated with carbonates.

3. In the post-treatment samples, an appreciable reduction of nitric acid extracted uranium fraction is noticeable, indicating that the uranium present with iron oxides and clay minerals prior to treatment has been remobilized (underwent dissolution), that later complexed with carbonate phases in the solution (along with surface adsorption and reprecipitation). The increased association of uranium with carbonate phases following phosphate treatment of uranium contaminated sediments has also been observed by Shi et al., 2009, “Inhibition Effect of Secondary Phosphate Mineral Precipitation on Uranium Release from Contaminated Sediments.”

4. No appreciable change in uranium association with amorphous oxides (Fe, Mn, and Al) occurred based on extraction using ammonium oxalate. This does not mean that amorphous oxides were not impacted, but rather similar concentrations of uranium are associated with these phases prior to and following the treatment. It is possible that dissolution and precipitation also occurred, but the net effect is small.



Note: Collocated boreholes are shown using the same color scheme.

Figure 6-18. Results from Sequential Extraction of Uranium Performed on Pretreatment Boreholes (Left) and Post-Treatment Boreholes (Right)

Figure 6-19 compares the pretreatment and post-treatment sequential extraction results for calcium. In the post-treatment samples, the nitric acid extracted calcium fraction decreased while fraction associated with weak and strong acetic acid extraction increased (along with the fraction extracted with oxalic acid). This indicates that calcium bearing clay and oxide mineral phases may have dissolved and reprecipitated with other components present in the solution, including phosphate and uranium. Calcium also undergoes ion exchange reactions once sodium (and potassium) contacts the sediments. It is the primary exchanger with sodium and potassium in the injected/infiltrated solution. The remedy depends on calcium being made available in solution via ion exchange, to complex with phosphate, leading to precipitation of amorphous monocalcium phosphate that slowly over several weeks recrystallizes to dicalcium to octacalcium phosphate and eventually forms hydroxyapatite over a period of months to years (PNNL-21733; Sumner, 2000, “Soil Fertility and Plant Nutrition”). The average ion exchange capacity of sediments is reported to be 1.2 to 2 meq/100 g, with 77 percent of ion exchange sites occupied with Ca^{2+}, and the total calcium available is 0.9 to 1.5 mmol/100 g (PNNL-18303, *Sequestration of Sr-90 Subsurface Contamination in the Hanford 100-N Area by Surface Infiltration of a Ca-Citrate-Phosphate Solution*). It is expected that some fraction of this calcium would exchange in the high Na-bearing phosphate solutions.

A separate study reported that 300 Area North Process Pond sediments contain 49 mg/L of water extractable calcium (PNNL-14022). Experiments conducted on these sediments (Wellman et al., 2007, “Efficacy of soluble sodium tripolyphosphate amendments for the in-situ immobilisation of uranium”) indicate that aqueous phosphate in the mobile phase tends to increase the dissolution rate of calcite. The reaction of phosphate with calcite involves surface adsorption followed by dissolution of calcite to facilitate precipitation of the more thermodynamically favored calcium-phosphate solid phases. About 30 percent of the uranium was found to be associated initially with carbonate solids within these sediments and, therefore, would undergo some type of mobilization due to dissolution followed by reprecipitation. Brown, 1980, “Calcium Phosphate Precipitation in Aqueous Calcitic Limestone Suspensions,” illustrated rapid sorption of phosphorus on calcareous sediments followed by rapid precipitation of hydroxyapatite under pH conditions similar to the ones existing for Stage A treatment.

Results from the sequential extraction of calcium indicate that calcium has been mobilized in the solution as a result of both dissolution of the carbonate bearing mineral phases (primarily calcite) and ion exchange reactions with sodium and potassium ions. The available calcium in solution then reacted with phosphate and carbonate in the pore water (along with available uranium complexes) and formed amorphous precipitates.


Pre-Treatment Calcium: Weak Acetic Acid

Post-Treatment Calcium: Weak Acetic Acid

Pre-Treatment Calcium: Strong Acetic Acid

Post-Treatment Calcium: Strong Acetic Acid

Pre-Treatment Calcium: Oxalate

Post-Treatment Calcium: Oxalate

Pre-Treatment Calcium: Nitric Acid

Post-Treatment Calcium: Nitric Acid

Note: Collocated boreholes are shown using the same color scheme.

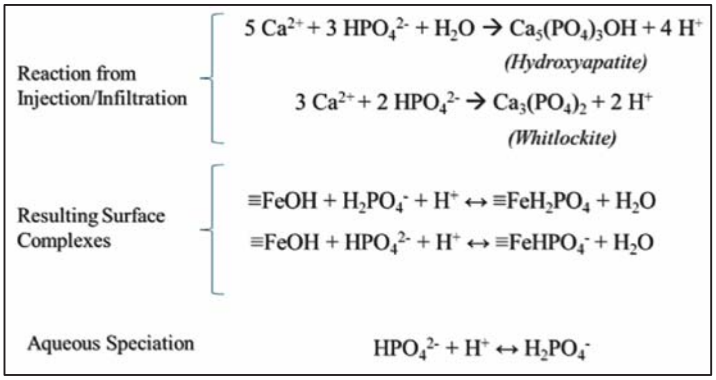
Figure 6-19. Results from Sequential Extraction of Calcium Performed on Pretreatment Boreholes (Left) and Post-Treatment Boreholes (Right)

Figure 6-20 shows the comparison for iron between pretreatment and post-treatment samples. Iron concentrations in the post-treatment sediment samples show a significant decrease in the nitric acid extractable fraction and a significant increase in the strong acetic acid extractable fraction. This reflects that iron initially associated with crystalline oxides and clay minerals has been dissolved and reprecipitated with carbonates. This is consistent with the changes observed for uranium and calcium. Sequential extraction results presented for aluminum (Figure 6-21) and manganese (Figure 6-22) show behavior similar to that observed for iron, indicating that crystalline oxides and clay mineral phases containing Fe, Mn, and Al have undergone dissolution and have reprecipitated with predominantly calcium phosphate and calcium carbonate bearing mineral phases. Uranium is also associated with these mineral phases either as part of the mineral phase (by incorporation) or by surface adsorption (forming both weak and strong surface complexes).

In the strong acetic acid extraction step, the iron concentration of the post-treatment samples is the highest among the elements analyzed. This indicates that iron played an important role in the reactions that occurred from injecting/infiltrating phosphate solutions at high concentrations. Almost half of the total iron in the pretreatment sample (C8936) has been dissolved away, based on results from collocated post-treatment borehole (C9582) sample, with an appreciable amount now co-precipitated with calcium carbonates and calcium phosphate (and some silicates). Surface complexation of phosphate ions with iron oxyhydroxide mineral phases (such as ferrihydrite and goethite) is an important process that occurs due to excess availability of orthophosphate that exceeds the buffering capacity of sediments.

The addition of concentrated sodium-potassium bearing phosphate solutions to the subsurface leads to release of Ca^{2+} from cation-exchange reactions with the sediment and dissolution of calcite. Based on the pH of the system, the predominant aqueous phosphate species in solution is either dihydrogen phosphate ($H_2PO_4^-$) or hydrogen phosphate (HPO_4^{2-}); both species are present in equal amounts around pH of 7.2 (Figure 6-23, part a), which is the second dissociation constant of phosphoric acid. If pH reduces from 7.2, then dihydrogen phosphate ($H_2PO_4^-$) becomes dominant; if it increases, then hydrogen phosphate (HPO_4^{2-}) would become the dominant species. As more Ca^{2+} becomes available in the solution, the aqueous complexation with phosphate species will likely lead to $CaHPO_4$ for the range of chemical conditions that are relevant to the subsurface at the 300 Area. The aqueous complex stability field is shown in part b of Figure 6-23.

With continued addition of phosphate and reaction with Ca^{2+}, the aqueous concentrations would increase, leading to precipitation of amorphous calcium phosphate that thermodynamically favors formation of mineral phases, such as hydroxyapatite and whitlockite, as conceptualized below. In this process, hydrogen ions, which could get consumed in the surface complexation reactions between existing iron oxyhydroxide minerals (e.g., present as surface coatings) and monohydrogen and dihydrogen phosphate anions, are released.



Reaction from Injection/Infiltration

$$5\ Ca^{2+} + 3\ HPO_4^{2-} + H_2O \rightarrow Ca_5(PO_4)_3OH + 4\ H^+$$

(Hydroxyapatite)

$$3\ Ca^{2+} + 2\ HPO_4^{2-} \rightarrow Ca_3(PO_4)_2 + 2\ H^+$$

(Whitlockite)

Resulting Surface Complexes

$$\equiv FeOH + H_2PO_4^- + H^+ \leftrightarrow \equiv FeH_2PO_4 + H_2O$$

$$\equiv FeOH + HPO_4^{2-} + H^+ \leftrightarrow \equiv FeHPO_4^- + H_2O$$

Aqueous Speciation

$$HPO_4^{2-} + H^+ \leftrightarrow H_2PO_4^-$$

Note: Collocated boreholes are shown using the same color scheme.

Figure 6-20. Results from Sequential Extraction of Iron Performed on Pretreatment Boreholes (Left) and Post-Treatment Boreholes (Right)

Notes: Weak acetic acid extractions for pretreatment samples from boreholes C8940 and C9451 were not conducted. Collocated boreholes are shown using the same color scheme.

Figure 6-21. Results from Sequential Extraction of Aluminum Performed on Pretreatment Boreholes (Left) and Post-Treatment Boreholes (Right)

Pre-Treatment Manganese: Weak Acetic Acid

Post-Treatment Manganese: Weak Acetic Acid

Pre-Treatment Manganese: Strong Acetic Acid

Post-Treatment Manganese: Strong Acetic Acid

Pre-Treatment Manganese: Oxalate

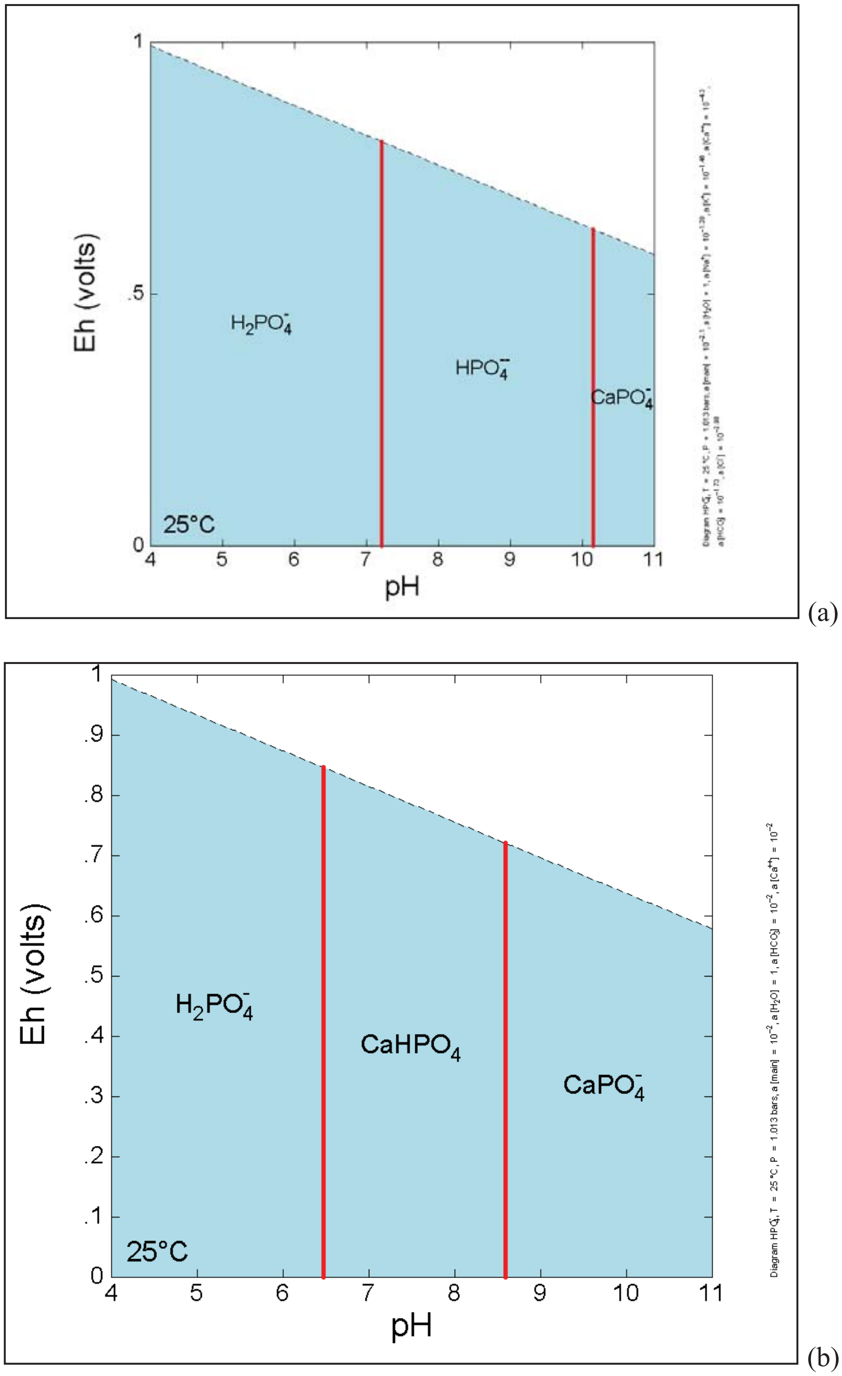
Post-Treatment Manganese: Oxalate

Pre-Treatment Manganese: Nitric Acid

Post-Treatment Manganese: Nitric Acid

Note: Collocated boreholes are shown using the same color scheme.

Figure 6-22. Results from Sequential Extraction of Manganese Performed on Pretreatment Boreholes (Left) and Post-Treatment Boreholes (Right)

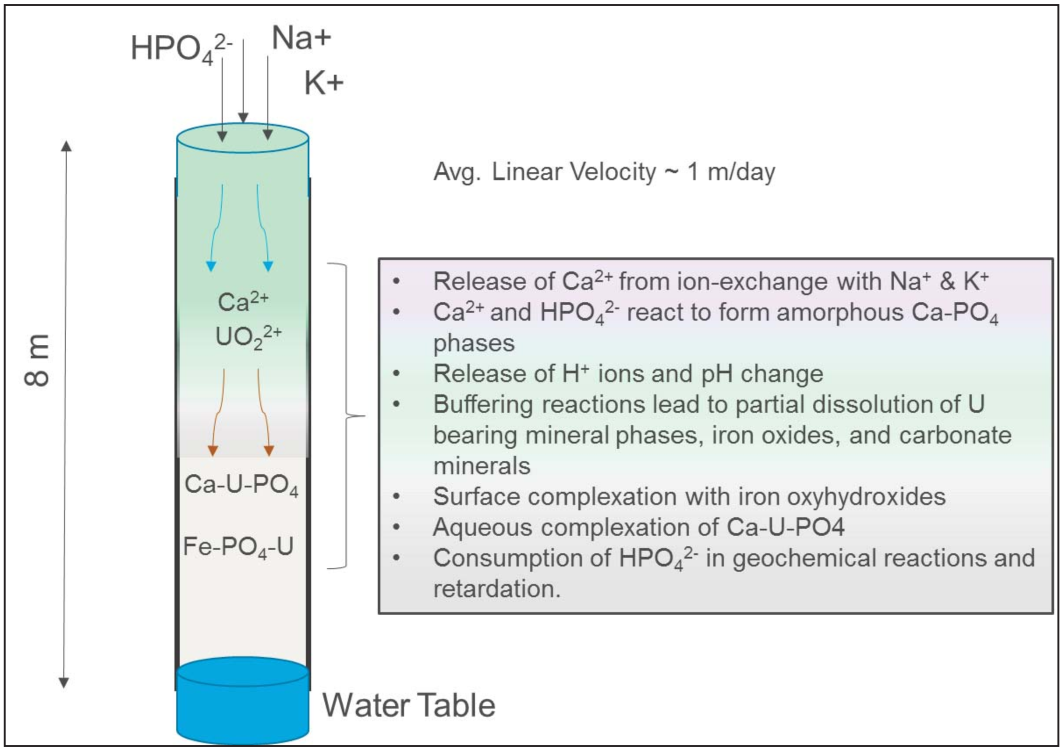


Note: Figure is based on activity of HPO_4^{2-}, HCO_3^-, and Ca^{2+} set at 10^{-2} in the solution.

Figure 6-23. Eh-pH Diagram Presenting the Orthophosphate Aqueous Complex Stability Field for (a) Infiltrated Water Composition and (b) Hypothetical Water Where Orthophosphate, Bicarbonate, and Calcium Concentrations Are Approximately Equal

With continued supply of phosphate and reactions leading to formation of calcium phosphate bearing mineral phases, the supply of hydrogen ions released to the solution could exceed the buffering capacity in the pore volume, leading to reduction in pH. The degree of pH reduction will be dependent upon the amount of reactive carbonate minerals (primarily calcite); clay minerals; oxides of Fe, Mn, and Al; and uranium bearing minerals. Small reductions in pH (even by half a pH unit) can lead to large changes in the activity of total dissolved iron and, therefore, favor dissolution of iron containing mineral phases, such as present in clay minerals (e.g., chlorite group) and hydrous ferric oxide bearing cement coatings around the grains. The chlorite group of phyllosilicate (clay) minerals contains Fe, Mg, Al, Mn, which would be released into the solution upon partial or complete dissolution of clay minerals. The released Fe (along with other metal ions such as Al and Mn) could get mobilized and react with dissolved species in the solution (predominantly Ca^{2+}, Na^{+}, $H_2PO_4^{-}$, HPO_4^{2-}, and HCO_3^{-}) leading to co-precipitation. These and related reactions are conceptualized in Figure 6-24 as phosphate bearing solutions infiltrate through the vadose zone.

The aqueous complexes formed by uranium will depend on the ratio of HPO_4^{2-}/HCO_3^{-} in the solution and pH. The stability field for such uranium complexes is presented in Figure 6-25. As long as the activity ratio of HPO_4^{2-}/HCO_3^{-} remains greater than 10^{-5} and pH is below 8, the primary aqueous complexes formed will be $UO_2(H_2PO_4)_2$ (a neutral species). Under these conditions, formation of uranyl orthophosphate mineral phase, $(UO_2)_3(PO_4)_2(H_2O)_4$, is favored assuming no other reactants are in the solution. Mehta et al. (2016) determined that when dissolved uranium, calcium, and phosphate are present together, uranium is structurally incorporated into a newly formed amorphous calcium phosphate solid. But when uranium is contacted with preformed amorphous calcium phosphate solids adsorption is the dominant removal mechanism for uranium. Both mechanisms are likely during Stage A treatment.



- Release of Ca^{2+} from ion-exchange with Na^{+} & K^{+}
- Ca^{2+} and HPO_4^{2-} react to form amorphous Ca-PO_4 phases
- Release of H^{+} ions and pH change
- Buffering reactions lead to partial dissolution of U bearing mineral phases, iron oxides, and carbonate minerals
- Surface complexation with iron oxyhydroxides
- Aqueous complexation of Ca-U-PO4
- Consumption of HPO_4^{2-} in geochemical reactions and retardation.

Figure 6-24. Conceptual Model of Probable Reactions Occurring in the Subsurface from Infiltration of Phosphate Bearing Solutions

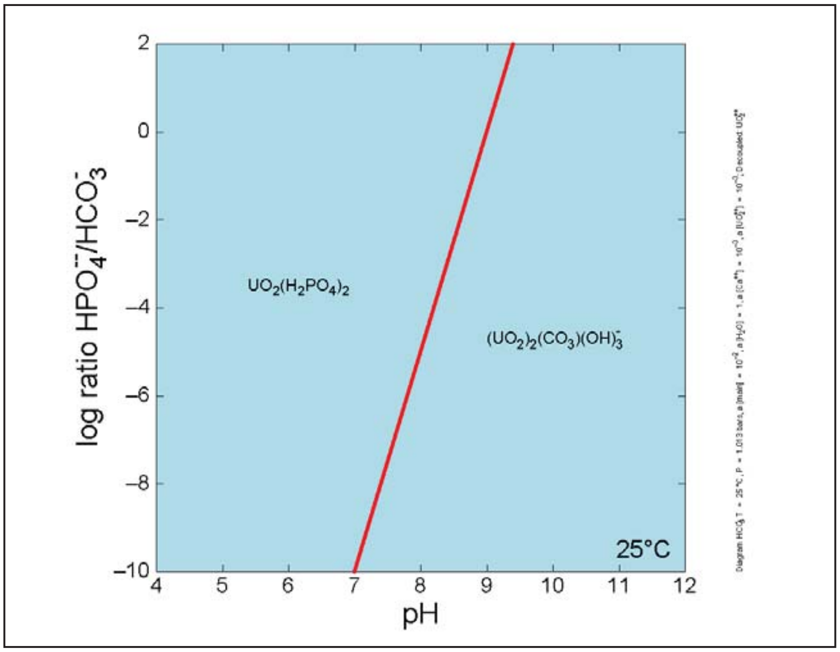


Figure 6-25. Stability Field of Uranium Aqueous Complexes Under Varying Orthophosphate to Bicarbonate Ratio and pH

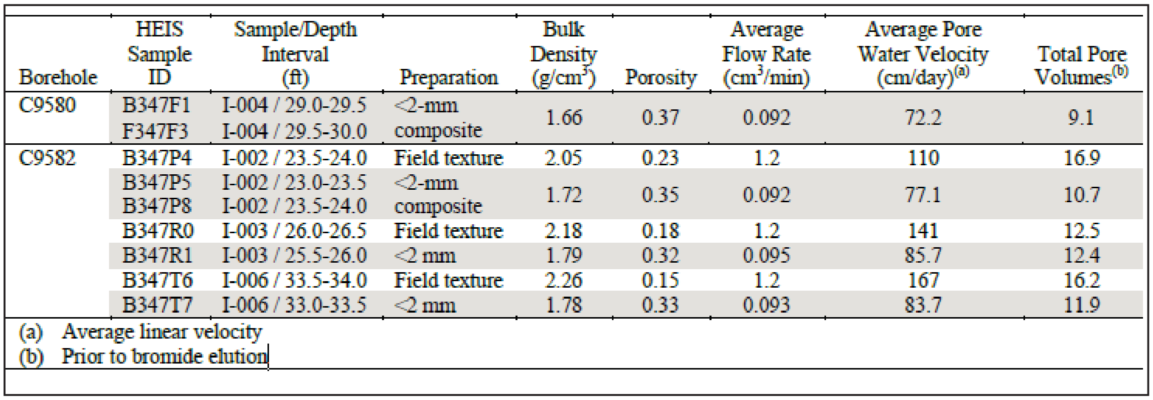
6.3.2 Flow-Through Column Leaching Tests

Flow-through column leach experiments were conducted on three intact (field-textured) samples and four repacked columns containing <2 mm size material from post-treatment boreholes. The sampling depth intervals selected on post-treatment boreholes is shown in Table 6-4. These depth intervals were selected, based on the uranium soil distribution and depth of the pretreatment samples.

The column experiments were performed using 15.2 cm (6 in.) long and 2.5 cm (1 in.) diameter glass columns. The influent water was a synthetic groundwater that is based on the groundwater composition at the 300 Area (average of 42 wells [Ma et al., 2010, “A field-scale reactive transport model for U(VI) migration influenced by coupled multirate mass transfer and surface complexation reactions”]).
The synthetic groundwater is a calcium-bicarbonate type water that is adjusted to pH of 7.3 and does not include phosphate, as documented in PNNL-25420.

The flow rate through the columns containing <2 mm size sediments was maintained at approximately 0.1 cm^3/min or 0.25 pore volumes per hour, yielding pore water velocities of about 70 to 90 cm/day.
For the columns containing field-textured sediment, the flow rate was approximately 1.5 cm^3/min or 0.25 pore volumes per hour yielding pore water velocities of about 110 cm to 180 cm/day. The column experiments were run for approximately 10 pore volumes, with two stop flow events: one approximately after 4 pore volumes for about 48 hours, and one at approximately 7 pore volumes for about 72 hours.
At the end of the tests, sodium bromide was injected to evaluate the breakthrough times for a conservative tracer. Additional details are provided in PNNL-25420.

Table 6-4. Flow-Through Column Test Parameters for Post-Treatment Samples



Borehole	HEIS Sample ID	Sample/Depth Interval (ft)	Preparation	Bulk Density (g/cm^3)	Porosity	Average Flow Rate (cm^3/min)	Average Pore Water Velocity (cm/day)[(a)]	Total Pore Volumes[(b)]
C9580	B347F1 F347F3	I-004 / 29.0-29.5 I-004 / 29.5-30.0	<2-mm composite	1.66	0.37	0.092	72.2	9.1
C9582	B347P4	I-002 / 23.5-24.0	Field texture	2.05	0.23	1.2	110	16.9
	B347P5 B347P8	I-002 / 23.0-23.5 I-002 / 23.5-24.0	<2-mm composite	1.72	0.35	0.092	77.1	10.7
	B347R0	I-003 / 26.0-26.5	Field texture	2.18	0.18	1.2	141	12.5
	B347R1	I-003 / 25.5-26.0	<2 mm	1.79	0.32	0.095	85.7	12.4
	B347T6	I-006 / 33.5-34.0	Field texture	2.26	0.15	1.2	167	16.2
	B347T7	I-006 / 33.0-33.5	<2 mm	1.78	0.33	0.093	83.7	11.9

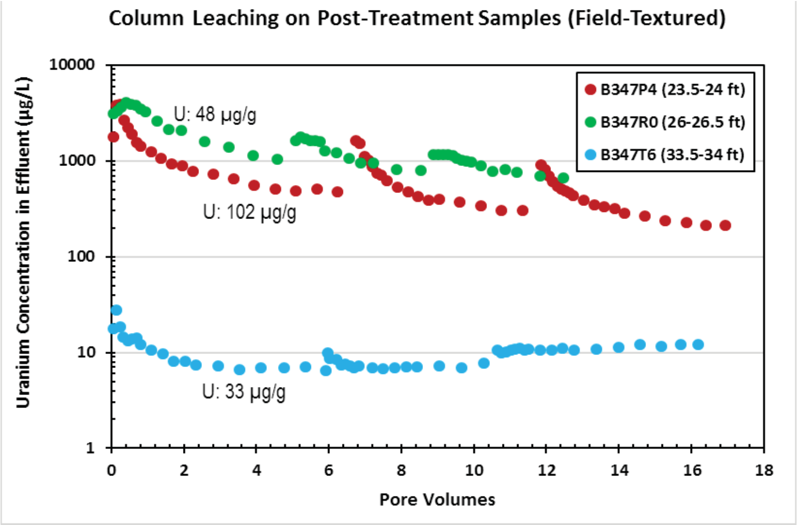
(a) Average linear velocity

(b) Prior to bromide elution

HEIS = Hanford Environmental Information System

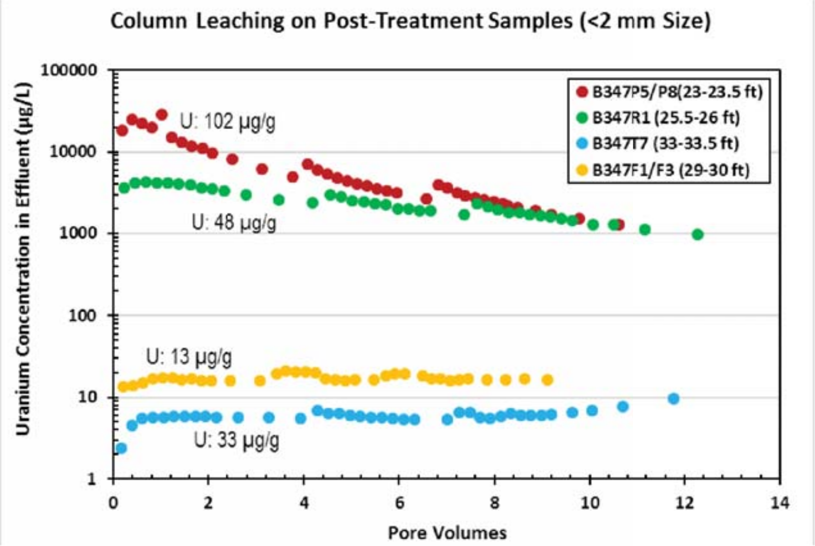
Uranium concentrations in the effluent as a function of pore volumes flushed are presented for the field-textured (intact) samples in Figure 6-26 and for the <2 mm size sediment samples in Figure 6-27. For the field-textured and <2 mm size sediments taken from adjacent depths same color scheme is used in the two figures for direct comparison. There is one extra sample analyzed for the <2 mm size sediment (from borehole C9580); all of the rest of the samples are taken from borehole C9582.

Results for field-textured sediments (Figure 6-26) show high initial uranium concentrations for two samples (B347P4/P5 and B347R0) of about 3,000 to 4,000 µg/L. The concentrations decline within the first two pore volumes, following which the rate of decline is slower. The intermittent increase in concentrations and gradual decline results from resumption of flow following the stop-flow event. Concentrations remain above 200 µg/L throughout the experiment duration for these two samples, indicating that uranium continues to leach out from dissolution of uranium bearing mineral phases. The leaching behavior of the third sample (B347T6), however, shows a remarkable difference, where the concentrations start low (< 30 µg/L) and remain low throughout the duration of the experiment (~10 µg/L). The total uranium soil concentration in all three samples is high (ranging from 33 to 102 µg/g), and the effluent concentrations are sustained, indicating that uranium mass has not been depleted. In fact, for the two samples that show high dissolved uranium concentrations, the total uranium soil concentration is different by a factor of two, which indicates that above a certain threshold soil concentration, there is enough uranium to sustain high concentrations in the effluent. The third sample that shows low dissolved uranium concentration seems to be affected by the phosphate concentrations. This sample is located at depth (10.2 to 10.4 m [33.5 to 34 ft]) and is, therefore, most likely impacted by injection in the PRZ. Figure 6-17 shows higher concentrations of phosphate distribution for borehole C9582 at depth, and it may have sequestered uranium through formation of calcium-uranium-phosphate bearing amorphous or mineral phases. Since all three post-treatment boreholes show similar high phosphate concentrations at depth (Figure 6-17), similar leaching behavior of uranium is expected in all three locations as indicated by B347T6. The higher uranium concentrations observed in the leaching tests for the other two samples indicate that perhaps at these depths (7 to 8 m [23.5 to 26.5 ft] bgs) high concentration of phosphate could not be delivered, since these depths are above the PRZ screened interval and are deep enough for the infiltrated solutions to deliver high concentrations of phosphate. It is possible that most of the phosphate reacted above, within the 4 to 6 m (13.1 to 19.7 ft) depth range during infiltration. The ERT image shown in Figure 6-10 indicates that 0.0004 S/m contour (and higher values) are restricted to a depth of 6 m (19.7 ft), indicating that high concentration phosphate bearing solutions are present at shallow depths.



Note: Total uranium soil concentrations based on sequential leach tests are shown next to the column test results.

Figure 6-26. Results of Effluent Uranium Concentrations from Column Leach Tests Performed on Field-Textured Sediments from Post-Treatment Samples

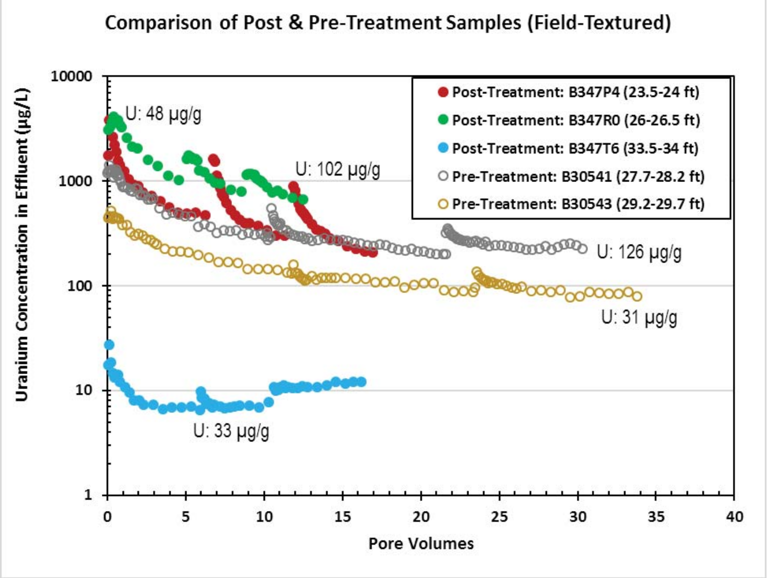


Note: Total uranium soil concentrations based on sequential leach tests are shown next to the column test results.

Figure 6-27. Results of Effluent Uranium Concentrations from Column Leach Tests Performed on <2 mm Size Sediments from Post-Treatment Samples

Figure 6-27 compares the results for the <2 mm size sediment samples. High effluent uranium concentrations from two samples (B347P5/P8 and B347R1) correspond to the two samples from field-textured samples. The concentrations from the other two samples are much lower. Sample B347T7 shows leaching behavior that is similar to the paired field-textured sample (B347T6) from deeper depths corresponding to the PRZ. Effluent concentrations remain at or below 10 µg/L, indicating that phosphate bearing mineral phases have sequestered uranium as per the remedy. Results from sample B347F1 (from borehole C9580), which is also from deeper depth that is representative of the PRZ, also show lower sustained concentrations where high phosphate concentrations are observed (Figure 6-17 for borehole C9580). Both deep samples where observed phosphate concentrations appear to be higher than background show lower leachable concentrations of uranium that are orders of magnitude smaller than other samples.

Results from flow-through column leach tests performed on pretreatment borehole samples are compared to the post-treatment borehole samples for the collocated boreholes. The pretreatment samples were collected from borehole C8936 (399-1-67), and column tests were performed on two samples from the lower vadose zone. Results of the column tests are discussed in SGW-58830. Tests were performed on both field-textured and <2 mm size sediments, but only results from field-textured samples are discussed here because the <2 mm size sediments showed similar results. The pretreatment field-textured sample B30541 was collected from a depth of 8.4 to 8.6 m (27.7-28.2 ft), while B30543 was collected from 8.9 to 9.1 m (29.2 to 29.7 ft). This pretreatment borehole (C8936 [399-1-67]) is collocated with borehole C9582. Flow-through column test results are compared in Figure 6-28, with the open circles indicating results from the two pretreatment samples. The flow-through column leaching behavior of pretreatment samples is similar to the leaching behavior observed for the two post-treatment samples that are located above the PRZ. In the pretreatment samples, initial high concentrations (>1,000 and >500 µg/L) of uranium are observed that decline over the first few pore volumes; however, after about five pore volumes, concentrations do not appear to vary much until after the stop flow events and remain high (above 100 µg/L). These results indicate that the leaching behavior of post-treatment samples located above the PRZ (but below 6 m [19.7 ft] depth) is similar to pretreatment samples. Perhaps the high phosphate concentrations from infiltration were not available to sequester the uranium at deeper depths because most of the phosphate may have reacted in the upper vadose zone. As discussed earlier, leaching characteristics of the samples collected from the PRZ show much lower leachability, indicating the effects of sequestration from phosphate injections.



Note: Total uranium soil concentrations based on sequential leach tests are shown next to the column test results.

Figure 6-28. Comparison of Effluent Uranium Concentrations Column Leach Tests Performed on Field-Textured Samples from Post-Treatment and Pretreatment Boreholes

6.3.3 Labile Uranium Batch Test

Aliquots of the air-dried <2-mm size fraction from the nine selected sample intervals were subjected to labile uranium leach testing (PNNL-25420). The labile uranium leach test measures the readily leachable uranium to estimate the relative proportion of total uranium that is leachable when contacted with sodium carbonate-bicarbonate solution. In this approach (Kohler et al., 2004, "Methods for Estimating Adsorbed Uranium(VI) and Distribution Coefficients of Contaminated Sediments"), a solution containing 0.0144 mol/L of sodium bicarbonate (NaHCO3) and 0.0028 mol/L of sodium carbonate (Na_2CO_3) with a pH of approximately 9.45 was added to the sediment at a solid-to solution ratio of 1 g/2 mL and was allowed to agitate on an orbital shaker for 1,000 hours (~42 days).

Results of the labile uranium testing are presented in Figure 6-29 for five different times. The results indicate that even after 66 days, the equilibrium had not been attained, and the uranium concentrations continued to increase. These results further indicate that uranium-containing carbonates are present in sufficient amount and continue to dissolve. This type of nonequilibrium, kinetically controlled leaching in contact with a bicarbonate water solution could be expected to continue under field conditions.

The amount of uranium leached is low for three samples taken at post-treatment borehole C9580, one sample taken at post-treatment borehole C9581, and two samples located at depth for the post-treatment borehole C9582 (B347R7 and B347T7). Based on vertical phosphate profiles shown in Figure 6-17, phosphate appears to have been delivered at high concentration at C9580. This is also supported by the high concentrations observed in the ERT survey resulting from faster migration rates of phosphate solution through the vadose zone (Figures 6-10 and 6-11). The sample taken at C9581 is from PRZ depth (8.5 to 8.7 m [28 to 28.5 ft]) where phosphate was delivered through PRZ injection. Based on these results, it is inferred that the labile uranium concentration remains relatively low in samples where phosphate concentration is observed to be above background due to possible reactions with calcium-phosphate.

6.3.4 Identification of Mineral Phases Using Surface Analysis

Selected samples from post-treatment boreholes were evaluated to identify uranium-bearing mineral phases and calcium phosphate precipitates using sequential application of surface analysis techniques, including cryogenic laser fluorescence spectroscopy, electron microprobe, and/or scanning electron microscope/energy dispersive x-ray (SEM/EDX) spectroscopy (PNNL-25420).

Analysis of samples from borehole C9580 with higher uranium concentrations indicated that U(VI) (uranium in hexavalent state) is adsorbed on quartz, and U(VI)-phosphate surface complexes are adsorbed on montmorillonite. Because quartz is the dominant mineral phase in Hanford vadose zone sediments and phyllosilicates often exist as fine surface coatings on soil and mineral grains, surface uranium complexes adsorbed to the mineral hosts are expected.

Analysis of fluorescence spectra from C9582 samples that were located above the PRZ (but deeper than 6 m [19.7 ft]), where soil uranium concentrations were found to be the highest but where appreciable phosphate was not observed, indicated the presence of uranyl-tricarbonate and noticeable levels of calcium carbonate minerals with adsorbed U(VI). None of the samples analyzed showed characteristic features of crystalline uranyl-phosphate precipitates. This was somewhat expected as amorphous monocalcium phosphate phases are predicted to form primarily with uranium incorporated in the solids instead of crystalline uranyl-phosphate under the prevailing chemical conditions (Mehta et al., 2016). Furthermore, uranium is nonuniformly dispersed in the sediment and present at concentrations below the detection limits of instrument. The EDX detection limit is > 500 ppm, which is greater than uranium concentration in all samples analyzed.

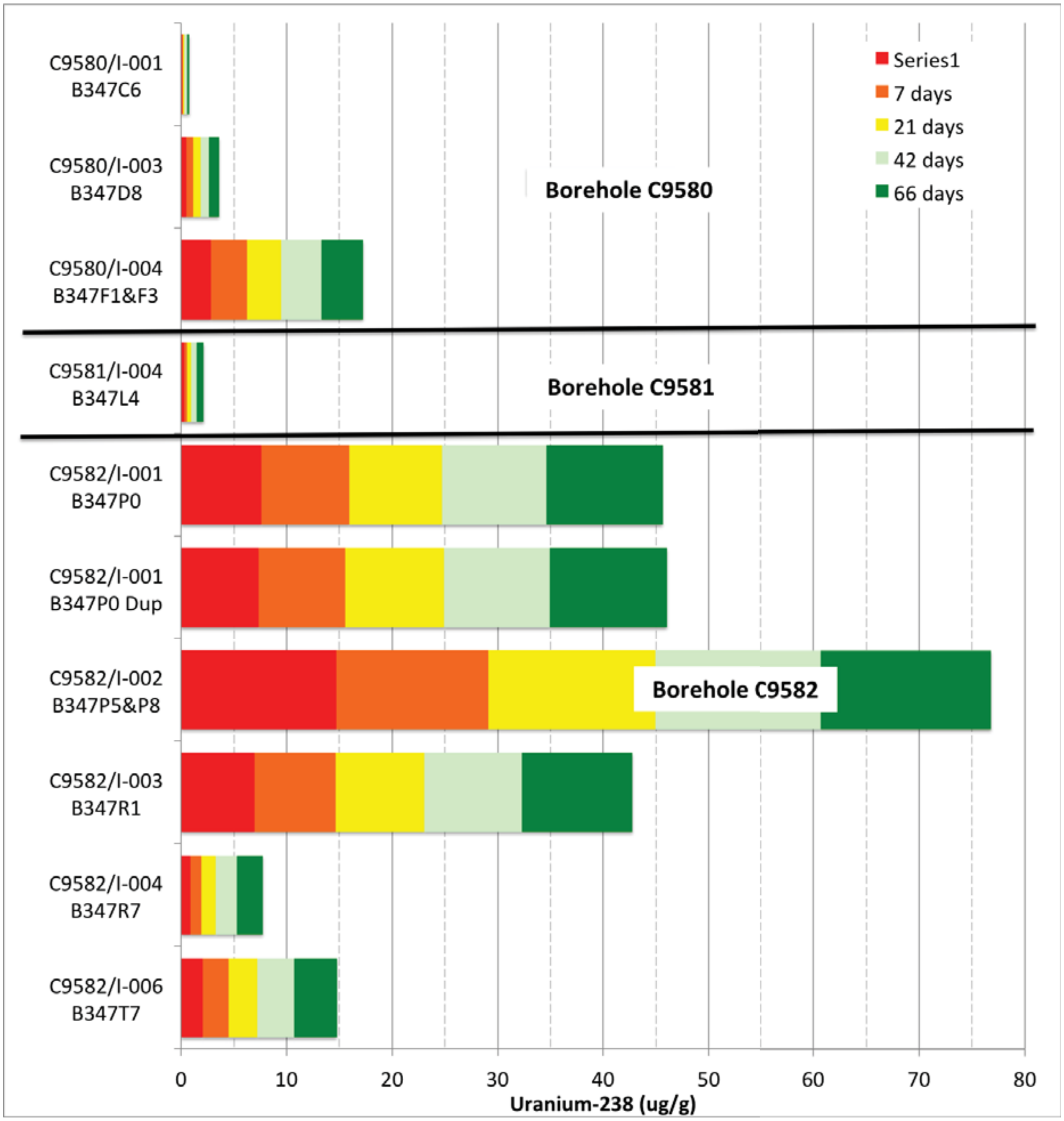
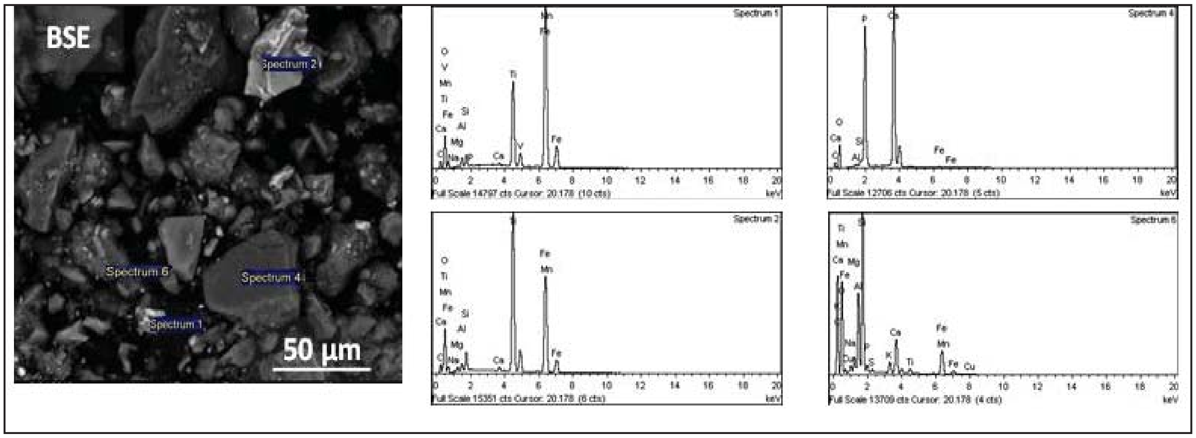
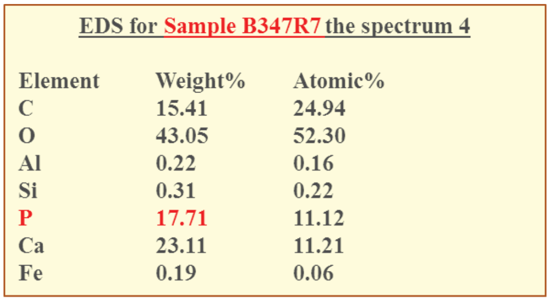


Figure 6-29. Composite Uranium Concentrations Recovered During Labile Leach Testing

Results from SEM/EDX spectroscopy and electron microprobe analysis of C9580 samples indicate that calcium and phosphorus are distributed uniformly, while iron is variably distributed. For the C9582 borehole sample (B347R7) collected in the PRZ at a depth of 9 to 9.1 m (29.5 to 30 ft), results indicate the presence of calcium, phosphorus, iron, and manganese (Figure 6-30). Results of the surface elemental analysis indicated about 18 percent of phosphorus and 23 percent of calcium by weight. The total uranium concentration in this sample was 31 µg/g.





EDS for Sample B347R7 the spectrum 4

Element	Weight%	Atomic%
C	15.41	24.94
O	43.05	52.30
Al	0.22	0.16
Si	0.31	0.22
P	17.71	11.12
Ca	23.11	11.21
Fe	0.19	0.06

Figure 6-30. Spectral Analysis and Elemental Mapping Results of B347R7 Sample Collected from Borehole C9582 at Depth of 9 to 9.1 m (29.5 to 30 ft)

6.3.5 Observations of High Moisture Content

All post-treatment borehole samples appeared to be much wetter than pretreatment borehole samples. All sampled intervals in the vadose zone were visibly very wet, even though the sediments were mostly gravel dominated and easily drainable. Post-treatment drilling was conducted about 2 months after completion of injection/infiltration.

Wellman et al. (2007) reported a steady increase in moisture content during the unsaturated column experiments using sodium tripolyphosphate solutions and attributed it to change in water retention characteristics as a result of reactions with phosphorus. Lutz et al., 1966, "Effect of Phosphorus on Some Physical Properties of Soils: II. Water Retention," studied the effect of adding phosphorus on physical properties of soils and concluded that phosphate bearing solutions increased the water holding properties of soils. They found it to be directly related to increase in the negative charge of the soil particles. This surface charge was closely related to the Al-phosphate to Fe-phosphate ratio. In some instances, even 50 parts per million of phosphorus concentrations in solution led to increased water holding capacity. They hypothesized that the negative charge of the particle might be increased by the phosphate ion replacing a hydroxyl ion on the octahedral layer of the clay crystal leading to increased negative charge that may attract polar water molecules.

6.4 Determination of Desorption Parameters Using Post-Treatment Flow-Through Column Leach Tests

Uranium sorption-desorption parameters are determined by matching the transport model based results with laboratory leaching test results conducted on post-treatment samples. A single-site kinetic sorption model is developed that evaluates the forward and reverse rates. A single-site sorption model is deemed adequate, based on the level of knowledge on uranium desorption characteristics from sediments following treatment with phosphate. The objective is to develop uranium desorption parameters that can be upscaled for usage in a 3D fate and transport model at the scale of the 300 Area.

Some of the column leaching characteristics and experimental setup details were presented in Section 3.2. Uranium leaching experiments were run with field-textured (intact bulk) sediment and with fine grain soil (<2 mm grain) for which the larger gravel was removed. Water is injected at the top of the column at a measured rate. During the time history of the experiment, effluent samples are collected from the end of the column, and the dissolved concentrations of uranium are measured. The experiments have two stop-flow events in order to demonstrate the impact of nonequilibrium sorption. The first stop flow event has a duration of 48 hours, while the second stop flow event has a duration of 72 hours.

Flow-through experiments also included injection of nonsorbing species (bromide). For the bromide experiments, the initial concentration within the column is zero, and the injection stream contains a known bromide concentration. The transport model without the sorption kinetics is used to match the nonsorbing bromide data, which provides a verification of the transport parameters.

Vadose zone soil samples representative of contamination during remediation activity were collected from multiple borehole locations within the 300 Area. The soil samples of interest for the experimental study (PNNL-25420) are shown in Table 6-5, which provides the borehole location, borehole interval and depth, sample preparation, column geometry, bulk density, water content, and injection rate.

Table 6-5. Selected Samples and Flow-Through Column Test Parameters

Borehole Identification	Sample Number	Sample Interval	Interval Depth (ft)	Sample Preparation	Length (cm)	Diameter (cm)	Bulk Density (gm/cm^3)	Water Content	Injection Rate (mL/hr)
C9580	B347F1F3	I-004	29.5 to 30	<2 mm size	15	2.5	1.66	0.372	5.53
C9582	B347P5P8	I-002	23.5 to 24	<2 mm size	15	2.5	1.72	0.380	5.54
	B347P4	I-002	23.5 to 24	Field-Textured	13.2	9.53	2.05	0.228	74.2
	B347R1	I-003	25.5 to 26	<2 mm size	15	2.5	1.79	0.338	5.69
	B347R0	I-003	26 to 26.5	Field-Textured	14.0	9.53	2.18	0.177	74.5
	B347T7	I-006	33 to 33.5	<2 mm size	15	2.5	1.78	0.347	5.61
	B347T6	I-006	33.5 to 34	Field-Textured	13.7	2.93	2.26	0.146	72.7

Boundary conditions matching the uranium leach column experimental conditions are applied. For each sample, estimates of the kinetic sorption reaction rates and partition coefficient are obtained by history matching the model results with the existing experimental data. The flow-through column initial uranium concentration is assigned to match the early time experimental results.

The mathematical model used for fitting the uranium leaching results is described in Appendix C. Results of the model fit are presented in Appendix C as estimated well and kinetic sorption-desorption parameter values. An alternative method for determining the kinetic sorption parameters is also discussed that assigns an estimated value of the reverse reaction rate for all samples. The estimated kinetic sorption-desorption parameters are used in the fate and transport modeling.

This page intentionally left blank.

7 Three-Dimensional Flow and Transport Modeling Using STOMP

The purpose of this chapter is to simulate the fate and transport of uranium in the vadose zone and unconfined groundwater aquifer to evaluate effectiveness of Stage A remedy. The modeling results will be used to predict possible changes in groundwater uranium concentrations in the near future.

This effort includes the simulation of uranium concentrations in the aquifer prior to the Stage A remedy along with a series of simulations, which will describe the impact of the remedial actions (phosphate injection and infiltration) on the uranium groundwater concentrations.

7.1 Background Information

The approach to the uranium fate and transport modeling within the 300-FF-5 OU uses a mathematical hydrogeological construct to represent the physical conditions within the vadose zone and unconfined aquifer. It also involves developing a conceptual model by incorporating some of the following important features, events, and processes that control the uranium transport:

- Seasonal fluctuations of flow in the Columbia River at the 300 Area can result in more than 3 m (9.8 ft) of change in river stage between the high discharge period (May to June) and the low discharge period (December to January) (Figure 7-1). These seasonal fluctuations are the driving mechanism for the rise and fall of the water table beneath the 300 Area for extended periods of time and for creating the dynamic hydraulic and geochemical environment found in the unconfined aquifer of the 300 Area. The seasonal fluctuations in river stage also lead to remobilization of the sorbed uranium mass from the lower part of the vadose zone as shown for 399-1-17A (Figure 7-1) due to rise in water table elevations.
- Seasonal river stage fluctuations lead to changes in the flow direction within the aquifer. Considerable variability in the flow direction also exists spatially as well within the same season. Changing flow directions can cause redistribution of uranium in the aquifer as well as in the PRZ above the water table.
- Effect of variably saturated conditions need to be considered in the modeling. The river stage fluctuations can temporally and spatially increase the water saturation and vary the chemical conditions that can lead to variable transport of uranium. Therefore, a coupled vadose zone and saturated-zone flow and transport need to be considered.
- The change in groundwater chemistry (i.e., alkalinity) within the unconfined aquifer due to mixing of groundwater with river water needs to be considered in the context of adsorption/desorption of uranium.
- Due to variable flow and chemical conditions, the sorption/desorption of uranium may be kinetically limited, and full equilibrium may not be established between dissolved and sorbed mass of uranium. The modeling will evaluate both equilibrium and nonequilibrium (kinetic) sorption.

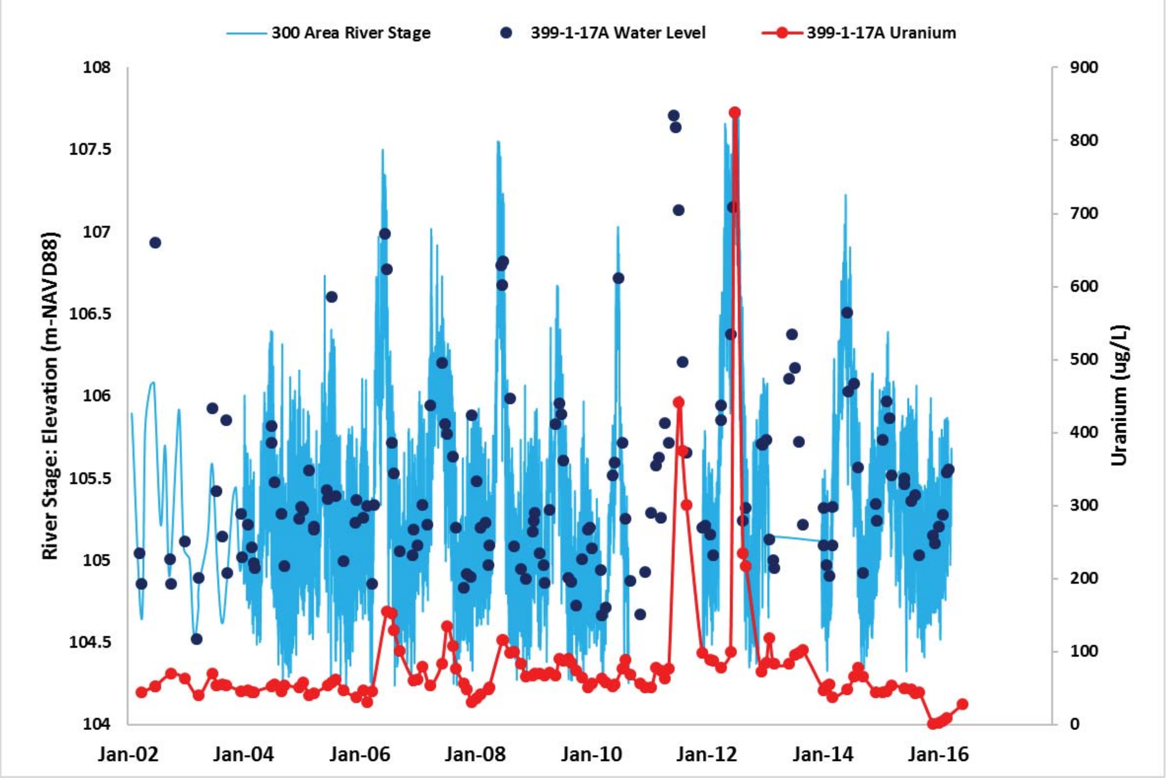
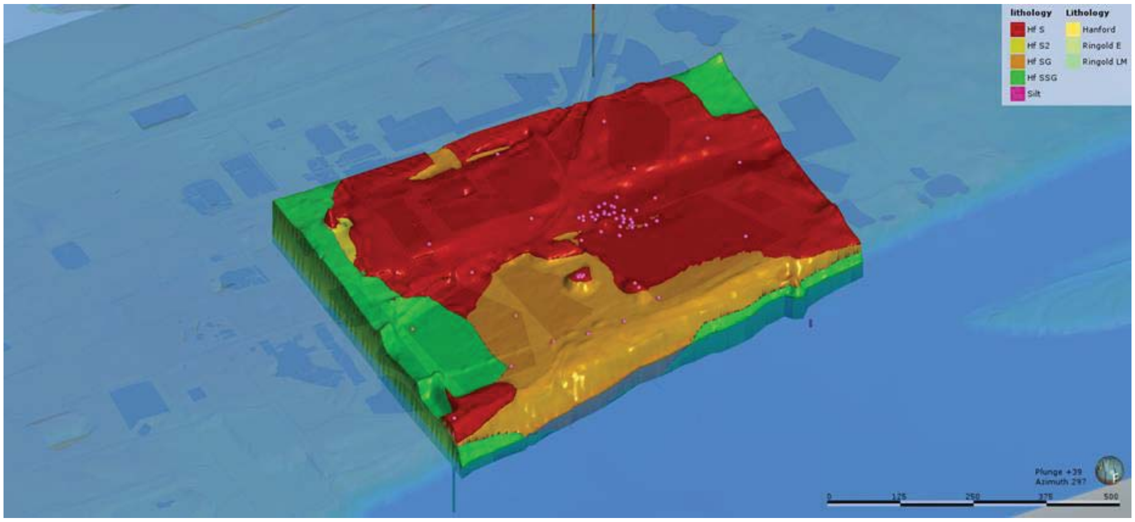


Figure 7-1. Columbia River Stage Fluctuations and Effect on Water Levels and Dissolved Uranium Concentration at Well 399-1-17A

7.2 Development of Hydrogeologic Model

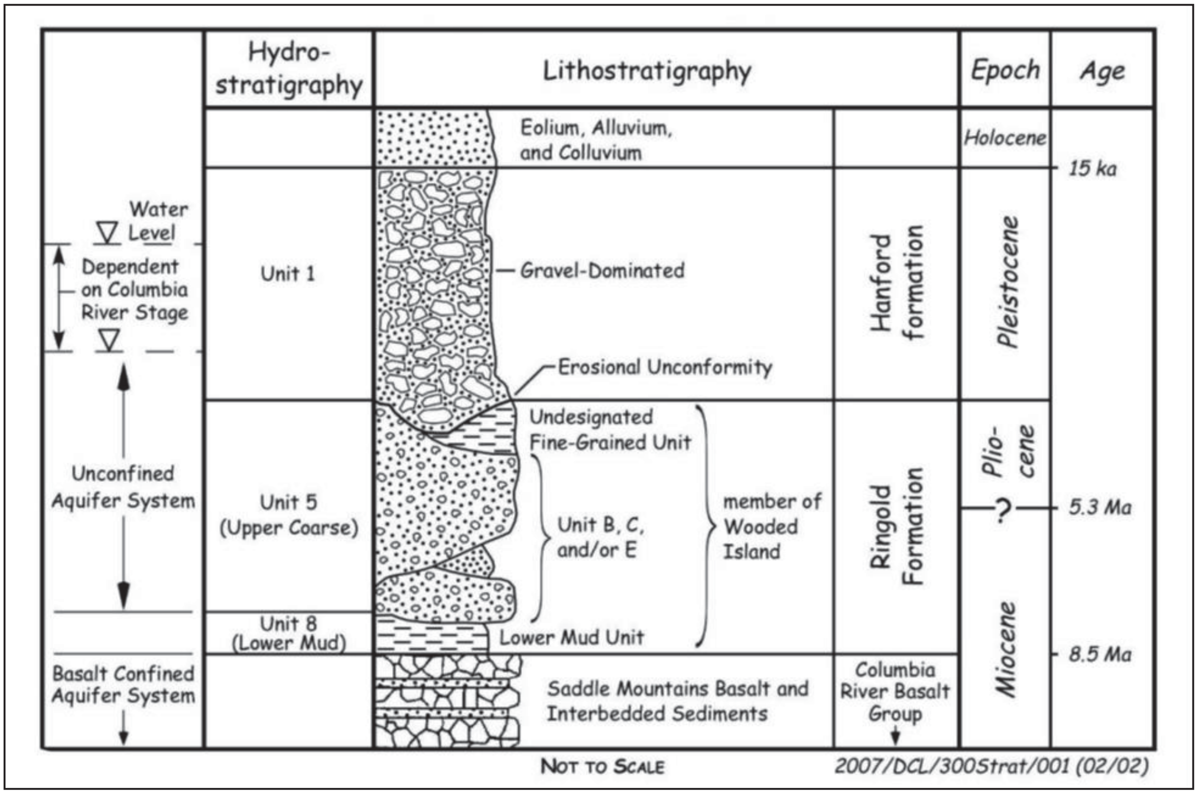
Leapfrog® Geo software (version 3.0.0) was used to create a 3D solid hydrogeologic model within the 300 Area (Figure 7-2). The geologic framework beneath the 300 Area consists of a Hanford formation (Hf) vadose zone made up of unconsolidated sandy gravels containing spatially (horizontally and vertically) variable amounts of silts and clays and a saturated zone of the same material underlain by more consolidated materials of the Ringold formation unit E (ECF-300FF5-16-0087, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit*, *Hanford*, *Washington*). Underlying Ringold unit E is the Ringold Lower Mud (RLM) unit consisting of predominantly silts and clays, and underlying the RLM is the Columbia River Basalt Group bedrock. A generalized hydrostratigraphic column for the 300 Area is presented in Figure 7-3.

® Leapfrog is a registered trademark of ARANZ Geo Limited, Christchurch, New Zealand.



Note: Geologic units: red = Hf sand unit 1, orange = Hf sandy gravel, yellow = Hf sand unit 2, and green = Hf silty sandy gravel. Pink dots represent detailed vadose zone model well locations. Blue semitransparent shading represents the water table surface.

Figure 7-2. View of the 300 Area Geologic Framework Model



Note: Figure is from DOE/RL-2009-30, *300 Area Decision Unit Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* (Figure 2-17).

Figure 7-3. Generalized Hydrostratigraphy at the 300 Area

The primary geologic unit of concern is the Hf because of the location of uranium contamination within the deep vadose and PRZ. In the existing Hanford South geologic framework model (GFM; ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*), the Hf is undifferentiated. Because the vertical and lateral distribution of fine materials in the vadose zone could affect the uranium contamination plume extents, it was necessary to construct a GFM specific to the 300 Area complete with detailed, differentiated Hf subunits. The subunits were defined by interpreting borehole geologic and geophysical logs obtained by accessing the Hanford Site Well Information and Document Lookup and from CHPRC for newly drilled boreholes as part of the Stage A EAA (ECF-300FF5-15-0014, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Establishment of the Stage A Enhanced Attenuation Area for 300-FF-5*). The following specific Hf geologic subunits comprise the upper portion of the 300 Area GFM:

- Hf is categorized into five sub-units from land surface downward based on the observed sequence of deposition in the study area:
    - Hf sand unit 1 – fine to coarse sand of mixed basaltic and felsic composition
    - Hf sandy gravel – unconsolidated mostly pebble to cobble gravels with sand
    - Hf sand unit 2 – unconsolidated, fine to coarse sand (mostly basalt) with some silt
    - Hf Silt – 100 percent silt unit identified in several wells drilled as part of the Stage A EAA uranium sequestration by polyphosphate remedy
    - Hf silty sandy gravel – unconsolidated mostly basalt pebble to cobble gravel with silt and sand
    - Hf gravel – unconsolidated predominantly basaltic pebble to cobble gravel with some sand and/or silt

The Hf subunits listed were interpreted, based on the following criteria:

- Hf Sand unit 1 – ≥90 percent sand of mostly basaltic composition
- Hf Sandy Gravel – between 50 percent and 60 percent gravel with sand fraction ranging 50 percent to 40 percent. Gravels are predominantly basaltic
- Hf Sand Unit 2 – 80 percent to 90 percent sand with silt, sand, or gravel fraction ranging from 20 percent to 10 percent
- Hf Silt – 100 percent silt described in borehole geologic logs as being moderately plastic and grayish-brown in color
- Hf Silty Sandy Gravel – 50 percent to 70 percent gravels to cobbles, 20 percent to 10 percent sands, and 20 percent to 10 percent silt (gravel to cobble fraction is mostly basaltic; sand is moderately to poorly sorted)
- Hf Gravel – 85 percent to 90 percent gravels with 15 percent to 10 percent sand and/or silt fractions (gravels are at least 50 percent basaltic)

The lower portion of the 300 Area GFM was constructed using interpolated unit-top surfaces for Ringold unit E and RLM. The surfaces were extracted from the Hanford south GFM (ECF-HANFORD-13-0029).

The information gained from the described GFM efforts and Stage A EAA drilling and sampling activities laid the backdrop for the EAA determination. Previous geological and characterization studies were instrumental in providing information used in the geologic and uranium contamination distribution modeling discussed herein.

7.3 Development of 3D STOMP Model Domain

The 3D STOMP model domain has been selected in a way that adequately covers the Stage A EAA, and it has some monitoring wells close to the boundary. Figure 7-4 shows the model domain location in the 300 Area.

The total dimension of the model domain is 600 m (1,968 ft) in the X direction (east-west) and 600 m (1,968 ft) in the Y direction (north-south). Vertically (Z direction), the model extends from ground surface to Ringold unit E. The vertical grid spacing was chosen to be 0.5 m (1.6 ft). Figure 7-5 shows the vertical discretization and the distribution of hydrogeologic units along the model cross-section. In the X and Y directions, grid spacing varies from 50 m to 6.25 m (164 to 20.5 ft). A finer grid spacing of 6.25 m (20.5 ft) was assigned in the EAA. The model has the following hydrogeologic zonations split between unsaturated (or variably saturated) and saturated zones:

Unsaturated Zone

- Hf silty sandy gravel (Hf SSG)
- Hf sand (Hf S; sand units 1 and 2 given the same hydraulic property)
- Hf sandy gravel (Hf SG)
- Hf gravel (Hf G)
- Hf silt (S)

Saturated Zone

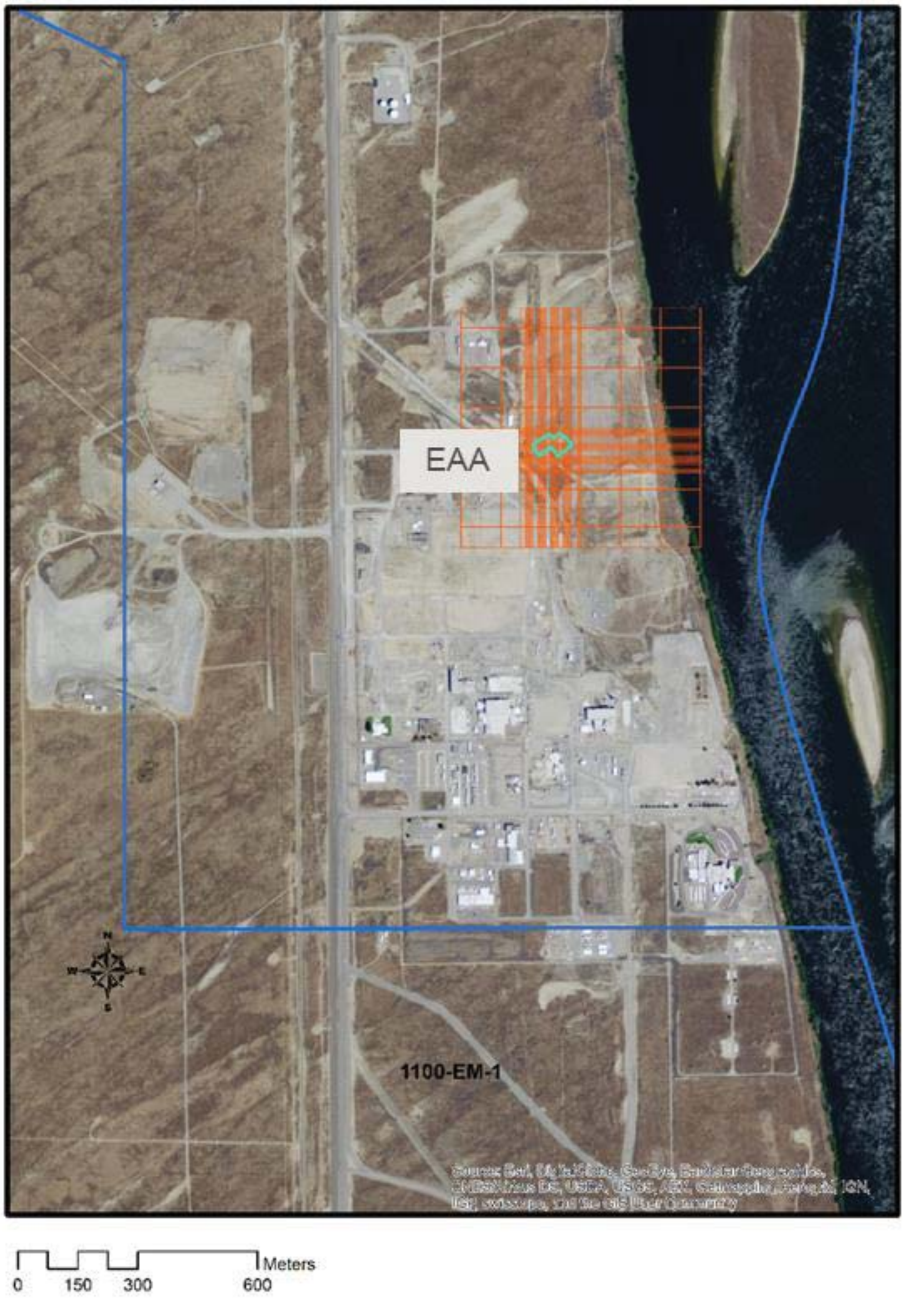
- Saturated Ringold unit E
- Saturated Hf
- Saturated Hanford 2 zone (a higher hydraulic conductivity zone)
- Saturated Hanford 3 zone (a lower hydraulic conductivity zone)
- Saturated silt
- River alluvium

7.4 Development of Flow Model

Development of the flow model involved deriving and applying appropriate flow boundary conditions and calibrating the hydraulic properties to match the field observations. The model grid is presented in Figure 7-6.

7.4.1 Recharge

The aerially applied recharge rate was based on the analysis (PNL-10285, *Estimated Recharge Rates at the Hanford Site*) of lysimeter drainage at the south caisson located in the Buried Waste Test Facility of the north 300 Area from July 1985 to June 1993. Over the 8-year period of record, recharge ranged from 2.4 to 11.1 cm/yr with an average of 5.54 cm/yr. Drainage data from the lysimeter reflect a nonvegetated cover and medium to coarse sand. The recharge boundary condition in the model was specified as a Neumann (specified flux) boundary condition with a flux rate of 5.54 cm/yr.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Note: The model grid is shown in orange, while the Stage A EAA is shown in green.

Figure 7-4. 3D STOMP Model Domain to Evaluate the Stage A Remedy

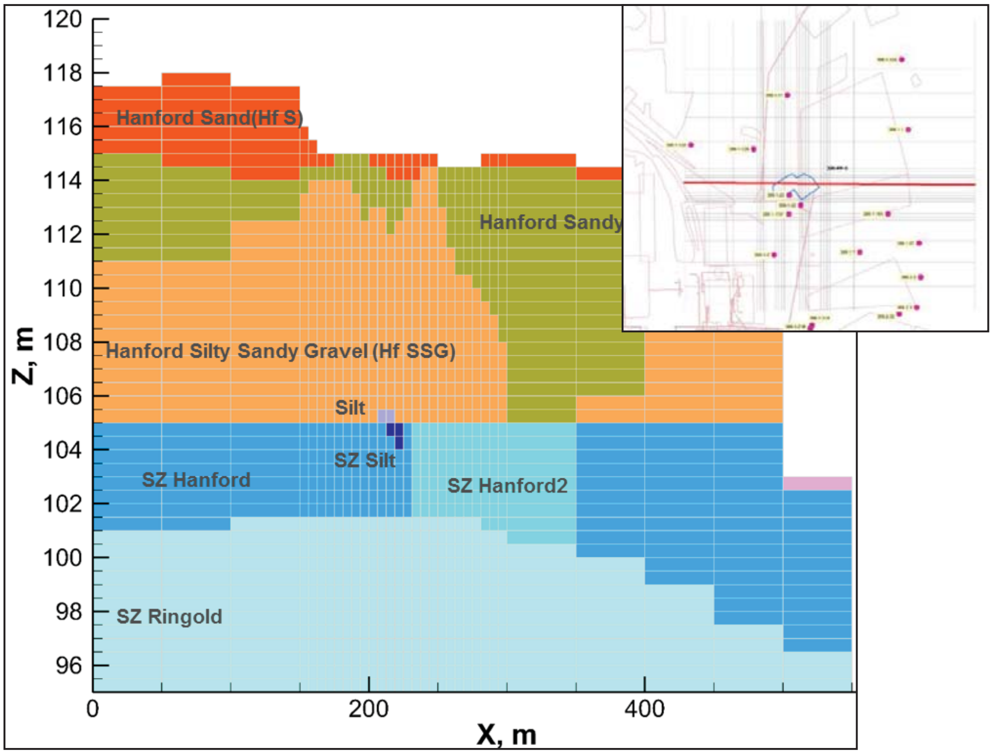
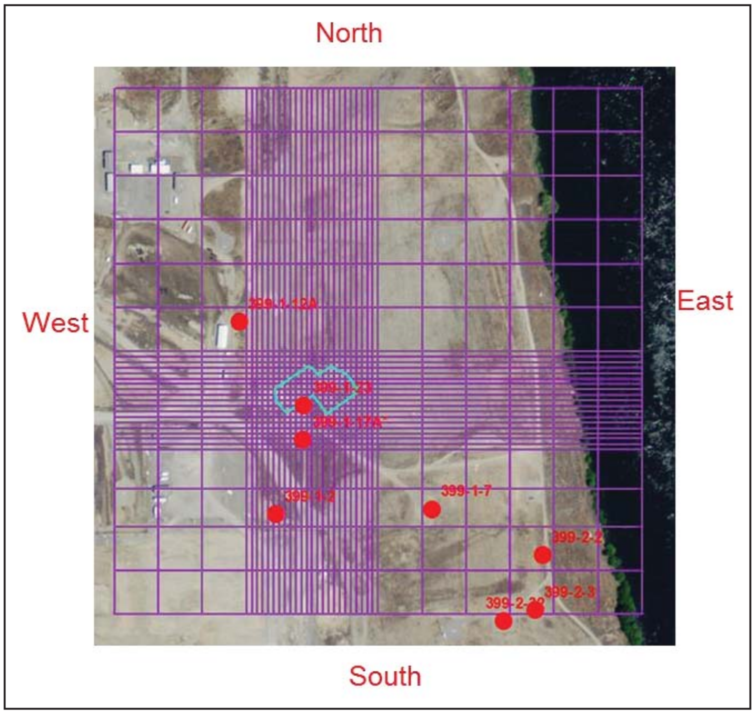


Figure 7-5. Distribution of Hydrogeologic Units along a Cross-Section



Note: The outline of Stage A EAA is shown in blue line.

Figure 7-6. Model Domain Showing the Grid Discretization along with Boundary Designations

Columbia River stage is a major driver in the hydrologic system in the 300 Area. Changes in Columbia River stage reflect the release of water upstream at Priest Rapids Dam to meet electric power demand. The seasonal cycle in river stage is related to the timing and volume of snowpack and snowmelt in the watershed with lower river stages typically occurring during fall and winter. The average range of diurnal fluctuations is ~0.5 m. Weekly, daily, and subdaily cycles are also evident from the river stage data.

Hourly Columbia River stage data from the river stage recorder in the 300 Area (river gauge station SWS-1) were used to set a time varying hydrostatic pressure at the river boundary. The SWS-1 river gage is located on the west bank of the Columbia River slightly south of the transect lines and is part of the monitoring network (Figure 7-7). The river stage data was collected manually beginning in 1991 at approximately monthly intervals until collection of automated hourly measurements began in January 2004. The river stage data were implemented in the model by averaging the hourly data over a daily cycle for the period starting from January 1, 2014, through December 31, 2015 (Figure 7-8). Over this period, the minimum and maximum river stages were 104.4 m and 107.1 m (342.5 and 351.3 ft), respectively. The median stage over this time period was 105.3 m (345.4 ft).

The east boundary of the model has been set up from the daily averaged SWS-1 river gage data. The gradient along the river has been interpolated from two stations (319 and 321), based on a computational fluid dynamic model of the Columbia river (PNNL-22886, *System-Scale Model of Aquifer, Vadose Zone, and River Interactions for the Hanford 300 Area – Application to Uranium Reactive Transport*). The interpolated value is 3.19E-04 m/m, which is used in applying flow boundary conditions at the river boundary of the model.

Figure 7-7. Location of the River Gage (SWS-1) in the 300 Area

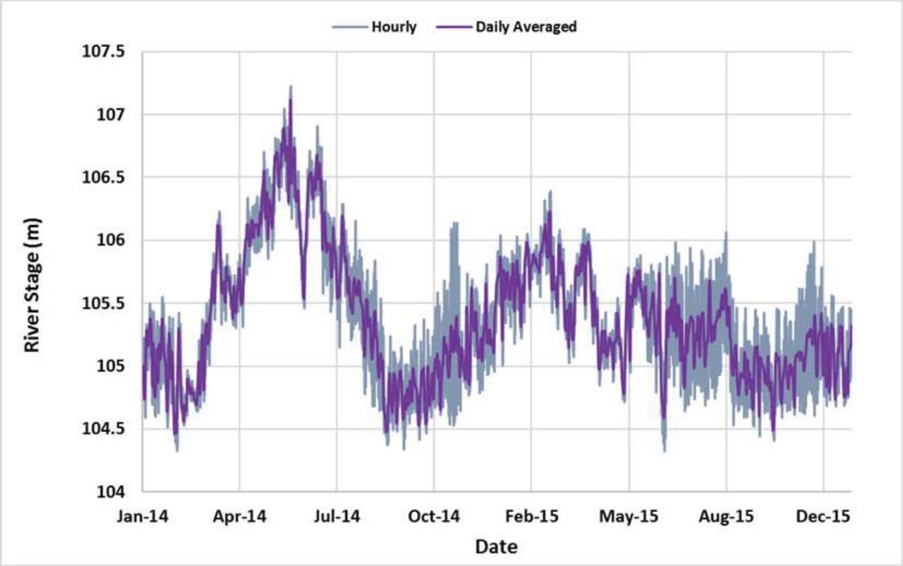


Figure 7-8. Comparison of Hourly and Daily Averaged Columbia River Stage Data at the 300 Area

7.4.2 Automated Water Level Network Data Usage

Hourly water level measurements from the automated water level network (AWLN) were used to assign flow boundary conditions on the inland edge of the model grid. A number of wells are part of the AWLN in the 300 Area, as shown in Figure 7-7. Subset of wells used for determining fate and transport model boundary conditions and for model calibration are presented in Figure 7-9.

Figure 7-9. Location of Automated Water Level Network in the Vicinity of Model Domain

The water level data at AWLN gage 399-1-12, the well located closest to the boundary of the model grid (Figure 7-6), were used to set time varying hydrostatic pressures at west and north boundaries. The south boundary was based on the water level data from nearby well 399-2-3. Because this well is slightly inland and upgradient of the south boundary, water levels from well 399-2-3 were modified by a constant -0.05 m (-0.16 ft) for the south boundary. This method resulted in better water level and tracer concentration matches.

The hourly water levels were averaged daily from 2014 through 2015, and daily varying boundary conditions were applied. The hourly and daily averaged water levels for 399-1-12 and 399-2-3 are shown in Figure 7-10 (a and b). Over the 2014 through 2015 simulation time period, the minimum, maximum, and median water levels at 399-1-12 were 104.8 m, 106.8 m, and 105.3 m, respectively; for well 399-2-3, the minimum, maximum, and median water levels were 104.7 m, 106.7 m, and 105.2 m, respectively. The period of sustained high water levels generally occurs during the months of May through August. Figure 7-11 presents the daily averaged hydraulic head of SWS-1 river gage and well 399-1-12 that are used for setting the east and west hydraulic boundaries, respectively.

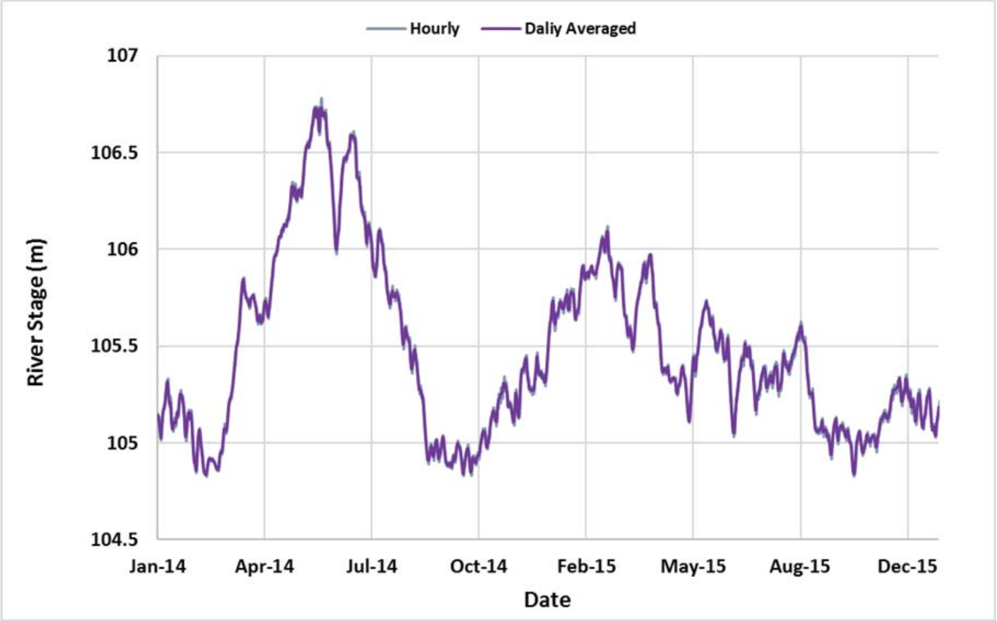
7.5 Model Calibration

Calibration of flow and transport parameters in the 3D STOMP model was undertaken to match the following measurements:

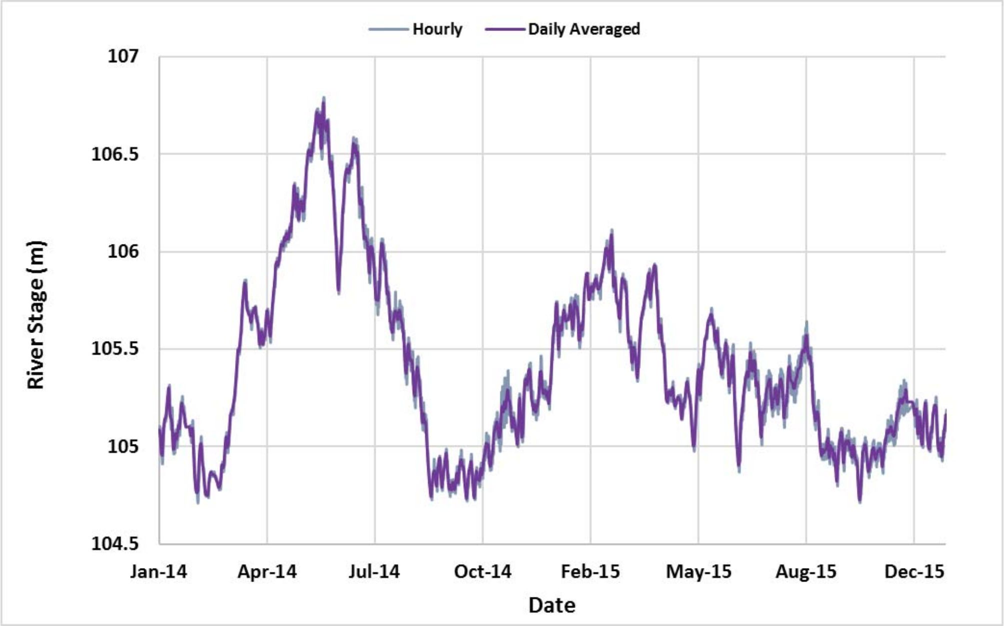
- Water levels in the selected monitoring wells where AWLN data were available
- Extent of river water and groundwater mixing, based on EC measurements from selected monitoring wells where AWLN data were available (EC of end-member waters [upgradient groundwater and river water] were estimated, and simple mixing was performed)
- Uranium concentrations and trends at selected monitoring wells over the past 20 years

In order to match the observed water levels and extent of river-groundwater mixing, adjustments were made to the spatial distribution of hydraulic conductivity in the saturated Hanford unit. Minor adjustments were also made to the boundary conditions. For matching uranium concentrations, the initial uranium soil concentrations were adjusted based on the gravel fraction. Details regarding specific choice of parameters is provided in the following sections.

The calibrations were performed manually. Since the focus of the work is on evaluating uranium concentrations prior to and following remedy treatment in Stage A, particular focus was placed on matching the uranium concentrations in nearby wells that have long-term monitoring records.



(a)



(b)

Figure 7-10. Daily and Hourly Averaged Water Levels at (a) 399-1-12 and (b) 399-3-3

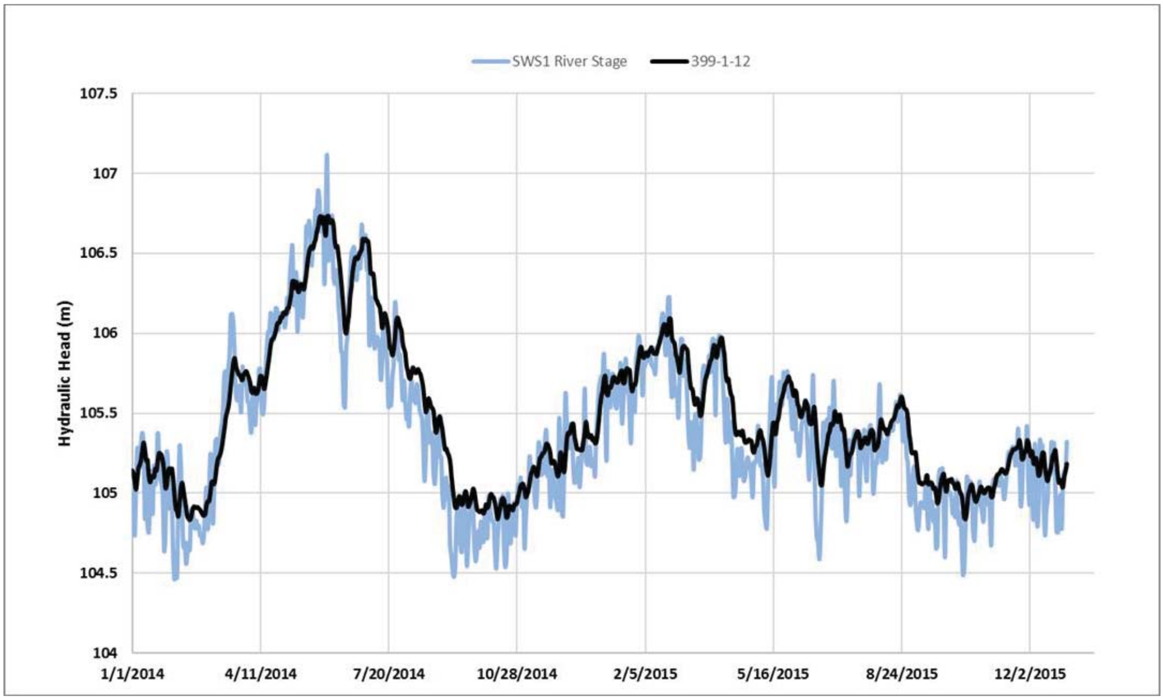


Figure 7-11. Comparison of Daily Averaged Hydraulic Heads for SWS-1 River Gage (East Boundary) and 399-1-12 (West Boundary)

7.6 Determination of Fate and Transport Parameters

The following fate and transport parameters were used in the model:

- Saturated zone hydraulic conductivity
- Macrodispersivity
- Porosity
- Particle density and bulk density
- Saturation pressure and relative permeability relationships
- Molecular diffusion coefficient
- Specific storativity
- Uranium sorption

7.6.1 Saturated Zone Hydraulic Conductivity

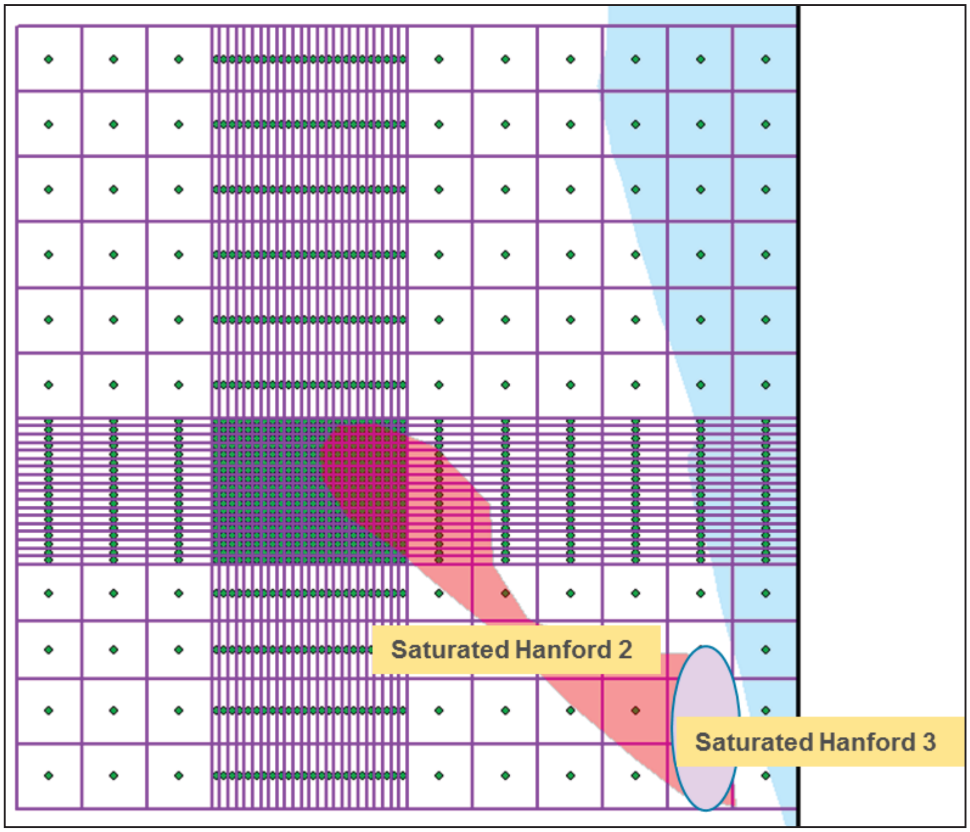
The saturated hydraulic conductivity of the Hanford formation has reportedly been difficult to determine from aquifer testing due to its highly transmissive nature. Constant rate aquifer tests conducted at wells screened in the saturated Hanford formation within the 300 Area resulted in values of horizontal hydraulic conductivity ranging from approximately 980 m/d to 15,000 m/d (PNL-6716, *Interim Characterization Report for the 300 Area Process Trenches*). Re-evaluation of these tests (PNNL-17708, *Three-Dimensional Groundwater Models of the 300 Area at the Hanford Site, Washington State*) identified recharge boundary effects in some cases leading to unreliable results. Aquifer test results with hydraulic conductivities >5,000 m/d were considered uncertain due to the low drawdown obtained during the tests (<0.1 m), making accurate analysis difficult. Horizontal hydraulic conductivity of the Hf is reported for previous two-dimensional (2D) and 3D numerical modeling studies: 2,000 to 10,000 m/d

(PNNL-17708), 1,500 m/d (Yabusaki et al., 2008, "Building conceptual models of field-scale uranium reactive transport in a dynamic vadose zone-aquifer-river system"), and 7,000 m/d (Ma et al., 2010). Average value of hydraulic conductivity determined from short-duration constant rate injection tests performed at the Integrated Field Research Challenge project site located within the 300 Area was about 7000 m/d with a range of ~4,600 to 11,000 m/d (PNNL-22886).

A spatially variable depth-averaged hydraulic conductivity field was determined for the Hanford formation in PNNL-22886 using a parameter estimation methodology. It resulted in a spatially variable permeability field that varied over an order of magnitude for the Hanford formation. Lower values of depth averaged permeability (1×10^{-10} m^2) were estimated close to the river that typically increased inland (4×10^{-9} m^2) when moving westwards. This information was used qualitatively during the model calibration exercise. The model calibration was primarily based on evaluation of (1) spatial and temporal trends in uranium concentrations, (2) changes in specific conductance due to river and groundwater mixing at monitoring wells, and (3) geologic information on preferential pathways within the surficial aquifer (e.g., a paleochannel). Based on this information, the saturated zone of the Hanford formation (Hf unit) was divided into the following three different hydraulic conductivity zones (Figure 7-12):

- Saturated Hanford 1 zone covers most of the model domain and was assigned a saturated hydraulic conductivity of 4,000 m/d, based on evaluation of past modeling studies.
- Saturated Hanford 2 zone covers an area of higher hydraulic conductivity (paleochannel) where preferential movement of uranium (and phosphate) has been observed. The saturated hydraulic conductivity of 6,000 m/d was assigned to this zone that resulted in a better match to uranium concentrations.
- Saturated Hanford 3 zone, a lower hydraulic conductivity zone of 1,000 m/d near the river, was assigned to dampen the effect of river stage fluctuations at the river-aquifer interface due to the presence of lower permeability lithologic unit near the base of the river channel. Hydraulic conductivities were shown to be smaller near the water-sediment interface and increasing exponentially with depth (Fritz and Arntzen, 2007, "Effect of Rapidly Changing River Stage on Uranium Flux through the Hyporheic Zone"). This lowering is also consistent with parameter estimation in other modeling studies (PNNL-22886; PNNL-17708).

Hydraulic testing of the Ringold formation gave reliable horizontal hydraulic conductivity estimates between 2 and 51 m/d (PNNL-17708). Of these estimates, horizontal hydraulic conductivity of 42 m/d was reported in PNL-6716 for pumping tests conducted at well 399-1-16A, while an averaged result of 43.25 m/d was reported in WHC-SD-EN-TI-052, *Phase I Hydrogeologic Summary of the 300-FF-5 Operable Unit, 300 Area*, for pumping tests conducted further from the current study but within the 300 Area (PNNL-17708). In previous 2D and 3D numerical modeling studies, the assigned Ringold unit E hydraulic conductivity value ranges from 15 m/d (Yabusaki et al., 2008) to 40 m/d (PNNL-17708; Ma et al., 2010). A horizontal hydraulic conductivity of 40 m/d was assigned to Ringold unit E and was not adjusted during model calibration since most of the flow occurs through the saturated Hanford formation.



Note: Saturated Hanford 1 is the portion that is not colored

Figure 7-12. Zones of Variable Hydraulic Conductivity for the Hanford Unit in the Unconfined Aquifer

The hydraulic conductivity of alluvium in the hyporheic zone of the Columbia River adjacent to the 300 Area has been estimated between 0.63 and 103.68 m/d (Fritz and Arntzen, 2007), based on slug tests conducted in nine piezometers with depths to top of screen ranging from 19 to 180 cm. Hydraulic conductivities were shown to be smaller near the water-sediment interface and increasing exponentially with depth. An effective vertical hydraulic conductivity was determined for three of the piezometers and ranged from 0.37 to 7.0 m/d. Hydraulic conductivity of the river alluvium was adjusted as part of model calibration.

The vertical hydraulic conductivity of the Hanford and Ringold units were set to 0.1 times the horizontal conductivity which is consistent with previous groundwater modeling studies that assume the vertical hydraulic conductivity of the Hanford and Ringold units range from 0.01 to 0.1 times the horizontal conductivity (NUREG/CR-6940, *Combined Estimation of Hydrogeologic Conceptual Model, Parameter, and Scenario Uncertainty with Application to Uranium Transport at the Hanford Site 300 Area*; PNNL-17708; Yabusaki et al., 2008). The river alluvium was simulated as isotropic. The previous study (PNNL-17708) that explicitly simulated river sediments also used an isotropic hydraulic conductivity.

The calibration involved running the model for the 2014-2015 2-year period and evaluating the fit between the simulated and observed heads at wells 399-1-12 and 399-2-2. At the location of each monitoring well, the model nodes that fell within the top and bottom screen elevation for each well were flagged for output of saturation, hydraulic head, and concentration. For each time step, the well nodes that registered a water saturation of 1.0 were used in the calculation of the average concentration at each well.

The arithmetic mean was used for the average where concentrations for all nodes were weighted equally. Determination of goodness of fit was done by visual inspection. Adjustments to parameters governing flow and transport were made and the simulation run again. This process was repeated until a suitable match was obtained between measured and simulated water levels.

Figure 7-13 shows the quarterly changes in the magnitude of Darcy flux and flow direction in the aquifer for selected times in Year 2014 due to the changes in the river stage. In the first quarter of the year, from January to April, the flow direction is from river to groundwater due to the high river stage. During the month of August, the flow direction reversal occurs because of the higher water level in the upgradient location than the river stage. The flow direction changes again during the month of December due to the high river stage. The calculated horizontal linear velocity in the saturated Hanford unit near the Stage A area is approximately 10 m/d and the Darcy flux is ~1.3 m/d and the hydraulic gradient is ~3.25E-4 m/m. The hydraulic gradient value is consistent with the observed gradient (3.0E-4 m/m) value in the field and the velocity estimates are consistent with the average tracer drift velocity of about 11 m/day reported by PNNL-22048, *Updated Conceptual Model for the 300 Area Uranium Groundwater Plume*.

