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14-AMRP-0223

JUN 25 2014

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Addressees:

SAMPLING INSTRUCTION FOR THE 300-FF-5 OPERABLE UNIT SUPPLEMENTAL POST ROD FIELD INVESTIGATION, SGW-56993, DRAFT A

This letter is transmitting the Sampling Instruction for the 300-FF-5 Operable Unit Supplemental Post ROD Field Investigation, SGW-56993, Draft A for your review. The Sampling Instruction was provided electronically on Tuesday, June 17, 2014.

The Sampling Instruction is for three boreholes located and designed to collect uranium soil concentration and uranium leachability data to refine the targeted uranium sequestration treatment location.

The Hanford Site 300 Area Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1 were signed in November 2013. Subsequently, Draft A of the 300 Area Remedial Design Report/Remedial Action Work Plan was submitted for review on May 22, 2014. The attached Sampling Instruction supports uranium sequestration described in the Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater, DOE/RL-2014-13-ADD2, Draft A.

If you have any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,

Ray J. Corey, Assistant Manager
for the River and Plateau

AMRP:KMT

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SGW-56993
Draft A

Sampling Instruction for the 300-FF-5 Operable Unit Supplemental Post ROD Field Investigation

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

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Approved for Public Release;
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SGW-56993
Draft A

Sampling Instruction for the 300-FF-5 Operable Unit Supplemental Post ROD Field Investigation

Program/Project: RS&I

A. R. Sherwood
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Date Published
June 2014

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

Contractor for the U.S. Department of Energy
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APPROVED
By Julia Raymer at 1:40 pm, Jun 10, 2014

Release Approval Date

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Signature Sheet

Title *Sampling Instruction for the 300-FF-5 Operable Unit Supplemental Post-ROD Field Investigation*

K.M. Thompson

U.S. Department of Energy, Richland Operations Office

Signature Date

D.A. Faulk

U.S. Environmental Protection Agency

Signature Date

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Terms

ASTM	American Society of Testing and Materials
bgs	below ground surface
CFR	*Code of Federal Regulations*
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQA	data quality assessment
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Documents*
HEIS	Hanford Environmental Information System
ICP-MS	inductively coupled plasma–mass spectrometry
ICP-OES	inductively coupled plasma–optical emission spectroscopy
N/A	not applicable
OU	operable unit
PRZ	periodically rewetted zone
QC	quality control
RDR/RAWP	remedial design report/remedial action work plan
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
SAF	sampling authorization form
SAP	sampling and analysis plan
SEM/EDS	scanning electron microscope/energy dispersive x-ray spectroscopy
SI	sampling instruction
SMR	Sample Management and Reporting
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WAC	*Washington Administrative Code*

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1 Introduction

The 300 Area encompasses approximately 105 km^2 (40 mi^2) adjacent to the Columbia River in the southern portion of the Hanford Site and includes the 300 Area Industrial Complex. This complex was comprised of buildings, facilities, and process units where uranium fuel production and research and development activities took place. Much of the 300 Area has been remediated. The remediation process was accomplished within two soil operable units (OUs), 300-FF-1 and 300-FF-2, which included liquid and solid waste disposal sites. The remediation process also includes the 300-FF-5 Groundwater OU. Contaminant releases at the waste disposal sites resulted in several groundwater contaminant plumes within the underlying 300-FF-5 Groundwater OU.