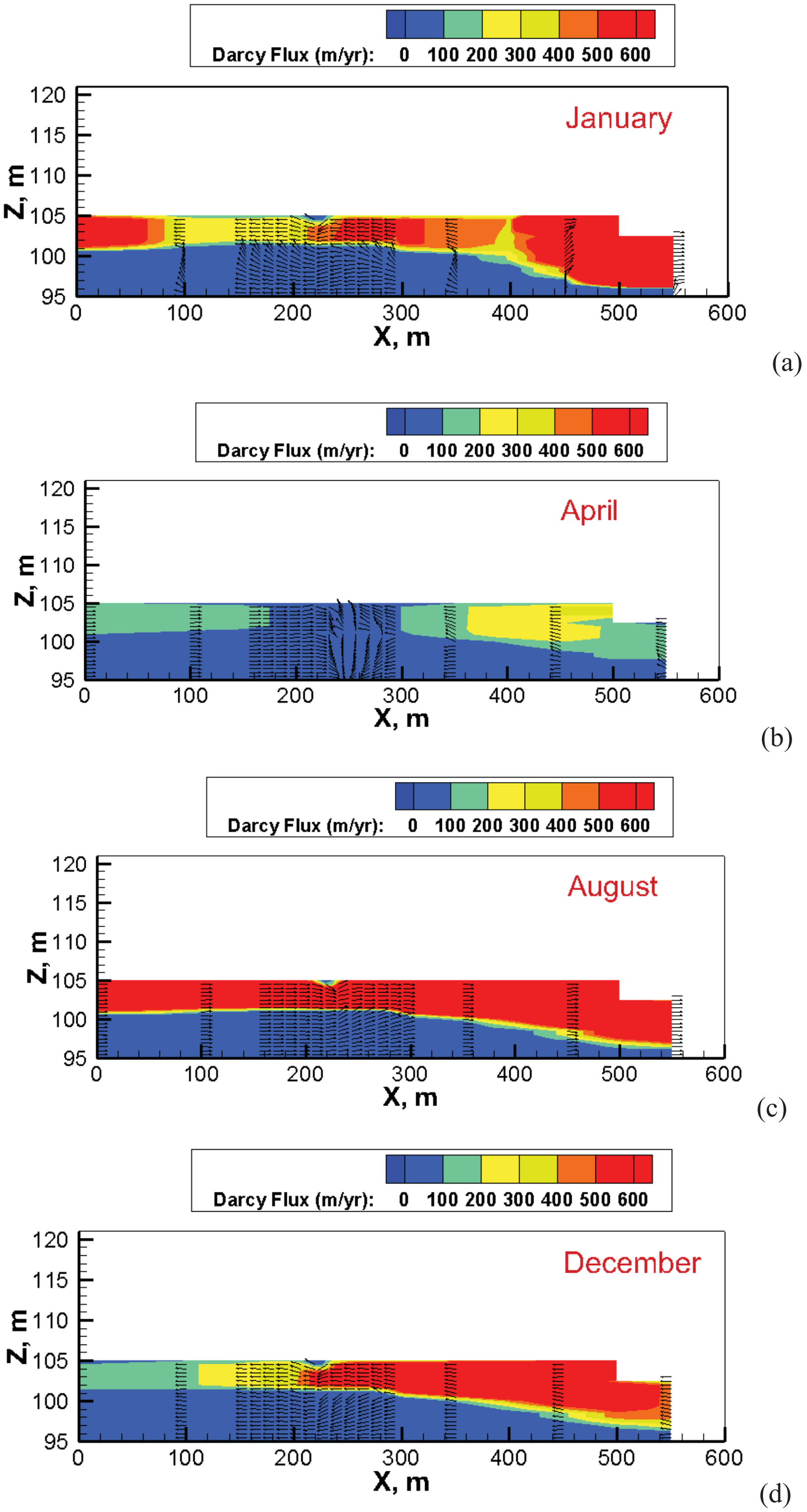
7.6.2 Macrodispersivity

The initial longitudinal macrodispersivity used in the models was 8.75 m for the saturated Hanford unit and Ringold unit E. A macrodispersivity of 8.75 m reflects the value derived using the weighted least squares method of Xu and Eckstein, 1995, “Use of Weighted Least-Squares Method in Evaluation of the Relationship Between Dispersivity and Field Scale,” based on the approximate plume length.
The longitudinal macrodispersivity was set to 1.0 m for the river alluvium units. These values are comparable to previous modeling studies that assigned values of 1 m to 3 m for the Hanford unit and values of 0.5 to 3.0 m for Ringold unit E (PNNL-17708; Ma et al., 2010; NUREG/CR-6940).

For all material property zones, except the Hanford vadose zone, the vertical transverse-to-longitudinal dispersivity ratio was set to 0.01 during calibration of the model. Previous modeling studies at Hanford have set the transverse-to-longitudinal dispersivity ratio from 0.01 to 1.0 (NUREG/CR-6940; PNNL-17708; Ma et al., 2010). Longitudinal macrodispersivity for the Hanford vadose zone (above the PRZ) was set at one-tenth of Hf longitudinal macrodispersivity, while the transverse dispersivity remained unchanged, because macrodispersivity in the unsaturated media is typically less than that in the saturated zone.

7.6.3 Porosity

Total porosity refers to both isolated and connected pore space. Diffusive porosity refers to the connected pore space and is the porosity through which flow and transport occurs in the model. For purposes of assigning values of diffusive porosity in the model, the diffusive porosity was assumed equal to values of total porosity listed in the literature. Total and diffusive porosity was specified as 0.177 cm^3/cm^3 for the Ringold Formation and river alluvium (PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessment* [Table 4.5]). Porosity for the Hf was specified as 0.167 cm^3/cm^3 (PNNL-14702, Table 4.5, Soil Class Hg). For all other units, the values are taken from PNNL-18564, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses: Fiscal Year 2008 Status Report*. For the silt unit, the value is 0.419 cm^3/cm^3; for all of the Hanford sand units, the value is 0.379 cm^3/cm^3. For Hanford gravel, the value is 0.102 cm^3/cm^3, and the rest are the same as the Hanford unit (0.167 cm^3/cm^3).



The line of the cross-section passes in an east-west direction through Stage A EAA as shown in previous figure.

Figure 7-13. Darcy Flux Distribution Along a 2D Cross-Section for Selected Times within a Year

7.6.4 Particle Density and Bulk Density

Bulk density for the Hf, taken as 2.23 g/cm^3, reflects the modal value of measurements for sandy gravel at the 300 Area (PNNL-17708, Table A.3). A bulk density of 2.23 g/cm^3 is also reasonable, given the range of bulk densities for Hanford coarse gravel of 1.56 to 2.42 g/cm^3 for a gravel content ranging from 50 to 85 percent, respectively (PNNL-14702, Table B-21). The particle density for the Hf was 2.68 g/cm^3, based on porosity of 0.167 cm^3/cm^3 and bulk density of 2.23 g/cm^3.

A particle density of 2.63 g/cm^3 and 2.66 g/cm^3 was reported (PNNL-17708, Appendix A) for Ringold unit E for the 300 Area with an average value of 2.65 g/cm^3 assigned in the model. Using a porosity of 0.177 for the Ringold unit gives a bulk density of 2.18 g/cm^3 and is nearly identical to the value of 2.17 g/cm^3 for Ringold sandy gravel for 82 percent gravel (PNNL-14702, Table B-27). Particle density of 2.76 g/cm^3 was used to represent the river alluvium (PNNL-17708). Using a diffusive porosity of 0.177 gives a bulk density of 2.27 g/cm^3.

The particle density value of 2.89 g/cm^3 was used to represent the silt unit (PNNL-18564); using a diffusive porosity of 0.419 gives a bulk density of 1.67 g/cm^3.

For all of the sand units, the particle density value of 2.57 g/cm^3 (PNNL-18564) was used; using a diffusive porosity of 0.379 gives a bulk density of 1.6 g/cm^3. For Hanford silty sandy gravel and sand gravel units, 2.31 g/cm^3 (PNNL-18564) was used; using a diffusive porosity of 0.167 gives a bulk density of 1.92 g/cm^3. For the Hanford gravel unit, the particle density value of 2.19 g/cm^3 (PNNL-18564) was used; using a diffusive porosity of 0.102 gives a bulk density of 1.97 g/cm^3.

7.6.5 Saturation-Pressure and Relative Permeability Relationships

The relationship between capillary pressure and saturation was characterized using the van Genuchten function (van Genuchten, 1980, "A Closed-form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils") and the Mualem pore distribution model (Mualem, 1976, "A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media"). In the models developed for the 300 Area, only Hf has the potential to be variably saturated. The parameters needed to describe the van Genuchten moisture retention constitutive relation and the Mualem relative permeability constitutive relation include the parameters such as α (proportional to the inverse of the air-entry matric potential), saturated and residual volumetric water contents, θ_s and θ_r, dimensionless fitting parameters n, and m, and saturated hydraulic conductivity, K_{sat}. The horizontal K_{sat} for the vadose zone units is taken to be 10 times the vertical K_{sat}. These parameters are presented in Table 7-1 and are based on statistical average of laboratory measurements summarized in PNNL-14702 (Table 4.5). The default option was used for the m parameter where $m = 1 - 1/n$.

Same hydraulic property set is used for the silty sandy gravel and sandy gravel unit due to lack of information. For the silt unit the hydraulic properties listed in PNNL-14702 (Table 4-5) for the Cold Creek Silt dominated unit were chosen. The α parameter of 0.017 1/cm for sandy gravel listed in PNNL-14702 (Table 4-5) was thought to represent too large of an air entry potential near the capillary fringe. As a result, α was assigned a value of 0.1 1/cm.

7.6.6 Molecular Diffusion Coefficient

The molecular diffusion option used in the model was conventional with a molecular diffusion coefficient of 2.5×10^{-9} m^2/s and solute partition option of continuous. The molecular diffusion coefficient, held constant during all simulations, was not included as a calibration parameter in the model. The uranium aqueous species effective molecular diffusion coefficient is set at 1×10^{-9} m^2/s.

7.6.7 Specific Storativity

Specific storativity, used in the model, was taken as the default value where it is equal to 1×10^{-7} × diffusive porosity. Specific storativity was held constant during all simulations and not included as a calibration parameter in the model.

7.6.8 Uranium Sorption

Uranium sorption-desorption parameters for simulating the pretreatment conditions are taken from ECF-300FF5-11-0151, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS*. These were developed based on the desorption experiments conducted by PNNL-SA-58541, *Uranium(VI) Release from Contaminated Vadose Zone Sediments: Estimation of Potential Contributions from Dissolution and Desorption*, and Liu et al., 2008, “Scale-dependent desorption of uranium from contaminated subsurface sediments.” The results presented in these papers are internally consistent and comprehensive and, therefore, are used exclusively for developing the sorption parameters before phosphate treatment. The sorption/desorption parameters presented here apply specifically to uranyl ion, which has the chemical formula of $(UO_2)^{2+}$, resulting in an oxidation state of +6. For simplicity, it is referred to in this report as U(VI). The uranyl ion forms from hydrolysis of uranium mineral during water-mineral interaction.

Based on information presented in ECF-300FF5-11-0151, the uranium K_d value of 3.17 mL/g was chosen for the aquifer (based on groundwater alkalinity), while a K_d value of 2.18 mL/g was chosen for the vadose zone. Both an equilibrium sorption and a kinetic sorption model was developed to cover the range of uncertainty expected in the uranium leaching characteristics. For the equilibrium sorption model the above mentioned K_d values are used. For the kinetic sorption-desorption model, the forward reaction rate constant was calculated to be 9.31×10^{-3} hr^{-1} based on a representative backward (desorption) rate constant of 5×10^{-4} hr^{-1} derived for field-textured samples (ECF-300FF5-11-0151). The kinetic model is implemented using the *Valocchi Sorption* option within the Kinetic Reactions card of STOMP input file.

7.7 Development of Initial Conditions

Simulations were initially conducted over a 2-year period (January 1, 2014 through December 31, 2015). This period coincides with complete water level data sets available for the inland and river model boundaries from well 399-1-12, and well 399-2-3 and the river gage, respectively. Additional wells within the model domain also had complete or nearly complete data sets for the same 2-year period that were useful in the calibration process. For the 2014 to 2015 period, 2014 exhibits the highest river stage and corresponding aquifer water levels, while the maximum river stage and aquifer water levels measured in 2015 are lower. High water levels are thought to be largely responsible for rewetting of the PRZ and increased influx of labile uranium from the top of the PRZ. This, in turn, is surmised to be responsible for generating periodic pulses to the uranium groundwater plumes with concentrations exceeding 60 to 90 µg/L. The high river stage during the summer of 2015 is lower than that observed in 2014 such that groundwater does not intersect sediments near the top of the PRZ that potentially contain higher soil uranium concentrations. Thus, the use of data from the 2014 to 2015 period provides a sampling of different flow behaviors and resulting uranium transport in the aquifer.

Boundary conditions are established by setting boundary pressures from observed data, as discussed earlier, and were based on a hydrostatic head distribution. The 3D flow and transport model was initially run for 15 cycles (30 years), starting from Year 1992, to establish the uranium concentrations in the aquifer under a “No Action” scenario. The hydraulic heads in the model rapidly equilibrated to the boundary conditions, and initial conditions were seen to diminish within the first 2-year cycle.
The 3D transport modeling of phosphate injection/infiltration, along with uranium transport, was

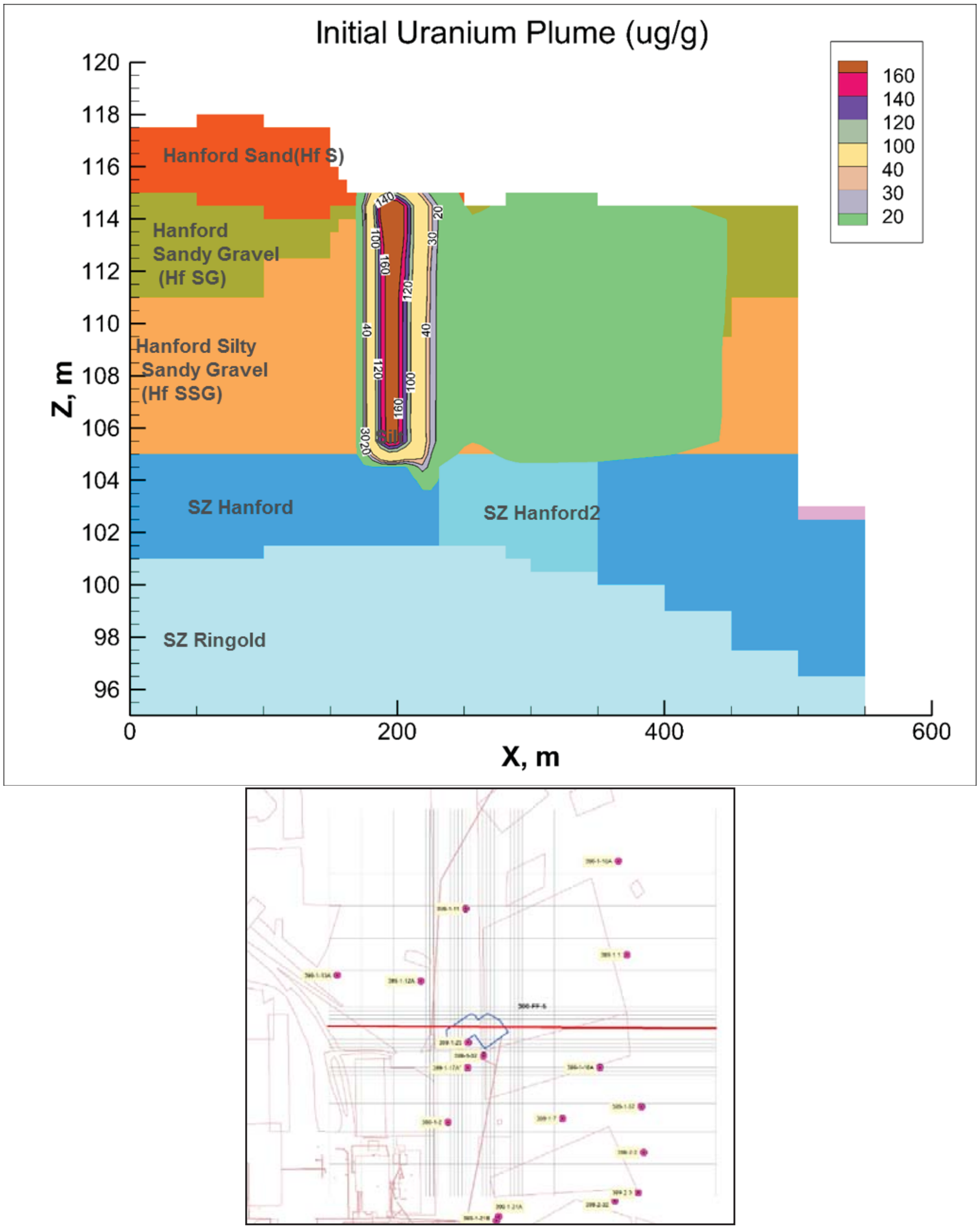
performed by exercising the model starting from Year 2015 and running it over the 2-year period (Year 2015 and 2016). Initial heads for the start of the model cycle were taken from the restart file, which was accessed by STOMP using the Restart option in the Solution Control Card of the STOMP input file.

Details of the data compilation and development of 3D uranium soil distribution can be found in ECF-300FF5-15-0087. Since the uranium soil concentrations were determined on <2 mm size sediment, soil concentrations were corrected for gravel content for the purpose of applying uranium mass on the bulk volume basis. This correction is necessary because almost all of the uranium mass is associated with the <2 mm size fraction, and a negligibly small amount is associated with the gravel fraction.

The gravel correction factor was derived by determining the fraction of <2 mm grain size in the 300 Area soils. The gravel content varies within the Stage A area due to varying lithologies. However, because most of the vadose zone and upper part of the unconfined aquifer is dominated by sandy gravel unit, a 60 percent gravel fraction was deemed reasonable. Uranium soil concentrations determined from the <2 mm size fraction were adjusted (multiplied by 0.4 for bulk volume), which is indicative of 40 percent of the sediment being <2 mm size that contains majority of uranium mass.

Prior to setting initial concentrations, the data were further adjusted for the component of uranium that would be exchangeable or labile (Figure 7-14). This was considered to be 60 percent based on evaluations presented in ECF-300FF5-11-0151. The gravel corrected bulk soil concentrations were multiplied by 0.6 to adjust for the labile fraction and the soil uranium plumes were reinterpolated.

Table 7-1 summarizes the model parameters following calibration. Figure 7-15 presents the hydraulic head comparisons among the observed and simulated heads for wells 399-1-12 and 399-2-2 that are located far from each other (Figure 7-16). Simulated hydraulic heads for all other wells within the model domain also show excellent matches with observations.



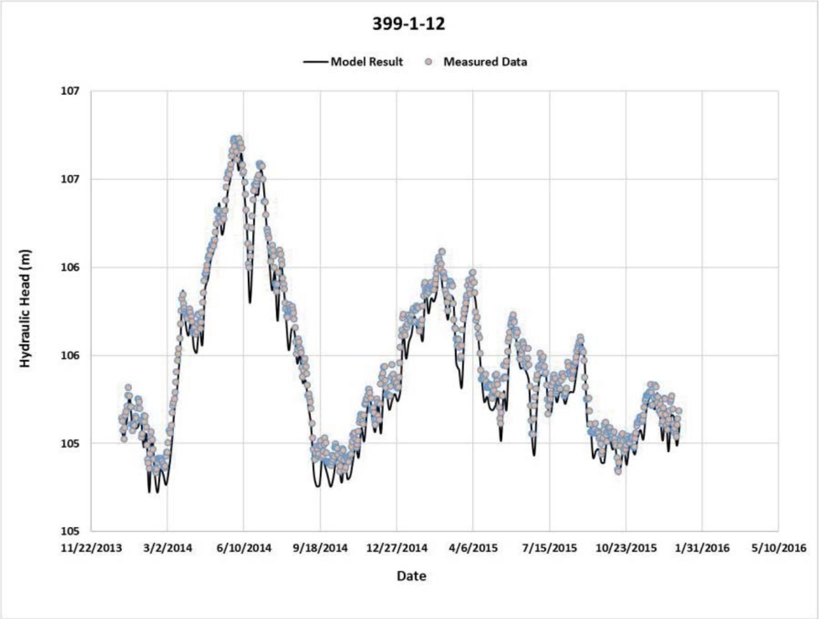
Note: The location of cross-section line is shown in the lower figure

Figure 7-14. Distribution of Initial Soil Labile Uranium Concentration Along an East-West-Trending Cross-Section Through the Stage A EAA

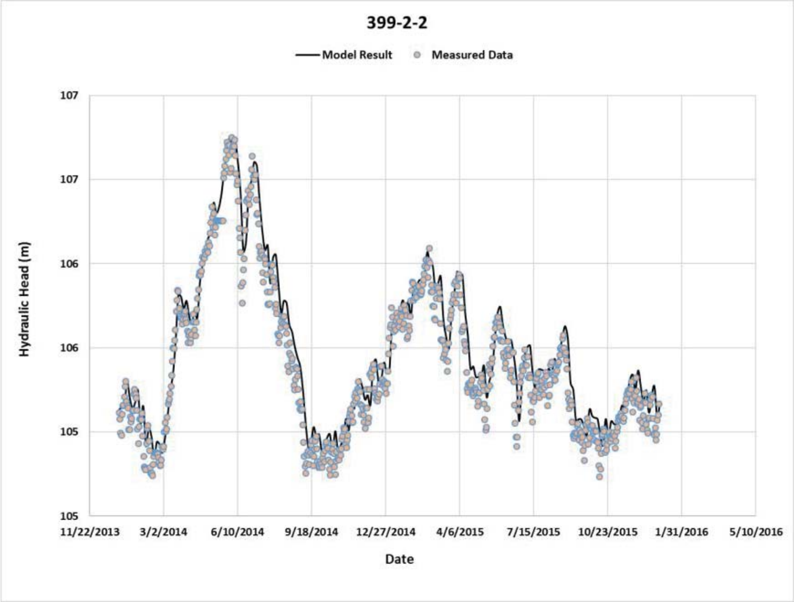
Table 7-1. Model Parameters Used in the Simulations

	Hanford Gravel (Hf G)	**Hanford Sand (Hf S)**	**Hanford Sandy Gravel (Hf SG)**	**Hanford Silty Sandy Gravel (Hf SSG)**	**Hanford Silt (S)**	**Saturated Silt (Saturated S)**	**Hanford (Saturated)**	**Hanford2 (Saturated)**	**Hanford 3 (Saturated)**	**Ringold Unit E (Saturated)**	**River Alluvium**
Horizontal K_{sat} (m/d)	12.6	3.2	2.85	2.85	0.5	0.5	4,000*	6,000*	1,000*	40	10*
K Anisotropy (K_z/K_x)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.0
Diffusive Porosity (cm^3/cm^3)	0.102	0.379	0.167	0.167	0.419	0.419	0.167	0.167	0.167	0.177	0.177
Longitudinal Dispersivity, α_L (m)	0.875	0.875	0.875	0.875	0.875	8.75	8.75	8.75	8.75	8.75	1
Dispersivity Anisotropy, α_T/α_L	0.1	0.1	0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01
van Genuchten α (1/cm)	0.007	0.027	0.017	0.017	0.005	0.005	0.082	0.082	0.082	0.008	0.008
van Genuchten n (-)	1.831	2.168	1.725	1.725	2.249	2.249	2.093	2.093	2.093	1.66	1.66
Residual Saturation (cm^3/cm^3)	0.196	0.0844	0.132	0.132	0.0954	0.0954	0.152	0.152	0.152	0.147	0.147
Particle Density, ρ_P (g/cm^3)	2.19	2.57	2.31	2.31	2.89	2.89	2.63	2.63	2.63	2.68	2.76
Bulk Density, ρ_B (g/cm^3)	1.97	1.6	1.92	1.92	1.68	1.68	2.19	2.19	2.19	2.21	2.27

* Based on model calibration.

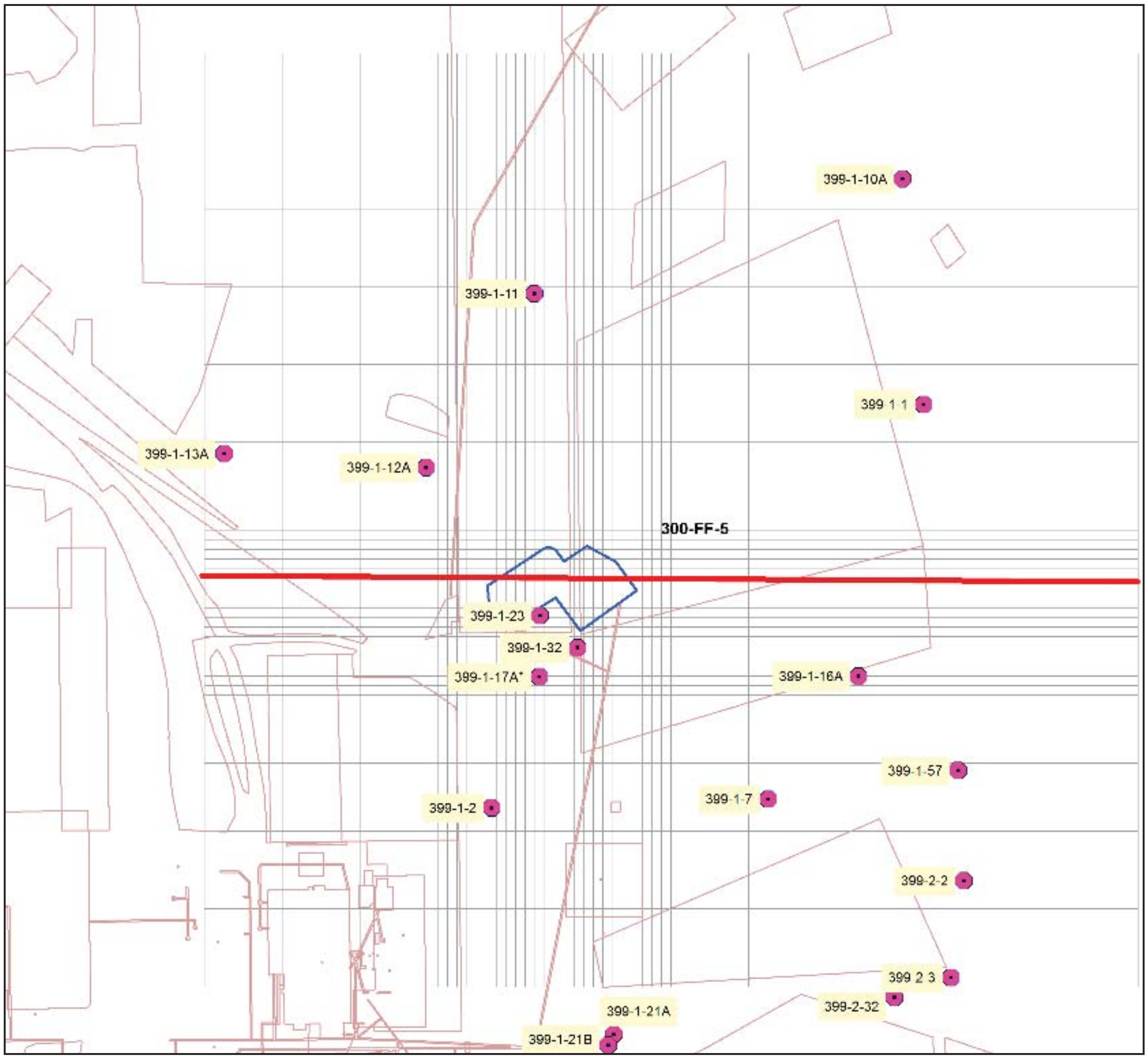


(a)



(b)

Figure 7-15. Comparison of Model Simulated Hydraulic Heads and Observed Heads at (a) 399-1-12 and (b) 399-2-2



Notes: The cross-section line (red line) is used for presenting Darcy flux distribution.

Well 399-1-12 is located in the northwest portion of the model domain, while 399-2-2 is located in the southeast portion of the model domain.

Figure 7-16. Location Map of Monitoring Wells within the Model Domain

7.8 Modeling Uranium and Phosphate Transport

This section provides details on uranium and phosphate transport modeling conducted using STOMP. 3D fate and transport modeling using STOMP was performed in three stages:

1. Modeling uranium transport prior to Stage A treatment
2. Modeling phosphate transport during treatment and post-treatment time periods
3. Modeling uranium transport during post-treatment times

7.8.1 Modeling Uranium Transport Prior to Treatment (No Action Case)

A fate and transport model was developed to estimate the uranium soil and groundwater concentrations prior to Stage A treatment. The emphasis of this model was to match the uranium concentrations in the aquifer observed over the past 20 years (approximately). Since some simplifications are inherent in modeling complex uranium leaching and transport characteristics within a dynamic aquifer, the focus was on matching the trend in uranium concentrations in selected wells where long-term monitoring records exist and to be reasonably close to the magnitude of uranium concentrations observed in the aquifer. The exact reconstruction of the past was not the objective of the model due to limited information on the uranium soil distribution and various past remediation activities. The hydraulic properties and boundary conditions developed for this model were used in the later models with minor changes where necessary.

Calibration of the uranium model included adjusting the maximum initial uranium concentrations (labile fraction) to better match with measured uranium concentrations from 1997 through 2015. Initial concentrations were adjusted by setting all saturated zone Hanford and Ringold unit soil concentrations to zero and all concentrations below background value to background, based on the understanding that the labile fraction would have been removed over many decades of pore volume flushing prior to start of the model.

The simulated uranium groundwater concentrations are compared to the observed concentration for selected monitoring wells in Figure 7-17 using both an equilibrium and kinetic sorption model. These simulations are performed assuming no remedial action has occurred (no action scenario) using hydraulic boundary conditions based on 2-year data from 2014-2015. These plots show how the transport model mimics the observed increases in the uranium groundwater concentrations during the typically high water month of June. Well 399-1-17A has the best long-term monitoring record of uranium concentrations. The simulation results (Figure 7-17) show that the kinetic model mimics the observed uranium groundwater concentrations more accurately than the equilibrium model. The model results show that during the typical high water month of June, uranium groundwater concentrations increase at the inland wells (Figure 7-17 a, b, c, and d), and decrease at the wells near the river (Figure 7-17 e and f). This behavior in the inland wells is a result of the rising water levels coming in contact with uranium mass within the upper portions of the PRZ, and capillary fringe, near the southern end of the 300 Area Process Trench, thereby increasing desorption from the soil to the aqueous phase and increasing concentrations in the groundwater. As water levels decline, uranium groundwater concentrations decrease due to reduced leaching from the PRZ. The decrease in uranium groundwater concentrations for the wells near the river is due to a combination of dilution and mixing from the influx of river water. Figure 7-18 shows the simulated uranium plume maps for equilibrium and kinetic sorption models for Years 2015, 2022, and 2040. The results presented herein demonstrate adequacy of the modeling methodology and choice of parameters at the scale of the model domain.

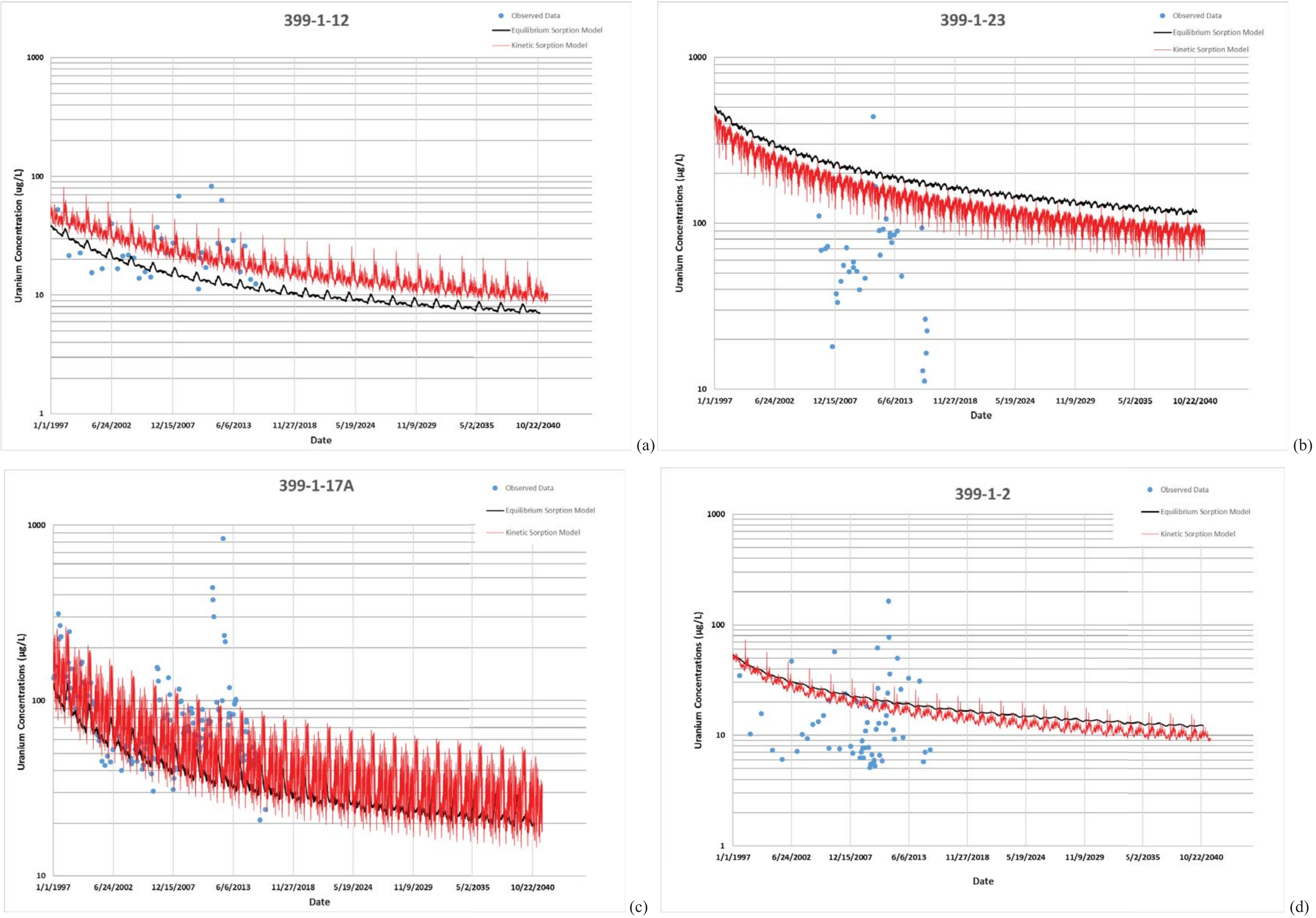
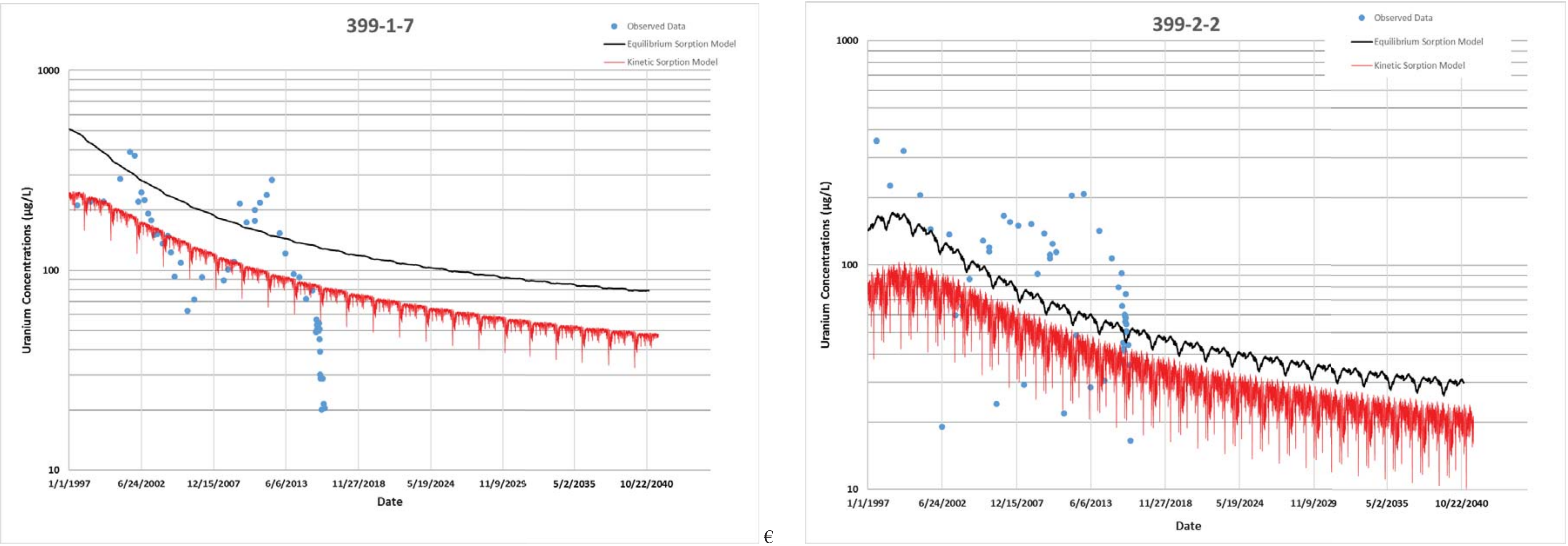


Figure 7-17. Measured and Simulated Groundwater Uranium Concentrations During the Calibration Period at Wells (a) 399-1-12, (b) 399-1-23, (c) 399-1-17A, (d) 399-1-2, (e) 399-1-7, and (f) 399-2-2¶(page 1 of 2)



€ (f)

Figure 7-17. Measured and Simulated Groundwater Uranium Concentrations During the Calibration Period at Wells (a) 399-1-12, (b) 399-1-23, (c) 399-1-17A, (d) 399-1-2, (e) 399-1-7, and (f) 399-2-2 (page 2 of 2)

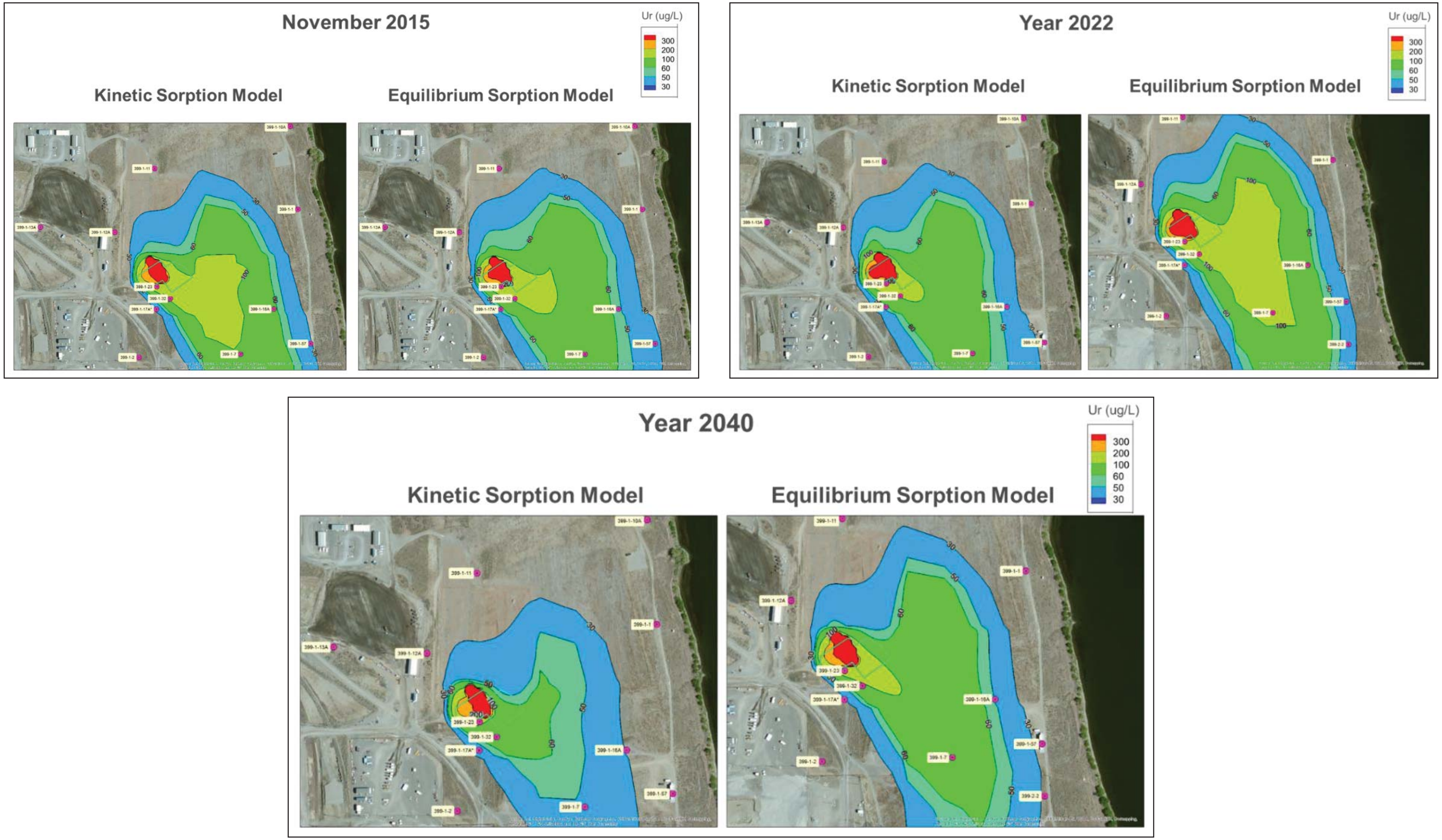


Figure 7-18. Simulated Uranium Plumes in Years 2015, 2022, and 2040 under No Action Scenario

This page intentionally left blank.

7.8.2 Phosphate Transport Modeling During and Post-Treatment Time Periods

Based on information derived from experimental data on phosphate migration and retardation and from observations of phosphate concentrations made during the treatment and post-treatment time periods, modeling of phosphate transport was undertaken. Phosphate injections and infiltration operations were simulated, and phosphate concentrations were compared to the observations made in the PRZ and aquifer wells. The results were used to demonstrate adequacy of parameters for modeling phosphate transport in the vadose zone and aquifer and for projecting concentrations in the aquifer.

Phosphate injection and infiltration were simulated, based on the operational records for Stage A. The rate of injection and infiltration along with timings and locations were consistent with the Stage A operation schedule (Table 6-1). To simulate the infiltration, as a modeling simplification, a constant rate of 212 L/min (56 gal/min) was applied over the first four days of infiltration and 303 L/min (80 gal/min) for the remaining 5 days.

For modeling transport of phosphate, the K_d value within the vadose zone was chosen to be 0.02 mL/g, based on experimental evaluations reported in PNNL-17818, Table 4.2. A 10 times higher value of 0.2 mL/g is applied to the saturated zone based on evaluation of monitoring data on phosphate migration in the aquifer. All other transport parameters (e.g., dispersivity and molecular diffusion) were left unchanged. The simulated phosphate concentrations are compared with the observed data for selected groundwater monitoring wells (Figure 7-19). The simulated plume maps of phosphate in the aquifer are presented in Figure 7-20 for times during the treatment and for the post-treatment time period.
For comparison, spatial plume maps are drawn based on available information from monitoring wells at selected times (Figure 7-21), which indicate that high phosphate concentrations persisted in the aquifer even after three weeks following injection. The simulated plume map for November 20, 2015 is compared with the interpolated map, based on the observed data from monitoring wells (Figure 7-22). The black contours in the figure show the simulated results, while other color contours are drawn from the measured phosphate concentration data. The simulated concentration contour of 250 mg/L is spatially located approximately where such concentrations are interpolated based on observations.

An assessment of any changes in aquifer hydraulic properties from phosphate injection/infiltration is provided in Appendix E. Evaluation of observed changes in water levels before and after treatment indicates that no or negligible changes have occurred in the aquifer properties within the Stage A EAA.

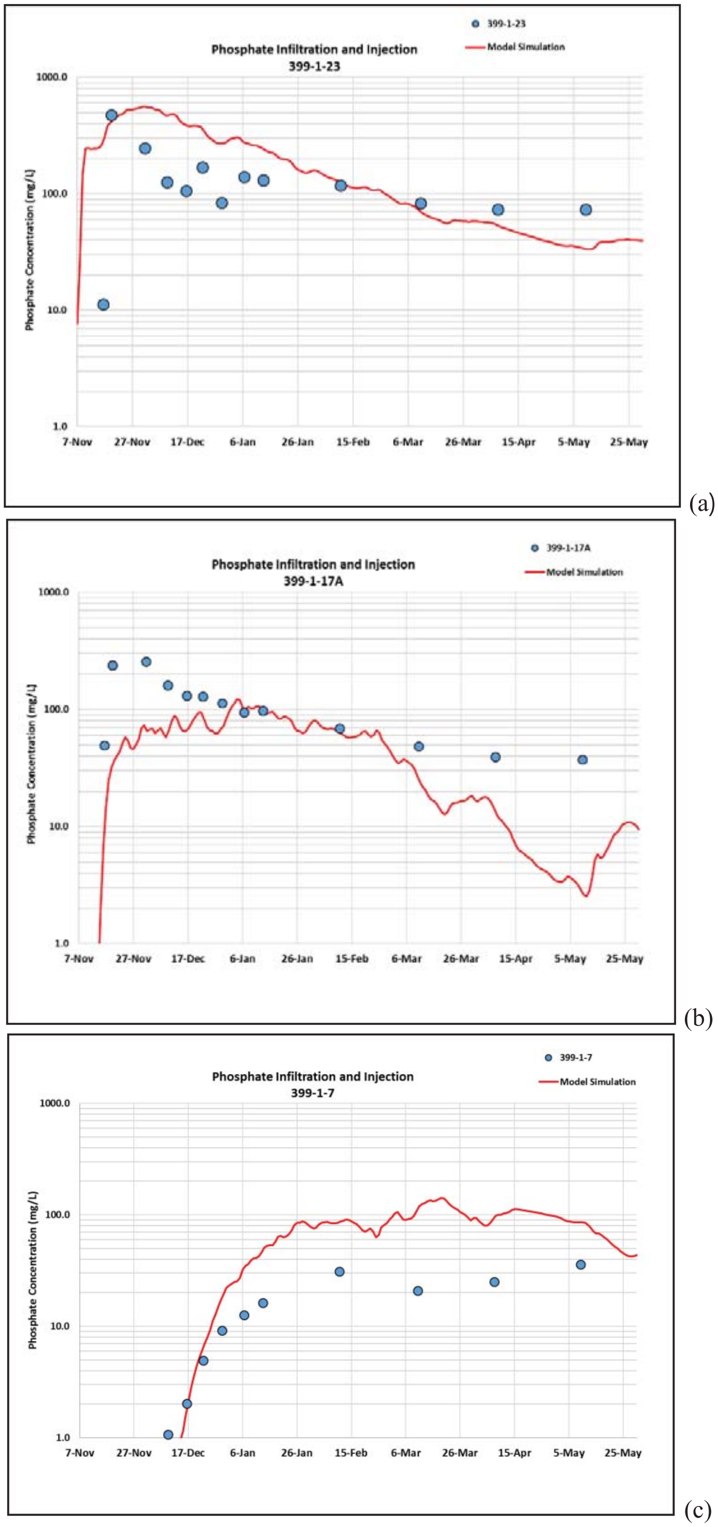


Figure 7-19. Simulated Phosphate Concentration in Aquifers (a) 399-1-23, (b) 399-1-17A, and (c) 399-1-7

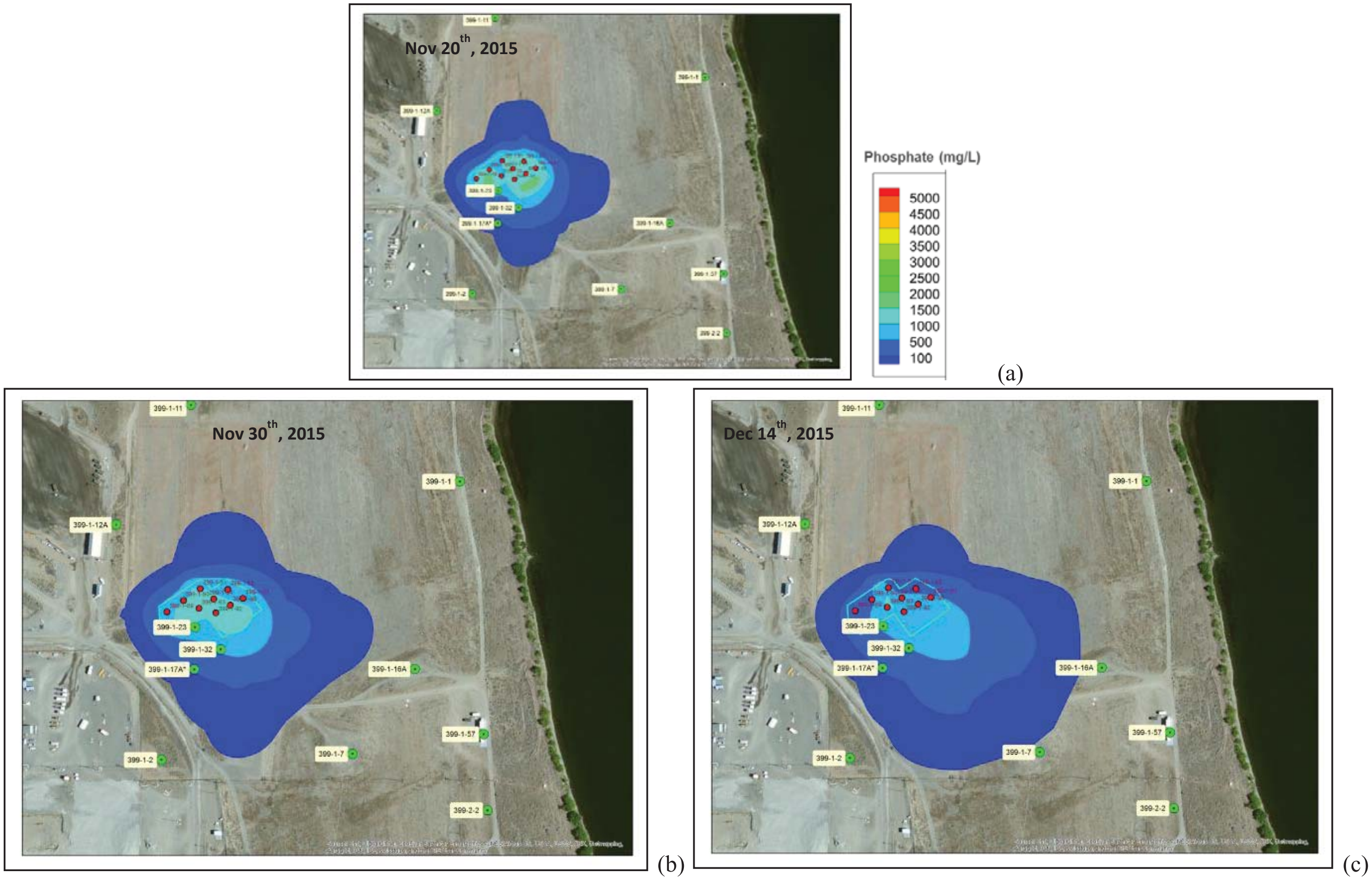


Figure 7-20. Simulated Phosphate Concentration Distribution in the Aquifer for (a) November 20, 2015; (b) November 30, 2015; (c) December 14, 2015; (d) December 20, 2015; (e) December 30, 2015; (f) January 15, 2016; and (g) December 31, 2016¶(page 1 of 2)

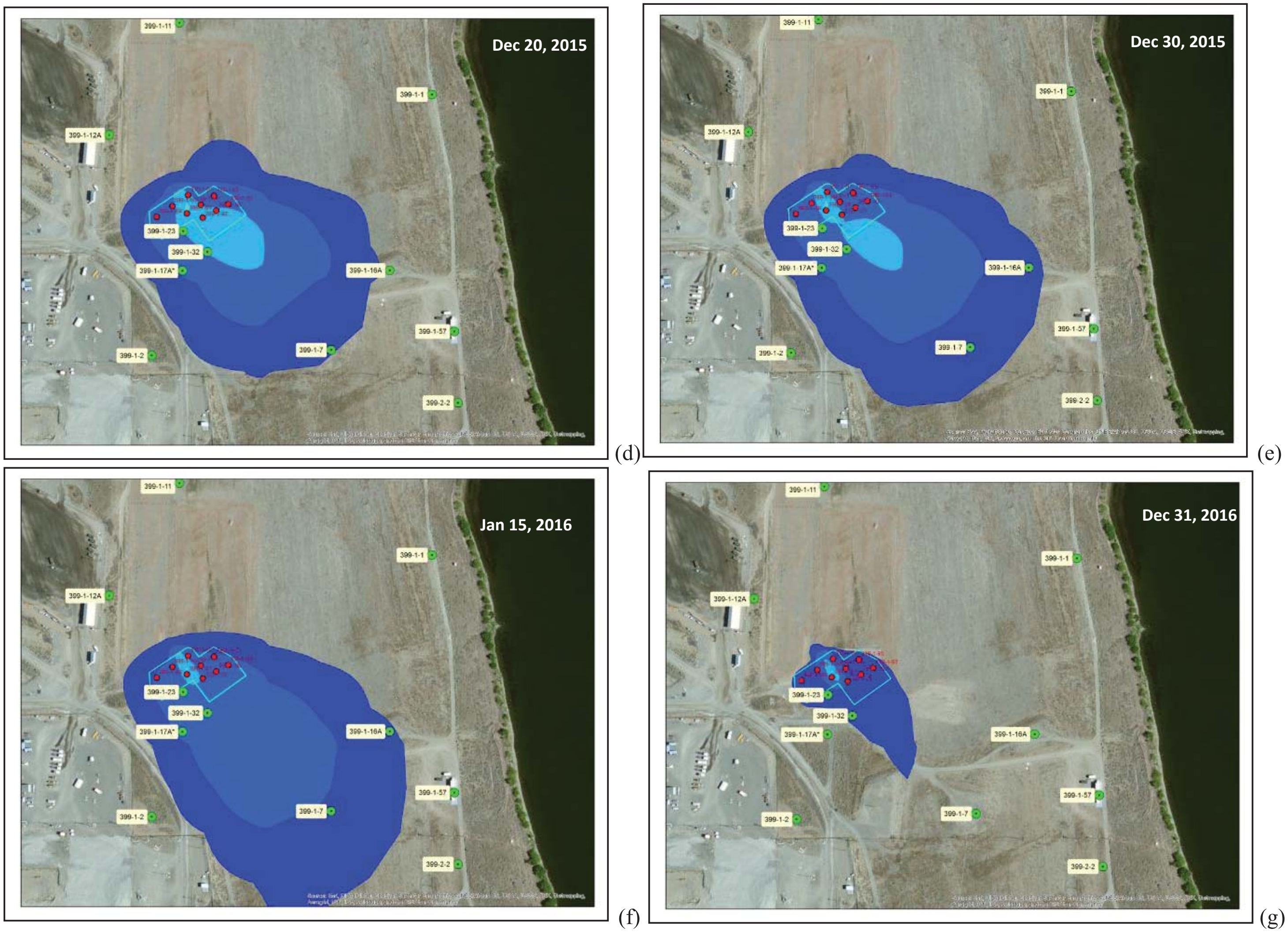
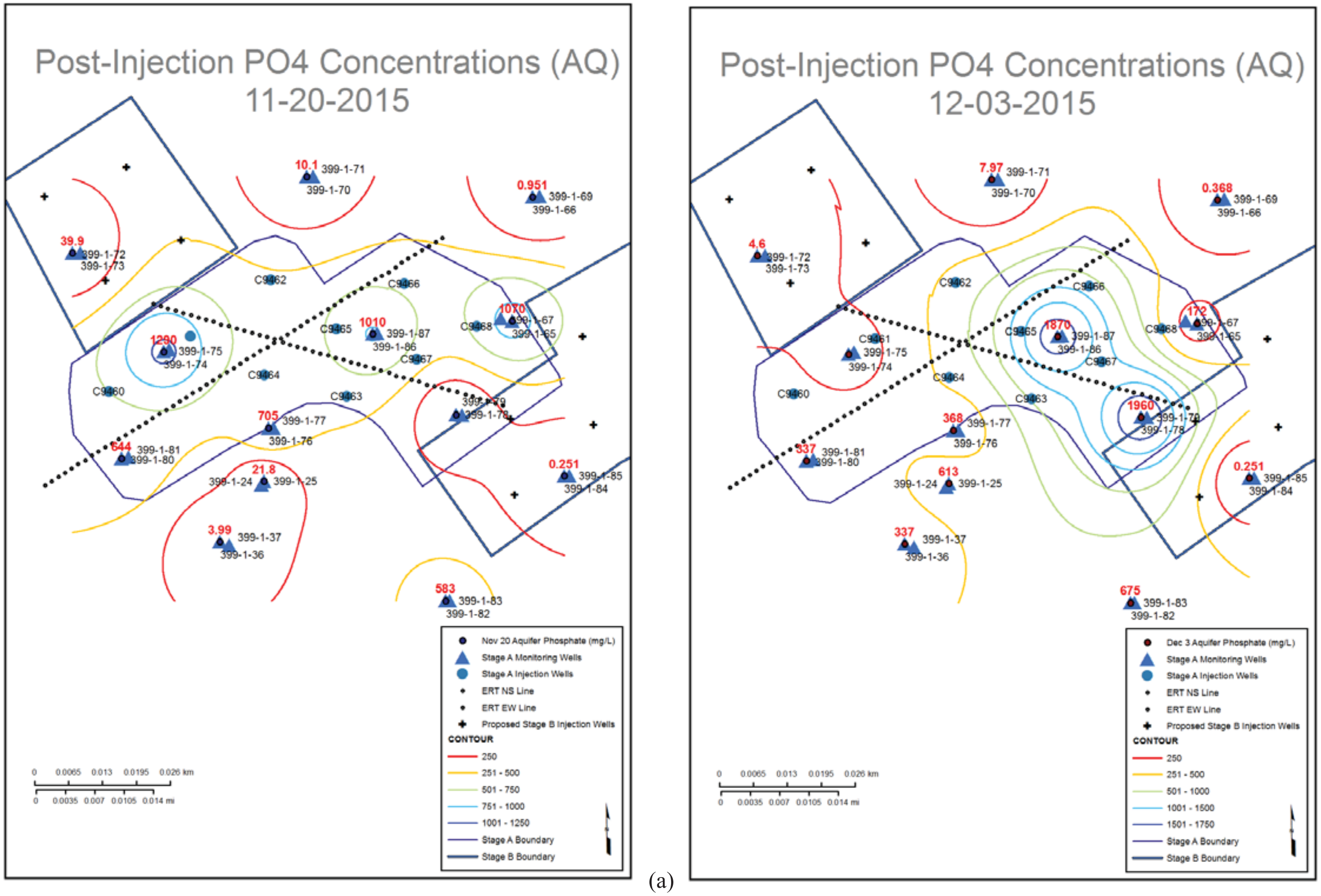
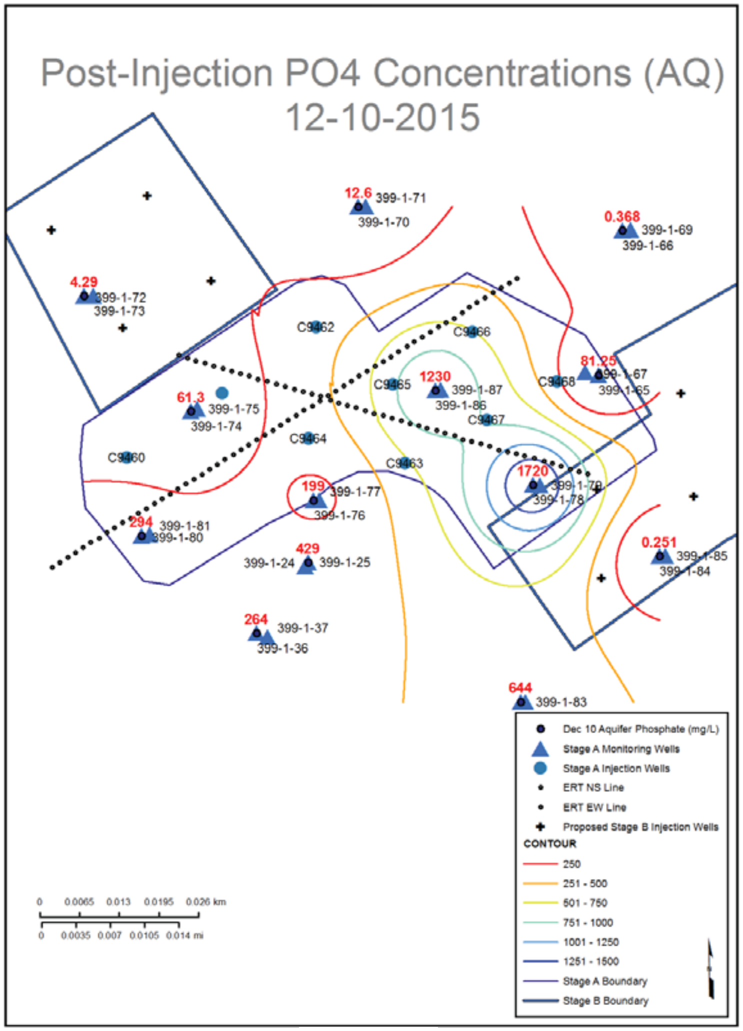


Figure 7-20. Simulated Phosphate Concentration Distribution in the Aquifer for (a) November 20, 2015; (b) November 30, 2015; (c) December 14, 2015; (d) December 20, 2015; (e) December 30, 2015; (f) January 15, 2016; and (g) December 31, 2016 (page 2 of 2)



(a) (b)

Figure 7-21. Post-Injection Phosphate Concentrations (mg/L) Contours based on Observations on (a) November 20, 2015; (b) December 3, 2015; (c) December 10, 2015¶page 1 of 2)



(c)

Figure 7-21. Post-Injection Phosphate Concentrations (mg/L) Contours based on Observations on (a) November 20, 2015; (b) December 3, 2015; (c) December 10, 2015 (page 2 of 2)

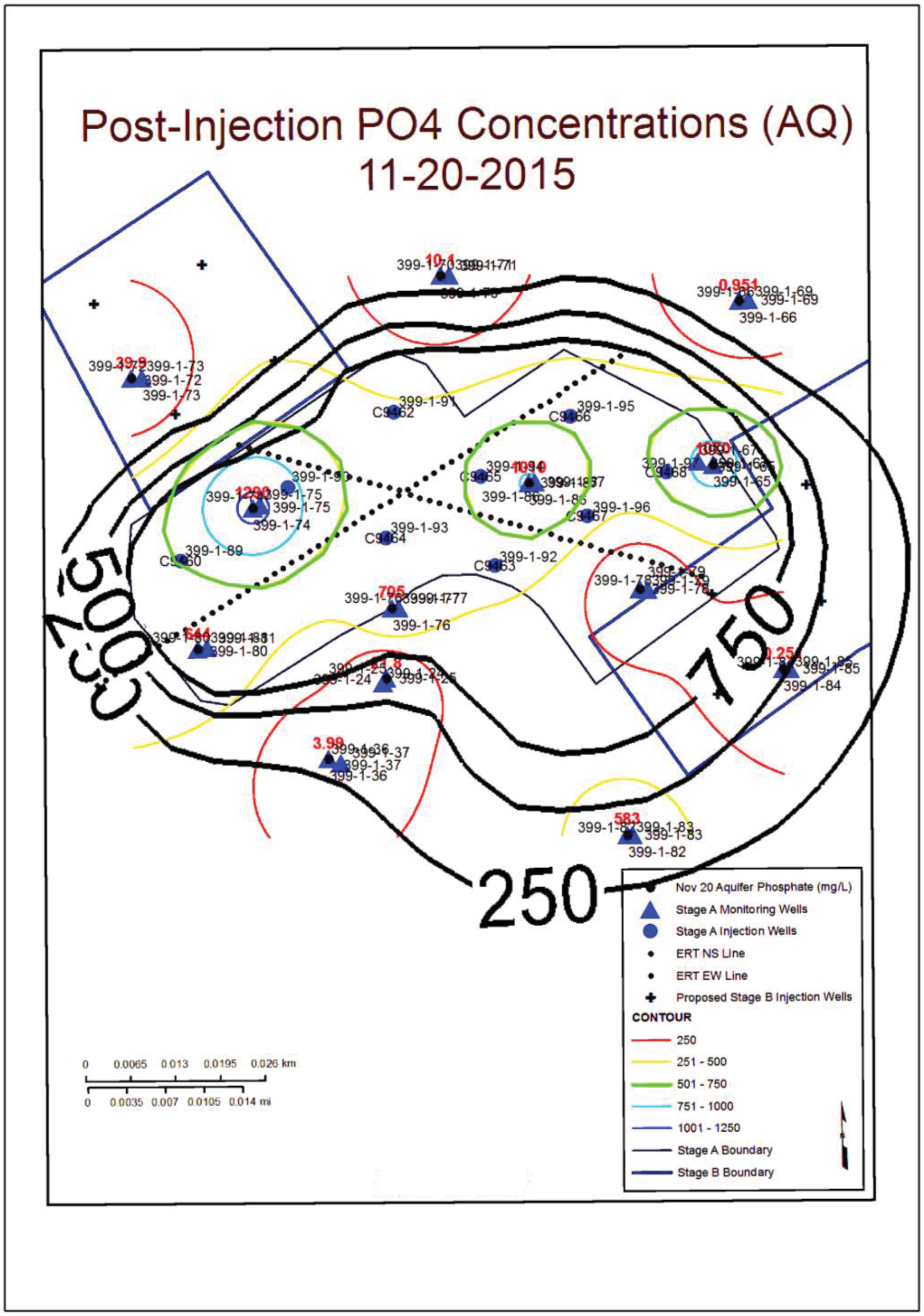


Figure 7-22. Phosphate Concentration (mg/L) Comparison between Model Simulated and Interpolated Data Based on Observations

7.8.3 Uranium Transport Modeling During and Post-Treatment Period

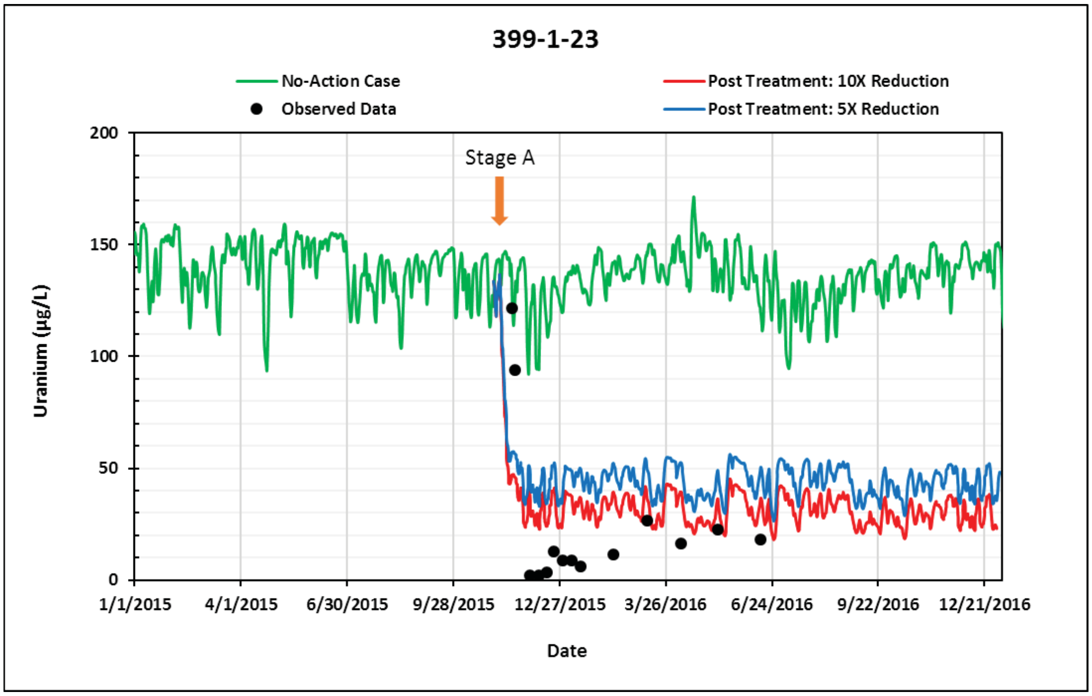
Fate and transport modeling of uranium during and following the phosphate treatment is conducted by simulating the effects of injection and infiltration during the operation period. For this purpose, the kinetic sorption-desorption model was used. Prior to that time, the uranium distribution within the vadose zone and aquifer was based on the pretreatment model results using the kinetic sorption model. During and following the treatment, the backward (desorption) rate constant[2] for kinetic sorption is reduced by factors of 5 and 10 within the Stage A EAA. The choice of reduction factor was based on the following considerations:

1. Flow-through column tests conducted on sediment samples collected from the PRZ, where higher phosphate concentrations were observed, indicated much lower uranium concentrations in the effluent compared to other samples that did not have high phosphate concentrations (see Section 6.3.1.2). A concentration reduction factor of 10 to 100 is noticeable during the leaching tests presented in Figures 6-26 and 6-27.
2. Based on fitting kinetic rate model to the flow-through column experiments (Appendix C) it was observed that the desorption rates are appreciably lower for the samples where phosphate concentrations are higher. In Appendix C.1.3, it is noted that <2 mm size sediment samples B347F1F3 and B347T7 have K_d values that are about factor of 5 to 10 greater than B347P5P8 and B247R1. For the field-textured (bulk) sediment samples, the K_d value for B347T6 is twice that of other two bulk sediment samples (B347R0 and B347P4). The samples showing higher K_d values are located at PRZ depths (Table 6-5) and have higher phosphate concentrations resulting from PRZ injections (and infiltration) as shown in Figure 6-17.
3. PNNL-17818 provides an estimate of the dissolution rate of uranium-rich calcite in the presence and absence of polyphosphate amended solution. Under varying phosphate concentration, the rate of uranium release is maintained at, or below, the minimum rate observed in the absence of aqueous phosphate, regardless of pH. The release rate within the pH range of 6 to 8 for solutions where phosphate is not present is about 10^{-8} mol/m^2/sec but under low to moderate phosphate concentrations (PO_4^{3-} of 10^{-2} mol/L) is typically a factor of 3 to 5 smaller.
4. Concentrations of uranium in the groundwater monitoring wells (e.g., 399-1-23 and 399-1-17A) in the vicinity of Stage A EAA have shown a sharp drop following the treatment (Figure 6-13) and have stayed low for the 6-month monitoring period for which the record currently exists.

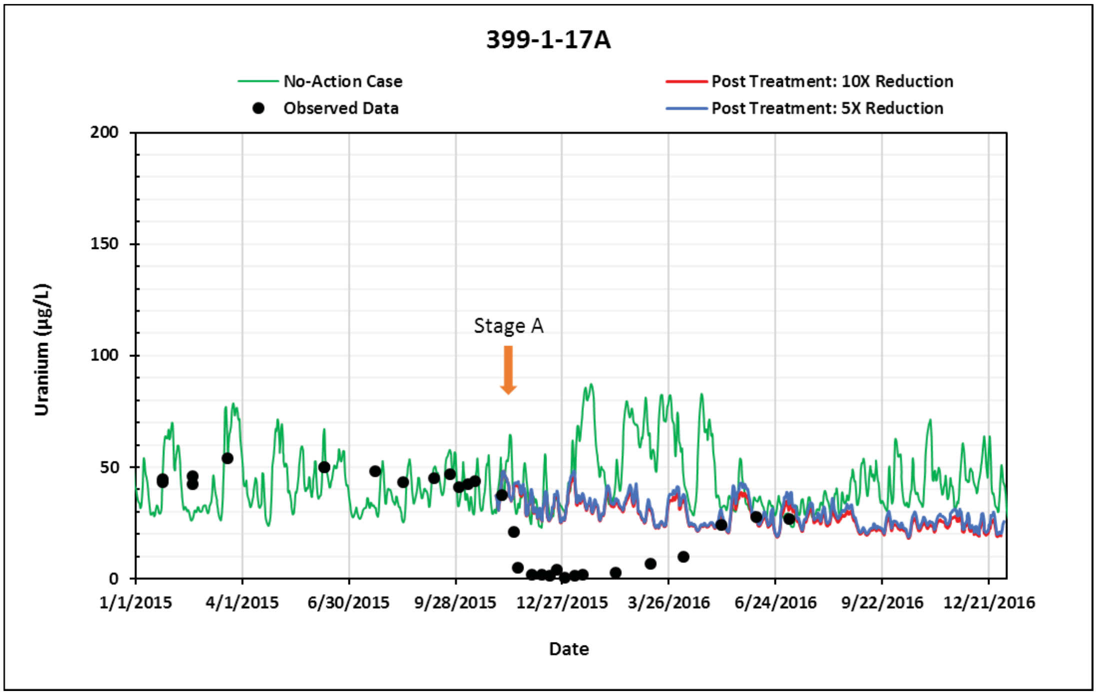
The modeling results related to uranium concentrations prior to and following the treatment are shown in the Figure 7-23 and compared to the observed concentrations at wells 399-1-23 and 399-1-17A. The results are presented for model cases where the backward (desorption) kinetic rate constant has been reduced by a factor of 5 and 10 to cover the probable range of uncertainty. The observed concentrations show a sharp decline in uranium concentration immediately following the Stage A treatment but then increase over time. The last three monthly observations indicate establishment of newly equilibrated concentrations that vary within a narrow range. The focus of the modeling is to match these concentrations as they are expected to persist in the aquifer over the near future.

---

[2] The forward reaction rate constant for kinetic sorption is calculated as the product of K_d, the backward (desorption) rate constant, and the ratio of bulk density to porosity. Increasing the value of K_d by a factor of 5 (or 10), while holding all other parameters constant, has the effect of reducing the backward (desorption) rate constant by a factor of 5 (or 10) compared to the pretreatment value.



(a)



(b)

Figure 7-23. Simulated Uranium Concentrations for (a) 399-1-23 and (b) 399-1-17A Compared to Observed Data Before and Following Treatment

The model predicted results match reasonably well with observed post-treatment uranium concentration trends in the field indicating that the desorption rates have indeed declined within the Stage A area as a result of phosphate injection and infiltration. A factor of 4 to 6 reduction in uranium concentrations is observed between the pretreatment and the post-treatment concentrations at well 399-1-23. This indicates that the remedy implemented for Stage A has been successful. The simulated concentrations in well 399-1-17A following treatment decline less steeply than at wells 399-1-23 because 399-1-17A is located further downgradient of Stage A EAA and, therefore, is influenced by uranium mass from areas outside the Stage A EAA. Nevertheless, some lowering of concentration (up to a factor of 2) along with the change in long-term trend is noticeable.

Figure 7-24 presents the footprint of predicted uranium plume at the end of Year 2016. The model predicts that due to the treatment, the extent of the high concentration uranium plume area in the aquifer has reduced considerably in the Stage A EAA area and remains reduced. This can be seen by comparing and contrasting the plume map under the no action scenario shown in part c of Figure 7-24.

The model setup used for short-term predictions (Figure 7-23) is extended to evaluate long-term uranium concentrations. For this purpose, the post-treatment model parameters are kept unchanged, and the model is exercised to run up to Year 2040. The results are presented in Figure 7-25 for the cases where the backward (desorption) kinetic rate constants are reduced by factors of 5 and 10. These results are compared to the no action case in order to compare the change predicted from phosphate treatment in Stage A EAA. The predictive cases are presented assuming that desorption rates are not going to change over the simulated time period. Due to these assumptions, the uncertainty in these estimates is high and need to be considered when making any decisions based on the model predictions. The long-term simulated concentrations for 399-1-23 show a gradual rise but remain below the no action case. The gradual rise reflects the combined effect of slow continued desorption of uranium into the aquifer from Stage A EAA and contribution to the aquifer from areas outside Stage A. The long-term simulated concentrations for 399-1-17A also continue to remain below the no action case.

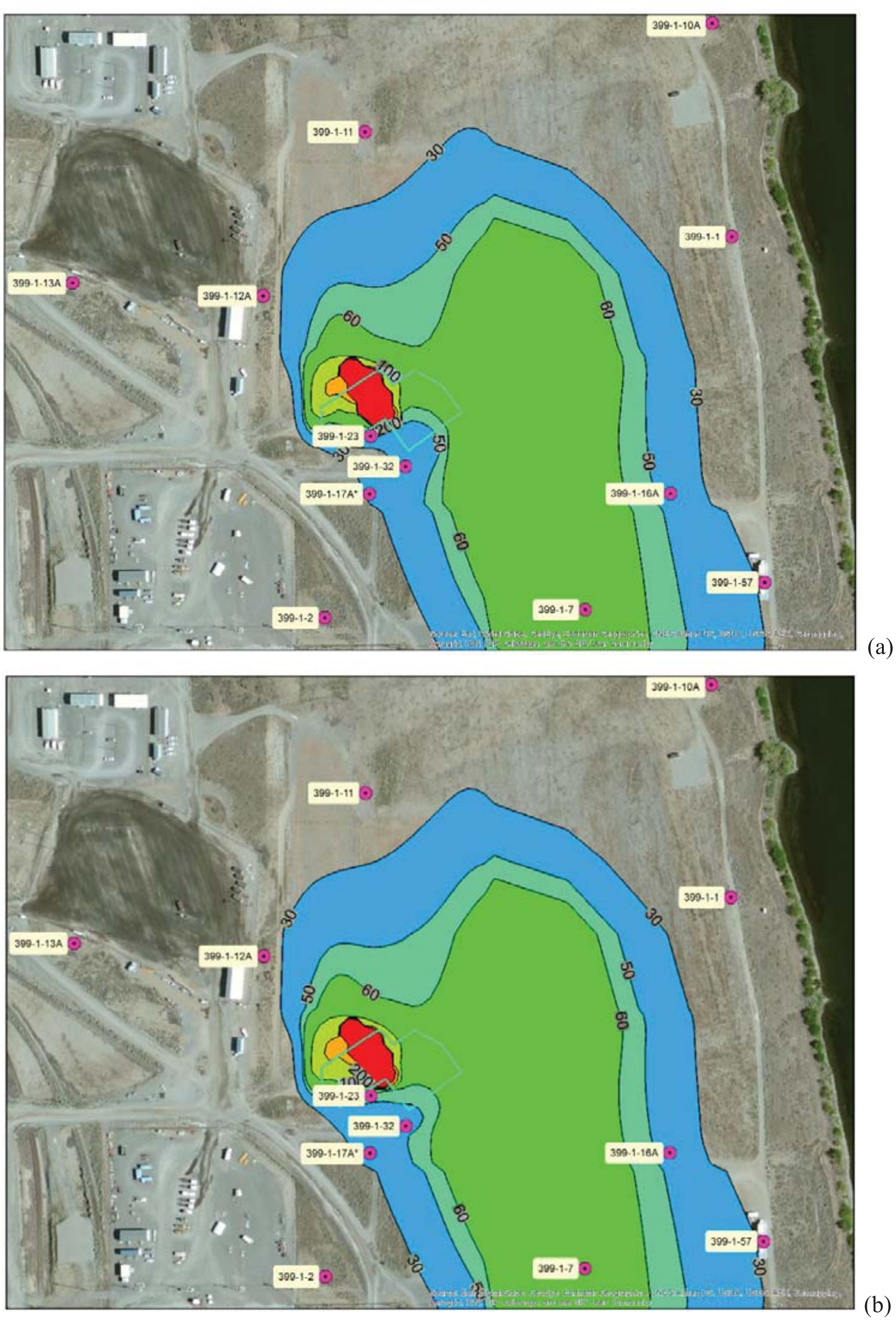
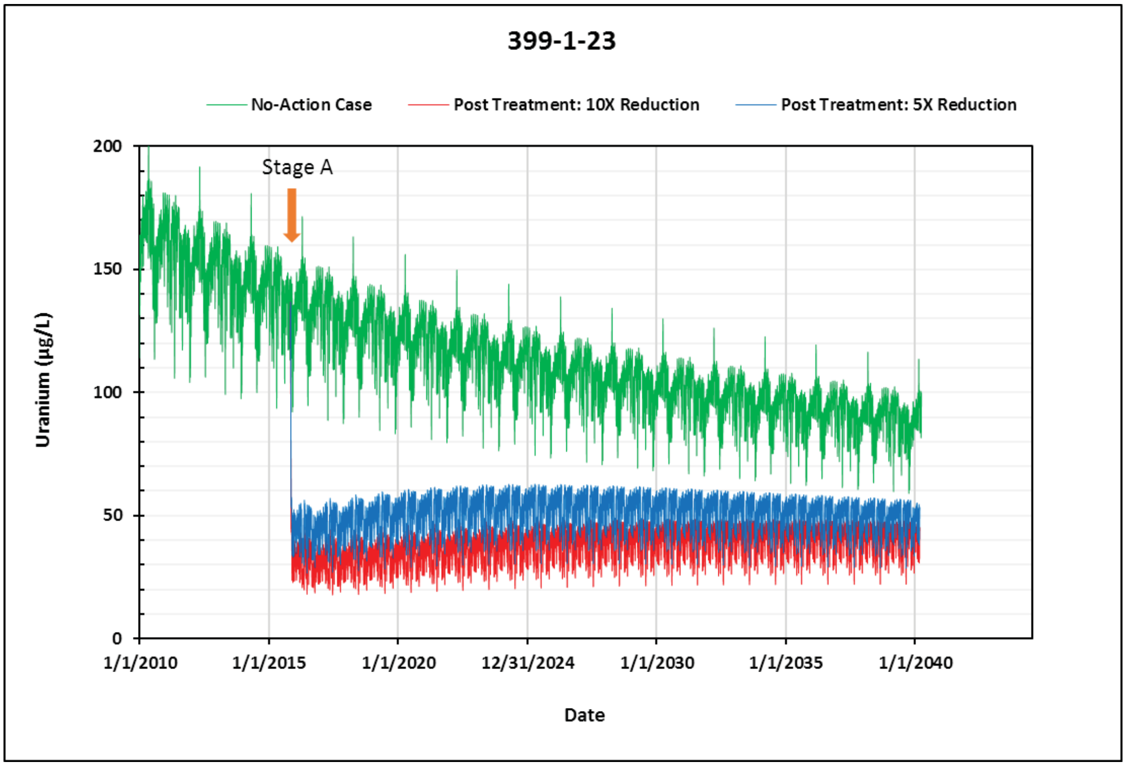


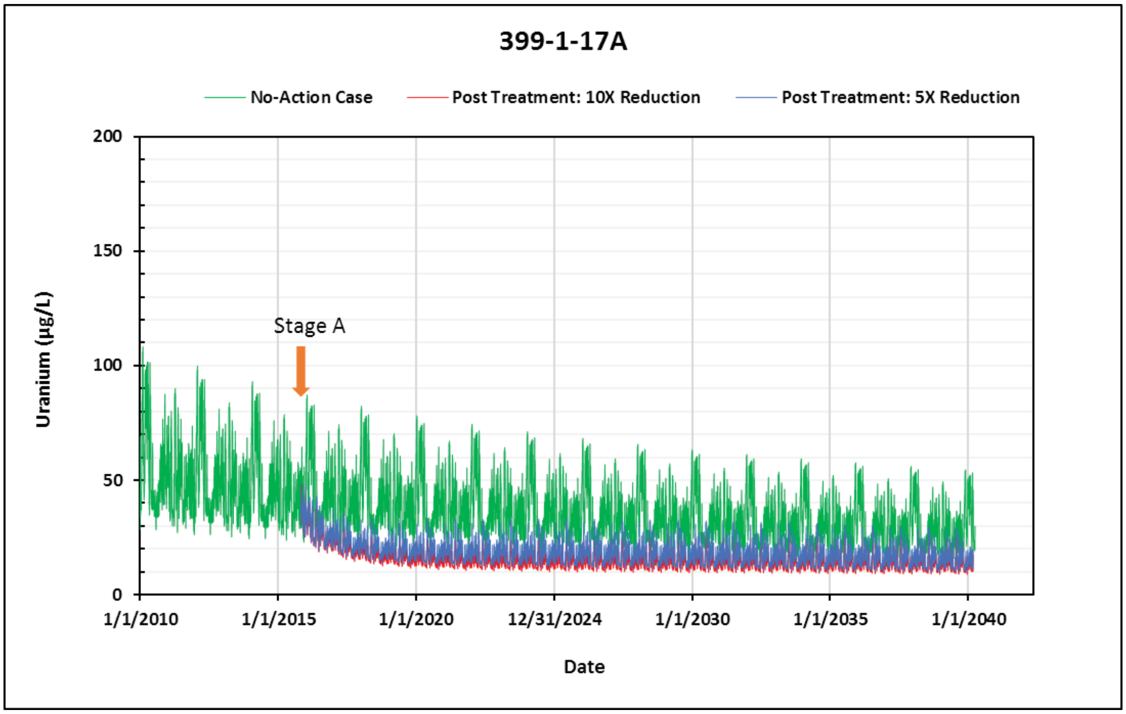
Figure 7-24. Post-Treatment Simulated Uranium Concentrations at End of December 2016 (a) 10 Times Reduction in Desorption Rate, (b) 5 Times Reduction in Desorption Rates, and (c) No Action Case¶(page 1 of 2)

(c)

Figure 7-24. Post-Treatment Simulated Uranium Concentrations at End of December 2016 (a) 10 Times Reduction in Desorption Rate, (b) 5 Times Reduction in Desorption Rates, and (c) No Action Case (page 2 of 2)



(a)



(b)

Figure 7-25. Long-Term Simulated Uranium Concentrations for (a) 399-1-23 and (b) 399-1-17A Comparing the Predicted Post-Treatment Results to the No Action Case

This page intentionally left blank.

8 Conclusions

The desired goal of injection and infiltration in Stage A EAA is to deliver phosphate at high concentrations to the vadose zone and top of the aquifer where uranium is present in the sediments in order to precipitate phosphate bearing mineral phases that can bind labile uranium and sequester it. This report summarizes the information gathered before, during, and post-treatment time periods and synthesizes all of the relevant information for developing a conceptual understanding of the phosphate solution-sediment interactions during and following the treatment.

Reactive-transport modeling was conducted to develop an understanding of the various reactions in the subsurface that lead to sequestration of uranium. For development of predictive fate and transport model, an understanding of the processes governing uranium sequestration is needed, so the proof-of-principle can be sufficiently justified. Geochemical and reactive transport modeling was performed to match the experiments and observations to justify the proof-of-principle. Information gathered from geochemical evaluations of pretreatment and post-treatment soil samples, sequential extraction tests, batch desorption and flow-through column tests, mineral phase analysis, and observations made in the field regarding uranium and phosphate concentrations in groundwater, are all used in developing parameters and conceptual models for conducting fate and transport calculations. A factor of 4 to 6 reduction in uranium concentrations is observed between the pretreatment concentrations and the post-treatment concentrations in the groundwater monitoring wells. This indicates that the remedy implemented for Stage A was successful in sequestering uranium in situ. The longer term predictive calculations indicate that the uranium concentrations will continue to remain below the pre-treatment levels; however, some small gradual increase in concentration over time may occur. However, due to a variety of modeling assumptions (e.g., in situ uranium mass distribution and sorption-desorption characteristics), the longer term predictive uncertainty is high and needs to be considered when making any decisions for Stage B design and implementation.

This page intentionally left blank.

9 References

Brown, James L., 1980, "Calcium Phosphate Precipitation in Aqueous Calcitic Limestone Suspensions," *Journal of Environmental Quality* 9(4):641-644.

CHPRC-00176, 2016, *STOMP Software Management Plan*, Rev. 4, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-00211, 2016, *STOMP Software Test Plan*, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-00222, 2016, *STOMP Functional Requirements Document*, Rev. 2, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-00269, 2016, *STOMP Requirements Traceability Matrix*, CHPRC Build 5, Rev. 4, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-00515, 2016, *STOMP Acceptance Test Report*, CHPRC Build 5, Rev. 4, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-01874, 2016, *The Geochemist's Workbench Integrated Software Management Plan Version 11.0.3*, Rev. 2, CH2M HILL Plateau Remediation Company, Richland, Washington.

DOE/RL-2009-30, 2010, *300 Area Decision Unit Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084376.

DOE/RL-2011-50, 2012, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093361.

DOE/RL-2014-13, 2015, *Integrated Remedial Design Report/Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units)*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081153H.

DOE/RL-2014-13-ADD2, 2015, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081151H.

DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079669H.

ECF-300FF5-11-0151, 2012, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS*, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078650H.

ECF-300FF5-15-0014, 2015, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Establishment of the Stage A Enhanced Attenuation Area for 300-FF-5*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-300FF5-16-0087, 2016, *Determination of Vadose Zone Uranium Concentration Distribution Extents and Development of a Three-Dimensional Geologic Framework Model for the 300-FF-5 Operable Unit, Hanford, Washington*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-HANFORD-13-0029, 2015, *Development of the Hanford South Geologic Framework Model, Hanford Site Washington*, Rev. 2, CH2M HILL Plateau Remediation Company, Richland, Washington.

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*, U.S. Environmental Protection Agency and U.S. Department of Energy, Richland, Washington, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087180.

Fritz, Brad G. and Evan V. Arntzen, 2007, "Effect of Rapidly Changing River Stage on Uranium Flux through the Hyporheic Zone," *Ground Water* 45(6):753-760. Available at: http://info.ngwa.org/GWOL/pdf/072682493.pdf.

Kohler, M., G.P. Curtis, D.E. Meece, and J.A. Davis, 2004, "Methods for Estimating Adsorbed Uranium(VI) and Distribution Coefficients of Contaminated Sediments," *Environ. Sci. Technol*. 38(1):240-247. Available at: http://pubs.acs.org/doi/pdf/10.1021/es0341236.

Liu, Chongxuan, John M. Zachara, Nikolla P. Qafoku, and Zheming Wang, 2008, "Scale-dependent desorption of uranium from contaminated subsurface sediments," *Water Resources Research* 44:13 pp. Available at: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1304&context=usdoepub.

Lutz, J.F., R.A. Pinto, R. Garcia-Lagos, and H.G. Hilton, 1966, "Effect of Phosphorus on Some Physical Properties of Soils: II. Water Retention," *Soil Sci. Soc. Amer. Proc*. 30(4):433-437.

Ma, R., C. Zheng, H. Prommer, J. Greskowiak, C. Liu, J. Zachara, and M. Rockhold, 2010, "A field-scale reactive transport model for U(VI) migration influenced by coupled multirate mass transfer and surface complexation reactions," *Water Resources Research* 46(5):1-17

Mehta, V. S., F. Maillot, Z. Wang, J.G. Catalano, and D.E. Giammar, 2016, "Effect of Reaction Pathway on the Extent and Mechanism of Uranium(VI) Immobilization with Calcium and Phosphate," *Environmental Science & Technology* 50:3128-3136.

Mualem, Yechezkel, 1976, "A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media," *Water Resources Research* 12(3):513-522. Available at: https://hwbdocuments.env.nm.gov/Los%20Alamos%20National%20Labs/TA%2054/11570.pdf.

NUREG/CR-6940, 2007, *Combined Estimation of Hydrogeologic Conceptual Model, Parameter, and Scenario Uncertainty with Application to Uranium Transport at the Hanford Site 300 Area*, PNNL-16396, U.S. Nuclear Regulatory Commission, Washington, D.C. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16396.pdf.

PNL-6716, 1988, *Interim Characterization Report for the 300 Area Process Trenches*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/servlets/purl/6676561-CQApoo/.

PNL-10285, 1995, *Estimated Recharge Rates at the Hanford Site*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/10122247.

PNNL-11216, 1997, *STOMP Subsurface Transport Over Multiple Phases Application Guide*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://stomp.pnl.gov/documentation/application.pdf.

PNNL-12030, 2000, *STOMP Subsurface Transport Over Multiple Phases Version 2.0 Theory Guide*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://stomp.pnl.gov/documentation/theory.pdf.

PNNL-14022, 2002, *300 Area Uranium Leach and Absorption Project*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14022.pdf.

PNNL-14702, 2006, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf

PNNL-15782, 2006, *STOMP Subsurface Transport Over Multiple Phases Version 4.0 User's Guide*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://stomp.pnl.gov/documentation/userguide.pdf.

PNNL-17708, 2008, *Three-Dimensional Groundwater Models of the 300 Area at the Hanford Site, Washington State*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17708.pdf.

PNNL-17818, 2008, *300 Area Treatability Test: Laboratory Development of Polyphosphate Remediation Technology for In Situ Treatment of Uranium Contamination in the Vadose Zone and Capillary Fringe*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17818.pdf.

PNNL-18303, 2009, *Sequestration of Sr-90 Subsurface Contamination in the Hanford 100-N Area by Surface Infiltration of a Ca-Citrate-Phosphate Solution*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18303.pdf.

PNNL-18564, 2009, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses: Fiscal Year 2008 Status Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18564.pdf.

PNNL-20004, 2010, *Remediation of Uranium in the Hanford Vadose Zone Using Ammonia Gas: FY 2010 Laboratory-Scale Experiments*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20004.pdf.

PNNL-21733, 2012, *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21733.pdf.

PNNL-22048, 2012, *Updated Conceptual Model for the 300 Area Uranium Groundwater Plume*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22048.pdf.

PNNL-22886, 2013, *System-Scale Model of Aquifer, Vadose Zone, and River Interactions for the Hanford 300 Area –Application to Uranium Reactive Transport*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22886.pdf.

PNNL-24911, 2015, *Analytical Data Report for Sediment Samples Collected From 300-FF-5 OU, Wells C8940 and C9451*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-25420, 2016, *Analytical Data Report for Sediment Samples Collected from 300-FF-5: Boreholes C9580, C9581, and C9582*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-SA-25232, 2016, *Stage A Uranium Sequestration Amendment Delivery Monitoring Using Time-Lapse Electrical Resistivity Tomography*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-SA-58541, 2007, *Uranium(VI) Release from Contaminated Vadose Zone Sediments: Estimation of Potential Contributions from Dissolution and Desorption*, U.S. Geological Survey, Menlo Park, California and Pacific Northwest National Laboratory, Richland, Washington. Available at: http://ifchanford.pnnl.gov/pdfs/bond_zachara_58541.pdf.

SGW-58830, 2015, *300-FF-5 Supplemental Post-ROD Field Investigation Summary*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079681H.

SGW-58976, 2015, *Field Instructions for Uranium Sequestration in the 300 Area*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078185H.

SGW-59455, 2016, *300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0077730H.

Shi, Z., C. Liu, J. M. Zachara, Z. Wang, and B. Deng, 2009, “Inhibition Effect of Secondary Phosphate Mineral Precipitation on Uranium Release from Contaminated Sediments,” *Environmental Science & Technology* 43:8344-8349.

Sumner, M.E., 2000, “Soil Fertility and Plant Nutrition,” *Handbook of Soil Science*, CRC Press, Boca Raton, Florida.

van Genuchten, M.Th., 1980, “A Closed-form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils,” *Soil Sci. Soc. Am. J.* 44(5):892-898. Available at: http://people.ucalgary.ca/~hayashi/glgy607/reading/van_Genuchten1980.pdf.

Wellman, Dawn M., Eric M. Pierce, and Michelle M. Valenta, 2007, “Efficacy of soluble sodium tripolyphosphate amendments for the in-situ immobilisation of uranium,” *Environ. Chem.* 4(5):293-300.

WHC-SD-EN-TI-052, 1992, *Phase I Hydrogeologic Summary of the 300-FF-5 Operable Unit, 300 Area*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196121502.

Xu, Moujin and Yoram Eckstein, 1995, "Use of Weighted Least-Squares Method in Evaluation of the Relationship Between Dispersivity and Field Scale," *Ground Water* 33(6):905-908. Available at: http://info.ngwa.org/gwol/pdf/952964066.PDF.

Yabusaki, Steven B., Yilin Fang, and Scott R. Waichler, 2008, "Building conceptual models of field-scale uranium reactive transport in a dynamic vadose zone-aquifer-river system," *Water Resources Research* 44(12):24 pp. Available at: http://onlinelibrary.wiley.com/doi/10.1029/2007WR006617/pdf.

This page intentionally left blank.

Appendix A

Presentation of Sampling Data for Selected Wells

This page intentionally left blank.

Terms

EAA	Enhanced Attenuation Area
PRZ	periodically rewetted zone

This page intentionally left blank.

A1 Presentation of Sampling Data for Selected Wells

In this appendix, several indicators are examined to provide information about how dissolved uranium concentrations have been affected by phosphate injection and infiltration. The following results are presented for selected well pairs:

- Phosphate to bicarbonate molar ratio compared to pH
- Concentration of uranium compared to the concentration of calcium
- Concentration of uranium compared to the concentration of phosphate
- Concentration of calcium compared to the concentration of phosphate
- Calcium/sodium ratio in milliequivalents per liter compared to pH

These comparisons are examined at three pairs of wells (399-1-65 and 399-1-67; 399-1-74 and 399-1-75; and 399-1-80 and 399-1-81); each pair consists of a well screened in the periodically rewetted zone (PRZ) and a well screened in the aquifer (Figure A-1). Two wells that are not part of a vadose zone/aquifer pairing but are just in the aquifer are also considered. The unpaired wells (399-1-23 and 399-1-17A) are located outside the Stage A Enhanced Attenuation Area (EAA) (see Chapter 6 [Figure 6-12a] in the main text of this calculation for location).

Most wells were measured once, at the beginning of September, but these samples have been omitted for ease of viewing. However, they do offer some insight into the background values. The data from these wells show that for all the sites, the background ratio of PO_4:HCO_3 is fairly low—typically on the order of ~0.001. At the time sampling of these wells ceased (after treatment), all of the wells had much higher PO_4:HCO_3 values, even if the values were declining.

A1.1 Phosphate to Bicarbonate Ratio Compared to pH

Figures A-2 through A-5 show a comparison of the phosphate to bicarbonate ratio to pH. The higher the ratio, the more phosphate there is relative to bicarbonate in the PRZ and groundwater. The greater the ratio of phosphate to bicarbonate, conditions for uranium bonding to phosphate are more favorable.

A1.2 Uranium Concentration Compared to Calcium Concentration

Figures A-6 through A-8 show a comparison of the uranium concentrations against the calcium concentrations for selected wells. The calcium concentrations in the PRZ wells show an increase as the uranium is being released indicating simultaneous ion exchange reactions. This indicates that favorable conditions are being created for reaction of calcium with incoming phosphate.

A1.3 Uranium Concentration Compared to Phosphate Concentration

Figures A-10 through A-13 show the concentrations of uranium and phosphate for the selected wells. Uranium breakthrough resulting from infiltration occurs earlier while phosphate concentrations remain low throughout that period. Phosphate concentrations increase following injections in the PRZ and aquifer. In the aquifer wells located outside the Stage A EAA (Figure A-13), the uranium concentrations show a steep drop, followed by a slow rebound which ends at a lower concentration than it began. The decline in uranium concentrations correspond with the increasing phosphate concentrations. Well 1-23 is missing the preinjection baseline data, but Well 1-17A starts out with a fairly high baseline uranium value before the rapid dropoff and gradual rebound. The phosphate data show a definite peak during uranium's lowest point.

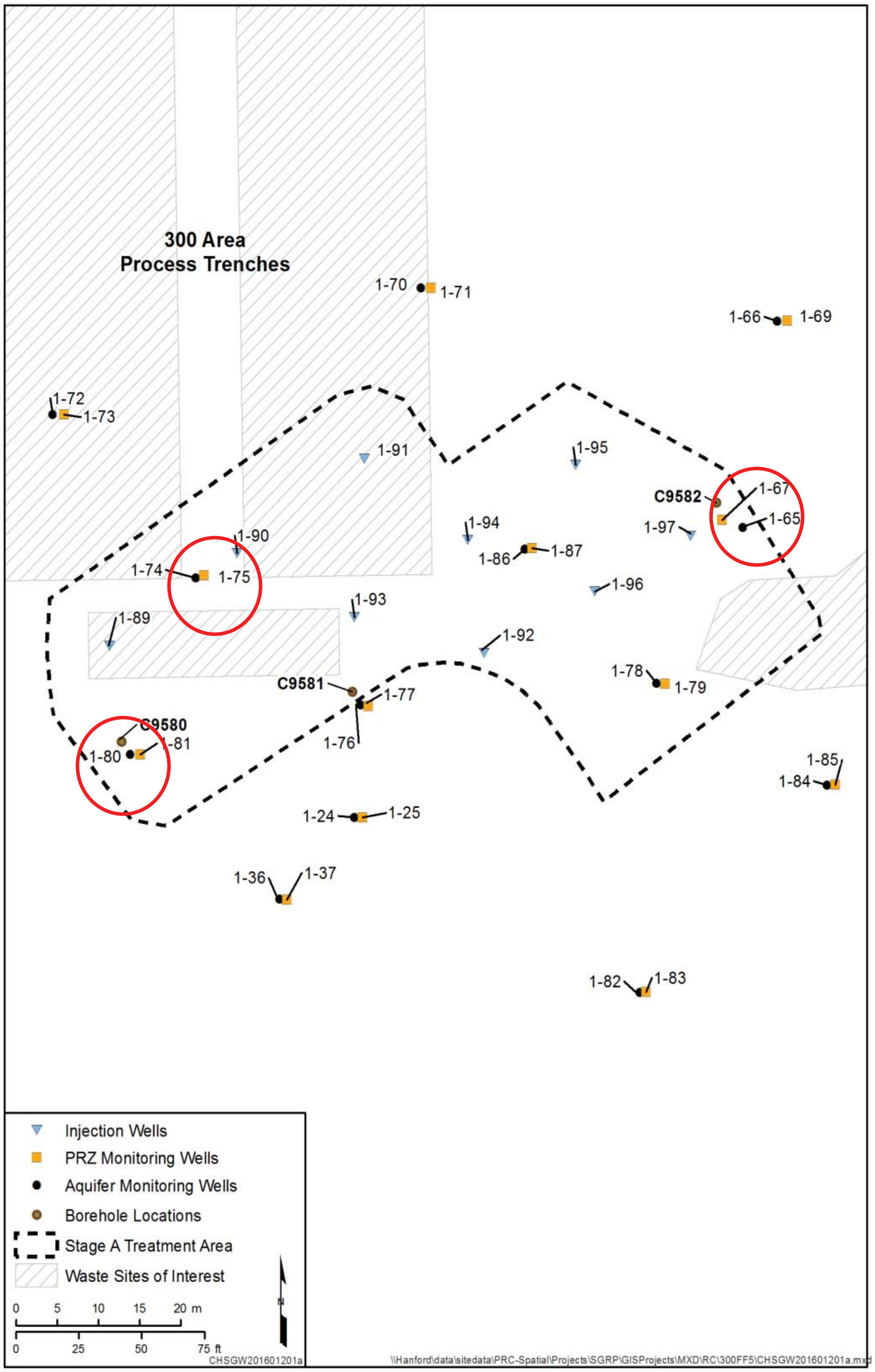
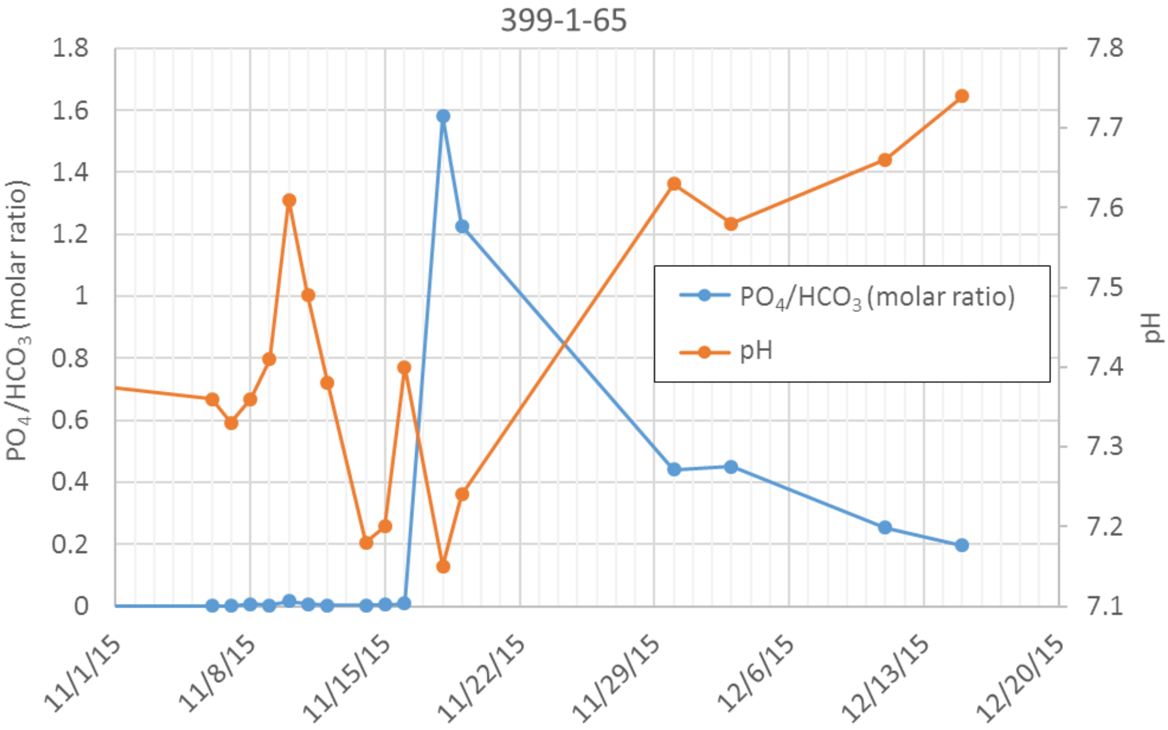


Figure A-1. Locations of Paired Vadose Zone Wells (PRZ Monitoring Wells) and Aquifer Monitoring Wells



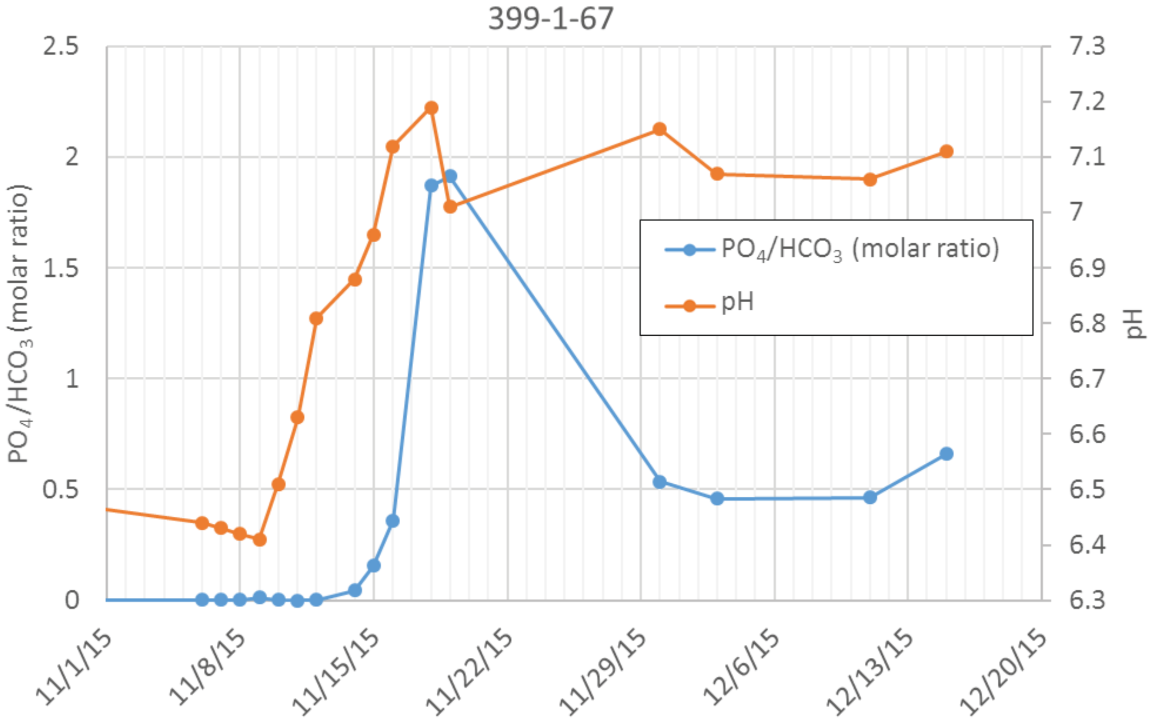


Figure A-2. Comparison of Phosphate to Bicarbonate Ratios to pH for Wells 399-1-65 and 399-1-67

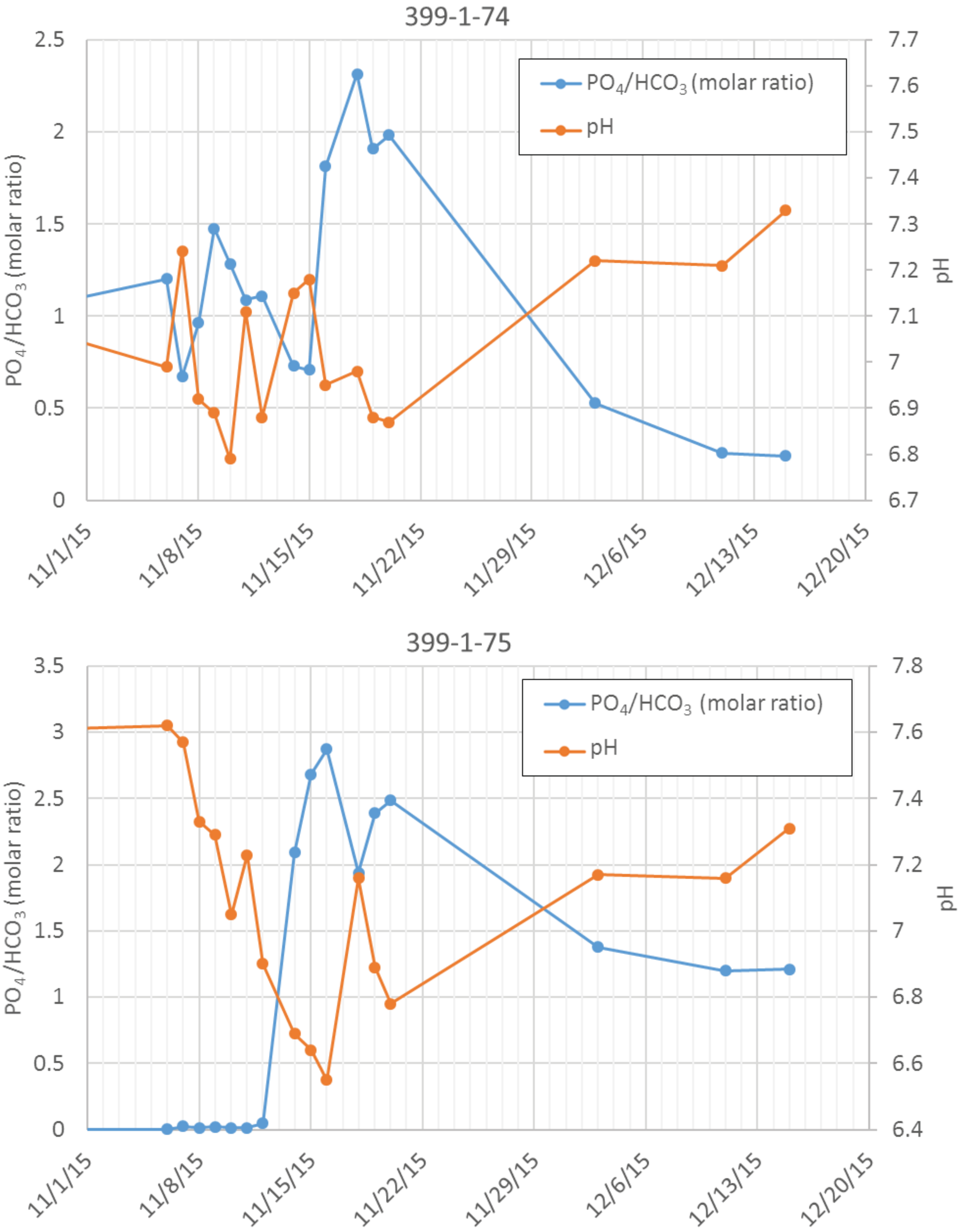
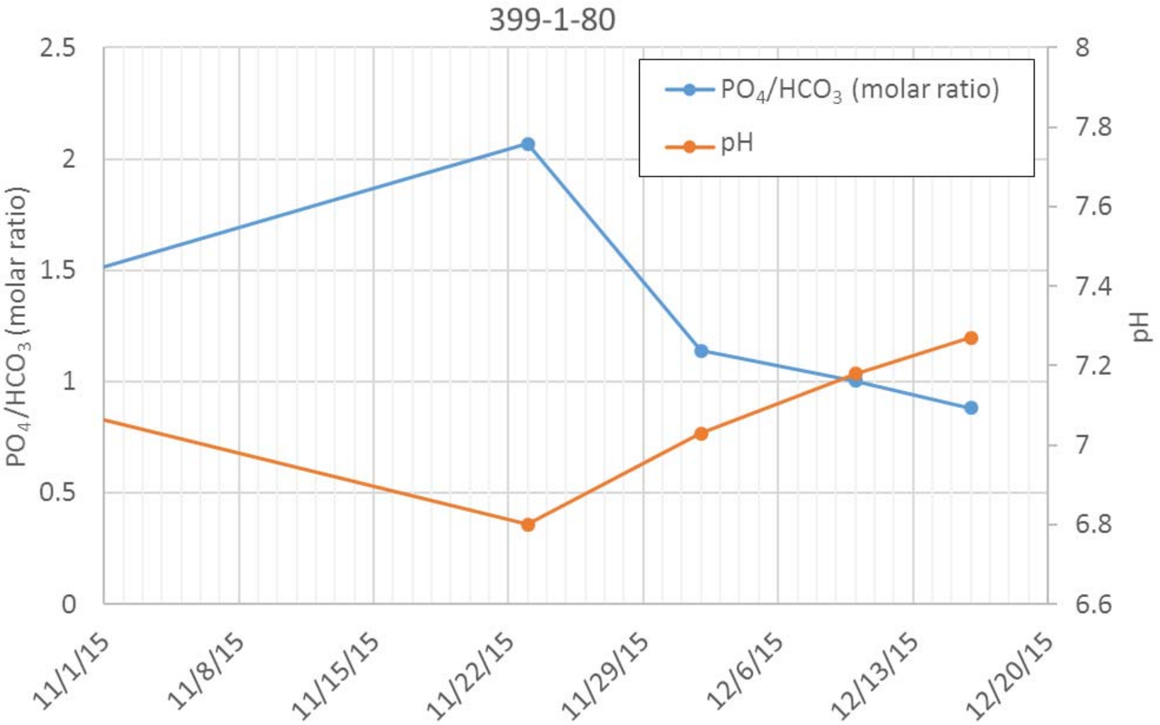


Figure A-3. Comparison of Phosphate to Bicarbonate Ratios to pH for Wells 399-1-74 and 399-1-75



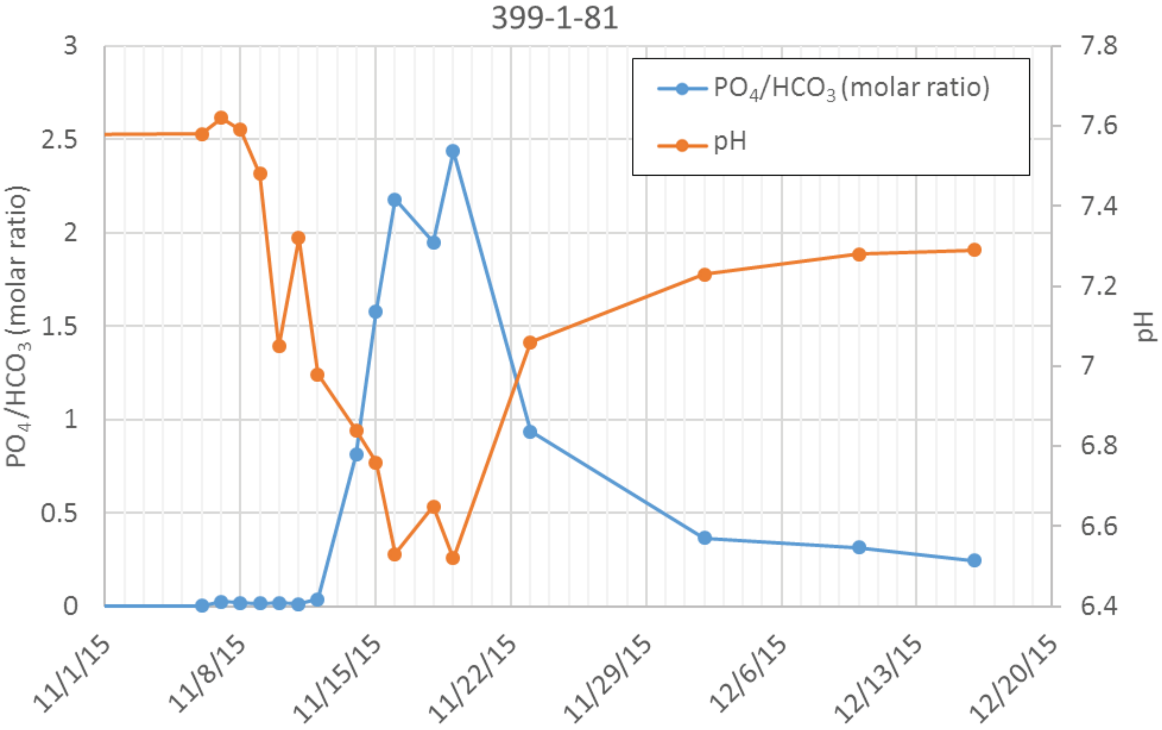
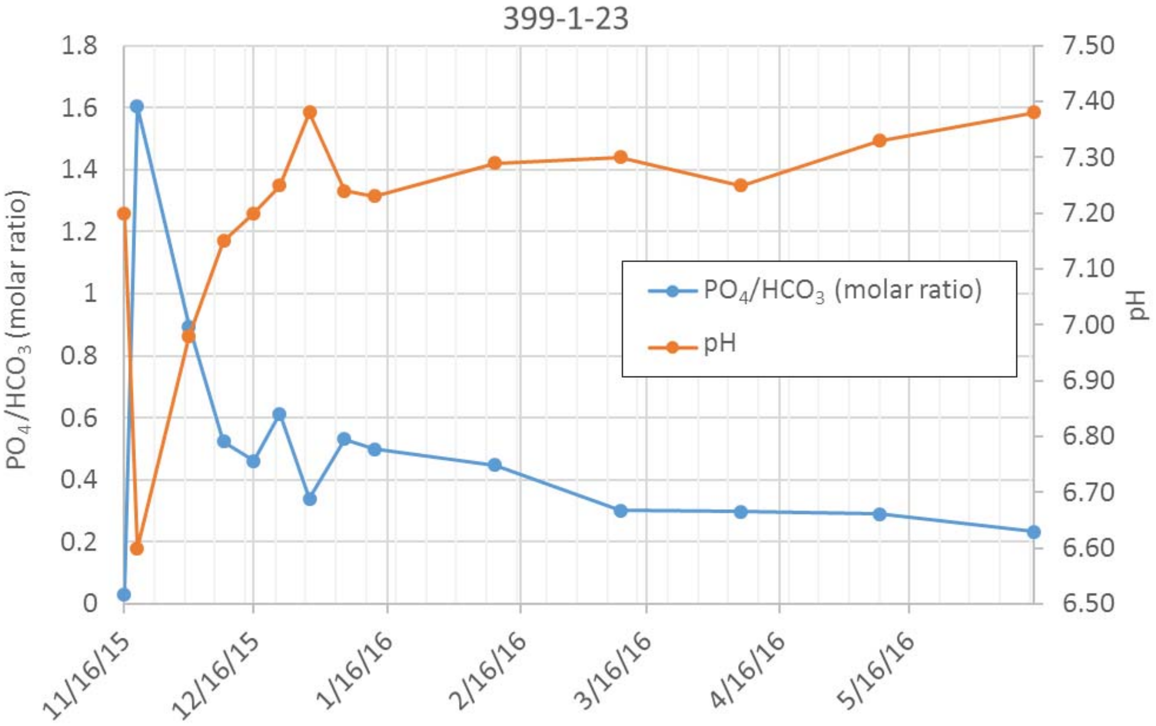


Figure A-4. Comparison of Phosphate to Bicarbonate Ratios to pH for Wells 399-1-80 and 399-1-81



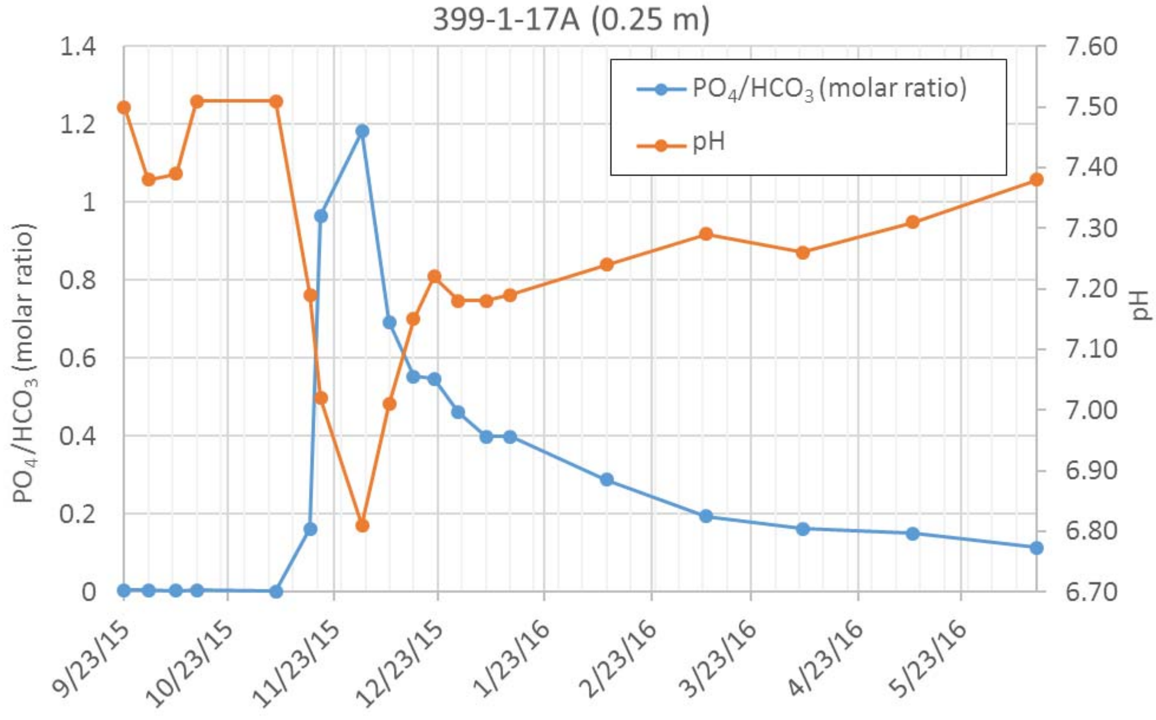
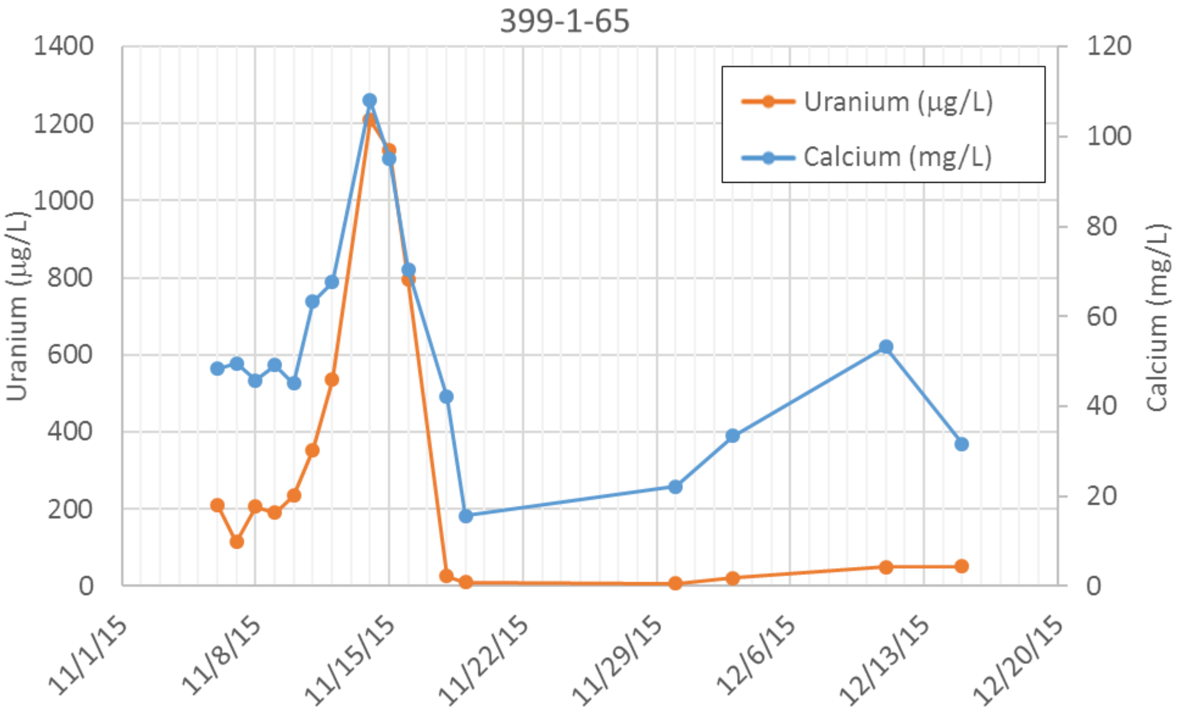


Figure A-5. Comparison of Phosphate to Bicarbonate Ratios to pH for Wells 399-1-23 and 399-1-17A



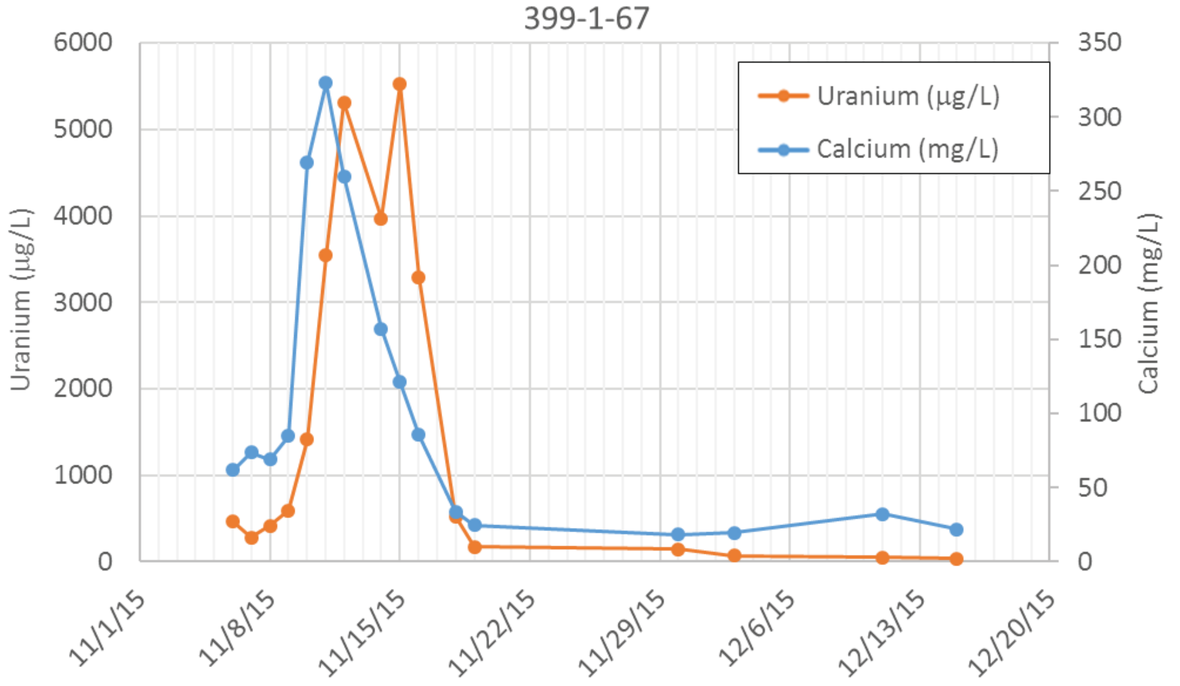
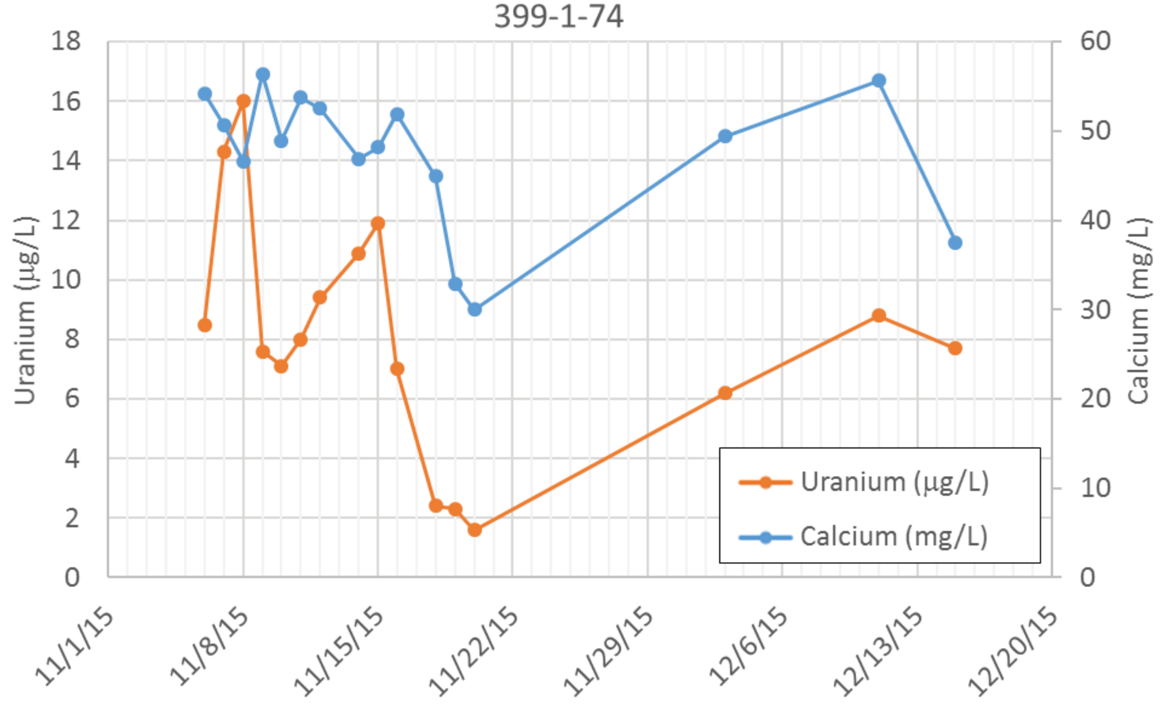


Figure A-6. Comparison of Uranium to Calcium Concentrations for Wells 399-1-65 and 399-1-67



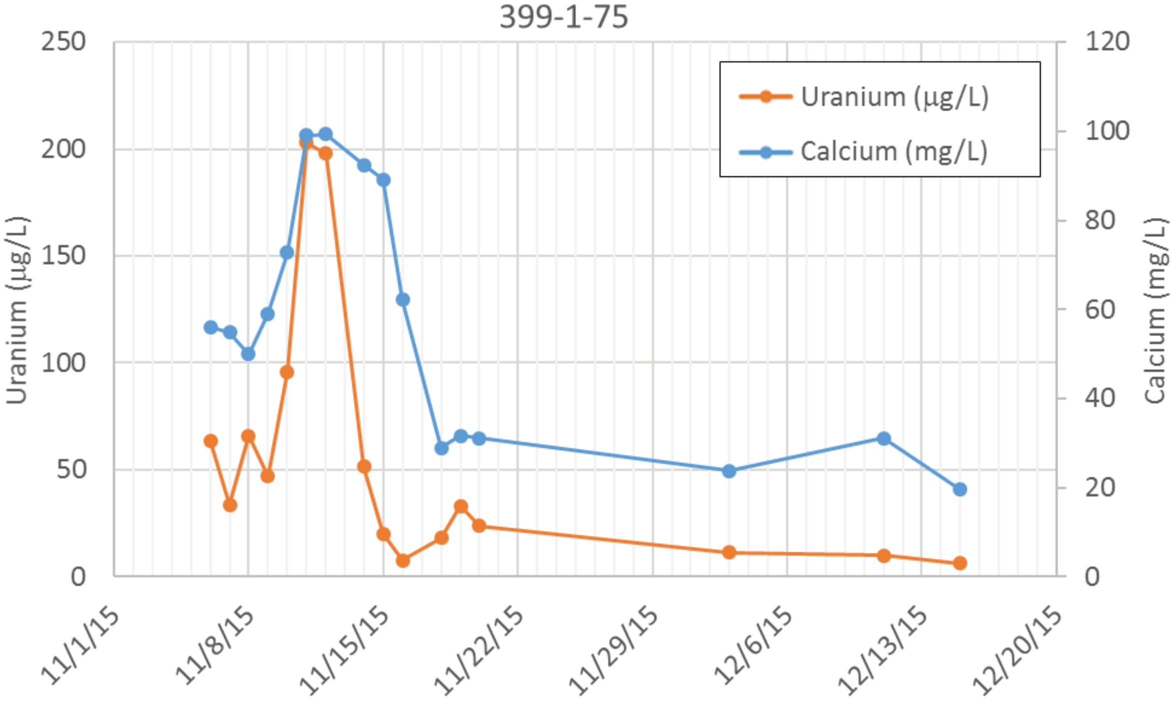


Figure A-7. Comparison of Uranium to Calcium Concentrations for Wells 399-1-74 and 399-1-75

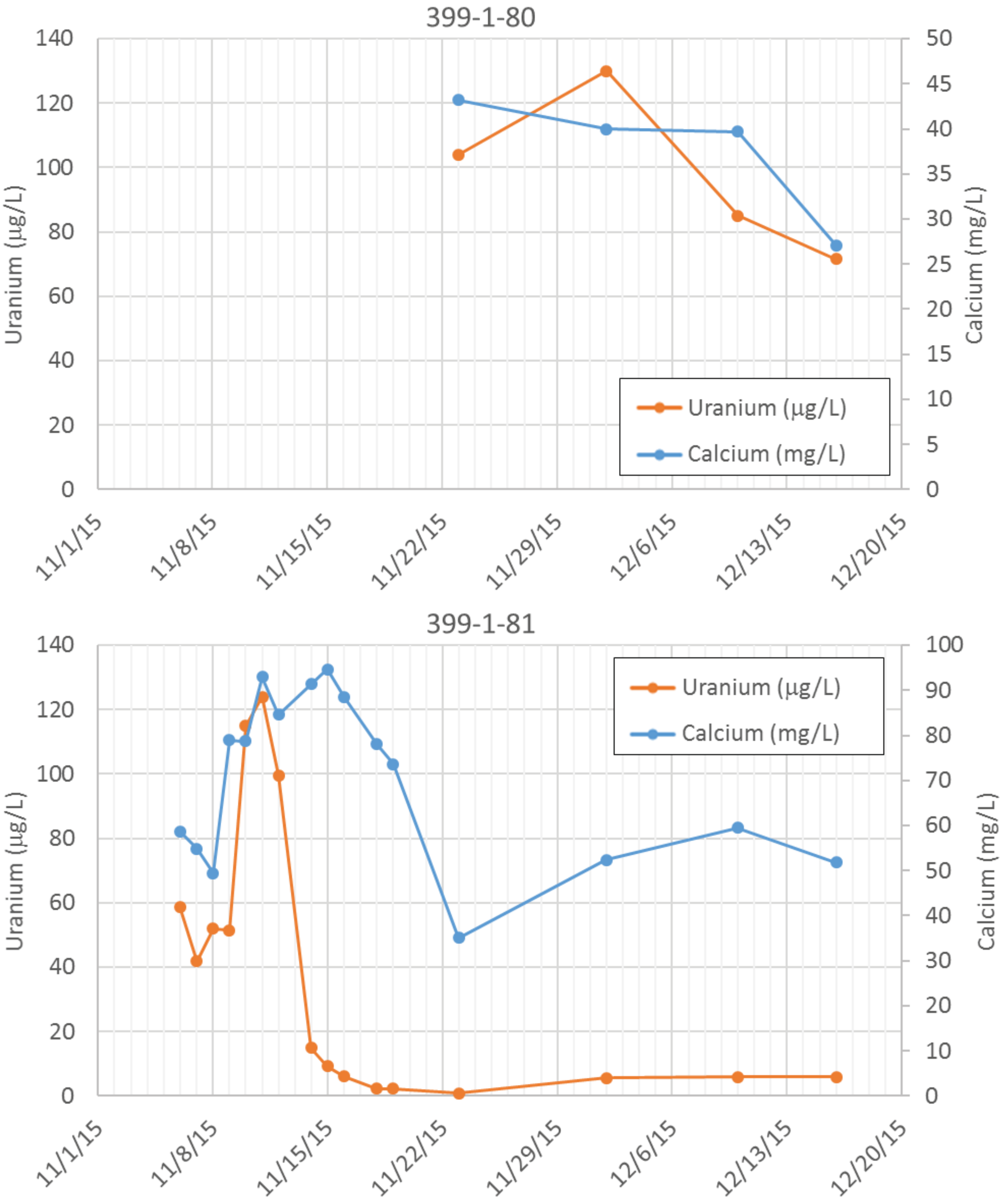
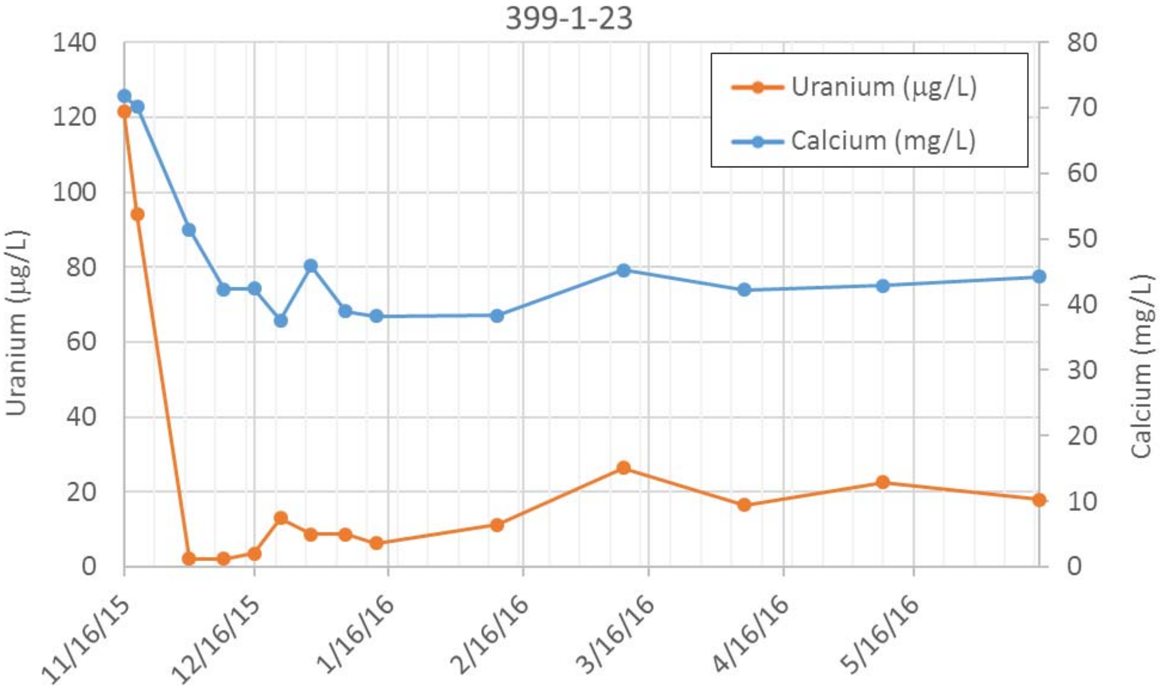


Figure A-8. Comparison of Uranium to Calcium Concentrations for Wells 399-1-80 and 399-1-81



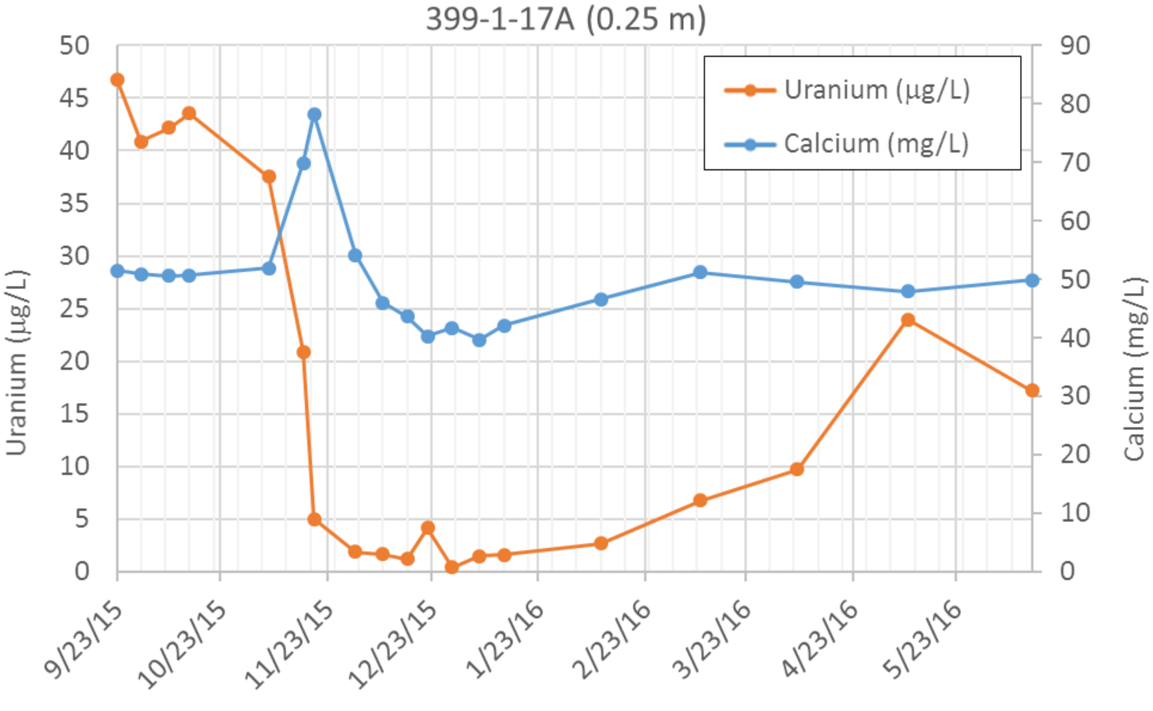
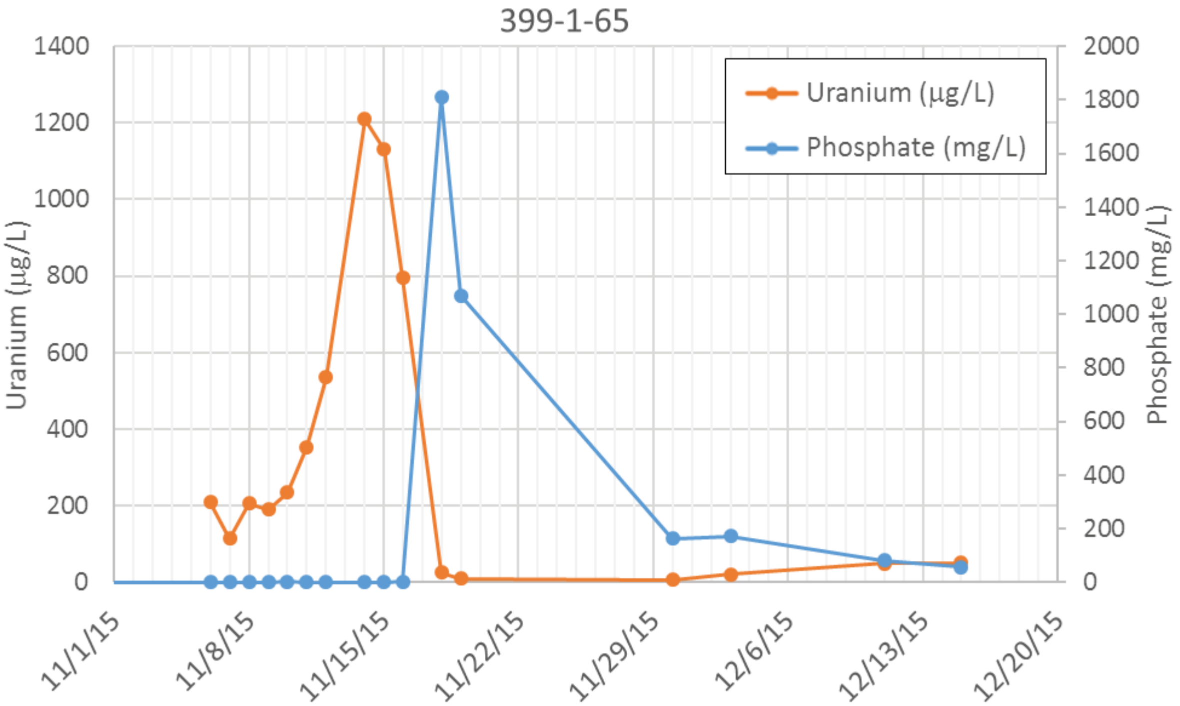


Figure A-9. Comparison of Uranium to Calcium Concentrations for Wells 399-1-23 and 399-1-17A



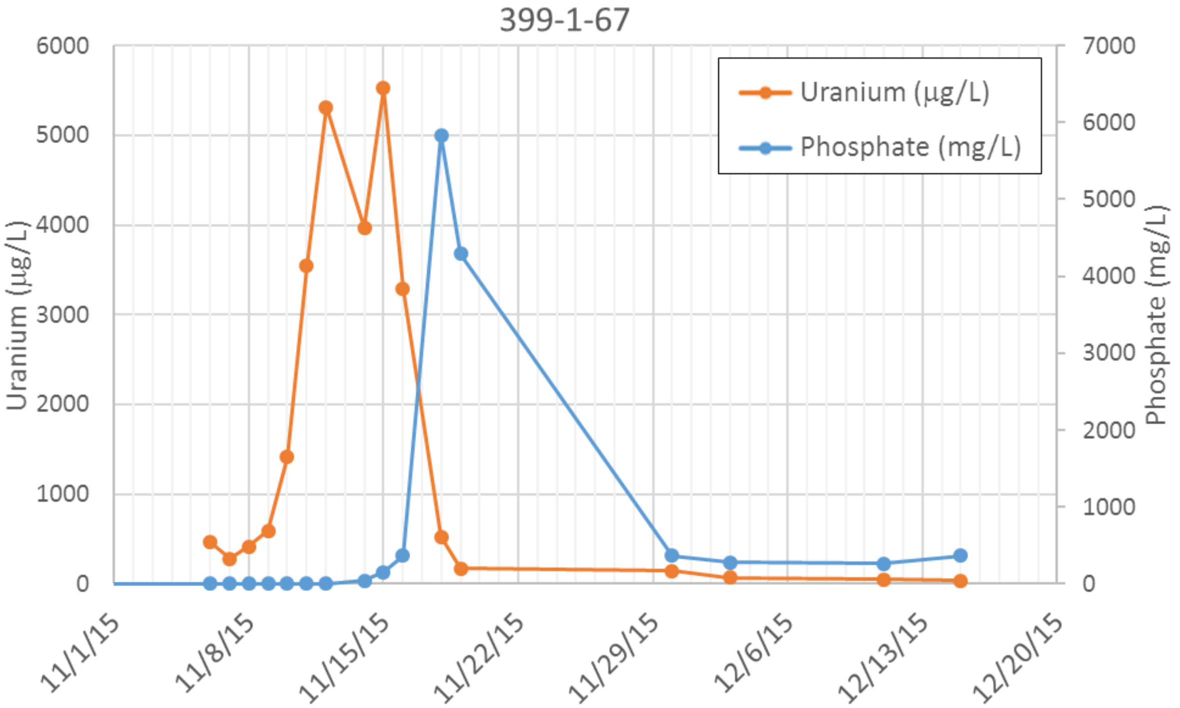
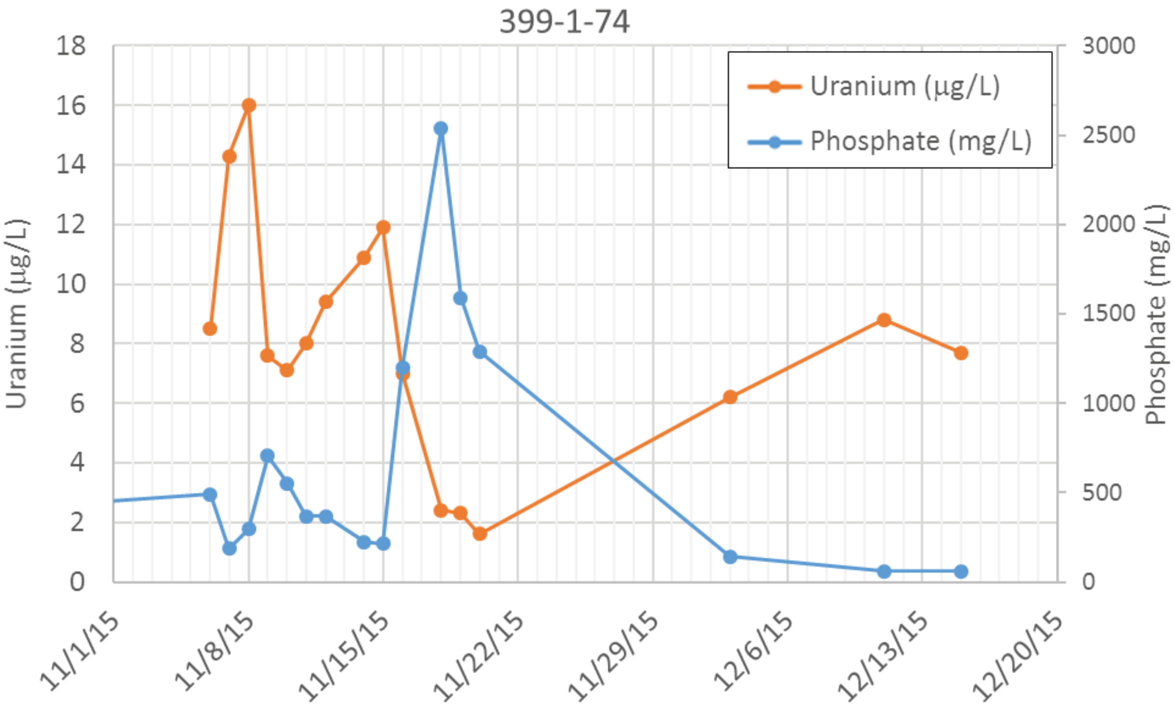


Figure A-10. Comparison of Uranium to Phosphate Concentrations for Wells 399-1-65 and 399-1-67



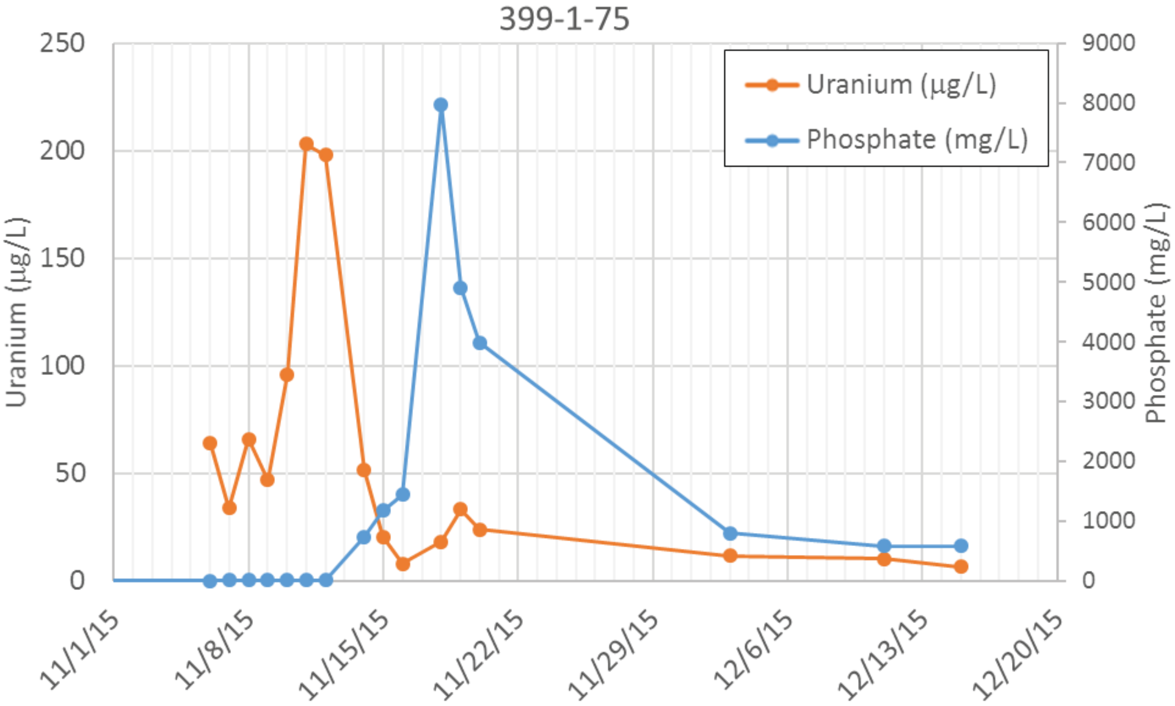
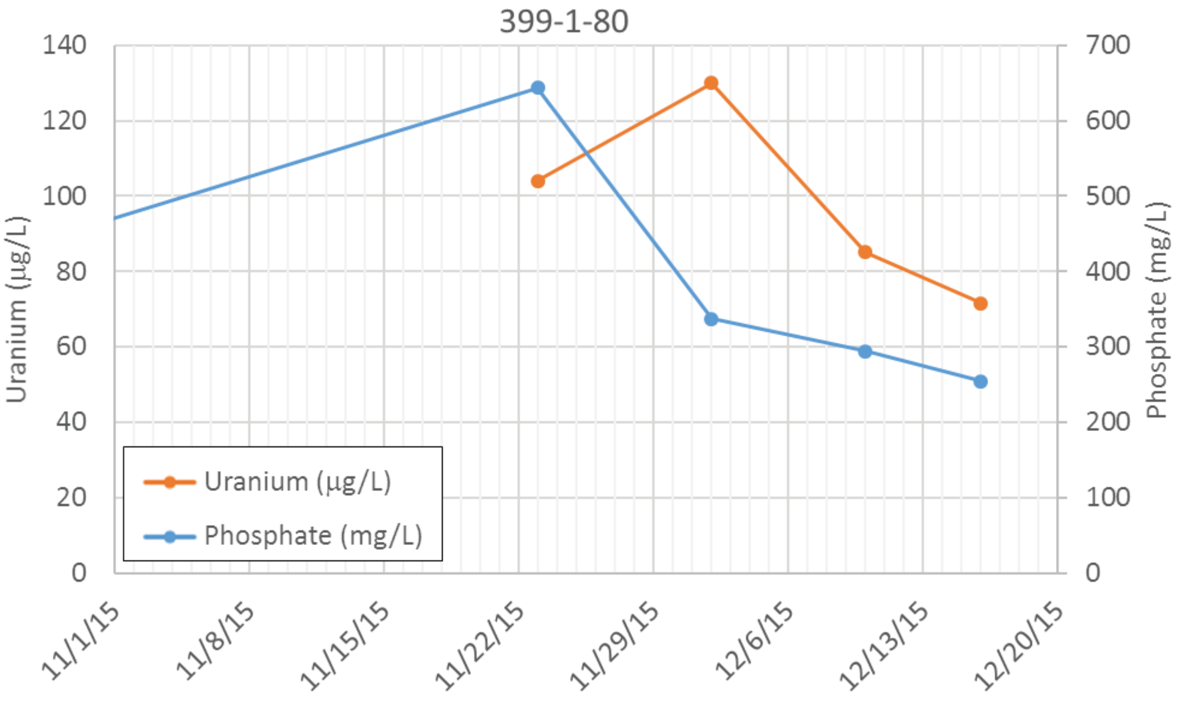


Figure A-11. Comparison of Uranium to Phosphate Concentrations for Wells 399-1-74 and 399-1-75



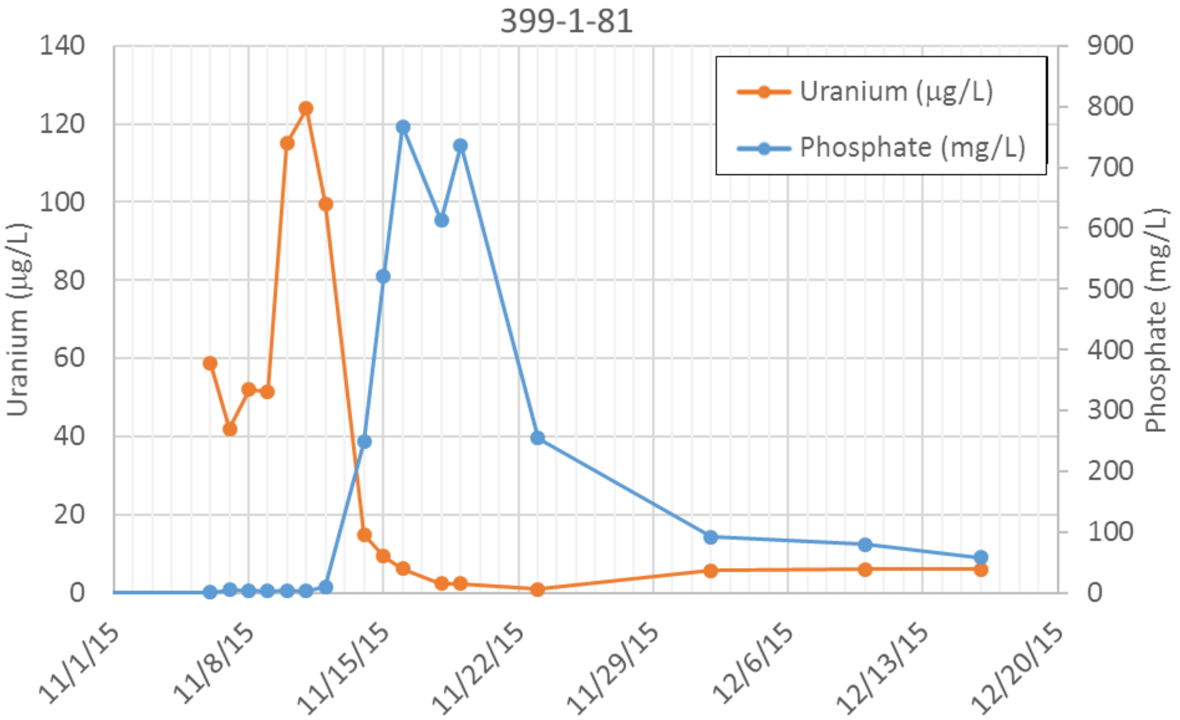
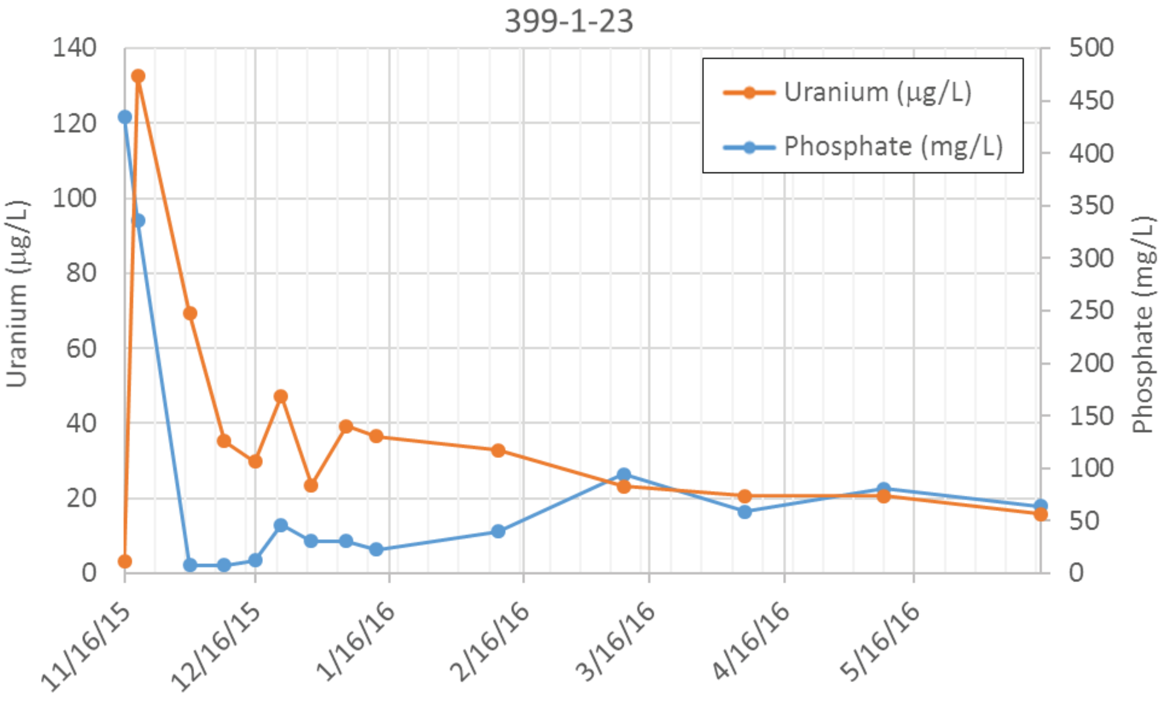


Figure A-12. Comparison of Uranium to Phosphate Concentrations for Wells 399-1-80 and 399-1-81



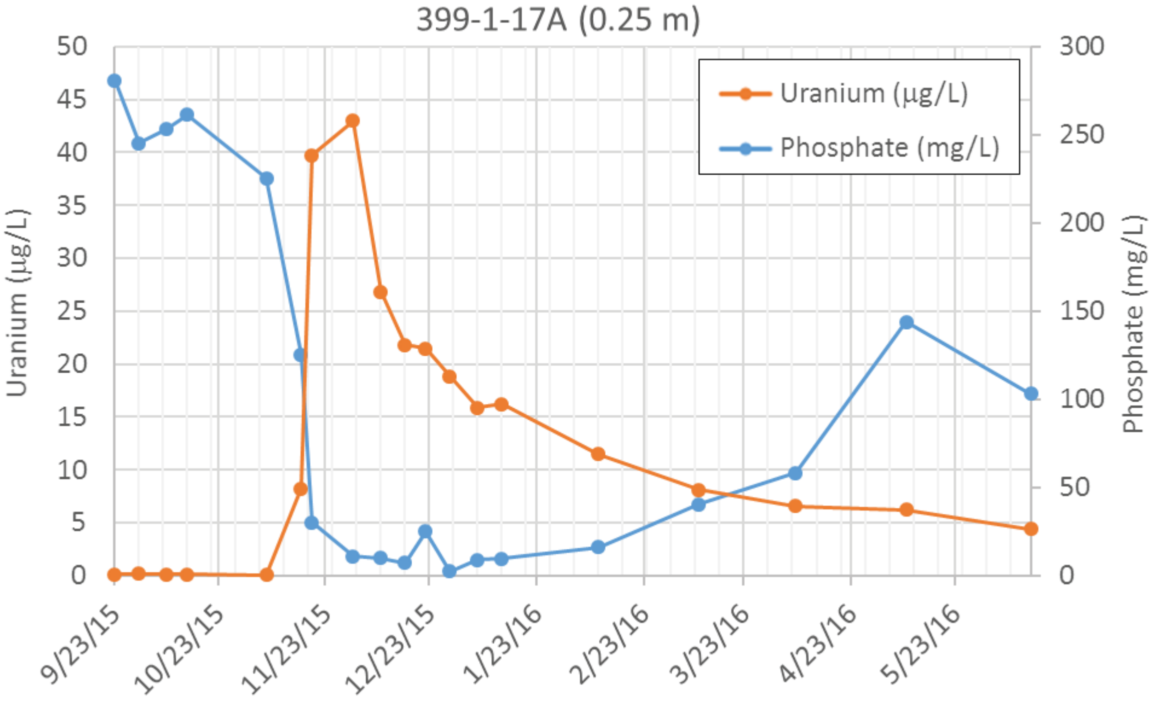


Figure A-13. Comparison of Uranium to Phosphate Concentrations for Wells 399-1-23 and 399-1-17A

A1.4 Calcium Concentration Compared to Phosphate Concentration

Figures A-14 through A-17 show the observed concentrations of calcium and phosphate for the selected wells. Since the goal of the injections/infiltration is to form calcium-uranium-phosphate complex, these results show that calcium was being made available in situ while phosphate was being infiltrated or injected.

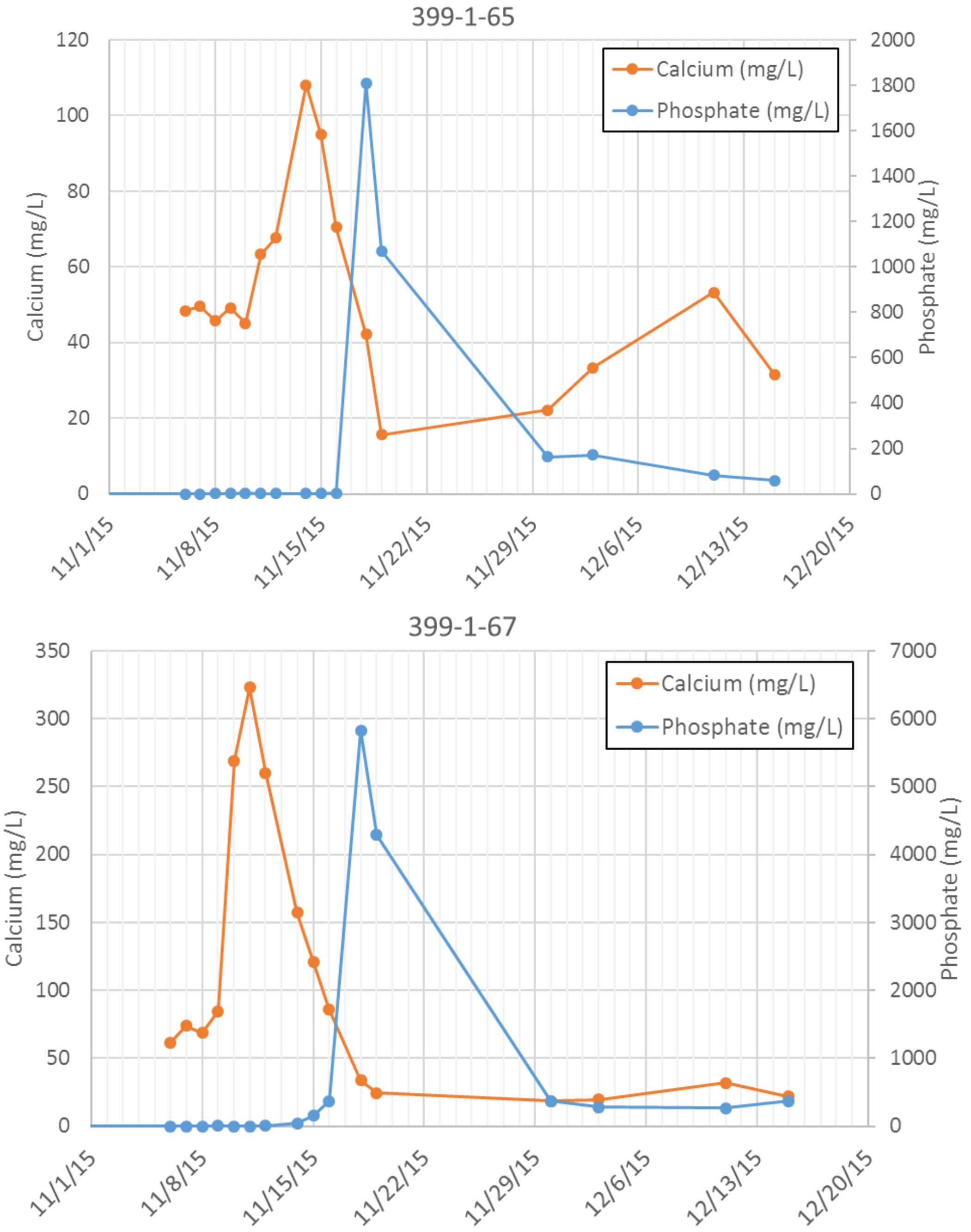
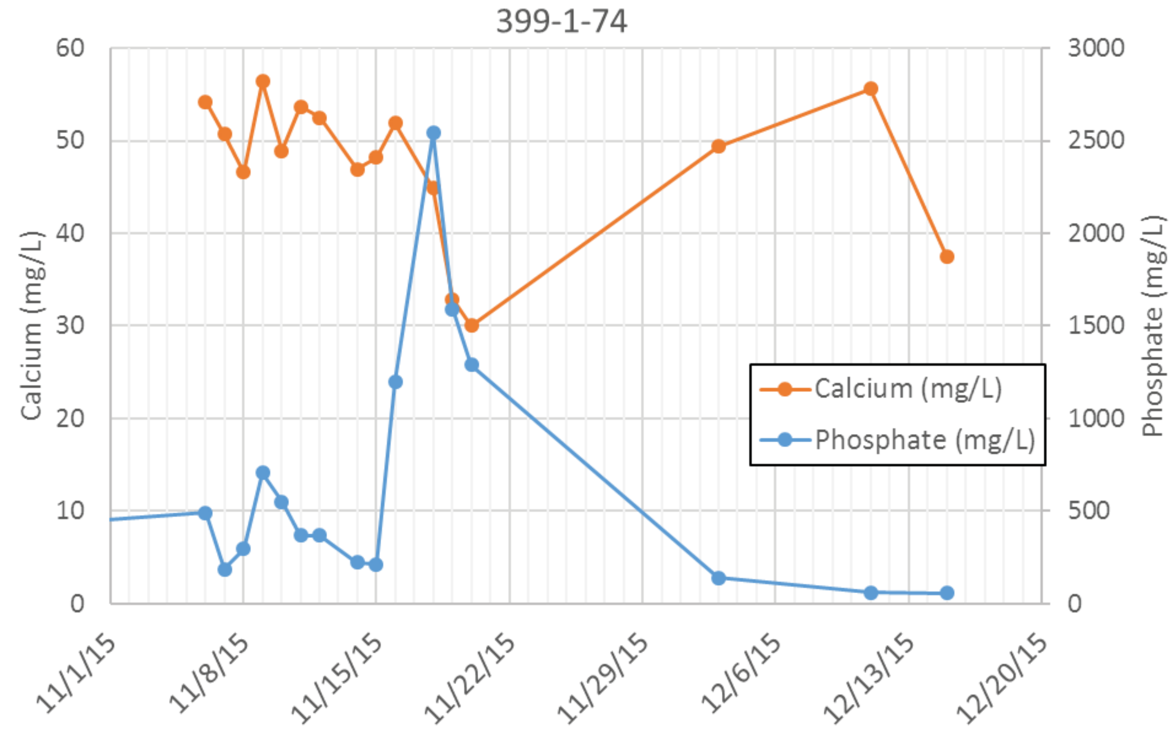


Figure A-14. Comparison of Calcium to Phosphate Concentrations for Wells 399-1-65 and 399-1-67

]



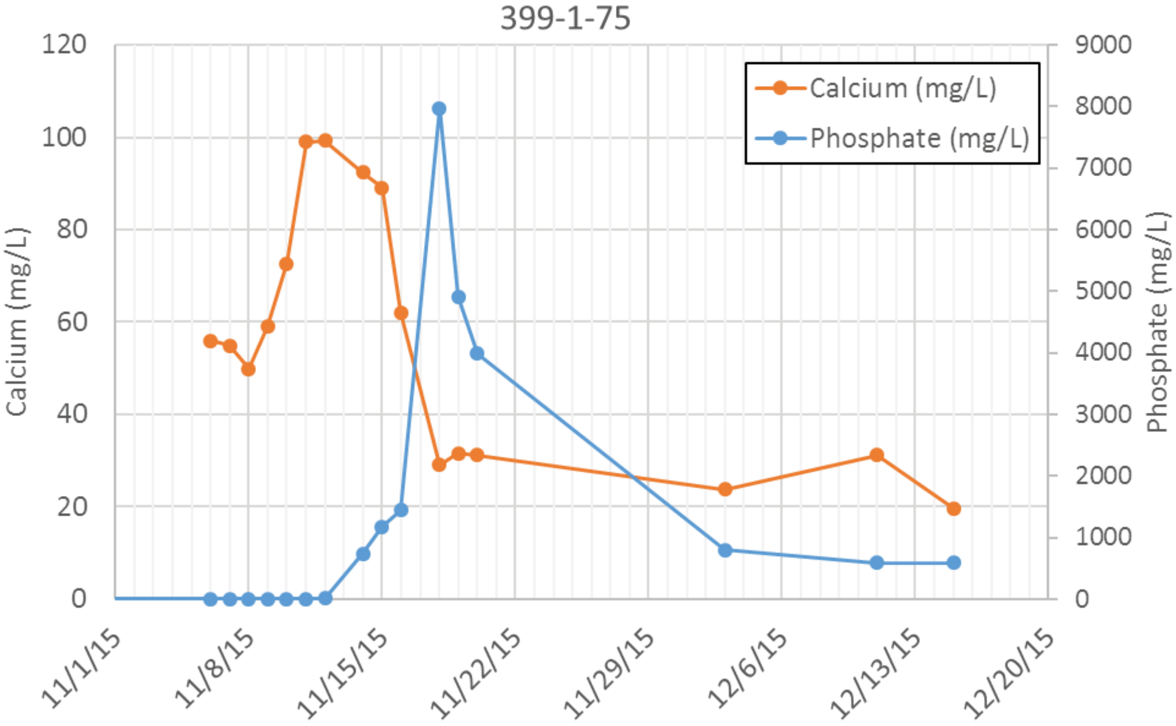
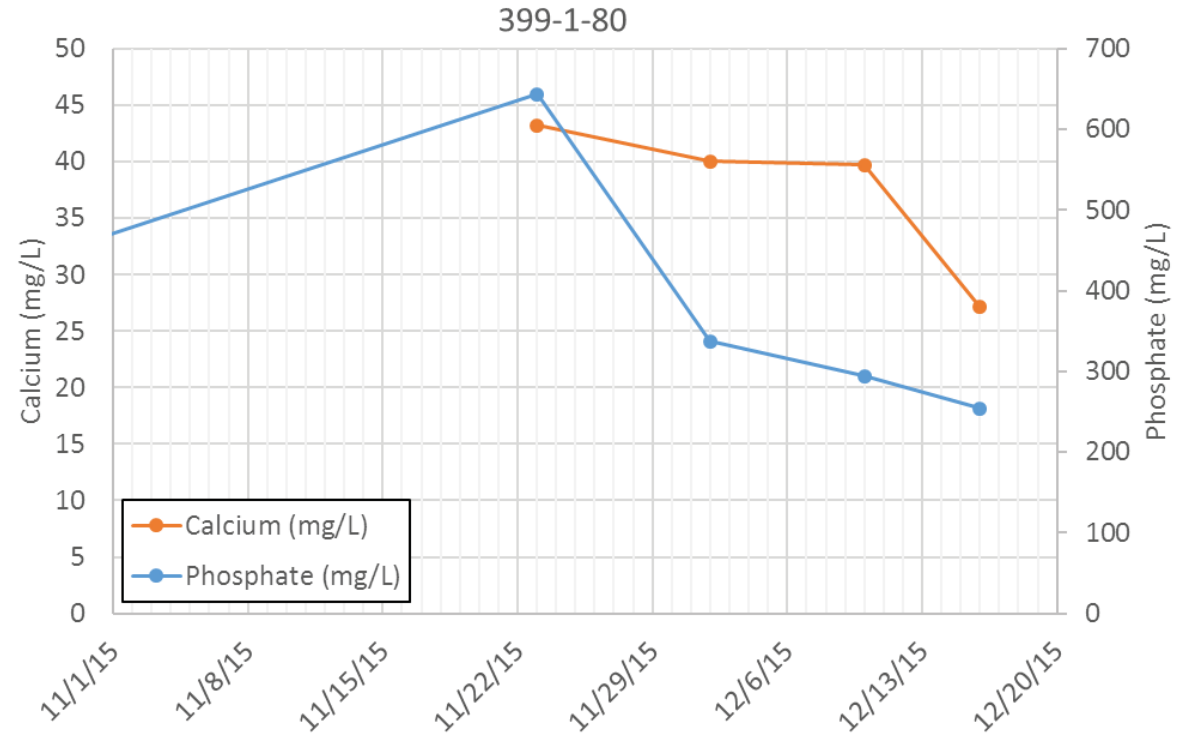


Figure A-15. Comparison of Calcium to Phosphate Concentrations for Wells 399-1-74 and 399-1-75



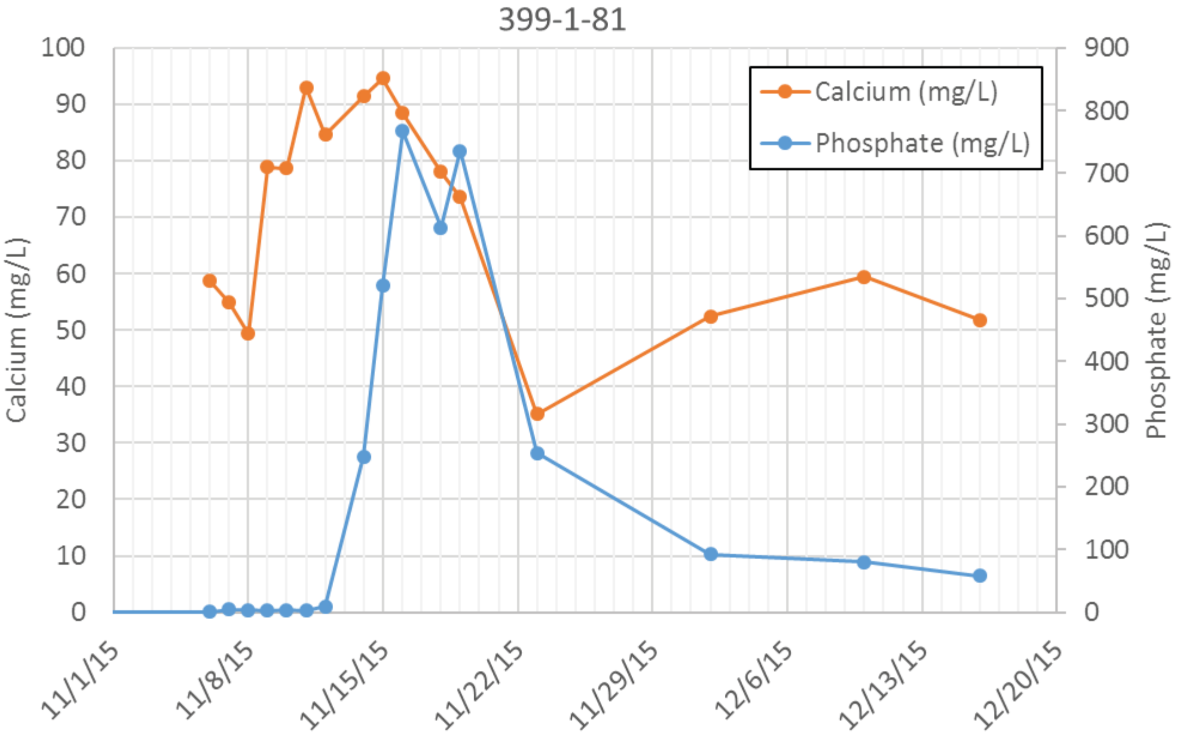
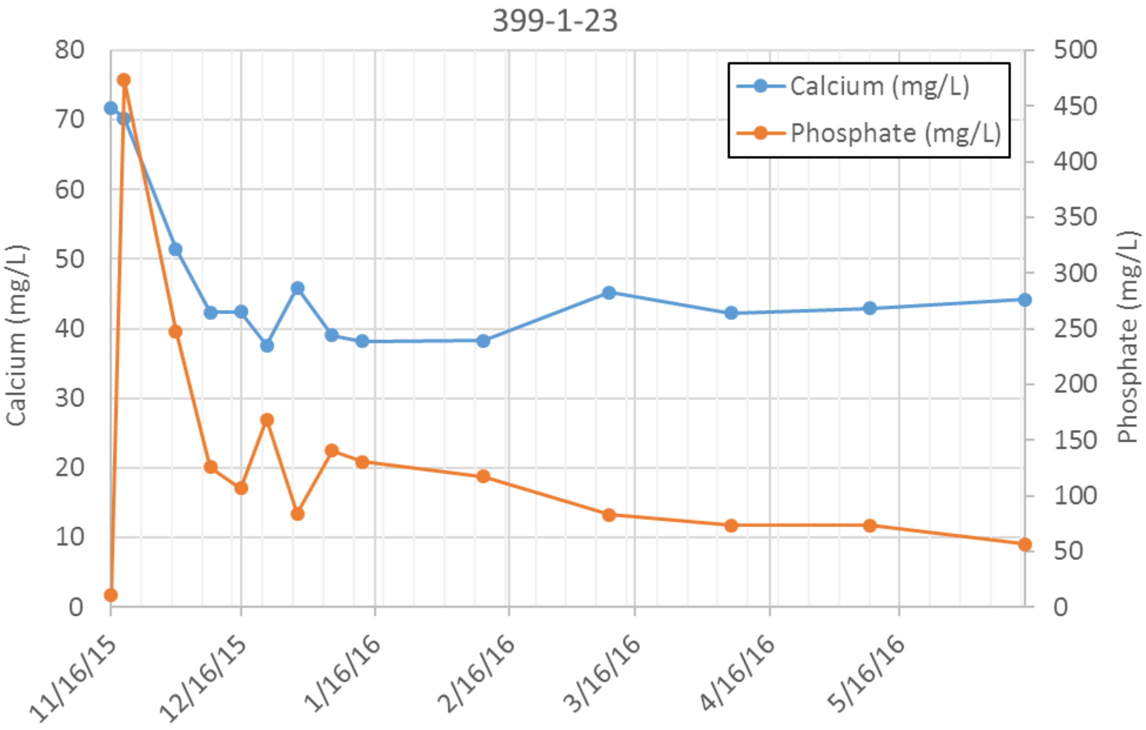


Figure A-16. Comparison of Calcium to Phosphate Concentrations for Wells 399-1-80 and 399-1-81



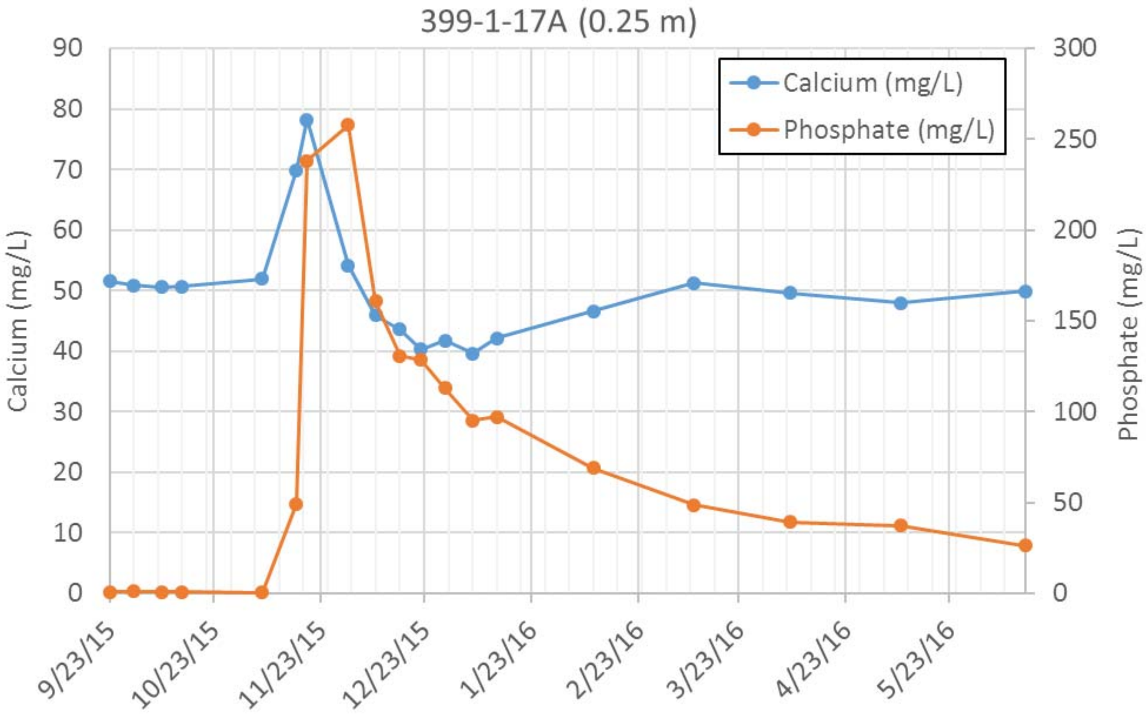


Figure A-17. Comparison of Calcium to Phosphate Concentrations for Wells 399-1-23 and 399-1-17A

A1.5 Calcium to Sodium Ratio Compared to pH

Figures A-18 through A-21 illustrate the Ca:Na ratio (in milliequivalents per liter) along with pH. The Ca:Na ratio changes as the Na rich solutions are infiltrated or injected. Because of concurrent geochemical reactions, pH declines first then gradually increases to pretreatment levels.

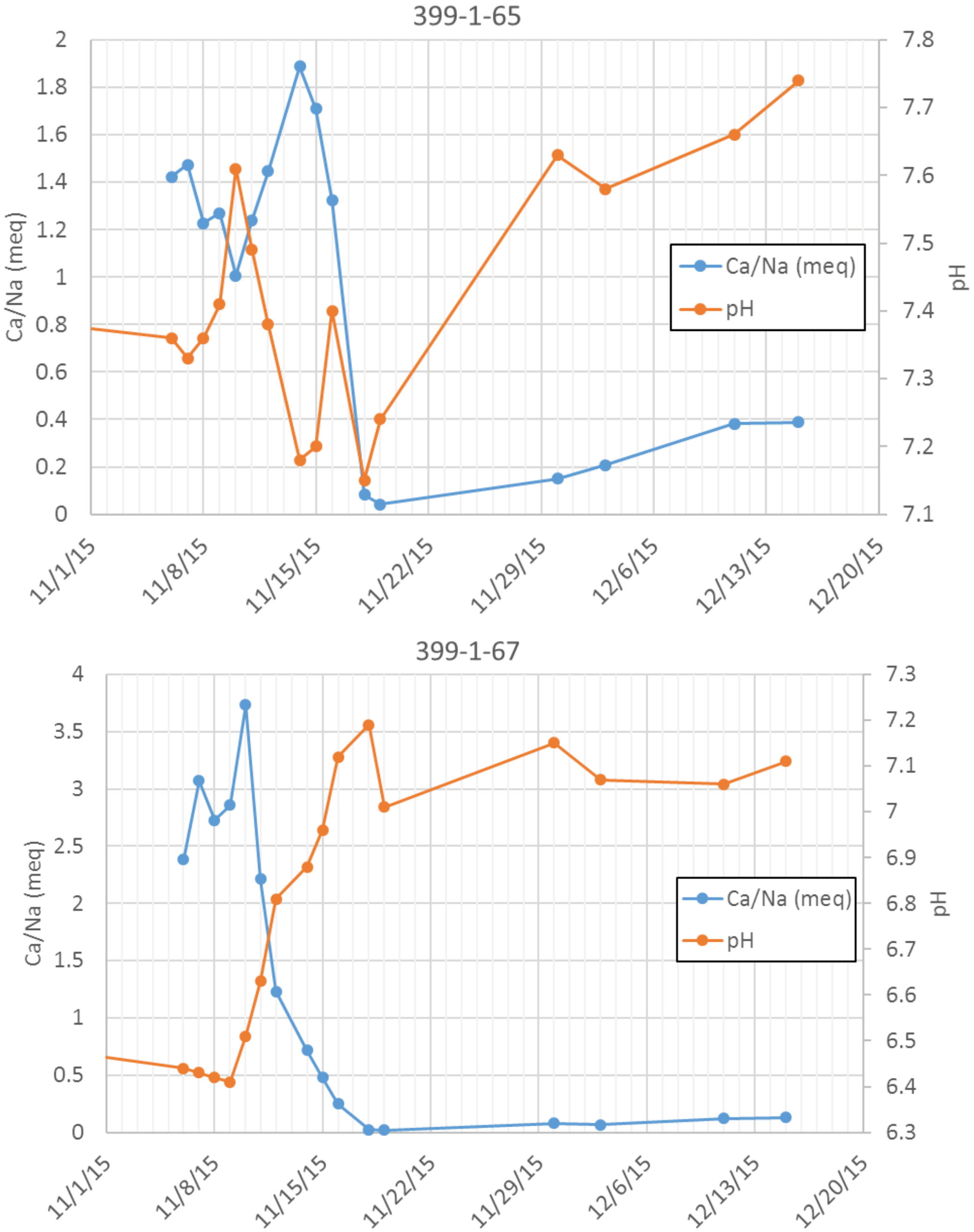
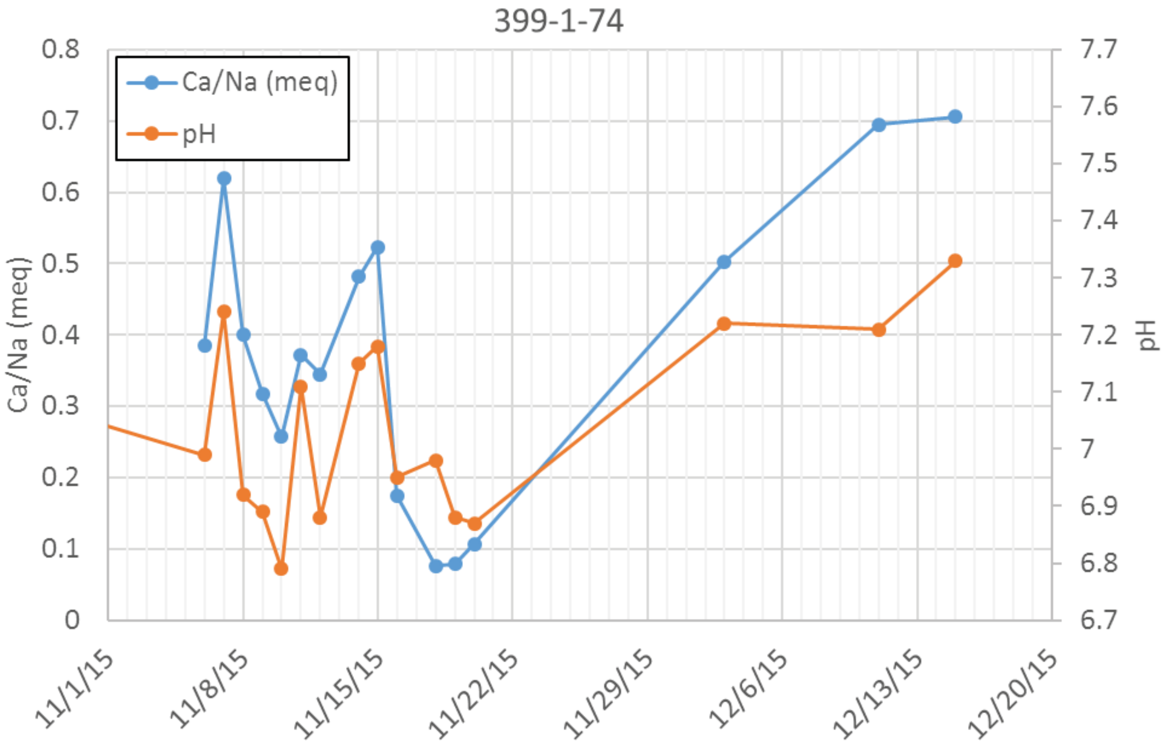


Figure A-18. Comparison of Calcium to Sodium Ratios and pH for Wells 399-1-65 and 399-1-67



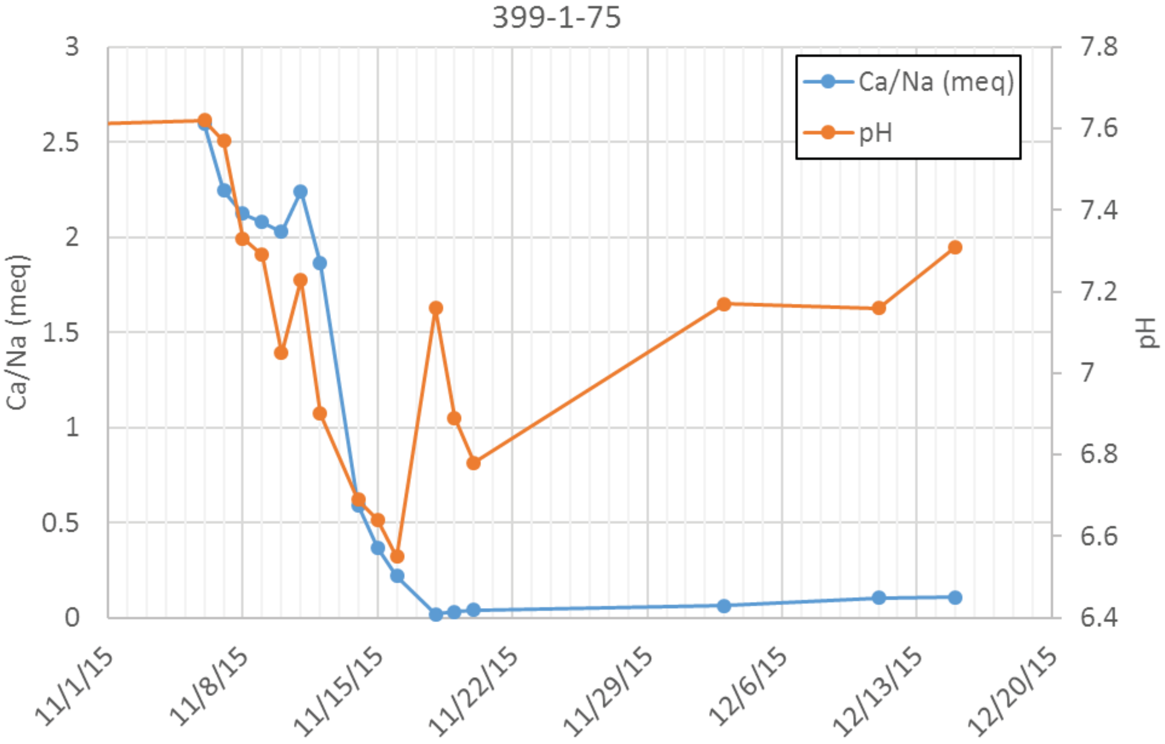
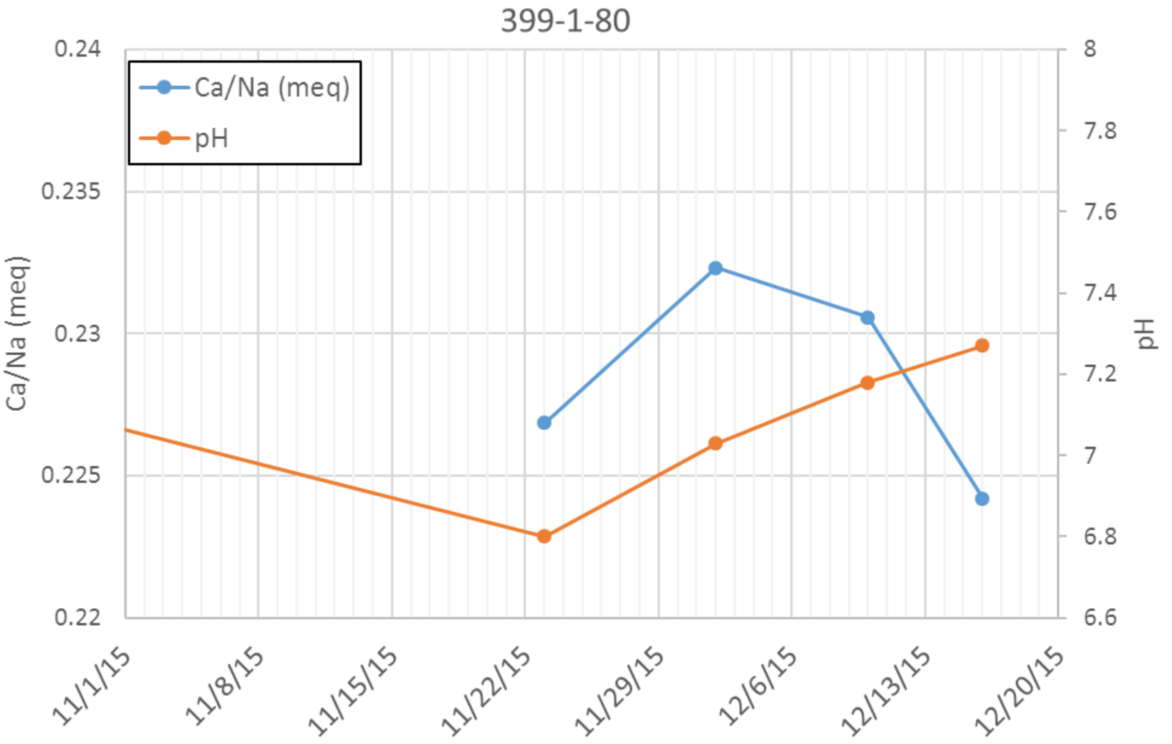


Figure A-19. Comparison of Calcium to Sodium Ratios and pH for Wells 399-1-74 and 399-1-75



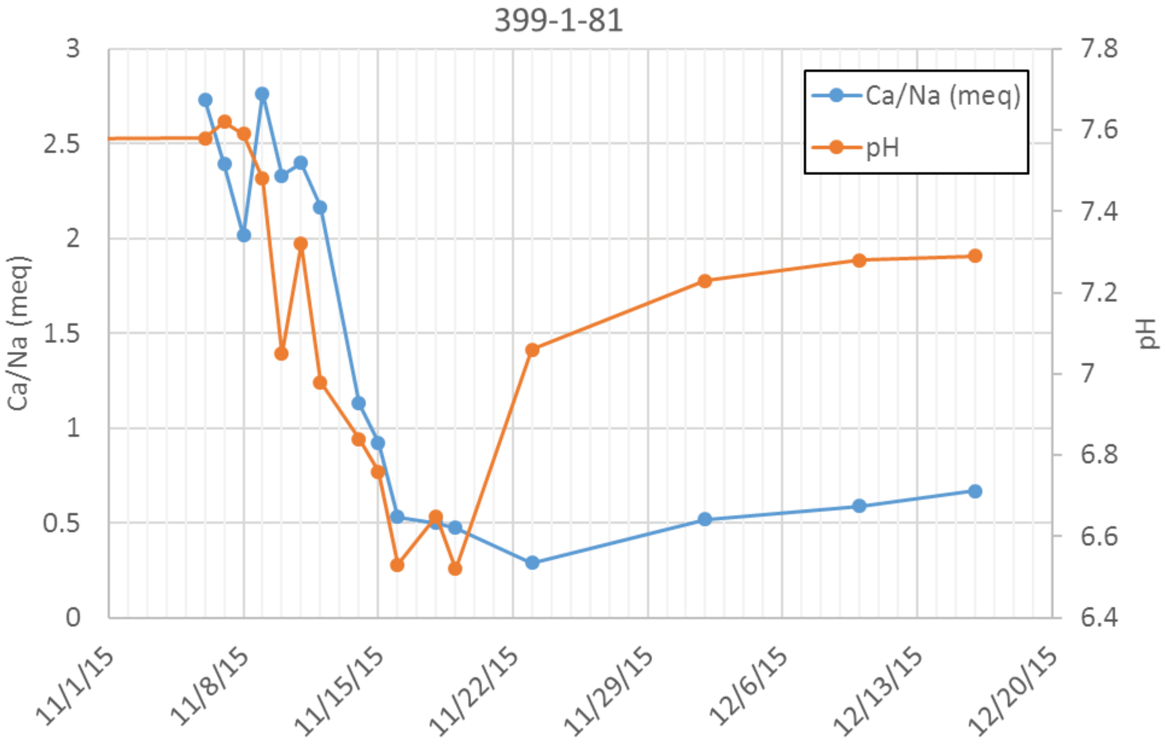
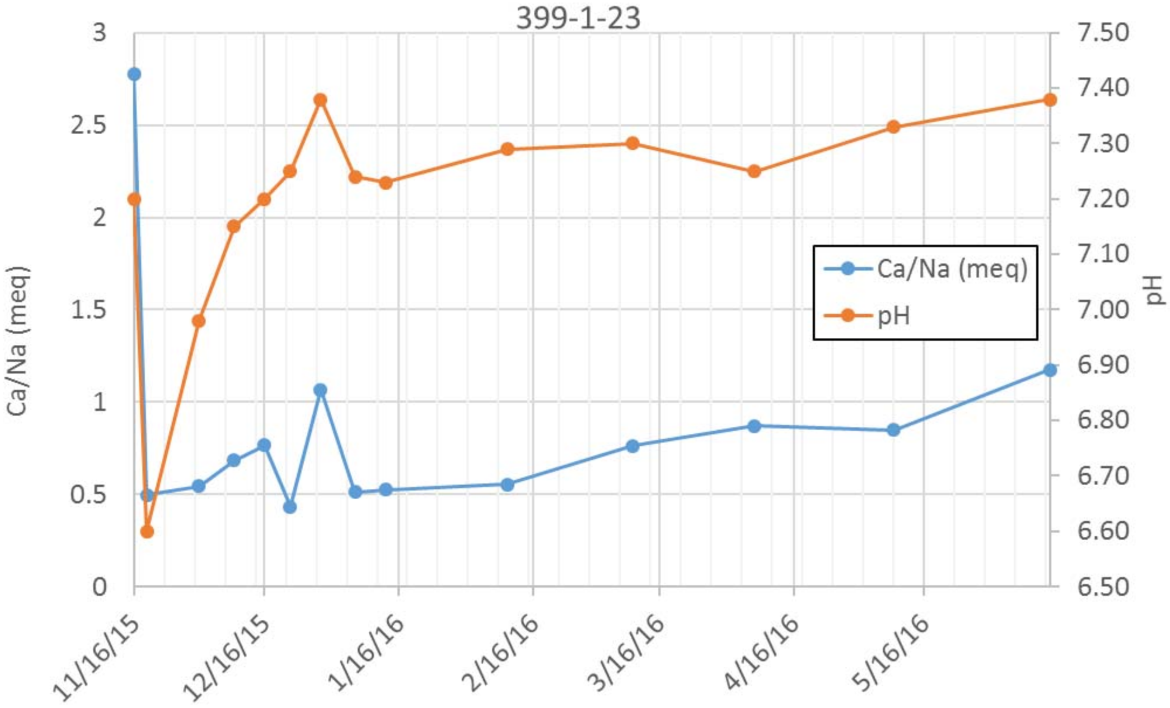


Figure A-20. Comparison of Calcium to Sodium Ratios and pH for Wells 399-1-80 and 399-1-81



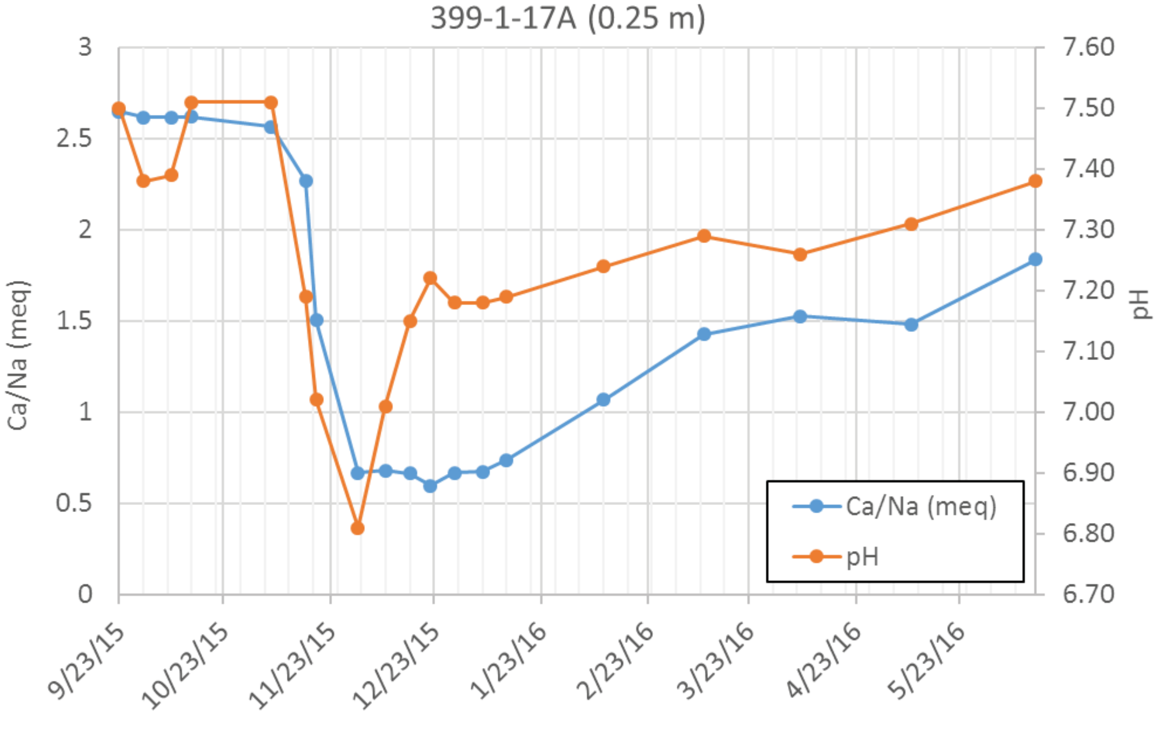


Figure A-21. Comparison of Calcium to Sodium Ratios and pH for Wells 399-1-23 and 399-1-17A

Appendix B

Geochemical Evaluations and Reactive Transport Modeling

This page intentionally left blank.

Terms

1D	one-dimensional
ERT	electrical resistivity tomography
GWB	Geochemist's Workbench
ppm	parts per million
PRZ	periodically rewetted zone

This page intentionally left blank.

B1 Geochemical Evaluations and Reactive Transport Modeling

Complex geochemical reactions occur within the host rock as a result of injecting or infiltrating high concentration of sodium phosphate bearing solutions. Although the ultimate goal is to sequester uranium from leaching to the groundwater, it is important to understand the geochemical processes from a mechanistic point of view that lead to sequestration of uranium. This information gained from this understanding will be used in developing lumped sorption-desorption parameters for predictive modeling using a fate and transport model.

A conceptual model of possible reactions resulting from infiltration of phosphate bearing solutions in the vadose zone is presented in Figure 6-24. The total thickness of the vadose zone (from base of infiltration lines to the water table) is approximately 8 m (26.2 ft). The average vertical velocity of the infiltrated solutions is about 1 m/day based on migration velocities estimated from electrical resistivity tomography (ERT) data (Figure 6-11). In order to gain an understanding of the geochemical reactions from phosphate-sediment interaction, a one-dimensional (1D) reactive transport model is developed using The Geochemist's Workbench (GWB) Version 11.

B1.1 Update of Existing Databases

For the purpose of evaluating geochemical reactions specific to the phosphate interactions, the following updates were made to the underlying databases based on information derived from published literature:

1. Added information about uranyl carbonate and phosphate bearing mineral phases to the thermodynamic database
2. Added reactions to the ion exchange database
3. Added surface species to the surface complexation database

In the default thermodynamic database called thermo.tdat, information regarding 624 minerals is included. However, based on the review of the database, some of the uranium carbonate and uranium phosphate minerals that could form (or dissolve) from reactions with injected/infiltrated solutions were not found. These were added based on review of literature. The following mineral phases were added based on information presented in Gorman-Lewis et al., 2008, "Review of Uranyl Mineral Solubility Measurements," and Gorman-Lewis et al., 2009, "Thermodynamic Properties of Autunite, Uranyl Hydrogen Phosphate, and Uranyl Orthophosphate from Solubility and Calorimetric Measurements":

Mineral Phase	Dissolution Reaction	Log K_{sp} (25°C)
Autunite	$Ca(UO_2)_2(PO_4)_2 \cdot 3H_2O = Ca^{2+} + 2UO_2^{2+} + 2PO_4^{3-} + 3H_2O$	-48.36
Uranyl Hydrogen Phosphate	$UO_2HPO_4 \cdot 3H_2O = UO_2^{2+} + HPO_4^{2-} + 3H_2O$	-13.17
Uranyl Orthophosphate	$(UO_2)_3(PO_4)_2 \cdot 4H_2O = 3UO_2^{2+} + 2PO_4^{3-} + 4H_2O$	-49.36
Andersonite	$Na_2CaUO_2(CO_3)_3(H_2O)_6 = 2Na^{+} + Ca2^{+} + UO_2^{2+} + 3CO_3^{2-} + 6H_2O$	-37.5
Liebigite	$Ca_2UO_2(CO_3)_3(H_2O)_{10} = 2Ca^{2+} + UO_2^{2+} + 3CO_3^{2-} + 10H_2O$	-36.9
Chernikovite	$(UO_2)HPO_4(H_2O)_4 = UO_2^{2+} + HPO_4^{2-} + 4H_2O$	-22.73

The following ion exchange reactions were added to the database called IonEx.sdat in order to model the cation exchange reactions with calcium once sodium and potassium bearing phosphate solutions are added. The ion exchange coefficients relative to Na^+ are presented following the Gaines-Thomas convention (Gaines and Thomas, 1953, "Adsorption Studies on Clay Minerals. II. A Formulation of the Thermodynamics of Exchange Adsorption"). The dataset is taken from Appelo and Postma, 2005, *Geochemistry, Groundwater and Pollution*, based on a compilation by Bruggenwert and Kamphorst, 1982, "Chapter 5: Survey of Experimental Information on Cation Exchange in Soil Systems":

Equation: $Na^+ + 1/i \cdot I\text{-}X_i \longleftrightarrow Na\text{-}X + 1/i \cdot I^+$

Ion Type (*I*)	Ion Exchange Coefficient ($K_{Na\backslash I}$)
Ca^{2+}	0.40
Mg^{2+}	0.50
Fe^{2+}	0.60
K^+	0.20

Two calcium-phosphate surface species were added to the existing database called FeOH+.sdat for modeling surface complexation with hydrous ferric oxide. This dataset contains the Dzombak and Morel, 1990, *Surface Complexation Modeling: Hydrous Ferric Oxide*, compilation, expanded to include surface complexation reactions for which binding constants have only been estimated (Dzombak and Morel, 1990 [Chapter 10, p. 299]). The surface complexation with calcium-phosphate species were missing in the database and was added based on information presented by Spiteri et al., 2008, "Surface complexation effects on phosphate adsorption to ferric iron oxyhydroxides along pH and salinity gradients in estuaries and coastal aquifers" (as modified from Gao and Mucci, 2001, "Acid Base Reactions, Phosphate and Arsenate Complexation, and their Competitive Adsorption at the Surface of Goethite in 0.7 M NaCl Solution"). The stability constants are given as intrinsic constants that are added to the weak surface sorption sites:

$\equiv FeOH(w) + Ca^{2+} + H_2PO_4^- \longleftrightarrow \equiv FeOCaHPO_4^- + 2H^+$ Log K (25°C) = -6.44

$\equiv FeOH(w) + Ca^{2+} + H_2PO_4^- \longleftrightarrow \equiv FeOCaH_2PO_4 + 2H^+$ Log K (25°C) = 0.19

B1.2 Reactive Transport Modeling of Controlled Laboratory Experiment Performed on Contaminated Sediment from 300 Area

Before evaluating the geochemical reactions in the vadose zone, validation of the existing database and adequacy of the current understanding of the possible reactions occurring from mixing of phosphate rich solutions with host sediments was undertaken. This was achieved by comparing the modeling results to the experimental results. Wellman et al., 2007, "Efficacy of soluble sodium tripolyphosphate Amendments for the in-situ immobilisation of uranium," report results of a carefully controlled laboratory experiment where uranium contaminated sediment sample that was taken from the North Process Pond in the 300 Area was flushed with sodium tripolyphosphate solution under both saturated and unsaturated conditions. The experiment conducted under unsaturated conditions is discussed here since it is more relevant to the geochemical reactions in the vadose zone from infiltrated and injected solutions.

As reported by Wellman et al. (2007), the sediment is coarsely textured with ~48 percent gravel, ~40 percent sand, and remaining fraction as silt and clay (~12 percent). The total uranium content within the sediment is 540 mg/kg (or µg/g) and the majority of the uranium is present as carbonates

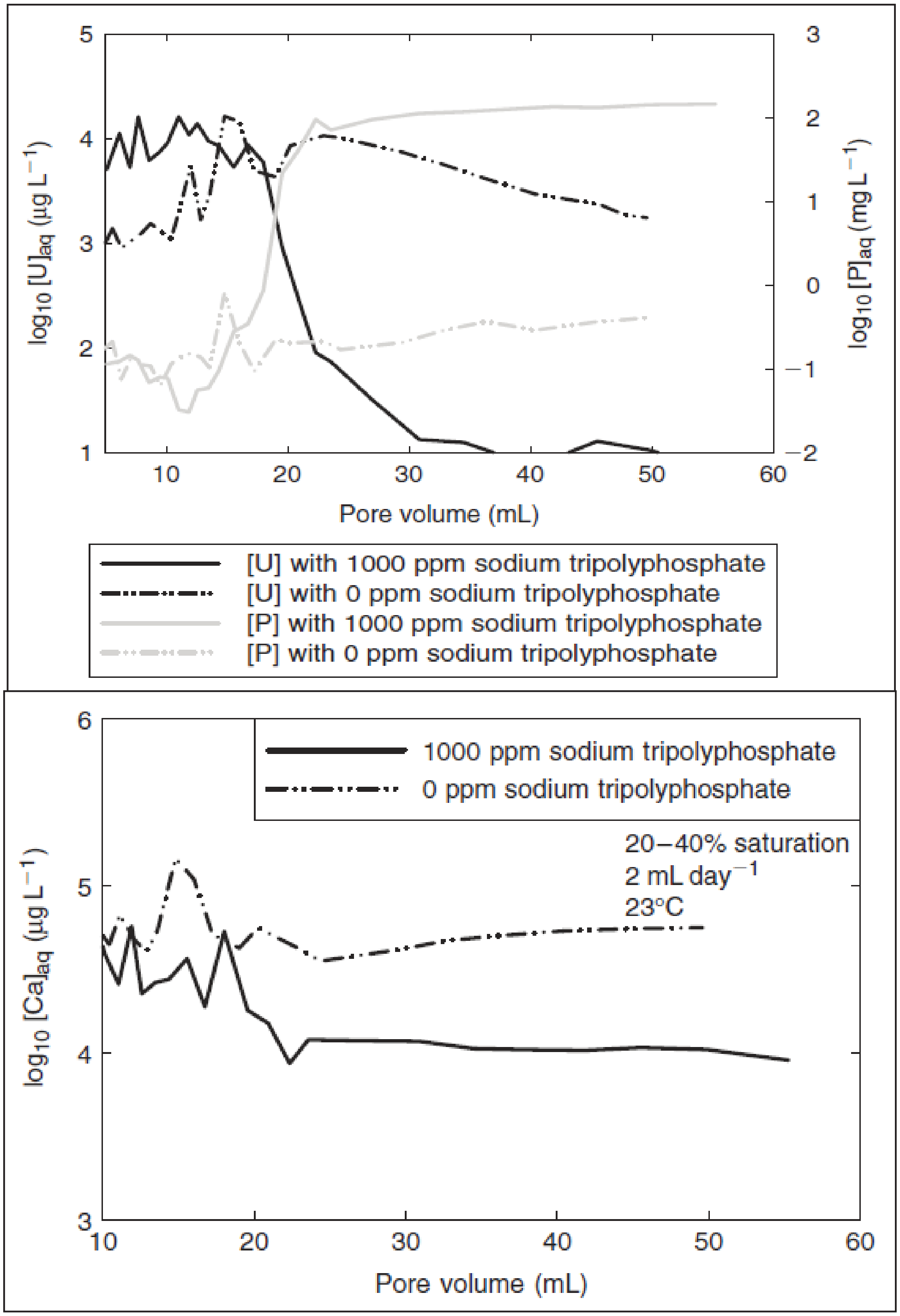
(~30 percent) and/or associated with amorphous iron and aluminum oxyhydroxides (~55 percent). Unsaturated column experiments were conducted using a pressurized unsaturated flow system where the water content was set to ~20 percent. The experiments were performed on <2 mm size sediments (sand, silt, and clay size) in a cylindrical column of length = 7.62 cm and radius = 0.96 cm. The influent solution containing 1,000 parts per million (ppm) sodium tripolyphosphate ($Na_5P_3O_{10}$) was prepared by mixing with the artificial groundwater (Table 1 of Wellman et al., 2007 shows groundwater composition). The 1,000 mg/L sodium tripolyphosphate ($Na_5P_3O_{10}$) has molecular weight of about 368 g/mole and results in a molar concentration of approximately 2.7×10^{-3} M. The resulting total P in the sodium tripolyphosphate solution is approximately 253 mg/L and sodium concentration is 312.5 mg/L. The pH of sodium tripolyphosphate solution is not mentioned in the report but is probably around 10. The pH of the initial groundwater solution was 8.2.

The flow rate was maintained at 0.08 mL/h. During the experiment, volumetric moisture content was monitored and found to be steady for the first 100 days (~41 pore volumes) at about 20 percent; subsequently, it increased steadily to ~40 percent until the test was terminated.

Considering a steady volumetric flow rate of 0.08 mL/h (or cm^3/h) through the cross-sectional area of 2.9 cm^2 results in a specific discharge of about 0.66 cm/day, and considering a volumetric moisture content of 0.2, the average linear pore water velocity is calculated to be 3.3 cm/day. This corresponds to about 2.4 days of residence time per pore volume.

Results of the experiment are shown in Figure B-1 in terms of effluent concentrations of uranium, phosphorus (P), and calcium as a function of pore volumes. The results are presented for experiments conducted with and without the 1,000 ppm sodium tripolyphosphate amendments. Note that concentration of total P is shown in mg/L while others are presented in µg/L. The results with the phosphate amendment are shown in solid lines and are of interest. The uranium concentrations fluctuate for first 20 pore volumes but remain near the initial concentration of about 5,000 µg/L and then drop rapidly over next 10 pore volumes to about 10 µg/L (similar to background groundwater concentration). This drop coincides with increasing concentration of P, which until then was being consumed in the reactions and/or being retarded due to sorption on the sediments. The P concentrations increase rapidly from 20 to 25 pore volumes but then continue to increase marginally for the remainder of the experiment. Calcium concentrations also show fluctuations between 10 and 20 pore volumes but then decline sharply after 15 pore volumes, reaching a local minimum after 20 pore volumes have passed. The concentrations do not change much past 25 pore volumes.

A 1D reactive transport model was developed using GWB based on the details of the experiment presented in Wellman et al. (2007). The modeling results are then compared to the experimental data. Updated databases (discussed earlier) were used to simulate precipitation and dissolution of phosphate bearing mineral phases, ion exchange reactions, and surface complexation reactions with iron oxyhydroxides. In the model, the ion exchange capacity is set at 0.2 meq/g (20 meq/100 g). This value is deemed reasonable given that the experiments are conducted on <2 mm size sediments with considerable silt and clay fraction (about 23 percent, when considering only <2 mm size). In addition, some minerals were added as reactants with kinetic reactions. These are presented in Table B-1. To match the results, the newly added uranyl carbonate minerals (Andersonite and Liebegite) had to be suppressed.



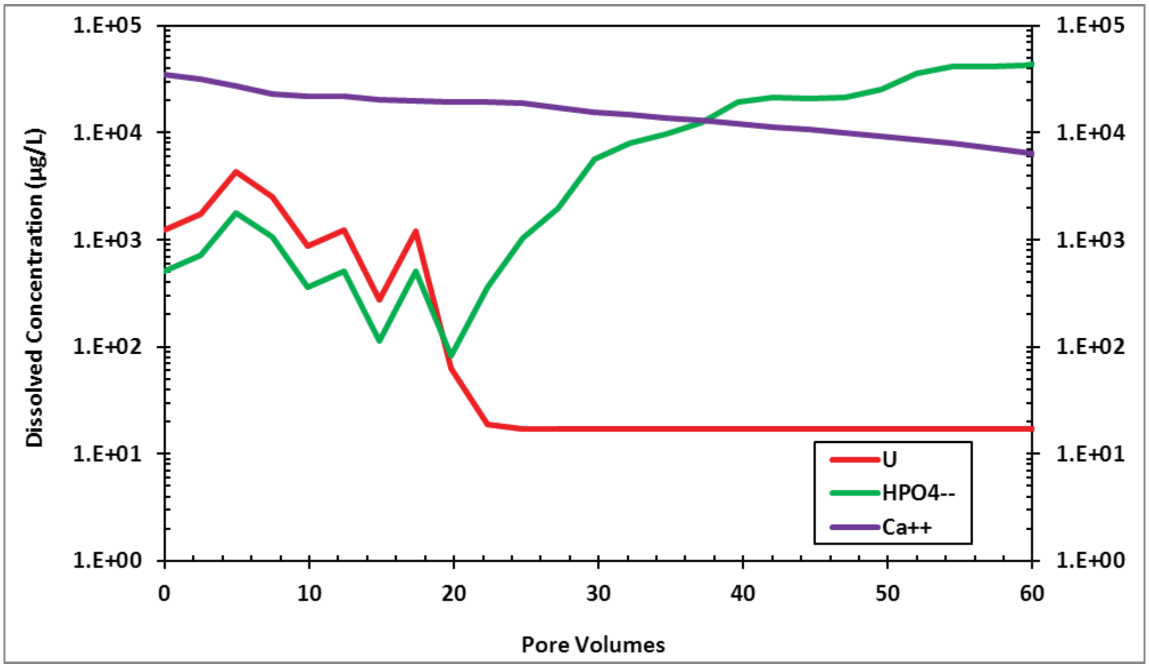
Reference: Wellman et al., 2007, "Efficacy of soluble sodium tripolyphosphate amendments for the in-situ immobilisation of uranium."

Figure B-1. Release of Uranium, Phosphorus, and Calcium from Unsaturated Column Experiments with and without Sodium Tripolyphosphate Amendments at 1,000 ppm Concentration

Table B-1. Mineral Reactants and Associated Parameters Considered for the Column Experiment

Mineral	Amount	Specific Surface Area (cm^2/g)	Dissolution Rate Constant ($mol/cm^2/s$)	Basis for Parameters
Quartz	0.45 (volume fraction in bulk volume)	1,000	4.2×10^{-18}	Volume fraction calculated by assuming 60% quartz content in the solid fraction and 25% porosity; any remaining solid fraction is considered inert. Dissolution rate constant is based on Rimstidt and Barnes, 1980, "The Kinetics of Silica-Water Reactions." Specific surface area is based on typical sand grains from Leamnson et al., 1969, *A Study of the Surface Areas of Particulate Microcrystalline Silica and Silica Sand*.
Calcite	0.0005 (volume fraction in bulk volume)	1,000	7.8×10^{-13}	Volume fraction is estimated based on calcium extracted by weak and strong acetic acid on pretreatment samples. Dissolution rate constant is derived from 1.55×10^{-6} $mol/m^3/s$ rate from Palandri and Kharaka, 2004, *A Compilation of Rate Parameters of Water-Mineral Interaction Kinetics for Application to Geochemical Modeling*. Specific surface area adjusted down based on uranium-calcite value of 3,000 cm^2/g in PNNL-17818, *300 Area Treatability Test: Laboratory Development of Polyphosphate Remediation Technology for In Situ Treatment of Uranium Contamination in the Vadose Zone and Capillary Fringe* (Table 3.3).
Ferrihydrite	0.001 (volume fraction in bulk volume)			The volume fraction is based on estimated amorphous iron oxide content using oxalate extraction on pretreatment samples.
Uranophane	30 mg/kg	10,000	7.8×10^{-13}	Surrogate for uranium bearing mineral phases is composed of carbonates and silicates and for uranium associated with calcite. Solid concentration is derived using 2,000 µg/L observed uranium concentration in water at start of the experiment (without any sodium tripolyphosphate) and considering K_d value of 15 mL/g based on Equation 2 of ECF-300FF5-11-0151, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS*. Dissolution rate constant set is same as that for calcite. Specific surface area is selected from range of 3,000 cm^2/g for uranium calcite and 748,800 cm^2/g for uranophane (Table 3.3 of PNNL-17818).

Results from the 1D reactive transport model using GWB are shown in Figure B-2 based on simulating the experimental conditions. The results match those observed in the experiment. High uranium[3] concentrations are maintained initially at around 1,000 µg/L with fluctuations up to 5,000 µg/L for the first 20 pore volumes and then decline over next 10 pore volumes to a value of 10 µg/L. Higher uranium concentrations can be achieved by introducing minerals with higher specific surface area and kinetic rate constants but due to lack of detailed characterization information have not been modeled. The phosphate concentration (represented in terms of HPO_4^{2-}) remains low for the first 20 pore volumes and then increases sharply from 20 to 25 pore volumes and then continues to increase gradually as in the experiment (Figure B-1). Calcium concentrations also behave in a manner similar to those observed in the experiment. They start in the range of 30,000 to 40,000 µg/L, then show a steady decline, but remain around 10,000 µg/L. The lower figure (in Figure B-2) shows the model predicted concentration time histories for Na^+, HCO_3^-, and pH. The Na^+ and HCO_3^- concentrations do not change much, but pH starts to show a decline with increasing pore volumes. The decline is steeper in first few pore volumes, and pH is about 6.2 after around 10 pore volumes. The pH declines slowly over next 50 pore volumes with a minimum value of about 5.7, indicating that reactions with minerals lead to excess H^+ ions in the solution. The simulated change in pH has not been reported in the experiments but likely occurs given that all other observations are consistent with the simulated results. Effluent uranium concentrations remain much higher over first 10 to 15 pore volumes when treated with sodium polyphosphate solutions, compared to solutions containing no sodium polyphosphate (Figure B-1). This probably results from dissolution of uranium bearing mineral phases due to change in pH.



Note: U is reported as $UO_2(H_2PO_4)_2$, the primary species; HPO_4^{2-} is the total concentration of phosphate presented in terms of HPO_4^{2-}.

Figure B-2. Simulated Results from 1D Reactive Transport Model of the Unsaturated Column Experiment Reported by Wellman et al. (2007) with Tripolyphosphate Amendment

---

[3] Uranium concentration is reported as $UO_2(H_2PO_4)_2$, which is the primary uranium bearing aqueous species. In order to convert this to the U elemental concentration, multiply with 0.51 value.

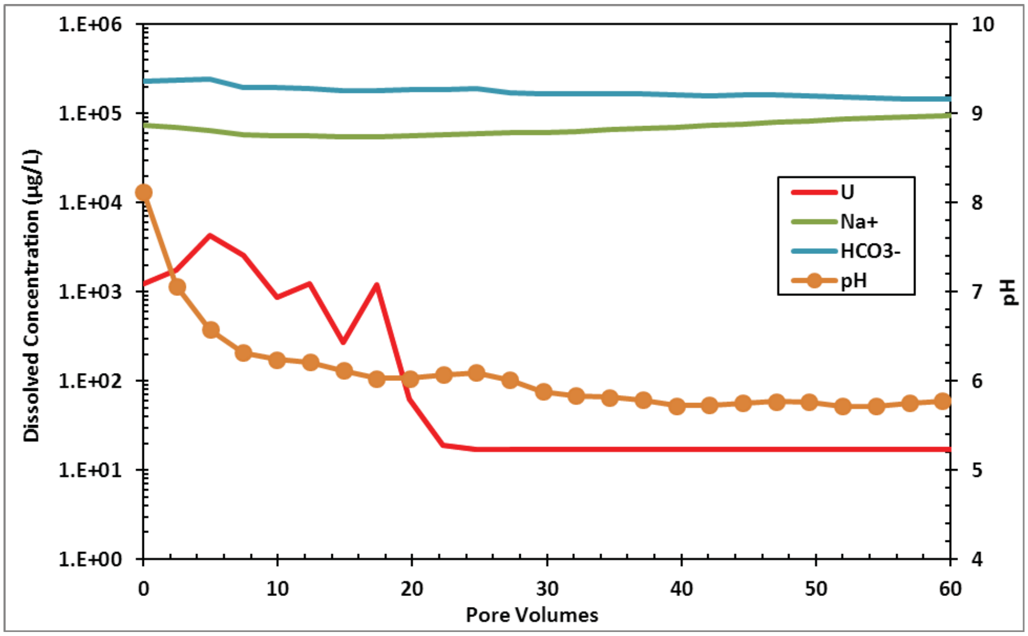
The calculated saturation indices of selected mineral phases as a function of pore volumes are presented in Figure B-3 to evaluate which mineral phases are thermodynamically favored for dissolution or precipitation. Increasing saturation index (increasing to one or greater) with increasing pore volume indicates conditions favorable for saturation and precipitation of minerals while declining values of saturation index (less than 1) indicates conditions leading to dissolution. Until about 15 pore volumes, the uranium bearing mineral phases were at or above saturation (saturation index >1) and continued to provide uranium to the solution at steady concentrations. However, the saturation index shows a steep decline after 15 pore volumes due to continued dissolution. This also coincides with the decline in uranium concentrations indicating that the mineral phase underwent dissolution due to inflow of phosphate solutions. The saturation indices of calcite (and to some extent quartz) also show steady decline. This results in response to pH buffering primarily by dissolution of uranium bearing mineral phases and carbonates. Uranophane[4] is considered in the model as a surrogate for uranium bearing mineral phases composed of carbonates and silicates and for uranium associated with calcite. Once the uranium bearing mineral phases are exhausted, pH buffering occurs primarily by dissolution of calcite (and perhaps by other carbonate mineral phases). In this process, the dissolution of clay minerals and existing iron oxyhydroxide mineral phases occurring as coatings around the quartz grains is also expected to occur. Following the dissolution of uranium bearing minerals and with increasing availability of Ca^{2+} ions in the solution (due to ion exchange reactions with Na^+ and from dissolution of calcite), the formation of calcium-phosphate mineral phases such as hydroxyapatite ($Ca_5(PO_4)_3OH$) and whitlockite ($Ca_3(PO_4)_2$) are favored. These show increasing saturation indices after about 20 pore volumes. These results are consistent with the experimental observations where the P concentrations increase from about 15 to 25 pore volumes and then reach a constant concentration indicating continued precipitation of calcium-phosphate bearing mineral phases.

Since phosphate is the primary reactant of interest, an evaluation is undertaken regarding the predominant speciation of HPO_4^{2-} based on the modeling results. The simulated distribution of phosphate species within the column experiment is presented in Figure B-4 at four different pore volumes. The x-axis shows the relative distance along the length of the column (0 is the start of the column and 1 is at the end of the column). After 5 pore volumes had passed through the column, the phosphate concentration distribution within the column is dominated by surface complexation reactions with iron oxyhydroxide (e.g., >(w)FeHPO4- and >(w)FeH2PO4). The concentration front has only moved to the relative distance of 0.6 at this stage. Other species, such as HPO_4^{2-} and $H_2PO_4^-$ are further retarded. Only minor concentrations of phosphate species have reached the end of the column (relative distance of 1). After 15 pore volumes, the distribution of phosphate is still dominated by surface complexation, but by now the concentration front has moved through and is near the end of the column indicating that all of the surface sorption sites associated with iron oxyhydroxide are in equilibrium with the solution and almost all sorption sites are filled. These surface reactions occur due to changes in surface charge from introduction of sodium tripolyphosphate solutions that leads to deprotonation and protonation reactions. After 22 pore volumes, concentrations associated with the surface species (e.g., >(w)FeHPO4- and >(w)FeH2PO4) are near maximum throughout the column, indicating that all of the buffering and reactions with available sorption sites have taken place. At this stage, the phosphate concentrations in the effluent show a steep rise, indicating breakthrough (Figure B-2). While >(w)FeHPO4- and >(w)FeH2PO4 concentrations are high within most of the column, they are much lower near the start of the column (relative distance of 0.1). This probably results from competition for surface sorption sites by species, such as >(w)FePO4--, which now occupy most of the sorption sites. Aqueous species HPO_4^{2-} is also

---

[4] According to PNNL-20004, *Remediation of Uranium in the Hanford Vadose Zone Using Ammonia Gas: FY 2010 Laboratory-Scale Experiments*, uranium bearing silicate (e.g., Na-boltwoodite) is predominantly dissolved (85 percent) in the acetic acid extraction. Therefore, some of the uranium fraction is present as silicate in addition to being associated with carbonates.

dominant up to relative distance of 0.2 but then its concentration drops. After 30 pore volumes have been flushed, the distribution of phosphate species reaches near steady state. The surface complexation of phosphate that results in formation of surface species >(w)FeHPO4-and >(w)FeH2PO4 is a dominant reaction.



Note: U reported as UO2(H2PO4)2, the primary species.

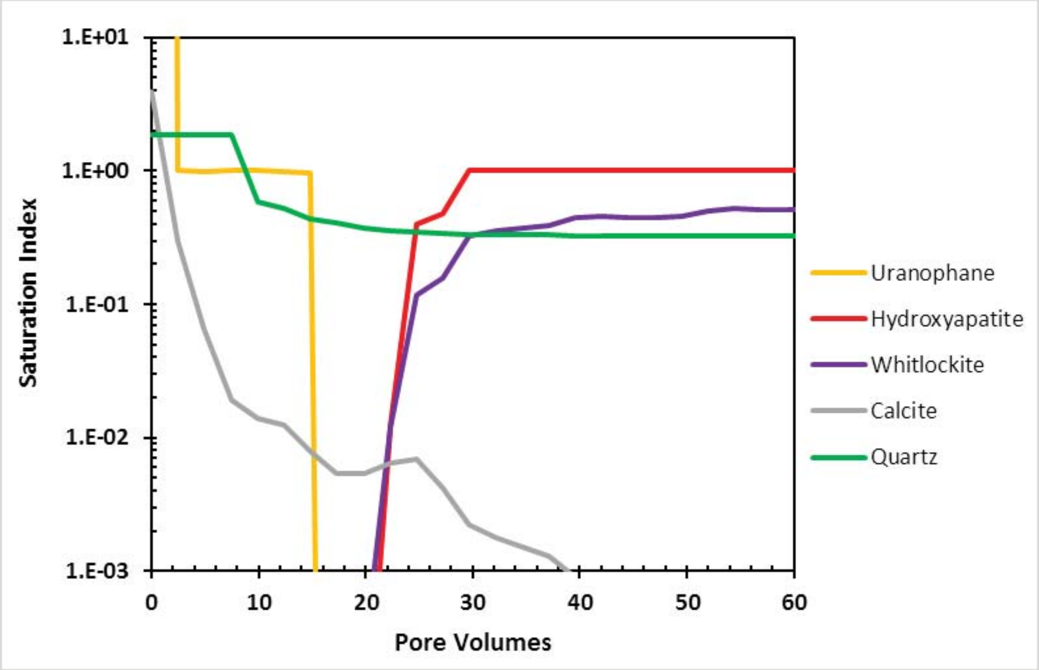


Figure B-3. Mineral Saturation Index as a Function of Pore Volume Using 1D Reactive Transport Model of the Unsaturated Column Experiment Reported by Wellman et al. (2007) with Tripolyphosphate Amendment

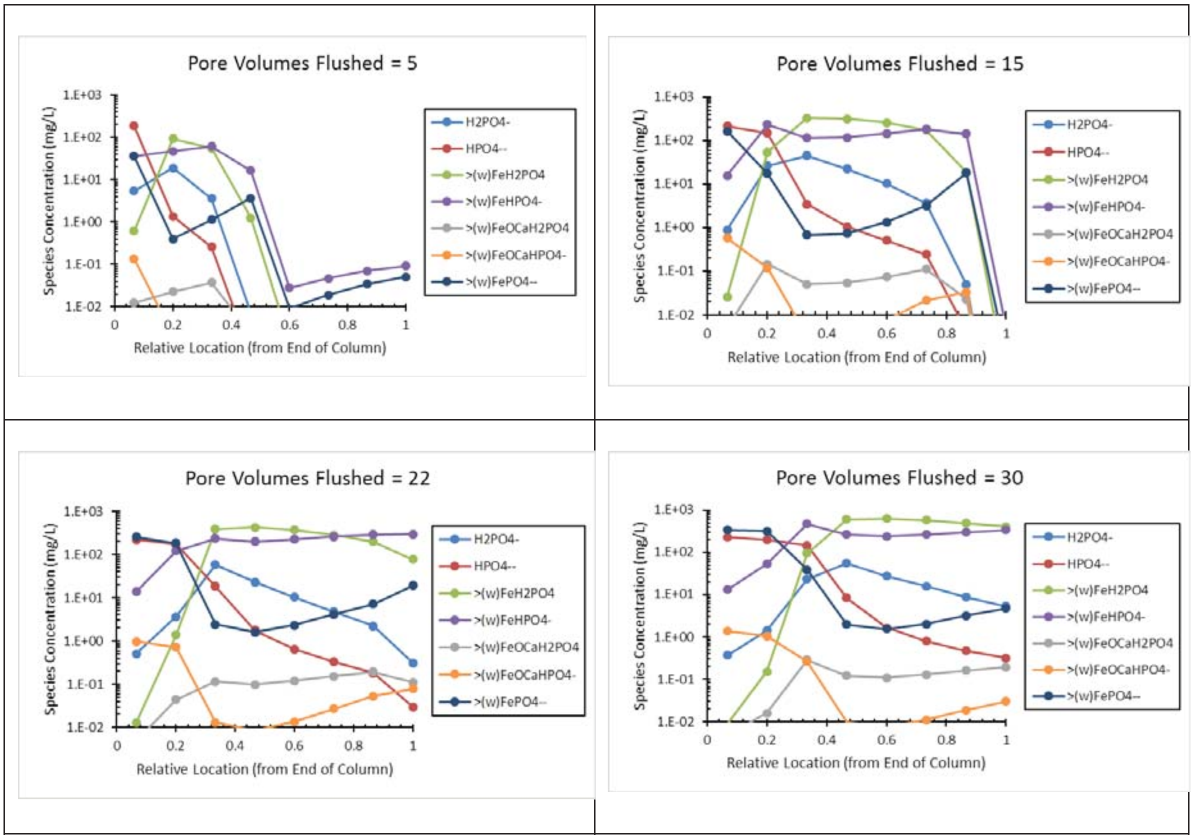


Figure B-4. Simulated Distribution of HPO_4^{2-} Species within the Column at Selected Pore Volumes

Based on modeling and evaluation of a carefully controlled laboratory experiment, where a uranium contaminated sediment sample from the North Process Pond in the 300 Area was flushed with sodium tripolyphosphate solution, the following inferred sequence of primary reactions are summarized:

1. As phosphate amendments are prepared in the pH range of 7 to 10, the predominant phosphate species in the solution will be HPO_4^{2-}.

2. As and when the sodium phosphate bearing solution contacts the sediment, the following reactions get initiated:

   a. Ion exchange reaction with Na^+ ion leads to release of Ca^{2+} in the solution:

   $$Na^+ + 0.5\ Ca\text{-}X_i \leftrightarrow Na\text{-}X + 0.5\ Ca^{2+}$$

   b. Ca^{2+} and HPO_4^{2-} react in the solution to form calcium-phosphate bearing mineral phases and result in deprotonation (release of H^+):

   $$5\ Ca^{2+} + 3\ HPO_4^{2-} + H_2O \rightarrow Ca_5(PO_4)_3OH + 4\ H^+$$

   $$\boxed{\text{Hydroxyapatite}}$$

   $$3\ Ca^{2+} + 2\ HPO_4^{2-} \rightarrow Ca_3(PO_4)_2 + 2\ H^+$$

   $$\boxed{\text{Whitlockite}}$$

3. As the pH starts to decline due to continued supply of H^+, buffering reactions start to occur where protons are consumed and pH is buffered. The following reactions consume protons:

    a. Surface complexation based reactions that are sensitive to changes in pH occur on both weak sites (>(w)FeOH) and strong binding sites (>(s)FeOH) that are collectively represented as (≡FeOH):

    $$\equiv FeOH + H_2PO_4^- + H^+ \leftrightarrow \equiv FeH_2PO_4 + H_2O$$
    $$\equiv FeOH + HPO_4^{2-} + H^+ \leftrightarrow \equiv FeHPO_4^- + H_2O$$

    It should be noted that surface complexation reactions with phosphate will occur just from supply of phosphate ions in the solutions even if the calcium and phosphate reactions were not occurring. The pH of the initial solution is around 8, which is near the point of zero net proton charge on the surface of iron oxyhydroxides. As the HPO_4^{2-} ions are introduced, and since the pH of the influent solution is different (~10) than the resident pore water pH, the charge balance in the solution changes and leads to surface complexation reactions due to amphoteric nature of iron oxyhydroxide surfaces.

    b. Mineral reactions that lead to consumption of protons can cause mineral phase dissolution. For uranium bearing mineral phases that are associated with carbonates and silicates (represented by uranophane mineral as shown below) such reactions would lead to dissolution of mineral and release of uranyl ion that could result in increased dissolved concentration of uranium:

    $$Ca(H_3O)_2(UO_2)_2(SiO_4)_2(H_2O)_3 + 6\,H^+ \leftrightarrow Ca^{2+} + 2UO_2^{\ 2+} + 2SiO_2 + 9H_2O$$

    c. Other carbonate bearing mineral phases, predominantly calcite, that are present in the sediments will undergo dissolution in order to consume protons:

    $$CaCO_3 + H^+ \rightarrow Ca^{2+} + HCO_3^-$$

4. While there is continued supply of phosphate, the released Ca^{2+} made available from the above two reactions will continue to bind with HPO_4^{2-} to form calcium-phosphate bearing mineral phases and in turn lead to deprotonation (as shown in Step 2). This cycle of deprotonation followed by consumption of protons will continue as long as supply of both phosphate and reacting iron oxyhydroxide surfaces and minerals (primarily uranium bearing carbonates and silicates and calcite) is maintained. If and when the surface capacity is reached (i.e., all surface sorption sites are at equilibrium with the influent solution) and if the buffering mineral phases (primary buffers) completely dissolve away, then the phosphate concentrations will rise in the effluent. Due to excess supply, the phosphate will start to react with the available calcium (that is still made available from ion exchange reactions) and start forming calcium phosphate bearing mineral phases. In this process any uranium in the solution will adsorb or get bound (forming uranyl orthophosphate or uranyl hydrogen phosphate) and be sequestered.

5. While surface reactions occur quickly and buffer the pH initially, the primary buffering reactions are expected to be controlled by the mineral phase dissolution. As a result, the kinetics of the mineral dissolution along with initial available amount of reactants plays an important role in describing the behavior of the system.

B.1.3 Reactive Transport Modeling to Simulate Stage A Infiltration and Injection

Based on the information learned from the controlled laboratory experiment performed under unsaturated conditions, reactive transport modeling was undertaken to simulate the infiltration of phosphate bearing solutions in Stage A and predict the probable reactions occurring in the subsurface.

A 1D column through the vadose zone was conceptualized, as shown in Figure 6-24. The vertical thickness of the column is set at 8 m (26.24 ft), which is the approximate distance from the point of infiltration to the water table within the Stage A area. The specific discharge through the column is calculated to maintain an average linear pore water velocity of 1 m/day, consistent with the ERT data. The moisture content was set at 0.2 for the duration of the infiltration. The infiltration was simulated for 9 days consistent with the infiltration period (November 7 through 15). The model simulation was run for an additional 6 days under no infiltration conditions to evaluate the effects during and post-infiltration for the total simulated duration of 15 days.

The model domain was discretized into 16 grid blocks of 0.5 m (1.6 ft) length each. Under constant flow conditions simulated, this discretization is deemed adequate. The initial pore water composition was based on the water composition of well 399-1-87 (a periodically rewetted zone [PRZ] well) from November 6, 2015 (prior to start of infiltration). Where major ion data were not available, the concentrations were based on sampling from well 399-1-17A on September 30, 2015. The infiltrated solution composition was based on sampling the mixing skid on Day 3 of infiltration, when influent concentrations were stable. The compositions of the solutions are presented in Table B-2. In addition, mineral reactants were added with kinetic reactions as presented in Table B-3. The cation-exchange capacity was set at 0.01 meq/g (1 meq/100 g), which is a typical value for the 300 Area sediments. PNNL-21733, *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment*, reports average cation exchange capacity of 1 to 2 meq/100 g with 77 percent ion exchange sites occupied with calcium and total surface calcium available for exchange is 0.9 to 1.5 mmol/100 g.

Table B-2. Composition of Initial Pore Water and Infiltrated Water for the Reactive Transport Simulations

Analyte	Pore Water Composition[a] (Concentrations in mg/L)	Infiltrated Water Composition[b] (Concentrations in mg/L)
Ca^{2+}	49.7	15.2
Na^{+}	33	1,440
Mg^{2+}	12	4
K^{+}	5.3	1,110
Fe (Total)	0.01	0.01
U (Total)	0.060	10^{-6}
$HCO3^{-}$	128	1,780
$NO3^{-}$	25	2
Cl^{-}	20.6	50
SO_4^{2-}	60.9	63
HPO_4^{2-}	0.01	1,600 (Total Phosphorus)
DO	9	8
pH	7.25	7.01

a. Based on water composition from PRZ well 399-1-87 and groundwater well 399-1-17A.

b. Based on composition from mixing skid on Day 3.

Table B-3. Mineral Reactants and Associated Parameters Considered for Modeling Stage A Infiltration

Mineral	Amount	Specific Surface Area (cm^2/g)	Dissolution Rate Constant ($mol/cm^2/s$)	Basis for Parameters
Quartz	0.45 (volume fraction in bulk volume)	1,000	4.2×10^{-18}	Volume fraction is calculated by assuming 60% quartz content in the solid fraction and 25% porosity. Dissolution rate is constant based on Rimstidt and Barnes, 1980, "The Kinetics of Silica-Water Reactions." Specific surface area is based on typical sand grains from Leamnson et al., 1969, *A Study of the Surface Areas of Particulate Microcrystalline Silica and Silica Sand*.
K-Feldspar	0.26 (volume fraction in bulk volume)	1,000	3×10^{-17}	Volume fraction is calculated by assuming 35% feldspar content in the solid fraction and 25% porosity. Dissolution rate constant is based on Blum and Stillings, 1995, "Feldspar Dissolution Kinetics." Specific surface area is the same as quartz.
Calcite	0.0015 (volume fraction in bulk volume)	1,000	7.8×10^{-13}	Volume fraction is estimated based on calcium extracted by weak and strong acetic acid on pretreatment samples. Dissolution rate constant is derived from 1.55×10^{-6} $mol/m^3/s$ rate from Palandri and Kharaka, 2004, *A Compilation of Rate Parameters of Water-Mineral Interaction Kinetics for Application to Geochemical Modeling*. Specific surface area is adjusted down, based on uranium-calcite value of 3,000 cm^2/g in PNNL-17818 (Table 3.3).
Kaolinite and Illite Clay Minerals	0.022	100,000	1×10^{-17}	Volume fraction is based on 3-6% clay content in the sediments. Dissolution rate constant is taken from Nagy, 1995, "Dissolution and Precipitation Kinetics of Sheet Silicates," and specific surface area is from Carrol and Walther, 1990, "Kaolinite Dissolution at 25°, 60°, and 80°C."
Ferrihydrite	0.002 (volume fraction in bulk volume)			The volume fraction is based on estimate of amorphous iron oxide content using oxalate extraction on pretreatment samples.

Table B-3. Mineral Reactants and Associated Parameters Considered for Modeling Stage A Infiltration

Mineral	Amount	Specific Surface Area (cm^2/g)	Dissolution Rate Constant ($mol/cm^2/s$)	Basis for Parameters
Uranophane	10 mg/kg	10,000	1×10^{-14}	Surrogate for uranium bearing mineral phases is composed of carbonates and silicates and for uranium associated with calcite. Solid concentration is derived using 1,500 µg/L observed uranium concentration in water at start of the column tests and considering K_d value of 15 mL/g based on Equation 2 of ECF-300FF5-11-0151, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS*, and assuming 40% gravel fraction. Dissolution rate constant is rounded up from the value used for calcite. Specific surface area is selected from range of 3,000 cm^2/g for uranium calcite and 748,800 cm^2/g for uranophane (Table 3.3 of PNNL-17818).

Results of the simulation are presented in terms of distribution of selected components in the fluid for selected times across the length of the column (Figure B-5). For each time point, a pair of results are presented with the left side showing the concentration of selected cations and anions of interest.
The HPO42- concentration shown on the left figure is the total concentration of phosphate represented as HPO42- while the right hand figure shows the speciation of HPO42- along with the pH of the solution.
The selected time points for display are concentrations at 0, 3.3, 6.3, 7.8, and 10.2 days after start of infiltration. Concentration distribution prior to infiltration is shown in figures related to 0 days.
For purpose of tracking simulated transport of a conservative (nonreactive) species, Br- is added to the infiltrated water at a concentration of 1 mg/L. This is done strictly for the purpose of simulation in order to compare the retardation of species compared to a conservative species (Br-).

After 3.3 days of infiltration of phosphate-rich solutions, the concentration of HPO42- shows a steep decline between 2.5 m and 4 m (8.2 and 13.1 ft) depth. This is indicative of a developing reaction front that leads to retardation of HPO42-. Behind this zone (between 0 and 2 m [0 to 6.5 ft] depth) the Ca2+ concentrations have declined to much lower values while in front of this zone (>4 m [>13.1 ft] depth), the concentrations are near the pre-infiltration levels. The U (elemental uranium) concentration also shows a steep decline at the reaction front just like HPO42- while Fe2+ shows elevated concentration behind the reaction front and slight increase ahead of the front from advective transport. The pH shows a steep decline between 2.5 and 3 m (8.2 and 9.8 ft) depth, with a low value of 5.75 that increases before and after this depth. The primary HPO42- species are surface complexed species >(w)FeH2PO4 and >(w)FeHPO4- and aqueous species HPO42- and H2PO4-. The concentration of these species follow the pH decline. The HPO42- reaction front is a net result of several reactions – as HPO42- is added to the sediments, the resulting deprotonation reactions lead to excess H+ ions (and pH reduction) that in turn leads to buffering reactions through ion exchange, surface complexation, and mineral phase dissolution. The elevated concentration of Fe2+ behind the reaction front indicates reactions between iron oxyhydroxide (and clay minerals) with incoming HPO42-.

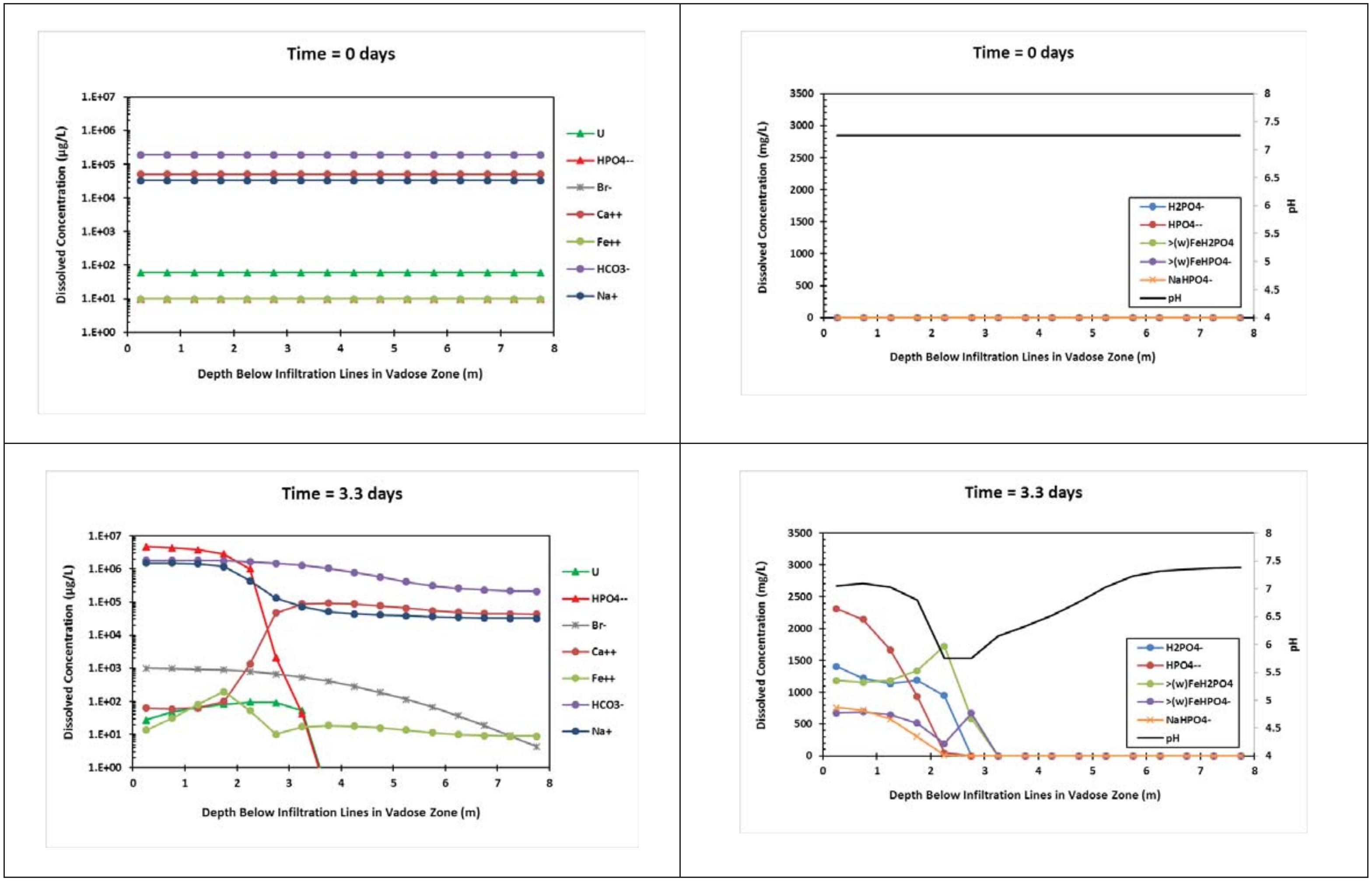


Figure B-5. Simulated Concentrations of Selected Constituents from Infiltration of Phosphate Bearing Solutions for Stage A (page 1 of 3)

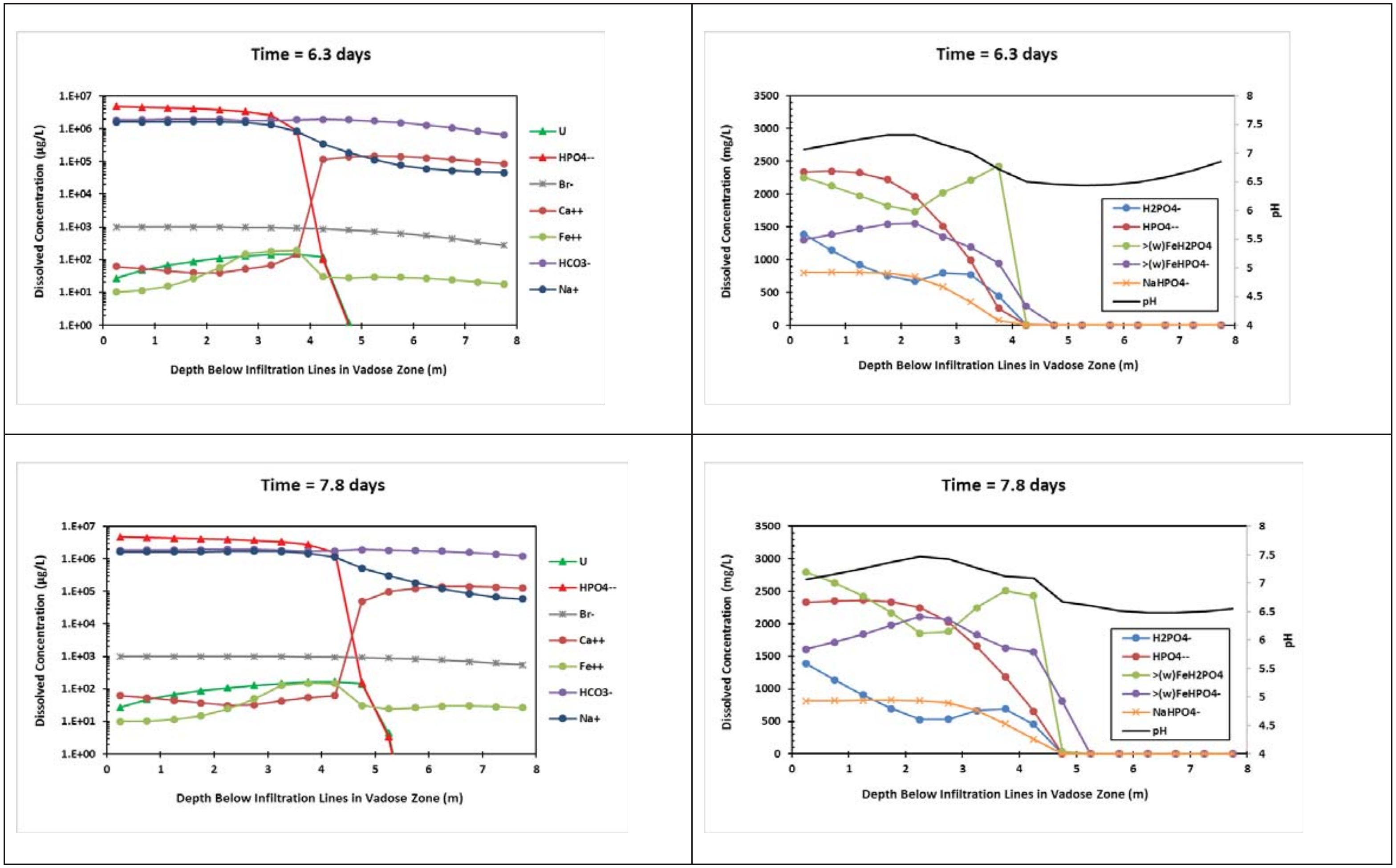
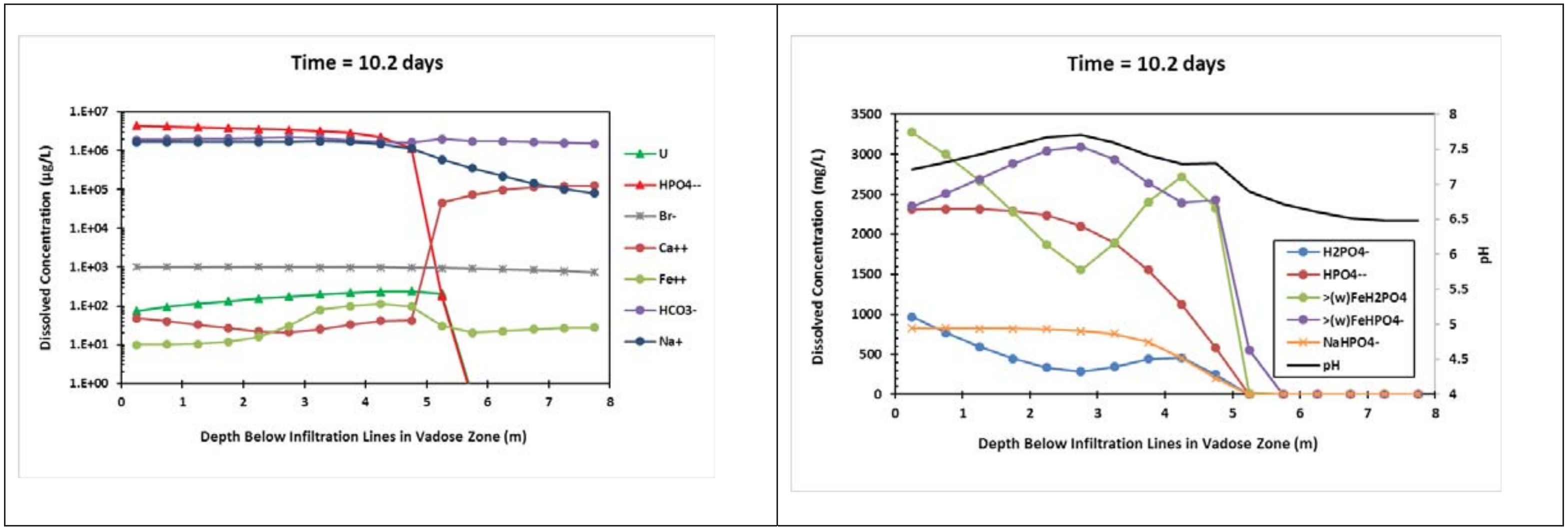


Figure B-5. Simulated Concentrations of Selected Constituents from Infiltration of Phosphate Bearing Solutions for Stage A (page 2 of 3)



Notes: Uranium concentrations presented here are the uranium elemental concentrations. Left hand side figures show concentrations of selected constituents, while right hand side figures show speciation of HPO_4^{2-} and pH variations.

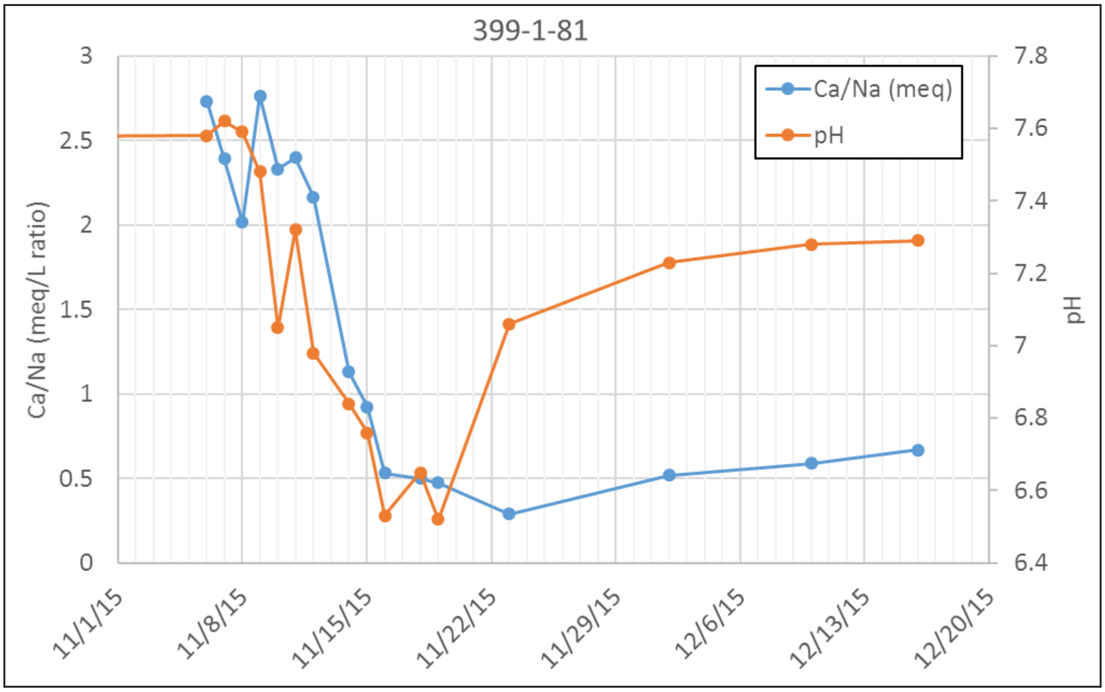
Figure B-5. Simulated Concentrations of Selected Constituents from Infiltration of Phosphate Bearing Solutions for Stage A (page 3 of 3)

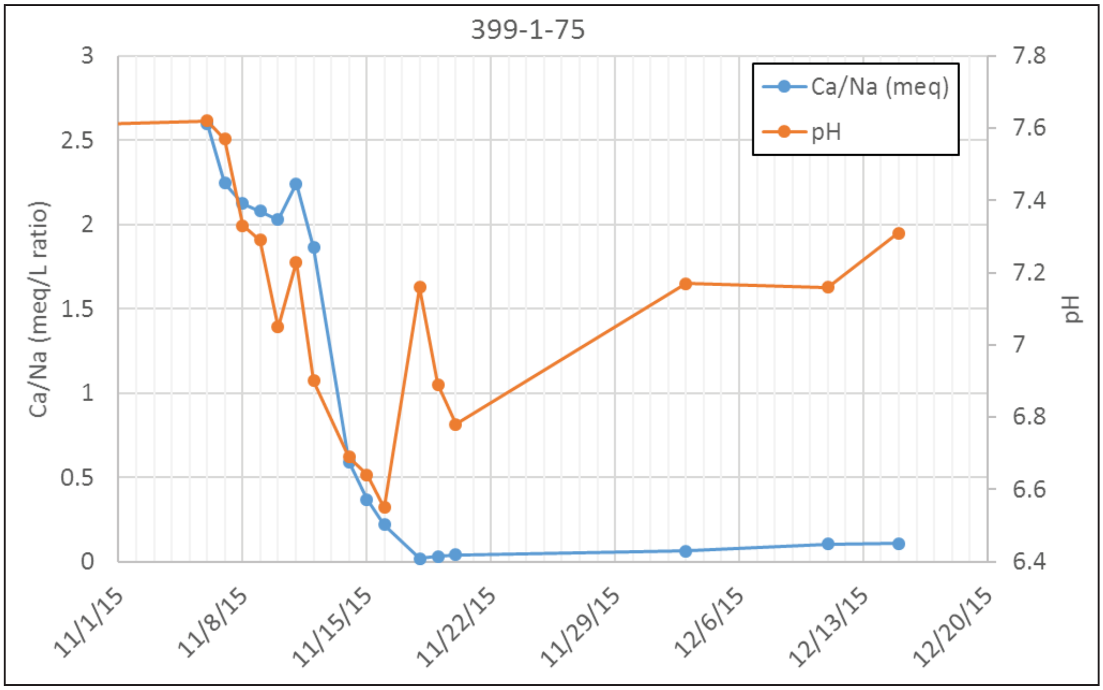
After 6.3 days, the reaction front has moved to about 4 to 5 m (13.1 to 16.4 ft) depth (below infiltration lines). Uranium concentrations shows a steep decline at the reaction front. Other ions, such as Ca^{2+} and Fe^{2+} show a similar behavior as seen for previous time. The dominant HPO_4^{2-} species also remain the same; however, the pH decline is no longer that steep and the lowest pH value is around 6.4 that occurs at depth of about 5 m (16.4 ft). By the end of 7.8 days, the front has moved only a little distance (~0.5 m [1.6 ft]) compared to its location at 6.3 days but the pH profile shows some recovery from ongoing buffering reactions, however, the pH remains lower in the region of 6 to 7 m (19.7 to 22.9 ft) depth. Behind the reaction front the pH shows a gradual increase indicating that the deprotonation reactions have slowed compared to proton consuming reactions, such as formation of surface species of phosphate and mineral dissolution of carbonates. After 10.2 days, the reaction front profile does not show much of a change compared to 7.8 days. This is because the infiltration stopped on the 9th day and, therefore, there is no advective transport in the model. The pH continues to climb gradually behind the reaction front and the surface complexed species of phosphate are the dominant species. The pH at a depth of 8 m (26.2 ft), which is also the end of the vadose zone, is around 6.5, indicating some reaction with leading edge of phosphate ions.

The majority of the phosphate remains within the depth of 0 to 6 m (0 to 19.7 ft) and does not show any breakthrough at the end of the vadose zone. At and beyond the reaction front, the uranium concentration remained low. By end of 8th day, about one pore volume has been flushed. This can be seen by the concentration profile of Br^- that is simulated as a conservative tracer. The breakthrough profile shows that more than half the initial concentration of Br^- reaches the end of the vadose zone by about 8 days.

The simulated results help explain the observations of the post-treatment sequential leach test samples taken at various depths. Dissolution of U, Ca, Fe, and Mn from oxides and clay mineral phases was inferred due to observed reduction in fraction extractable by the strong nitric acid with corresponding increase in the fraction associated with the carbonates (weak and strong acetic acid extraction) indicating re-precipitation. In addition, the simulated results are consistent with the reduction in pH observed during daily monitoring of the PRZ wells. Figure B-6 presents the observations from the two PRZ wells (399-1-81 and 399-1-75) located within the Stage A area. The pH declines during the infiltration period (November 7 through 15) while the Ca/Na concentration ratio (in terms of meq/L concentration) show a continued decline as Na bearing fluids move through the vadose zone. Similar qualitative behavior is seen in the simulated results where the Na concentrations continue to rise. Figure B-7 presents the observations in terms of uranium and phosphate concentrations for the same two PRZ wells. During the infiltration time period (November 7 through 15), the uranium concentrations show an initial increase followed by sharp decline while the phosphate concentrations remain negligibly small. The initial increase in uranium could be partially due to dissolution of mineral phases in order to buffer the pH change. The increase in phosphate observed after November 15 is due to start of PRZ and aquifer injections. Small increase prior to November 15 may be due to either phosphate arriving from prior aquifer injection (November 9) or due to breakthrough of phosphate from infiltration at this time. The initial increase in uranium followed by decline and negligible phosphate in the PRZ along with declining pH and Ca/Na ratio all are consistent with the simulated results.

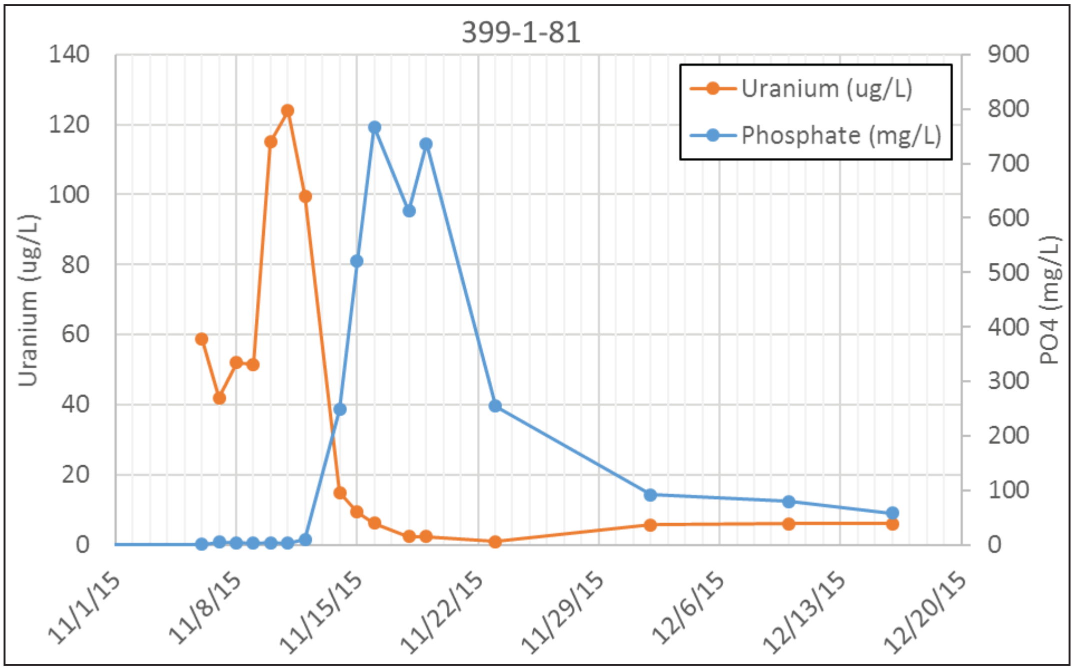
While the simulated results are qualitatively similar and provide useful understanding of the system behavior, they are not directly comparable to the observations due to various simplifications made for conducting the simulations: the concentration of the infiltrated solution was fixed over the 9-day time period even though considerable variability was observed as shown in Figure 6-3 in terms of phosphate concentrations. In addition, the linear pore water velocity was held constant at 1 m/day even though variability exists due to variable rates of infiltration (Table 6-1) and from field-scale heterogeneities observed from ERT images.





Note: The ratio of Ca/Na concentrations (in terms of meq/L) is shown on the left, while pH is shown on the right side.

Figure B-6. Observations from Daily Monitoring of PRZ Wells 399-1-81 and 399-1-75



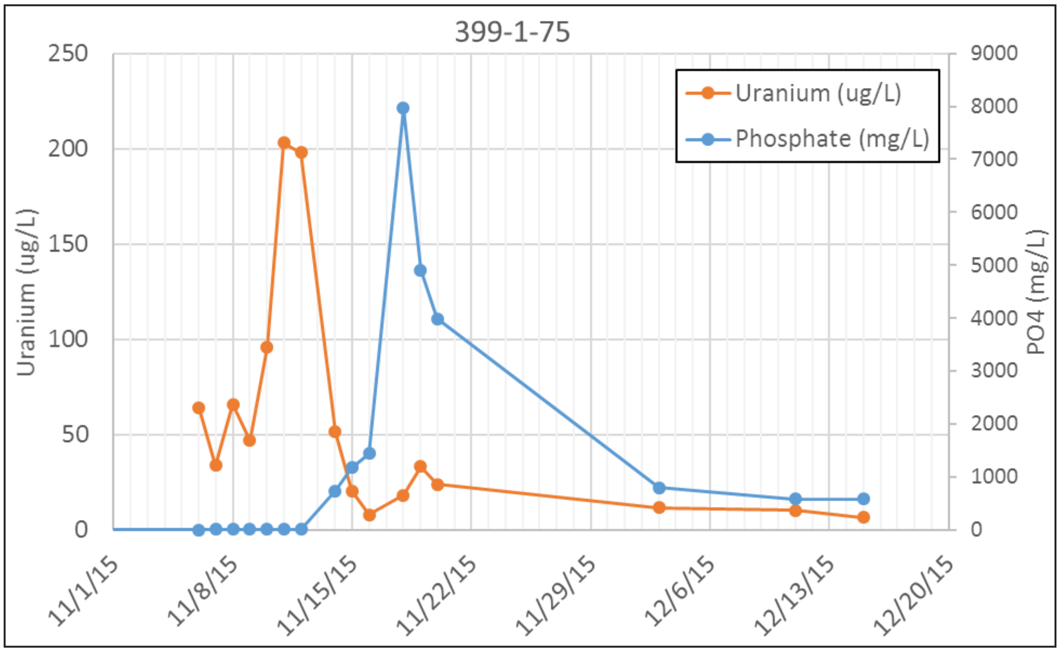


Figure B-7. Observations from Daily Monitoring of PRZ Wells 399-1-81 and 399-1-75 for Uranium and Phosphate Concentrations

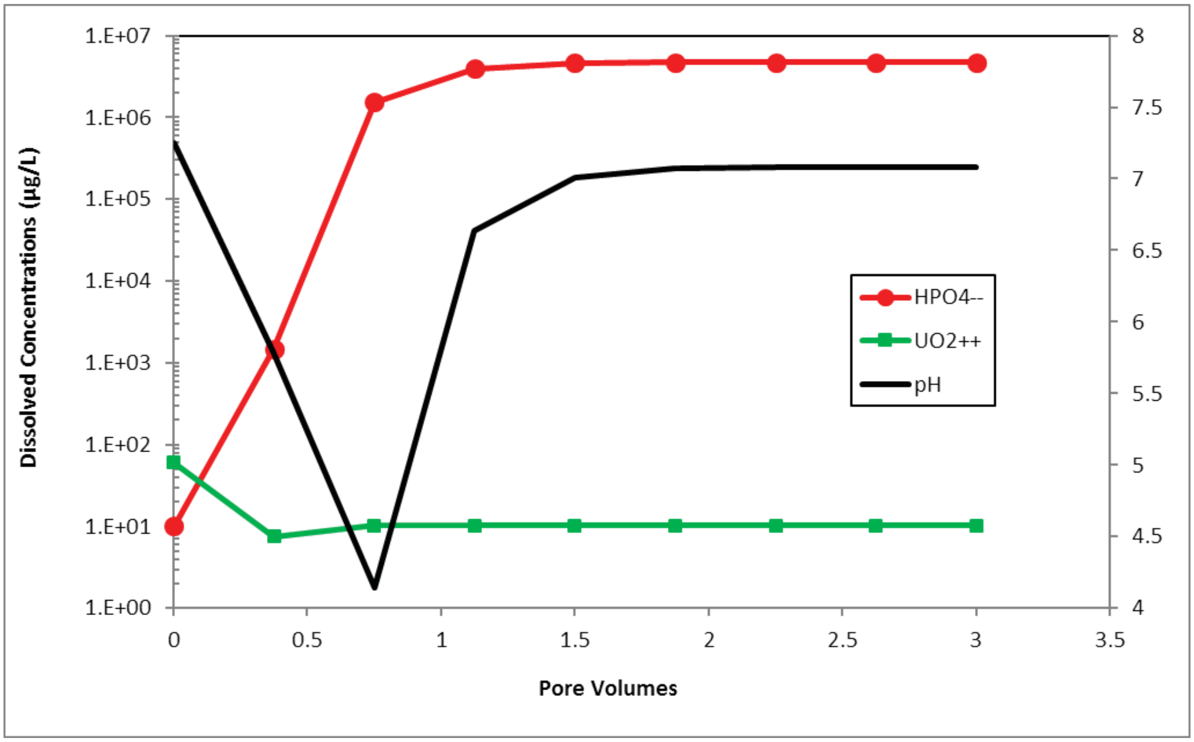


Figure B-8. Simulated Results of Conducting Injection

To simulate the effects of injection, a simplified calculation was made where the model setup for the infiltration (as discussed earlier) was used, but the flow rate was increased by a factor of 10. Results are presented in Figure B-8 for a distance located about 5 m (16.4 ft) from the injection point. The results are shown in terms of pore volumes at that location. HPO_4^{2-} concentrations increase quickly, while uranium concentrations go down and reach the background levels (~10 µg/L). The pH also reduces due to phosphate injection and resulting reactions but quickly recovers and reaches the value of injected solution.

B2 References

Appelo, C.A.J. and D. Postma, 2005, *Geochemistry, Groundwater and Pollution*, 2nd Edition, A.A. Balkema Publishers, Leiden, The Netherlands.

Blum, Alex E. and Lisa L. Stillings, 1995, “Feldspar Dissolution Kinetics,” Chapter 7 in *Chemical Weathering Rates of Silicate Minerals*, A.F. White and S.L Brantley (Eds.), Mineralogical Society of America, *Reviews in Mineralogy* 31(1):291-352.

Bruggenwert, M.G.M. and A. Kamphorst, 1982, “Chapter 5: Survey of Experimental Information on Cation Exchange in Soil Systems,” in *Soil Chemistry*: *B. Physico-Chemical Models*, *Developments in Soil Science* 5(B):141-203.

Carrol, Susan A. and John V. Walther, 1990, “Kaolinite Dissolution at 25°, 60°, and 80°C,” *American Journal of Science* 290:797-810. Available at: http://earth.geology.yale.edu/~ajs/1990/07.1990.02Carroll.pdf.

Dzombak, David A. and François M.M. Morel, 1990, *Surface Complexation Modeling: Hydrous Ferric Oxide*, John Wiley & Sons, Inc., New York.

ECF-300FF5-11-0151, 2012, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS*, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078650H

Gaines, George L. and Henry C. Thomas, 1953, "Adsorption Studies on Clay Minerals. II. A Formulation of the Thermodynamics of Exchange Adsorption," *J. Chem. Phys.* 21:714-718.

Gao, Yan and Alfonso Mucci, 2001, "Acid Base Reactions, Phosphate and Arsenate Complexation, and their Competitive Adsorption at the Surface of Goethite in 0.7 M NaCl Solution," *Geochimica et Cosmochimica Acta* 65(14):2361-2378.

Gorman-Lewis, Drew, Peter C. Burns, and Jeremy B. Fein, 2008, "Review of uranyl mineral solubility measurements," *J. Chem. Thermodynamics* 40:335-352. Available at: http://www3.nd.edu/~fein/Publications/Gorman-Lewis%20JThermo%20(40)335.pdf.

Gorman-Lewis, D., T. Shvareva, K. Kubatko, P.C. Burns, D.M. Wellman, B. McNamara, J.E. Szymanowski, A. Navrotsky, and J.B. Fein, 2009, "Thermodynamic Properties of Autunite, Uranyl Hydrogen Phosphate, and Uranyl Orthophosphate from Solubility and Calorimetric Measurements," *Environ. Sci. Technol*. 43:7416-7422. Available at: http://www3.nd.edu/~fein/Publications/Gorman-Lewis%20EST%20(43)7416.pdf.

Leamnson, R.N., Josephus Thomas, Jr., and H.P. Ehrlinger III, 1969, *A Study of the Surface Areas of Particulate Microcrystalline Silica and Silica Sand*, Circular 444, Illinois State Geological Survey, Urbana, Illinois. Available at: https://www.ideals.illinois.edu/bitstream/handle/2142/44623/studyofsurfacear444leam.pdf?sequence=2.

Nagy, Kathryn L., 1995, "Dissolution and Precipitation Kinetics of Sheet Silicates," Chapter 5 in *Chemical Weathering Rates of Silicate Minerals*, A.F. White and S.L Brantley (Eds.), Mineralogical Society of America, *Reviews in Mineralogy* 31(1):173-234.

Palandri, James L. and Yousif K. Kharaka, 2004, *A Compilation of Rate Parameters of Water-Mineral Interaction Kinetics for Application to Geochemical Modeling*, U.S. Geological Survey Open File Report 2004-1068, U.S. Geological Survey, Menlo Park, California. Available at: https://pubs.usgs.gov/of/2004/1068/pdf/OFR_2004_1068.pdf.

PNNL-17818, 2008, *300 Area Treatability Test: Laboratory Development of Polyphosphate Remediation Technology for In Situ Treatment of Uranium Contamination in the Vadose Zone and Capillary Fringe*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17818.pdf.

PNNL-20004, 2010, *Remediation of Uranium in the Hanford Vadose Zone Using Ammonia Gas: FY 2010 Laboratory-Scale Experiments*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20004.pdf.

PNNL-21733, 2012, *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21733.pdf.

Rimstidt, J.D. and H.L. Barnes, 1980, "The Kinetics of Silica-Water Reactions," *Geochimica et Cosmochimica Acta* 44(11):1683-1699.

Spiteri, Claudette, Philippe Van Cappellen, and Pierre Regnier, 2008, “Surface complexation effects on phosphate adsorption to ferric iron oxyhydroxides along pH and salinity gradients in estuaries and coastal aquifers,” *Geochimica et Cosmochimica Acta* 72(14):3431-3445. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.9074&rep=rep1&type=pdf.

Wellman, Dawn M., Eric M. Pierce, and Michelle M. Valenta, 2007, “Efficacy of soluble sodium tripolyphosphate amendments for the in-situ immobilisation of uranium,” *Environ. Chem.* 4(5):293-300.

Appendix C

Mathematical Model for Estimating Kinetic Sorption-Desorption Parameters

This page intentionally left blank.

C1 Introduction

The flow-through column tests performed to evaluate the leaching behavior of uranium provide useful information for quantifying the desorption rates. A single-site kinetic sorption-desorption model is developed to estimate the kinetic rates. The mathematical model (ECF-300FF5-11-0151, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS*) describes the transport of a solute by dispersion and advection with kinetic sorption between the liquid and solid phases. The kinetic sorption is modeled by both a forward reaction rate from the liquid phase to the solid phase and a reverse reaction rate from solid to liquid. The geometry is represented by a one-dimensional column with length (L). The mathematical model consists of mass balance equations for both the dissolved and solid concentrations. The dissolved mass balance equation is as follows:

$$\theta \frac{\partial C}{\partial t} = \theta D \frac{\partial^2 C}{\partial z^2} - v \frac{\partial C}{\partial z} - \rho_b \frac{\partial q}{\partial t}, \quad 0 < z < L \qquad \textbf{Eq. 1}$$

where the z-axis is oriented along the length of the column. The solid mass balance or sorption kinetic equation is as follows:

$$\rho_b \frac{\partial q}{\partial t} = \alpha_f \theta C - \alpha_r \rho_b q \qquad \textbf{Eq. 2}$$

The forward/reverse reaction rates satisfy the relation:

$$\alpha_f = \alpha_r K_d \left(\frac{\rho_b}{\theta} \right) \qquad \textbf{Eq. 3}$$

where:

C: dissolved concentration $[\mu gm\ of\ U / cm^3\ of\ water]$

q: sorbed concentration, $[\mu gm\ of\ U / gm\ of\ solid]$

θ: water content, water volume/bulk volume [dimensionless]

v: Darcy velocity, water volume/area/time $[cm/hr]$

D: dispersion coefficient $[cm^2/hr]$

ρ_b: bulk density, matrix mass/bulk volume $[gm/cm^3]$

α_f: forward reaction rate (sorption) $[hr^{-1}]$

α_r: reverse reaction rate (desorption) $[hr^{-1}]$

K_d: equilibrium constant, volume water/matrix mass $[cm^3/gm]$

The sorption kinetic equation (Eq. 2) can be expressed in terms of only the reverse reaction rate by the reaction rate relation (Eq. 3). The sorption kinetic equation is written as follows:

$$\frac{\partial q}{\partial t} = \alpha_r K_d C - \alpha_r q$$ **Eq. 4**

If Q_{inj} denotes the water injection rate, then the discharge or Darcy velocity is equal to the water injection rate per unit area normal to flow direction.

The model assumes that there is no dispersion across the upper and lower boundary of the column. The bromide experiments have an initial concentration of zero within the column. At the top boundary, an influent with known bromide concentration is maintained over time. The effluent concentration exiting the bottom of the column represents the experimental measured concentration.

The uranium experiments have zero concentration of influent, while initially the column contains uranium in both dissolved and solid states. The transport and kinetic sorption are in equilibrium initially. This implies that the dissolved and solid concentrations are constant throughout the column. At initial time, the solid concentration in equilibrium with the dissolved concentration requires the following:

$$\frac{\partial q}{\partial t}(z,0) = 0$$

which from Eqs. 2 and 3 implies the initial condition for the solid concentration: $q(z,0) = K_d C(z,0)$

The experimental results are presented as dissolved concentration a function of cumulative water pore volumes. The relation between time and pore volumes during flow periods is as follows:

$$PVs = \frac{Q_{inj} t}{\theta V_{bulk}}$$

where:

$Q_{inj} = water\ injection\ rate\ [cm^3 / hr]$

$t = time\ [hr]$

$V_{bulk} = column bulk\ volume\ [cm^3]$

C1.1 Numerical Model for Kinetic Sorption-Desorption Parameter Derivation

The mathematical model is approximated by a finite difference scheme. Consider a finite difference discretization of space and time. Let the index I denote the spatial cell index, i = 1, 2, …, N_z, where N_z is the number of grid cells. Let the time discretization be denoted $0 = t_0 < t_1 < t_2 < \ldots < t_{N_t}$, where N_t is the number of time steps. The discretization is fully implicit and uses approximations, which are first order for time derivatives, first order upstream weighting for advective transport, and second order for dispersive transport. The discretization for the ith cell and time step from t_n to t_{n+1} for the sorption kinetics, Eq. 4, is as follows:

$$\rho_b \frac{q_i^{n+1} - q_i^n}{\Delta t} = \alpha_r \rho_b K_d C_i^{n+1} - \alpha_r \rho_b q_i^{n+1} \qquad \textbf{Eq. 5}$$

Solve Eq. 5 for the sorbed concentration yields as follows:

$$q_i^{n+1} = \frac{\alpha_r \Delta t K_d}{1 + \alpha_r \Delta t} C_i^{n+1} + \frac{1}{1 + \alpha_r \Delta t} q_i^n \qquad \textbf{Eq. 6}$$

Now discretize the transport equation (Eq. 1), and substitute for q_i^{n+1} the expression in Eq. 6. Expressing the resulting difference equation in tridiagonal form yields the following:

$$\begin{aligned} -\left(\frac{\theta D}{\Delta z^2} + \frac{v}{\Delta z}\right) C_{i-1}^{n+1} + \left(\frac{2\theta D}{\Delta z^2} + \frac{v}{\Delta z} + \frac{\theta}{\Delta t} + \frac{\alpha_r \rho_b K_d}{1 + \alpha_r \Delta t}\right) C_i^{n+1} - \frac{\theta D}{\Delta z^2} C_{i+1}^{n+1} \\ = \frac{\theta}{\Delta t} C_i^n + \frac{\alpha_r \rho_b}{1 + \alpha_r \Delta t} q_i^n \end{aligned} \qquad \textbf{Eq. 7}$$

This system of equations uses known information at the beginning of the time step, C_i^n and q_i^n, to calculate the water concentrations C_i^{n+1}. Once the dissolved concentrations are computed, Eq. 6 provides the sorbed concentrations q_i^{n+1}. Appropriate boundary conditions are applied at the upper and lower boundary cells. The initial data are as follows:

$$C(z,0) = C_{initial} \text{ and } q(z,0) = K_d C(z,0) = q_{initial}$$

For the uranium leach experiments, a no flow condition at the upper cell (influent) is imposed for both dispersive and advective transport. At the lower boundary, there is no dispersive transport out of the column. The advective mass transport at the lower boundary of the column ($i = N_z$) is computed as follows:

$$Q_{inj} \Delta t C_{Nz}^{n+1}$$

C1.2 Determination of Kinetic Sorption-Desorption Parameters

A MATLAB computer model representing the numerical model was implemented (an example presented in Appendix B). The following information was obtained from the experimental test setup:

- Column length
- Column diameter
- Water content
- Injection rate
- Soil bulk density

These parameters are provided for all samples in Table 6-5. Dispersion coefficient was estimated as $D = 10^{-3} cm^2 / hr$ for all cases.

For the uranium tests, the initial water concentration is estimated from the early time experimental results. The fitting parameters include the partition coefficient, K_d , and the reverse reaction rate, f_r . The forward sorption rate is computed from Eq. 3. At initial time it is assumed that the liquid/solid concentrations are in equilibrium; consequently, the initial solid concentration is $q(z,0) = K_d C(z,0)$. The history match of the experimental data is obtained by manually adjusting the partition coefficient and the reverse reaction rate until a best fit of the experimental data is obtained.

The nonsorbing bromide simulations assume that the initial column concentration is zero, and the influent has a specified dissolved concentration. Since bromide is nonsorbing, the partition coefficient is zero; consequently, both the forward and reverse reaction rates are zero. The bromide transport properties are all known, and the bromide simulations require no history matching process.

C1.3 Simulation Results

Four column experiments were run with a fine grain soil (<2 mm soil) for which the coarse grains were removed. These four fine grain (<2 mm size) soil sample tests were denoted as B347F1F3, B347P5P8, B247R1, and B347T7 (Table 6-5). Three field-textured (bulk) soil tests were denoted as B347P4, B347R0, and B347T6 (Table 6-5). Results for these seven sample cases were obtained for both bromide (nonsorbing) and uranium (sorbing).

A summary for all samples of the history match results for the kinetic reaction parameters is provided in Table C-1. The parameters include the initial dissolved concentration, partition coefficient, and reverse reaction rate determined from the history match of the sample data. The forward reaction rate is computed from Eq. 3.

Table C-1. Kinetic Reaction Parameters Used to History Match Post-Treatment Uranium Leach Experiments

Sample Number	Soil Type	Initial Dissolved Concentration (µg/cm^3)	K$_d$ (cm^3/g)	Reverse Rate (1/hr)	Forward Rate (1/hr)
B347F1F3	Fine Grain (<2 mm)	0.02	9	0.009	0.361
B347P5P8	Fine Grain (<2 mm)	25	0.30	0.07	0.095
B347P4	Field-Textured (Bulk)	2.7	0.40	0.03	0.108

Table C-1. Kinetic Reaction Parameters Used to History Match Post-Treatment Uranium Leach Experiments

Sample Number	Soil Type	Initial Dissolved Concentration (μg/cm^3)	K_d (cm^3/g)	Reverse Rate (1/hr)	Forward Rate (1/hr)
B247R1	Fine Grain (<2 mm)	4.6	1.2	0.06	0.381
B347R0	Field-Textured (Bulk)	4.0	0.3	0.06	0.222
B347T7	Fine Grain (<2 mm)	0.007	5	0.017	0.436
B347T6	Field-Textured (Bulk)	0.016	0.98	0.019	0.288

C1.3.1 Sample B347F1F3 Fine Grain (<2 mm Size) Soil

Input and simulation results for sample B347F1F3 fine grain (<2 mm size) soil with bromide transport are shown in Table C-2 and Figure C-1, respectively. The numerical model results are in good agreement with the experimental results. The dissolved concentration on input have units of μg/cm^3 but are reported in Figure C-1 with μg/L units. This is the case for all subsequent results.

Table C-2. Input Parameters for Sample B347F1F3 Fine Grain (<2 mm Size) Soil with Bromide Transport

Column Length (cm)	15
Column Diameter (cm)	2.5
Number of Spatial Grid Cells	50
Time Step Size (hr)	0.1
Water Content (Dimensionless)	0.37
Dispersion (cm^2/hr)	0.001
Water Injection Rate (cm^3/hr)	5.53
Injection Stream Concentration (μg/cm^3)	0.05
Initial Concentration (μg/cm^3)	0

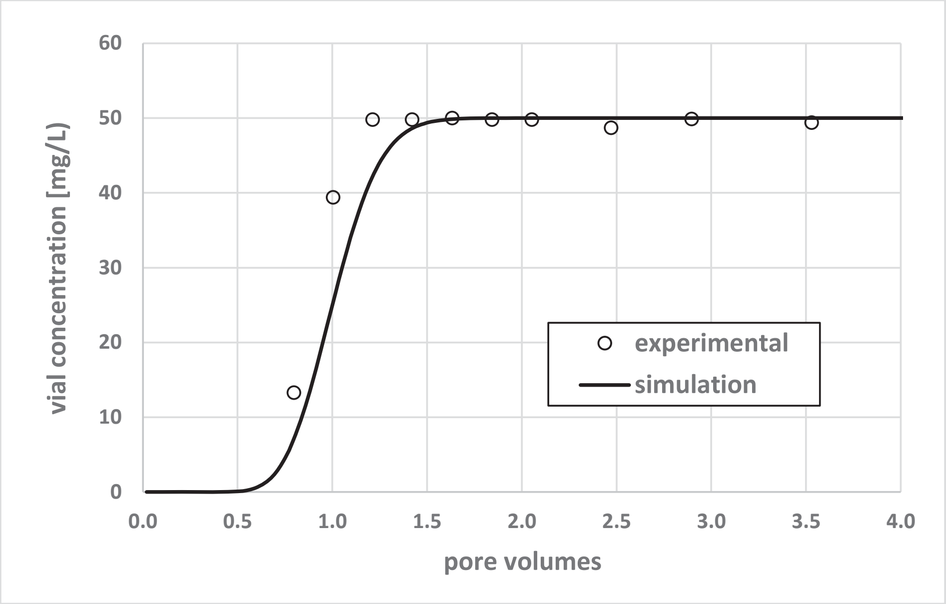


Figure C-1. Sample B347F1F3 Fine Grain (<2 mm Size) Soil with Bromide Transport

Input and simulation results for sample B347F1F3 fine grain (<2 mm size) soil with uranium transport are shown in Table C-3 and Figure C-2, respectively. Table C-3 provides the input data, together with the partition coefficient and reverse sorption rate, which yields the best fit of experimental data.
The simulation results in Figure C-2 show some disparity with the experimental results.
The concentration responses for the first 4 to 5 pore volumes are completely different. The experimental results start at a low concentration and increase, while the numerical simulation concentration decays from the initial concentration.

Table C-3. Input Parameters, Partition Coefficient, and Reverse Sorption Rate for Sample B347F1F3 Fine Grain (<2 mm Size) Soil with Uranium Transport

Column Length (cm)	15
Column Diameter (cm)	2.5
Number of Spatial Cells	50
Time Step (hr)	0.825
Water Content	0.372
Injection Rate (cm^3/hr)	5.53
Diffusion Coefficient (cm^2/hr)	0.001
Soil Bulk Density (g/cm^3)	1.66
K_d (cm^3/g)	9
Initial Water Concentration (µg/cm^3)	0.02
Initial Solid Concentration (µg/g)	0.18
Reverse Sorption Rate (1/hr)	0.0090
Forward Sorption Rate (1/hr)	0.361

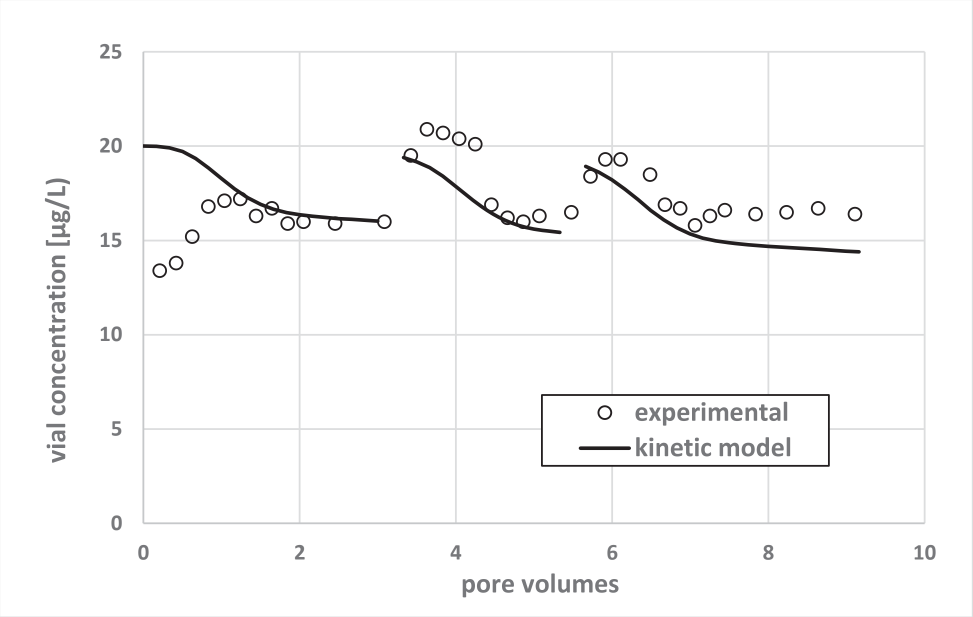


Figure C-2. Sample B347F1F3 Fine Grain (<2 mm size) Soil with Uranium Transport

C1.3.2 Sample B347P5P8 Fine Grain (<2 mm Size) Soil

Input and simulation results for sample B347P5P8 fine grain (<2 mm size) soil with bromide transport are shown in Table C-4 and Figure C-3, respectively. The simulation results are in good agreement with the experimental results.

Table C-4. Input Parameters for Sample B347P5P8 Fine Grain (<2 mm Size) Soil with Bromide Transport

Column Length (cm)	15
Column Diameter (cm)	2.5
Number of Spatial Grid Cells	50
Time Step Size (hr)	0.06
Water Content (Dimensionless)	0.22
Dispersion (cm^2/hr)	0.001
Water Injection Rate (cm^3/hr)	5.53
Injection Stream Concentration (µg/cm^3)	0.05
Initial Concentration (µg/cm^3)	0

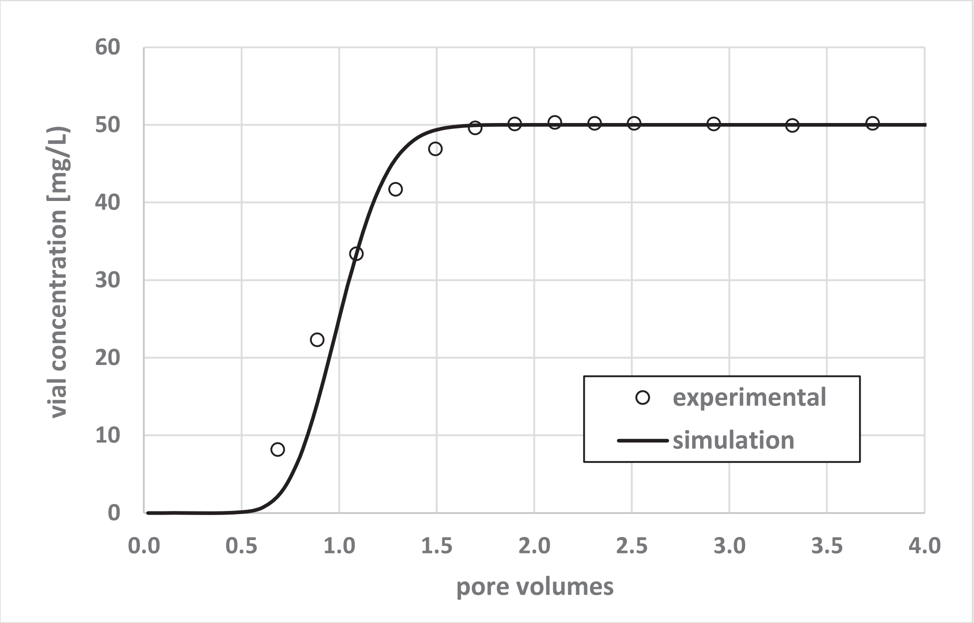


Figure C-3. Sample B347P5P8 Fine Grain (<2 mm Size) Soil with Bromide Transport

Input and simulation results for sample B347P5P8 fine grain (<2 mm size) soil and uranium transport are shown in Table C-5 and Figure C-4, respectively. Table C-4 provides the input data, together with the partition coefficient and reverse sorption rate, which yields the best fit of experimental data. The simulation is in good agreement with the experimental data.

Table C-5. Input Parameters and Reverse Sorption Rate for Sample B347P5P8 Fine Grain (<2 mm Size) Soil with Uranium Transport

Column Length (cm)	15
Column Diameter (cm)	2.5
Number of Spatial Cells	50
Time Step (hr)	0.85
Water Content	0.380
Injection Rate (cm^3/hr)	5.54
Diffusion Coefficient (cm^2/hr)	0.001
Soil Bulk Density (g/cm^3)	1.72
K_d (cm^3/g)	0.3
Initial Water Concentration (µg/cm^3)	25
Initial Solid Concentration (µg/g)	7.5
Reverse Sorption Rate (1/hr)	0.07
Forward Sorption Rate (1/hr)	0.095

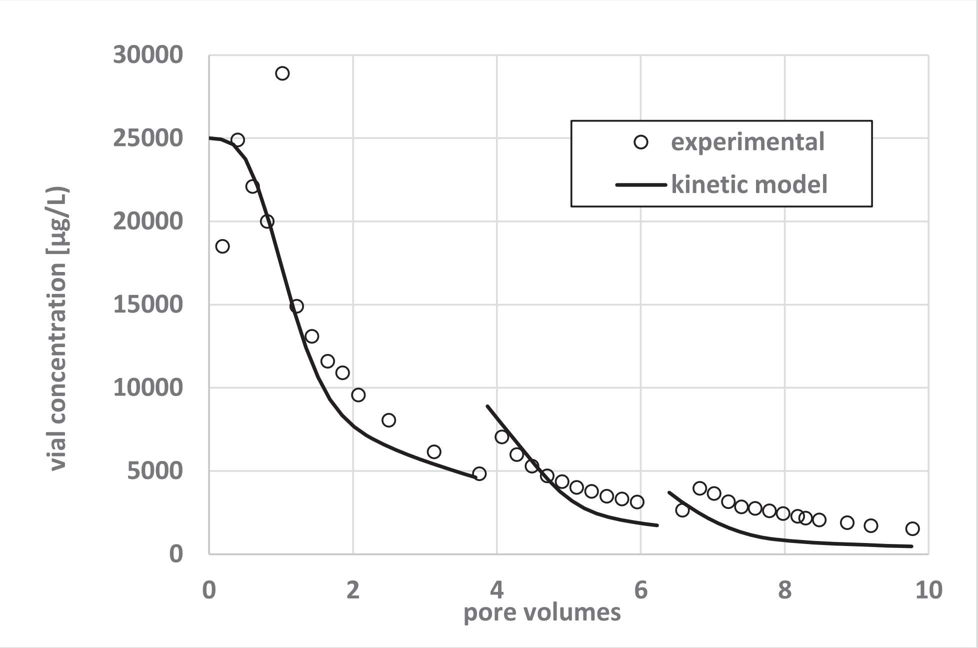


Figure C-4. Sample B345P5P8 Fine Grain (<2 mm Size) Soil with Uranium Transport

C1.3.3 Sample B347P4 Field-Textured (Bulk) Soil

Input and simulation results for sample B347P4 field-textured (bulk) soil with bromide transport are shown in Table C-6 and Figure C-5, respectively. The simulation results and experimental results both approach the injection concentration of 50 µg/L. The simulation concentration results match the observations.

Table C-6. Input Parameters for Sample B347P4 Field-Textured (Bulk) Soil with Bromide Transport

Column Length (cm)	13.2
Column Diameter (cm)	9.53
Number of Spatial Grid Cells	50
Time Step Size (hr)	0.14
Water Content (Dimensionless)	0.22
Dispersion (cm^2/hr)	0.001
Water Injection Rate (cm^3/hr)	74.4
Injection Stream Concentration (µg/cm^3)	0.05
Initial Concentration (µg/cm^3)	0

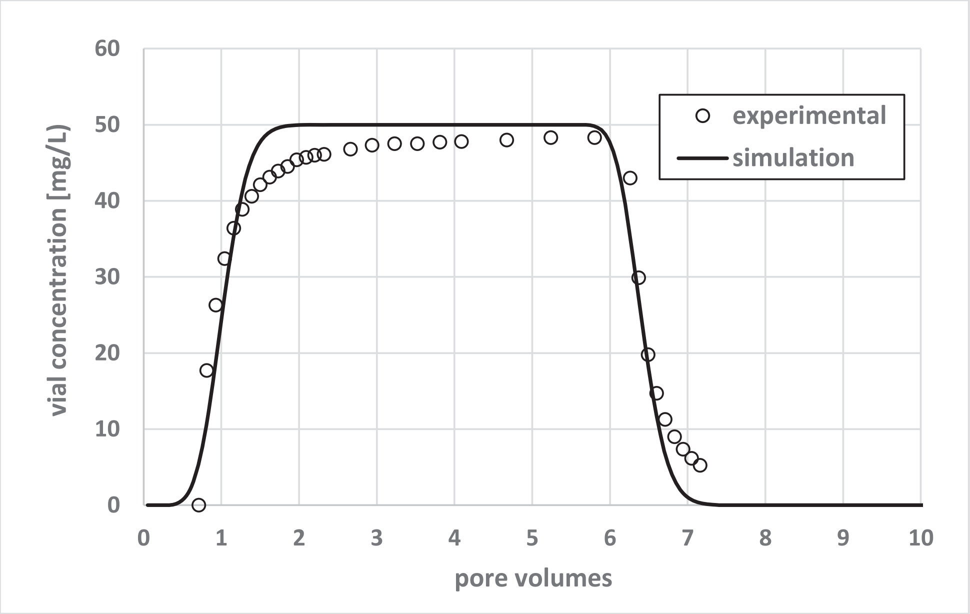


Figure C-5. Sample B347P4 Field-Textured (Bulk) Soil with Bromide Transport

Input and simulation results for sample B347P4 field-textured (bulk) soil with uranium transport are shown in Table C-7 and Figure C-6, respectively. Table C-6 provides the input data, together with the partition coefficient and the reverse sorption rate, which yields the best fit of experimental data. The simulation is in good agreement with the experimental data.

Table C-7. Input Parameters and Reverse Sorption Rate for Sample B347P4 Field-Textured (Bulk) Soil with Uranium Transport

Column Length (cm)	13.2
Column Diameter (cm)	9.53
Number of Spatial Cells	50
Time Step (hr)	0.835
Water Content	0.228
Injection Rate (cm^3/hr)	74.2
Diffusion Coefficient (cm^2/hr)	0.001
Soil Bulk Density (g/cm^3)	2.05
K_d (cm^3/g)	0.40
Initial Water Concentration (µg/cm^3)	2.7
Initial Solid Concentration (µg/g)	1.08
Reverse Sorption Rate (1/hr)	0.030
Forward Sorption Rate (1/hr)	0.108

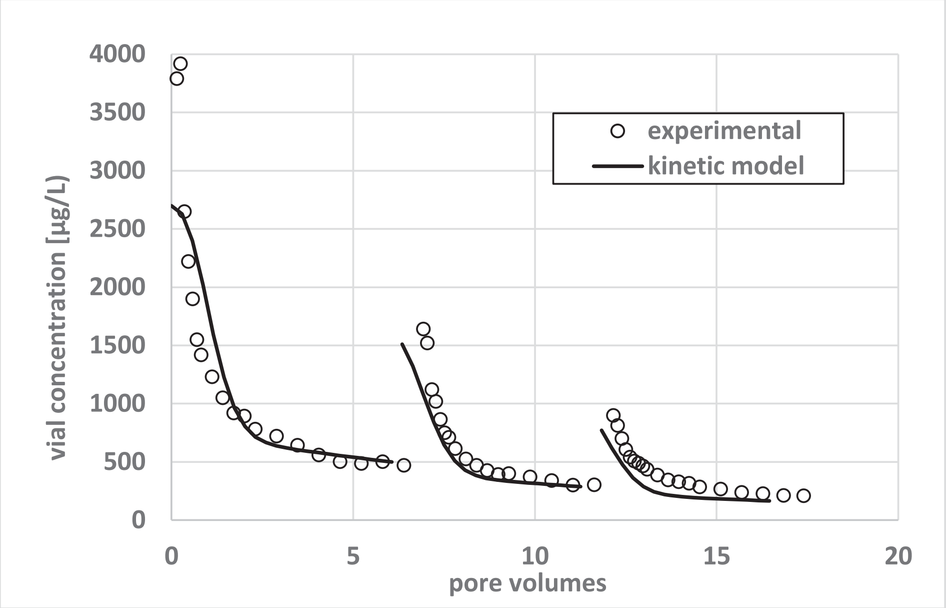


Figure C-6. B347P4 Field-Textured (Bulk) Soil with Uranium Transport

C1.3.4 Sample B347R1 Fine Grain (<2 mm Size) Soil

Input and simulation results for sample B347R1 fine grain (<2 mm size) soil and bromide transport are shown in Table C-8 and Figure C-7, respectively. The simulation results and experimental results both approach the injection concentration of 50 µg/L with very good agreement between the simulation model and the experimental data.

Table C-8. Input Parameters for Sample B347R1 Fine Grain (<2 mm Size) Soil with Bromide Transport

Column Length (cm)	15
Column Diameter (cm)	2.5
Number of Spatial Grid Cells	50
Time Step Size (hr)	0.1
Water Content	0.34
Dispersion (cm^2/hr)	0.001
Water Injection Rate (cm^3/hr)	5.7
Injection Stream Concentration (µg/cm^3)	0.05
Initial Concentration (µg/cm^3)	0

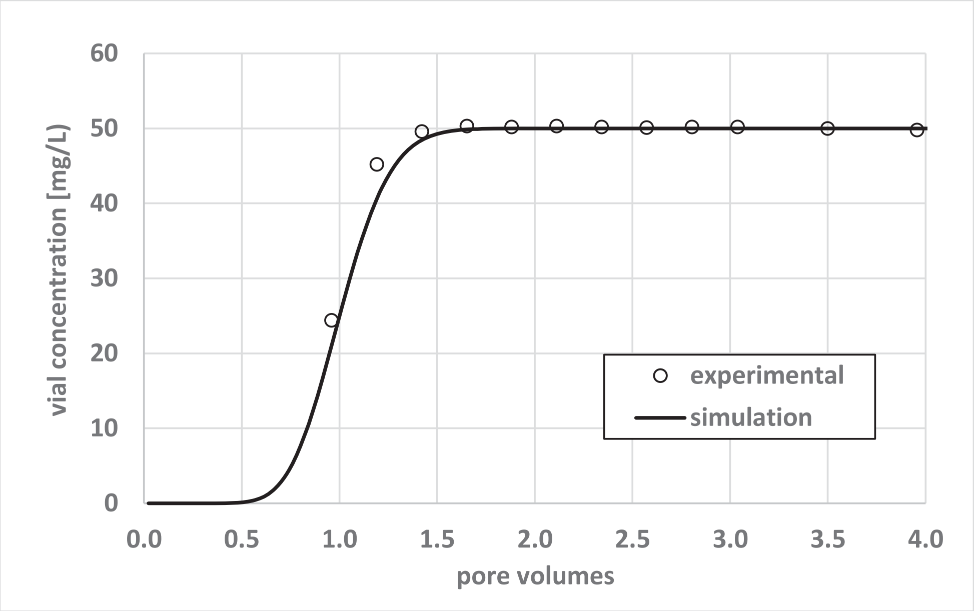


Figure C-7. Sample B347R1 Field-Textured (Bulk) Soil with Bromide Transport

Input and simulation results for sample B347R1 field-textured (bulk) soil and uranium transport are shown in Table C-9 and Figure C-8, respectively. Table C-9 provides the input data, together with the partition coefficient and reverse sorption rate, which yields the best fit of experimental data. The results in Figure C-8 are in good agreement with the observations.

Table C-9. Input Parameters and Reverse Sorption Rate for Sample B347R1 Fine Grain (<2 mm Size) Soil with Uranium Transport

Column Length (cm)	15
Column Diameter (cm)	2.5
Number of Spatial Cells	50
Time Step (hr)	0.825
Water Content	0.338
Injection Rate (cm^3/hr)	5.69
Diffusion Coefficient (cm^2/hr)	0.001
Soil Bulk Density (g/cm^3)	1.79
K_d (cm^3/g)	1.2
Initial Water Concentration (μg/cm^3)	4.6
Initial Solid Concentration (μg/g)	5.52
Reverse Sorption Rate (1/hr)	0.06
Forward Sorption Rate (1/hr)	0.381

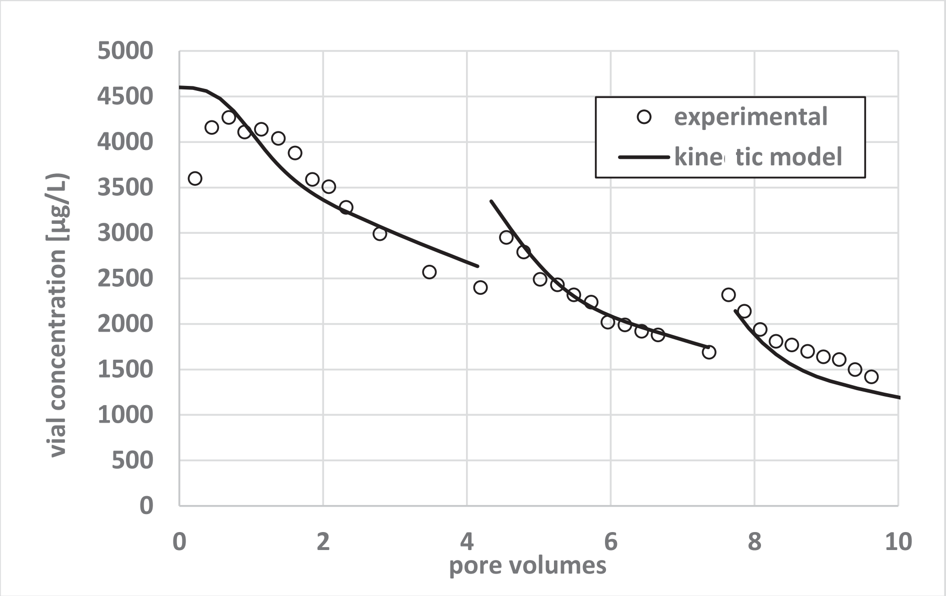


Figure C-8. Input Parameters and Reverse Sorption Rate for Sample B347R1 Fine Grain (<2 mm Size) Soil with Uranium Transport

C1.3.5 Sample B347R0 Field-Textured (Bulk) Soil

Input and simulation results for sample B347R0 are shown in Table C-10 and Figure C-9. The agreement is good between the simulated model results and experimental data.

Table C-10. Input Parameters for B347R0 Field-Textured (Bulk) Soil with Bromide Transport

Column Length (cm)	14
Column Diameter (cm)	9.53
Number of Spatial Grid Cells	50
Time Step Size (hr)	0.115
Water Content	0.17
Dispersion (cm^2/hr)	0.001
Water Injection Rate (cm^3/hr)	74.5
Injection Stream Concentration (µg/cm^3)	0.05
Initial Concentration (µg/cm^3)	0

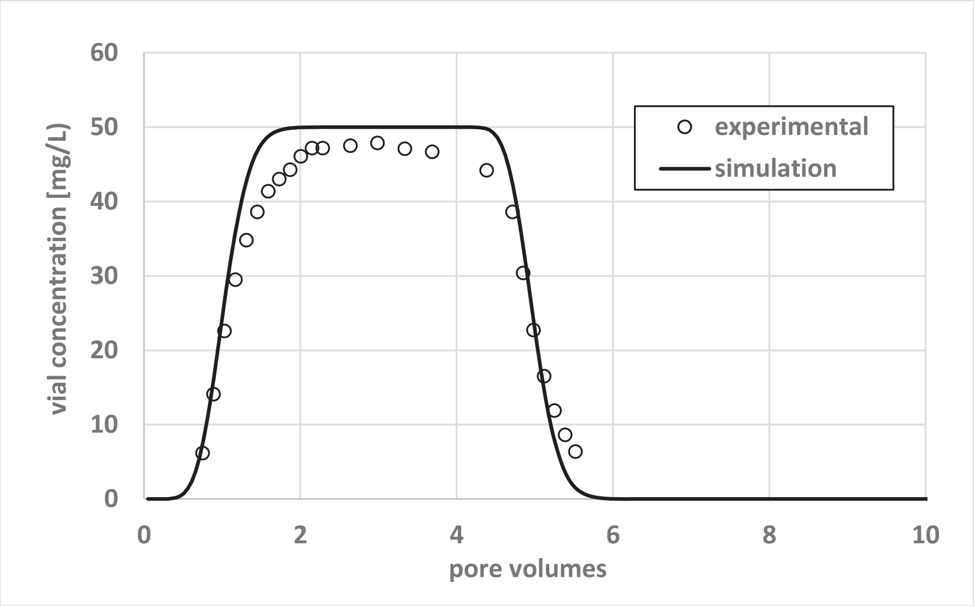


Figure C-9. Sample B347R0 Field-Textured (Bulk) Soil with Bromide Transport

Input and simulation results for sample B347R0 field-textured (bulk) soil with uranium transport are shown in Table C-11 and Figure C-10, respectively. Table C-11 provides the input data, together with the partition coefficient and the reverse sorption rate, which yields the best fit of experimental data. The results in Figure C-10 are in good agreement over the first 10 pore volumes.

Table C-11. Input Parameters and Reverse Sorption Rate for Sample B347R0 Field-Textured (Bulk) Soil with Uranium Transport

Column Length (cm)	14
Column Diameter (cm)	9.53
Number of Spatial Cells	50
Time Step (hr)	0.75
Water Content	0.177
Injection Rate (cm^3/hr)	74.5
Diffusion Coefficient (cm^2/hr)	0.001
Soil Bulk Density (g/cm^3)	2.18
K_d (cm^3/g)	0.3
Initial Water Concentration (µg/cm^3)	4.0
Initial Solid concentration (µg/g)	1.2
Reverse Rate (1/hr)	0.06
Forward Rate (1/hr)	0.222

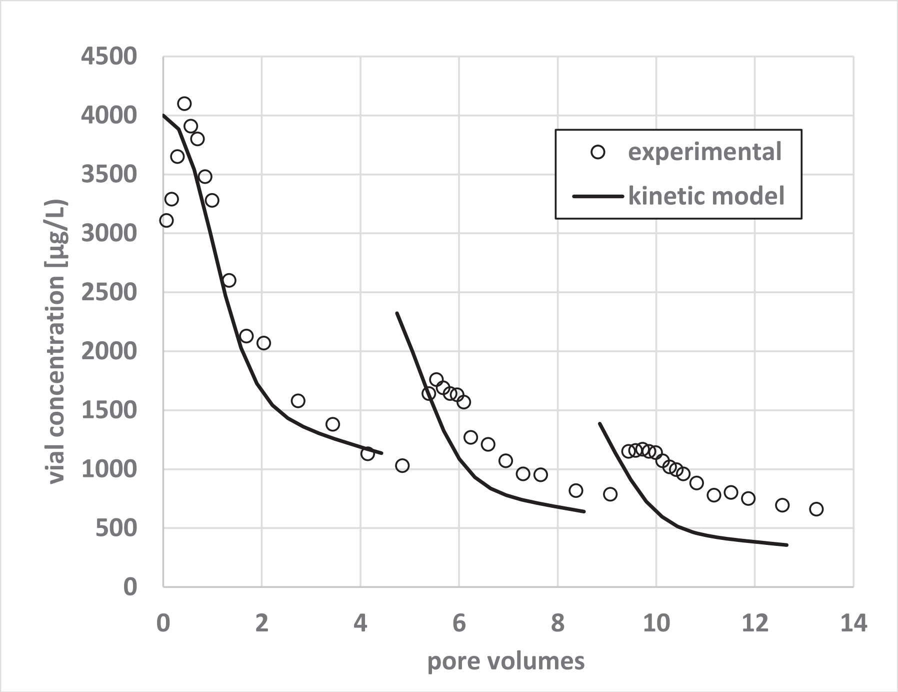


Figure C-10. Sample B347R0 Field-Textured (Bulk) Soil with Uranium Transport

C1.3.6 Sample B347T7 Fine Grain (<2 mm Size) Soil

Input and simulation results for sample B347T7 are shown in Table C-12 and Figure C-11, respectively. The agreement is excellent between the simulation model results and experimental data.

Table C-12. Input Parameters for Sample B347T7 Fine Grain (<2 mm Size) Soil with Bromide Transport

Column Length (cm)	15
Column Diameter (cm)	2.5
Number of Spatial Grid Cells	50
Time Step Size (hr)	0.1
Water Content	0.35
Dispersion (cm^2/hr)	0.001
Water Injection Rate (cm^3/hr)	5.58
Injection Stream Concentration (µg/cm^3)	0.05
Initial Concentration (µg/cm^3)	0

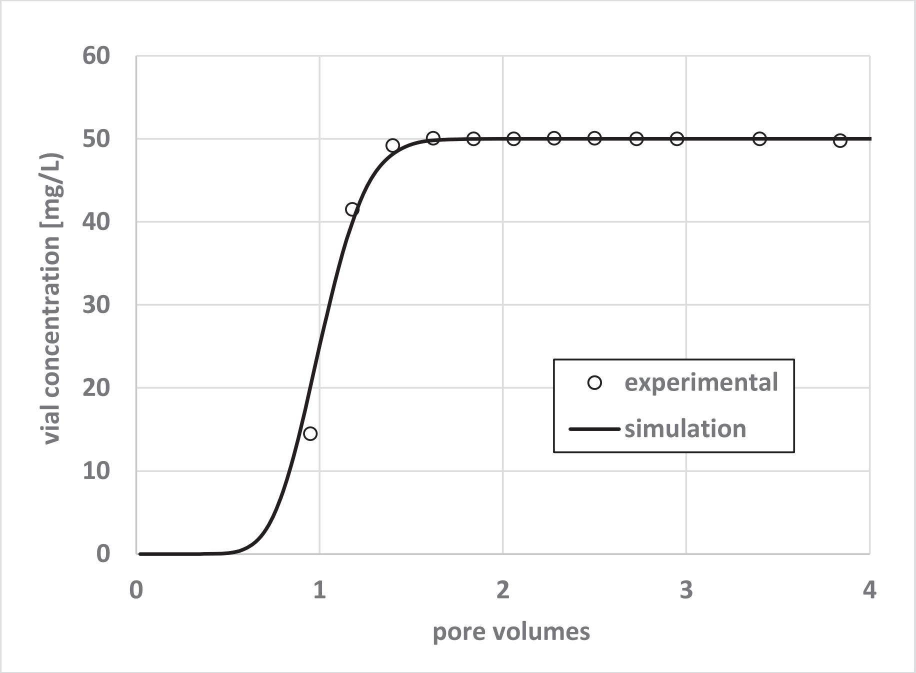


Figure C-11. Sample B347T7 Fine Grain (<2 mm Size) Soil with Bromide Transport

Input and simulation results for sample B347T7 field-textured (bulk) soil with uranium transport are shown in Table C-13 and Figure C-12, respectively. Table C-13 provides the input data, together with the partition coefficient and reverse sorption rate, which yields the best fit of experimental data. The results in Figure C-12 are in good agreement during most of the simulation. Concentrations remain low and vary within a narrow range over multiple pore volumes.

Table C-13. Input Parameters and Sorption Rates for Sample B347T7 Fine Grain (<2 mm Size) Soil with Uranium Transport

Column Length (cm)	15
Column Diameter (cm)	2.5
Number of Spatial Cells	50
Time Step (hr)	0.875
Water Content	0.347
Injection Rate (cm^3/hr)	5.61
Diffusion Coefficient (cm^2/hr)	0.001
Soil Bulk Density (g/cm^3)	1.78
K_d (cm^3/g)	5
Initial Water Concentration (µg/cm^3)	0.007
Initial Solid Concentration (µg/g)	0.035
Reverse Rate (1/hr)	0.017
Forward Rate (1/hr)	0.2

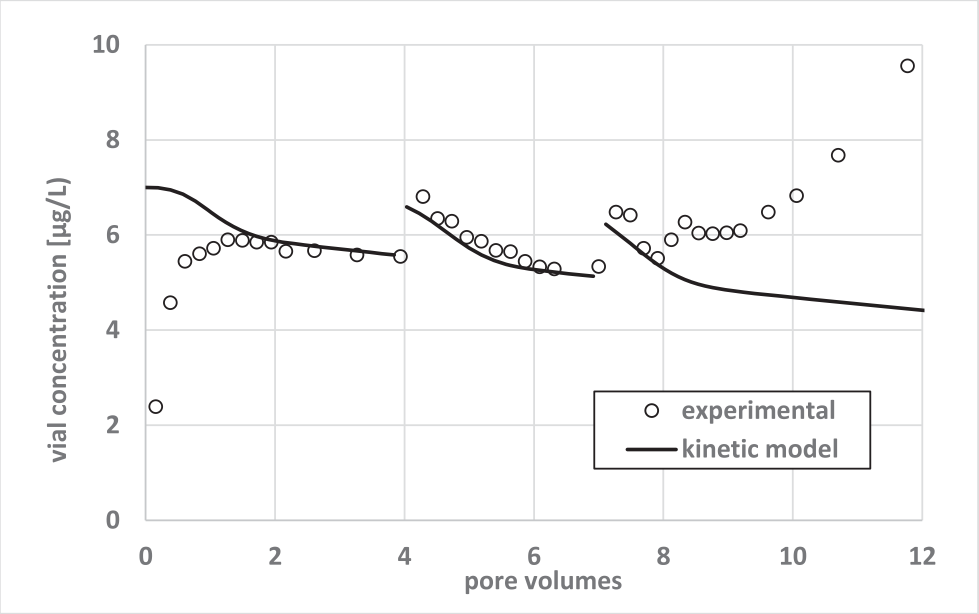


Figure C-12. Sample B347T7 Fine Grain (<2 mm Size) Soil with Uranium Transport

C1.3.7 Sample B347T6 Field-Textured (Bulk) Soil

Input and simulation results for sample B347T6 field-textured (bulk) soil with bromide transport are shown in Table C-14 and Figure C-13, respectively. The results in Figure C-13 show some disparity between the simulation results and experimental data, but qualitatively the behavior is in agreement.

Table C-14. Input Parameters and Sorption Rates for Sample B347T6 Field-Textured (Bulk) Soil with Bromide Transport

Column Length (cm)	13.7
Column Diameter (cm)	9.53
Number of Spatial Grid Cells	50
Time Step Size (hr)	0.065
Water Content	0.14
Dispersion (cm^2/hr)	0.001
Water Injection Rate (cm^3/hr)	72.7
Injection Stream Concentration (µg/cm^3)	0.05
Initial Concentration (µg/cm^3)	0

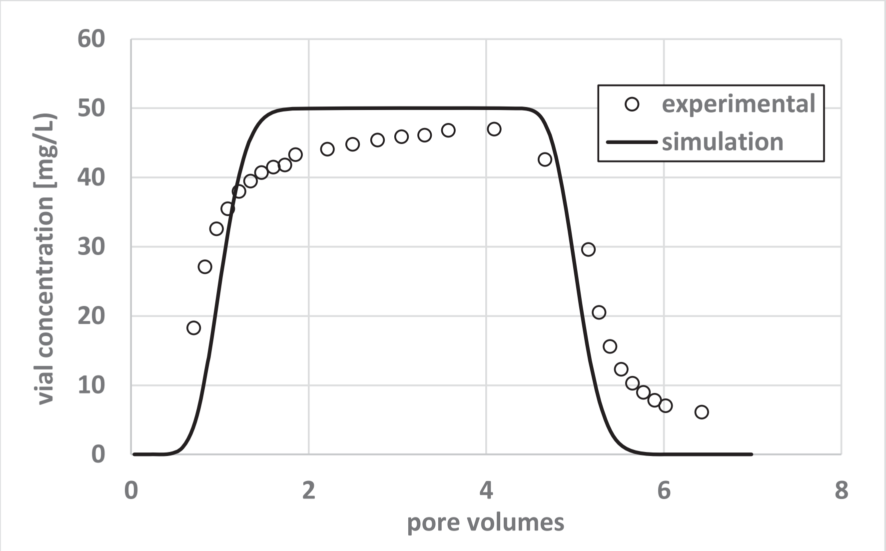


Figure C-13. Sample B347T6 Field-Textured (Bulk) Soil with Bromide Transport

Input and simulation results for sample B347T6 field-textured (bulk) soil with uranium transport are shown in Table C-15 and Figure C-14, respectively. Table C-15 provides the input data, together with the partition coefficient and the reverse sorption rate, which yields the best fit of experimental data.
The results in Figure C-14 are in good agreement over first 10 pore volumes. The increase in concentration observed after 10 pore volumes may be related to dissolution of additional uranium bearing mineral phases.

Table C-15. Input Parameters and Sorption Rates for Sample B347T6 Field-Textured (Bulk) Soil and Uranium Transport

Column Length (cm)	13.7
Column Diameter (cm)	9.53
Number of Spatial Cells	50
Time Step (hr)	0.76
Water Content	0.146
Injection Rate (cm^3/hr)	72.7
Diffusion Coefficient (cm^2/hr)	0.001
Soil Bulk Density (g/cm^3)	2.26
K_d (cm^3/g)	0.98
Initial Water Concentration (µg/cm^3)	0.016
Initial Solid Concentration (µg/g)	0.01568
Reverse Rate (1/hr)	0.019
Forward Rate (1/hr)	0.288

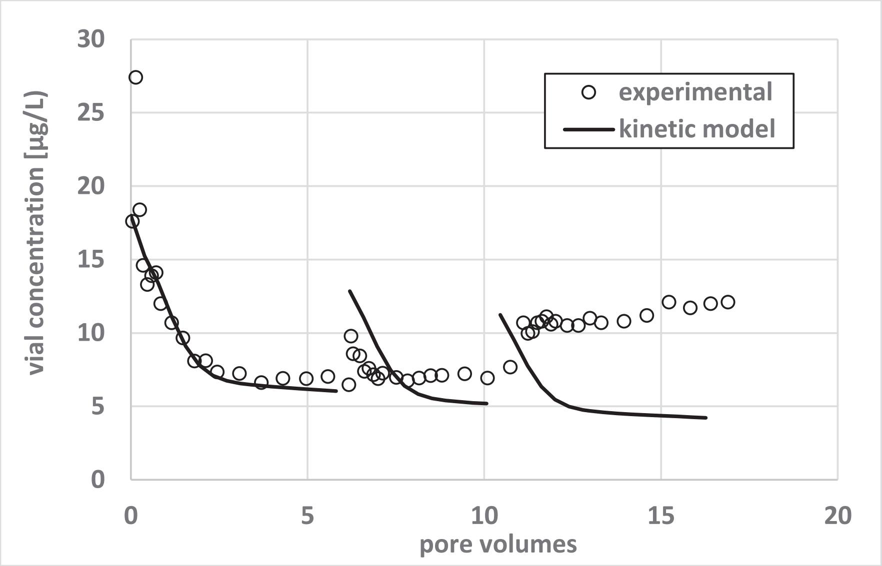


Figure C-14. Sample B347T6 Field-Textured (Bulk) Soil with Uranium Transport

C.2 Alternative Parameter Matching of Experimental Data

An alternative method for determination of kinetic sorption parameters assumes a value for the reverse reaction rate. The experimental data are matched by adjusting the partition coefficient (K_d) to provide the best fit to the data by the numerical model results. The value selected is taken to be representative of the reverse rates provided by Table C-1. An arithmetic average of the reverse rates for the seven samples in Table C-1 yields a value of 0.038/hr. A rounded up value of 0.03/hr is assigned as the reverse reaction rate for all samples. The partition coefficients, together with the reverse and forward reaction rates for the seven samples, are shown in Table C-16. Figures C-15 through C-21 show the model fits to the observed results, indicating reasonable matches. For some samples, the initial dissolved concentration was varied slightly from the Table C-1 values.

In this approach, since the reverse rate is fixed and fit is made by changing the K_d value that also affect the forward rate, comparing the K_d value among different samples provides insight into the variable leaching characteristics. By comparing the fine grain (<2 mm size) sediment results, B347F1F3 and B347T7 have K_d values that are about a factor of 5 to 10 greater than B347P5P8 and B247R1. For the field-textured (bulk) sediment samples, the K_d value for B347T6 is twice that of the other two bulk sediment samples (B347R0 and B347P4). The samples showing higher K_d values are located at periodically rewetted zone (PRZ) depths (Table 6-5) and have higher phosphate concentrations resulting from PRZ injections (and infiltration), as shown in Figure 6-17.

Table C-16. History Match Parameters for the Final Post-Treatment Uranium Leach Results with Reverse Reaction Rate of 0.03/Hr

Sample Number	Soil Type	Initial Dissolved Concentration (µg/cm^3)	K$_d$ (cm^3/G)	Reverse Rate (1/Hr)	Forward Rate (1/Hr)
B347F1F3	Fine Grain (<2 mm size)	0.018	5.0	0.03	0.67
B347P5P8	Fine Grain (<2 mm Size)	27	0.30	0.03	0.041
B347P4	Field-Textured (Bulk)	2.7	0.40	0.03	0.11
B247R1	Fine Grain (<2 mm Size)	4.6	1.4	0.03	0.22
B347R0	Field-Textured (Bulk)	4.0	0.4	0.03	0.15
B347T7	Fine Grain (<2 mm Size)	0.0065	4.0	0.03	0.62
B347T6	Field-Textured (Bulk)	0.016	0.70	0.03	0.33

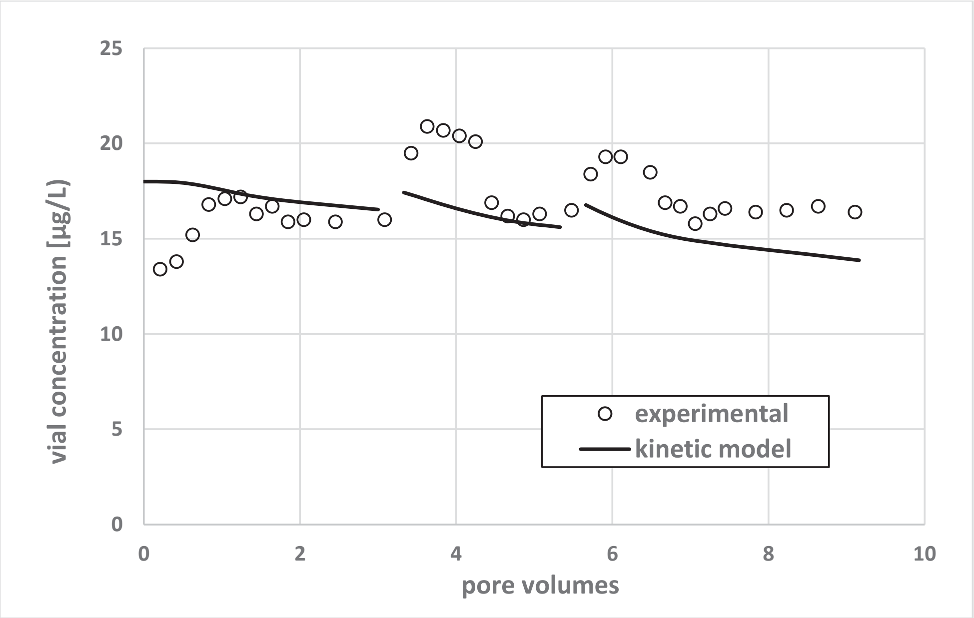


Figure C-15. Sample B347F1F3 Fine Grain (<2 mm Size) Soil with Uranium Transport; Reverse Rate = 0.03/Hr

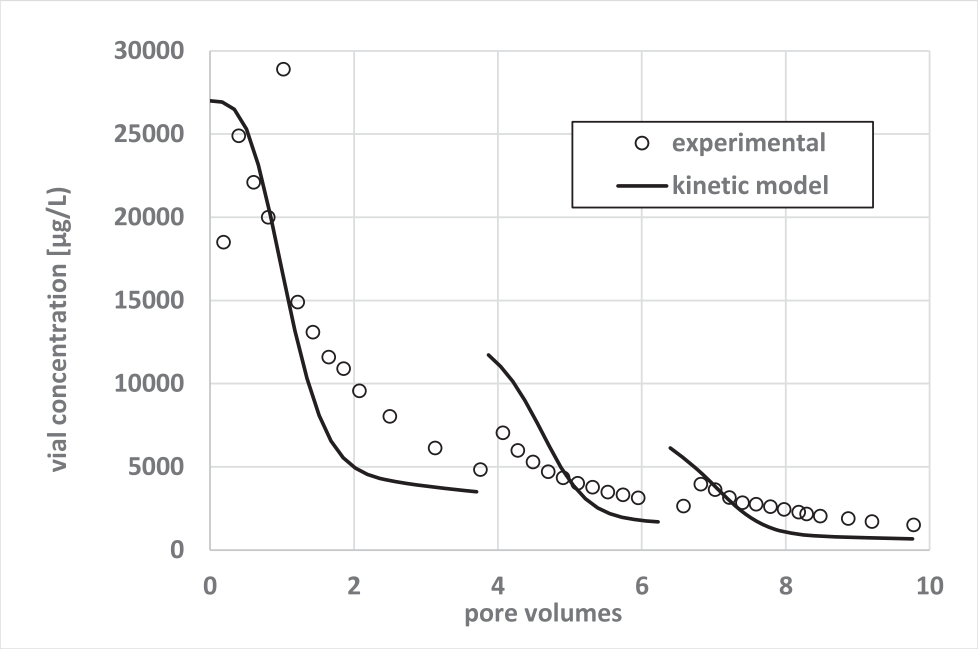


Figure C-16. Sample B345P5P8 Fine Grain (<2 mm Size) Soil with Uranium Transport; Reverse Rate = 0.03/Hr

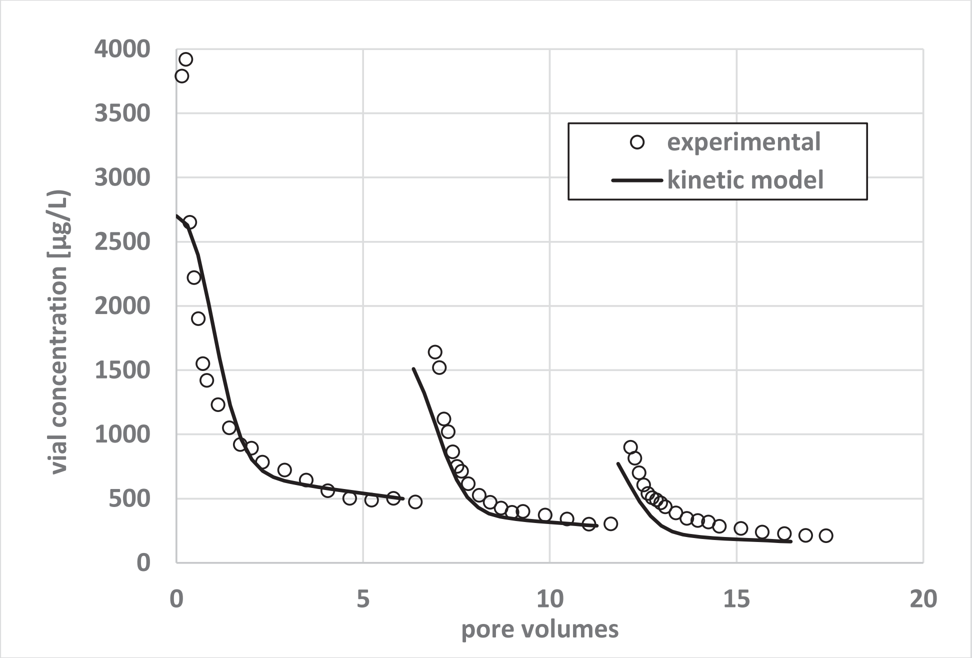


Figure C-17. B347P4 Field-Textured (Bulk) Soil with Uranium Transport; Reverse Rate = 0.03/Hr

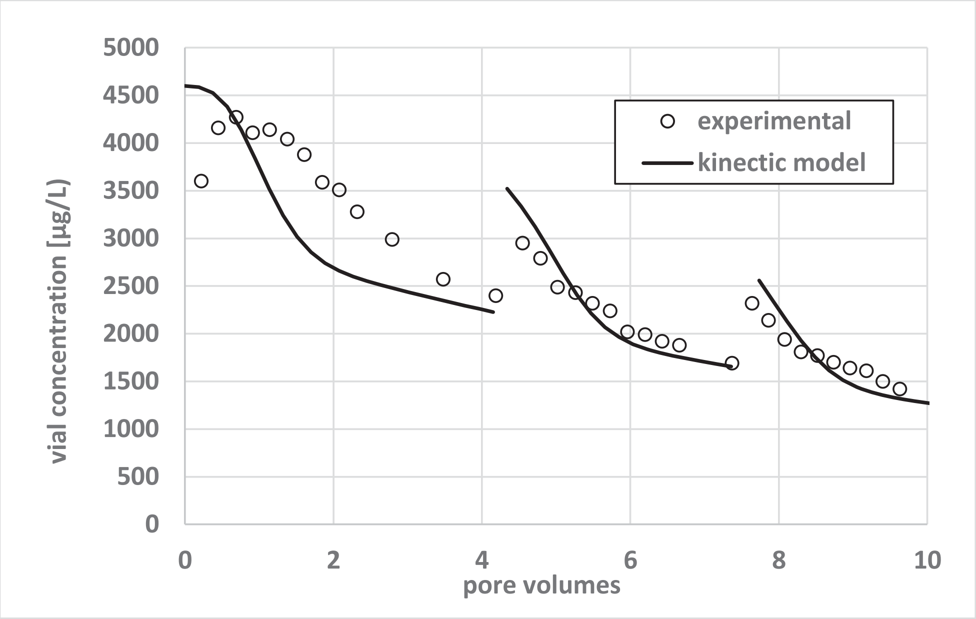


Figure C-18. B347R1 Fine Grain (<2 mm Size) Soil with Uranium Transport; Reverse Rate = 0.03/Hr

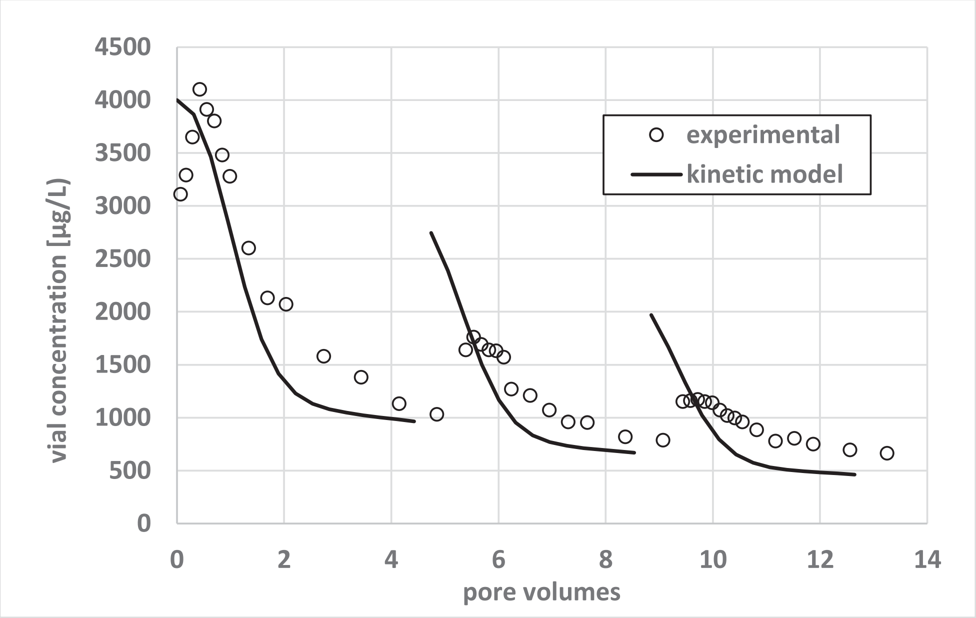


Figure C-19. Sample B347R0 Field-Textured (Bulk) Soil with Uranium Transport; Reverse Rate = 0.03/Hr

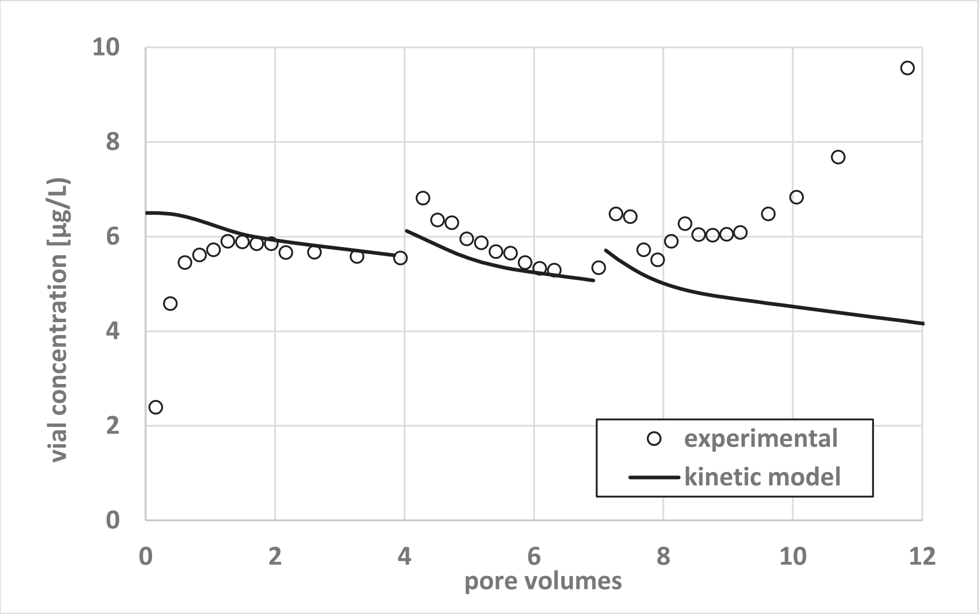


Figure C-20. Sample B347T7 Fine Grain (<2 mm Size) Soil with Uranium Transport; Reverse Rate = 0.03/Hr

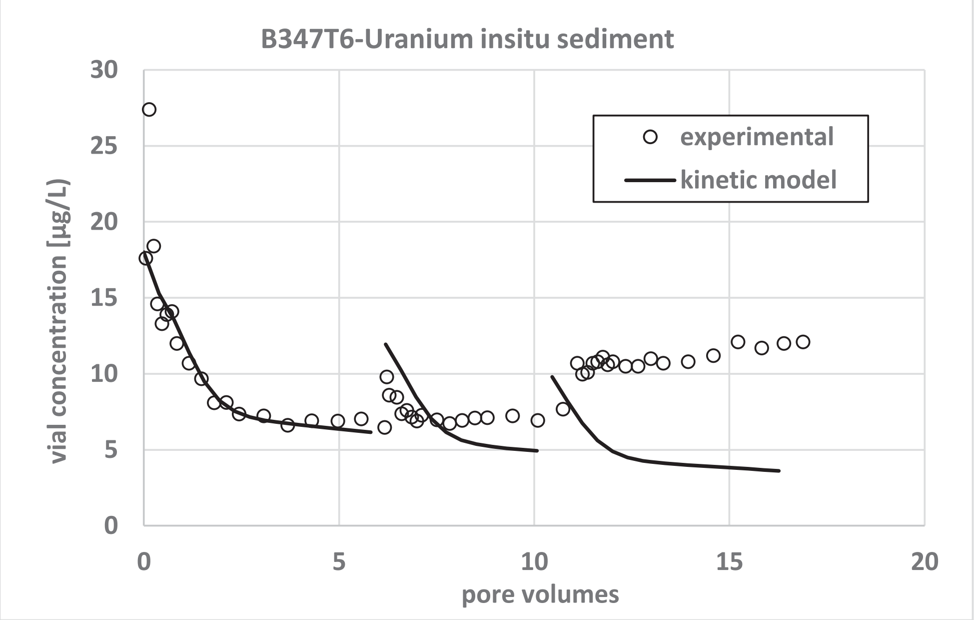


Figure C-21. Sample B347T6 Field-Textured (Bulk) Soil with Uranium Transport; Reverse Rate = 0.03/Hr

This page intentionally left blank.

Appendix D

MATLAB Files for Sample B347P4 Bulk Soil Kinetic Sorption Model Calculation

This page intentionally left blank.

D1 Introduction

The kinetic sorption model calculations were implemented as MATLAB® script using two files. The file “fd_transport.m” (finite difference transport) initially runs the input file “transport_data.m”. The input file initiates the necessary model input in MATLAB Workspace (i.e., memory). Inputs include the geometry of the column, soil properties, uranium sorption parameters, initial conditions, one-dimensional spatial discretization, and time step schedule. After execution of the input file, “fd_transport.m” calculates the concentration time history of uranium transport within the column and effluent exiting the column. Each script block is explained further in the comment lines (preceded by the percent [%] sign).

All experimental samples were conducted with two stop flow or shut-in events. The elapsed time during flow is computed by the volume per unit pore volume multiplied by the pore volumes and divided by the injection rate. During a stop flow event, the pore volumes are constant.

Concentrations are known at the beginning of a time step, and the numerical model calculation provides the concentrations at the end of the time step. The time step calculation uses matrix inversion and matrix/vector multiplication utilizing MATLAB built-in matrix functions. The resulting solution for the concentrations satisfies the finite difference equations for the uranium transport within the column subject to the initial concentrations and the boundary conditions at the upper and lower column boundaries. The time iteration continues to update these concentration profiles at all time steps. Within each time step, the evaluated concentrations and designed flows (injected pore volumes) are used to evaluate mass fluxes and check the mass balance. After each time step, the column effluent (exiting) concentration is stored, and a mass balance is calculated. Output is exported to a Microsoft Excel® file (e.g., “B347P4_insitu_U_Kinetic.xlsx”), which includes mass balance results, input parameters, and time history of the effluent concentration.

The Excel output file is designed with a preset graph to compare the simulated result with experimental data. Values for the relevant parameters are set, and the model is run. Model results are compared to experimental results, and model parameters are manually adjusted until a best fit of the experimental data is obtained. This history matching procedure is carried out for all relevant samples.

® MATLAB is a registered trademark of The MathLab, Inc., Natick, Massachusetts.

® Microsoft and Excel are registered trademarks of Microsoft Corporation, Redmond, Washington.

D2 MATLAB Input File Used to Match Uranium Leaching Sample B347P4 Experimental Results Using Single-Site Kinetic Sorption Model

File Name: Transport_Data.m

```
%Input data for Uranium kinetic sorption leaching model
%Reference Data: Rashid, H, Groundwater Flow and Uranium Transport Modeling in %Support
of the 300 Area FF-5 RI/FS Document, CHPRC/EP&SP, Oct. 2012.
%units internal to code:
%length[cm]
%time[hr]
%concentration[mmol/cm^3]
%mass[g]
%
%Input data for Uranium sample B347P4 bulk soil
%Reference Data: Rashid, H, Groundwater Flow and Uranium Transport Modeling
%in Support of the 300 Area FF-5 RI/FS Document, CHPRC/EP&SP, Oct. 2012.
%Reference data includes column geometry, water content, soil bulk density,
%injection rate, and dispersion coefficient.
%The Uranium input data is pre-processed from the reference data.
%units internal to code:
%length[cm]
%time[hr]
%concentration[micro-mol/cm^3]
%mass[g]
%
%column length [cm]
L = 13.2;
%discretization of column
Nz = 50;
delz = L/Nz;
z = zeros(Nz,1);
z(1) = 0.5*delz;
for i = 2:Nz
 z(i) = z(i-1) + delz;
end
%diameter of column [cm] and area normal to tranport [cm^2]
diameter_column = 9.53;
Az = pi()*(diameter_column/2)^2;
%cell bulk volume[cm^3]
Vol_total = Az*L;
%saturated water content (saturated porosity)
wtr_content = 0.228;
%volume water per pore volume
Vwtr_per_PV = wtr_content*Vol_total;
%
%Water injection rate [cm^3/hr]
inj_rate = 74.2;
%Darch velocity [cm/hr]
v = inj_rate/Az;
%Dispersion coefficient [cm^2/hr]
Dispersion = 1.E-3;
%
%bulk density [g/cm^3]
bulk_density = 2.05;
%
```

```
%sorption coefficient [cm^3-water/g-solid]
%if Kd_flag = 0, no sorption (bromide); otherwise sorption (U-238)
Kd_flag = 1;
if Kd_flag == 1;
 analyte = {'U-238'};
%Kd [ml/g = cm^3/g]
 K_d = 0.4;
else
 analyte = {'bromide'};
 K_d = 0;
end
%reverse reaction rate [1/hr]
rate_r = 3.E-2;
%forward reaction rate
rate_f = rate_r*K_d*bulk_density/wtr_content;
%conc_water_initial [micro-g-U/Vwtr]
conc_water_initial = 2.7;
%initial conditions [conc_solid: micro-g-U/g-solid]
conc_solid_initial = K_d*conc_water_initial;
initial_mass_solid = bulk_density*Vol_total*conc_solid_initial;
initial_mass_water = wtr_content*Vol_total*conc_water_initial;
%the *_old are the beginning of time step values. For 1st time step this is
%the initial values
conc_old = zeros(Nz,1);
conc_old_solid = zeros(Nz,1);
conc_old = conc_water_initial*ones(Nz,1);
conc_old_solid = conc_solid_initial*ones(Nz,1);
%initial mass in place
initial_massinplace = initial_mass_water + initial_mass_solid;
%
%time array [hr] and number of time steps
end_time = 167;
NT = 200;
delt = end_time/NT;
t = zeros(NT,1);
t(1) = delt;
%%
for it = 2:NT
 t(it) = t(it-1) + delt;
end
input = zeros(13,1);
%input includes transport parameters, numerical discretization, partition
%coefficient, initial concentrations, reverse and forward kinetic rates.
%input is written to output file B347P4_insitu_U_Kinetic
input = [L,diameter_column,Nz,delt,wtr_content,inj_rate,Dispersion,...
bulk_density,K_d,conc_water_initial,conc_solid_initial,rate_r,rate_f];
'fini transport_initial_data'
```

D3 MATLAB Transport File Used To Match Sample B347P4 Results Using Single-Site Kinetic Sorption Model File name: fd_transport.m

```
%Uranium transport calculation for Sample B347P4
%finite difference solution of advective/dispersive transport with
%kinetic sorption
%
clc
%clf
clear
format long
%read input data
%
transport_data
%
%
%initialize pore volumes
pore_volumes = zeros(NT,1);
vial_conc = zeros(NT,1);
balance_ke = zeros(NT,1);
balance_te = zeros(NT,1);
mass_wtr = zeros(NT,1);
mass_solid = zeros(NT,1);
mass_out = zeros(NT,1);
mass_wtr2 = zeros(NT,1);
mass_solid2 = zeros(NT,1);
%start time step loop
time = 0;
sol_mass = wtr_content*Az*delz*conc_water_initial;
for it = 1:NT
%
 conc = zeros(Nz,1);
 conc_solid = zeros(Nz,1);
 time = time + delt;
%1st shut-in period
 if 17.84 < time && time < 65.84
 v = 0;
 else
 v = inj_rate/Az;
 end
%2nd shut-in period
 if time > 70
 if 80.33 < time && time < 152.33
 v = 0;
 else
 v = inj_rate/Az;
 end
 end
%
%generate coefficient matrix.
 coef = zeros(Nz,Nz);
 A = -(wtr_content*Dispersion/delz/delz + v/delz);
 B = 2*wtr_content*Dispersion/delz/delz + v/delz + wtr_content/delt ...
 + rate_r*bulk_density*K_d/(1+rate_r*delt);
 C = - wtr_content*Dispersion/delz/delz;
 for i = 1:Nz
```

```
 if i == 1
 coef(i,i) = wtr_content*Dispersion/delz/delz + v/delz ...
 + wtr_content/delt + rate_r*bulk_density*K_d/(1+rate_r*delt);
 coef(i,i+1) = C;
 elseif i == Nz
 coef(i,i-1) = A;
 coef(i,i) = wtr_content*Dispersion/delz/delz + v/delz ...
 + wtr_content/delt + rate_r*bulk_density*K_d/(1+rate_r*delt);
 else
 coef(i,i-1) = A;
 coef(i,i) = B;
 coef(i,i+1) = C;
 end
 end
%compute inverse of coefficient matrix
 A_inv = zeros(Nz,Nz);
 A_inv = inv(coef);
%assign rhs vector
 rhs = zeros(Nz,1);
 for i = 1:Nz
 rhs(i) = wtr_content*conc_old(i)/delt ...
 + bulk_density*rate_r*conc_old_solid(i)/(1+rate_r*delt);
 end
%solution for water concentration
 conc = A_inv*rhs;
%solution for solid concentration
 for i = 1:Nz
 conc_solid(i) = (rate_r*delt*K_d*conc(i)/(1+rate_r*delt))...
 + conc_old_solid(i)/(1 + rate_r*delt);
 end
%mass balance kinectic equation and transport equation
 balance_ke(it) = 0;
 balance_te(it) = 0;
 mass_wtr(it) = 0;
 mass_solid(it) = 0;
 for i = 1:Nz;
 mass_ke = bulk_density*(conc_solid(i)-conc_old_solid(i))/delt...
 -rate_r*bulk_density*K_d*conc(i)...
 + rate_r*bulk_density*conc_solid(i);
 if i == 1
 mass_te = (wtr_content/delt)*(conc(i)-conc_old(i))...
 + (wtr_content*Dispersion/delz/delz)*(conc(i)-conc(i+1))...
 + (v/delz)*conc(i)...
 + (rate_r*bulk_density/(1+rate_r*delt))*(K_d*conc(i)-conc_old_solid(i));
 elseif i == Nz
 mass_te = (wtr_content/delt)*(conc(i)-conc_old(i))...
 + (wtr_content*Dispersion/delz/delz)*(conc(i)-conc(i-1))...
 + (v/delz)*(conc(i)-conc(i-1))...
 + (rate_r*bulk_density/(1+rate_r*delt))*(K_d*conc(i)-conc_old_solid(i));
 else
 mass_te = (wtr_content/delt)*(conc(i)-conc_old(i))...
 + (wtr_content*Dispersion/delz/delz)*(-conc(i-1)+2*conc(i)-conc(i+1))...
 + (v/delz)*(conc(i)-conc(i-1))...
 + (rate_r*bulk_density/(1+rate_r*delt))*(K_d*conc(i)-conc_old_solid(i));
 end
 if abs(mass_ke) > balance_ke(it)
 balance_ke(it) = abs(mass_ke);
```

```
 end
 if abs(mass_te) > balance_te(it);
 balance_te(it) = abs(mass_te);
 end
%mass in place
 mass_wtr(it) = mass_wtr(it) + delz*Az*wtr_content*conc(i);
 mass_solid(it) = mass_solid(it)...
 + delz*Az*bulk_density*conc_solid(i);
%
%end loop over grid cells
 end
%cumulative mass out
 if it == 1
 mass_out(it) = v*delt*Az*conc(Nz);
 else
 mass_out(it) = mass_out(it-1) + v*delt*Az*conc(Nz);
 end
%update conc_old
 conc_old = conc;
 conc_old_solid = conc_solid;
%number of cumulative pore volumes at time t(it)
%pore_volumes(it) = inj_rate*delt/Vwtr_per_PV;
 if (it) == 1
 pore_volumes(it) = v*Az*delt/Vwtr_per_PV;
 else
 pore_volumes(it) = pore_volumes(it-1) + v*Az*delt/Vwtr_per_PV;
 end
%vial concentration mg/L
 if v == 0
 vial_conc(it) = vial_conc(it-1);
 else
 vial_conc(it) = 1000*conc(Nz);
 end
%
%end of time step loop
end
%write input
xlswrite('B347P4_insitu_U_Kinetic.xlsx',transpose(input),'Input','B2')
%write time history of pore volumes and concentration
xlswrite('B347P4_insitu_U_Kinetic.xlsx',t,'B347P4_U_Kinetic','C5:C204')
xlswrite('B347P4_insitu_U_Kinetic.xlsx',pore_volumes,'B347P4_U_Kinetic','D5:D
204')
xlswrite('B347P4_insitu_U_Kinetic.xlsx',vial_conc,'B347P4_U_Kinetic','E5:E204
')
%write balance equation results
xlswrite('B347P4_insitu_U_Kinetic.xlsx',t,'balance','B4:B203')
xlswrite('B347P4_insitu_U_Kinetic.xlsx',balance_ke,'balance','C4:C203')
xlswrite('B347P4_insitu_U_Kinetic.xlsx',balance_te,'balance','D4:D203')
%
xlswrite('B347P4_insitu_U_Kinetic.xlsx',initial_mass_water,'balance','F3')
xlswrite('B347P4_insitu_U_Kinetic.xlsx',initial_mass_solid,'balance','G3')
xlswrite('B347P4_insitu_U_Kinetic.xlsx',mass_wtr,'balance','F4:F203')
xlswrite('B347P4_insitu_U_Kinetic.xlsx',mass_solid,'balance','G4:G203')
xlswrite('B347P4_insitu_U_Kinetic.xlsx',mass_out,'balance','H4:H203')
%
delete('*.tmp')
'fini fd_transport'
```

Appendix E

Assessment of Effect of Polyphosphate Injection/Infiltration on Aquifer Properties

This page intentionally left blank.

E1 Assessment of Effect of Polyphosphate Injection/Infiltration on Aquifer Properties

This appendix assesses the effect of polyphosphate injections/infiltration on hydraulic properties of the aquifer (such as porosity or permeability) in the vicinity of the treatment zone. Stage A Enhanced Attenuation Area (EAA) and surrounding wells are shown in Figure E-1.

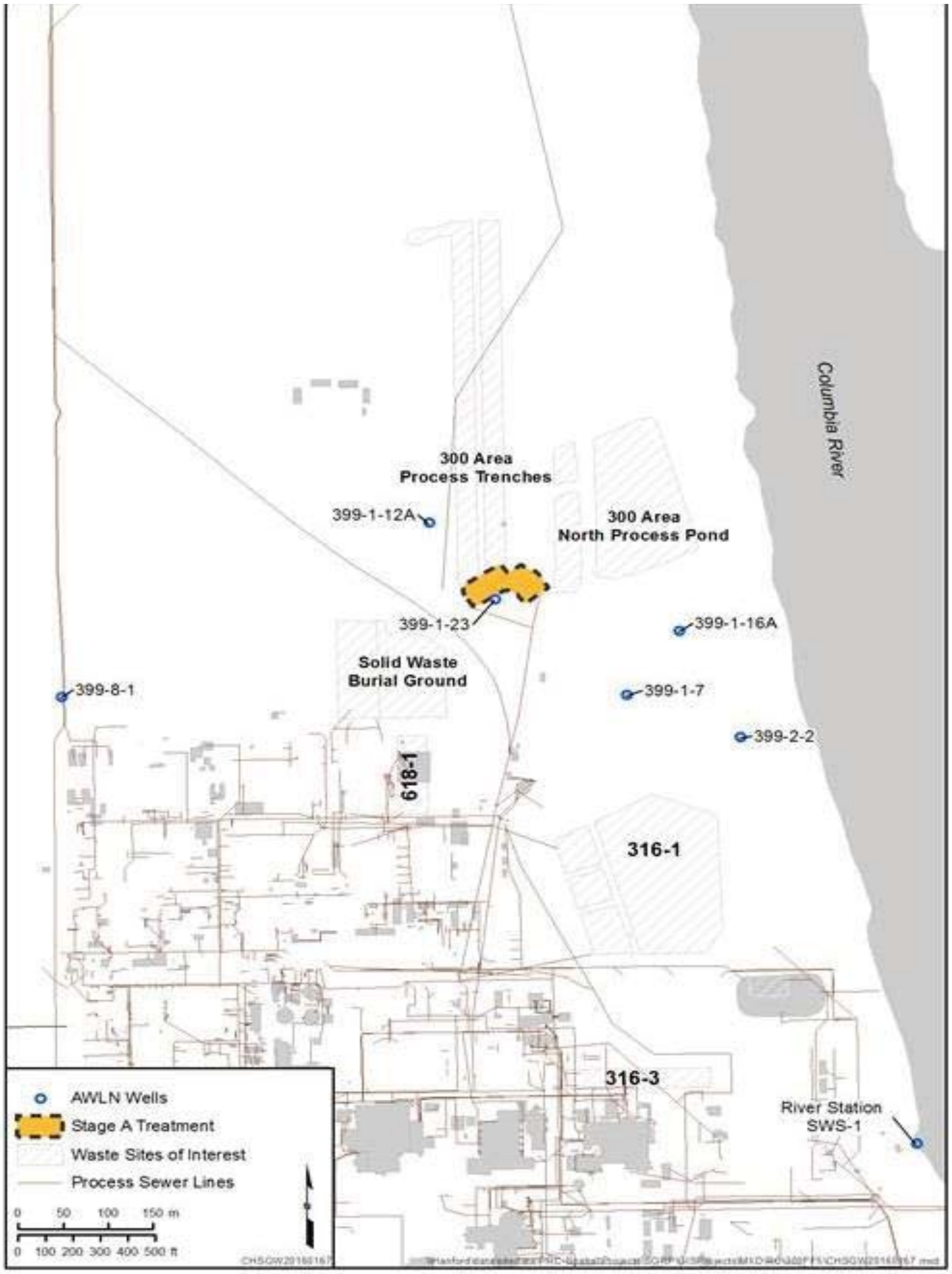


Figure E-1. Stage A EAA and Monitoring Wells

E2 Water Table Elevations

For this analysis, the water level elevations from two monitoring wells were examined: 399-1-23, which is located just outside the Stage A treatment area, and 399-1-12, which is located northwest and upgradient of the study area. Both wells are continuously monitored as part of the automated water level network in 15 to 30 minute intervals and the data records are available for water level elevation in m (above mean sea level).

The assumption for this analysis is that well 399-1-23 water levels could be influenced by injections due to proximity to the injection sites, but well 399-1-12 should not be affected by changes caused by injection due to its up-gradient location and distance from the Stage A treatment area. The water level elevations for both wells are shown in Figure E-2. The plot depicts changes in water levels prior to treatment (injection/infiltration), during treatment (marked as time of interest), and for some time period after treatment.

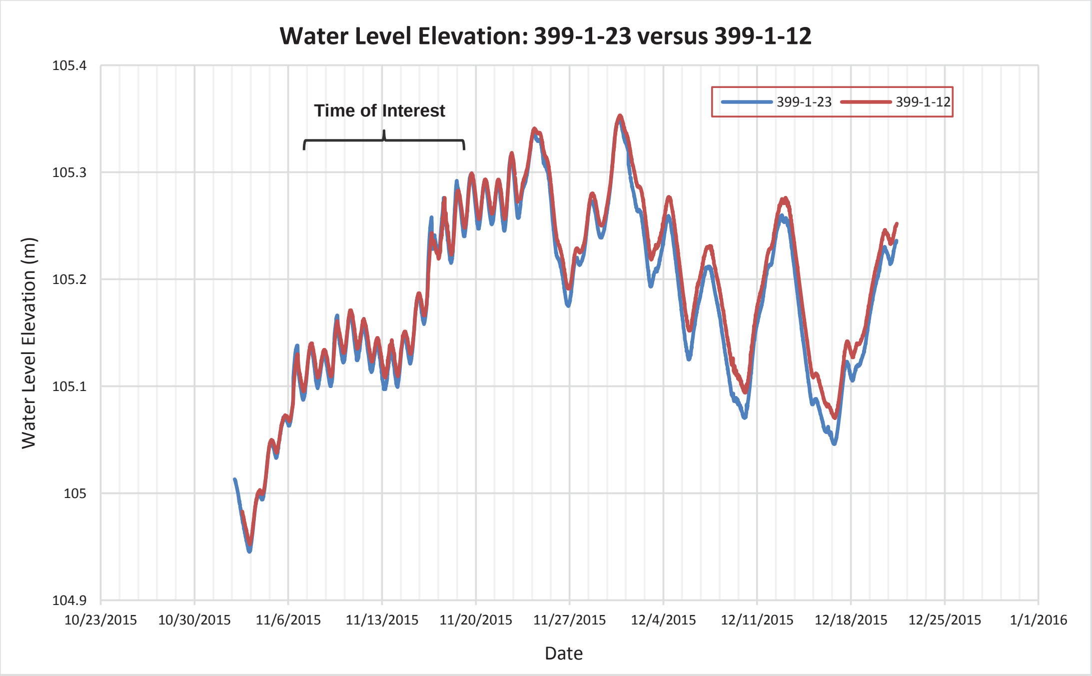


Figure E-2. Water Level Elevation Difference for 399-1-23 and 399-1-12

Throughout the observation time period, both wells showed a similar trend with minor differences resulting from differences in their respective locations. In the pretreatment and during treatment (time of interest), water level fluctuations in both wells remained similar (and virtually overlapping) indicating negligible or no impact of changes in the aquifer properties during treatment. Following the treatment, water levels between the two wells also remained very similar, indicating negligible or no impact on aquifer properties following treatment. During the treatment, the frequency of water level perturbations appeared to be enhanced, but they are likely induced by river stage fluctuations since both wells showed similar changes.

Water levels and specific conductance measurements for well 399-1-23 are 399-1-12 are presented in Figure E-3 and Figure E-4, respectively. Specific conductance for 399-1-23 shows step increases during the time of treatment (November 6 through November 17, 2015), indicating that it was receiving polyphosphate solutions when they were injected/infiltrated in the Stage A EAA. Specific conductance increased from 0.5 mS/cm to over 1.5 mS/cm. On the other hand, specific conductance in well 399-1-12 remained at background levels, indicating no or negligible influence of polyphosphate solutions during treatment. Given that 399-1-23 showed large increases in specific conductance during injection of polyphosphate solution, it continued to have similar water level trends as 399-1-12, which indicates that no appreciable changes in aquifer properties (porosity or permeability) have occurred.

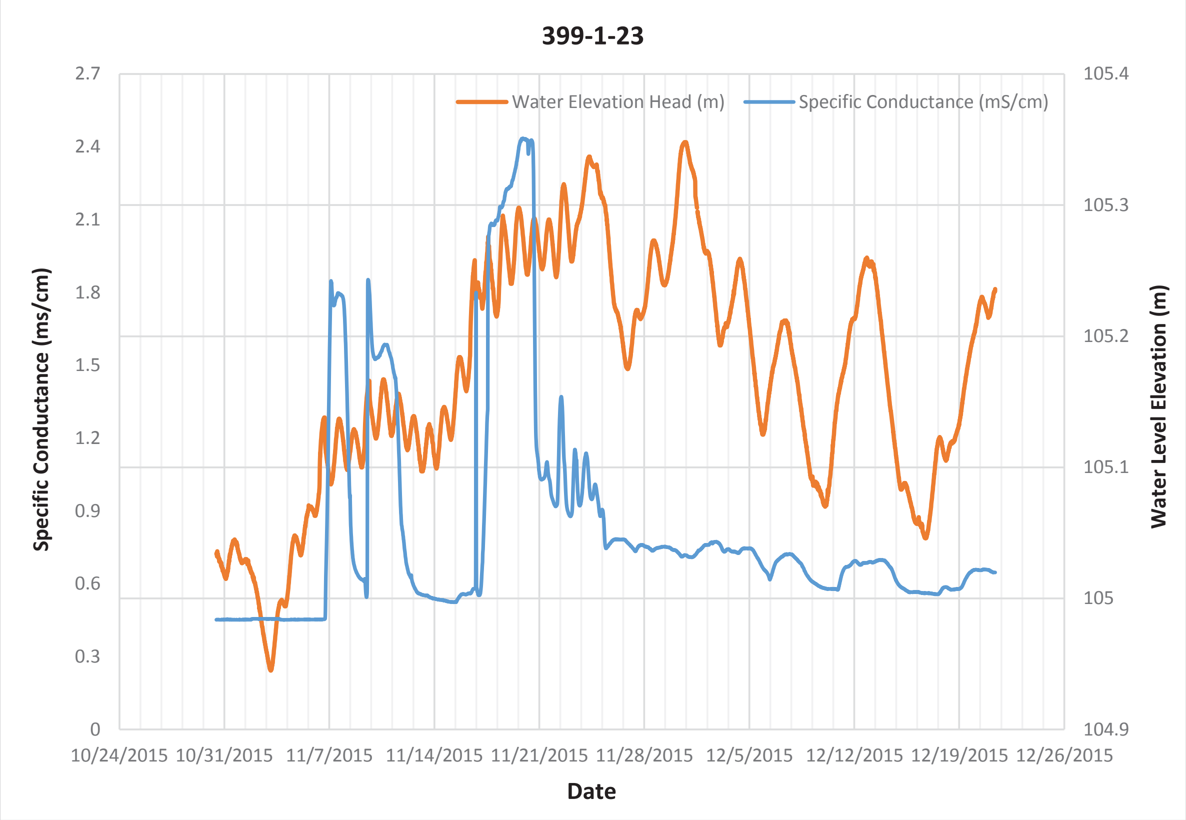


Figure E-3. Specific Conductance and Water Level Elevation Correlation Graph for 399-1-23

Absolute difference in heads between the two wells is presented in Figure E-5 to evaluate any significant changes. Due to location differences, some head differences are expected, and the trend typically varies from a 0.01 to 0.015 m difference. However, some rise in water levels was noticeable in well 399-1-23 during the time of injection (marked as time of interest between November 6 and 18, 2015), indicating influence of the nearby injection well. The larger difference after December 1, 2015 is correlated to the general rise in water level reflecting increasing river stage. This perhaps results in slight increase in vertical gradients within the aquifer; therefore, head differences between the two wells are slightly larger, and part of natural variation is expected with the rise and fall of river stage. Based on these observations, it is concluded that no or negligible change in aquifer properties occurred due to polyphosphate injections.

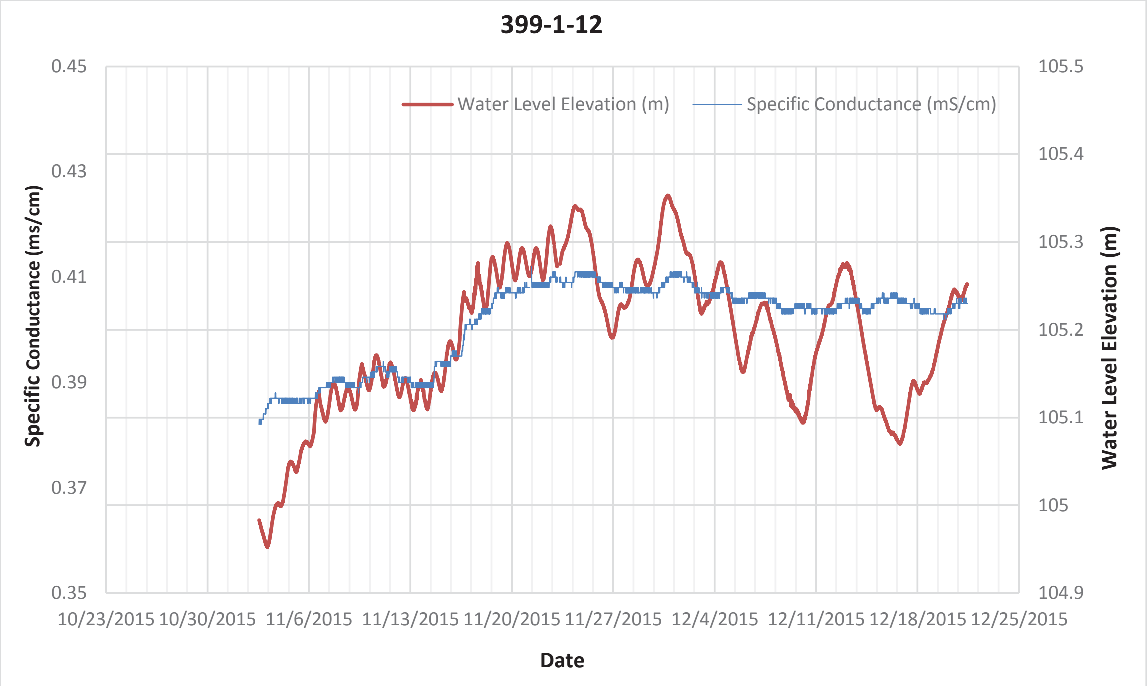


Figure E-4. Specific Conductance and Water Level Elevation for 399-1-12

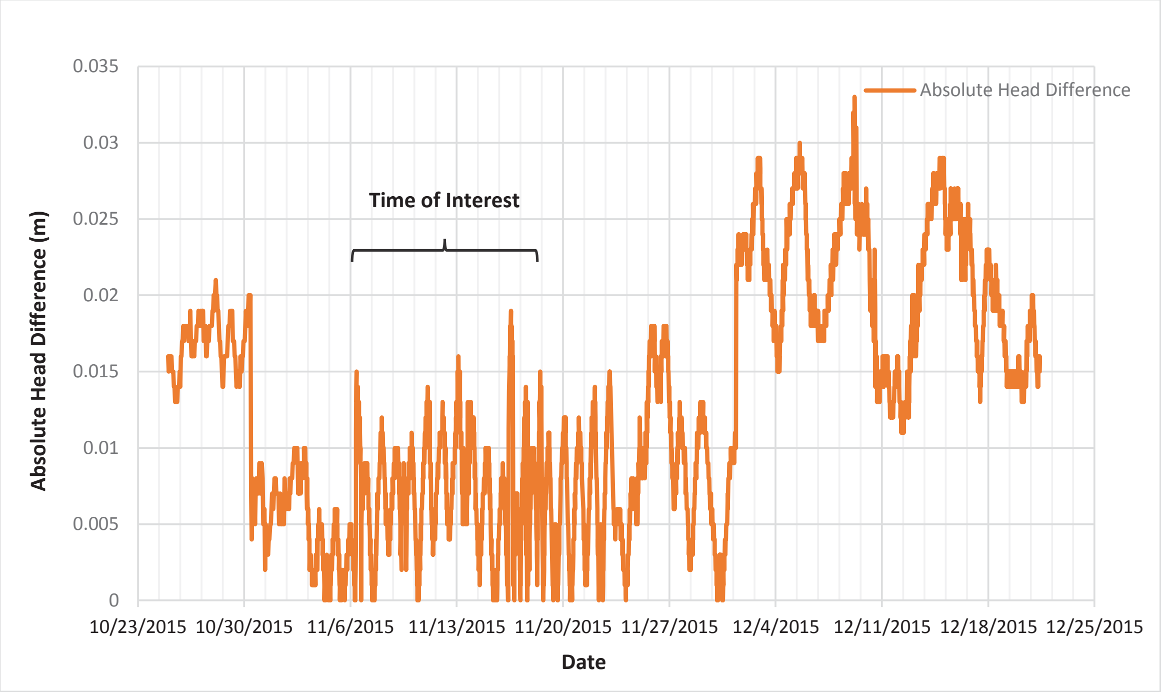


Figure E-5. Absolute Head Difference for 399-1-23 Versus 399-1-12

E3 Time Travel Calculations

This section estimates travel time by calculating how long polyphosphate took to reach downstream monitoring wells. For this analysis, three wells were used: 399-1-23, 399-1-7, and 399-2-2 (Figure E-1). These wells are located along an inferred flow path within the aquifer. Normalized specific conductance values were calculated for all three wells to find the first peak value for each well as shown in Figure E-6.

To calculate the travel time, well 399-1-23 was used as a base point to find the distance between each well using X and Y coordinates, then the date and time of the first peak were determined from the plot. Finally, travel velocity from well 399-1-23 to other wells was calculated for each well, and results are presented in Table E-1. The travel times shown in the table are with respect to well 399-1-23. The peak concentration took approximately 20 days to reach well 399-1-7, leading to an estimated average linear velocity of 9.2 m/day. The peak concentration in well 399-2-2 was observed approximately after 28 days, indicating an average linear velocity of 11.5 m/day. These average linear velocity estimates following injection are similar to the velocity estimated in previous studies (prior to injection) (PNNL-18529, *300 Area Uranium Stabilization Through Polyphosphate Injection: Final Report*; PNNL-22048) indicating that the aquifer properties have not been altered.

Table E-1. Travel Time Calculation Results

Well	Travel Time from Max (Days)	Velocity (m/d)
399-1-7	20.49	9.2
399-2-2	28	11.5
▨	Average Velocity	10.3

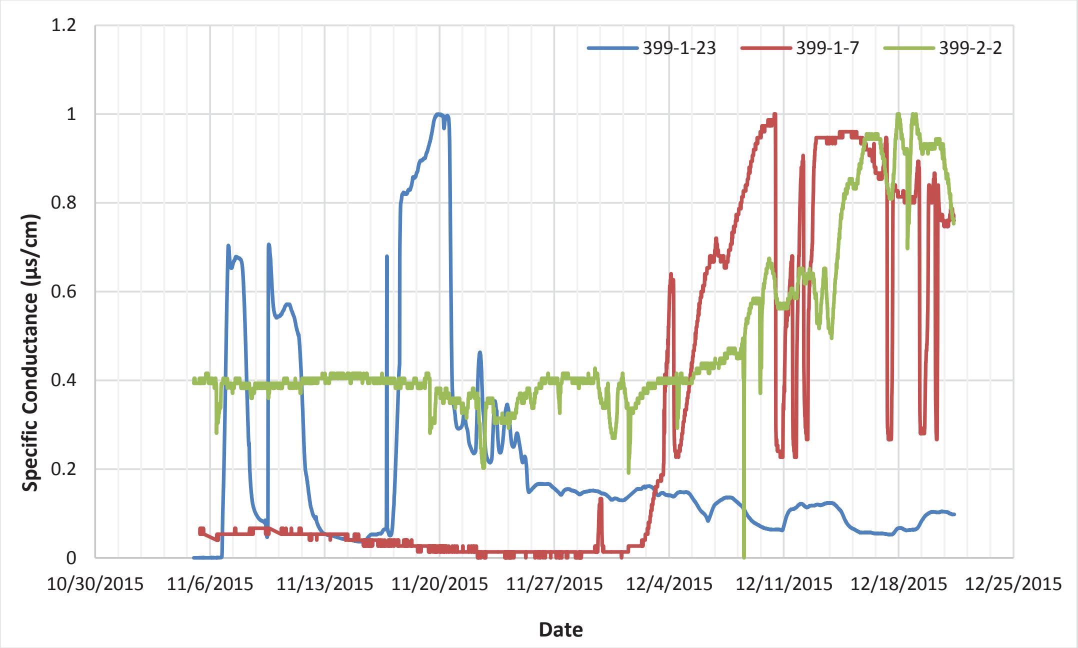


Figure E-6. Observed Specific Conductance as a Function of Time for Groundwater Monitoring Wells 399-1-23, 399-1-7, and 399-2-2

E4 References

PNNL-18529, 2009, *300 Area Uranium Stabilization Through Polyphosphate Injection: Final Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-18529.pdf.

PNNL-22048, 2012, *Updated Conceptual Model for the 300 Area Uranium Groundwater Plume*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22048.pdf.

Appendix F

Software Installation and Checkout Forms

This page intentionally left blank.

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

Software Owner Instructions:

Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

Software Subject Matter Expert Instructions:

Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

GENERAL INFORMATION:

1. Software Name: STOMP (Subsurface Transport Over Multiple Phases) Software Version No.: Bld 4

EXECUTABLE INFORMATION:

2. Executable Name (include path):

```
All executable files installed in directory [redacted]/bin
---------------------------------   ----------------------------
MD5 File Signature                  Executable File Name
---------------------------------   ----------------------------
6536b8e12d8c5b83dca76f2c947b6153  stomp-wae-bcg-chprc04i.x
e0cdf04bc1a2f6c55c5a1b499939f663  stomp-wae-bcg-chprc04l.x
6e72340bb39f6056e232fe5ff241c4d4  stomp-wae-bd-chprc04i.x
3f837a0fb8d9f47dbcada686f542d7fc  stomp-wae-bd-chprc04l.x
7e5b4cc36a8991b3d5a8ea2ed155ce47  stomp-wae-cgsq-chprc04i.x
00a898c0c3ec06817485781ad1c9ec46  stomp-wae-cgsq-chprc04l.x
f18ff5ab5667065d8ab12657344fb6a0  stomp-wae-cgst-chprc04i.x
061af86cf21ad8435b046d0efabe971b  stomp-wae-cgst-chprc04l.x
3c8111a9855dc0e430bf3c8a7abcf37e  stomp-w-bcg-chprc04i.x
20436d615a94955a2ce8eecdb8cba546  stomp-w-bcg-chprc04l.x
8b3df29df21d040189c3e2a50ef823bb  stomp-w-bd-chprc04i.x
066a289a75aedb933eb2536da5d7d1ff  stomp-w-bd-chprc04l.x
c8e62ad7a0d9b6fca39d8a8952ef5d8e  stomp-w-cgsq-chprc04i.x
28ad16806e1307aca51fd7bf89793e75  stomp-w-cgsq-chprc04l.x
6c25051016db2fe1f883a7caaaab1e97  stomp-w-cgst-chprc04i.x
ff9ff6f29b3469419ffaece87d7e772b  stomp-w-cgst-chprc04l.x
0c3e3fba40f5b93e71bcf9586432fd27  stomp-w-r-bcg-chprc04i.x
78492aee80a8c2d0a4e82aabf4a9c213  stomp-w-r-bcg-chprc04l.x
84b129786aba9c4be884e15e45a67389  stomp-w-r-bd-chprc04i.x
e990f1566c8099a8d54508de3da9cd88  stomp-w-r-bd-chprc04l.x
18a589a2b55aab2db290efea19b39351  stomp-w-r-cgsq-chprc04i.x
6569959476772a137df35ce874821889  stomp-w-r-cgsq-chprc04l.x
```

3. Executable Size (bytes): MD5 signatures above uniquely identify each executable file

COMPILATION INFORMATION:

4. Hardware System (i.e., property number or ID):

Tellus Subsurface Modeling Platform

5. Operating System (include version number):

```
Linux tellusmgmt.rl.gov 2.6.18-308.4.1.el5 #1 SMP Tue Apr 17 17:08:00 EDT 2012 x86_64
x86 64 x86 64 GNU/Linux
```

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):

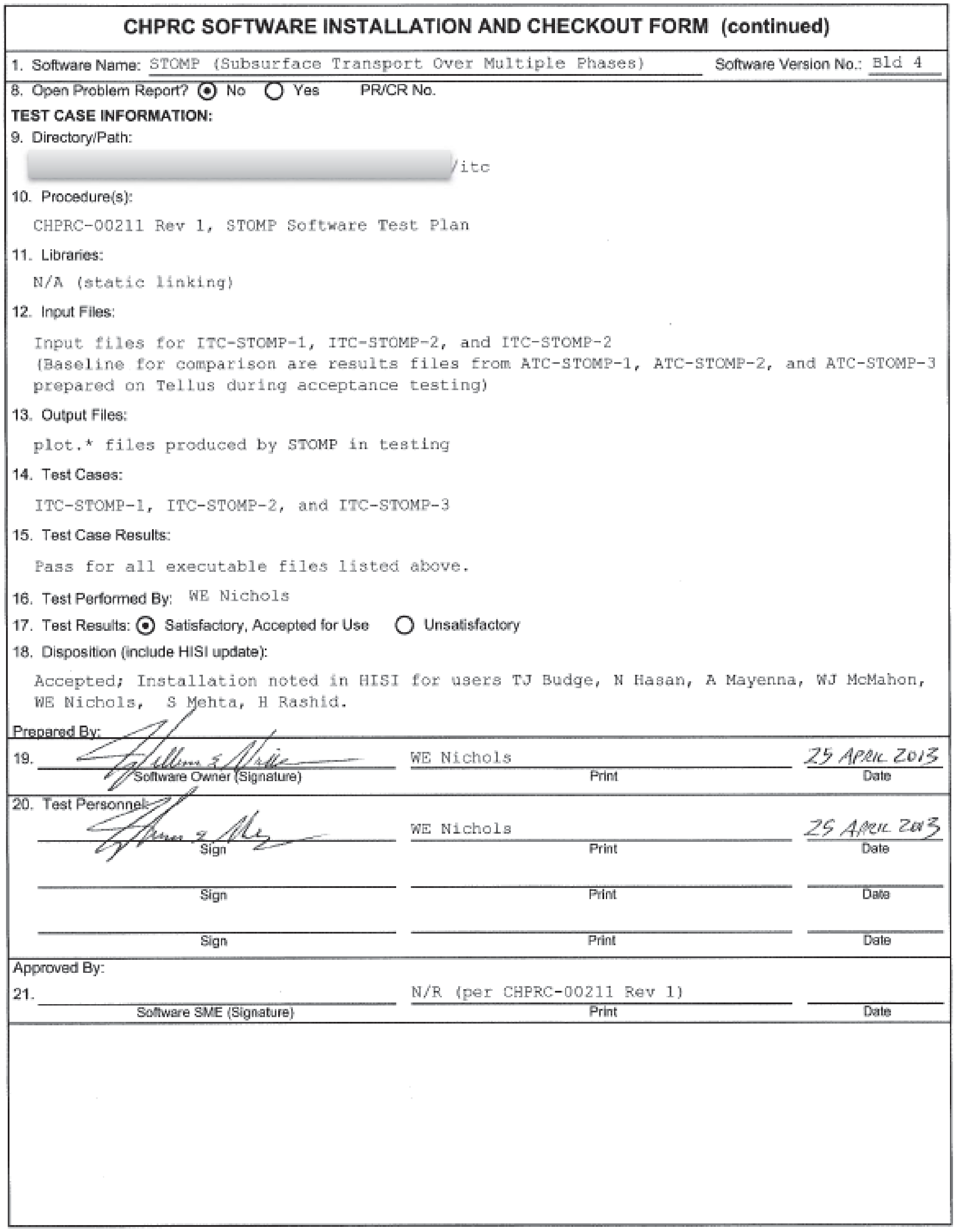
Green Linux Cluster

7. Operating System (include version number):

```
Linux green 3.2.0-35-generic #55-Ubuntu SMP Wed Dec 5 17:42:16 UTC 2012 x86_64 x86_64
x86 64 GNU/Linux
```

Page 1 of 2

A-6005-149 (REV 0)



CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: STOMP (Subsurface Transport Over Multiple Phases) Software Version No.: Bld 4

8. Open Problem Report? ● No ○ Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:

[redacted]/itc

10. Procedure(s):

CHPRC-00211 Rev 1, STOMP Software Test Plan

11. Libraries:

N/A (static linking)

12. Input Files:

Input files for ITC-STOMP-1, ITC-STOMP-2, and ITC-STOMP-2
(Baseline for comparison are results files from ATC-STOMP-1, ATC-STOMP-2, and ATC-STOMP-3 prepared on Tellus during acceptance testing)

13. Output Files:

plot.* files produced by STOMP in testing

14. Test Cases:

ITC-STOMP-1, ITC-STOMP-2, and ITC-STOMP-3

15. Test Case Results:

Pass for all executable files listed above.

16. Test Performed By: WE Nichols

17. Test Results: ● Satisfactory, Accepted for Use ○ Unsatisfactory

18. Disposition (include HISI update):

Accepted; Installation noted in HISI for users TJ Budge, N Hasan, A Mayenna, WJ McMahon, WE Nichols, S Mehta, H Rashid.

Prepared By:

19. Software Owner (Signature) | WE Nichols Print | 25 APRIL 2013 Date

20. Test Personnel:

Sign | WE Nichols Print | 25 APRIL 2013 Date

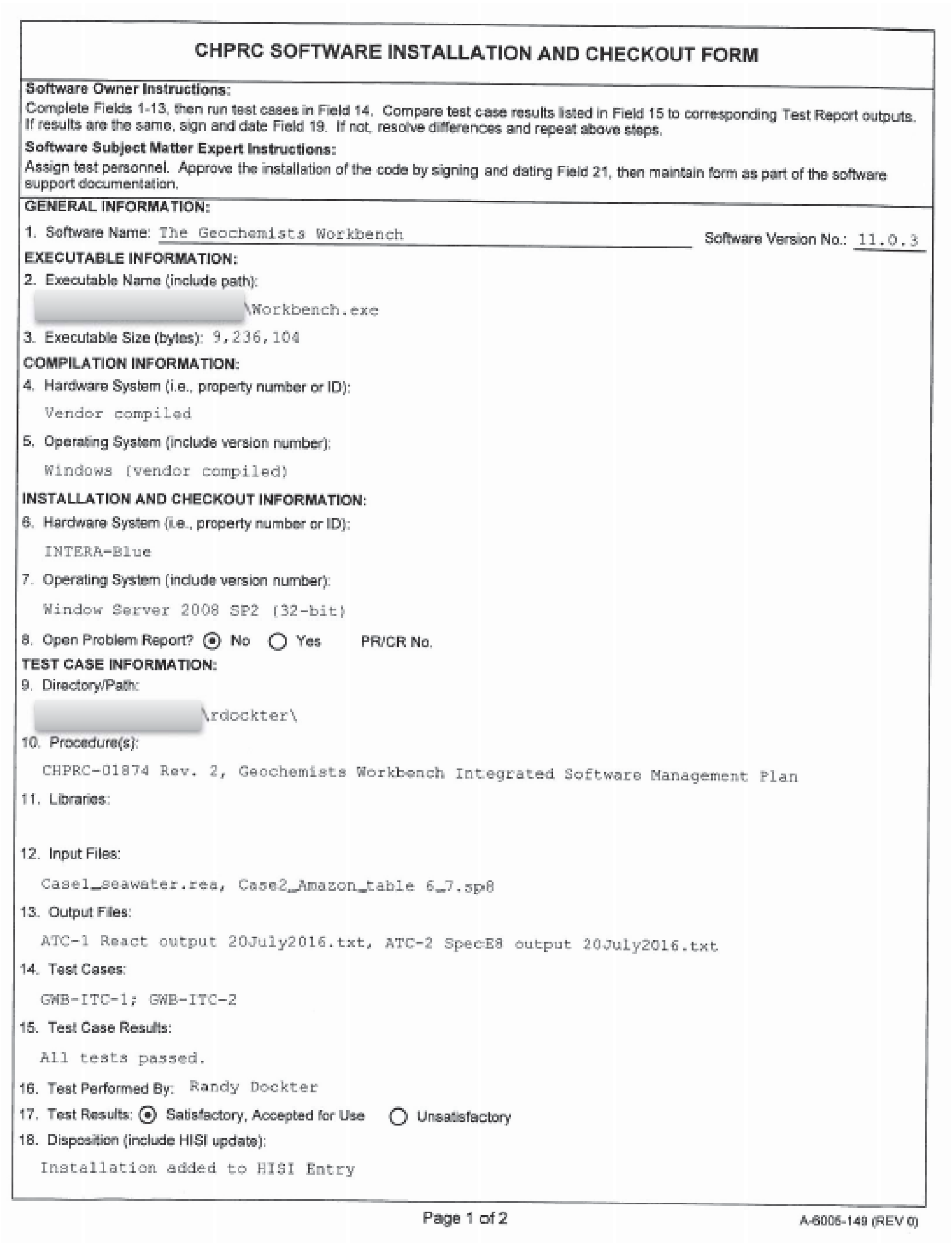
Sign | Print | Date

Sign | Print | Date

Approved By:

21. Software SME (Signature) | N/R (per CHPRC-00211 Rev 1) Print | Date

Page 2 of 2 A-6005-149 (REV 0)



CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

Software Owner Instructions:
Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

Software Subject Matter Expert Instructions:
Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

GENERAL INFORMATION:

1. Software Name: The Geochemists Workbench Software Version No.: 11.0.3

EXECUTABLE INFORMATION:

2. Executable Name (include path):
[redacted]\Workbench.exe

3. Executable Size (bytes): 9,236,104

COMPILATION INFORMATION:

4. Hardware System (i.e., property number or ID):
Vendor compiled

5. Operating System (include version number):
Windows (vendor compiled)

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):
INTERA-Blue

7. Operating System (include version number):
Window Server 2008 SP2 (32-bit)

8. Open Problem Report? ● No ○ Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:
[redacted]\rdockter\

10. Procedure(s):
CHPRC-01874 Rev. 2, Geochemists Workbench Integrated Software Management Plan

11. Libraries:

12. Input Files:
Case1_seawater.rea, Case2_Amazon_table 6_7.sp8

13. Output Files:
ATC-1 React output 20July2016.txt, ATC-2 SpecE8 output 20July2016.txt

14. Test Cases:
GWB-ITC-1; GWB-ITC-2

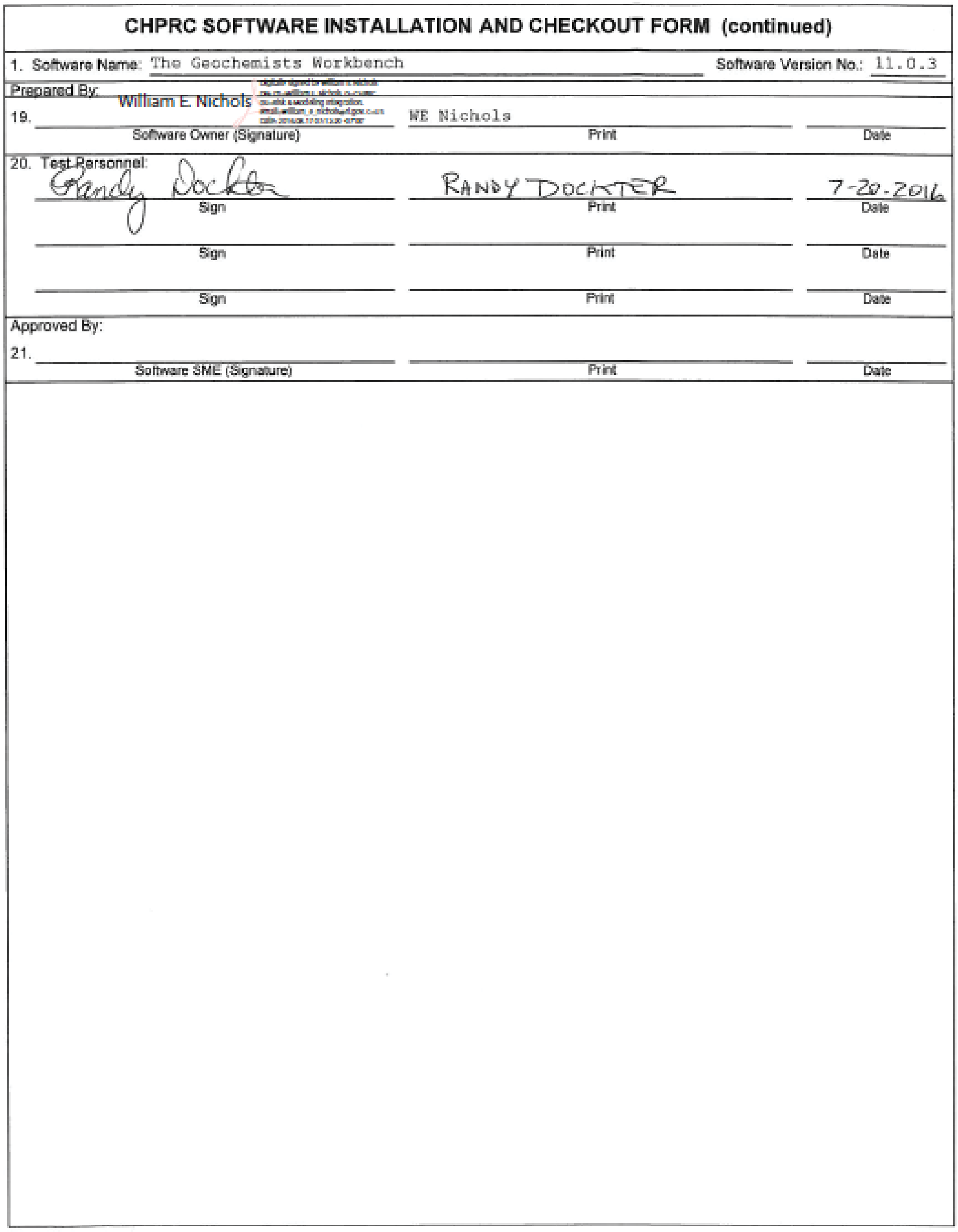
15. Test Case Results:
All tests passed.

16. Test Performed By: Randy Dockter

17. Test Results: ● Satisfactory, Accepted for Use ○ Unsatisfactory

18. Disposition (include HISI update):
Installation added to HISI Entry

Page 1 of 2 A-6006-149 (REV 0)



CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: The Geochemists Workbench Software Version No.: 11.0.3

Prepared By:

19. William E. Nichols — WE Nichols

Software Owner (Signature)	Print	Date

20. Test Personnel:

Randy Dockter	RANDY DOCKTER	7-20-2016
Sign	Print	Date
Sign	Print	Date
Sign	Print	Date

Approved By:

21.

Software SME (Signature)	Print	Date

Page 2 of 2 A-6005-149 (REV 0)

Appendix H

Long-Term Groundwater Monitoring Data

This page intentionally left blank.

H1 Long-Term Groundwater Monitoring Data

Four wells (399-1-17A, 399-1-7, 399-2-1, and 399-2-2) downgradient of the enhanced attenuation area will be monitored for uranium and gross alpha twice a year for 5 years in June (high river stage) and December (low river stage) in accordance with DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*. The locations of the monitoring wells are shown on Figure 3-3. The contaminant data will be compared to historical data trends to evaluate whether leachable uranium in the periodically rewetted zone was reduced. The samples were also analyzed for the groundwater characteristics of specific conductance, pH, temperature, and water level. Analytical results for samples collected in December 2015 (low river stage) and June 2016 (high river stage) are provided in Table H-1. The data are stored in the Hanford Environmental Information System database, and users also may retrieve the data via the internet through the U.S. Department of Energy Environmental Dashboard Application available at: https://ehs.hanford.gov/eda/.

H2 References

DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079669H.

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

Table H-1. Groundwater Analytical Results for 300-FF-5 Operable Unit Long-Term Monitoring Wells Downgradient of the Enhanced Attenuation Area

Sample Date	Sample Number	Gross Alpha[a] (pCi/L)	Uranium[b] (µg/L)	Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (°C)	Water Level Elevation[f] (m NAVD88)
Well 399-1-17A							
12/06/2015							105.15
	B33D84			665	7	16.7	
	B33D85		1.56				
	B33J38	0.52 U					
06/08/2016							105.85
	B35856			498	7.38	18.4	
	B35857		27.6				
	B35858		25.4				
	B35KW3	29.3					
Well 399-1-7							
12/06/2015							105.14
	B33J40			512	7.51	16.8	
	B33J41	27.0					
	B33J42		56.7				
06/14/2016							105.69
	B35D62			524	7.45	17.6	
	B35D61		15.0				
	B35D63	7.57					
Well 399-2-1							
12/06/2015							105.13
	B33J43			443	7.43	16.4	
	B33J45	107.0	121.0				

Table H-1. Groundwater Analytical Results for 300-FF-5 Operable Unit Long-Term Monitoring Wells Downgradient of the Enhanced Attenuation Area

Sample Date	Sample Number	Gross Alpha[a] (pCi/L)	Uranium[b] (µg/L)	Specific Conductance[c] (µS/cm)	pH Measurement[d] (pH Units)	Temperature[e] (ºC)	Water Level Elevation[f] (m NAVD88)
06/07/2016							106.01
	B35D64			287	7.46	15.7	
	B35D65	41.3	69.7				
Well 399-2-2							
12/04/2015							105.19
	B33J46			449	7.47	16	
	B33J47	47.2					
	B33J48		96.0				
06/30/2016							105.67
	B35D68			326	7.45	16.1	
	B35D66		34.0				
	B35D67		34.0				
	B35D69	11.9					
	B35D70	16.1					

Reference: NAVD88, 1988, National Geodetic Survey.

a. EPA Method 9310.

b. EPA Method 6020.

c. EPA Method 120.1. Specific conductivity using field probe.

d. EPA Method 150.1. pH using field probe.

e. EPA Method 170.1. Temperature using field probe.

f. Water level measured using water level measurement tape.

EPA = U.S. Environmental Protection Agency

NAVD88 = North American Vertical Datum of 1988

This page intentionally left blank.

Appendix I

Technical Memorandum

This page intentionally left blank.

I Technical Memorandum

This appendix provides the technical memorandum that documents completion of the Stage A enhanced attenuation remedy: CHPRC-02799, Rev. 1, *Performance Measure PM-30-5-16: Complete Stage A 300-FF-5 Uranium Sequestration Injections*. The injection skid monitoring data sheets, the infiltration skid monitoring data sheets, and the sequestration operations logbook are included as appendices to the memorandum.

This page intentionally left blank.

CHPRC-02799
Revision 1

Performance Measure PM-30-5-16: Complete Stage A 300-FF-5 Uranium Sequestration Injections

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

P.O. Box 1600
Richland, Washington 99352

CHPRC-02799
Revision 1

Performance Measure PM-30-5-16: Complete Stage A 300-FF-5 Uranium Sequestration Injections

Date Published
May 2016

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

P.O. Box 1600
Richland, Washington 99352

APPROVED
By Julia Raymer at 2:13 pm, May 26, 2016

Release Approval Date

TECHNICAL MEMORANDUM

Performance Measure PM-30-5-16: Complete Stage A 300-FF-5 Uranium Sequestration Injections

Prepared for:	300-FF-5 Operable Unit
Prepared by:	Randy Hermann
CC:	Marty Doornbos Patrick Baynes Randy Hermann Virginia Rohay Sunil Mehta Gene Ng Correspondence Control (MSIN G3-39)
Date:	January 20, 2016
Doc Number	CHPRC-02799, REV. 0

1 Introduction

The purpose of this technical memorandum is to document that Performance Measure PM-30-5-16 has been met through successful completion of the following objective and completion criteria:

- Objective: "Complete Stage A 300-FF-5 uranium sequestration injections by March 31, 2016."
- Completion Criteria: "By March 31, 2016, complete the Stage A 300-FF-5 uranium sequestration injections. Provide technical memo documenting completion of injections with supporting documentation from log books and field data sheets."

2 Remedial Design Report/Remedial Action Work Plan (RDR/RAWP) Design Parameters

The enhanced attenuation using the uranium sequestration component of the groundwater remedy involves infiltrating and injecting phosphate solutions to the vadose zone and periodically rewetted zone (PRZ) to sequester, or bind, residual mobile uranium to form insoluble minerals. The target area for application of the phosphate solutions is a 1 ha (3 ac) area containing a persistent source of uranium contamination to groundwater. Phosphate will be injected into the top of the aquifer to mitigate potential impacts to the aquifer from uranium that may be carried downward during phosphate application in the vadose zone.

Uranium sequestration will be implemented using a staged approach. Stage A will consist of performing infiltration/injection in one quadrant of the Enhanced Attenuation Area (EAA), covering approximately 0.3 ha (0.75 ac).

Phosphate will be introduced into the vadose zone using buried irrigation drip line or perforated piping. Injection wells will be used for injecting phosphate into a zone spanning the PRZ and top of the aquifer. The top of aquifer treatment zone will be in place during phosphate infiltration and maintained for a short period afterwards to possibly react with uranium that leaches into groundwater as a result of the phosphate solution applied to the vadose zone.

Phosphate injections will be performed when groundwater conditions are favorable (e.g., during lower river stages). The application in the PRZ will be scheduled to maximize phosphate contact with the PRZ when the PRZ is unsaturated. A detailed description of the approach is provided in DOE/RL-2014-13-ADD2, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater* (hereinafter called the remedial design report/remedial action work plan [RDR/RAWP]). Specific details are provided in Section 4.1.2.1 of the RDR/RAWP, and phosphate design elements are described in the following subsections.

2.1 Phosphate Infiltration Design Elements

- Conduct continuous (24 hours per day) operation over the 0.3 ha (0.75 ac) Stage A treatment area for the estimated 5 day infiltration period.
- Monitor the advancement of the infiltration wetting front real time using electrical resistivity tomography (ERT).
- Adjust infiltration rates to maximize the contact time of phosphate solution in the vadose zone during the estimated 5 day infiltration period while minimizing the potential for flushing phosphate solution too quickly through the vadose zone and PRZ.

2.2 Phosphate Aquifer Injection Design Elements

- Conduct phosphate injections into the nine Stage A aquifer injection well screens intermittently over approximately 7 days.
- Initiate injections the day before beginning phosphate infiltration, resume during infiltration, and conclude the day after finishing phosphate infiltration to establish a layer of phosphate in groundwater below the infiltration area to remediate uranium that may be flushed to groundwater during infiltration operations.
- Conduct phosphate injections into the nine Stage A aquifer well screens. Injections into at least six wells at a time, during daytime hours, while varying the locations of the six wells being injected over the 7 days to maximize the distribution of phosphate in groundwater below the infiltration area.

2.3 Phosphate PRZ Injection Design Elements

- Conduct phosphate injections into the nine Stage A PRZ injection well screens over approximately 3 days after completing infiltration, when moisture content in the PRZ will be maximized from infiltration activities.
- Conduct PRZ injections into at least six wells at a time during daytime hours.

2.4 Phosphate Concentrate Design Element

Built into each treatment method (infiltration and injection) are the phosphate concentration and phosphate mass design elements. Monosodium phosphate and pyrophosphate solutions are mixed with river water at target ratios and delivered for infiltration and injection. RDR/RAWP (DOE/RL-2014-13-ADD2) Tables 3-2 and 3-4, respectively, provide the phosphate reagent formulation parameters. Table 1 shows the target treatment concentrations along with target total volumes for each treatment method based on the assumed flow rates and schedule presented in Table 4-3 of the RDR/RAWP. Multiplying the chemical concentration by the target total volume gives the chemical mass to be delivered to the treatment area. This is the key design parameter of the Stage A enhanced attenuation.

Table 1. Uranium Sequestration Stage A Design Summary

Design Parameter	Infiltration	PRZ Injection	Aquifer Injection
Chemical Concentration (mg/L)			
Monosodium Phosphate	5,699	9,409	9,409
Pyrophosphate	665	1,097	1,097
Target Total Volume (L)	3,679,420	1,635,298	1,635,298
Chemical Mass (kg)			
Monosodium Phosphate	20,969	15,387	15,387
Pyrophosphate	2,447	1,794	1,794

3 Operational Completion Summary

Installation of the treatment system occurred between June 2015 and October 2015. Installation commenced with drilling 9 injection wells and 30 monitoring wells from June through mid-August. Well drilling was followed by installation of the infiltration system during the last half of August. The infiltration system consists of a network of high-density polyethylene drip lines installed approximately 1.8 m (6 ft) below ground. Emitters rated at 8 L (2 gal) per hour were welded to the inside of the tubing. The drip lines were spaced 2 m (6.5 ft) apart, resulting in a total of 44 lines aligned southeast to northwest. During September and October, the mixing skids, chemical tanks, river pumps, power supplies, aboveground hoses, and all other required infrastructure were assembled and tested prior to initiating treatment. Figure 1 shows the layout of the infiltration system, injection wells, and monitoring wells in the 0.3 ha (0.75 ac) Stage A EAA.

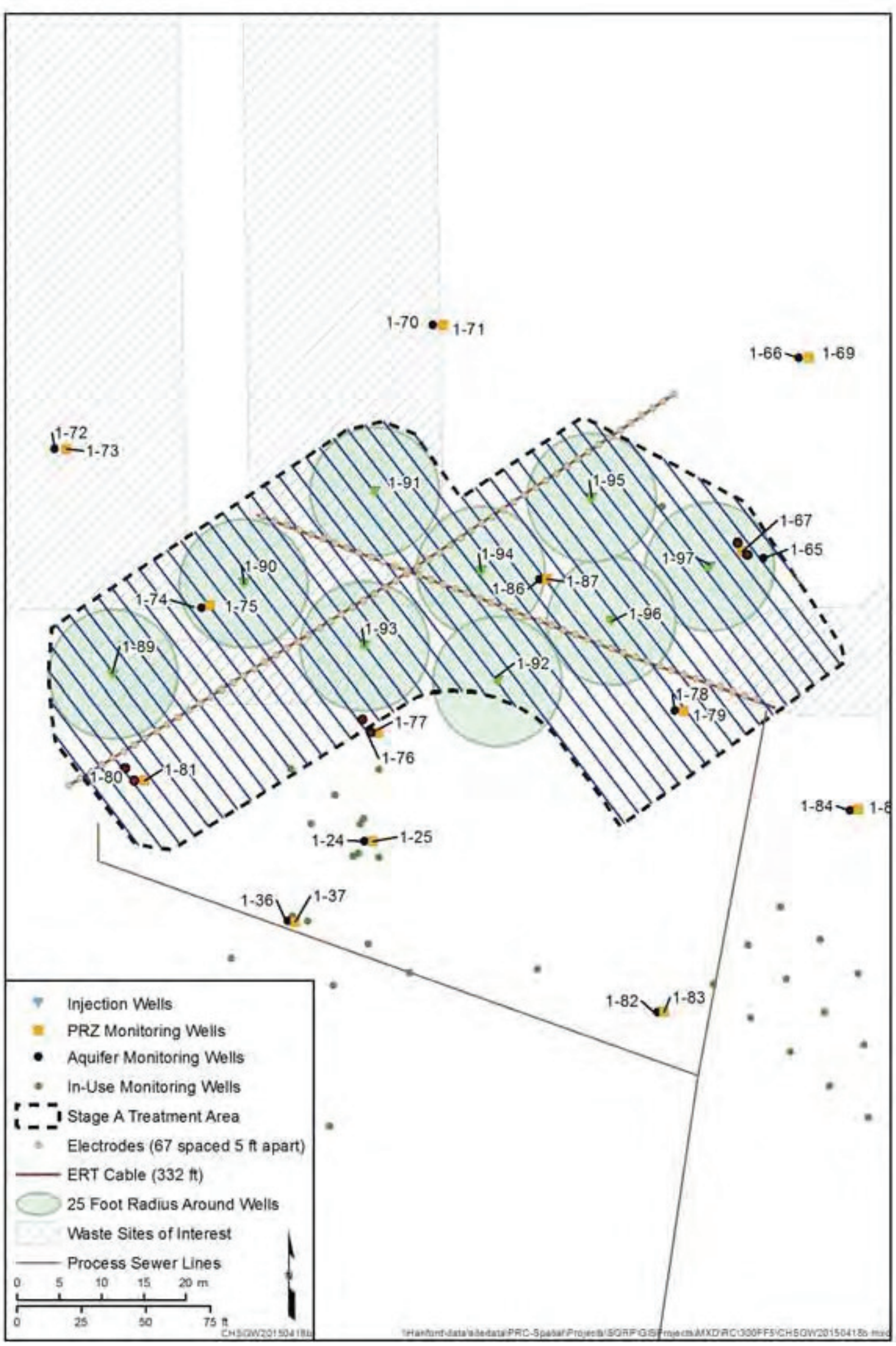


Figure 1. Installation of the Stage A EAA Wells and Infiltration System

The operational period for uranium sequestration Stage A infiltration and injections was November 6, 2015, through November 18, 2015. The daily operational activities are summarized in Table 2.

Table 2. Uranium Sequestration Stage A Operational Summary

Operational Day (Date)	Aquifer Injection (Wells)*	PRZ Injection (Wells)*	Infiltration Rate Achieved (gal/min)	Injection Rate Achieved (gal/min)
1 (Nov. 6)	1-89, 1-90, 1-91, 1-92, 1-93, 1-94	---	---	300
2 (Nov. 7)	---	---	56	---
3 (Nov. 8)	---	---	56	---
4 (Nov. 9)	1-92, 1-93, 1-94, 1-95, 1-96, 1-97	---	56	300
5 (Nov. 10)	---	---	56	---
6 (Nov. 11)	---	---	83	---
7 (Nov. 12)	---	---	80	---
8 (Nov. 13)	---	---	80	---
9 (Nov. 14)	---	---	80	---
10 (Nov. 15)	---	---	80	---
11 (Nov. 16)	1-95, 1-96, 1-97, 1-89, 1-90, 1-91	1-89, 1-90, 1-91, 1-92, 1-93, 1-94	---	300
12 (Nov. 17)	---	1-92, 1-93, 1-94, 1-95, 1-96, 1-97	---	300
13 (Nov. 18)	---	1-95, 1-96, 1-97, 1-89, 1-90, 1-91	---	300

* All wells begin with “399-”.

The following subsections compare operational performance to the design parameters of the RDR/RAWP (DOE/RL-2014-13-ADD2). All flow rates, flow volumes, and mixing rates were monitored and recorded by operations personnel. The injection and infiltration data sheets can be found in Appendix A and Appendix B, respectively. The operating logbook, found in Appendix C, contains information related to the operational schedule, shift changes, and maintenance activities.

3.1 Infiltration Completion Evaluation

Based on groundwater conductivity data and ERT imaging collected during Stage A operations, the infiltration design elements were achieved. Infiltration commenced on November 7, 2015, and concluded on November 15, 2015.

Because actual infiltration network flow rates were lower than originally planned, the period for infiltration was extended from 5 days to 9 days of 24 hour operations to deliver the target mass of polyphosphate chemicals. Groundwater conductivity data collected from PRZ and aquifer piezometers and ERT imaging showed that chemical concentration and distribution goals were met with lateral spread of phosphate solution throughout the treatment area and complete vertical migration of the solution through the vadose zone to groundwater.

Groundwater conductivity data collected during infiltration and initial aquifer injections from PRZ and aquifer piezometers, presented in Figure 2, show a sustained increase in conductivity over most of the Stage A area after approximately 4 days. Aquifer injections conducted on operational days 1 and 4 make it difficult to conclude that the phosphate solution wetting front had reached the PRZ, based on evaluation of conductivity alone. However, due to the sustained increase in conductivity in most wells after day 5, along with ERT imaging shown in Figure 3, the wetting front was observed to reach the PRZ at this time. Groundwater samples were collected daily during operations from 7 monitoring wells with the exception of on operational day 8, due to resource availability constraints. Figure 2 shows no data for this day.

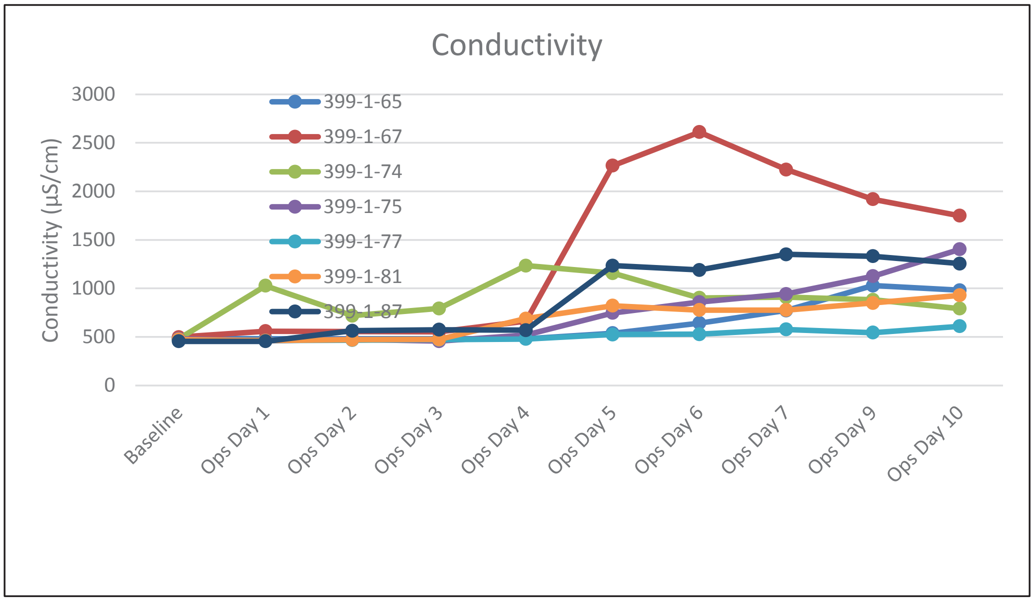


Figure 2. Conductivity Measured in Monitoring Wells during Operations

Figure 3 provides ERT imaging for infiltration days (1, 4, 5, and 9). The color scale represents the change in electrical conductivity (EC) of the subsurface compared to pretreatment conditions (Infiltration Day 1). The phosphate amendment is highly electrically conductive and causes a large increase in EC upon application. Color progression from blue to red in the ERT images represent an increase in EC caused by the presence of phosphate solution. Though difficult to distinguish in Figure 3, the groundwater is fairly static at 105 m (344.5 ft) above mean sea level. Images show phosphate solution intruding on the water table on day 4. This is represented where light blue and green colors approach a sharp horizontal line where the colors changes seem to stop. The phosphate solution infiltration progressed for an additional 5 days to increase the moisture content of PRZ sediments. No change in EC was expected to be measured with ERT below the top of the water table due to decreasing resolution with depth and the high dilution rate as treatment solutions disperses into the aquifer however, as observed on the left side of the image (western treatment area) noticeable changes in EC were detected into the aquifer. Further discussion and analysis of the ERT monitoring will be provided in the Stage A Performance Report.

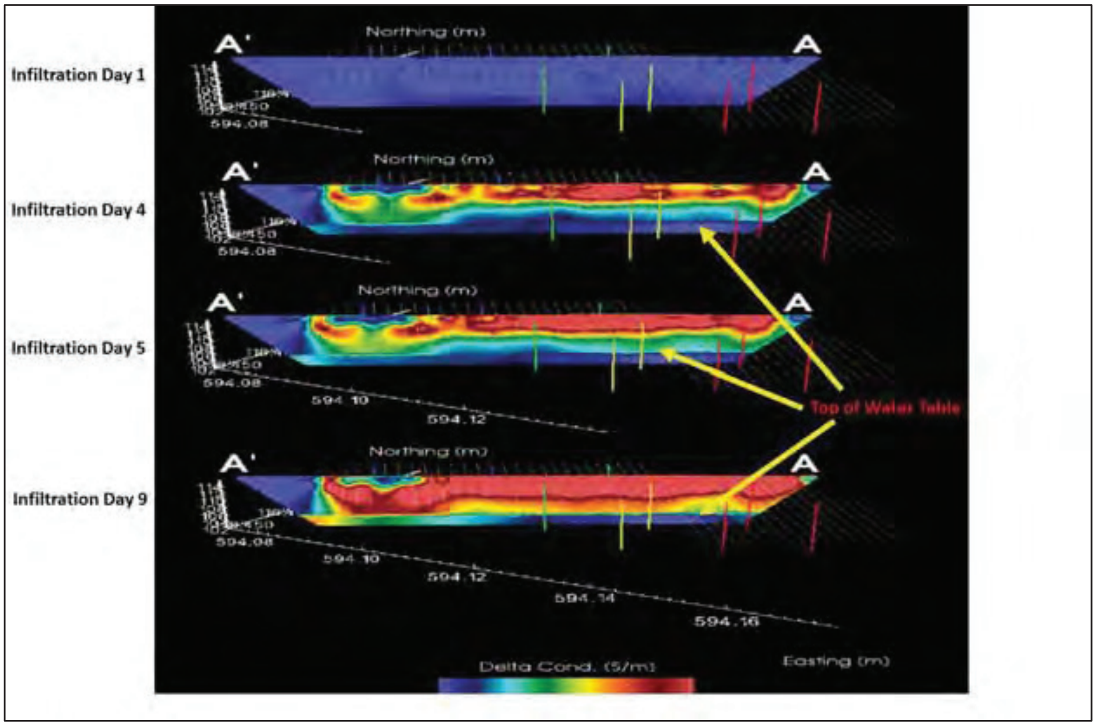


Figure 3. ERT Imaging of Phosphate Solution Migration through the Vadose Zone to Groundwater

Table 3 summarizes the Stage A infiltration chemical solution design parameters along with concentrations, volumes, and chemical mass delivered during operations. Calculations for chemical concentrations observed during operations (shown in Table 3) were based on starting concentration of each treatment solution as reported by the chemical vendor, multiplied by a dilution factor from mixing with river water.

Table 3. Stage A Infiltration Solution and Treatment Summary

Treatment Solution	Stage A Operations	Design Parameter
Monosodium Phosphate Infiltration Concentration (mg/L)	6,454	5,699[a]
Pyrophosphate Infiltration Concentration (mg/L)	757	665[a]
Total Volume (L)	3,338,555	3,679,420[b]
Monosodium Phosphate Mass Infiltrated (kg)	21,547	20,969
Pyrophosphate Mass Infiltrated (kg)	2,527	2,447

a. DOE/RL-2014-13-ADD2, Table 3-2.

b. DOE/RL-2014-13-ADD2, Table 4-3.

As shown in Table 3, the amount of phosphate that was delivered to the subsurface through infiltration exceeded the design parameters. This information, along with the supporting conductivity data and ERT imaging, demonstrates that the Stage A infiltration objectives have been met.

3.2 Aquifer Injection Completion Evaluation

The sequencing of the Stage A aquifer injections specified in the RDR/RAWP (DOE/RL-2014-13-ADD2) was to inject phosphate solution into the aquifer at least 1 day before, during, and after the phosphate infiltration period to establish a layer of phosphate in groundwater below the infiltration area to attempt to capture uranium that may be flushed to groundwater during infiltration operations.

Based on the operational schedule summarized in Table 2, the Stage A aquifer injection objective was achieved. As shown in Table 2, aquifer injections were conducted on operational day 1, the day prior to the start of infiltration; on operational day 4, the third day of infiltration; and on operational day 11, the day after infiltration was completed.

Table 4 summarizes the Stage A aquifer injection chemical solution concentrations and volumes achieved during operations and the design specification concentration and volumes. Calculations of chemical concentrations observed during operations (shown in Table 4) were based on starting concentration of each treatment solution as reported by the chemical vendor, multiplied by a dilution factor from mixing with river water. Chemical mass injection goals were exceeded.

Table 4. Stage A Aquifer Injection Solution and Treatment Summary

Treatment Compound	Stage A Operations	Design Parameter
Monosodium Phosphate Aquifer Injection Concentration (mg/L)	9,747	9,409[a]
Pyrophosphate Aquifer Injection Concentration (mg/L)	1,109	1,097[a]
Total Volume (L)	1,681,650	1,635,298[b]
Monosodium Phosphate Mass Infiltrated (kg)	16,391	15,387
Pyrophosphate Mass Infiltrated (kg)	1,865	1,794

a. DOE/RL-2014-13-ADD2, Table 3-4.

b. DOE/RL-2014-13-ADD2, Table 4-3.

3.3 PRZ Injection Completion Evaluation

Based on the operational schedule summarized in Table 2, the Stage A PRZ injection objectives were achieved. PRZ injections were conducted over a 3 day period after infiltrations were completed.

The infiltrated phosphate solution had penetrated the PRZ sediments for approximately 5 days prior to the initiation of PRZ injections, so moisture content was maximized during injections.

Table 5 summarizes the Stage A PRZ injection chemical solution concentrations and volumes achieved during operations and the design specification concentrations and volumes. Calculations of chemical concentrations observed during operations (shown in Table 5) were based on starting concentration of each treatment solution as reported by the chemical vendor, multiplied by a dilution factor from mixing with river water. Chemical mass injection goals were exceeded.

Table 5. Stage A PRZ Injection Solution Concentrations and Volumes

Treatment Compound	Stage A Operations	Design Parameter
Monosodium Phosphate PRZ Injection Concentration (mg/L)	9,742	9,409[a]
Pyrophosphate PRZ Injection Concentration (mg/L)	1,085	1,097[a]
Total Volume (gallons)	1,792,638	1,635,298[b]
Monosodium Phosphate Mass Infiltrated (kg)	17,464	15,387
Pyrophosphate Mass Infiltrated (kg)	1,945	1,794

a. DOE/RL-2014-13-ADD2, Table 3-4.

b. DOE/RL-2014-13-ADD2, Table 4-3.

4 Conclusions

Stage A EAA treatment occurred over 13 days of operations from November 6, 2015, through November 18, 2015. Operations were initiated by injection into the aquifer on day 1, followed by 10 days of continuous infiltration during which a second aquifer injection was accomplished. ERT imaging and sustained increases to groundwater conductivity confirmed that infiltration solution had reached the PRZ and aquifer by the fifth day of infiltration. Infiltration was continued for 5 additional days to deliver the required amount of chemical to the vadose zone and to ensure that PRZ moisture content was maximized prior to injection into the PRZ. Directly following the conclusion of infiltration, the final aquifer injection commenced and was followed by 3 days of injections into the PRZ.

Target treatment mass of phosphate compounds of 20,969 kg for infiltration, 15,387 kg for PRZ injection, and 15,387 kg, prescribed in the RDR/RAWP (DOE/RL-2014-13-ADD2) for aquifer injection, was met during Stage A operations. This memorandum documents the completion of Stage A 300-FF-5 Operable Unit uranium sequestration injections. The effectiveness of Stage A uranium sequestration will be summarized in the Stage A Performance Report.

5 Reference

DOE/RL-2014-13-ADD2, 2015, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081151H.

Appendix A

Injection Skid Monitoring Data Sheets

This page intentionally left blank.

Appendix A - Injection Skid Monitoring Data Sheet

Skid #1 Round 1	**Operator(s):** Ramirez, ANDOR			
Write well numbers in spaces provided	**Totalizer Readings**		**Start of Injections**	**End of Injections**
	River Water	FQI-N1-1A or -[✓ 1B]	0	132912
	Chem Injection#1 (Monosodium Phosphate)	FQI-N1-2A or [✓ 2B]	0	14098
	Chem Injection#2 (Pyrophosphate)	FQI-N1-3A or -[✓ 3B]	0	8288
	Overall Mixture	FQI-N1-4A or [✓ 4B]	0	113077
	(399-1- 89)	FQI-N1-4	0	25212
	(399-1- 90)	FQI-N1-5	0	23442
	(399-1- 91)	FQI-N1-6	0	27687
	(399-1- 92)	FQI-N1-7	0	26310
	(399-1- 93)	FQI-N1-8	0	28355
	(399-1- 94)	FQI-N1-9	0	25471

Comments

During hourly recording, note any observations, irregularities, and/or problems such as system downtime, totalizer maintenance/outage/re-set in log book

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					**Field Parameters - Injection Solution** Field parameters will be measured and recorded once every 4 hours					After flow rate is stable take 1st skid sample, take 2nd at 4-hour mark, and third/final at end of injections (8 hr). Where a sample is required, it is noted in this column.
Date	Hour	Time	FQI-N1-2A or -[✓ 2B] Chem 1 (gpm)	FQI-N1-3A or -[✓ 3B] Chem 2 (gpm)	FQI-N1-1A or -[✓ 1B] River (gpm)	FQI-N1-4A or -[✓ 4B] Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ mg/L RH 2-4-16	
11/6/2015	Pre Start	0841	?	?	?	?	?	6.79	12.1	136	231	10.19	Columbia River Water Sample
11/6/2015	0	0854	28.7	16.4	263	253 ①	✓	6.68	12.3	9200	238	10.16	Flow Rate Stable – Take first skid sample 832L19
11 ~~10~~/6/15 am 11/6/15	1	0941	28.7	16.3	262	~~[illegible]~~ ①	✓	☒	☒	☒	☒	☒	
11 ~~10~~/6/15 am 11/6/15	2	1041	28.5	16.3	261	300	✓	☒	☒	☒	☒	☒	

Comments: Ultra Meter II S/N 6212777CH. Conductivity Instrument (HYS) 0709000121336W.

① Total flow meter reading oscillating, added well flows = 309.2 0947 11/6/2015

Appendix A - (Cont.) Injection Skid Monitoring Data Sheet

Injection Round: 1
Skid ID: #1
Operator(s): ANDOR, RAMIREZ.
Wells: 399-1-89, 90, 91, 92, 93 & 94

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N1-2A or -2B Chem 1 (gpm)	FQI-N1-3A or -3B Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	FQI-N1-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L RH 2-4-16	Comments After flow rate is stable take 1st skid sample, take 2nd at 24 hr mark, and third/final at end of injections. Where a sample is required, it is noted in this column Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.	
11/6/15	3	1154	28.6	16.3	262	305	✓							
11/6/15	4	1254	28.5	16.3	261	305	✓	6.91	15.8c	10,550	201	9.95		B32L20
11/6/15	5	1354	28.5	16.4	262	306	✓							
11/6/15	6	1454	28.5	16.4	261	282	✓							
	7	1554	28.4	16.3	260	305	✓							
	8 FINAL	1646	28.4	16.2	260	304	✓	6.96	13.9c	10,400	180	10.10	Take final skid sample, at time of shutdown	B32L21

Comments:

Phosphate Solution Infiltration/Injection Operations

Published Date: 11/05/15 **Effective Date: 11/05/15**

Appendix A - Injection Skid Monitoring Data Sheet

Skid #1 Round 2	**Operator(s):** Ramirez / Farth / PLAYTER			
	Totalizer Readings		**Start of Injections**	**End of Injections**
	River Water	FQI-N1-1A or [✓ 1B]	132912	250669
	Chem Injection#1 (Monosodium Phosphate)	FQI-N1-2A or [✓ -2B]	14093	27976
	Chem Injection#2 (Pyrophosphate)	FQI-N1-3A or [✓ -3B]	8288	16900
Write well numbers in spaces provided	Overall Mixture	FQI-N1-4A or [✓ -4B]	113077	210819
	(399-1- 95)	FQI-N1-4	25212	42686
	(399-1- 96)	FQI-N1-5	23442	53030
	(399-1- 97)	FQI-N1-6	27687	42439
	(399-1- 92)	FQI-N1-7	26310	53144
	(399-1- 94)	FQI-N1-8	~~25471~~ 28355	50583
	(399-1- 93)	FQI-N1-9	~~28355~~ 25471 3/10/16	55940

Comments

During hourly recording, note any observations, irregularities, and/or problems such as system downtime, totalizer maintenance/outage/re-set in log book

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					**Field Parameters - Injection Solution** Field parameters will be measured and recorded once every 4 hours					After flow rate is stable take 1st skid sample, take 2nd at 4-hour mark, and third/final at end of injections (8 hr). Where a sample is required, it is noted in this column.	
Date	Hour	Time	FQI-N1-2A or [✓ 2B] Chem 1 (gpm)	FQI-N1-3A or [✓ 3B] Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	FQI-N1-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm) 11/9/15	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ mg/L	RH 2-4-16	
11/9/15 Day 4	Pre Start	634	0	0	0	~~[illegible]~~ 11/9/15	✓	5.98	14.6	4716 ~~471.6~~	276	8.04	Columbia River Water Sample	→ B32JM43
11/9/15	0	0935	28.3	16.1	260	304.4	✓	6.99	14.7	10,350	260	8.28	Flow Rate Stable – Take first skid sample	~~B33XT2~~
11/9/15	1	1026	28.1	16.2	254	300.3	✓	☒	☒	☒	☒	☒		B349K5 SEC 1/13/16
11/9/15 Day 4	2	1120	27.9	16.0	256	299.9	✓	☒	☒	☒	☒	☒		

Comments:

Appendix A - (Cont.) Injection Skid Monitoring Data Sheet

Injection Round: Round 2
Skid ID: # 1
Wells: 399-1-95, 96, 97, 92, 94, 93
Operator(s): Faith/Ramirez

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours					Comments After flow rate is stable take 1st skid sample, take 2nd at 24 hr mark, and third/final at end of injections. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
Date	Hour	Time	FQI-N1-2A or -2B Chem 1 (gpm)	FQI-N1-3A or -3B Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	FQI-N1-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L RH 2-4-16	
11/9/15	3	1220	27.8	16.2	258	302	✓						
11/9/15	4	1309	27.8	15.9	255	298.7	✓	6.99	15.7	10380	270	9.30	
11/9/15	5	1410	27.8	15.9	256	299.7	✓						
11/9/15	6	1505	27.7	16.1	255	298.8	✓						
N/A	7												
11/9/15	8 FINAL	1600	28.2	16.1	256	300.6	✓	7.05	14.8	9145	242	8.26	Take final skid sample, at time of shutdown

SEC 1/13/16
~~B33XT4~~
B349K6

SEC 1/13/16
~~B33XT8~~
B349K7

Comments:

Appendix A - Injection Skid Monitoring Data Sheet

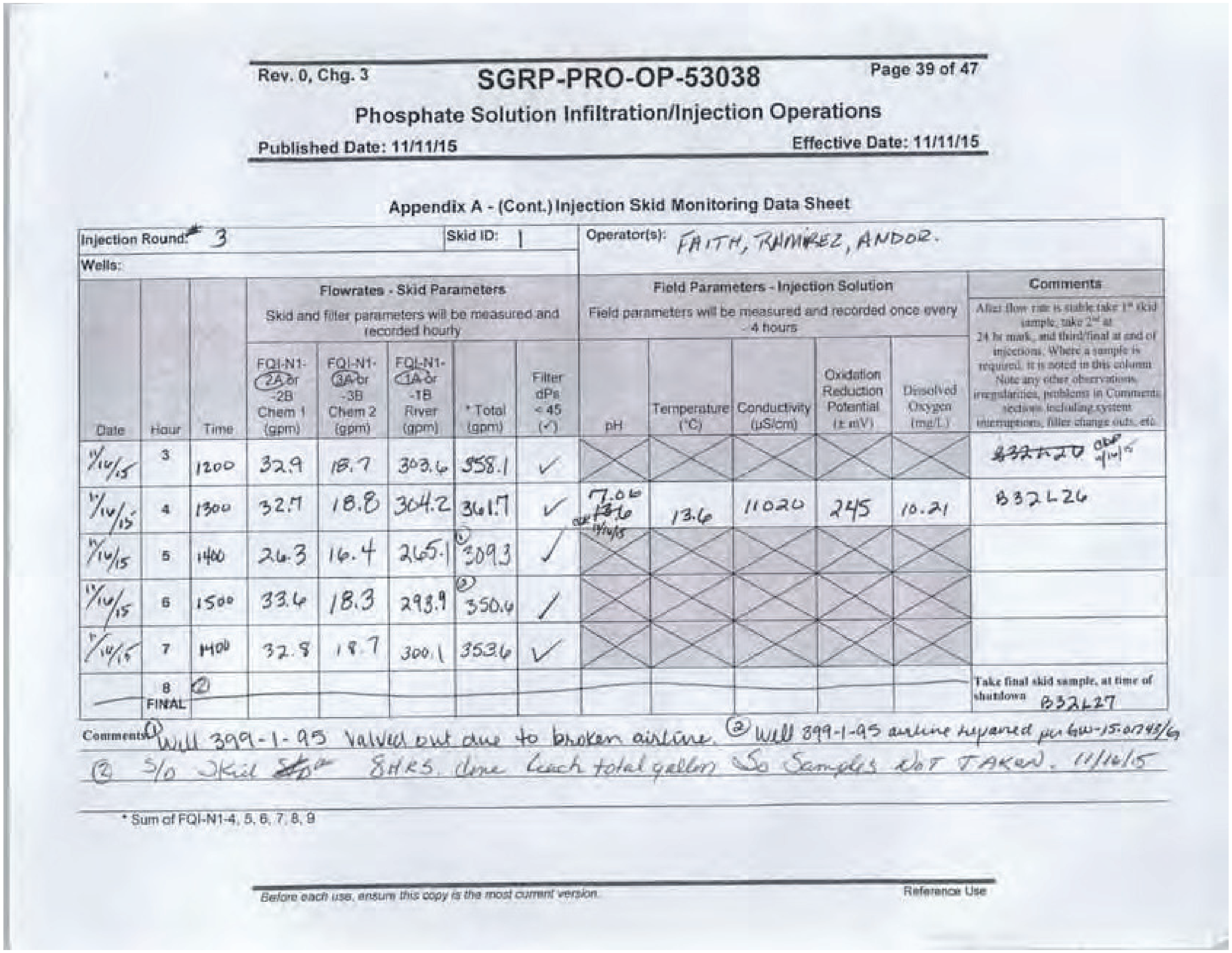
Skid #1 Round #3 Operator(s): FAITH, RAMIREZ, ANDOR

Write well numbers in spaces provided	Totalizer Readings		Start of Injections	End of Injections	Comments
	River Water	FQI-N1-1A or -1B	250448	377654	During hourly recording, note any observations, irregularities, and/or problems such as system downtime, totalizer maintenance/outage/re-set in log book
	Chem Injection#1 (Monosodium Phosphate)	FQI-N1-2A or -2B	27999	41956	
	Chem Injection#2 (Pyrophosphate)	FQI-N1-3A or -3B	16763	24635	
	Overall Mixture	FQI-N1-4A or -4B	218034	314034 *	
	(399-1- 95)	FQI-N1-4	42686	64448	
	(399-1- 96)	FQI-N1-5	53030	84560	
	(399-1- 97)	FQI-N1-6	42 440	53629	
	(399-1- 89)	FQI-N1-7	53 147	81390	
	(399-1- 90)	FQI-N1-8	50584	77578	
	(399-1- 91)	FQI-N1-9	55940	86 887	

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N1-2A or -2B Chem 1 (gpm)	FQI-N1-3A or -3B Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 4-hour mark, and third/final at end of injections (8 hr). Where a sample is required, it is noted in this column.
11/16/15	Pre Start	0920	0	0	0	0	✓	7.95	12.9	28.01	188	10.23	Columbia River Water Sample B32JL9
11/16/15	0	930	27.9	15.8	255.7	302.7	✓	7.07 ①	14.5 ①	11,150 ①	①198	①9.03	Flow Rate Stable – Take first skid sample B32L28 or 4PT ① 0 HOUR samples were taken late (at 12:00)
11/16/15	1	1000	29.1	15.8	256.3	303.0	✓	☒	☒	☒	☒	☒	
11/16/15	2	1100	29.3	16.1	257.6	307.7	✓	☒	☒	☒	☒	☒	

Comments: * NOT Accurate READING. Total READING is 448, 492 gallon. Sum of wells FQI-N1 4,5,6,7,8,9

* Sum of FQI-N1-4, 5, 6, 7, 8, 9



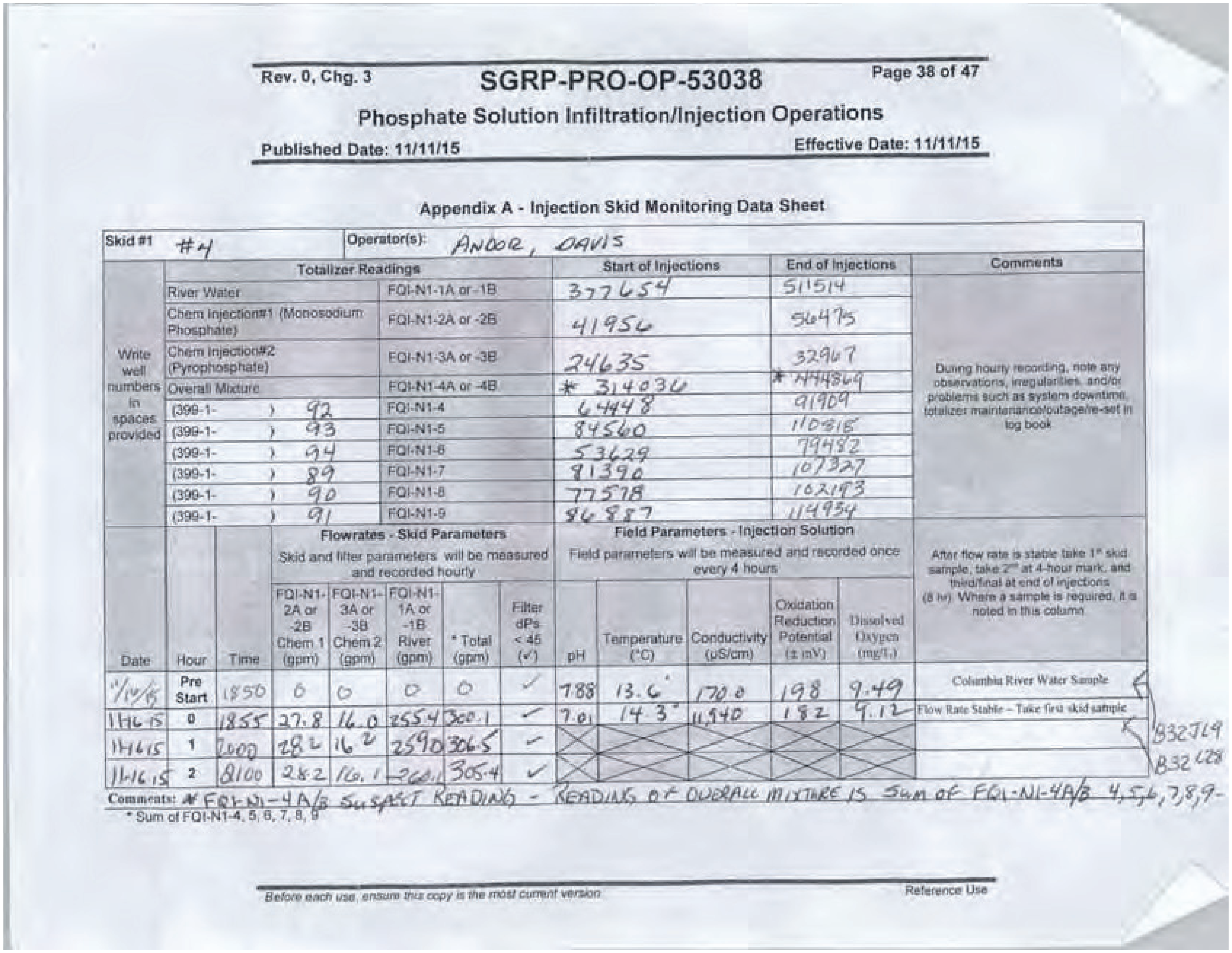
Appendix A - (Cont.) Injection Skid Monitoring Data Sheet

Injection Round: # 3
Skid ID: 1
Operator(s): FAITH, RAMIREZ, ANDOR.
Wells:

Date	Hour	Time	Flowrates - Skid Parameters: FQI-N1-2A or -2B Chem 1 (gpm)	FQI-N1-3A or -3B Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Injection Solution: pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	Comments
			Skid and filter parameters will be measured and recorded hourly					Field parameters will be measured and recorded once every ~4 hours					After flow rate is stable take 1st skid sample, take 2nd at 24 hr mark, and third/final at end of injections. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/14/15	3	1200	32.9	18.7	303.6	358.1	✓						~~B32L20~~ CAF 11/14/15
11/14/15	4	1300	32.7	18.8	304.2	361.7	✓	7.06 ~~[illegible]~~ CAF 11/14/15	13.6	11020	245	10.21	B32L26
11/14/15	5	1400	26.3	16.4	265.1	① 309.3	✓						
11/14/15	6	1500	33.6	18.3	298.9	② 350.6	✓						
11/14/15	7	1400	32.8	18.7	300.1	353.6	✓						
	8 FINAL	②											Take final skid sample, at time of shutdown B32L27

Comments: ① Well 399-1-95 valved out due to broken airline. ② Well 399-1-95 airline repaired per GW-15-0748/6
② S/O Skid ~~S/D~~ 8HRS. done reach total gallon So Samples NOT TAKEN. 11/16/15

* Sum of FQI-N1-4, 5, 6, 7, 8, 9



Phosphate Solution Infiltration/Injection Operations

Published Date: 11/11/15 Effective Date: 11/11/15

Appendix A - Injection Skid Monitoring Data Sheet

Skid #1 #4

Operator(s): ANDOR, DAVIS

	Totalizer Readings		Start of Injections	End of Injections	Comments
	River Water	FQI-N1-1A or -1B	377654	511514	During hourly recording, note any observations, irregularities, and/or problems such as system downtime, totalizer maintenance/outage/re-set in log book
	Chem Injection#1 (Monosodium Phosphate)	FQI-N1-2A or -2B	41956	56475	
	Chem Injection#2 (Pyrophosphate)	FQI-N1-3A or -3B	24635	32967	
Write well numbers in spaces provided	Overall Mixture	FQI-N1-4A or -4B	* 314036	* 444869	
	(399-1-) 92	FQI-N1-4	64448	91909	
	(399-1-) 93	FQI-N1-5	84560	110818	
	(399-1-) 94	FQI-N1-6	53629	79482	
	(399-1-) 89	FQI-N1-7	81390	107327	
	(399-1-) 90	FQI-N1-8	77578	102193	
	(399-1-) 91	FQI-N1-9	86887	114934	

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours					After flow rate is stable take 1st skid sample, take 2nd at 4-hour mark, and third/final at end of injections (8 hr). Where a sample is required, it is noted in this column
Date	Hour	Time	FQI-N1-2A or -2B Chem 1 (gpm)	FQI-N1-3A or -3B Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	
11/16/15	Pre Start	1850	0	0	0	0	✓	7.88	13.6°	170.0	198	9.49	Columbia River Water Sample
11-16-15	0	1855	27.8	16.0	255.4	300.1	✓	7.01	14.3°	11,940	182	9.12	Flow Rate Stable – Take first skid sample
11-16-15	1	2000	28.2	16.2	2590	306.5	✓	☒	☒	☒	☒	☒	
11-16-15	2	2100	28.2	16.1	260.1	305.4	✓	☒	☒	☒	☒	☒	

B32JL9
B32L28

Comments: * FQI-N1-4A/B SUSPECT READING - READING OF OVERALL MIXTURE IS SUM OF FQI-N1-4A/B 4,5,6,7,8,9-

* Sum of FQI-N1-4, 5, 6, 7, 8, 9

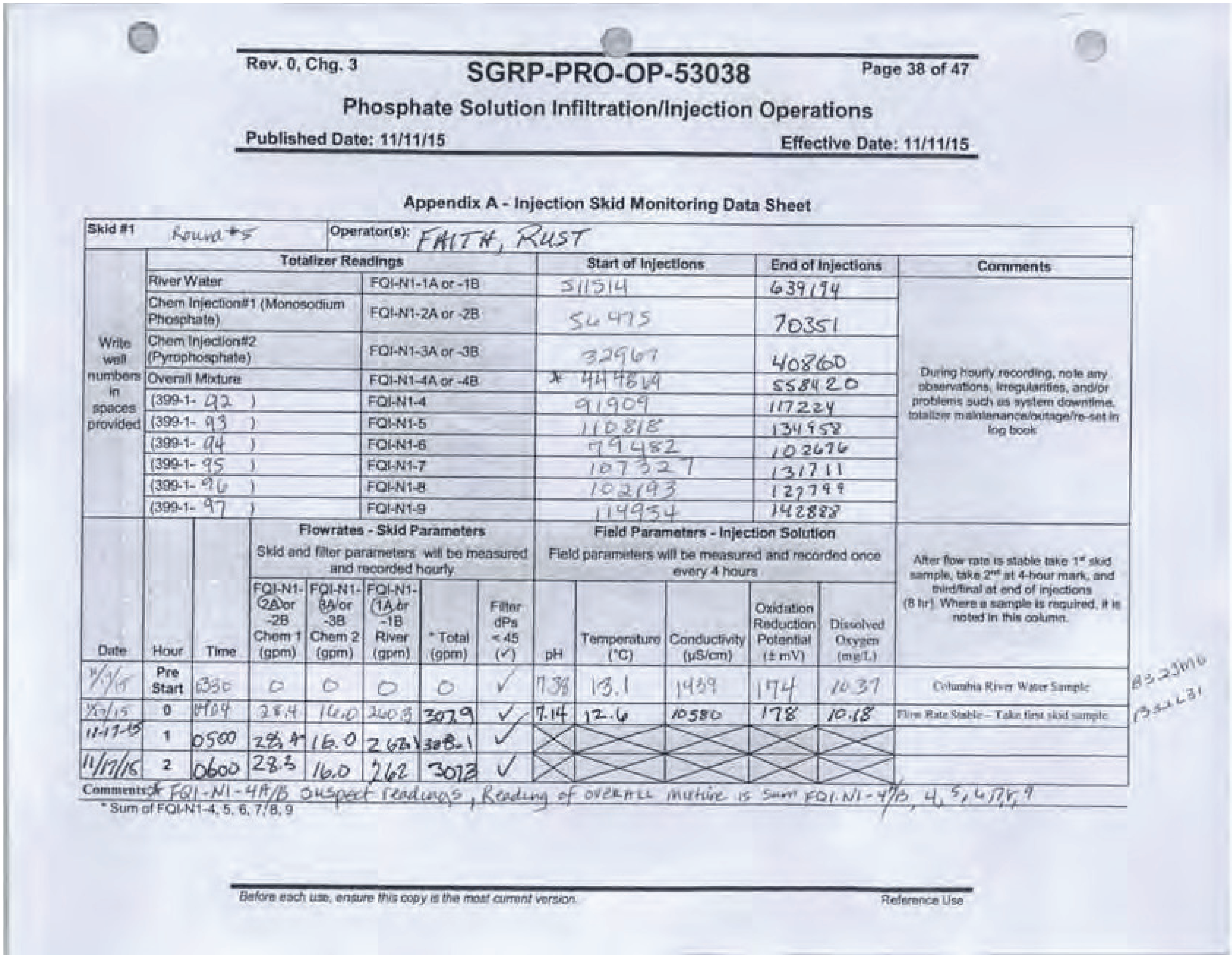
Appendix A - (Cont.) Injection Skid Monitoring Data Sheet

Injection Round: 4
Skid ID: 1
Operator(s): Faith, Rust
Wells: 89-94

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N1-2A or -2B Chem 1 (gpm)	FQI-N1-3A or -3B Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24 hr mark, and third/final at end of injections. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments section including system interruptions, filter change outs, etc.
11-16-15	3	2200	28.2	16.1	260.1	306.5	–						B32L29
11-16-15	4	2300	28.2	16.1	259.8	306.5	✓	7.09	13.8	11,860	194	9.45	~~B32L27~~ dbc 11/17/15
	5	0001	28.5	16.1	258.2	306.5	✓						
11-17-15	6	01:00	28.3	16.3	259.4	307.0	✓						
11-17-15	7	02:00	28.5	16.2	260.7	308.4	✓						
11-17-15	8 FINAL	03:00	28.5	16.3	262.2	308.8	✓	7.06	13.9	10,800	198	9.50	Take final skid sample, at time of shutdown ~~B32L29~~ dbc 11/17/15 B32L30

Comments:

* Sum of FQI-N1-4, 5, 6, 7, 8, 9



Rev. 0, Chg. 3

SGRP-PRO-OP-53038

Page 38 of 47

Phosphate Solution Infiltration/Injection Operations

Published Date: 11/11/15

Effective Date: 11/11/15

Appendix A - Injection Skid Monitoring Data Sheet

Skid #1 Round #5	**Operator(s):** FAITH, RUST			
Totalizer Readings		**Start of Injections**	**End of Injections**	**Comments**
River Water	FQI-N1-1A or -1B	511514	639194	During hourly recording, note any observations, irregularities, and/or problems such as system downtime, totalizer maintenance/outage/re-set in log book
Chem Injection#1 (Monosodium Phosphate)	FQI-N1-2A or -2B	54475	70351	
Chem Injection#2 (Pyrophosphate)	FQI-N1-3A or -3B	32967	40860	
Overall Mixture	FQI-N1-4A or -4B	* 444864	558420	
Write well numbers in spaces provided (399-1- 92)	FQI-N1-4	91909	117224	
(399-1- 93)	FQI-N1-5	110818	134958	
(399-1- 94)	FQI-N1-6	99482	102676	
(399-1- 95)	FQI-N1-7	107327	131711	
(399-1- 96)	FQI-N1-8	102193	127799	
(399-1- 97)	FQI-N1-9	114954	142888	

Date	Hour	Time	**Flowrates - Skid Parameters** Skid and filter parameters will be measured and recorded hourly: FQI-N1-[✓ 2A]or -2B Chem 1 (gpm)	FQI-N1-[✓ 3A]/or -3B Chem 2 (gpm)	FQI-N1-[✓ 1A] or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	**Field Parameters - Injection Solution** Field parameters will be measured and recorded once every 4 hours: pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 4-hour mark, and third/final at end of injections (8 hr). Where a sample is required, it is noted in this column.
11/16/15	Pre Start	1330	0	0	0	0	✓	7.38	13.1	1439	174	10.37	Columbia River Water Sample
11/16/15	0	1404	28.4	16.0	260.3	302.9	✓	7.14	12.6	10580	178	10.18	Flow Rate Stable – Take first skid sample
11-17-15	1	0500	28.4	16.0	263.1	308.1	✓	☒	☒	☒	☒	☒	
11/17/15	2	0600	28.3	16.0	262	301.3	✓	☒	☒	☒	☒	☒	

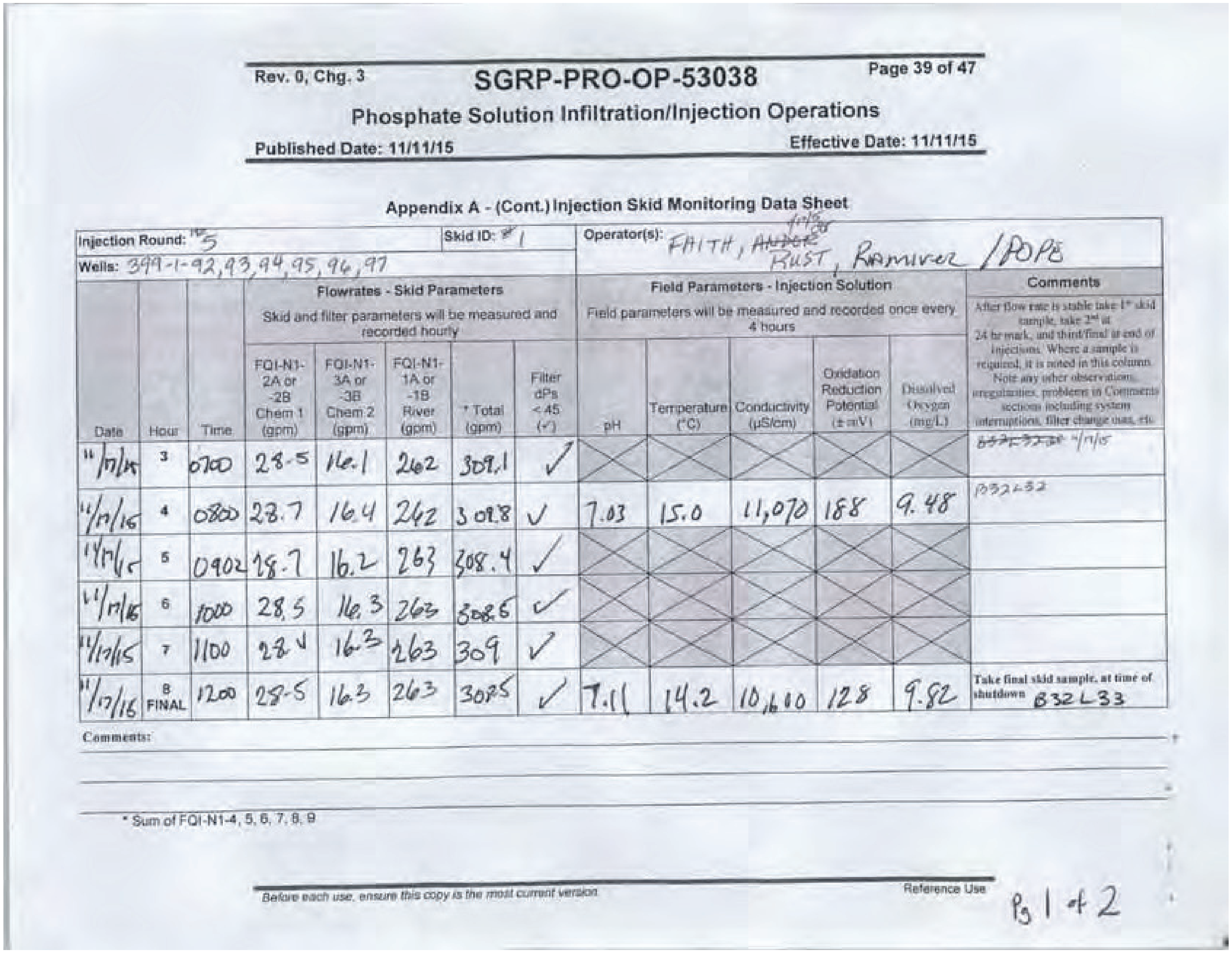
B32JM6
B32LL31

Comments: * FQI-N1-4A/B suspect readings, Reading of overall mixture is sum FQI-N1-4/B, 4, 5, 6, 7/8, 9

* Sum of FQI-N1-4, 5, 6, 7/8, 9

Before each use, ensure this copy is the most current version.

Reference Use



Rev. 0, Chg. 3 **SGRP-PRO-OP-53038** Page 39 of 47

Phosphate Solution Infiltration/Injection Operations

Published Date: 11/11/15 Effective Date: 11/11/15

Appendix A - (Cont.) Injection Skid Monitoring Data Sheet

Injection Round: #5	Skid ID: # 1
Wells: 399-1-92, 93, 94, 95, 96, 97	Operator(s): FAITH, ~~ANDER~~ RUST, Ramirez / POPE

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N1-2A or -2B Chem 1 (gpm)	FQI-N1-3A or -3B Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24 hr mark, and third/final at end of injections. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/17/15	3	0700	28.5	16.1	262	309.1	✓	☒	☒	☒	☒	☒	~~B32L32~~ 11/17/15
11/17/16	4	0800	28.7	16.4	242	308.8	✓	7.03	15.0	11,070	188	9.48	B32L32
11/17/15	5	0902	28.7	16.2	263	308.4	✓	☒	☒	☒	☒	☒	
11/17/16	6	1000	28.5	16.3	263	308.5	✓	☒	☒	☒	☒	☒	
11/17/15	7	1100	28 ✓	16.3	263	309	✓	☒	☒	☒	☒	☒	
11/17/16	8 FINAL	1200	28.5	16.3	263	308.5	✓	7.11	14.2	10,600	128	9.82	Take final skid sample, at time of shutdown B32L33

Comments:

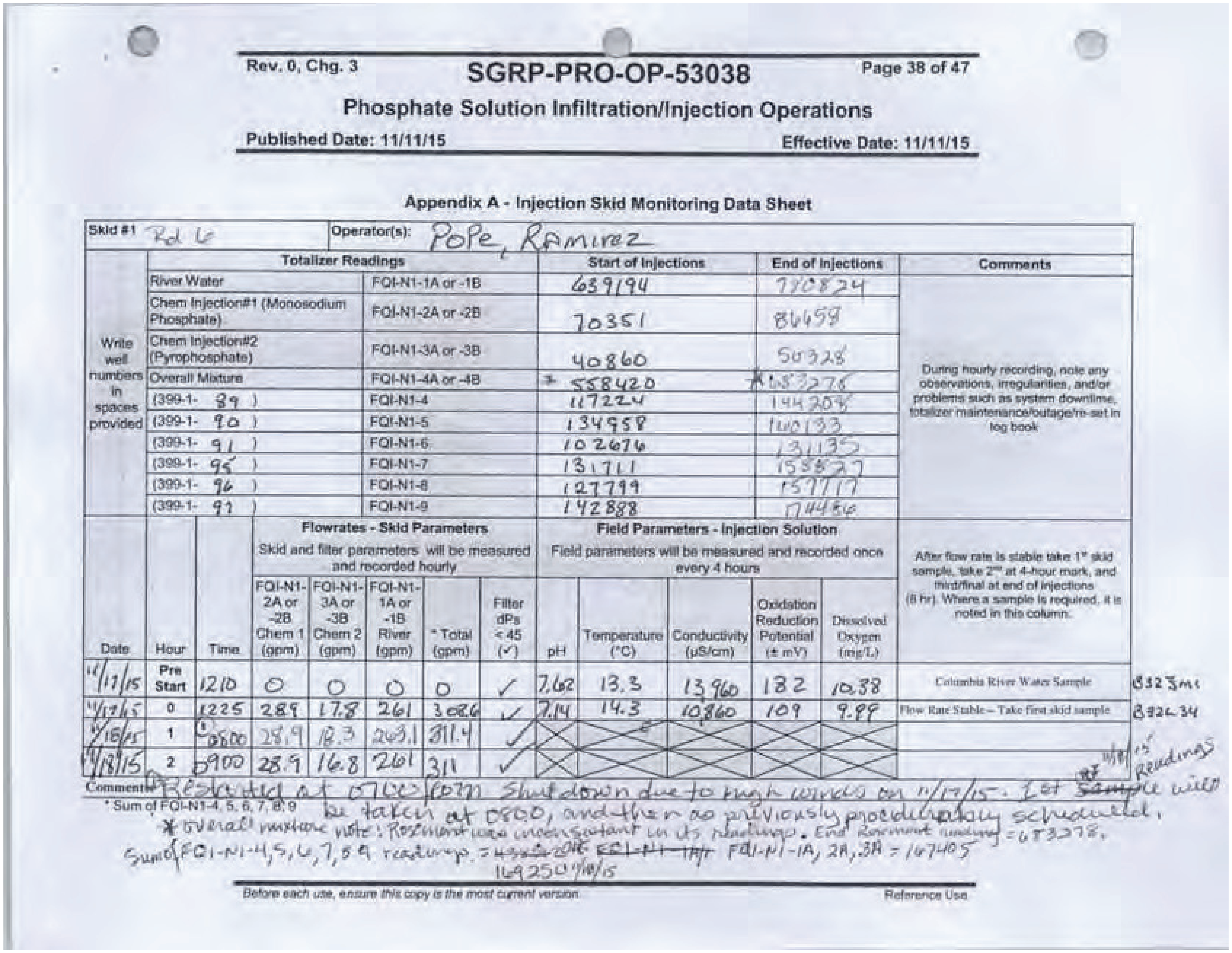
* Sum of FQI-N1-4, 5, 6, 7, 8, 9

Before each use, ensure this copy is the most current version Reference Use

Pg 1 of 2

Instrument	S/N	Cal Due Date	Check Std (Pre)	Standard
Myron L pH	6221191	2-3-16	4.05 @ 20.2°C	Std. 4.01 @ 25C
[redacted]	[redacted]	[redacted]	6.98 @ 20.2°C	Std. 7.00 @ 25C
[redacted]	[redacted]	[redacted]	10.04 @ 20.1°C	Std. 10.01 @ 25C
Myron L Cond	[redacted]	[redacted]	446.4 @ 20.0°C	Std. 442uS @ 25C
Myron L ORP	[redacted]	[redacted]	233 mV@20.2°C	Std. 231 mV @ 25C
pH 4.00 Hach	Lot#: A5243	Exp Date: Aug 2019	Name:	
pH 7.00 Hach	Lot#: A5237	Exp Date: Aug 2017	Date:	
pH 10.0 Hach	Lot#: A5260	Exp Date: Sept 2016	Procedure:	
Cond Myron L 442	Lot#: 121741 AS	Exp Date:		
ORP YSI ZOBELL	Lot#: 15B 100453	Exp Date:		

Pg 2 of 2



Rev. 0, Chg. 3 **SGRP-PRO-OP-53038** Page 38 of 47

Phosphate Solution Infiltration/Injection Operations

Published Date: 11/11/15 Effective Date: 11/11/15

Appendix A - Injection Skid Monitoring Data Sheet

Skid #1 Rd 6

Operator(s): Pope, Ramirez

	Totalizer Readings		Start of Injections	End of Injections	Comments
Write well numbers in spaces provided	River Water	FQI-N1-1A or -1B	639194	770824	During hourly recording, note any observations, irregularities, and/or problems such as system downtime, totalizer maintenance/outage/re-set in log book
	Chem Injection#1 (Monosodium Phosphate)	FQI-N1-2A or -2B	70351	86458	
	Chem Injection#2 (Pyrophosphate)	FQI-N1-3A or -3B	40860	50328	
	Overall Mixture	FQI-N1-4A or -4B	* 558420	*683278	
	(399-1- 89)	FQI-N1-4	117224	144208	
	(399-1- 90)	FQI-N1-5	134958	160133	
	(399-1- 91)	FQI-N1-6	102676	131135	
	(399-1- 95)	FQI-N1-7	131711	155827	
	(399-1- 96)	FQI-N1-8	127799	157717	
	(399-1- 97)	FQI-N1-9	142888	174456	

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours					After flow rate is stable take 1st skid sample, take 2nd at 4-hour mark, and third/final at end of injections (8 hr). Where a sample is required, it is noted in this column.	
Date	Hour	Time	FQI-N1-2A or -2B Chem 1 (gpm)	FQI-N1-3A or -3B Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)		
11/17/15	Pre Start	1210	0	0	0	0	✓	7.62	13.3	13,960	182	10.38	Columbia River Water Sample	B323M1
11/17/15	0	1225	28.9	17.8	261	308.6	✓	7.14	14.3	10,860	109	9.99	Flow Rate Stable – Take first skid sample	B32C34
11/18/15	1	0800	28.9	18.3	263.1	311.4	✓							
11/18/15	2	0900	28.9	16.8	261	311	✓							

Comments: Restarted at 0700 from shutdown due to high winds on 11/17/15. 1st ~~sample~~ 11/18/15 Readings will be taken at 0800, and then as previously procedurally scheduled.
*Overall mixture note: Rosemount was inconsistant in its readings. End Rosemount reading = 683278.
Sum of FQI-N1-4,5,6,7,8,9 readings = ~~[illegible]~~ ~~FQI-N1-1A/~~ FQI-N1-1A, 2A, 3A = 167405
169250 11/18/15

* Sum of FQI-N1-4, 5, 6, 7, 8, 9

Before each use, ensure this copy is the most current version. Reference Use

Appendix A - (Cont.) Injection Skid Monitoring Data Sheet

Injection Round: 6

Skid ID: 1

Operator(s): Facth, Ramirez.

Wells: 399-1-89, 90, 91, 95, 96, 97

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N1-2A or -2B Chem 1 (gpm)	FQI-N1-3A or -3B Chem 2 (gpm)	FQI-N1-1A or -1B River (gpm)	* Total (gpm)	Filter dPs <45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24 hr mark, and third/final at end of injection. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments section, including system interruptions, filter change outs, etc.
11/18/15	3	1000	28.9	16.9	263	310.1	✓						
11/18/15	4	1100	33.2	19.9	300	356.1	✓	7.09	13.2	10680	218	9.98	B32L35
11/18/15	5	1200	33.2	19.8	300	355	✓						
11/18/15	6	1300	33.2	19.6	300	356.4	✓						
11/18/15	7	0	0	0	0	0	0						
11/18/15	8 FINAL	0	0	0	0	0	0	7.22	12.8	11780	177	9.71	Take final skid sample at time of shutdown B32L36

Comments: Met the target parameters during hour #6 @ 1242. Took reading at 1300 hrs.

* Sum of FQI-N1-4, 5, 6, 7, 8, 9

This page intentionally left blank.

Appendix B

Infiltration Skid Monitoring Data Sheets

This page intentionally left blank.

Appendix C - Infiltration Skid Monitoring Data Sheet

Skid #2

Operator(s): ANDOR / PLAYTER

Totalizer Readings		Start of Injections	End of Injections	Comments
River Water	FQI-N2-1A or [✓ 1B]	0	795611	During hourly recording, note any observations, irregularities, and/or problems such as system downtime, totalizer maintenance/outage/re-set in Comments sections
Chem Injection#1 (Monosodium Phosphate)	FQI-N2-2A or [✓ 2B]	0	53004	
Chem Injection#2 (Pyrophosphate)	FQI-N2-3A or [✓ 3B]	0	33338	
Overall Mixture	FQI-N2-4A or [✓ 4B]	0	956011 ①	
	FQI-N2-4	0	293981	
	FQI-N2-5	0	298244	
	FQI-N2-6	0	290969	

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours					After flow rate is stable take 1st skid sample, take 2nd at 4-hour mark, and third/final at end of injections (8 hr). Where a sample is required, it is noted in this column.
Date	Hour	Time	FQI-N2-2A or [✓ 2B] Chem 1 (gpm)	FQI-N2-3A or [✓ 3B] Chem 2 (gpm)	FQI-N2-1A or [✓ 1B] River (gpm)	FQI-N2-4A or [✓ 4B] Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L RH 2-4-16	
11/7/15	Pre Start	0710	3.3	2.1	56	76	✓	7.08	13.3	154.6	275	11.78	Columbia River Water Sample B32JM2
11/7/15	0	0716	3.3	2.8	56	85	✓	6.94	12.8	13,940	210	13.11	Flow Rate Stable – Take first skid sample B32L37
11/7/15	1	0800	3.1	2.5	52	65	✓	☒	☒	☒	☒	☒	
11/7/15	2	0900	2.9	2.0	49	59	✓	☒	☒	☒	☒	☒	

Day 1

Comments: ① TOTAL FLOW METER FQI-N2-4A READINGS ARE ERRATIC. STARTING HOUR #2 LOGGING THE SUM OF METERS FQI-N2-4,5 & 6 ~~TO [illegible]~~ FOR TOTAL FLOW.

Phosphate Solution Infiltration/Injection Operations

Published Date: 11/05/15 Effective Date: 11/05/15

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: Skid #2

Operator(s): Andrew/Playter

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-2A or [✓ -2B] Chem 1 (gpm)	FQI-N2-3A or [✓ -3B] Chem 2 (gpm)	FQI-N2-1A or [✓ -1B] River (gpm)	FQI-N2-4A or [✓ 4B] Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L RH 2-4-16	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/7/15	3	1000	2.8	2.0	47	57.1	✓	☒	☒	☒	☒	☒	
11/17/15	4	1100	2.9	2.0	48	57.3	✓	6.97	15.0 C	13,830	203	8.50	
11/7/15	5	1200	2.8	2.1	47	56.2	✓	☒	☒	☒	☒	☒	
11/7/15	6	1300	2.8	1.7	48	57	✓	☒	☒	☒	☒	☒	
11/7/15	7	1400	2.9	2.0	49	58.3	✓	☒	☒	☒	☒	☒	
11/7/15	8	1500	2.9	2.0	48	58.1	✓	6.9	15.9	13,620	216	965	

B32L38

B32L39

Comments:

Phosphate Solution Infiltration/Injection Operations

Published Date: 11/05/15 Effective Date: 11/05/15

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): ANDOR / PLAYTER / FAITH / RAMIREZ

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or [✓ 2B] Chem 1 (gpm)	FQI-N2-3A or [✓ 3B] Chem 2 (gpm)	FQI-N2-1A or [✓ 1B] River (gpm)	FQI-N2-4A or [✓ 4B] Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ mg/L	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/7/15	9	1615	2.6	2.1	41	49.1	✓	☒	☒	☒	☒	☒	RH 2-4-16
11/7/15	10	1700	2.7	2.1	45	54.4	✓	7.01	15.0	16,530	209	942	
11/7/15	11	1800	2.7	2.2	45	49.9	✓	☒	☒	☒	☒	☒	
11/7/15	12	1925	1.4	1.0	49	51.4	✓	☒	☒	☒	☒	☒	
11/7/15	13	2020	2.5	1.8	45	49.3	✓	☒	☒	☒	☒	☒	
11/7/15	14	2110	2.4	1.7	45	49.3	✓	6.87	16.1	13,460	279	8.85	

B32L40

B32L41

Comments: SYSTEM SHUT DOWN FOR 45 MIN (1530-1615) TO FIX LEAK IN HOSE

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): FAITH/RAMIREZ

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
Date	Hour	Time	FQI-N2- ① [✓ 2A] or [✓ -2B] Chem 1 (gpm)	FQI-N2- 3A or [✓ -3B] Chem 2 (gpm)	FQI-N2- 1A or [✓ -1B] River (gpm)	FQI-N2- 4A or [✓ -4B] Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ mg/L RH 2-4-16	
11/7/15	15	2205	2.5	1.7	45	49.2	✓	☒	☒	☒	☒	☒	
11/7/15	16	2305	2.5	1.5	45	49.0	✓	6.88	16.2	16,260	268	8.86	
11/8/15	17	0005	2.5	1.4	44	48.1	✓	☒	☒	☒	☒	☒	
11/8/15	18	0105	2.6	1.6	44	49.0	✓	☒	☒	☒	☒	☒	
11/8/15	19	0215	① 3.0	1.8	49	53.8	✓	☒	☒	☒	☒	☒	
11/8/15	20	0300	3.0	1.7	49	53.7	✓	6.90	14.6	10,780	289	7.94	

B32L42

B32L43

Comments: ① At 0200, Readings will now be taken at FQI-N2-2A, due to a Flow rate issue between the Flow meter on SKID and the Control Panel display.

Before each use, ensure this copy is the most current version. Reference Use

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Faith / Ramirez, Windsor /

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ mg/L RH 2-4-16	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/8/15	21	0400	2.9	1.8	48	52.7	✓						
11/8/15	22	0500	2.9	1.9	48	52.8	✓	6.93	14.02	10,280	277	8.60	
11/8/15	23	0600	2.9	2.1	46.8	51.6	✓						
11/8/15	24	0700	2.8	2.1	46.8	50.8	✓						
11/8/15	25	0800	2.8	2.0	46.5	50.8	✓						
11/8/15	26	0900	2.8	2.1	45.5	50.5	✓	7.08	15.2	~~6 8300~~ 6830 11/8/15	231	9.25	

B32L44

B32L45

Day 2

Comments:

SGRP-PRO-OP-53038

Phosphate Solution Infiltration/Injection Operations

Published Date: 11/05/15 Effective Date: 11/05/15

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID:

Operator(s):

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L RH 2-4-16	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.	
11/9/15	27	1000	3.0	2.8	47.9	53.8 ~~47.7~~ DOWN 11-8-15 1000	11-8-15 [illegible] ~~52.9~~ ✓	☒	☒	☒	☒	☒	UP 44 HZ	
11/8/15	28	1100	2.9	2.3	47.3	52.5	✓	7.07	13.0	6995 ~~69950~~ au 11/8/15	192	6.60	N/A	B32L46
11/8/15	29	1200	2.9	2.2	47.2	52.5	✓	☒	☒	☒	☒	☒		
11/8/15	30	1300	2.9	1.9	47.3	52.4	✓	☒	☒	☒	☒	☒		
11/6/15	31	1400	2.9	2.0	46.9	52.0	✓	☒	☒	☒	☒	☒		
11/8/15	32	1500	2.8	2.3	46.7	52.0	✓	7.12	15.7	au 11/8/15 ~~71990~~ 7199	147	4.24	N/A	B32L47

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID:

Operator(s): Billings + VANDOR

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
			FQI-N2-[✓ 2A] or -2B Chem 1 (gpm)	FQI-N2-[✓ 3A] or -3B Chem 2 (gpm)	FQI-N2-[✓ 1A] or -1B River (gpm)	FQI-N2-[✓ 4A] or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L	
11/8/15	33	1600	3.0	1.9	48.6	53.7	✓	☒	☒	☒	☒	☒	RH 2-4-16
11/8/15	34	1700	3.0	2.0	48.4	53.4	✓	7.10	14.7	6906	150	5.84	
11/8/15	35	1800	2.9	2.1	48.3	52.7	✓	☒	☒	☒	☒	☒	
11/8/15	36	1900	3.0	2.3	47.7	52.9	✓	☒	☒	☒	☒	☒	
11/8/15	37	2000	2.9	2.0	47.8	53.1	✓	☒	☒	☒	☒	☒	
11/8/15	38	2100	2.9	2.0	47.9	52.9		7.11	14.2 °C	6898	~~214~~ 11/8/15 209	9.17	

B32L48

B32L49

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: S

Operator(s): ANDOR, Billings

			Flowrates - Skid Parameters					Field Parameters - Infiltration Solution					Comments
			Skid and filter parameters will be measured and recorded hourly					Field parameters will be measured and recorded once every 4 hours					After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-[✓ 3A] or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L	
11/8/15	39	2200	2.9	2.0	47.9	52.8	✓	☒	☒	☒	☒	☒	RH 2-4-16
11/8/15	40	2300	2.9	1.9	48	52.8	✓	6.89	15.7	8574	235	878	B349T2
11/9/15	41	0001 ~~24~~ 11/9/15	2.9	1.8	48	52.7	✓	☒	☒	☒	☒	☒	
11/9/15	42	0103	2.9	1.7	48	52.6	✓	☒	☒	☒	☒	☒	
11/9/15	43	0200	2.9	1.9	48	52.8	✓	☒	☒	☒	☒	☒	
11/9/15	44	0300	2.9	1.9	47	51.8	✓	7.08	14.7	6940	246	883	B349T3

RM Walker ~~B32 1~~ ~~B32150~~ SEC 1/13/16

RM Walker ~~B32~~ ~~B32151~~ SEC 1/13/16

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): FAHH / RAmirez

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-[✓ 2A] or -2B Chem 1 (gpm)	FQI-N2-[✓ 3A] or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ mg/L	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/9/15	45	0400	2.9	1.9	48	52.8	✓						RH 2-4-16
11/9/15	46	0500	2.8	2.2	47	52.0	✓	6.96	14.2 c	8,043	240	8.79	
11/9/15	47	0612	2.8	2.6	46	51.4	✓						
11/9/15	48	0700	2.8	1.9	46	50.7	✓						
11/9/15	49	0800	2.8	2.1	46	50.9	✓						
11/9/15	50	0905	2.8	1.7	46	50.5	✓	7.01	14.2	7377	265	8.74	

SEC 1/13/16
~~B33XT0~~
B349T4

SEC 1/13/16
~~B33XT1~~
B349T5

Day 3

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: *2								**Operator(s):** Faulk/Ramirez					
			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					**Field Parameters - Infiltration Solution** Field parameters will be measured and recorded once every 4 hours					**Comments**
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-[✓ 3A] or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ mg/L	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/9/15	51	1010	2.0	2.1	47	51.1	✓						RH 2-4-16
11/9/15	52	1110	2.6	1.9	47	51.5	✓	7.03	15.5	7728	255	8.87	
11/9/15	53	1210	2.6	1.6	46	50.2	✓						
11/9/15	54	1306	2.6	1.7	46	50.3	✓						
11/9/15	55	1400	2.6	1.6	47	51.2	✓						
11/9/15	56	1500	2.6	1.6	47	51.2	✓	7.01	14.9	6265	240	8.54	

SEC 1/13/16
~~B33XT3~~
B349T6

SEC 1/13/16
~~B33XT4~~
B349T7

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID:

Operator(s): Playtor / Billingsley

Date	Hour	Time	**Flowrates - Skid Parameters** Skid and filter parameters will be measured and recorded hourly FQI-N2- [✓ 2A] or -2B Chem 1 (gpm)	FQI-N2- [✓ 3A] or -3B Chem 2 (gpm)	FQI-N2- [✓ 1A] or -1B River (gpm)	FQI-N2- 4A or -4B Total (gpm)	Filter dPs < 45 (✓)	**Field Parameters - Infiltration Solution** Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L	**Comments** After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/9/15	57	1600	2.7	1.8	48.5	53.1	✓						RH 2-4-16
11/9/15	58	1700	2.7	1.8	48.3	53.0	✓	7.09	15.0	6316 ~~6316~~ 11/9/15	210	9.59 ~~220~~ 11/9/15	
11/9/15	59	1800	2.7	1.7	48.7	53.1	✓						
11/9/15	60	1900	2.7	2.0	48.2	53.2	✓						
11/9/15	61	2000	2.7	1.8	48.2	53	✓						
11/9/15	62	2100	2.7	1.8	48.6	53.1	✓	7.09	15.4	6460	192	9.25	

~~B33X45~~ 11-9-15

SEC 4/13/16 ~~B33X45~~ B349T8

SEC 4/13/16 ~~B33X46~~ B349T9

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Playter / Billingsley / Wise

Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ mg/L	Comments: After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					**Field Parameters - Infiltration Solution** Field parameters will be measured and recorded once every 4 hours					
11/9/15	63	2200	2.7	2.2	48.3	53.2	✓						RH 2-4-16
11/9/15	64	2300	2.7	1.9	48.8	53.5	✓	7.21	14.9	6377	148	9.24	
11-10-15	65	0010	2.7	1.9	49.0	53.6	✓						
11-10-15	66	0105	2.7	2.1	48.9	53.7	✓						
11/10/15	67	0205	2.7	1.9	49.1	53.7	✓						
11/10/15	68	0300	2.7	2.0	48.5	53.2	✓	7.21	13.9	6335	157	8.96	mg/L

SEC 1/13/16
~~B33K17~~
B349V0

SEC 1/13/16
~~B33K18~~
B349V1

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Wm Wise / ANDOR, Ramirez

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-[✓ 2A] or -2B Chem 1 (gpm)	FQI-N2-[✓ 3A] or -3B Chem 2 (gpm)	FQI-N2-[✓ 1A] or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/10/15	69	0400	2.7	1.7	48.6	53.0	✓						RH 2-4-16
11/10/15	70	0500	2.7	1.8	48.1	52.6	✓	7.24	13.9	6326	147	9.25 mg/L	
11/10/15	71	0600	2.6	2.1	47.6	52.2	✓						
11/10/15	72	0700	3.2	2.0	48	53.2	✓						
11/10/15	73	0800	3.0	2.0	48	53	✓						
11/10/15	74	0900	3.0	2.2	48	53.2	✓	6.95	14.3	7812	226	9.30 mg/L	

Day 4

SEC 1/13/16 ~~B33X19~~

~~B33X19~~ ~~B33X1~~ B349V2

SEC 1/13/16 ~~B33XV0~~ B349V3

Comments:

TH

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: Skid #2

Operator(s): Rameriz, Anoor

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/10/15	75	1000	3.0	2.0	48	53	✓						RH 2-4-16
11/10/15	76	1100	3.0	2.0	48	53	✓	7.27	14.6	7038	185	9.40 mg/L	
11/10/15	77	1200	3.2	2.1	49.	54.3	✓						
11/10/15	78	1300	3.1	2.0	48.5	53.5	✓						
11/10/15	79	1400	3.0	2.1	49	54.1	✓						
11/10/15	80	1500	11/10/15 ~~1~~3.0	2.0	49	54	✓	7.28	14.5 C	6746	175	9.83	

SEC 1/13/16
~~B33XV1~~
B349V4

~~B33~~ AA
~~B3Z~~ AA 11/10/15
SEC 1/13/16
~~B33XV2~~
B349V5

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): AWOOR

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
Date	~~Hour~~ 81	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L	
11/10/15	~~1700~~	1600	3.0	2.3	48.5	53.8	✓	☒	☒	☒	☒	☒	RH 2-4-16
11/10/15	82 ~~17~~	1700	3.0	1.9	49.1	54	✓	7.17	14.6°	7422	159	10.01	
11/10/15	83	1800	2.9	2.0	48.8	53.6	✓	☒	☒	☒	☒	☒	
11/10/15	84	1900	3.0	2.1	48.6	53.6	✓	☒	☒	☒	☒	☒	
11/10/15	85	2000	2.9	2.1	48.7	54.3	✓	☒	☒	☒	☒	☒	
11/10/15	86	2100	2.9	1.8	48.9	48.8	✓	7.18	14.4	7279	150	9.70	

B349V6
~~B33XV5~~
SEC 1/13/16

B349V7
~~B33XV4~~
SEC 1/13/16

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): ANDOR / Patterson.

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/10/15	87	2200	2.9	1.9	49.0	53.9		☒	☒	☒	☒	☒	RH 2-4-16
11/10/15	88	2300	2.9	1.8	49.2	53.8		7.28	13.6°C	6670	155	9.06	
11/11/15	89	0010	2.5	1.8	49.0	53.9		☒	☒	☒	☒	☒	
11/11/15	90	0100	2.8	2.4 ~~8~~ 11/11	48.3	54.1		☒	☒	☒	☒	☒	
11/11/15	91	0200	2.9	2.0	49.8	54.1		☒	☒	☒	☒	☒	
11/11/15	92	0301	2.9	2.0	49.6	54.0		7.25	12.6	6440	174	9.58	

B349V8
SEC 1/13/16 ~~B33XV5~~
~~B33XV6~~ aw
~~B33V5~~ aw 11/10/15

B349V9
~~B33XV6~~
SEC 1/13/16

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): Patterson /

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
			FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	FQI-N2-4A or -4B Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (~~µg/L~~) mg/L	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/11/15	93	0400 ~~0300~~ 11/11/15	2.8	1.9	48.4	49.5	✓						RH 2-4-16
11/11/15	94	0500	2.8	2.0	48.1	53.2	✓	7.21	12.0	6546	157	9.57	
11/11/15	95	0600	3.0	2.0	47.9	52.5	✓						
11/11/15	96	0700	3.0	2.0	49.0	54	✓						
11/11/15	97	0800	3.0	2.1	48	53.1	✓						
11/11/15	98	0900	3.0	2.1	49.1	54.2	✓	6.99	14.8°c	6980	215	9.56	

B349W0
~~B33[illegible]~~
SEC 1/13/16

Day 5

B349W1
~~B33[illegible]~~
SEC 1/13/16

Comments:

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: # 2

Operator(s): RAMEREZ, ANDOR

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* ~~FQI-N2-4A or -4B~~ Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ (mg/L)	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
11/11/15	99	1000	3.0	2.0	49.3	54.2	✓	✗	✗	✗	✗	✗	
11/11/15	100	1100	3.0	2.1	49.2	54.3	✓	✗	✗	✗	✗	✗	
11/11/15	101	1200	3.0	2.1	49.7	54.2	✓	✗	✗	✗	✗	✗	
11/11/15	102	1300	3.0	2.0	50	55	✓	7.15	15.2	6714	200	9.81	

Comments:

SEC 4/13/16 ~~B33~~ ~~B33KV8~~ B349W2

* Sum OF FQI-N2-4,5,6

Pg 1 of 2

Instrument	S/N	Cal Due Date	Check Std (Pre)	Standard
Myron L pH	6212777	1-21-16	4.07 @ 18.9°C	Std. 4.01 @ 25C
[redacted]	[redacted]	[redacted]	7.04 @ 19.1 °C	Std. 7.00 @ 25C
			10.07 @ 18.7°C	Std. 10.01 @ 25C
Myron L Cond	[redacted]	[redacted]	453 @ 17.1°C	Std. 442uS @ 25C
Myron L ORP			231 mV@17 °C	Std. 231 mV @ 25C
pH 4.00 Hach	Lot#: A5243	Exp Date: Aug 2019	Name:	
pH 7.00 Hach	Lot#: A5237	Exp Date: Aug 2017	Date:	
pH 10.0 Hach	Lot#: A5260	Exp Date: Sept 2016	Procedure:	
Cond Myron L 442	Lot#: 121741 AS	Exp Date: 12-19-15		
ORP YSI ZOBELL	Lot#: 15B 100453	Exp Date: 11-10-15		

pg 2 of 2

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): Ramirez – ANOOR –

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* ~~FQI-N2-4A or -4B~~ Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen ~~(µg/L)~~ (mg/L)	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
* 11/11/15	103	1410 ~~1400~~	4.7	2.6	78.1	85.6	✓						
11/11/15	104	1510	4.8	3.1	79.3	87.2	✓						
11/11/15	105	1610	4.7	3.0	78.9	86.9	✓						
11/11/15	106	1705	4.7	3.0	79.0	86.6	✓	7.29	14.6	6329	178	10.33	

SEC 1/13/16
~~B33XV9~~
B349W3

Comments: * New 20psi Regulators installed on 1400 Hrs Readings
New Ratio's 4.7 Mono, 3.0 Pyro – River Flow 78-80 GPm

* Sum of FQI-N2-4,5,6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): PLAYTER

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/11/15	107	1803	4.7	2.9	78.4	86.3	✓	☒	☒	☒	☒	☒	
11/11/15	108	1905	4.7	3.1	77.9	86	✓	☒	☒	☒	☒	☒	
11/11/15	109	2006	4.7	2.9	77.4	85.3	✓	☒	☒	☒	☒	☒	
11/11/15	110	2100	4.7	2.8	77.4	84.9	✓	7.17	14.6	6595	167	9.72	

B349W4 ~~B33XW0~~
SEC
1/13/16

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): PLAYTER / Faith

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/11/15	111	2200	4.6	3.0	77.1	84.8	✓						
11/11/15	112	2300	4.7	2.9	77.0	83.9	✓						
11/12/15	113	0004	4.7	3.0	77.0	84.7	✓						
11/12/15	114	0100	4.7	2.8	77.0	84.5	✓	7.19	15.0	8145	164	9.53	SEC 1/13/16 ~~B33XW1~~ B349W5

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Faith

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
			FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	
11/12/15	115	0200	4.7	3.0	77	84.7	✓	☒	☒	☒	☒	☒	
11/12/15	116	0300	4.7	2.8	78	84.5	✓	☒	☒	☒	☒	☒	
11/12/15	117	0400	4.7	2.8	78	84.5	✓	☒	☒	☒	☒	☒	
11/13/15	118	0500	4.6	3.1	77	84.7	✓	7.21	14.9	6934	157	9.28	~~B33XW8~~ 11/12/15 SEE 11/13/15 ~~B33XW6~~ B349W6

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Faith

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/12/15	119	600	4.7	3.1	77	84.8	✓	☒	☒	☒	☒	☒	
11/12/15	120	700	4.6	3.2	77	84.8	✓	☒	☒	☒	☒	☒	
11/12/15	121	800	4.6	3.5	76	84.1	✓	☒	☒	☒	☒	☒	
11/12/15	122	900	4.6	3.2	75	84.8	✓	7.21 ~~14.7~~ CDF 11/12/15	14.7	6799	162	9.65	

Day 6

SBC 1/13/16

B349W7

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Faustin Ramey [illegible]

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/12/15	123	1000	4.6	3.1	74	84.7	✓	X	X	X	X	X	
11/12/15	124	1100	4.7	3.2	73	82.1	✓	X	X	X	X	X	
11/12/15	125	1200	4.6	3.3	73	81.0	✓	X	X	X	X	X	
11/12/15	124	1300	4.6	3.1	73	80.7	✓	7.07	14.4	7343	221	9.83 mg/L	

1/13/16 SGC ~~B335H4~~

Comments: B349W8

* Sum of FQI-N2-4, 5, 6

Pg. 1 of 2

Instrument	S/N	Cal Due Date	Check Std (Pre)	Standard
Myron L pH	622 1191	2-3-16	4.01 @ 19.4°C	Std. 4.01 @ 25C
[redacted]	[redacted]	[redacted]	7.02 @ 19 °C	Std. 7.00 @ 25C
[redacted]	[redacted]	[redacted]	10.01 @ 19.4°C	Std. 10.01 @ 25C
Myron L Cond	[redacted]	[redacted]	447 @ 19 °C	Std. 442uS @ 25C
Myron L ORP	[redacted]	[redacted]	231 mV@ 18.4°C	Std. 231 mV @ 25C
pH 4.00 Hach	Lot#: A5243	Exp Date: Aug 2019	Name:	
pH 7.00 Hach	Lot#: A5237	Exp Date: Aug 2017	Date:	
pH 10.0 Hach	Lot#: A5260	Exp Date: Sept 2016	Procedure:	
Cond Myron L 442	Lot#: 121741 AS	Exp Date:		
ORP YSI ZOBELL	Lot#: 15B 100453	Exp Date:		

Pg 2 of 2

Phosphate Solution Infiltration/Injection Operations

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): Andoz, Ramirez

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
			FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/12/15	127	1400	4.6	3.1	73	80.6	✓						
11/12/15	128	1500	4.6	3.1	73	80.6	✓						
11/12/15	129	1600	4.6	3.1	73	80.6	✓						
11/12/15	130	1700	4.7	3.4	74.6	82.8	✓	7.28	13.8	7278	164	9.86	~~B33XW5~~ SBC 4/13/16 B349W9

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): Billingsly

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
			FQI-N2- [✓ 2A] or -2B Chem 1 (gpm)	FQI-N2- [✓ 3A] or -3B Chem 2 (gpm)	FQI-N2- [✓ 1A] or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	
11/12/15	131	1800	4.7	3.3	74.5	81.9	✓						
11/12/15	132	1900	4.7	3.3	74.2	82.1	✓						
11/12/15	133	2000	4.6	3.1	76.2	84	✓						
11/12/15	134	2100	4.6	3.1	76.1	84.1	✓	7.28	13.8	6867	187	9.67	~~B33XW6~~ SEC 4/13/16

Comments: B349X0

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): Billingsly / ANDOR

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	
11/12/15	135	2200 ~~2100~~ ~~[illegible]~~ 11/12	4.6	3.1	76	83.9	✓	☒	☒	☒	☒	☒	
11/12/15	136	2300	4.6	3.1	76.7	84.6	✓	☒	☒	☒	☒	☒	
11/13/15	137	2400	4.6	3.1	76.3	84.2	✓	☒	☒	☒	☒	☒	See
11/13/15	138	0100	4.6	3.1	76.0	83.9	✓	7.38	13.4 C	6920	144	9.58	~~B33XW7~~ 1/13/16 ~~Bx~~ B349X1

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): ANDOR

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/13/15	139	0200	4.6	3.1	75.7	83.9	✓						
11/13/15	140	0300	4.6	3.1	76.3	81.2	✓						
11/13/15	141	0400	4.6	3.1	76.8	84.1	✓						
11/13/15	142	0500	4.5	3.4	76.5	83.2	✓	7.37	13.8	7005	133	9.19	~~B33XW8~~ B349X2

SEC 1/13/16

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): PLAYTER / Ramirez

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/13/15	~~142~~ 143 CDE 11/13/15	0600	4.6	3.1	74	81.7	✓	X	X	X	X	X	
11/13/15	~~143~~ 144 CDE 11/13/15	0700	4.6	3.1	73	80.7	✓	X	X	X	X	X	
11/13/15	~~144~~ 145 CDE 11/13/15	0800	4.6	3.1	72	79.7	✓	X	X	X	X	X	
11/13/15	~~145~~ 146 CDE 11/13/15	0900	4.5	3.1	73.2	81.2	✓	7.21	13.6	7233	112	9.53	~~B33XX0~~ SEC 1/13/16 B349X3

Day 7

Comments:

* Sum of FQI-N2-4, 5, 6

Pg 1 of 2

Instrument	S/N	Cal Due Date	Check Std (Pre)	Standard
Myron L pH	6212777	1-21-16	4.08 @ 20 °C	Std. 4.01 @ 25C
[redacted]	[redacted]	[redacted]	6.98 @ 20 °C	Std. 7.00 @ 25C
			10.02 @ 20 °C	Std. 10.01 @ 25C
Myron L Cond	[redacted]	[redacted]	446.9 @ 20 °C	Std. 442uS @ 25C
Myron L ORP			230 mV@20 °C	Std. 231 mV @ 25C
pH 4.00 Hach	Lot#: A5243	Exp Date: Aug 2019	Name:	
pH 7.00 Hach	Lot#: A5237	Exp Date: Aug 2017	Date:	
pH 10.0 Hach	Lot#: A5260	Exp Date: Sept 2016	Procedure:	
Cond Myron L 442	Lot#: 121741 AS	Exp Date: 12-18-15		
ORP YSI ZOBELL	Lot#: 15B 100453	Exp Date: 12-10-15		

Pg 2 of 2

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): PLAYTER / Ramirez

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/13/15	147 ODR ~~146~~	1000	4.6	3.1	74	82	✓	☒	☒	☒	☒	☒	
11/13/15	148 ODR 11/13/15 ~~147~~	1100	4.6	3.1	73	80.9	✓	☒	☒	☒	☒	☒	
11/13/15	149 ODR 11/13/15 ~~148~~	1200	4.6	3.1	72.6	80.3	✓	☒	☒	☒	☒	☒	
11/13/15	150 ODR 11/13/15 ~~149~~	1300	4.6	3.0	72.3	79.8	✓	7.3	14.6	7335	172	9.82	~~B33XX1~~ SEC 11/13/15 B349X4

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): PLAYTON / RAMIREZ

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/13/15	11/13/15 151 ~~150~~ CDR	1400	4.7	3.1	73.9	81.8	✓						
11/13/15	11/13/15 152 ~~151~~ CDR	1500	4.7	3.3	73.3	81.0	✓						
11/13/15	11/13/15 153 ~~152~~ CDR	1600	4.6	3.1	73	80.7	✓						
11/13/15	11/13/15 154 ~~153~~ CDR	1700	4.6	3.3	73	80.7	✓	7.13	15.7	7456	169	8.93	~~B33XX2~~ SEC 4/13/16 B349X5

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Faith

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-[✓ 2A] or -2B Chem 1 (gpm)	FQI-N2-[✓ 3A] or -3B Chem 2 (gpm)	FQI-N2-[✓ 1A] or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/13/15	155 ~~154~~ 11/13/15	1800	4.7	3.1	74.8	82.5	✓	☒	☒	☒	☒	☒	
11/13/15	156 ~~155~~ 11/13/15	1900	4.7	3.0	75	84.7	✓	☒	☒	☒	☒	☒	
11/13/15	157 ~~156~~ 11/13/15	2000	4.7	3.3	74	~~82.8~~ 82.2 11-13-15	✓	☒	☒	☒	☒	☒	
11/13/15	158 ~~157~~ 11/13/15	2100	4.7	3.1	74	82.0	✓	7.24	15.5	7368	175	9.10	~~B33XX3~~ SEC 1/13/16 B349X6

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Faith

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/13/15	CD 159 ~~158~~ 11/13/15	2200	4.7	3.0	74	81.9	✓	X	X	X	X	X	
11/13/15	CD 160 ~~159~~ 11/13/15	2300	4.7	3.0	76	83.9 ~~85.9~~ 1/14/15 CBZ	✓	X	X	X	X	X	
11/14/15	CD 161 ~~160~~ 11/13/15	0001	4.6	3.0	76	83.9	✓	X	X	X	X	X	
11/14/15	CD 162 ~~161~~ 11/13-15	0100	4.8	2.9	76	82.9	✓	7.18	15.5	7212	151	9.27	

1/13/16 SEC ~~B33X44~~

Comments:

B349X7

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2
Operator(s): Faith

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	
11/14/15	163	0200	47	3.0	75	82.4	✓	X	X	X	X	X	
11/14/15	164	0300	47	3.1	75	82.7	✓	X	X	X	X	X	
11/14/15	165	0400	47	3.1	74	82.1	✓	X	X	X	X	X	
11/14/15	166	0500	47	2.9	75	83.1	✓	7.22	14.9	8057	152	9.47	

See ~~B35XX5~~ 1/13/16

Comments:

B349X8

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Billingsley

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2- [✓ 2A] or -2B Chem 1 (gpm)	FQI-N2- [✓ 3A] or -3B Chem 2 (gpm)	FQI-N2- [✓ 1A] or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/14/15	167	0600	4.7	3.0	73.5	81.2	✓	☒	☒	☒	☒	☒	
11/14/15	168	0700	4.8	3.0	72.6	80.3	✓	☒	☒	☒	☒	☒	
11/14/15	169	0800	4.7	2.8	71.6	79.3	✓	☒	☒	☒	☒	☒	
11/14/15	170	0900	4.7	3.7	70.4	78.8	✓	6.96	15.1	7540	170	9.65	

Day 8

B33mX1

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): Billingsley / Ramirez

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2- [✓ 2A] or -2B Chem 1 (gpm)	FQI-N2- [✓ 3A] or -3B Chem 2 (gpm)	FQI-N2- [✓ 1A] or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/14/15	171	1000	4.6	3.3	70.2	78.2	✓	X	X	X	X	X	
11/14/15	172	1100	4.6	3.4	69.9	78.1	✓	X	X	X	X	X	
11/14/15	173	1200	4.6	3.3	69.9	77.9	✓	X	X	X	X	X	
11/14/15	174	1300	4.6	3.0	70	77.8	✓	7.03	16.16	7952	230	9.42	

B33mx2

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): Billingsley / Ramirez

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/14/15	175	1400	4.6	3.2	70.1	78	✓						
11/14/15	176	1500	4.6	3.2	70.1	78.4	✓						
11/14/15	177	1600	4.6	3.3	70.3	78.5	✓						
11/14/15	178	1700	4.7	3.1	70.9	78.7	✓	7.19	15.0	7487	237	9.45	B33MX3

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: # 2							**Operator(s):**					
			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					**Field Parameters - Infiltration Solution** Field parameters will be measured and recorded once every 4 hours				**Comments** After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	
11/14/15	179	1800	4.7	3.1	71.3	79.1	✓	X	X	X	X	X	
11/14/15	180	1900	4.7	3.1	71.3	79.1	✓	X	X	X	X	X	
11/14/15	181	2000	4.7	2.9	71.5	80.0	✓	X	X	X	X	X	
11/14/15	182	2100	4.7	3.0	73.2	80.9	✓	7.07	14.1	7389	225	9.60	

B33mx4

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s):

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/14/15	183	2200	4.6	3.0	73.1	81.2	✓	X	X	X	X	X	
11/14/15	184	2300	4.6	3.1	73.1	81.3	✓	X	X	X	X	X	
11/15/15	185	0000	4.6	3.1	72.9	80.4	✓	X	X	X	X	X	
11/15/15	186	0100	4.6	2.9	72.9	80.8	✓	7.11	13.6	7113	189	9.68	B33MX5

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): Playter

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/15/15	187	0200	4.6	2.9	73.9	80.7	✓						
11/15/15	188	0300	4.8	3.1	73.4	80.6	✓						
11/15/15	189	0400	4.6	2.9	72.9	80.7	✓						
11/15/15	190	0500	4.3	2.2	73.4	80.4	✓	7.17	12.1	6724	206	9.29	B33MX6

Comments:

* Sum of FQI-N2-4, 5, 6

Phosphate Solution Infiltration/Injection Operations

Published Date: 11/11/15 Effective Date: 11/11/15

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: # 2

Operator(s): Andre, Faith.

Day 9

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/15/15	191	0600	4.4	2.4	73	80.1	① ✓	☒	☒	☒	☒	☒	
11/15/15	192	0700	4.1	2.6	71.6	78.6	✓	☒	☒	☒	☒	☒	
11/15/15	193 ~~192~~	0800	4.3	2.7	71.5	78.1	✓	☒	☒	☒	☒	☒	
11/15/15	194 ~~193~~	0900	4.3	2.7	70.7	78.8	✓	7.12	13.8	7036	221	959	B33MX7

Comments: ① Opened P1-F1A1, F2A1, F3A1 Valves per management direction due to adjustments made on Skid #2.

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): FAITH, ANDOR

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly FQI-N2-[✓ 2A] or -2B Chem 1 (gpm)	FQI-N2-[✓ 3A] or -3B Chem 2 (gpm)	FQI-N2-[✓ 1A] or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	Comments After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/15/15	195 ~~194~~	1000	4.2	2.8	70.4	77.5	✓	☒	☒	☒	☒	☒	
11/15/15	196 ~~195~~	1100	4.3	2.8	70.3	77.6	✓	☒	☒	☒	☒	☒	
11/15/15	197 ~~196~~	1200	4.2	28	69.7	76.8	① ✓	☒	☒	☒	☒	☒	
11/15/15	198 ~~197~~	1300 ~~1200~~ OSF 11/15/15	4.2	2.8	70.1	77.1	✓	7.29	14.5	7524	213	9.80	B33MX8

Comments: ① Filters have been changed out. all Filters online per management direction.

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): FAITH ANDOR

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/15/15	199	1400	4.2	2.8	69.6	77.1	✓						
11/15/15	200	1500	4.2	2.7	69.6	76.9	✓						
11/15/15	201	1600	4.4	2.8	69.7	77.1	✓						
11/15/15	202	1700	4.3	2.7	70.2	77.3	✓	7.22	15.2	7583	201	9.73	B33MX9

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: 2

Operator(s): Billingsley

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters/ Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
			FQI-N2-[✓ 2A] or -2B Chem 1 (gpm)	FQI-N2-[✓ 3A] or -3B Chem 2 (gpm)	FQI-N2-[✓ 1A] or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/15/15	203	1800	4.3	2.8	70.3	77.7	✓	X	X	X	X	X	
11/15/15	204	1900	4.3	2.7	71.1	78.1	✓	X	X	X	X	X	
11/15/15	205	2000	4.3	2.7	71.1	78.4	✓	X	X	X	X	X	
11/15/15	206	2100	4.3	2.7	71.5	78.8	✓	7.22	13.9	7190	215	9.30	B33mY0

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): Billingsley / Playter

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-[✓ 2A] or -2B Chem 1 (gpm)	FQI-N2-[✓ 3A] or -3B Chem 2 (gpm)	FQI-N2-[✓ 1A] or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/15/14	207	2200	4.4	2.6	71.8	79.5	✓	☒	☒	☒	☒	☒	
11/15/14	208	2300	4.4	2.7	72.1	79.8	✓	☒	☒	☒	☒	☒	
11/16/~~14~~ 15 KM	11/16/15 209	0000	4.4	2.7	72.5	80.1	✓	☒	☒	☒	☒	☒	
11/16/15	210	0100	4.4	2.7	73.8	80.1	✓	7.09	12.7	7058	214	9.57	1333 mg/l

Comments:

* Sum of FQI-N2-4, 5, 6

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s):

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/16/15	211	0200	4.4	2.7	73.3	80.4	✓						
11/16/15	212	0300	4.4	2.7	73.2	80.1	✓						
11/16/15	213	0400	4.4	2.7	73.2	80.3	✓						
11/16/15	214	0500	4.4	2.7	73.2	80.3	✓	6.99	12.6	7185	209	9.11	B33MY2

Comments:

* Sum of FQI-N2-4, 5, 6

52,442
33,335
Px

Phosphate Solution Infiltration/Injection Operations

Appendix C - (Cont.) Infiltration Skid Monitoring Data Sheet

Skid ID: #2

Operator(s): RAmeriz, Playtra, Anbora / Faith

Date	Hour	Time	Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Infiltration Solution Field parameters will be measured and recorded once every 4 hours					Comments
			FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	After flow rate is stable take 1st skid sample, take 2nd at 24-hour mark, and third/final at end of infiltrations. Where a sample is required, it is noted in this column. Note any other observations, irregularities, problems in Comments sections including system interruptions, filter change outs, etc.
11/16/15	215	0600	4.4	2.7	73.2	80.6	✓						
11/16/15	216	0700	4.4	2.9	73.0	80.4	✓						
11/16/15	217	0800	4.2	2.6	72.9	80.0	✓						
11/16/15		0810	①	①	①	①	①	①	①	①	①	①	B33MY3

Comments: ① Target totals met. SKID #2 shutdown per procedure.

* Sum of FQI-N2-4, 5, 6

Appendix C - Infiltration Skid Monitoring Data Sheet

Skid #2

Operator(s): Faith, Ramirez, ANDOR.

Totalizer Readings		Start of Injections	End of Injections	Comments
River Water	FQI-N2-1A or [✓ -1B]		795611	During hourly recording, note any observations, irregularities, and/or problems such as system downtime, totalizer maintenance/outage/re-set in Comments sections
Chem Injection#1 (Monosodium Phosphate)	FQI-N2[✓ -2A] or -2B		53004	
Chem Injection#2 (Pyrophosphate)	FQI-N2-3A or [✓ -3B]		33338	
Overall Mixture ①	FQI-N2-4A or -4B		① 956011	
	FQI-N2-4		293981	
	FQI-N2-5		298244	
	FQI-N2-6		290969	

			Flowrates - Skid Parameters Skid and filter parameters will be measured and recorded hourly					Field Parameters - Injection Solution Field parameters will be measured and recorded once every 4 hours					After flow rate is stable take 1st skid sample, take 2nd at 4-hour mark, and third/final at end of injections (8 hr). Where a sample is required, it is noted in this column.
Date	Hour	Time	FQI-N2-2A or -2B Chem 1 (gpm)	FQI-N2-3A or -3B Chem 2 (gpm)	FQI-N2-1A or -1B River (gpm)	* Total (gpm)	Filter dPs < 45 (✓)	pH	Temperature (°C)	Conductivity (µS/cm)	Oxidation Reduction Potential (± mV)	Dissolved Oxygen (mg/L)	
11/16/15	Pre Start												Columbia River Water Sample
	0												Flow Rate Stable – Take first skid sample
	1							☒	☒	☒	☒	☒	
	2							☒	☒	☒	☒	☒	

Comments: ① overall mixture note: Rosemont was inconsistant in its Readings - End Rosemont Reading = 956011. FQI-N2-1B, 2A & 3B readings = 881953. Sum of FQI-N2-4,5,6 = 883194. Totals listed per R. Herman per DA. 11/16/15 OD Faith

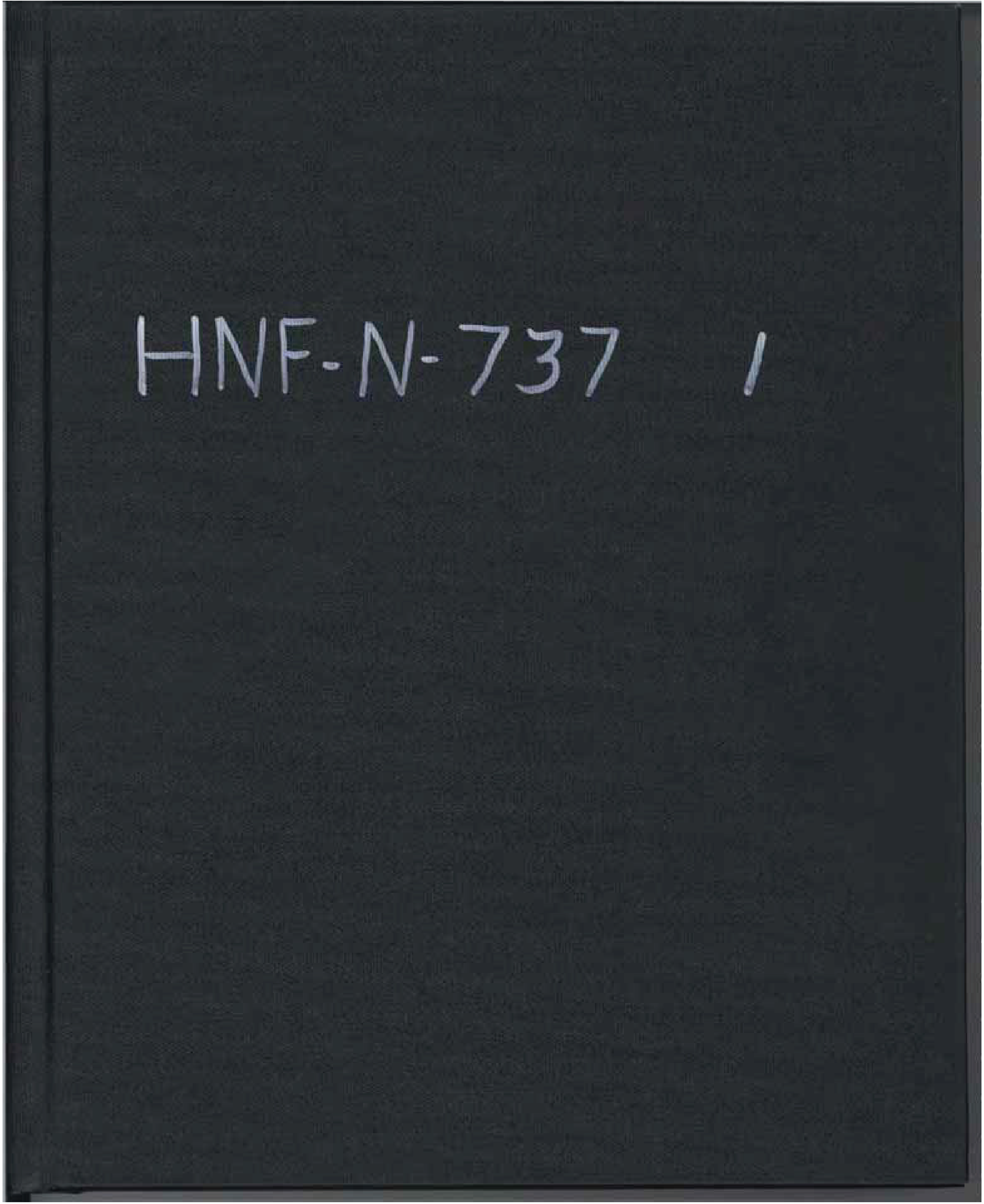
* Sum of FQI-N2-4, 5, 6

This page intentionally left blank.

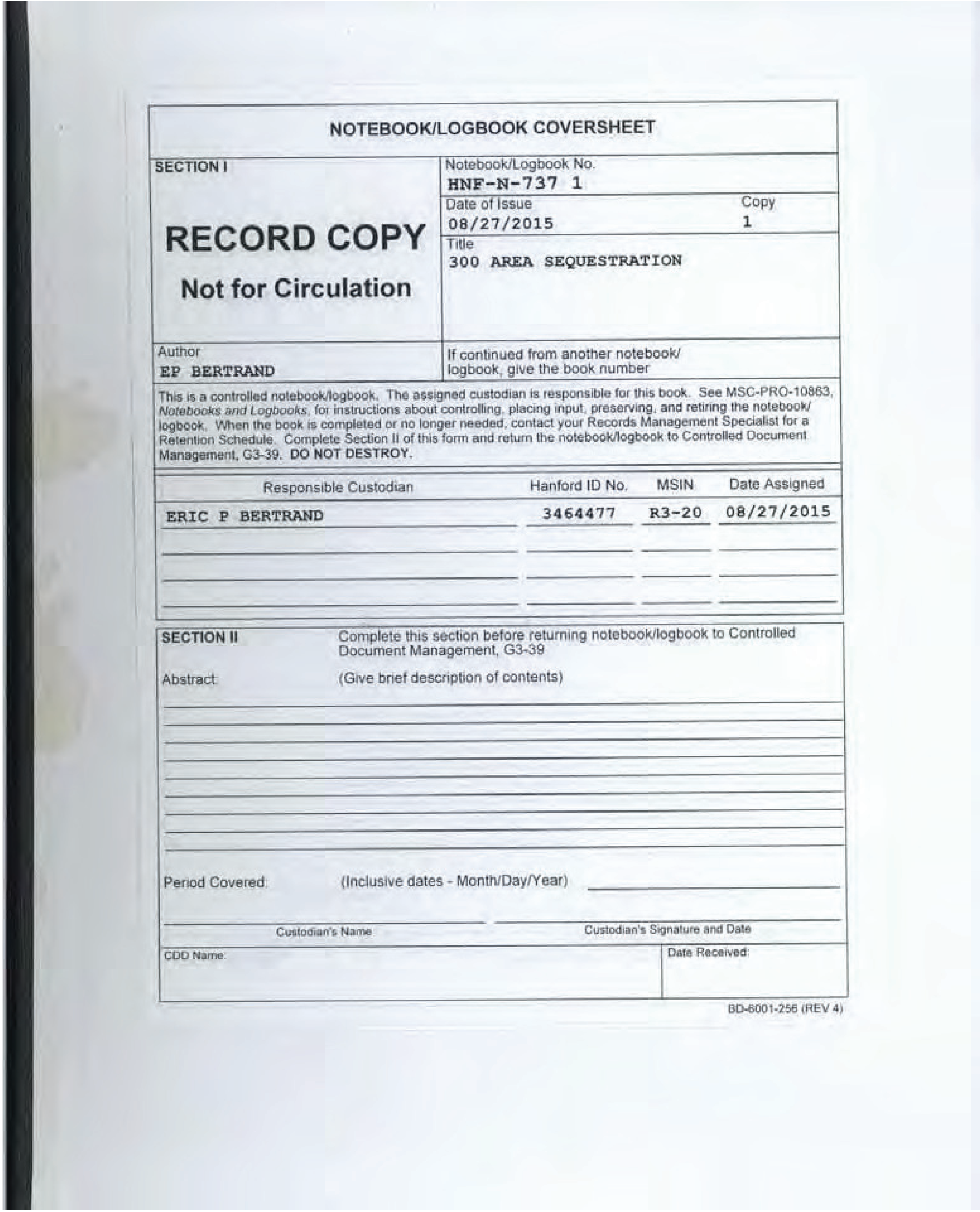
Appendix C

HNF-N-737

This page intentionally left blank.



HNF-N-737 1



NOTEBOOK/LOGBOOK COVERSHEET

SECTION I

RECORD COPY

Not for Circulation

Notebook/Logbook No. HNF-N-737 1

Date of Issue 08/27/2015

Copy 1

Title 300 AREA SEQUESTRATION

Author EP BERTRAND

If continued from another notebook/ logbook, give the book number

This is a controlled notebook/logbook. The assigned custodian is responsible for this book. See MSC-PRO-10863, *Notebooks and Logbooks*, for instructions about controlling, placing input, preserving, and retiring the notebook/ logbook. When the book is completed or no longer needed, contact your Records Management Specialist for a Retention Schedule. Complete Section II of this form and return the notebook/logbook to Controlled Document Management, G3-39. **DO NOT DESTROY.**

Responsible Custodian	Hanford ID No.	MSIN	Date Assigned
ERIC P BERTRAND	3464477	R3-20	08/27/2015

SECTION II Complete this section before returning notebook/logbook to Controlled Document Management, G3-39

Abstract: (Give brief description of contents)

Period Covered: (Inclusive dates - Month/Day/Year)

Custodian's Name

Custodian's Signature and Date

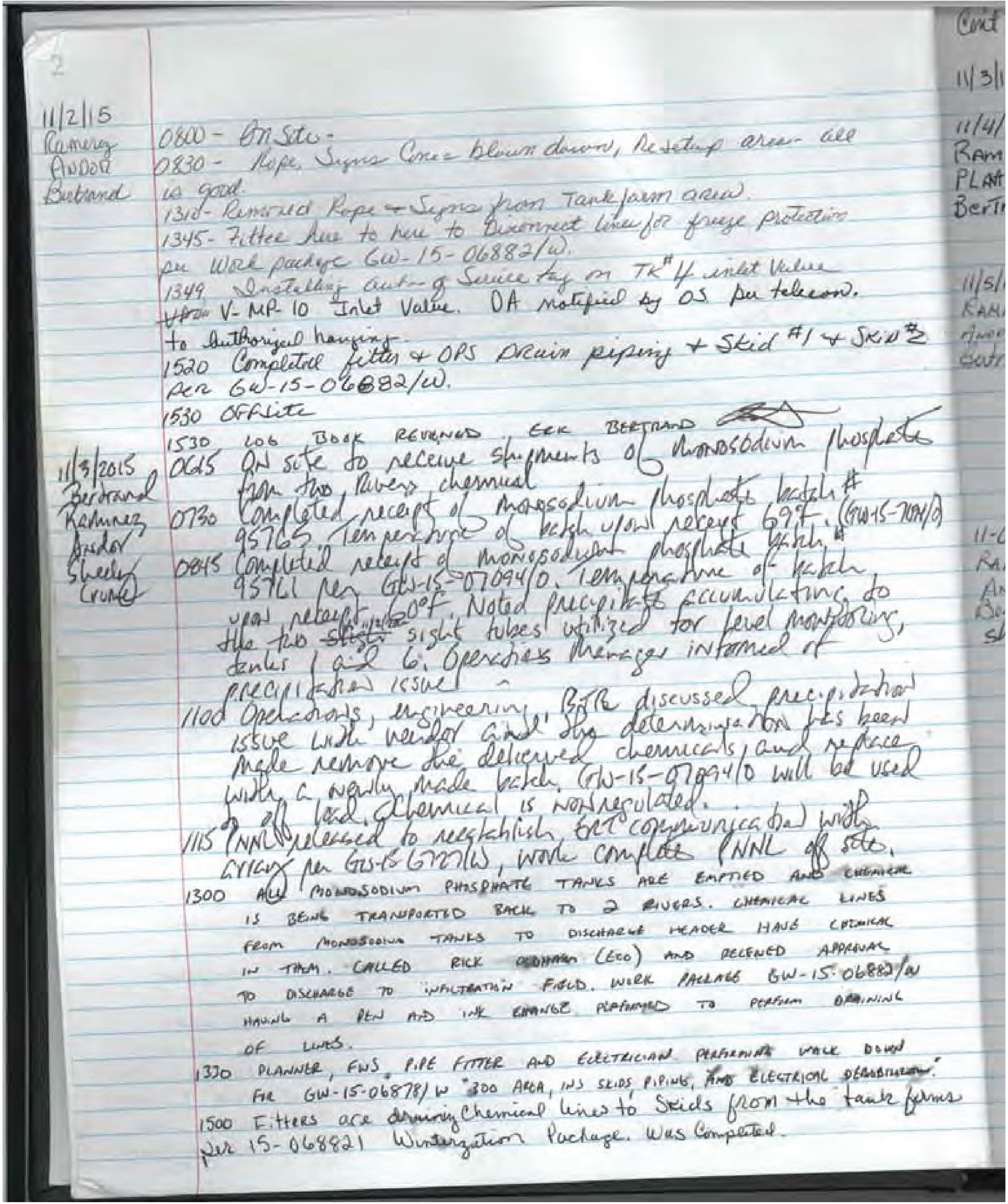
CDD Name:

Date Received:

BD-6001-256 (REV 4)

1

10/27/2015
Ramirez 0907 – Started transfer of Monosodium Phosphate. to
Andol. Storage tanks
Bertrand 0937 – Completed Transfer of MonoSodium Phosphate.
Dup. 11 17 – Started PYRO ~~Mono~~ Sodium phosphate. to Storage tank
1140 – Completed Transfer of Pyro ~~Mono~~ Sodium phosphate.
0955 – Started Transfer of mono phosphate to Chem tanks.
– late Entry –
1515 filters ok on Skids, and also. Sixpackers Ready to go.
1525 REVIEWED LOG BOOK. ERIC BERTRAND 10/27/15
10/28/15 onsite at 0715.
Andoe ~~0825~~ 0740 Started Monosodium Phosphate Transfer to Receiving
Ramirez tanks S/D down at 0825 due to noticing crystaling in site tubes
Bertrand Shutdown transfer. Call Supervisor, will remind on what happens
next. Drain Pump was also froze up. Returned to Two Rivers.
0841 Pyrophosphate Transfer ~~Started~~ Started to Receiving Tank.
0910 S/D down, Pyrophosphate transfers completed tanks are full.
1120 Discovered a leak/spill on TK #4 Monophoate. Contacted Supervisor
Rope off are and Hung Signs around area. Regrouping on recovery.
1430 Started pumping TP-4 tank to tanker, (Two Rivers) – Sent back.
Isolated all Valves on tanks.
1520 Access to area has a barrier at the speedbump area needs
to be clear by OPS Supervisor – for entry – Phone # is on Sign at barrier.
Completed fixing Rosemont flow Controller;
1530 Offsite for the Day.
1535 PROCEDURE SGRP-PRO-OP-52729 "Spill or leak response for pump and treat activities" was used to handle spill/leak on the #4 MONOSODIUM PHOSPHATE TANK. All proper notifications were made. Log book reviewed. ERIC BERTRAND 10/28/15
10/29/15 0800 – ON SITE AND FUELER ON SITE TO REFUEL
Ramirez LIGHT PLANTS AND GENERATORS
Bertrand 0932 – ELECTRICIAN ON SITE TO INSPECT SAMPLE VAN
1047 STARTED TRANSFER OF MONOSODIUM PHOSPHATE TO 2 RIVERS TANKER. ERIC BERTRAND
1118 TRANSFER COMPLETE (TANKER FULL). APPROX. 4,000 gallons OF MONOSODIUM PHOSPHATE REMAINING IN TANKS. ERIC BERTRAND
1520 ALL MONOSODIUM PHOSPHATE FROM TANKS 1-6 AND ASSOCIATED HOSE HAVE BEEN DRAINED BACK TO 2 RIVERS TANKER AND REMOVED FROM SITE. AREA BARRICADED AROUND TANKS (MONOSODIUM PHOSPHATE 2, 4 & 6) TO PREVENT ACCESS TO SPILL AREA AT THE BOTTOM OF TANK 4. CLEAN UP OF AREA WILL OCCUR AT A LATER DATE. ERT POWER SUPPLY REPLACED AND BACK IN OPERATION. LOG BOOK REVIEWED ERIC BERTRAND



2

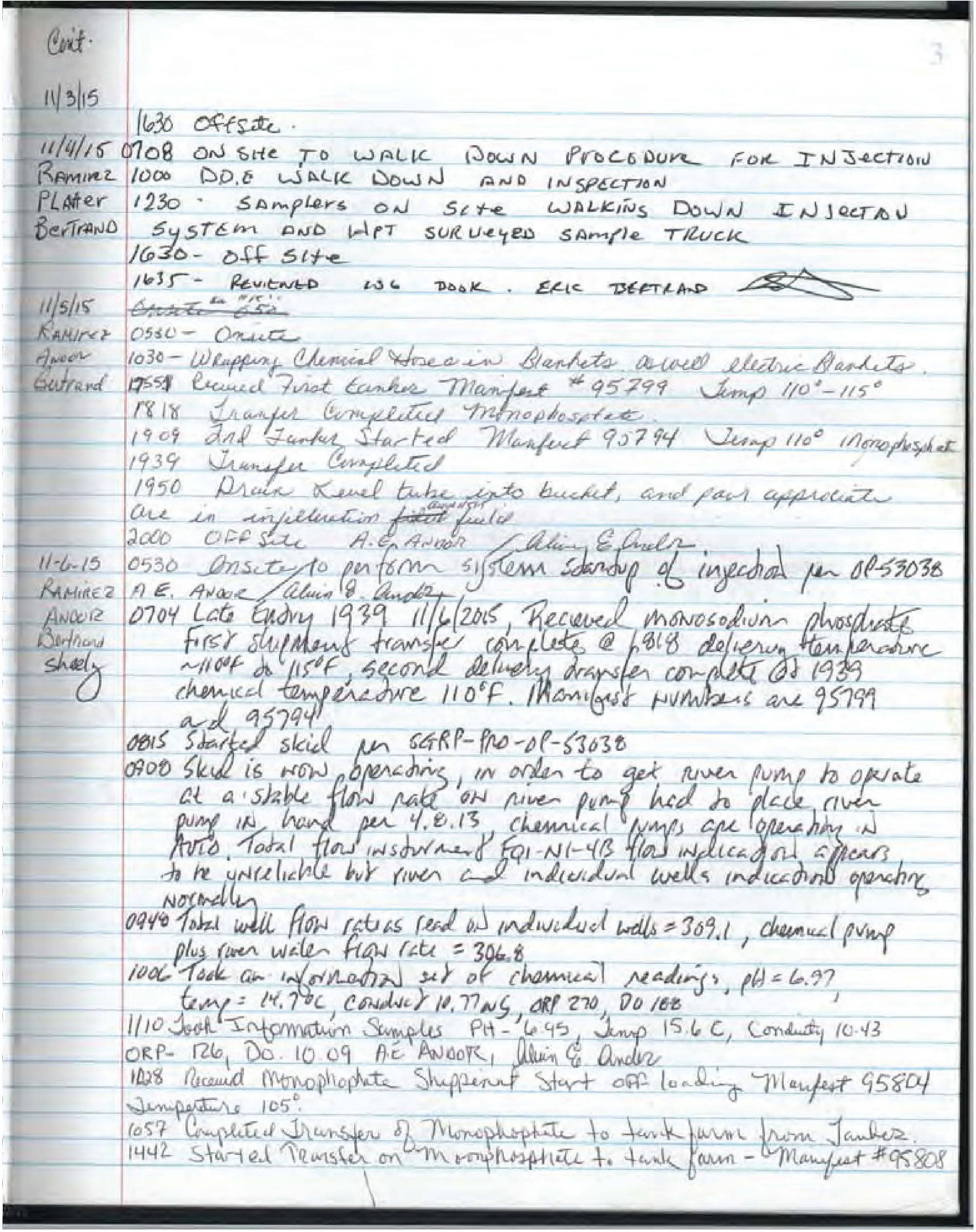
11/2/15
Ramerez
Andor
Bertrand

0800 - On Site -
0830 - Rope, Signs Cones blown down, Resetup area - all is good.
1310 - Removed Rope + Signs from Tank farm area.
1345 - Fitter here to help to Disconnect lines for freeze protection per Work package GW-15-06882/W.
1349 Installing out of Service tag on TK# 4 inlet Valve V-MP-10 Inlet Valve. OA notified by OS per telecon. to Authorized hanging.
1520 Completed fitter + OPS drain piping + Skid #1 + Skid #2 per GW-15-06882/W.
1530 Offsite
1530 LOG BOOK REVIEWED ERK BERTRAND

11/3/2015
Bertrand
Ramirez
Andor
Sheeley
Crum

0615 On site to receive shipments of monosodium phosphate from Two Rivers chemical
0730 Completed receipt of monosodium phosphate batch # 95765. Temperature of batch upon receipt 69°F. (GW-15-7094/0)
0845 Completed receipt of monosodium phosphate batch # 95761 per GW-15-07094/0. Temperature of batch upon receipt 60°F. Noted precipitate accumulating to the two ~~sight~~ sight tubes utilized for level monitoring, tanks 1 and 6. Operations Manager informed of precipitation issue.
1100 Operations, engineering, BTR discussed precipitation issue with vendor and the determination has been made remove the delivered chemicals, and replace with a newly made batch. GW-15-07094/0 will be used to off load. Chemical is nonregulated.
1115 PNNL released to reestablish BTR communication with cyclers per GW-15-[illegible]/W, work complete PNNL off site.
1300 ALL MONOSODIUM PHOSPHATE TANKS ARE EMPTIED AND CHEMICAL IS BEING TRANSPORTED BACK TO 2 RIVERS. CHEMICAL LINES FROM MONOSODIUM TANKS TO DISCHARGE HEADER HAVE CHEMICAL IN THEM. CALLED RICK [redacted] (ECO) AND RECEIVED APPROVAL TO DISCHARGE TO INFILTRATION FIELD. WORK PACKAGE GW-15-06882/W HAVING A PEN AND INK CHANGE PERFORMED TO PERFORM DRAINING OF LINES.
1330 PLANNER, FWS, PIPE FITTER AND ELECTRICIAN PERFORMING WALK DOWN FOR GW-15-06878/W "300 AREA, ILS SKIDS, PIPING, AND ELECTRICAL DEACTIVATION".
1500 Fitters are draining Chemical lines to Skids from the tank farms per 15-068821 Winterization Package. Was Completed.

Cont
11/3/1
11/4/
RAM
PLAN
BerT
11/5/
RAM
Ando
Bertr
11-C
Ra
An
Bo
Sh



Cont.

3

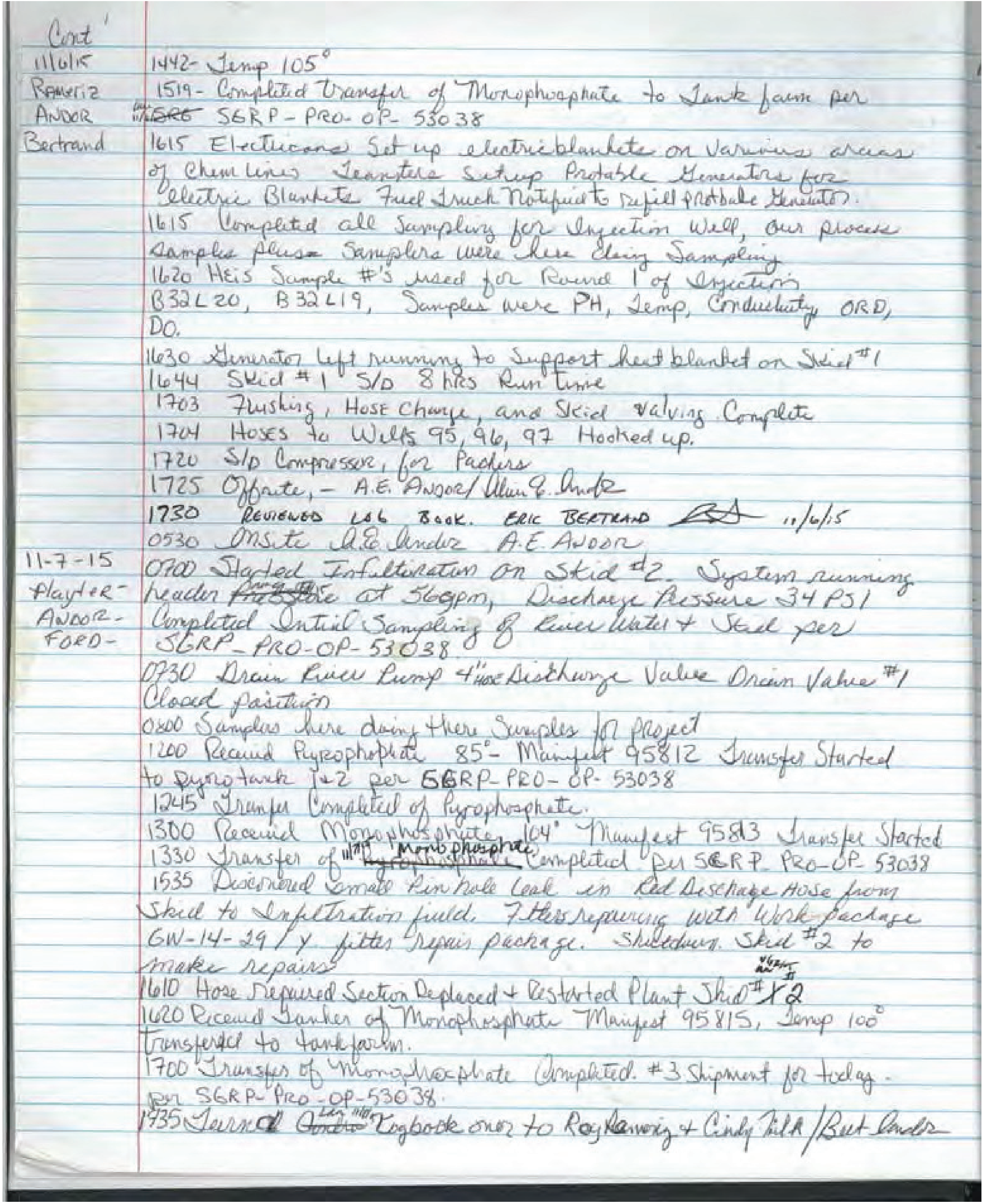
11/3/15

1630 Offsite.

11/4/15 0708 ON SITE TO WALK DOWN PROCEDURE FOR INJECTION
RAMIREZ 1000 DOE WALK DOWN AND INSPECTION
PLATER 1230 - SAMPLERS ON SITE WALKING DOWN INJECTION
BERTRAND SYSTEM AND HPT SURVEYED SAMPLE TRUCK
1630 - OFF SITE
1635 - REVIEWED LOG BOOK. ERIC BERTRAND

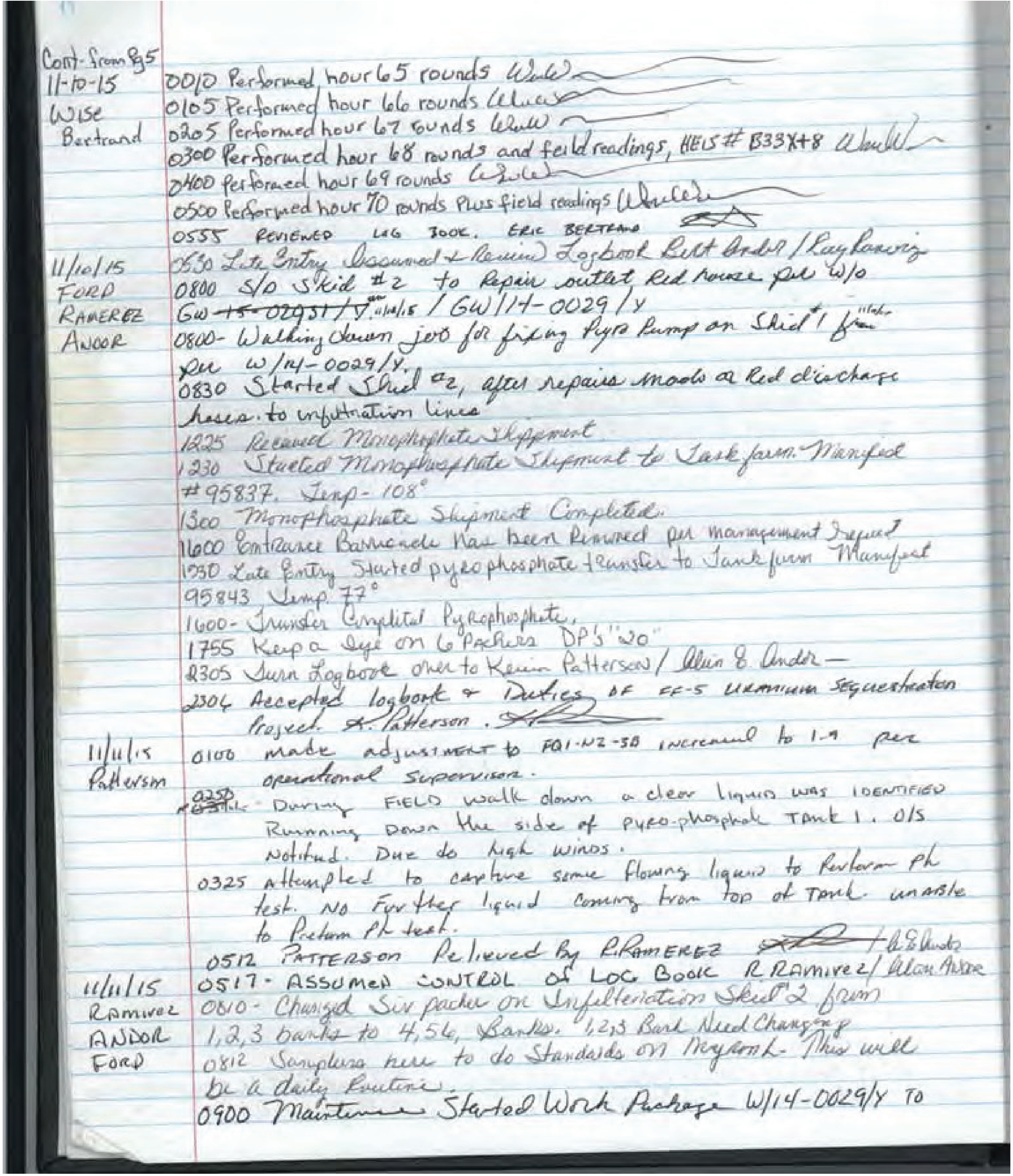
11/5/15 ~~[illegible]~~
RAMIREZ 0530 - Onsite
Amoor 1030 - Wrapping Chemical Hose in Blankets as well electric Blankets.
Bertrand 1755 Received First tanker Manifest # 95799 Temp 110°-115°
1818 Transfer Completed Monophosphate.
1909 2nd Tanker Started Manifest 95794 Temp 110° Monophosphat
1939 Transfer Completed
1950 Drain Level tube into bucket, and pour appropriate are in infiltration ~~field~~ gallery field
2000 OFF Site A.E. ANDOR Alvin E. Andor

11-6-15 0530 Onsite to perform system startup of injection per OP-53038
RAMIREZ A.E. Andor Alvin E. Andor
ANDOR 0704 Late Entry 1939 11/6/2015, Received monosodium phosphate
Bertrand first shipment transfer complete @ 1818 delivery temperature
Sheely ~110°F to 115°F, second delivery transfer complete at 1939 chemical temperature 110°F. Manifest numbers are 95799 and 95794
0815 Started skid per SGRP-PRO-OP-53038
0900 Skid is now operating, in order to get river pump to operate at a stable flow rate on river pump had to place river pump in hand per 4.8.13 chemical pumps are operating in Auto. Total flow instrument FQI-NI-4B flow indication appears to be unreliable but river and individual wells indications operating normally
0940 Total well flow rates read on individual wells = 309.1, chemical pump plus river water flow rate = 306.8
1006 Took an informational set of chemical readings, pH = 6.97, temp = 14.7°C, conduct 10.77mS, ORP 270, DO 10.8
1110 Took Information Samples PH - 6.95, Temp 15.6 C, Conductiy 10.43
ORP - 126, DO. 10.09 A.E. ANDOR, Alvin E. Andor
1028 Received Monophosphate Shippment Start off loading Manifest 95804
Temperature 105°.
1057 Completed Transfer of Monophosphate to tank farm from Tanker.
1442 Started Transfer on Monophosphate to tank farm - Manifest #95808

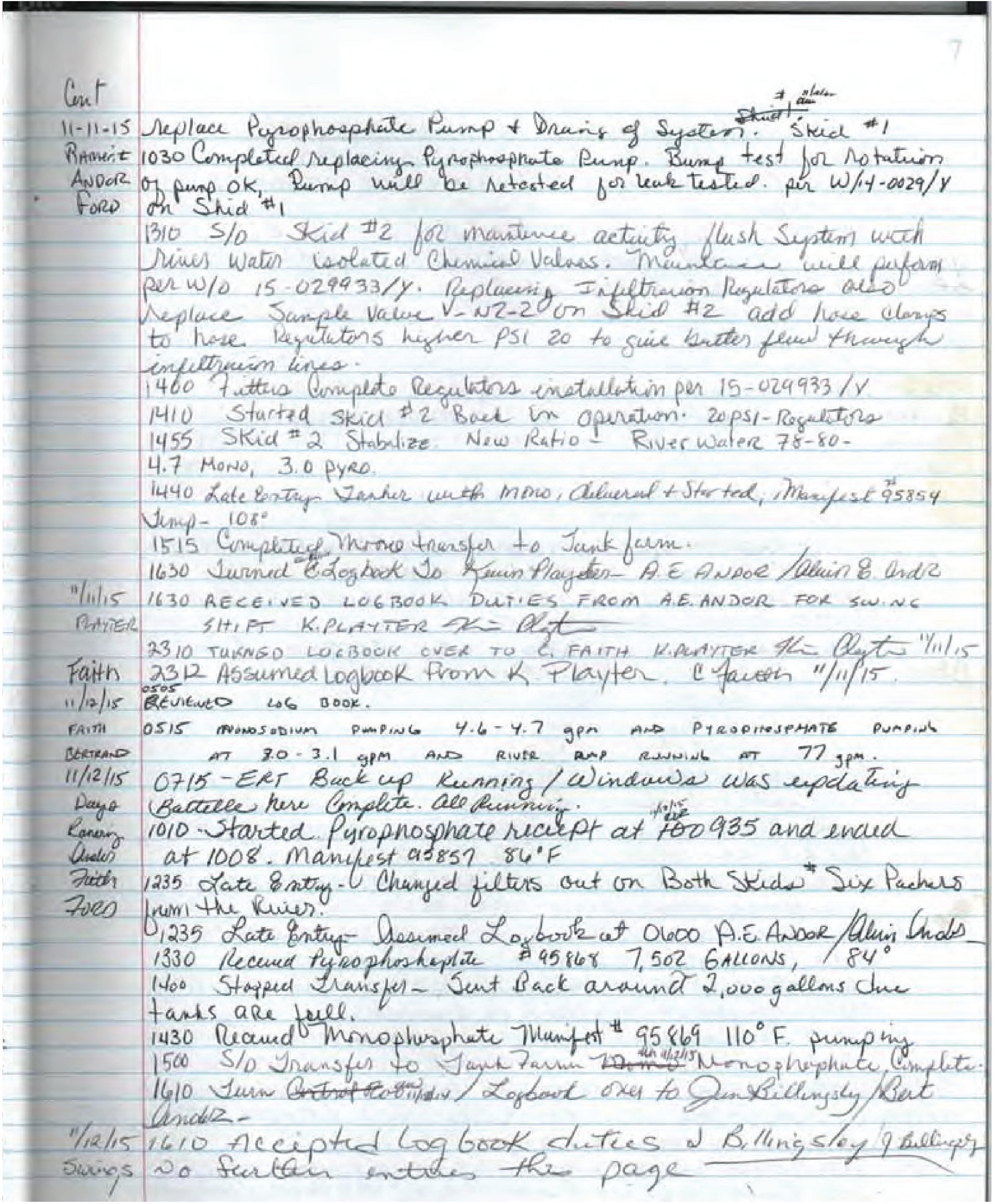


Cont'
11/6/15 1442- Temp 105°
Rameriz 1519- Completed Transfer of Monophosphate to Tank farm per
Andor ~~SGRE~~ SGRP-PRO-OP-53038
Bertrand 1615 Electricians Set up electric blankets on Various areas
of Chem Lines Teamsters Setup Protable Generators for
Electric Blankets Fuel Truck Notified to refill protable Generator.
1615 Completed all Sampling for Injection Well, our process
samples plus Samplers were here doing Sampling
1620 HEIS Sample #'s used for Round 1 of Injection
B32L20, B32L19, Samples were PH, Temp, Conductivity, ORD,
DO.
1630 Generator left running to Support heat blanket on Skid #1
1644 Skid #1 S/D 8 hrs Run time
1703 Flushing, Hose Change, and Skid Valving Complete
1704 Hoses to Wells 95, 96, 97 Hooked up.
1720 S/D Compressor, for Packers
1725 Offsite, - A.E. Andor/ Alan E. Andor
1730 REVIEWED LOG BOOK. ERIC BERTRAND 11/6/15
0530 Onsite A.E. Andor A.E. ANDOR
11-7-15 0700 Started Infiltration on Skid #2. System running
Playter- header ~~Pressure~~ at 56gpm, Discharge Pressure 34 PSI
Andor- Completed Initial Sampling of River Water + Skid per
Ford- SGRP-PRO-OP-53038
0730 Drain River Pump 4" hose Discharge Valve Drain Valve #1
Closed position
0800 Samplers here doing there Samples for project
1200 Received Pyrophosphate 85°- Manifest 95812 Transfer Started
to pyro tank 1+2 per SGRP-PRO-OP-53038
1245 Transfer Completed of Pyrophosphate.
1300 Received Monophosphate 104° Manifest 95813 Transfer Started
1330 Transfer of ~~Pyrophosphate~~ Monophosphate Completed per SGRP-PRO-OP-53038
1535 Discovered small Pin hole leak in Red Discharge Hose from
Skid to Infiltration field. Fitters repairing with Work package
GW-14-29 / Y fitters repair package. Shutdown Skid #2 to
make repairs
1610 Hose Repaired Section Replaced + Restarted Plant Skid # ~~1~~ 2
1620 Received Tanker of Monophosphate Manifest 95815, Temp 100°
transferred to tank farm.
1700 Transfer of Monophosphate Completed. #3 Shipment for today.
per SGRP-PRO-OP-53038.
1935 Turned ~~Andor~~ Logbook over to Roy Ramirez + Cindy Tilk / Bert Andor

11-7-15 1738 Assumed Logbook duties from B. Ander and Kevin Playter.
C Faith 1730 Received Tanker of Monosodium Phosphate. Transfer started at
R Ramirez 0654 and stopped at 0737. Manifest 95821. Temperature ~110.
Bertrand Transfer of Monosodium Phosphate completed per SGRP-PRO-OP-53038.
11-8-15 0200 At this time readings will now be taken at FQI-NZ-2A, due to a Flow
rate issue between the Flow Meter on SKID and the Control panel display.
0415 Walkdown of System and Area, cleared water from Blanket Heaters. No
issues found.
0532 Turned Logbook over to Kevin Playter. C. Faith. R Ramirez
11/8/15 0532 ASSUMED LOGBOOK DUTIES FROM C.FAITH K.PLAYTER
FORD 0750 SAMPERS ON SITE FOR ROUTINE PROJECT SAMPLES
PLAYTER 0824 FUEL TRUCKS ON SITE TO FILL UP GENERATORS
1619 FUEL TRUCK ON SITE TO FILL UP GENERATORS
1730 TURNED LOGBOOK OVER TO B.ANDER K.PLAYTER 11/8/15
11/08/15 1730 Received Logbook from Kevin Playter / Bert Ander
ANDER 2119 UPON REVIEW OF PREVIOUS CONDUCTIVITY READINGS, IT WAS DISCOVERED
BILLINGSLEY THAT AN ERROR WAS MADE RECORDING MICROSIEMENS AS
CRUME MILLISIEMENS ON THE ROUNDS DATA SHEETS. THE ERRORS WERE
CORRECTED AND EMPHASIS WILL BE PLACED ON RECORDING READINGS
IN CORRECT UNITS.
2330 Turn ~~Control Room~~ Logbook over to Ray Ramirez / Cindy Faith —
11/8/15 2332 Assumed Logbook duties. C Faith R Ramirez
C Faith 0600 Attempted to Start up SKID #1, AFD-NI-3 showed FAULT.
R. Ramirez 0730 Troubleshooting & Repair on P-NI-3 started.
0830 SKID #1 Started at target flowrates. P-NI-3 operating
normally. P-NI-1 in hand & P-NI-2, 3 in Auto.
0845 Samplers arrived to sample for project.
0915 Received Pyrophosphate 91°F Manifest 95822.
1145 Received monosodium phosphate 114°F manifest 95829.
1400 Received monosodium phosphate 114°F manifest 95831.
1622 Turned Logbook over to J. Billingsley. C Faith 11/9/15
11/9/15 1622 Assumed logbook duties J Billingsley
1627 Completed injections to wells 399-1-92 thru 97
Injected 13,883 gallons monosodium phosphate,
8,412 gallons pyro phosphate.
Skid 1 flushed, shutdown, isolated and
drained.
1113 Turned logbook over to Will Wise. J Billingsley
11/9/15
2314 recieved shift turnover and accepted duties of PF-5 U sequestration
NCO. Wm Wise W Wise Continued on Page 6 W Wise →



Cont-from pg 5
11-10-15 0010 Performed hour 65 rounds
Wise 0105 Performed hour 66 rounds
Bertrand 0205 Performed hour 67 rounds
0300 Performed hour 68 rounds and feild readings, HEIS # B33X+8
0400 performed hour 69 rounds
0500 Performed hour 70 rounds Plus field readings
0555 REVIEWED LOG BOOK. ERIC BERTRAND
11/10/15 0630 Late Entry Assumed & Review Logbook Bert Andor / Ray Ramirez
FORD 0800 S/D Skid #2 to Repair outlet Red hose per W/O
RAMEREZ GW ~~15-02951/Y~~ 11/10/15 / GW/14-0029/Y
ANDOR 0800- Walking down job for fixing Pyro Pump on Skid #1 from 11/10/15 per W/14-0029/Y.
0830 Started Skid #2, after repairs made a Red discharge hoses to infiltration lines
1225 Received Monophosphate Shipment
1230 Started Monophosphate Shipment to Tank farm Manifold #95837. Temp - 108°
1300 Monophosphate Shipment Completed.
1600 Entrance Barricade Has been Removed per management Request
1530 Late Entry Started pyrophosphate transfer to Tank farm Manifold 95843 Temp 77°
1600- Transfer Completed Pyrophosphate.
1755 Keep a Eye on 6 Packers DP's "20"
2305 Turn Logbook over to Kevin Patterson / Alan E. Andor —
2304 Accepted logbook & Duties of FF-5 Uranium Sequestration Project. K. Patterson.
11/11/15 0100 made adjustment to FQI-NZ-5B increased to 1.9 per operational supervisor.
Patterson 0250 ~~0315~~ During FIELD walk down a clear liquid was IDENTIFIED Running Down the side of Pyro-phosphate Tank 1. O/S Notified. Due to high winds.
0325 Attempted to capture some flowing liquid to Perform ph test. No Further liquid coming from top of Tank unable to Preform ph test.
0512 PATTERSON Relieved By R.RAMEREZ / A.E. Andor
11/11/15 0517 - ASSUMED CONTROL OF LOG BOOK R.RAMIREZ / Alan Andor
Ramirez 0810 - Changed Six packer on Infilteration Skid 2 from
ANDOR 1,2,3 banks to 4,5,6, Banks. 1,2,3 Bank Need Changing
FORD 0812 Samplers here to do Standards on Myron L. This will be a daily Routine.
0900 Maintenance Started Work Package W/14-0029/Y TO



7

Cont
11-11-15 Replace Pyrophosphate Pump & Drain of System. ~~Skid~~ # Water AEA Skid #1
Ramirez 1030 Completed replacing Pyrophosphate Pump. Bump test for rotation
Andor of pump OK, Pump will be retested for leak tested. per W/14-0029/Y
Ford on Skid #1
1310 S/O Skid #2 for maintence activity flush System with
River Water isolated Chemical Valves. Maintance will perform
per W/O 15-029933/Y. Replacing Infiltration Regulators also
replace Sample Valve V-N2-2 on Skid #2 add hose clamps
to hose. Regulators higher PSI 20 to give better flow through
infiltration lines.
1400 Fitters Complete Regulators installation per 15-029933/Y
1410 Started Skid #2 Back in operation. 20PSI-Regulators
1455 Skid #2 Stabilize New Ratio - River Water 78-80-
4.7 Mono, 3.0 Pyro.
1440 Late Entry Tanker with Mono, delivered & Started, Manifest # 95854
Temp - 108°
1515 Completed Mono transfer to Tank farm.
1630 Turned Logbook To Kevin Playter - A.E Andor / Alvin E. Andor
11/11/15 1630 RECEIVED LOGBOOK DUTIES FROM A.E. ANDOR FOR SWING
PLAYTER SHIFT K.PLAYTER Kevin Playter
2310 TURNED LOGBOOK OVER TO C. FAITH K.PLAYTER Kevin Playter 11/11/15
Faith 2312 Assumed Logbook from K Playter. C Faith 11/11/15.
11/12/15 0505 REVIEWED LOG BOOK.
FAITH 0515 MONOSODIUM PUMPING 4.6-4.7 gpm AND PYROPHOSPHATE PUMPING
BERTRAND AT 3.0-3.1 gpm AND RIVER PUMP RUNNING AT 77 gpm.
11/12/15 0715 - ERT Back up Running / Windows was updating
Days (Battelle here Complete. All Running.
Ramirez 1010 - Started Pyrophosphate receipt at ~~100~~ 0935 and ended
Andor at 1008. Manifest 95857 86°F
Faith 1235 Late Entry - Changed filters out on Both Skids * Six Packers
Ford from the River.
1235 Late Entry - Assumed Logbook at 0600 A.E. Andor / Alvin Andor
1330 Received Pyrophosphate # 95868 7,502 GALLONS, / 84°
1400 Stopped Transfer - Sent Back around 2,000 gallons due
tanks are full.
1430 Received Monophosphate Manifest # 95869 110° F. pumping
1500 S/O Transfer to Tank Farm ~~Mono~~ AEA 11/12/15 Monophosphate Complete.
1610 Turn ~~Control Room~~ [illegible] / Logbook over to Jim Billingsly / Bert
Andor -
11/12/15 1610 Accepted Logbook duties J Billingsley J Billingsley
Swings No further entries this page

Cont from pg 7

11/12/15 1700 Field readings of infiltration solution

Billingsly taken.

Ford 2100 Field readings of infiltration solution

Bertrand taken.

2317 Turn over logbook to B Andor J Billingsley

11/12/15 2317 Assumed Control Room duties from Jan Billingsley

~~Billingsly~~ A.E. ANDOR / Alvin E Andor

Bertrand 0530 Turn Logbook over to Roy Ramirez + Kevin Playter / Bert Andor

Andor A.E. ANDOR.

0540 LOG BOOK REVIEWED. ERIC BERTRAND

11/13/15 0540 ASSUMED CONTROL OF LOG BOOK R Ramirez

Playter 0736 - SAMPLER ON SITE TO SWITCH OUT MYRON

Ramirez 0850 - RECEIVED 321 GALLONS OF PYROPHOSPHATE ALONG W/ BALANCE OF

CRUME SHIPMENT FROM 11/12/15 DAYSHIFT. TEMP: 84°F. RECEIVED 3,512 GALLONS OF MONOSODIUM PHOSPHATE, TEMP: 100°F. CHEMICAL RECEIPT COMPLETED AT 0905.

1140 - RECEIVED 6,435 GALLONS OF MONOSODIUM PHOSPHATE, TEMP 108°F Chemical RECEIPT complete At 1200 pm

1430 RECEIVED 4,622 GALLONS OF MONOSODIUM PHOSPHATE. TEMP 82°F. CHEMICAL RECEIPT COMPLETE AT 1455.

1740 - RELINQUISHED LOG BOOK TO ERIC BERTRAND R Ramirez

CFaith 1820 Assumed logbook duties. CFaith CFaith

1925 Finished a walkdown of work area, checking for leaks & uprighting stantions. No new leaks found.

Turned logbook over to R. Ramirez. CDFaith

11/14/15 0535 - ASSUMED CONTROL OF LOG BOOK R Ramirez

Billingsly 0540 - VALVED IN FILTERS 1, 2 AND 3 AND VALVED OUT 4, 5 AND 6

Ramirez ON SIX PACK

Boam 0800 - RECEIVED 6,479 GALLONS OF MONOSODIUM PHOSPHATE COMPLETED UNLOADING AT 0826, TEMP 112°F

0850 RECEIVED 7,218 GALLONS OF PYROPHOSPHATE. TEMP 84°F

0915 COMPLETED UNLOADING OF CHEMICAL

1055 - RECEIVED 4,461 GALLONS OF MONOSODIUM PHOSPHATE TEMP 102°F.

1125 - COMPLETED UNLOADING OF CHEMICALS

1705 REVIEWED LOGBOOK & RNDSHEETS. [illegible]

1730 TURNED OVER LOG BOOK TO ERIC BERTRAND R Ramirez

11/14/15 1730 ASSUMED LOGBOOK DUTIES, SKID #2 AT 78 GPM AND CHEMICALS

PLAYTER AT 4.7 FOR CHEM 1 AND 3.1 FOR CHEM 2 K. PLAYTER

0500 CHANGED CHEMICAL RATIOS

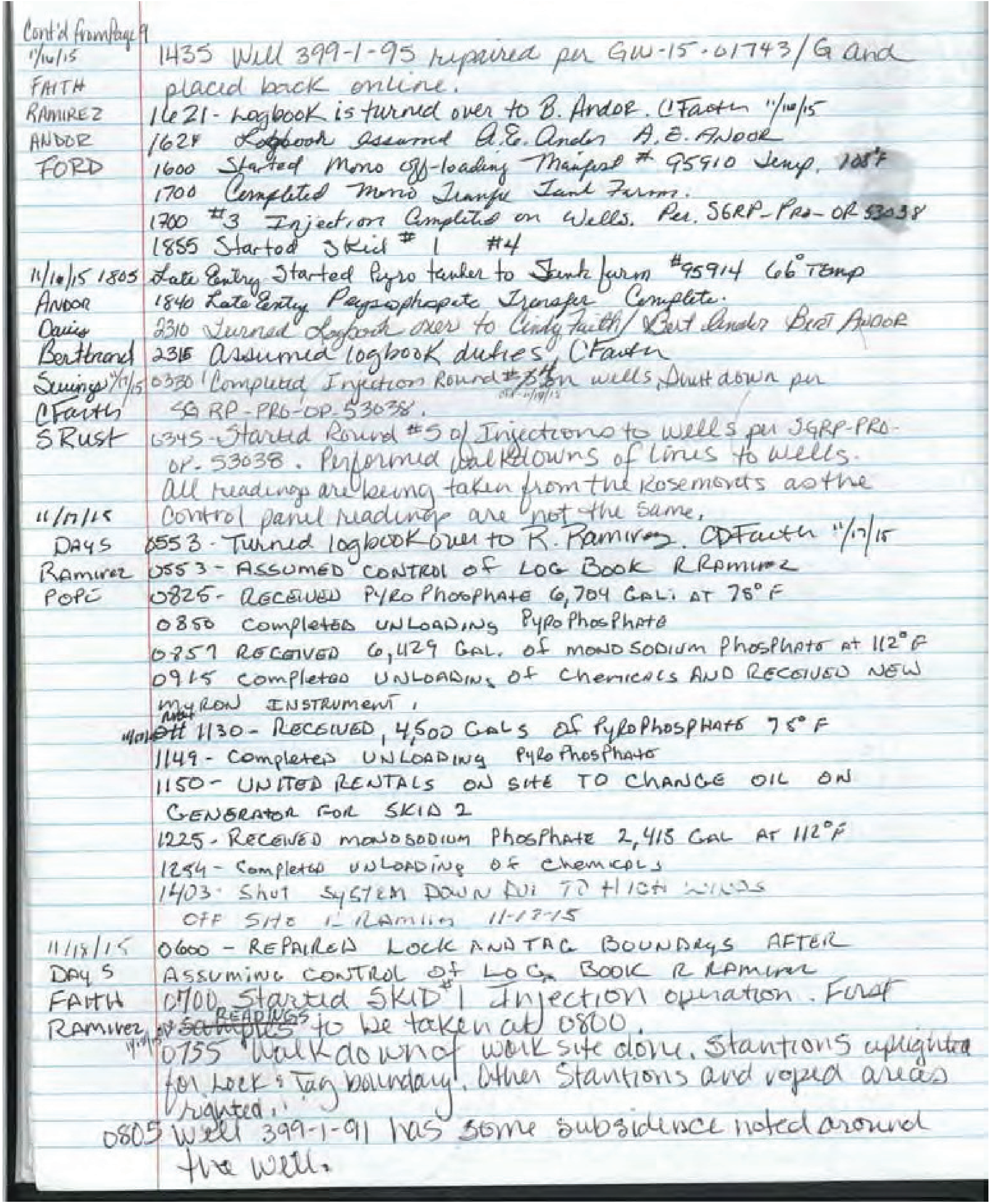
0530 TURNED LOGBOOK OVER TO B. ANDOR K. PLAYTER 11/15/15

0530 Received Logbook + Assumed + Review A.E. ANDOR / Alvin E Andor

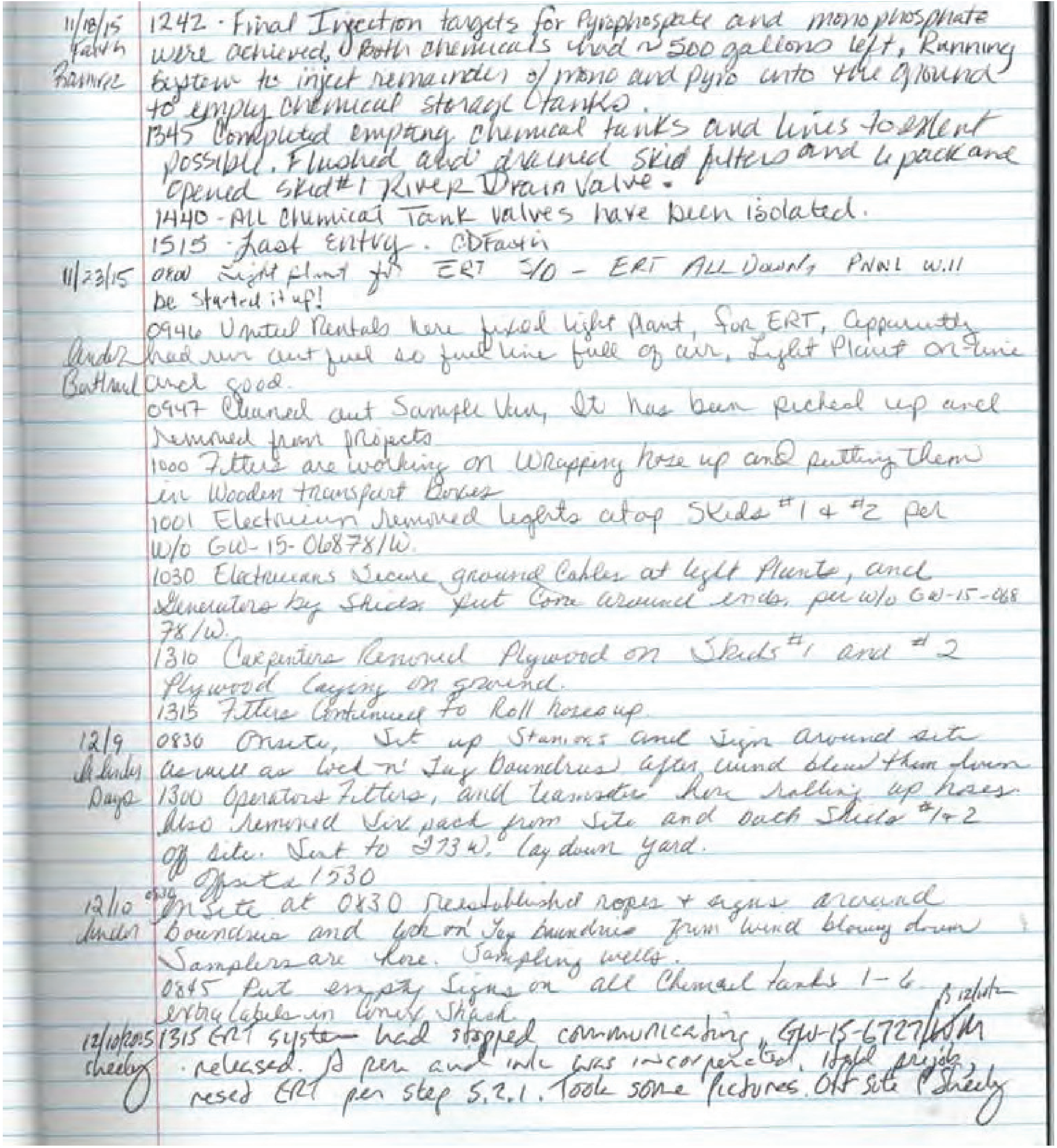
11/15/15

A. Andor 0615- Adjust Chem pumps (Pyro) + (Mono) also put 4,5,6, filters
Cindy Faith back on line. Chemical pumps adjusted to + filters open to allowing
Tom Ford more River water flow.
Days 0730 Samplers brought Myron L. Sample meter
1140 Filters here to Replace filters on Skid #2 (River) Side filters
for W/O 15-04754 Y. All Canisters are on-line (6)
1315 Received 6054 gallons of Monosodium Phosphate. Transfer
started at 1220 and ended at 1305. Manifest number 95843, Temp
118 °F.
1400 Took Levels on Pyrophosphate, Monophosphate Pyro 11' 5226
AND, Mono 13' 6398.
1730 Turn Logbook over to Jon Billingsley / Bert Andor
11/15/15 1733 Accepted logbook from B Andor. J Billingsley
Billingsley 1106 completed filter skid 2 data
Swings/Days monitoring for swing shift.
1116 Turn logbook over to K Playter J Billingsley
11/15/15 ~~1116~~ ACCEPTED LOGBOOK FROM J. BILLINGSLEY K. PLAYTER
PLAYTER 2316 SKID #2 IS ON LINE AND RUNNING ABOUT 80 GPM CHEMICAL
#1 IS 4.4 GPM CHEMICAL #2 IS 2.7 GPM

0545 TURNED LOGBOOK OVER TO B. ANDOR K. PLAYTER
0545 Received Logbook duties from + Assumed from K. Playter / Bert Andor
C.Faith 0605 Started valve line-up of Skid #1 for Injection per procedure
11/16/15 SGRP-PRO-OP-53038. Filters 4, 5, & 6 are open for use on
Ramirez Skid #1.
ANDOR 0608 Late Entry: Recieved logbook duties. CDFaith 11/16/15
FORD 0810 Started shut down of Skid #2 per procedure SGRP-PRO-OP-53038.
Target totals for Monosodium Phosphate: 52940 and Totals
for Pyrophosphate: 33,335 were reached.
The infiltration header was flushed and drained.
0815- The chemical lines need to be flushed and drained.
0930- Started SKID #1 and commenced injections into Well's
399-1-95, 96, 97, 89, 90 and 91. Retest completed satisfactorily
for new Pyrophosphate pump per GW-15-02931/Y.
1055 Late Entry for 1013-Started Recieving Pyrophosphate. Transfer
ended at 1045. Total receipt 7280 gallons. Manifest 95894, 70 °F.
1215- Increased total flow to approximately 350 gpm.
Placed Mono pump "IN HAND".
1310 Started Receipt of Monosodium Phosphate. Manifest
11/16/15 95908, 110 °F. 6523 gallons. Chemical Receipt completed at 1330
CDF ~~1330~~ 1355- Valved out 399-1-95 due to broken airline.
1413- Started receipt of Monosodium Phosphate - Manifest 95903, 106 °F
1500 Chemical receipt completed.



Cont'd from Page 9
11/16/15 1435 Well 399-1-95 repaired per GW-15-01743/G and
FAITH placed back online.
RAMIREZ 1621 - Logbook is turned over to B. Andor. CFaith 11/16/15
ANDOR 1624 Logbook assumed A.E. Andor A.E. ANDOR
FORD 1600 Started Mono off-loading Manifest # 95910 Temp. 108°F
1700 Completed Mono Transfer Tank Farm.
1700 #3 Injection Completed on Wells. Per. SGRP-PRO-OP 53038
1855 Started Skid # 1 #4
11/16/15 1805 Late Entry Started Pyro tanker to Tank farm #95914 66° Temp
ANDOR 1840 Late Entry Pyrophospate Transfer Complete.
Davis 2310 Turned Logbook over to Cindy Faith / Bert Andor BERT ANDOR
Berthrand 2315 Assumed logbook duties. CFaith
Sevings 11/17/15 0330 Completed Injection Round #~~5~~4 on wells, Shut down per
CFaith SGRP-PRO-OP-53038.
SRust 0345 - Started Round #5 of Injections to wells per SGRP-PRO-
OP-53038. Performed walkdowns of lines to wells.
All readings are being taken from the Rosemounts as the
11/17/15 control panel readings are not the same.
DAYS 0553 - Turned logbook over to R. Ramirez. CDFaith 11/17/15
Ramirez 0553 - ASSUMED CONTROL of LOG BOOK RRamirez
POPE 0825 - RECEIVED PYRO Phosphate 6,704 GAL. AT 75° F
0850 Completed UNLOADING PyroPhosphate
0857 RECEIVED 6,429 GAL. of MONOSODIUM Phosphate at 112° F
0915 Completed UNLOADING of Chemicals AND RECEIVED NEW
MYRON INSTRUMENT.
1130 - RECEIVED 4,500 GALS of PyroPhosphate 75° F
1149 - Completed UNLOADING PyroPhosphate
1150 - UNITED RENTALS ON SITE TO CHANGE OIL ON
GENERATOR FOR SKID 2
1225 - RECEIVED MONOSODIUM Phosphate 2,415 GAL AT 112°F
1254 - Completed UNLOADING of Chemicals
1403 - SHUT SYSTEM DOWN DUE TO HIGH WINDS
OFF SITE R RAMIREZ 11-17-15
11/18/15 0600 - REPAIRED LOCK AND TAG BOUNDARYS AFTER
DAY S ASSUMING CONTROL of LOG BOOK R RAMIREZ
FAITH 0700 Started SKID #1 Injection operation. First
RAMIREZ ~~samples~~ READINGS to be taken at 0800.
0755 Walkdown of work site done. Stantions uprighted
for Lock & Tag boundary. Other Stantions and roped areas
righted.
0805 Well 399-1-91 has some subsidence noted around
the well.



11/18/15 Faustin Ramirez
1242 · Final Injection targets for Pyrophosphate and monophosphate were achieved, Both chemicals had ~500 gallons left, Running system to inject remainder of mono and pyro into the ground to empty chemical storage tanks.
1345 Completed emptying chemical tanks and lines to extent possible. Flushed and drained skid filters and 6 pack and opened skid#1 River Drain Valve.
1440 - All Chemical Tank valves have been isolated.
1515 - Last Entry. CDFaustin

11/23/15 Andez Barthal
0800 Light plant for ERT S/D - ERT All Down, PNNL will be started it up!
0946 United Rentals here fixed light plant, for ERT, apparently had run out fuel so fuel line full of air, Light Plant on-line and good.
0947 Cleaned out Sample Van, It has been picked up and removed from projects
1000 Fitters are working on Wrapping hose up and putting them in Wooden transport Boxes
1001 Electrician removed lights atop Skids #1 & #2 per W/O GW-15-06878/W.
1030 Electricians secure ground cables at light plants, and Generators by Skids put Cone around ends, per w/o GW-15-068 78/W.
1310 Carpenters Removed Plywood on Skids #1 and #2 Plywood laying on ground.
1315 Fitters Continued to Roll hoses up.

12/9 A Linder Days
0830 Onsite, Set up Stanions and Sign around site as well as lock n' tag boundries after wind blew them down
1300 Operators Fitters, and teamsters here rolling up hoses. Also removed six pack from site and both Skids #1+2 off site. Sent to 273W. lay down yard.
Offsite 1530

12/10 Linder
0830 On site at 0830 reestablished ropes + signs around boundaries and lock on tag boundries from wind blowing down. Samplers are here. Sampling wells.
0845 Put empty signs on all Chemical tanks 1-6. B 12/10 entry labels in Conex Shed.

12/10/2015 Sheely
1315 ERT system had stopped communicating, GW-15-6727/W/M released. A pen and ink was incorporated. Held prejob, reset ERT per step 5.2.1. Took some pictures. Off site C Sheely

This page intentionally left blank.

Appendix J

Data Validation Report

This page intentionally left blank.

J Data Validation Report

Data validation was performed for analytical data collected to support implementation of the Stage A enhanced attenuation remedy. This appendix provides the data validation report: VSR16-003, *Project 300FF5 U SEQUES, CERC15*.

This page intentionally left blank.

CHPRC - REVIEW COMMENT RECORD (RCR)

1. Date 03/16/2016

2. Review No.

3. Project No.

Page 1 of 1

5. Document Number(s)/Title(s) VSR16-003

6. Program/Project/Building Number

7. Reviewer Scot Fitzgerald

8. Organization/Group Sample Management and Reporting

9. Location/Phone MO277/373-7495

17. Comment Submittal Approval

03/16/2016 Date

Scot Fitzgerald Organization Manager (optional) (print and sign)

10. Agreement With Indicated Comment Disposition(s)

Date

Reviewer/Point of Contact (print and sign)

Author/Originator (print and sign)

11. CLOSED

3/21/16 Date

Reviewer/Point of Contact (print and sign)

Scot Fitzgerald Author/Originator (print and sign)

12. Item	13a. Comments	13b. Basis	13c. Recommendation	14. Reviewer Concurrence Required (Y or N)	15. Disposition (provide justification if NOT accepted)	16. Status
1	2. Page 35 Completeness, Major and Minor Deficiencies – Discussion of unusable and J flagged results due to sample receipt temperature is still in the document.		Update narrative to resolve discrepancy	Y		Closed

A-6004-835 (REV 1)

CHPRC - REVIEW COMMENT RECORD (RCR)

1. Date 03/16/2016

2. Review No.

3. Project No.

Page 1 of 1

5. Document Number(s)/Title(s) VSR16-003

6. Program/Project/Building Number

7. Reviewer Jadie Kaas

8. Organization/Group SGRP QA

9. Location/Phone MO2216 / 376-2949

17. Comment Submittal Approval

Jodie Kaas

03/16/2016 Date

Jadie Kaas Organization Manager (optional) (print and sign)

10. Agreement With Indicated Comment Disposition(s)

Reviewer/Point of Contact (print and sign)

Date

Author/Originator (print and sign)

11. CLOSED

Reviewer/Point of Contact (print and sign)

3/21/16 Date

Jadie Kaas Jadie Kaas Author/Originator (print and sign)

12. Item	13a. Comments	13b. Basis	13c. Recommendation	14. Reviewer Concurrence Required (Y or N)	15. Disposition (provide justification if **NOT** accepted)	16. Status
1	Page 33 under lab blanks discussion there is a typo – the SDG should read SL1897		Correct typo			Closed
2	Page 45 lists the Alkalinity MDL>requested DL., page 35 states “all reported sample MDLs with associated non-detected sample results were below the CRDLs.		Correct discrepancy			Closed

A-6004-835 (REV 1)

ANALYTICAL QUALITY ASSOCIATES, INC.

PO Box 21987
Albuquerque, NM 87154
1-888-678-5447
www.aqainc.net

Data Validation Report for CH2M Hill Plateau Remediation Company

VSR16-003
Project 300FF5 U SEQUES, CERC15

Chemical Validation - Level C

Validation Performed By: Eyda Hergenreder
Eyda Hergenreder **Date:** 03-10-2016

Technical Review By: Ellen McEntee
Ellen McEntee **Date:** 03-10-2016

Quality Review By: Mary A. Donivan
Mary Donivan
Quality Assurance Manager **Date:** 03-17-2016

TABLE OF CONTENTS

Metals

General Chemistry

Date: 10 March 2016
To: CH2M Hill (technical representative)
From: Analytical Quality Associates, Inc.
Project: 300FF5 U SEQUES, CERC15
Subject: Inorganics - Sample Data Groups (SDGs) SL1897, SL1995, SL2015 and SL2023

INTRODUCTION

This memorandum presents the results of data validation for SDGs SL1897, SL1995, SL2015 and SL2023 prepared by TestAmerica Laboratories, Inc. A list of samples validated along with the analytical methods is provided in the following table.

Sample ID	Sample Date	Media	Validation Level	Analytical Methods
B32K93	08/28/15	Water	C	6010C & 6020A
B32K95	08/28/15	Water	C	6010C & 6020A
B32K90	08/28/15	Water	C	6010C & 6020A
B32K87	08/28/15	Water	C	6010C & 6020A
B32K84	08/28/15	Water	C	6010C & 6020A
B32K39	08/31/15	Water	C	6010C & 6020A
B32K30	08/31/15	Water	C	6010C & 6020A
B32K33	08/31/15	Water	C	6010C & 6020A
B32K24	08/31/15	Water	C	6010C & 6020A
B32K99	08/31/15	Water	C	6010C & 6020A
B32K36	08/31/15	Water	C	6010C & 6020A
B32K66	08/28/15	Water	C	6010C & 6020A
B32K69	08/28/15	Water	C	6010C & 6020A
B32K72	08/28/15	Water	C	6010C & 6020A
B32K27	08/31/15	Water	C	6010C & 6020A
B32K48	09/02/15	Water	C	6010C & 6020A
B32K51	09/02/15	Water	C	6010C & 6020A
B32K42	09/02/15	Water	C	6010C & 6020A
B32K45	09/02/15	Water	C	6010C & 6020A
B32K60	09/02/15	Water	C	6010C & 6020A
B32K63	09/02/15	Water	C	6010C & 6020A
B32K21	09/01/15	Water	C	6010C & 6020A
B32K18	09/01/15	Water	C	6010C & 6020A
B32KB1	09/01/15	Water	C	6010C & 6020A
B32K97	09/01/15	Water	C	6010C & 6020A
B32K54	09/01/15	Water	C	6010C & 6020A
B32K57	09/01/15	Water	C	6010C & 6020A
B32K78	09/01/15	Water	C	6010C & 6020A
B32K75	09/01/15	Water	C	6010C & 6020A
B32K81	09/01/15	Water	C	6010C & 6020A
B32KX9	11/09/15	Liquid	C	6010C
B32L10	11/09/15	Liquid	C	6010C

B32L54	11/08/15	Liquid	C	6010C
B32L04	11/07/15	Liquid	C	6010C
B32L07	11/08/15	Liquid	C	6010C
B32YY4	11/14/15	Water	C	6010C and 6020A
B32YY5	11/14/15	Water	C	6010C and 6020A
B32YY8	11/14/15	Water	C	6010C and 6020A
B32YY9	11/14/15	Water	C	6010C and 6020A
B33002	11/14/15	Water	C	6010C and 6020A
B33003	11/14/15	Water	C	6010C and 6020A
B33011	11/14/15	Water	C	6010C and 6020A
B33010	11/14/15	Water	C	6010C and 6020A
B33015	11/14/15	Water	C	6010C and 6020A
B33014	11/14/15	Water	C	6010C and 6020A
B33019	11/15/15	Water	C	6010C and 6020A
B33018	11/15/15	Water	C	6010C and 6020A
B33022	11/15/15	Water	C	6010C and 6020A
B33023	11/15/15	Water	C	6010C and 6020A
B33031	11/15/15	Water	C	6010C and 6020A
B33030	11/15/15	Water	C	6010C and 6020A
B33035	11/15/15	Water	C	6010C and 6020A
B33034	11/15/15	Water	C	6010C and 6020A
B33042	11/15/15	Water	C	6010C and 6020A
B33043	11/15/15	Water	C	6010C and 6020A
B32L56	11/18/15	Liquid	C	6010C and 6020A
B33KY4	11/17/15	Liquid	C	6010C and 6020A

Data validation was conducted in accordance with the CHPRC validation statement of work and the Field Instruction for Uranium Sequestration in the 300 Area, SGW-58976, Rev. 0 (SAP). Appendices 1 through 4 provide the following information as indicated below:

Appendix 1. Glossary of Data Reporting Qualifiers
Appendix 2. Summary of Data Qualification
Appendix 3. Data Validation Supporting Documentation
Appendix 4. Additional Documentation Requested by Client

DATA QUALITY OBJECTIVES

- **Holding Times and Sample Preservation**

Holding times are calculated from Chain-of-Custody forms to determine the validity of the results. The holding time requirement for ICP and ICP-MS metals are analysis within 180 days of sample collection. Sample preservation requires acid preservation with nitric acid to pH <2.

The samples were analyzed within the prescribed holding times and properly preserved.

- **Blanks**

The blank data results are reviewed to assess the extent of contamination introduced through sampling, sample preparation, and analysis.

Laboratory Blanks

All laboratory blank results were acceptable.

Trip Blanks

All trip blank results were acceptable with the following exception.

For SDG SL1897, the Ca result for trip blank sample B32K95 was > the MDL but <2X the MDL. The Ca result for associated sample B32K93 was > RL and was not qualified.

Field Blanks

No field blanks were submitted for validation.

Equipment Blanks

No equipment blanks were submitted for validation.

- **Accuracy**

Accuracy is evaluated by reviewing matrix spike sample results, laboratory control sample and ICP-AES interference check sample results. According to the SAP, the laboratory control sample accuracy limits are 80% to 120% and the matrix spike sample accuracy limits are 75% to 125%. The limits for reported analytes not listed in the SAP are specified by the DV procedure. The interference check sample limits are ones specified by the DV procedure.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) Samples

All MS/MSD recoveries were acceptable with the following exceptions.

For SDG SL2015, the MS recovery for Ca and the MS and MSD recoveries for Na were > the upper acceptance limit. The Ca and Na parent sample results were >4X the spike concentration; therefore, data should not be qualified.

For SDG SL2023, The MS recovery for K was > the upper acceptance limit, the MS recovery for Na was < the lower acceptance limit but ≥30% and the MSD recoveries for K and Na were <30%. The K and Na parent sample results were >4X the spike concentration, therefore data should not qualified.

Laboratory Control Samples (LCSs)

All LCS recoveries were acceptable.

ICP-AES Interference Check Samples (ICSs)

ICS data was not included in the data package. Sample results should not be qualified based on this.

- **Precision**

Precision is evaluated by reviewing MS/MSD results, field duplicate sample results, field split sample results, and ICP serial dilution results. These QC results provide information on the laboratory reproducibility and whether sampling activities are adequate to acquire consistent sample results. According to the SAP, the relative percent difference (RPD) limits are ≤20%. The limits for reported analytes not listed in the SAP are specified by the DV procedure. When duplicate RPDs exceed the limits and have associated results <5X the SAP required detection limits (or <5X the laboratory reporting limits for analytes not listed in the SAP) with differences <1X the required detection limits no precision infraction occurred. The serial dilution limits are ones specified by the DV procedure.

MS/MSD Samples

All MS/MSD RPD values were acceptable.

Field Duplicate Samples

All field duplicate results were acceptable.

Field Split Samples

No field splits were submitted for validation.

ICP Serial Dilution Samples

ICS serial dilution data was not included in the data package. Sample results should not be qualified based on this.

- **ICP-MS Internal Standards**

The analysis of ICP-MS internal standards is used to determine the existences and magnitude of instrument drift and physical interferences. The criteria for evaluation of internal standard results apply to all samples (including QC) analyzed during the analytical run, beginning with the calibration.

ICP-MS internal standards data was not included in the data package. Sample results should not be qualified based on this.

- **Detection Limits**

Reported MDLs are compared against the contractually required detection limits (CRDLs) to ensure that laboratory detection limits meet the required criteria.

All reported sample MDLs were below the CRDLs.

- **Completeness**

SDGs SL1897, SL1995, SL2015 and SL2023 were submitted for validation and verified for completeness. Completeness is based on the percentage of data determined to be valid (i.e., not rejected). The completion percentage was 100%.

MAJOR DEFICIENCIES

None found.

MINOR DEFICIENCIES

There were no minor deficiencies leading to qualification of sample results as estimates. It should be noted that the laboratory did not sign the “received by” field of the Chain-of-Custody for sample B32K69.

REFERENCES

GRP-GD-003, Rev. 1, Change 0, *Data Validation for Chemical Analyses*, July 2012.

SGW-58976, Rev. 0, *Field Instructions for Uranium Sequestration in the 300 Area*, July 2015.

Appendix 1

Glossary of Data Reporting Qualifiers

Qualifiers that may be applied by data validators in compliance with the CHPRC statement of work are as follows:

- **U —** The constituent was analyzed for, but was not detected. The data should be considered usable for decision-making purposes.
- **UJ —** The constituent was analyzed for and was not detected. Due to a quality control deficiency identified during data validation the value reported may not accurately reflect the RL. The data should be considered usable for decision-making purposes.
- **J —** Indicates the constituent was analyzed for and detected. The associated value is estimated due to a quality control deficiency identified during data validation. The data should be considered usable for decision-making purposes.
- **J+ —** Indicates the constituent was analyzed for and detected. The associated value is estimated with a suspected positive bias due to a quality control deficiency identified during data validation. The data should be considered usable for decision-making purposes.
- **J- —** Indicates the constituent was analyzed for and detected. The associated value is estimated with a suspected negative bias due to a quality control deficiency identified during data validation. The data should be considered usable for decision-making purposes.
- **N —** The analysis indicates the presence of an analyte that has been tentatively identified.
- **NJ —** The analysis indicates the presence of an analyte that has been tentatively identified and the associated numerical value represents its approximate concentration.
- **NJ+ —** The analysis indicates the presence of an analyte that has been tentatively identified. The associated value is estimated with a suspected positive bias due to a quality control deficiency identified during data validation.
- **NJ- —** The analysis indicates the presence of an analyte that has been tentatively identified. The associated value is estimated with a suspected negative bias due to a quality control deficiency identified during data validation.
- **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 decision-making purposes.
- **R —** Indicates the constituent was analyzed for and detected; however, due to an identified quality control deficiency the data should be considered unusable for decision-making purposes.

Appendix 2

Summary of Data Qualification

Inorganic Data Qualification Summary			
SDGs:SL1897, SL1995, SL2015 and SL2023	Reviewer: AQA	Project: 300FF5 U SEQUES, CERC15	Page 1 of 1
Analyte(s)	**Qualifier**	**Samples Affected**	**Reason**
Metals	NA	None	NA

Comments: None

Appendix 3

Data Validation Supporting Documentation

VALIDATION LEVEL:	A	B	C	D	E
PROJECT: 300FF5 U SEQUES, CERC15			DATA PACKAGE: VSR16-003		
VALIDATOR: Eyda Hergenreder		LAB: TestAmerica		DATE: 03/10/16	
			SDG: SL1897, SL1995, SL2015, SL2023		
ANALYSES PERFORMED					
SW-846/ICP X	SW-846/GFAA	SW-846/Hg	SW-846 Cyanide	SW-846/ICPMS X	
SAMPLES/MATRIX					
Water SL1897: B32K93, B32K95, B32K90, B32K87, B32K84, B32K39, B32K30, B32K33, B32K24, B32K99					
B32K36, B32K66, B32K69, B32K72, B32K27, B32K48, B32K51, B32K42, B32K45, B32K60, B32K63, B32K21, B32K18, B32KB1, B32K97, B32K54, B32K57, B32K78, B32K75, B32K81					
SL2015: B32YY4, B32YY5, B32YY8, B32YY9, B33002, B33003, B33011, B33010, B33015, B33014 B33019, B33018, B33022, B33023, B33031, B33030, B33035, B33034, B33042, B33043					
Liquid					
SL1995: B32KX9, B32L10, B32L54, B32L04, B32L07 SL2023: B32L56, B33KY4					

1. DATA PACKAGE COMPLETENESS AND CASE NARRATIVE

Technical verification documentation present? .... Yes No N/A

Comments:

SL1897: Received by on COC was not completed for sample B32K69

2. INSTRUMENT PERFORMANCE AND CALIBRATIONS (Levels D and E)

Initial calibrations performed on all instruments? .... Yes No N/A

Initial calibrations acceptable? .... Yes No N/A

ICP interference checks acceptable? .... Yes No N/A

ICV and CCV checks performed on all instruments? .... Yes No N/A

ICV and CCV checks acceptable? .... Yes No N/A

Standards traceable? .... Yes No N/A

Standards expired? .... Yes No N/A

Calculation check acceptable? .... Yes No N/A

Comments:____

3. BLANKS (Levels B, C, D, and E)

ICB and CCB checks performed for all applicable analyses? (Levels D, E) .... Yes No N/A

ICB and CCB results acceptable? (Levels D, E) .... Yes No N/A

Laboratory blanks analyzed? .... Yes No N/A

Laboratory blank results acceptable? .... Yes No N/A

Field blanks analyzed? (Levels C, D, E) .... Yes No N/A

Field blank results acceptable? (Levels C, D, E) .... Yes No N/A

Transcription/calculation errors? (Levels D, E) .... Yes No N/A

Comments:____

SDG SL1897: Trip Blank B32K95: Ca 68.4 ug/L

4. ACCURACY (Levels C, D, and E)

MS/MSD samples analyzed? Yes No N/A

MS/MSD results acceptable? Yes No N/A

MS/MSD standards NIST traceable? (Levels D, E) Yes No N/A

MS/MSD standards expired? (Levels D, E) Yes No N/A

LCS/BSS samples analyzed? Yes No N/A

LCS/BSS results acceptable? Yes No N/A

Standards traceable? (Levels D, E) Yes No N/A

Standards expired? (Levels D, E) Yes No N/A

Transcription/calculation errors? (Levels D, E) Yes No N/A

Performance audit sample(s) analyzed? Yes No N/A

Performance audit sample results acceptable? Yes No N/A

Comments:

SDG SL2015: Ca MS 175%*; Na MS 199%*/MSD 236%*

SDG SL2023: K MS 135%*/MSD -395%*, Na MS 40%*/MSD -465*

*Parent sample result >4X spike concentration

5. PRECISION (Levels C, D, and E)

Duplicate RPD values acceptable? .... Yes No N/A

Duplicate results acceptable? .... Yes No N/A

MS/MSD standards NIST traceable? (Levels D, E) .... Yes No N/A

MS/MSD standards expired? (Levels D, E) .... Yes No N/A

LCS/LCSD duplicates run due to insufficient sample material? .... Yes No N/A

Field duplicate RPD values acceptable? .... Yes No N/A

Field split RPD values acceptable? .... Yes No N/A

Transcription/calculation errors? (Levels D, E) .... Yes No N/A

Comments:____

____

____

____

____

____

____

____

6. ICP QUALITY CONTROL (Levels D and E)

ICP serial dilution samples analyzed? .... Yes No N/A

ICP serial dilution %D values acceptable? .... Yes No N/A

ICP post digestion spike required? .... Yes No N/A

ICP post digestion spike values acceptable? .... Yes No N/A

Standards traceable? .... Yes No N/A

Standards expired? .... Yes No N/A

Transcription/calculation errors? .... Yes No N/A

Comments:____

7. HOLDING TIMES (all levels)

Samples properly preserved? .... Yes No N/A

Sample holding times acceptable? .... Yes No N/A

Comments:____

8. RESULT QUANTITATION AND DETECTION LIMITS (all levels)

Results reported for all requested analyses? .... Yes No N/A

Results supported in the raw data? (Levels D, E) .... Yes No N/A

Samples properly prepared? (Levels D, E) .... Yes No N/A

Detection limits meet RDL? .... Yes No N/A

Transcription/calculation errors? (Levels D, E) .... Yes No N/A

Comments:____

Appendix 4

Additional Documentation Requested By Client

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-055

TestAmerica Job ID: 160-13589-1
SDG: SL1897

Method: 6010C - Metals (ICP)

Lab Sample ID: MB 160-209385/1-A
Matrix: Water
Analysis Batch: 210218

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 209385

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Calcium	54.2	U	1000	54.2	ug/L		09/03/15 15:59	09/09/15 20:18	1
Potassium	456	U	5000	456	ug/L		09/03/15 15:59	09/09/15 20:18	1

Lab Sample ID: MB 160-209385/1-A
Matrix: Water
Analysis Batch: 210333

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 209385

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Magnesium	50.5	U	1000	50.5	ug/L		09/03/15 15:59	09/10/15 14:05	1
Sodium	105	U	1000	105	ug/L		09/03/15 15:59	09/10/15 14:05	1

Lab Sample ID: LCS 160-209385/2-A
Matrix: Water
Analysis Batch: 210218

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 209385

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Calcium			10000	10730		ug/L		107	80 - 120		
Potassium			10000	10680		ug/L		107	80 - 120		

Lab Sample ID: LCS 160-209385/2-A
Matrix: Water
Analysis Batch: 210333

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 209385

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Magnesium			10000	9282		ug/L		93	80 - 120		
Sodium			10000	10050		ug/L		101	80 - 120		

Lab Sample ID: 160-13589-1 MS
Matrix: Water
Analysis Batch: 210218

Client Sample ID: B32K93
Prep Type: Total/NA
Prep Batch: 209385

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Calcium	52700		10000	64230		ug/L		116	75 - 125		
Potassium	5680		10000	16600		ug/L		109	75 - 125		

Lab Sample ID: 160-13589-1 MS
Matrix: Water
Analysis Batch: 210333

Client Sample ID: B32K93
Prep Type: Total/NA
Prep Batch: 209385

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Magnesium	11000		10000	20750		ug/L		98	75 - 125		
Sodium	24800		10000	35130		ug/L		103	75 - 125		

Lab Sample ID: 160-13589-1 MSD
Matrix: Water
Analysis Batch: 210218

Client Sample ID: B32K93
Prep Type: Total/NA
Prep Batch: 209385

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Calcium	52700		10000	63740		ug/L		111	75 - 125	1	20

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-055

TestAmerica Job ID: 160-13589-1
SDG: SL1897

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: 160-13589-1 MSD
Matrix: Water
Analysis Batch: 210218

Client Sample ID: B32K93
Prep Type: Total/NA
Prep Batch: 209385

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Potassium	5680		10000	17370		ug/L		117	75 - 125	5	20

Lab Sample ID: 160-13589-1 MSD
Matrix: Water
Analysis Batch: 210333

Client Sample ID: B32K93
Prep Type: Total/NA
Prep Batch: 209385

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Magnesium	11000		10000	21120		ug/L		101	75 - 125	2	20
Sodium	24800		10000	35500		ug/L		107	75 - 125	1	20

Lab Sample ID: MB 160-210508/1-A
Matrix: Water
Analysis Batch: 211062

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 210508

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Calcium	54.2	U	1000	54.2	ug/L		09/11/15 13:32	09/14/15 17:45	1
Magnesium	50.5	U	1000	50.5	ug/L		09/11/15 13:32	09/14/15 17:45	1
Potassium	456	U	5000	456	ug/L		09/11/15 13:32	09/14/15 17:45	1
Sodium	105	U	1000	105	ug/L		09/11/15 13:32	09/14/15 17:45	1

Lab Sample ID: LCS 160-210508/2-A
Matrix: Water
Analysis Batch: 211062

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 210508

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Calcium	10000	11330		ug/L		113	80 - 120
Magnesium	10000	9659		ug/L		97	80 - 120
Potassium	10000	9928		ug/L		99	80 - 120
Sodium	10000	10030		ug/L		100	80 - 120

Lab Sample ID: 160-13629-1 MS
Matrix: Water
Analysis Batch: 211062

Client Sample ID: B32K27
Prep Type: Total/NA
Prep Batch: 210508

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Calcium	73000		10000	80780		ug/L		78	75 - 125
Magnesium	14600		10000	24170		ug/L		95	75 - 125
Potassium	4250	B	10000	14340		ug/L		101	75 - 125
Sodium	24400		10000	34560		ug/L		102	75 - 125

Lab Sample ID: 160-13629-1 MSD
Matrix: Water
Analysis Batch: 211062

Client Sample ID: B32K27
Prep Type: Total/NA
Prep Batch: 210508

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Calcium	73000		10000	80650		ug/L		76	75 - 125	0	20
Magnesium	14600		10000	23910		ug/L		93	75 - 125	1	20
Potassium	4250	B	10000	14640		ug/L		104	75 - 125	2	20
Sodium	24400		10000	35220		ug/L		108	75 - 125	2	20

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-055

TestAmerica Job ID: 160-13589-1
SDG: SL1897

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: MB 160-210925/1-A
Matrix: Water
Analysis Batch: 211197

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 210925

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Calcium	54.2	U	1000	54.2	ug/L		09/14/15 13:53	09/15/15 14:20	1
Magnesium	50.5	U	1000	50.5	ug/L		09/14/15 13:53	09/15/15 14:20	1
Potassium	456	U	5000	456	ug/L		09/14/15 13:53	09/15/15 14:20	1
Sodium	105	U	1000	105	ug/L		09/14/15 13:53	09/15/15 14:20	1

Lab Sample ID: LCS 160-210925/2-A
Matrix: Water
Analysis Batch: 211197

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 210925

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Calcium			10000	11350		ug/L		114	80 - 120		
Magnesium			10000	9774		ug/L		98	80 - 120		
Potassium			10000	10020		ug/L		100	80 - 120		
Sodium			10000	10040		ug/L		100	80 - 120		

Lab Sample ID: 160-13655-1 MS
Matrix: Water
Analysis Batch: 211197

Client Sample ID: B32K48
Prep Type: Total/NA
Prep Batch: 210925

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Calcium	56800		10000	67820		ug/L		110	75 - 125		
Magnesium	12400		10000	22530		ug/L		101	75 - 125		
Potassium	5570		10000	15830		ug/L		103	75 - 125		
Sodium	24000		10000	34940		ug/L		110	75 - 125		

Lab Sample ID: 160-13655-1 MSD
Matrix: Water
Analysis Batch: 211197

Client Sample ID: B32K48
Prep Type: Total/NA
Prep Batch: 210925

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Calcium	56800		10000	64630		ug/L		78	75 - 125	5	20
Magnesium	12400		10000	21900		ug/L		95	75 - 125	3	20
Potassium	5570		10000	15520		ug/L		99	75 - 125	2	20
Sodium	24000		10000	34190		ug/L		102	75 - 125	2	20

Method: 6020A - Metals (ICP/MS)

Lab Sample ID: MB 160-209384/1-A
Matrix: Water
Analysis Batch: 211966

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 209384

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Uranium	0.23	U	1.0	0.23	ug/L		09/03/15 15:57	09/18/15 21:18	2

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-055

TestAmerica Job ID: 160-13589-1
SDG: SL1897

Method: 6020A - Metals (ICP/MS) (Continued)

Lab Sample ID: LCS 160-209384/2-A
Matrix: Water
Analysis Batch: 211966

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 209384

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Uranium	1000	1000		ug/L		100	80 - 120

Lab Sample ID: 160-13589-1 MS
Matrix: Water
Analysis Batch: 211966

Client Sample ID: B32K93
Prep Type: Total/NA
Prep Batch: 209384

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Uranium	46.8		1000	1086		ug/L		104	75 - 125

Lab Sample ID: 160-13589-1 MSD
Matrix: Water
Analysis Batch: 211966

Client Sample ID: B32K93
Prep Type: Total/NA
Prep Batch: 209384

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Uranium	46.8		1000	1116		ug/L		107	75 - 125	3	20

Lab Sample ID: MB 160-210504/1-A
Matrix: Water
Analysis Batch: 211492

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 210504

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Uranium	0.23	U	1.0	0.23	ug/L		09/11/15 13:18	09/16/15 22:32	2

Lab Sample ID: LCS 160-210504/2-A
Matrix: Water
Analysis Batch: 211492

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 210504

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Uranium	1000	1017		ug/L		102	80 - 120

Lab Sample ID: 160-13629-1 MS
Matrix: Water
Analysis Batch: 211492

Client Sample ID: B32K27
Prep Type: Total/NA
Prep Batch: 210504

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Uranium	150		1000	1177		ug/L		103	75 - 125

Lab Sample ID: 160-13629-1 MSD
Matrix: Water
Analysis Batch: 211492

Client Sample ID: B32K27
Prep Type: Total/NA
Prep Batch: 210504

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Uranium	150		1000	1194		ug/L		104	75 - 125	1	20

Lab Sample ID: MB 160-210928/1-A
Matrix: Water
Analysis Batch: 211967

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 210928

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Uranium	0.23	U	1.0	0.23	ug/L		09/14/15 13:56	09/18/15 22:52	2

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-055

TestAmerica Job ID: 160-13589-1
SDG: SL1897

Lab Sample ID: LCS 160-210928/2-A
Matrix: Water
Analysis Batch: 211967

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 210928

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Uranium			1000	1051		ug/L		105	80 - 120		

Lab Sample ID: 160-13655-1 MS
Matrix: Water
Analysis Batch: 211967

Client Sample ID: B32K48
Prep Type: Total/NA
Prep Batch: 210928

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Uranium	32.2		1000	1091		ug/L		106	75 - 125		

Lab Sample ID: 160-13655-1 MSD
Matrix: Water
Analysis Batch: 211967

Client Sample ID: B32K48
Prep Type: Total/NA
Prep Batch: 210928

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Uranium	32.2		1000	1060		ug/L		103	75 - 125	3	20

Method: 310.1 - Alkalinity

Lab Sample ID: MB 160-208691/1
Matrix: Water
Analysis Batch: 208691

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	0.54	U	5.0	0.54	mg/L			08/31/15 15:01	1
Bicarbonate Alkalinity	0.54	U	5.0	0.54	mg/L			08/31/15 15:01	1
Carbonate Alkalinity	0.54	U	5.0	0.54	mg/L			08/31/15 15:01	1
Hydroxide Alkalinity	0.54	U	5.0	0.54	mg/L			08/31/15 15:01	1

Lab Sample ID: HLCS 160-208691/3
Matrix: Water
Analysis Batch: 208691

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Alkalinity			400	371.0		mg/L		93	90 - 110		
Bicarbonate Alkalinity			400	371.0		mg/L		93	90 - 110		

Lab Sample ID: LCS 160-208691/2
Matrix: Water
Analysis Batch: 208691

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Alkalinity			200	186.0		mg/L		93	90 - 110		
Bicarbonate Alkalinity			200	186.0		mg/L		93	90 - 110		

Lab Sample ID: 160-13527-A-1 MS
Matrix: Water
Analysis Batch: 208691

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Alkalinity	0.54	U	100	94.00		mg/L		94	80 - 120		
Bicarbonate Alkalinity	0.54	U	100	94.00		mg/L		94	80 - 120		

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: F15-055

TestAmerica Job ID: 160-14750-1
SDG: SL1995

Method: 6010C - Metals (ICP)

Lab Sample ID: MB 160-225414/1-A
Matrix: Water
Analysis Batch: 226904

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 225414

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Calcium	54.2	U	1000	54.2	ug/L		12/03/15 16:06	12/11/15 18:00	1
Magnesium	50.5	U	1000	50.5	ug/L		12/03/15 16:06	12/11/15 18:00	1
Potassium	456	U	5000	456	ug/L		12/03/15 16:06	12/11/15 18:00	1

Lab Sample ID: MB 160-225414/1-A
Matrix: Water
Analysis Batch: 230096

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 225414

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sodium	105	U	1000	105	ug/L		12/03/15 16:06	12/30/15 12:13	1

Lab Sample ID: LCS 160-225414/2-A
Matrix: Water
Analysis Batch: 226904

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 225414

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Calcium	10000	10960		ug/L		110	80 - 120
Magnesium	10000	9960		ug/L		100	80 - 120
Potassium	10000	9799		ug/L		98	80 - 120

Lab Sample ID: LCS 160-225414/2-A
Matrix: Water
Analysis Batch: 230096

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 225414

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Sodium	10000	9758		ug/L		98	80 - 120

Lab Sample ID: 160-14770-A-13-B MS
Matrix: Water
Analysis Batch: 226904

Client Sample ID: Matrix Spike
Prep Type: Total/NA
Prep Batch: 225414

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Calcium	52800		10000	64170		ug/L		114	75 - 125
Magnesium	11600		10000	21900		ug/L		103	75 - 125
Potassium	5890		10000	15870		ug/L		100	75 - 125
Sodium	31400		10000	41190		ug/L		98	75 - 125

Lab Sample ID: 160-14770-A-13-C MSD
Matrix: Water
Analysis Batch: 226904

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total/NA
Prep Batch: 225414

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Calcium	52800		10000	64560		ug/L		118	75 - 125	1	20
Magnesium	11600		10000	22020		ug/L		104	75 - 125	1	20
Potassium	5890		10000	15900		ug/L		100	75 - 125	0	20
Sodium	31400		10000	41390		ug/L		100	75 - 125	0	20

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-064 / X15-065

TestAmerica Job ID: 160-14872-1
SDG: SL2015

Method: 6010C - Metals (ICP)

Lab Sample ID: MB 160-222822/1-A
Matrix: Water
Analysis Batch: 224721

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 222822

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Calcium	54.2	U	1000	54.2	ug/L		11/19/15 16:16	11/30/15 08:35	1
Sodium	105	U	1000	105	ug/L		11/19/15 16:16	11/30/15 08:35	1

Lab Sample ID: LCS 160-222822/2-A
Matrix: Water
Analysis Batch: 224721

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 222822

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Calcium	10000	11020		ug/L		110	80 - 120
Sodium	10000	9831		ug/L		98	80 - 120

Lab Sample ID: 160-14872-1 MS
Matrix: Water
Analysis Batch: 224721

Client Sample ID: B32YY4
Prep Type: Dissolved
Prep Batch: 222822

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Calcium	157000	D	10000	174300	D	ug/L		175	75 - 125
Sodium	252000	D	10000	271600	D	ug/L		199	75 - 125

Lab Sample ID: 160-14872-1 MSD
Matrix: Water
Analysis Batch: 224721

Client Sample ID: B32YY4
Prep Type: Dissolved
Prep Batch: 222822

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Calcium	157000	D	10000	167300	D	ug/L		105	75 - 125	4	20
Sodium	252000	D	10000	275300	D	ug/L		236	75 - 125	1	20

Method: 6020A - Metals (ICP/MS)

Lab Sample ID: MB 160-222823/1-A
Matrix: Water
Analysis Batch: 224377

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 222823

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Uranium	0.23	U	1.0	0.23	ug/L		11/19/15 16:18	11/26/15 01:54	2

Lab Sample ID: LCS 160-222823/2-A
Matrix: Water
Analysis Batch: 224377

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 222823

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Uranium	1000	1007		ug/L		101	80 - 120

Lab Sample ID: 160-14872-1 MS
Matrix: Water
Analysis Batch: 224377

Client Sample ID: B32YY4
Prep Type: Dissolved
Prep Batch: 222823

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Uranium	3970		1000	5139		ug/L		117	75 - 125

QC Sample Results

Method: 6020A - Metals (ICP/MS) (Continued)

Lab Sample ID: 160-14872-1 MSD
Matrix: Water
Analysis Batch: 224377

Client Sample ID: B32YY4
Prep Type: Dissolved
Prep Batch: 222823

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Uranium	3970		1000	5200		ug/L		123	75 - 125	1	20

Method: 310.1 - Alkalinity

Lab Sample ID: MB 160-222867/1
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Bicarbonate Alkalinity	0.54	U	5.0	0.54	mg/L			11/20/15 09:17	1
Carbonate Alkalinity	0.54	U	5.0	0.54	mg/L			11/20/15 09:17	1

Lab Sample ID: HLCS 160-222867/3
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits
Bicarbonate Alkalinity	400	370.0		mg/L		92	90 - 110

Lab Sample ID: LCS 160-222867/2
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Bicarbonate Alkalinity	200	187.0		mg/L		93	90 - 110

Lab Sample ID: 160-14833-A-5 MS
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Bicarbonate Alkalinity	213		100	306.0		mg/L		93	80 - 120

Lab Sample ID: 160-14833-A-5 DU
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Bicarbonate Alkalinity	213		214.0		mg/L		0.5	20
Carbonate Alkalinity	0.54	U	0.54	U	mg/L		NC	20

QC Sample Results

Method: 6010C - Metals (ICP)

Lab Sample ID: MB 160-227715/1-A
Matrix: Water
Analysis Batch: 231720

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 227715

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Calcium	F4.2	U	1000	F4.2	ugjL		12j16j1F 1F:07	01j11j16 15:14	1
Magnesium	F0.F	U	1000	F0.F	ugjL		12j16j1F 1F:07	01j11j16 15:14	1
Potassium	4F6	U	F000	4F6	ugjL		12j16j1F 1F:07	01j11j16 15:14	1
Sodium	10F	U	1000	10F	ugjL		12j16j1F 1F:07	01j11j16 15:14	1

Lab Sample ID: LCS 160-227715/2-A
Matrix: Water
Analysis Batch: 231720

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 227715

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Calcium	10000	11500		ugjL		115	30 - 120
Magnesium	10000	7802		ugjL		78	30 - 120
Potassium	10000	770F		ugjL		77	30 - 120
Sodium	10000	7857		ugjL		78	30 - 120

Lab Sample ID: 160-14933-1 MS
Matrix: Other Aqueous Sample
Analysis Batch: 231720

Client Sample ID: B32L56
Prep Type: Total/NA
Prep Batch: 227715

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Calcium	13F00	B D	10000	50550	B D	ugjL		113	8F - 12F
Magnesium	4010	B D	10000	15630	B D	ugjL		78	8F - 12F
Potassium	1720000	D	10000	175F000	D	ugjL		15F	8F - 12F
Sodium	2200000	D	10000	2201000	D	ugjL		40	8F - 12F

Lab Sample ID: 160-14933-1 MSD
Matrix: Other Aqueous Sample
Analysis Batch: 231720

Client Sample ID: B32L56
Prep Type: Total/NA
Prep Batch: 227715

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Calcium	13F00	B D	10000	27F50	B D	ugjL		110	8F - 12F	5	20
Magnesium	4010	B D	10000	15030	B D	ugjL		71	8F - 12F	4	20
Potassium	1720000	D	10000	1332000	D	ugjL		-57F	8F - 12F	5	20
Sodium	2200000	D	10000	21F1000	D	ugjL		-46F	8F - 12F	2	20

Method: 6020A - Metals (ICP/MS)

Lab Sample ID: MB 160-227718/1-A
Matrix: Water
Analysis Batch: 230919

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 227718

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Uranium	0.25	U	1.0	0.25	ugjL		12j16j1F 1F:14	01j06j16 17:F0	2

QC Sample Results

Method: 6020A - Metals (ICP/MS) (Continued)

Lab Sample ID: LCS 160-227718/2-A
Matrix: Water
Analysis Batch: 230919

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 227718

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Uranium			1000	1008		ugjL		101	30 - 120		

Lab Sample ID: 160-14933-1 MS
Matrix: Other Aqueous Sample
Analysis Batch: 230919

Client Sample ID: B32L56
Prep Type: Total/NA
Prep Batch: 227718

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Uranium	F.3	U	1000	76F.7	D	ugjL		78	8F - 12F		

Lab Sample ID: 160-14933-1 MSD
Matrix: Other Aqueous Sample
Analysis Batch: 230919

Client Sample ID: B32L56
Prep Type: Total/NA
Prep Batch: 227718

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Uranium	F.3	U	1000	7F7.4	D	ugjL		76	8F - 12F	1	20

Method: 310.1 - Alkalinity

Lab Sample ID: MB 160-224347/1
Matrix: Water
Analysis Batch: 224347

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Bicarbonate Alkalinity as CaCO5	0.F4	U	F.0	0.F4	mgjL			11j2Fj1F 13:F0	1
Carbonate Alkalinity as CaCO5	0.F4	U	F.0	0.F4	mgjL			11j2Fj1F 13:F0	1

Lab Sample ID: HLCS 160-224347/3
Matrix: Water
Analysis Batch: 224347

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Bicarbonate Alkalinity as CaCO5			400	588.0		mgjL		74	70 - 110		

Lab Sample ID: LCS 160-224347/2
Matrix: Water
Analysis Batch: 224347

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Bicarbonate Alkalinity as CaCO5			200	170.0		mgjL		7F	70 - 110		

Method: 310.1 - Alkalinity - DL

Lab Sample ID: 160-14957-A-1 MS
Matrix: Water
Analysis Batch: 224347

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Bicarbonate Alkalinity as CaCO5 - DL	F60		F01	1020		mgjL		72	30 - 120		

Date: 10 March 2016
To: CH2M Hill (technical representative)
From: Analytical Quality Associates, Inc.
Project: 300FF5 U SEQUES, CERC15
Subject: General Chemistry - Sample Data Groups (SDGs) SL1897, SL1995, SL2015. SL2023, WC0618, WC0720, WC0722, WC0723 and WC0726

INTRODUCTION

This memorandum presents the results of data validation for SDGs SL1897, SL1995, SL2015, SL2023, WC0618, WC0720, WC0722, WC0723 and WC0726 prepared by TestAmerica Laboratories, Inc. A list of samples validated along with the analytical methods is provided in the following table.

Sample ID	Sample Date	Media	Validation Level	Analytical Methods
B32K93	08/28/15	Water	C	EPA 310.1
B32K95	08/28/15	Water	C	EPA 310.1
B32K90	08/28/15	Water	C	EPA 310.1
B32K87	08/28/15	Water	C	EPA 310.1
B32K84	08/28/15	Water	C	EPA 310.1
B32K39	08/31/15	Water	C	EPA 310.1
B32K30	08/31/15	Water	C	EPA 310.1
B32K33	08/31/15	Water	C	EPA 310.1
B32K24	08/31/15	Water	C	EPA 310.1
B32K99	08/31/15	Water	C	EPA 310.1
B32K36	08/31/15	Water	C	EPA 310.1
B32K66	08/28/15	Water	C	EPA 310.1
B32K69	08/28/15	Water	C	EPA 310.1
B32K72	08/28/15	Water	C	EPA 310.1
B32K27	08/31/15	Water	C	EPA 310.1
B32K48	09/02/15	Water	C	EPA 310.1
B32K51	09/02/15	Water	C	EPA 310.1
B32K42	09/02/15	Water	C	EPA 310.1
B32K45	09/02/15	Water	C	EPA 310.1
B32K60	09/02/15	Water	C	EPA 310.1
B32K63	09/02/15	Water	C	EPA 310.1
B32K21	09/01/15	Water	C	EPA 310.1
B32K18	09/01/15	Water	C	EPA 310.1
B32KB1	09/01/15	Water	C	EPA 310.1
B32K97	09/01/15	Water	C	EPA 310.1
B32K54	09/01/15	Water	C	EPA 310.1
B32K57	09/01/15	Water	C	EPA 310.1
B32K78	09/01/15	Water	C	EPA 310.1
B32K75	09/01/15	Water	C	EPA 310.1

B32K81	09/01/15	Water	C	EPA 310.1
B32KX9	11/09/15	Other Liquid	C	EPA 310.1
B32L10	11/09/15	Other Liquid	C	EPA 310.1
B32L54	11/08/15	Other Liquid	C	EPA 310.1
B32L04	11/07/15	Other Liquid	C	EPA 310.1
B32L07	11/08/15	Other Liquid	C	EPA 310.1
B32YY5	11/14/15	Water	C	EPA 310.1
B32YY9	11/14/15	Water	C	EPA 310.1
B33003	11/14/15	Water	C	EPA 310.1
B33011	11/14/15	Water	C	EPA 310.1
B33015	11/14/15	Water	C	EPA 310.1
B33019	11/15/15	Water	C	EPA 310.1
B33023	11/15/15	Water	C	EPA 310.1
B33031	11/15/15	Water	C	EPA 310.1
B33035	11/15/15	Water	C	EPA 310.1
B33043	11/15/15	Water	C	EPA 310.1
B32L56	11/18/15	Other Liquid	C	EPA 310.1
B32KY4	11/17/15	Other Liquid	C	EPA 310.1
B32L57	11/18/15	Other Liquid	C	EPA 300.0
B339X7	12/16/15	Water	C	EPA 300.0
B339V4	12/16/15	Water	C	EPA 300.0
B339N8	12/16/15	Water	C	EPA 300.0
B339V8	12/16/15	Water	C	EPA 300.0
B339Y0	12/16/15	Water	C	EPA 300.0
B339N4	12/16/15	Water	C	EPA 300.0
B339R4	12/16/15	Water	C	EPA 300.0
B339R0	12/16/15	Water	C	EPA 300.0
B339L4	12/16/15	Water	C	EPA 300.0
B339T6	12/16/15	Water	C	EPA 300.0
B339T2	12/16/15	Water	C	EPA 300.0
B339V0	12/16/15	Water	C	EPA 300.0
B339L0	12/16/15	Water	C	EPA 300.0
B339R8	12/16/15	Water	C	EPA 300.0

Data validation was conducted in accordance with the CHPRC validation statement of work and the Field Instructions for Uranium Sequestration in the 300 Area, SGW-58976, Rev. 0 (SAP). Appendices 1 through 4 provide the following information as indicated below:

Appendix 1.	Glossary of Data Reporting Qualifiers
Appendix 2.	Summary of Data Qualification
Appendix 3.	Data Validation Supporting Documentation
Appendix 4.	Additional Documentation Requested by Client

DATA QUALITY OBJECTIVES

- **Holding Times and Sample Preservation**

Holding times are calculated from Chain-of-Custody forms to determine the validity of the results. The holding time requirements are as follows:

- All anions except nitrate, nitrite, and phosphate – analysis within 28 days of sample collection
- Nitrate, nitrite, and phosphate – analysis within 48 hours of collection
- Alkalinity – analysis within 14 days of sample collection

Sample preservation requires chilling to <6 degrees Celsius.

The samples were analyzed within the prescribed holding times and properly preserved with the following exceptions.

For SDGs WC0618, WC0720, WC0722, WC0723 and WC0726 the cooler temperatures were >6 degrees Celsius. However, the samples were delivered to the laboratory directly after sampling and data should not be qualified as a result.

- **Blanks**

The blank data results are reviewed to assess the extent of contamination introduced through sampling, sample preparation, and analysis.

Laboratory Blanks

All laboratory blank results were acceptable with the following exception.

For SDG SL1879, the alkalinity and bicarbonate alkalinity blank results were > the method detection limit (MDL) but < the reporting limit (RL). The alkalinity and bicarbonate alkalinity results for sample B32K99 were detects < the RLs and should be qualified as non-detects at the RL (2.0 mg/L) and flagged “U.” All other sample results were detects > the RL and were not qualified.

Trip Blanks

All trip blank results were acceptable with the following exceptions.

For SDG SL1897, alkalinity and bicarbonate alkalinity were detected in trip blank sample B32K99; however the results were further qualified as non-detects.

For SDG WC0720, orthophosphate was detected in trip blank sample B339Y0.

Field Blanks

No field blanks were submitted for validation.

Equipment Blanks

No equipment blanks were submitted for validation.

- **Accuracy**

Accuracy is evaluated by reviewing matrix spike sample results and laboratory control sample results. According to the SAP, the matrix spike sample accuracy limits are 75% to 125% and the laboratory control sample accuracy limits are 80% to 120%. The limits for reported analytes not listed in the SAP are specified by the DV procedure.

Matrix Spike (MS) Samples

All MS recoveries were acceptable with the following exception.

For SDG WC0726, the MS recovery for orthophosphate was < the lower acceptance limit. All orthophosphate sample results were detects and should be qualified as estimates and flagged “J.”

Laboratory Control Samples (LCSs)

All LCS recoveries were acceptable.

- **Precision**

Precision is evaluated by reviewing laboratory duplicate sample results, field duplicate sample results, and field split sample results. These QC results provide information on the laboratory reproducibility and whether sampling activities are adequate to acquire consistent sample results. According to the SAP, the relative percent difference (RPD) limits are ≤20%. The RPD limits for reported analytes not listed in the SAP are specified by the DV procedure. When duplicate RPDs exceed the limits and have associated results <5X the reporting limits with difference <1X the required detection limits no precision infraction occurred.

Laboratory Duplicate Samples

All laboratory duplicate results were acceptable.

Field Duplicate Samples

All field duplicate results were acceptable.

Field Split Samples

No field splits were submitted for validation.

- **Detection Limits**

Reported MDLs are compared against the contractually required detection limits (CRDLs) to ensure that laboratory detection limits meet the required criteria.

For SDG SL2023, the alkalinity MDLs were > the requested CRDLs.

- **Completeness**

SDGs SL1897, SL1995, SL2015, SL2023, WC0618, WC0720, WC0722, WC0723 and WC0726 were submitted for validation and verified for completeness. Completeness is based on the percentage of data determined to be valid (i.e., not rejected). The completion percentage was 100%.

MAJOR DEFICIENCIES

None found.

MINOR DEFICIENCIES

There were minor deficiencies leading to qualification of sample results as estimates due to blank contamination and low matrix spike recovery. See the table in Appendix 2 for a listing of all affected sample results.

It should be noted that the laboratory did not sign the “received by” field of the Chain-of-Custody for sample B32K69

REFERENCES

GRP-GD-003, Rev. 1, Change 0, *Data Validation for Chemical Analyses*, July 2012.

SGW-58976, Rev. 0, *Field Instructions for Uranium Sequestration in 300 Area*, July 2015.

Appendix 1

Glossary of Data Reporting Qualifiers

Qualifiers that may be applied by data validators in compliance with the CHPRC statement of work are as follows:

- **U —** The constituent was analyzed for, but was not detected. The data should be considered usable for decision-making purposes.
- **UJ —** The constituent was analyzed for and was not detected. Due to a quality control deficiency identified during data validation the value reported may not accurately reflect the RL. The data should be considered usable for decision-making purposes.
- **J —** Indicates the constituent was analyzed for and detected. The associated value is estimated due to a quality control deficiency identified during data validation. The data should be considered usable for decision-making purposes.
- **J+ —** Indicates the constituent was analyzed for and detected. The associated value is estimated with a suspected positive bias due to a quality control deficiency identified during data validation. The data should be considered usable for decision-making purposes.
- **J- —** Indicates the constituent was analyzed for and detected. The associated value is estimated with a suspected negative bias due to a quality control deficiency identified during data validation. The data should be considered usable for decision-making purposes.
- **N —** The analysis indicates the presence of an analyte that has been tentatively identified.
- **NJ —** The analysis indicates the presence of an analyte that has been tentatively identified and the associated numerical value represents its approximate concentration.
- **NJ+ —** The analysis indicates the presence of an analyte that has been tentatively identified. The associated value is estimated with a suspected positive bias due to a quality control deficiency identified during data validation.
- **NJ- —** The analysis indicates the presence of an analyte that has been tentatively identified. The associated value is estimated with a suspected negative bias due to a quality control deficiency identified during data validation.
- **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 decision-making purposes.
- **R —** Indicates the constituent was analyzed for and detected; however, due to an identified quality control deficiency the data should be considered unusable for decision-making purposes.

Appendix 2

Summary of Data Qualification

General Chemistry Data Qualification Summary			
SDGs: SL1897, SL1995, SL2015, SL2023, WC0618, WC0720, WC0722, WC0723, WC0726	Reviewer: AQA	Project: 300FF5 U SEQUES, CERC15	Page 1 of 1
Analyte(s)	**Qualifier**	**Samples Affected**	**Reason**
Alkalinity, Bicarbonate Alkalinity	2.0U	B32K99	Method blank contamination
Orthophosphate	J	B339L0, B339R8	Low matrix spike recovery

Comments: None

Appendix 3

Data Validation Supporting Documentation

VALIDATION LEVEL:	A	B	C	D	E
PROJECT: 300FF5 U SEQUES, CERC15			DATA PACKAGE: VSR16-003		
VALIDATOR: Eyda Hergenreder		LAB: TestAmerica		DATE: 03/10/16	
			SDG: SL1897, SL1995, SL2015, SL2023, WC0618 WC0720, WC0722, WC0723, WC0726		
ANALYSES PERFORMED					
Anions/IC X	TOC	TOX	TPH-418.1	Oil and Grease	Alkalinity X
Ammonia	BOD/COD	Chloride	Chromium-VI	pH	NO_3/NO_2
Sulfate	TDS	TKN	Phosphate		
SAMPLES/MATRIX Water					
SL1897: B32K93, B32K95, B32K90, B32K87, B32K84, B32K39, B32K30, B32K33, B32K24, B32K99, B32K36, B32K66, B32K69, B32K72, B32K27, B32K48, B32K51, B32K42, B32K45, B32K60, B32K63, B32K21, B32K18, B32KB1, B32K97, B32K54, B32K57, B32K78, B32K75, B32K81 SL2015: B32YY5, B32YY9, B33003, B33011, B33015, B33019, B33023, B33031, B33035, B33043					
WC0720: B339X7, B339V4, B339N8, B339V8, B339Y0, B339N4 WC0722: B339R4, B339R0, B339L4					
WC0723: B339T6, B339T2, B339V0 WC0726: B339L0, B339R8					
Other Liquid					

SL1995: B32KX9, B32L10, B32L54, B32L04, B32L07
SL2023: B32L56, B33KY4
WC0618: B32L57

1. DATA PACKAGE COMPLETENESS AND CASE NARRATIVE

Technical verification documentation present? .... Yes No N/A

Comments:

SDG SL1897: Received by was not completed on the COC for sample B32K69

2. INSTRUMENT PERFORMANCE AND CALIBRATIONS (Levels D and E)

Initial calibrations performed on all instruments? .... Yes No N/A

Initial calibrations acceptable? .... Yes No N/A

ICV and CCV checks performed on all instruments? .... Yes No N/A

ICV and CCV checks acceptable? .... Yes No N/A

Standards traceable? .... Yes No N/A

Standards expired? .... Yes No N/A

Calculation check acceptable? .... Yes No N/A

Comments:________________________________

3. BLANKS (Levels B, C, D, and E)

ICB and CCB checks performed for all applicable analyses? (Levels D, E) .... Yes No N/A

ICB and CCB results acceptable? (Levels D, E) .... Yes No N/A

Laboratory blanks analyzed? .... Yes No N/A

Laboratory blank results acceptable? .... Yes No N/A

Field blanks analyzed? (Levels C, D, E) .... Yes No N/A

Field blank results acceptable? (Levels C, D, E) .... Yes No N/A

Transcription/calculation errors? (Levels D, E) .... Yes No N/A

Comments:________________________________

SL1879: MB batch 209347 alkalinity and bicarbonate alkalinity 0.50 mg/L

SL1879: trip blank sample B32K99: alkalinity and bicarbonate alkalinity 0.50 mg/L
WC0720: trip blank sample B339Y0: orthophosphate 0.33 mg/L

4. ACCURACY (Levels C, D, and E)

Spike samples analyzed? .... Yes No N/A

Spike recoveries acceptable? .... Yes No N/A

Spike standards NIST traceable? (Levels D, E) .... Yes No N/A

Spike standards expired? (Levels D, E) .... Yes No N/A

LCS/BSS samples analyzed? .... Yes No N/A

LCS/BSS results acceptable? .... Yes No N/A

Standards traceable? (Levels D, E) .... Yes No N/A

Standards expired? (Levels D, E) .... Yes No N/A

Transcription/calculation errors? (Levels D, E) .... Yes No N/A

Performance audit sample(s) analyzed? .... Yes No N/A

Performance audit sample results acceptable? .... Yes No N/A

Comments:

WC0726: Orthophosphate MS 40%

5. PRECISION (Levels C, D, and E)

Duplicate RPD values acceptable? .... Yes No N/A

Duplicate results acceptable? .... Yes No N/A

MS/MSD standards NIST traceable? (Levels D, E) .... Yes No N/A

MS/MSD standards expired? (Levels D, E) .... Yes No N/A

LCS/LCSD duplicates run due to insufficient sample material? .... Yes No N/A

Field duplicate RPD values acceptable? .... Yes No N/A

Field split RPD values acceptable? .... Yes No N/A

Transcription/calculation errors? (Levels D, E) .... Yes No N/A

Comments:______________________________

6. HOLDING TIMES (all levels)

Samples properly preserved? .... Yes No N/A

Sample holding times acceptable? .... Yes No N/A

Comments:______________________________

SDG WC0618: Cooler temperature upon receipt at the laboratory was 14.5C

SDG WC0720: Cooler temperature upon receipt at the laboratory was 11.3C

SDG WC0722: Cooler temperature upon receipt at the laboratory was 13.3C

SDG WC0723: Cooler temperature upon receipt at the laboratory was 15.4C

SDG WC0726: Cooler temperature upon receipt at the laboratory was 8.4C

7. RESULT QUANTITATION AND DETECTION LIMITS (all levels)

Results reported for all requested analyses? .... Yes No N/A

Results supported in the raw data? (Levels D, E) .... Yes No N/A

Samples properly prepared? (Levels D, E) .... Yes No N/A

Detection limits meet RDL? .... Yes No N/A

Transcription/calculation errors? (Levels D, E).. Yes No N/A

Comments:

SDG SL2023: Alkalinity MDL >requested DL.

Appendix 4

Additional Documentation Requested By Client

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-055

TestAmerica Job ID: 160-13589-1
SDG: SL1897

Lab Sample ID: 160-13655-1 MSD
Matrix: Water
Analysis Batch: 211967

Client Sample ID: B32K48
Prep Type: Total/NA
Prep Batch: 210928

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Uranium	32.2		1000	1060		ug/L		103	75 - 125	3	20

Method: 310.1 - Alkalinity

Lab Sample ID: MB 160-208691/1
Matrix: Water
Analysis Batch: 208691

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	0.54	U	5.0	0.54	mg/L			08/31/15 15:01	1
Bicarbonate Alkalinity	0.54	U	5.0	0.54	mg/L			08/31/15 15:01	1
Carbonate Alkalinity	0.54	U	5.0	0.54	mg/L			08/31/15 15:01	1
Hydroxide Alkalinity	0.54	U	5.0	0.54	mg/L			08/31/15 15:01	1

Lab Sample ID: HLCS 160-208691/3
Matrix: Water
Analysis Batch: 208691

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits
Alkalinity	400	371.0		mg/L		93	90 - 110
Bicarbonate Alkalinity	400	371.0		mg/L		93	90 - 110

Lab Sample ID: LCS 160-208691/2
Matrix: Water
Analysis Batch: 208691

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Alkalinity	200	186.0		mg/L		93	90 - 110
Bicarbonate Alkalinity	200	186.0		mg/L		93	90 - 110

Lab Sample ID: 160-13527-A-1 MS
Matrix: Water
Analysis Batch: 208691

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Alkalinity	0.54	U	100	94.00		mg/L		94	80 - 120
Bicarbonate Alkalinity	0.54	U	100	94.00		mg/L		94	80 - 120

Lab Sample ID: 160-13527-A-1 DU
Matrix: Water
Analysis Batch: 208691

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Alkalinity	0.54	U	0.54	U	mg/L		NC	20
Bicarbonate Alkalinity	0.54	U	0.54	U	mg/L		NC	20
Carbonate Alkalinity	0.54	U	0.54	U	mg/L		NC	20
Hydroxide Alkalinity	0.54	U	0.54	U	mg/L		NC	20

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-055

TestAmerica Job ID: 160-13589-1
SDG: SL1897

Method: 310.1 - Alkalinity (Continued)

Lab Sample ID: MB 160-209347/1
Matrix: Water
Analysis Batch: 209347

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	0.500	B	2.0	0.22	mg/L			09/03/15 12:47	1
Bicarbonate Alkalinity	0.500	B	2.0	0.22	mg/L			09/03/15 12:47	1
Carbonate Alkalinity	0.22	U	2.0	0.22	mg/L			09/03/15 12:47	1
Hydroxide Alkalinity	0.22	U	2.0	0.22	mg/L			09/03/15 12:47	1

Lab Sample ID: HLCS 160-209347/3
Matrix: Water
Analysis Batch: 209347

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Alkalinity			400	374.0		mg/L		93	90 - 110		
Bicarbonate Alkalinity			400	374.0		mg/L		93	90 - 110		

Lab Sample ID: LCS 160-209347/2
Matrix: Water
Analysis Batch: 209347

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Alkalinity			200	188.0		mg/L		94	90 - 110		
Bicarbonate Alkalinity			200	188.0		mg/L		94	90 - 110		

Lab Sample ID: 160-13602-1 MS
Matrix: Water
Analysis Batch: 209347

Client Sample ID: B32K39
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Alkalinity	126		100	207.0		mg/L		81	80 - 120		
Bicarbonate Alkalinity	126		100	207.0		mg/L		81	80 - 120		

Lab Sample ID: 160-13602-1 DU
Matrix: Water
Analysis Batch: 209347

Client Sample ID: B32K39
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Alkalinity	126			126.0		mg/L				0	20
Bicarbonate Alkalinity	126			126.0		mg/L				0	20
Carbonate Alkalinity	0.22	U		0.22	U	mg/L				NC	20
Hydroxide Alkalinity	0.22	U		0.22	U	mg/L				NC	20

Lab Sample ID: MB 160-210949/1
Matrix: Water
Analysis Batch: 210949

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	0.54	U	5.0	0.54	mg/L			09/14/15 13:04	1
Bicarbonate Alkalinity	0.54	U	5.0	0.54	mg/L			09/14/15 13:04	1
Carbonate Alkalinity	0.54	U	5.0	0.54	mg/L			09/14/15 13:04	1
Hydroxide Alkalinity	0.54	U	5.0	0.54	mg/L			09/14/15 13:04	1

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-055

TestAmerica Job ID: 160-13589-1
SDG: SL1897

Method: 310.1 - Alkalinity (Continued)

Lab Sample ID: HLCS 160-210949/3
Matrix: Water
Analysis Batch: 210949

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits
Alkalinity	400	374.0		mg/L		93	90 - 110
Bicarbonate Alkalinity	400	374.0		mg/L		93	90 - 110

Lab Sample ID: LCS 160-210949/2
Matrix: Water
Analysis Batch: 210949

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Alkalinity	200	186.0		mg/L		93	90 - 110
Bicarbonate Alkalinity	200	186.0		mg/L		93	90 - 110

Lab Sample ID: 160-13655-1 MS
Matrix: Water
Analysis Batch: 210949

Client Sample ID: B32K48
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Alkalinity	126		100	212.0		mg/L		86	80 - 120
Bicarbonate Alkalinity	126		100	212.0		mg/L		86	80 - 120

Lab Sample ID: 160-13655-1 DU
Matrix: Water
Analysis Batch: 210949

Client Sample ID: B32K48
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Alkalinity	126		124.0		mg/L		2	20
Bicarbonate Alkalinity	126		124.0		mg/L		2	20
Carbonate Alkalinity	0.54	U	0.54	U	mg/L		NC	20
Hydroxide Alkalinity	0.54	U	0.54	U	mg/L		NC	20

QC Sample Results

Method: 310.1 - Alkalinity

Lab Sample ID: MB 160-221275/1
Matrix: Water
Analysis Batch: 221275

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Bicarbonate Alkalinity as CaCO3	0.54	U	5.0	0.54	mg/L			11/11/15 07:28	1
Carbonate Alkalinity as CaCO3	0.54	U	5.0	0.54	mg/L			11/11/15 07:28	1

Lab Sample ID: HLCS 160-221275/3
Matrix: Water
Analysis Batch: 221275

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits
Bicarbonate Alkalinity as CaCO3	400	372.0		mg/L		93	90 - 110

Lab Sample ID: LCS 160-221275/2
Matrix: Water
Analysis Batch: 221275

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Bicarbonate Alkalinity as CaCO3	200	188.0		mg/L		94	90 - 110

Lab Sample ID: 160-14714-A-2 MS
Matrix: Water
Analysis Batch: 221275

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Bicarbonate Alkalinity as CaCO3	124		100	216.0		mg/L		92	80 - 120

Lab Sample ID: 160-14714-A-2 DU
Matrix: Water
Analysis Batch: 221275

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Bicarbonate Alkalinity as CaCO3	124		124.0		mg/L		0	20
Carbonate Alkalinity as CaCO3	0.54	U	0.54	U	mg/L		NC	20

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-064 / X15-065

TestAmerica Job ID: 160-14872-1
SDG: SL2015

Method: 6020A - Metals (ICP/MS) (Continued)

Lab Sample ID: 160-14872-1 MSD
Matrix: Water
Analysis Batch: 224377

Client Sample ID: B32YY4
Prep Type: Dissolved
Prep Batch: 222823

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Uranium	3970		1000	5200		ug/L		123	75 - 125	1	20

Method: 310.1 - Alkalinity

Lab Sample ID: MB 160-222867/1
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Bicarbonate Alkalinity	0.54	U	5.0	0.54	mg/L			11/20/15 09:17	1
Carbonate Alkalinity	0.54	U	5.0	0.54	mg/L			11/20/15 09:17	1

Lab Sample ID: HLCS 160-222867/3
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits
Bicarbonate Alkalinity	400	370.0		mg/L		92	90 - 110

Lab Sample ID: LCS 160-222867/2
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Bicarbonate Alkalinity	200	187.0		mg/L		93	90 - 110

Lab Sample ID: 160-14833-A-5 MS
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Bicarbonate Alkalinity	213		100	306.0		mg/L		93	80 - 120

Lab Sample ID: 160-14833-A-5 DU
Matrix: Water
Analysis Batch: 222867

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Bicarbonate Alkalinity	213		214.0		mg/L		0.5	20
Carbonate Alkalinity	0.54	U	0.54	U	mg/L		NC	20

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Pro9ectjSite: / 1F-0FF

TestAmerica Job ID: 160-14755-1
SDG: SL2025

Method: 6020A - Metals (ICP/MS) (Continued)

Lab Sample ID: LCS 160-227718/2-A
Matrix: Water
Analysis Batch: 230919

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 227718

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Uranium			1000	1008		ugjL		101	30 - 120		

Lab Sample ID: 160-14933-1 MS
Matrix: Other Aqueous Sample
Analysis Batch: 230919

Client Sample ID: B32L56
Prep Type: Total/NA
Prep Batch: 227718

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Uranium	F.3	U	1000	76F.7	D	ugjL		78	8F - 12F		

Lab Sample ID: 160-14933-1 MSD
Matrix: Other Aqueous Sample
Analysis Batch: 230919

Client Sample ID: B32L56
Prep Type: Total/NA
Prep Batch: 227718

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Uranium	F.3	U	1000	7F7.4	D	ugjL		76	8F - 12F	1	20

Method: 310.1 - Alkalinity

Lab Sample ID: MB 160-224347/1
Matrix: Water
Analysis Batch: 224347

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Bicarbonate Alkalinity as CaCO5	0.F4	U	F.0	0.F4	mgjL			11j2Fj1F 13:F0	1
Carbonate Alkalinity as CaCO5	0.F4	U	F.0	0.F4	mgjL			11j2Fj1F 13:F0	1

Lab Sample ID: HLCS 160-224347/3
Matrix: Water
Analysis Batch: 224347

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Bicarbonate Alkalinity as CaCO5			400	588.0		mgjL		74	70 - 110		

Lab Sample ID: LCS 160-224347/2
Matrix: Water
Analysis Batch: 224347

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Bicarbonate Alkalinity as CaCO5			200	170.0		mgjL		7F	70 - 110		

Method: 310.1 - Alkalinity - DL

Lab Sample ID: 160-14957-A-1 MS
Matrix: Water
Analysis Batch: 224347

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Bicarbonate Alkalinity as CaCO5 - DL	F60		F01	1020		mgjL		72	30 - 120		

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Pro9ectj Site: / 1F-0FF

TestAmerica Job ID: 160-14755-1
SDG: SL2025

Lab Sample ID: 160-14957-A-1 DU
Matrix: Water
Analysis Batch: 224347

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Bicarbonate Alkalinity as CaCO5 - DL	F60			F60.0		mgjL				0	20
Carbonate Alkalinity as CaCO5 - DL	2.8	U		2.8	U	mgjL				NC	20

QC Sample Results

Method: 300.0 - Anions, Ion Chromatography

Lab Sample ID: MB 300-2050/5
Matrix: Water
Analysis Batch: 2050

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Orthophosphate as P	0.041	U	0.082	0.041	mg/L			11/18/15 16:39	1

Lab Sample ID: LCS 300-2050/6
Matrix: Water
Analysis Batch: 2050

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Orthophosphate as P			6.53	6.89		mg/L		106	80 - 120

Lab Sample ID: 300-1594-A-1 MS
Matrix: Water
Analysis Batch: 2050

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Orthophosphate as P	590	D	65.3	669	D	mg/L		123	75 - 125

Lab Sample ID: 300-1594-A-1 DU
Matrix: Water
Analysis Batch: 2050

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Orthophosphate as P	590	D		601	D	mg/L				2	20

Lab Sample ID: MB 300-2051/5
Matrix: Water
Analysis Batch: 2051

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	0.10	U	0.20	0.10	mg/L			11/18/15 16:39	1
Sulfate	0.13	U	0.25	0.13	mg/L			11/18/15 16:39	1

Lab Sample ID: LCS 300-2051/6
Matrix: Water
Analysis Batch: 2051

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Chloride			16.0	16.9		mg/L		105	80 - 120
Sulfate			20.0	21.3		mg/L		106	80 - 120

Lab Sample ID: 300-1594-A-1 MS
Matrix: Water
Analysis Batch: 2051

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Chloride	38	D	160	200	D	mg/L		101	75 - 125
Sulfate	41	D	200	235	D	mg/L		97	75 - 125

QC Sample Results

Method: 300.0 - Anions, Ion Chromatography (Continued)

Lab Sample ID: 300-1594-A-1 DU
Matrix: Water
Analysis Batch: 2051

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Chloride	38	D		38.4	D	mg/L				1	20
Sulfate	41	D		41.2	D	mg/L				2	20

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-070

TestAmerica Job ID: 300-1860-1
SDG: WC0720

Method: 300.0 - Anions, Ion Chromatography

Lab Sample ID: MB 300-2392/5
Matrix: Water
Analysis Batch: 2392

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Nitrate as N	0.014	U	0.028	0.014	mg/L			12/16/15 12:02	1
Nitrite as N	0.019	U	0.038	0.019	mg/L			12/16/15 12:02	1
Orthophosphate as P	0.041	U	0.082	0.041	mg/L			12/16/15 12:02	1

Lab Sample ID: LCS 300-2392/6
Matrix: Water
Analysis Batch: 2392

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Nitrate as N			2.26	2.33		mg/L		103	80 - 120		
Nitrite as N			3.04	3.15		mg/L		103	80 - 120		
Orthophosphate as P			6.53	6.73		mg/L		103	80 - 120		

Lab Sample ID: 300-1861-A-1 MS
Matrix: Water
Analysis Batch: 2392

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Nitrate as N	0.71	D	0.452	1.19	D	mg/L		106	75 - 125		
Nitrite as N	0.043	B D	0.609	0.588	D	mg/L		90	75 - 125		
Orthophosphate as P	3.0	D	1.31	4.35	D	mg/L		106	75 - 125		

Lab Sample ID: 300-1861-A-1 DU
Matrix: Water
Analysis Batch: 2392

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Nitrate as N	0.71	D		0.715	D	mg/L				0.7	20
Nitrite as N	0.043	B D		0.0425	B D	mg/L				0.7	20
Orthophosphate as P	3.0	D		2.95	D	mg/L				0.6	20

Lab Sample ID: MB 300-2393/5
Matrix: Water
Analysis Batch: 2393

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	0.10	U	0.20	0.10	mg/L			12/16/15 12:02	1
Fluoride	0.025	U	0.050	0.025	mg/L			12/16/15 12:02	1
Sulfate	0.13	U	0.25	0.13	mg/L			12/16/15 12:02	1

Lab Sample ID: LCS 300-2393/6
Matrix: Water
Analysis Batch: 2393

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Chloride			16.0	16.3		mg/L		102	80 - 120		
Fluoride			4.00	4.09		mg/L		102	80 - 120		
Sulfate			20.0	20.5		mg/L		102	80 - 120		

QC Sample Results

Method: 300.0 - Anions, Ion Chromatography (Continued)

Lab Sample ID: 300-1861-A-1 MS
Matrix: Water
Analysis Batch: 2393

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Chloride	10	D	3.20	13.7	D	mg/L		106	75 - 125		
Fluoride	0.050	U	0.800	0.939	D	mg/L		117	75 - 125		
Sulfate	45	D	4.00	49.0	D	mg/L		109	75 - 125		

Lab Sample ID: 300-1861-A-1 DU
Matrix: Water
Analysis Batch: 2393

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Chloride	10	D		10.4	D	mg/L				0.9	20
Fluoride	0.050	U		0.050	U	mg/L				NC	20
Sulfate	45	D		45.0	D	mg/L				0.8	20

QC Sample Results

Method: 300.0 - Anions, Ion Chromatography

Lab Sample ID: MB 300-2394/5
Matrix: Water
Analysis Batch: 2394

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Nitrate as N	0.014	U	0.028	0.014	mg/L			12/16/15 14:45	1
Nitrite as N	0.019	U	0.038	0.019	mg/L			12/16/15 14:45	1
Orthophosphate as P	0.041	U	0.082	0.041	mg/L			12/16/15 14:45	1

Lab Sample ID: LCS 300-2394/6
Matrix: Water
Analysis Batch: 2394

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Nitrate as N	2.26	2.33		mg/L		103	80 - 120
Nitrite as N	3.04	3.14		mg/L		103	80 - 120
Orthophosphate as P	6.53	6.65		mg/L		102	80 - 120

Lab Sample ID: 300-1871-1 MS
Matrix: Water
Analysis Batch: 2394

Client Sample ID: B339R4
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Nitrate as N	5.9	D	0.452	6.28	D	mg/L		91	75 - 125
Nitrite as N	0.038	U	0.609	0.548	D	mg/L		90	75 - 125
Orthophosphate as P	19	D	1.31	20.4	D	mg/L		75	75 - 125

Lab Sample ID: 300-1871-1 DU
Matrix: Water
Analysis Batch: 2394

Client Sample ID: B339R4
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Nitrate as N	5.9	D	5.85	D	mg/L		0.3	20
Nitrite as N	0.038	U	0.038	U	mg/L		NC	20
Orthophosphate as P	19	D	19.4	D	mg/L		0.09	20

Lab Sample ID: MB 300-2395/5
Matrix: Water
Analysis Batch: 2395

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	0.10	U	0.20	0.10	mg/L			12/16/15 14:45	1
Fluoride	0.025	U	0.050	0.025	mg/L			12/16/15 14:45	1
Sulfate	0.13	U	0.25	0.13	mg/L			12/16/15 14:45	1

Lab Sample ID: LCS 300-2395/6
Matrix: Water
Analysis Batch: 2395

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Chloride	16.0	16.2		mg/L		102	80 - 120
Fluoride	4.00	4.08		mg/L		102	80 - 120
Sulfate	20.0	20.3		mg/L		102	80 - 120

QC Sample Results

Client: CH2M Hill Plateau Remediation Company
Project/Site: X15-070

TestAmerica Job ID: 300-1871-1
SDG: WC0722

Method: 300.0 - Anions, Ion Chromatography (Continued)

Lab Sample ID: 300-1871-1 MS
Matrix: Water
Analysis Batch: 2395

Client Sample ID: B339R4
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Chloride	23	D	3.20	26.2	D	mg/L		94	75 - 125
Fluoride	0.30	D	0.800	1.06	D	mg/L		95	75 - 125
Sulfate	57	D	4.00	60.7	D	mg/L		93	75 - 125

Lab Sample ID: 300-1871-1 DU
Matrix: Water
Analysis Batch: 2395

Client Sample ID: B339R4
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Chloride	23	D	23.1	D	mg/L		0.3	20
Fluoride	0.30	D	0.303	D	mg/L		0.6	20
Sulfate	57	D	57.0	D	mg/L		0.05	20

QC Sample Results

I nieHt: I 2CM 2imPrateau RemediatioHI ompaHy
Project/Site: X15-070

TestAmerica Job ID: 300-187C-1
SDG: WI 07C3

Method: 300.0 - Anions, Ion Chromatography

Lab Sample ID: MB 300-2394/5
Matrix: Water
Analysis Batch: 2394

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Nitrate as N	0.014	U	0.0C8	0.014	mg/L			1C/16/15 14:45	1
Nitrite as N	0.019	U	0.038	0.019	mg/L			1C/16/15 14:45	1
Orthophosphate as P	0.041	U	0.08C	0.041	mg/L			1C/16/15 14:45	1

Lab Sample ID: LCS 300-2394/6
Matrix: Water
Analysis Batch: 2394

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Nitrate as N			C.C6	C.33		mg/L		103	80 - 1C0		
Nitrite as N			3.04	3.14		mg/L		103	80 - 1C0		
Orthophosphate as P			6.53	6.65		mg/L		10C	80 - 1C0		

Lab Sample ID: 300-1871-A-1 MS
Matrix: Water
Analysis Batch: 2394

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Nitrate as N	5.9	D	0.45C	6.C8	D	mg/L		91	75 - 1C5		
Nitrite as N	0.038	U	0.609	0.548	D	mg/L		90	75 - 1C5		
Orthophosphate as P	19	D	1.31	C0.4	D	mg/L		75	75 - 1C5		

Lab Sample ID: 300-1871-A-1 DU
Matrix: Water
Analysis Batch: 2394

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Nitrate as N	5.9	D		5.85	D	mg/L				0.3	C0
Nitrite as N	0.038	U		0.038	U	mg/L				NI	C0
Orthophosphate as P	19	D		19.4	D	mg/L				0.09	C0

Lab Sample ID: MB 300-2395/5
Matrix: Water
Analysis Batch: 2395

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
I hnoride	0.10	U	0.C0	0.10	mg/L			1C/16/15 14:45	1
Fnuoride	0.0C5	U	0.050	0.0C5	mg/L			1C/16/15 14:45	1
Sunfate	0.13	U	0.C5	0.13	mg/L			1C/16/15 14:45	1

Lab Sample ID: LCS 300-2395/6
Matrix: Water
Analysis Batch: 2395

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
I hnoride			16.0	16.C		mg/L		10C	80 - 1C0		
Fnuoride			4.00	4.08		mg/L		10C	80 - 1C0		
Sunfate			C0.0	C0.3		mg/L		10C	80 - 1C0		

QC Sample Results

Method: 300.0 - Anions, Ion Chromatography (Continued)

Lab Sample ID: 300-1871-A-1 MS
Matrix: Water
Analysis Batch: 2395

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Chloride	C3	D	3.C0	C6.C	D	mg/L		94	75 - 1C5
Fluoride	0.30	D	0.800	1.06	D	mg/L		95	75 - 1C5
Sulfate	57	D	4.00	60.7	D	mg/L		93	75 - 1C5

Lab Sample ID: 300-1871-A-1 DU
Matrix: Water
Analysis Batch: 2395

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Chloride	C3	D	C3.1	D	mg/L		0.3	C0
Fluoride	0.30	D	0.303	D	mg/L		0.6	C0
Sulfate	57	D	57.0	D	mg/L		0.05	C0

QC Sample Results

Method: 300.0 - Anions, Ion Chromatography

Lab Sample ID: MB 300-2394/25
Matrix: Water
Analysis Batch: 2394

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
. itrate as .	0401U	g	040M8	0401U	mLX6			1MXICXINM0:1C	1
. itrite as .	04019	g	04038	04019	mLX6			1MXICXINM0:1C	1
Orthoyhosyhate as u	040U1	g	0408M	040U1	mLX6			1MXICXINM0:1C	1

Lab Sample ID: LCS 300-2394/26
Matrix: Water
Analysis Batch: 2394

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
. itrate as .	M4MC	M43U		mLX6		10U	80 - 1M0
. itrite as .	340U	341C		mLX6		10U	80 - 1M0
Orthoyhosyhate as u	C4N3	C478		mLX6		10U	80 - 1M0

Lab Sample ID: 300-1658-1 MS
Matrix: Water
Analysis Batch: 2394

Client Sample ID: B339L0
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
. itrate as .	U47	D	04UNM	N41C	D	mLX6		98	7N- 1MN
. itrite as .	04038	g	04C09	04NNN	D	mLX6		91	7N- 1MN
Orthoyhosyhate as u	U48	D .	1431	N430	D .	mLX6		U0	7N- 1MN

Lab Sample ID: 300-1658-1 DU
Matrix: Water
Analysis Batch: 2394

Client Sample ID: B339L0
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
. itrate as .	U47	D	U4C9	D	mLX6		04N	M0
. itrite as .	04038	g	04038	g	mLX6		. I	M0
Orthoyhosyhate as u	U48	D .	U48M	D	mLX6		048	M0

Lab Sample ID: MB 300-2397/25
Matrix: Water
Analysis Batch: 2397

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
I hroripe	0410	g	04M0	0410	mLX6			1MXICXINM0:1C	1
FnRoripe	040MN	g	040N0	040MN	mLX6			1MXICXINM0:1C	1
GRnfate	0413	g	04MN	0413	mLX6			1MXICXINM0:1C	1

Lab Sample ID: LCS 300-2397/26
Matrix: Water
Analysis Batch: 2397

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
I hroripe	1C40	1C43		mLX6		10M	80 - 1M0
FnRoripe	U400	U41M		mLX6		103	80 - 1M0
GRnfate	M040	M04N		mLX6		103	80 - 1M0

QC Sample Results

I rieHt: I 2MP 2imu mateaR d emepiatioH I omyaHS
u ro/ectXGite: 5 1N-070

TestAmerica Job ID: 300-187C-1
GDW: j I 07MC

Method: 300.0 - Anions, Ion Chromatography (Continued)

Lab Sample ID: 300-1658-1 MS
Matrix: Water
Analysis Batch: 2397

Client Sample ID: B339L0
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
I hmoripe	1C	D	34M0	1943	D	mLX6		99	7N- 1MN		
FnRoripe	043N	D	04800	1410	D	mLX6		9U	7N- 1MN		
GRnfate	N0	D	U400	N349	D	mLX6		97	7N- 1MN		

Lab Sample ID: 300-1658-1 DU
Matrix: Water
Analysis Batch: 2397

Client Sample ID: B339L0
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
I hmoripe	1C	D		1C40	D	mLX6				04N	M0
FnRoripe	043N	D		043U8	D	mLX6				04J	M0
GRnfate	N0	D		U948	D	mLX6				04J	M0

Appendix K

Lessons Learned

This page intentionally left blank.

K Lessons Learned

Post-job review meetings covering the 300-FF-5 Operable Unit (OU) Stage A uranium sequestration activities were held on December 9 and 10, 2015. Representatives of the groups and disciplines that supported and executed installation and operation of the Stage A enhanced attenuation system participated in the meetings. The primary purpose of the post-job review was to identify lessons learned from the 300-FF-5 OU Stage A uranium sequestration activities for application to the planning and execution of the follow-on Stage B uranium sequestration activities.

The post-job review for the Stage A uranium sequestration activities was conducted during two meetings. The first meeting was held on December 9, 2015 and was attended by personnel involved with the setup, testing, operation, and decommissioning of the chemical injection system. The second meeting was held on December 10, 2015 and was attended primarily by project scientists, system engineers, and other technical support personnel. This appendix provides the final report covering both sessions.

This page intentionally left blank.

300-FF-5 STAGE A URANIUM SEQUESTRATION POST-JOB REVIEW AND LESSONS LEARNED

1 Introduction

The primary purpose of this post-job review was to collect and identify lessons learned from the 300-FF-5 Sequestration Project (Stage A) design, installation, operation, and recovery, with the intent to improve these activities for Stage B. The project will incorporate these lessons into the relevant documentation (e.g., contracts, work packages, and operating procedures) for Stage B.

The post-job review for Stage A of the 300-FF-5 Sequestration project was conducted in two meetings. The first meeting, conducted on December 9, 2015, was attended by personnel involved with the setup, testing, operation, and decommissioning of the chemical injection system. The second meeting, conducted on December 10, 2015, consisted primarily of project scientists and other technical support personnel. This report outlines the main topics covered in the meetings. Attached to the report is a listing of personnel who attended both meetings.

The meetings covered a range of topics and addressed experiences gained from Stage A, including initial design through chemical injection. The meeting facilitator followed the post-job review process outlined in the CHPRC Post-ALARA/Post-Job Review form A-6004-821.

Following the meetings, it was determined that the post-job review report would be developed using an alternative report format. The format was developed to present the variety of lessons discussed at the meetings more clearly. However, the reformatted document still meets the intent of the post-job review process.

2 Hazards

2.1 Biological

The initial hazards identification did not identify a need to address the hazards presented by snakes. However, once the fieldwork commenced, rattlesnakes were encountered, and this hazard was subsequently addressed in the work documents. Action was taken to protect personnel working in the area. Workers were required to wear snake chaps when working off the gravel in brushy areas. This potential for encountering snakes needs to be specifically addressed in the pre-job briefings, especially for the area near, and along, the Columbia River, which rattlesnakes inhabit.

Insects were also identified as a bigger nuisance than was anticipated from the original job hazards analysis. Insects, particularly wasps, were particularly noticeable around the chemical mixing trailers and mobile office.

2.2 Environmental

Since Stage A was set up and performed late in the summer and early fall, fire hazards were a particular concern. All plant material in the area was extremely dry. Originally, the work scope was planned for earlier in the year when the fire hazard would not have been as significant. If allowable, Stage B should be performed in the spring to alleviate this concern.

Initial work planning did not sufficiently anticipate the impact of the high winds, which caused numerous problems, when encountered. For future work, more effective wind control measures, such as the use of wind breaks/barriers, are necessary. The project team was required to borrow barriers from PFP. The project needs to procure barriers of their own, and have them at the job site ready for use. If possible, recommend procuring the PFP barriers once they are finished with them.

Work along the river presented a variety of hazards and challenges that were greater issues than originally estimated. For example, the vegetation and slippery rocks created fall hazards, especially when personnel were handling equipment.

2.3 Electrical Resistance Tomography (ERT) System

A critique of the subcontractor's (PNNL) installation of the ERT probes prior to the start of the sequestration operation revealed that the electrical voltages for the ERT probes were greater than 50 volts and the DOE-0336 *Hanford Site Lockout/Tagout Procedure* hazardous energy control requirements would apply. Following the critique, project operations personnel took the appropriate action to ensure that the project work processes incorporated applicable hazardous energy control requirements prior to the commencement of sequestration operations.

The impacts of PNNL performing excavation for the ERT probe installation were not initially adequately addressed by the project.

2.4 Hoses & Fittings

Workers discovered that handling the large diameter water hoses coming from the river pumps was very difficult, especially on slippery rocks along the river shore. Extreme care is required when working with hoses and other bulky equipment. Additional personnel or appropriate mechanical means may be required to move these hoses. Following Stage A, a forklift was inappropriately used to drag the HDPE piping. Additionally, just using a large number of personnel in moving heavy HDPE piping is not sufficient. A worker was injured while assisting in manually moving HDPE during Stage A cleanup.

One individual was significantly sprayed with river water while draining a large diameter hose. Care needs to be taken to ensure personnel are adequately protected from wetting when working with hoses. For example, use of rain gear when disconnecting and draining the lines may be appropriate.

2.5 Electrical Cables

It was recommended that two electricians be used to handle long runs of 480v electrical cables, which are heavy and cumbersome in rough terrain.

2.6 Safety Shower & Portable Eyewash

Early in the setup for stage A, the pump trailer skids and the bulk chemical storage tanks were collocated, and the safety shower and portable eyewash station setup was planned accordingly. After a number of subsequent configuration design changes, this equipment was no longer collocated, which required staging of additional emergency equipment due to the new physical separation.

Steps need to be taken to ensure the emergency eyewash stations can be safely used during cold temperatures. Arrangements had to be taken to ensure the eyewash water was adequately warmed so it could be used during cold weather. Better planning and preparation is needed for future sequestration activities, especially if cold weather conditions can be expected.

Strong consideration should be given to the purchase of a portable emergency shower for any future sequestration activities. Given the large amount of bulk chemical being handled, a shower installation would be a wise investment. It is possible for a worker to be accidentally sprayed with a large amount of chemical.

2.7 Lighting

Stage A operated on a 24 hour basis and, in a few instances, Operations personnel found that the amount of temporary lighting staged for the project was insufficient for the work that was being performed after dark. Lighting surveys were conducted prior to the start of Stage A, which determined the initial placement of temporary lighting. The equipment was relocated and the work area expanded following the placement of the lighting. Thus, when operations began, the lighting was no longer in its optimum location. When planning for Stage B, the lighting survey should not be performed until the finalized equipment locations have been determined.

Operations personnel determined that portable light needed to be staged at the chemical storage tank farm.

One area where adequate lighting was staged was at the head of the access road. This light was very effective and needs to be continued in later sequestration work. The lighting helped personnel find the main road exit onto the access road for the sequestration project.

In general, a more extensive lighting study should be performed prior to the Stage B setup, which will help eliminate future lighting issues.

2.8 Ground Excavation

Repair of one of the wells supporting Stage A was required, as the upper several feet of the material surrounding the well were to be excavated. This activity was not planned to occur during sequestration setup, and created an unexpected challenge/potential hazard during the sequestration pumping system setup, with the workers having to work around the well excavation and repair activities. The well work required the use of heavy equipment that was not originally anticipated during the initial work planning for the sequestration setup.

2.9 Bulk Chemicals

Early in Stage A operations, it was discovered that the initial piping configuration for the handling of the chemicals at the tank farm was not the optimum configuration for the activities being supported during Stage A operations. Working with the chemical supplier and project maintenance and engineering personnel, a more effective chemical tank farm piping and valving configuration was identified. The new configuration was less complex, easier to use, and enhanced operational efficiency. It is important to recreate the final Stage A configuration for use in Stage B. An equipment/hose configuration engineering sketch would be an effective way of capturing the desired configuration.

After encountering challenges with less than optimum bulk chemical concentrations, project personnel were required to pump down the storage tanks and return their content to the chemical supplier. Performing the pump down required physical handling of the hoses in order to ensure all of the contents of the tanks and hoses were emptied. The heavy hoses present potential ergonomic challenges. If pumping down the bulk chemical tanks is anticipated during Stage B, any potential ergonomic challenges should be addressed as part of system setup.

3 Injuries

No significant injuries were encountered during Stage A. However, several first aid events included bug bites and stings, worker strain while moving HDPE, and one worker sprayed with river water during hose leak testing. All incidents were handled appropriately.

4 Work Planning and Control

4.1 Work Planning

If more worker involvement had been included during the Stage A job planning, setup and operation of the sequestration system could have been more efficient, including effective hazard identification. There was a lot of worker involvement, but it could have been improved. Multiple walk downs were performed, but some did not include all the required personnel, which was a missed opportunity.

4.2 Pre-Job Briefing

In general, all Stage A pre-job testing and operation briefings were effective and covered the necessary topics, such as work to be performed, precautions, limitations, and personal protective equipment. All personnel treated the briefings seriously.

One effective action that worked well was the delegation of some pre-job briefings by the Operations Supervisor (OS) to other field personnel, such as the Site Project Manager or Maintenance Field Work Supervisor (FWS). This action allowed the OS to focus on other key aspects of work site activities. In the future, consideration should be given for inclusion of a second OS in order to address the workload during day shift activities more effectively. The single OS was often spread too thin, given the amount and variety of activities occurring simultaneously. A single OS was determined to be adequate for back shift operation.

4.3 Ecological Review

Some project personnel indicated that the Stage A Ecological Review was not completed in a timely manner, which created work planning slowdowns and led to some project delays. For example, restrictions associated with river access could have been identified and addressed earlier. For Stage B, the project needs to ensure a thorough and complete Ecological Review before work planning commences.

4.4 Coordination of Personnel

There are opportunities for improvement in all areas of the Stage B job type coordination, including design, setup, testing, operation, and decommissioning. In particular, equipment assembly and operational procedure testing revealed some personnel confusion regarding effective assembly and system testing. These efforts need to be coordinated more effectively in the future.

One challenge not initially anticipated was the extent of personnel orchestration the OS required, due to the large work area footprint as well as the number and variety of personnel working in parallel. The constant coming and going interrupted pre-job briefings and support of other field activities, distracting the supervisory personnel.

The access road barrier at the entrance to the work site greatly assisted the OS by effectively controlling the flow of personnel into the site. However, the road barrier did create some challenges by requiring personnel accessing the job site to call the OS, at times causing distractions to the OS.

It was recommended that a designated parking area be setup for personnel, as parking sometimes created problems.

Stage A attracted many personnel who had no direct involvement with the project. Effectively controlling access to the work site should be considered, thereby lessening distraction of workers and supervision. While fieldwork is in progress, site access should be limited to only those with a critical need at the site.

The number of rope barriers set up for Stage A confused personnel. Prior to Stage B, optimal barrier placement and signage should be considered. Photo overlays or site maps that clearly designate barrier location and personnel ingress/egress access points should be provided to the Shift Office for briefing personnel prior to their arrival at the job site.

At times during Stage A, there was insufficient supervision of the work being performed by the ERT subcontractor. When the subcontractor installs the infiltration lines for Stage B, the project needs to ensure adequate oversight of the subcontractor's work in order to avoid the type of problems encountered prior to Stage A (refer to S&GRP Critique Report 2015-07 "Stop work Regarding Installation of ERT Probes by PNNL at the 300-FF-5 Sequestration Project" for further details).

Some Craft questioned the level of Craft oversight for the amount of "Skill of Craft" task activity and whether supervision could have been used more effectively in support of other activities.

The project interface with the sampling organization was very effective. No issues were identified. Continue the same working relationships in Stage B sequestration.

There was great personnel support of all overtime activities. No issues were identified. Continue these practices in Stage B sequestration.

There was great teamster support throughout the entire project. Continue these same practices in the future.

Ensure the Crafts are involved as early as possible in Stage B and use as many of the same Craft involved in Stage A, as possible.

For Stage B, address potential Craft jurisdictional issues early. A few jurisdictional issues occurred during Stage A.

- There was an issue with the teamsters regarding the chemical supplier moving the chemical tanks. For Stage B, a tilt-trailer will be purchased for teamsters to move the chemical tanks.
- Teamsters and pipefitters questioned the use of a subcontractor for excavation and installation of the infiltration system. Prior to Stage B, more comprehensive Plant forces work review will need to be performed.
- The only unexpected issue due to the cold weather conditions was the determination of which personnel would place heating blankets and pads on equipment for freeze protection.

4.5 Work Scheduling & Release

In general, daily work scheduling and release could have been more effective. Often, parallel work activities were being performed, which spread supervision pretty thin. Supervision needs to be empowered to limit the amount of work activity to what they can effectively control.

One action that would greatly help in managing the work site is more effective scheduling of routine deliveries of equipment and chemicals.

Operationally, many felt the use of a standalone Operational Test Procedure (OTP) for system testing would have kept things simpler than they actually were.

4.6 Work Packages & Procedures

The bulk of the Stage A equipment setup was determined to be a "Skill of the Craft" in nature. Nevertheless, the work package used to set up the equipment was overly prescriptive, and created a lot of "no value" paperwork. Future sequestration work planning needs to recognize this fact in order to eliminate a significant amount of frustration on the part of the Crafts and their supervision. Prior to Stage B, use of a dedicated work planning team would optimally incorporate "Skill of the Craft" principles in the planning.

Treating the system setup more like a construction project (e.g., Green Field Project) would greatly simplify things. Many felt the project administratively overkilled setup and testing in Stage A.

The work package used for Stage A combined electrical and mechanical activities. In the future, it is recommended that two separate work packages be developed. This approach would lead to increased work efficiency.

Some personnel did not have sufficient time to adequately review the work package. Additionally, no work package workability review was performed. Had one been performed, a number of problems were encountered in the field during equipment setup would have been avoided.

Since most of the equipment setup/assembly was "Skill of the Craft" work, consider using a Short Form JCS work package. This approach would greatly simplify fieldwork and enhance efficiency.

Craft supervision emphasized the need to use the KISS approach toward work package development wherever possible. Multiple simple work packages, rather than one large complex work package, would be better for equipment assembly and testing. Additionally, simpler work packages would be more appropriate in the future because personnel have gained a great deal of experience from Stage A and, presumably, much of the same hardware will be used in the future.

It was identified that field personnel would derive a great benefit from an engineering field sketch of the hose layout (water and chemical). A sketch makes visualization of the desired operational configuration easier and would have benefitted the operational part of Stage A. The sketch would have greatly improved setup efficiency, eliminated rework, and simplified the work package.

Engineering should limit, to the extent possible, the number of formal engineering drawings for a temporary activity of this kind. It would greatly ease modifications when required. The need for periodic changes to a formal drawing slowed down the fieldwork during Stage A. A sketch with a "suggested layout" would have been much easier to deal with.

The experience from Stage A revealed that far too many pen and ink changes to the work package led to a number of project delays. This experience revealed a need to improve the work planning process, prior to the Stage B. For example, consider issuing multiple smaller work packages that contain less complex detail.

It was felt that the Stage A operating procedure took far too long to make workable. However, the procedure worked very well once all the issues were addressed. Given the Stage A experience, the procedure should be effectively used in Stage B with minimal changes.

Prior to Stage B, ensure all permits (e.g., excavation, fire) are still current. Revise as necessary before any fieldwork commences.

5 System Design

5.1 Criteria, Metrics and Specifications

It was identified that the initial equipment design criteria were not identified early enough in the planning effort. This led to a number of changes that delayed the start of Stage A. For Stage B, lock down equipment design as early as possible and involve the Craft personnel in this activity. Their experience will be useful to Engineering in determining the most effective hardware to be used, which will simplify and speed up equipment setup and testing.

Engineering needs to determine the functional design criteria as early as possible for Stage B, and then finalize the design. Many thought the design kept changing, which led to unnecessary rework and schedule delays at the start of Stage A. Scientists and Engineering need to work closely to lock in the design as early as possible.

Prior to Stage B system setup, complete the sequestration system configuration/design (i.e., river pumping, chemical mixing, infiltration, chemical storage). Lock down before field setup commences. During Stage A, the design and associated system configuration kept evolving after the initial setup was established, causing a lot of unnecessary rework and frustration. Aspects of the system evolution had a "back of the envelope, design as you go along" feeling for operations and maintenance personnel. For Stage B, consider using a more formal final design approach that incorporates the lessons learned from Stage A. Have the system configuration formalized in a drawing before field setup commences.

Early on, a better definition of what we actually needed to do upfront would have meant significantly less rework and improved timeliness of the evolution, including avoiding cold weather operation.

Conversely, there should not be an overly prescriptive definition associated with the Sampling and Analysis Plan (SAP) and the Remedial Design Report (RDR), particularly in the use of larger plus/minus range tolerances. Had this been in place initially, there would have been fewer bulk chemical challenges. The allowance for some flexibility would have more effectively supported field setup and subsequent operation. For example, where possible, state "solution needs to be alkaline between the range of x and y," instead of "pH must be 7.6."

Regarding RDR and SAP tables and volumes, only use the most important sets of data (i.e., remove all unnecessary data and options, which only cause confusion during field operations). Give Operations personnel only the specific set of metrics they need for their use in the field, which will eliminate the confusion that occurred in Stage A. For example, give gallons of chemical instead of concentrations, mixing ratio, and so forth. Personnel want to be precise, but measurements need to be geared to actual field measurement capabilities.

For Stage B, establish a set of clear criteria for project personnel to use in determining when pumping operations have been successfully completed.

The data from Stage A are still being collected at this time and the final determination of relevant requirements and specifications have not been determined.

A number of personnel recommended that the project re-address the impacts on sequestration based on the river stage. Initially, it was due to the projected river stage that the early September injections were desired. For many reasons, it would be desirable to commence injections earlier in the year. An analysis should be performed to determine if that is possible. The river fluctuated plus/minus one meter during Stage A, and review of preliminary data indicated that Periodically Rewetted Zone (PRZ) wetting was not an issue in Stage A. The river fluctuations were determined from Automated Water Level Network data.

Nevertheless, it is recognized that moving the sequestration to earlier in the calendar year may not be technically feasible.

5.2 Chemical Specifications

Project scientists will need to re-evaluate the chemical concentrations that will be used, based on data collected from Stage A, before any concentration determinations are made for Stage B.

There is a need to review the Geo-Chemical modeling prior to Stage B. This was the first time this particular chemical mixture and concentration was used on a large scale. These mixtures are complex (e.g., high salt solutions that behaved nonlinearly at various concentrations) and originally, their behavior in the field was not fully understood, leading to precipitation-related issues. Better upfront understanding of any chemical mixture behavior should go a long way toward avoiding future issues.

Provide Operations personnel the most appropriate measure of chemical injection. Is it the quantity of chemical pumped, or is it a desired flow rate for a specified time?

The primary goal was to get the appropriate concentration of chemical delivered to the PRZ in order to bind the uranium. At the time of the post job review, the project had not collected any uranium leachability data.

5.3 Field Monitoring

The RDR states that water level measurements would be collected during Stage A pumping. It was determined this was not feasible, and it was not done. This requirement will need to be addressed before Stage B.

There was a lack of clearly defined operational data for use by Operations personnel in Stage A pumping operations. Ensure operational data to be used by Operations is defined before Stage B. The data would have been of great use had they been available during Stage A. It would have also ensured that all applicable requirements and specifications had been captured by Operations personnel.

For Stage B, the project scientists need to clearly define exactly what data need to be collected. Determining this early on will ensure better preparation and less rework regarding equipment/ instrumentation setup and operation.

Sampling data showed that detectible chemical concentrations started showing up in the 10 foot PRZ three to four days after initiation of infiltration.

During Stage A, it was learned that the ERT system can actually measure whether the process is flushing uranium while performing infiltration.

Prior to implementation of Stage B, there needs to be a determination of the most effective means to measure conductivity during pumping operations. Will there be a greater reliance on the ERT grid data or by sampling monitoring wells? During the post job review, the pros and cons of each were discussed.

5.4 Miscellaneous Items

There is a need to determine exactly how many wells and boreholes (monitoring and injection) will need to be installed for Stage B. However, this can only be determined once the data are collected and analyzed from Stage A.

From the initial analysis of data from Stage A, it appears the chemical injection wells functioned as intended.

There is a belief, based on preliminary data analysis of Stage A data, that fewer injection wells will have to be installed for Stage B. This would be of great benefit if proved to be accurate. Consider not using PRZ chemical injection in Stage B. Preliminary Stage A data results seem to support the thesis that the injections were not of much value. The infiltration system seemed to be sufficient for both the unsaturated zone and the PRZ. However, more extensive data analysis will be required before any final decision is made. This will take several more months to accomplish.

Consideration should be given to performing a series of 8-hour injections, rather than a 24 hour continuous injection evolution, for Stage B. This approach can be formally determined once all Stage A data analysis is complete. The approach could have a number of operational benefits.

Consider implementing a TPA change notice if it would clarify the sequestration requirements for Stage B.

6 Hardware

6.1 Large Hoses/Lines

Stage A required multiple flexible water hoses of various types and sizes. Some of the larger hoses were difficult for Craft personnel to move by hand. The work crew encountered a number of problems during initial staging, connection, and recovery of these hoses. Future work planning needs to address these challenges.

Regarding the large diameter, red discharge hoses from each mixing skid, Craft personnel suggested using a solid, 45-degree downward-angled fitting to ensure the rubber hose did not collapse or pinch. Such a fitting would sustain a much smoother run from the mixing skid to the injection field.

Personnel discovered the need to ensure all hose connection fittings are sufficiently water tight before actual water pumping operations commence. During initial hose pressurization, many of the connection fittings leaked, some significantly. This, in turn, required a dedicated effort to ensure all fittings were adequately tightened.

Craft personnel encountered a number of issues with the various types of hose clamps, which led to multiple water leaks during equipment setup and testing. Engineering needs to ensure that clamp torque values are provided as well as better coupling of clamp types to hose types. For example, there were some band clamps that were not well matched to the types of hoses (e.g., flat collapsible or solid round). Another suggestion involved double clamping some fittings to the hoses to stop leakage.

A number of 100 foot and 50 foot water hose segments were used in the operation. Craft personnel found that shorter, 25 foot segments were much easier to handle. To improve personnel safety in the future, use 25 foot segments only.

The hose winder unit used for the red hoses did not work very well. If the red hose is used in the future, a better hose winder will be necessary. The hose winder worked well for the smaller hoses.

One consideration for Stage B sequestration is to use spare HDPE piping in place of the large diameter hoses. The project has lots of this material, and many feel that it would be more effective than the hoses. Another suggestion was the use of fire hose for some applications.

There was strong, universal opinion that the large red hoses coming off the chemical mixing skids discharge were not the best design for the application as they are flat prior to pressurization, which caused multiple problems. A more ridged hose or hard pipe should be used.

Crimp fittings on the smaller red hoses caused problems at the pressure regulators. If the same hoses are used in the future, different crimp fittings are needed.

Another problem encountered with the red hoses is that, over time, these hoses leached out the chemical being pumped. A type of hose that does not have this characteristic should be used. The red hoses were subject to frequent pinching/kinks, which was an operational distraction. In the future, a better hose or solid elbow installation would eliminate these distractions.

The ability to drain river water from the hoses directly onto the ground greatly simplified equipment operation and handling. This procedure needs to continue in the future to prevent operations from becoming more complicated and costly.

A personnel walkway over the chemical mixing skid discharge lines would be a beneficial safety aid. During Stage A, personnel were frequently required to walk over the lines, creating an unnecessary tripping hazard.

6.2 Infiltration system

Early in the project, following the installation of a series of monitoring and injection wells but prior to the start of Stage A, a broad area was excavated to support the installation of the infiltration lines. Unfortunately, the work was performed outside the authorized scope of the excavation work permit. Care needs to be taken to ensure that the excavation work permit is current, and that any specified requirements such as DOE-0344 *Hanford Site Excavating, Trenching, and Shoring Procedure (HSETSP)* are adequately met.

A number of the fittings associated with the infiltration system did not perform well, especially those associated with the regulators. Prior to Stage B, the Craft should be involved to determine, procure, and use better fittings.

Early in Stage A, the flow rates in the individual infiltration lines were not as high as anticipated. Once the pressure regulators were changed out, the flow rates increased.

During equipment testing, it was discovered there was no easy way to determine if there was flow in an infiltration line. A small vent valve at the end of these lines is an easy way to check water flow. In addition, consider the installation of an isolation valve in each line as well as a pressure gauge downstream of the pressure regulator in each line.

In the future, the project needs to learn the most effective approach for the installation of the infiltration lines. Stage A encountered some serious problems with this activity. One alternative is to perform the bulk excavation and installation of infiltration lines prior to the installation of additional monitoring wells. This would be the preferred approach for Stage B.

It is possible that some of the infiltration lines did not work. It is believed they could have been clogged with sand and chemical precipitation. Consider using a different material, instead of fine sand, when installing the infiltration lines to prevent clogging and enhance the effectiveness of chemical infiltration. Installing an inverted half pipe over the infiltration lines or running the infiltration lines inside a perforated pipe would significantly reduce line clogging and improve infiltration performance.

Determine if the line spacing used in Stage A is appropriate for Stage B. If possible, consider a wider spacing than the 6.5 feet, possibly 10 to 15 feet. The wider spacing would greatly ease installation in the field.

Keep the physical line distance from the mixing skid to the infiltration lines as short as practical in order to optimize pumping operations.

6.3 River Pumps

The large physical separation of the river pumps from their adjustable frequency devices (AFDs) is not the optimum configuration for system operation. Ideally, they need to be closer together. In the future, if there is a cost effective opportunity to bring them closer together, it should be done. This action is nice, but not critical.

Pump testing for Stage B may have new challenges, potentially due to the need for collecting and disposing of the purge water volumes. This may be required because of the large volume involved, and the potential effect on the local hydrology, if the water were drained directly onto the ground.

The construction of stairs for river access was a very good action, and needs to be used again in the Stage B.

A suggestion was made to incorporate changes to the platform used by personnel when on the boat in order to make working with heavy equipment on the river easier.

6.4 Chemical Mixing Skids

Consideration should be given to use larger capacity chemical mixing pumps. The existing pumps did not provide sufficient discharge pressure to the infiltration system. Different pumps would provide more efficient service and optimize the function of the infiltration system, which is especially important, given that Stage B involves treatment of much larger areas.

Consider replacing the mixing skid chemical pumps with metering pumps if allowed by chemical process injection flow requirements.

It will be necessary, prior to the next use of the mixing skid, to rework all the globe valve internals, in order to prevent leakage. The chemicals being pumped negatively affected the ability of the valves to properly seat. Another alternative might be to use valves more suitable for the material being pumped.

Operationally, Engineering was unfamiliar with the chemical mixing skid/chemical mixing ratio control. The experienced engineers who designed the mixing skids are no longer on the project. Sufficient time should be scheduled for personnel to become familiar with this equipment before they are required for actual sequestration operation. Consider using a test assembly at the 200W P&T for this purpose. This assembly could also be used for system and procedure testing.

Design the chemical mixing pump to operate in an automatic mode for Stage B. Factor the "Auto" mode of operation into the testing program to ensure it functions as intended.

Use of the six-pack filters was felt to be an effective and beneficial design. Their adjacent position to the chemical mixing skids should be continued in Stage B. The project needs to ensure sufficient availability of the 50-micron filter cartridges prior to the next use of these filters. Also, need to continue using the wooden hose support structures to elevate the river hoses to the six-pack filters. They worked very well and should be used again.

Provide a step assembly for shorter stature personnel to use when accessing the mixing skids to take readings.

7 Chemicals

The actual amount of chemical handling required by personnel in support of Stage A was much greater than originally expected, based on bench testing. As a result, a significant number of challenges associated with utilization of the bulk chemical were encountered during Stage A. These challenges caused a number of delays and increased Stage A costs significantly. The project should have recognized that the scale of operation was different from laboratory bench tests, and been prepared for the issues ahead of time. Unfortunately, the laboratory tests clearly did not prepare us for the actual field conditions encountered (i.e., volumes and temperatures). Prior to the implementation of Stage B, a number of specific lessons need to be learned. Further review based on the Stage A experience is necessary in order for the project to be prepared for Stage B.

Given the challenges encountered with the proper chemical mixing under various temperature conditions, it would be valuable to have a chemical mixing contingency plan in place before Stage B.

Need to determine the optimum chemical mixture to be used in the future (Na2PO4 vs. NaPO4).

It was good that the sequestration chemical was not regulated. Since there were a number of chemical leaks, there was no environmental concern when some leaked. Whenever a leak was discovered, it was properly reported, cleaned up, and disposed. In a number of areas, such as the chemical tank farm, spill containment was established prior to the commencement of operations.

If, in the future, the project scientists consider using a different chemical, it should also be unregulated. A regulated product would greatly complicate design, setup, operation, and decommissioning. If at all possible, stay with the same chemical product used in Stage A.

During Stage A, there was an unexpected amount of chemical precipitation out of solution, which caused a number of operational issues. Later in Stage A, this condition was essentially resolved. These lessons need to be carried over to Stage B.

One of the biggest challenges the project did not consider in association with the injection chemicals was the impact of the cold temperatures encountered due to setup delays. However, after a number of trials, a formulation was found that effectively worked, including the supplier heating the chemical prior to delivery at the site. If cold weather conditions are possible in Stage B, this formulation needs to be used again.

Consider re-evaluating the high chemical concentrations that were used. Consider lowering the concentration, and changing the mixing ratios, which would simplify injection operations. The river pump maximum capacity of 255 gpm will limit the ability to dilute the concentration, and this limitation will need to be considered unless a different a pump is used. A higher level of dilution would have a positive effect on the system components, and would be a desirable course of action, if it can be justified.

The chemical supplier's contract was not precise enough to require the vendor to supply the required product, and its associated documentation, that was actually needed. Prior to Stage B, the supplier's contract needs to be revised.

Need to clearly understand how the chemical supplier (i.e., Two Rivers) mixes the bulk chemicals prior to delivery. This information needs to be formally delivered, and is necessary in order to better plan how to use the chemical for injection. Additionally, we need an accurate certificate of analysis of the mixture sent to the field. These data are necessary for accurate determination of the desired concentration under various environmental conditions.

Have the chemical supplier use an instrument to measure phosphate concentration real time to ensure mixture consistency.

During Stage A, the chemical contractor and project scientists were very supportive and responsive to addressing operational challenges associated with the chemicals.

Early in Stage A, Operations personnel encountered unexpected challenges with the chemical line layout that was initially installed. Modifications were made to the configuration and no more issues were encountered. This final layout needs to be retained for Stage B.

Experience gained from Stage A determined that it would be desirable, if possible, to locate the chemical storage tanks closer to the chemical skids. The closer location would help optimize pumping operations by significantly shortening the long hose runs. In conjunction with moving the tanks, or alternatively the trailers, consider creating a differential height between the tanks and trailers to ensure an optimum net positive suction head for the trailer pumps. If there are other overriding considerations, such as personnel safety, and ease of chemical delivery truck unloading, the relocating of the tanks is not as critical for operational success.

The trailer flow meters caused a number of issues during the Stage A activity. There is a need to repair, and replace these units in order to enhance reliability. Additionally, consider relocating the flow meters to the discharge lines in order to optimize/simplify operations.

8 ERT System & Data Collection

Consider using an increased number of data loggers during Stage B. Additional data loggers would also be appropriate for the remaining data collection from Stage A. The data loggers are used to collect conductivity data. Consideration should be given to automate the collection and transmission of data collected from the loggers for Stage B. This action would greatly enhance this analysis of data on a real time basis.

During Stage A, it was determined that the daily monitoring (reading) of 26 piezometers is unrealistic. Prior to Stage B, the frequency of these readings should be reassessed.

9 Radiological

There were essentially no radiological challenges associated with this work. If there had been, the work would have been greatly complicated. For example, given the number of leaks encountered, contamination control would have been a challenge. It is assumed Stage B will also have minimal radiological implications. If not, a great deal of redesign and work planning will be necessary before any field activities can commence.

10 Training & Qualification

Training of all personnel was effective, and there were no issues encountered in this area. The project had a small core group of experienced personnel (i.e., NR-2 Sequestration). This greatly aided in the training and qualification of additional personnel. It is important to use, to the extent possible, the personnel who performed this project in any future sequestration activity.

11 Waste Handling

Better direction in collecting, handling, and disposing of chemical wastes is necessary. Given the large quantity of chemicals used and number of associated chemical lines and fittings in the project, the anticipated amount of waste management actions were underestimated. Recognizing that Stage B will be handling significantly larger quantities of bulk chemical, and have even more potential for leaks, the need for better upfront waste management planning is essential.

12 Miscellaneous

Incorporate the basic philosophy that "If It Ain't Broke Don't Fix It." Most aspects of the Stage A worked well once they were fined tuned. For Stage B, minimize the amount of changes to only those that simplify the process, and make the project more efficient and cost effective.

Careful consideration should be given to addressing how equipment used in the Stage A is going to be properly stored for reuse (consider storage in Building 273W). It will also be necessary to label and inventory the equipment to ensure it will not "disappear" over time.

The re-use of some ¼-inch poly tubing to supply air to the well packers caused problems. The tubing had been used in an earlier sequestration project at NR-2 and was being reused for Stage A. It was discovered that the poly tubing had become brittle due to long-term UV exposure. During Stage A, this material was replaced in its entirety following a tubing break. Recommend the tubing again be replaced prior to Stage B to avoid unexpected air leaks.

One action taken early on in Stage A was the removal of the overhead electrical lines. This greatly simplified subsequent work activities, especially those requiring the use of heavy equipment.

The staging of a small portable office was a good action, and should be continued in the future. However, a little larger office would have been beneficial. Also, locate in the office a printer for use. Initially, there was no printer, and it was determined that one was needed. During Stage B, testing will be needed to verify the printer functions when logged into the system. Provision of a wireless fax/copier would also be great benefit to personnel.

To more effectively plan Stage B, ensure the field setup and testing is performed early enough in the year to ensure pumping operations are performed and completed, especially before freezing weather conditions are likely to develop. The cold weather conditions encountered during Stage A led to a variety of operational challenges that should be avoided in the future. For Stage B, if practical, avoid any cold weather conditions. However, if cold weather operations are necessary, ensure the project is adequately prepared. For example, have an air compressor of sufficient capacity at the site to remove water from the lines and hoses for freeze protection.

One negative impact due to cold weather was that there was insufficient electrical power available for the required electrical blankets to keep temperature sensitive equipment warm. If required to perform future winter operations, additional or larger capacity portable generators and heating blankets will be necessary.

The only equipment damage that was encountered during the project was the discovery of a small leak on the bottom of one of the bulk chemical storage tanks. This leak will need to be addressed before the affected tank can be placed back into service. The leaking chemical storage tank was pumped down, and was not used further during Stage A.

Determining upfront what hardware and consumables will be needed during Stage B and ensuring that sufficient materials are staged onsite will eliminate a lot of lost time traveling to the 200 Area for parts, thus improving efficiency.

Since the work activity is a mixed gender activity, consideration should be given for both male and female toilet facilities.

13 Summary

In general, it was determined that the Stage A sequestration was a successful operation. The project was able to inject a sufficient amount of chemical to meet design goals. However, the experience from Stage A revealed a significant number of lessons learned that will need to be addressed before the project evolves into Stage B sequestration. Following are some of the more significant lessons learned:

- The optimum chemical mixture and concentration
- The optimum number of wells to be used
- The necessity of chemical injection into the saturated zone
- The optimum types of hoses and fittings
- The most appropriate ERT system configuration
- The need to simplify the work documents used to setup and test the sequestration system
- The need to involve O&M personnel as early as possible for hazards identification and equipment determination
- The optimum configuration of the infiltration system
- The safest and most efficient way to install the infiltration system
- The most effective way(s) to control fieldwork activities (setup, testing and operations)
- The most effective means to control the number of personnel at the work site

One of the project's most noticeable strengths was the consistently high level of teamwork exhibited by all personnel from the various organizations who participated in the project. Additionally, the entire project was conducted with no regulatory noncompliances. Finally, there were no near miss events, only a few minor personnel injuries, and a minor amount of equipment damage.

Attachment: Post Job Review Meeting Attendance Rosters

Post Job Review Facilitator: Robert Barmettlor R. Barmettlor Date: 2/17/16

Project Manager: Patrick Baynes Patrick A Baynes Date: 2/17/16

PRC POST-ALARA / POST-JOB REVIEW

Page 5 of

Site:

Facility:

Related AJHA Number: (enter N/A if no AJHA is applicable to this feedback):

AJHA Feedback ID (if known):

Work Number:

Post-Job/ALARA Review Lessons Learned Roster

Name (print)	Date	Signature
Bob Barmettlor.	12/9/15.	
ERIC BERTRAND	12/9/15	
Ben Tabayoyon	12/9/15	
A.E. ANDOR	12/9/15	
Jose Gutierrez	12-9-15	
Greg Larson	12-9-15	
ROGER WHITLOCK	12/9/15	
ERNESD M. BALDWIN	12/9/15	
DAN GILLIAN	12/9/15	
Craig Maydole	12/9/15	
K E Weeks	12/9/15	
Dave St. John	12/4/15	
Kelly Whitley	12/9/15	Kelly Whitley
Patrick Baynes	12/9/15	Patrick A Baynes
Randy Hermann	12/9/15	

PRC POST-ALARA / POST-JOB REVIEW	Page 5 of 5

Site: 300-FF-5 **Facility:** 300-FF-5

Related AJHA Number: (enter N/A if no AJHA is applicable to this feedback): N/A.

AJHA Feedback ID (if known): N/A. **Work Number:**

Post-Job/ALARA Review Lessons Learned Roster

Name (print)	Date	Signature
R. Barmettler.	12/10/15.	R Barmettler
Farah Elloy	12/10/15	
Virginia Rohay	12/10/15	Virginia J Rohay
Patrick Baynes	12/10/15	Patrick A Baynes
Sunil Mehta	12/10/15	
Randy Hermann	12/10/15	

A-6004-821 (REV 4)

This page intentionally left blank.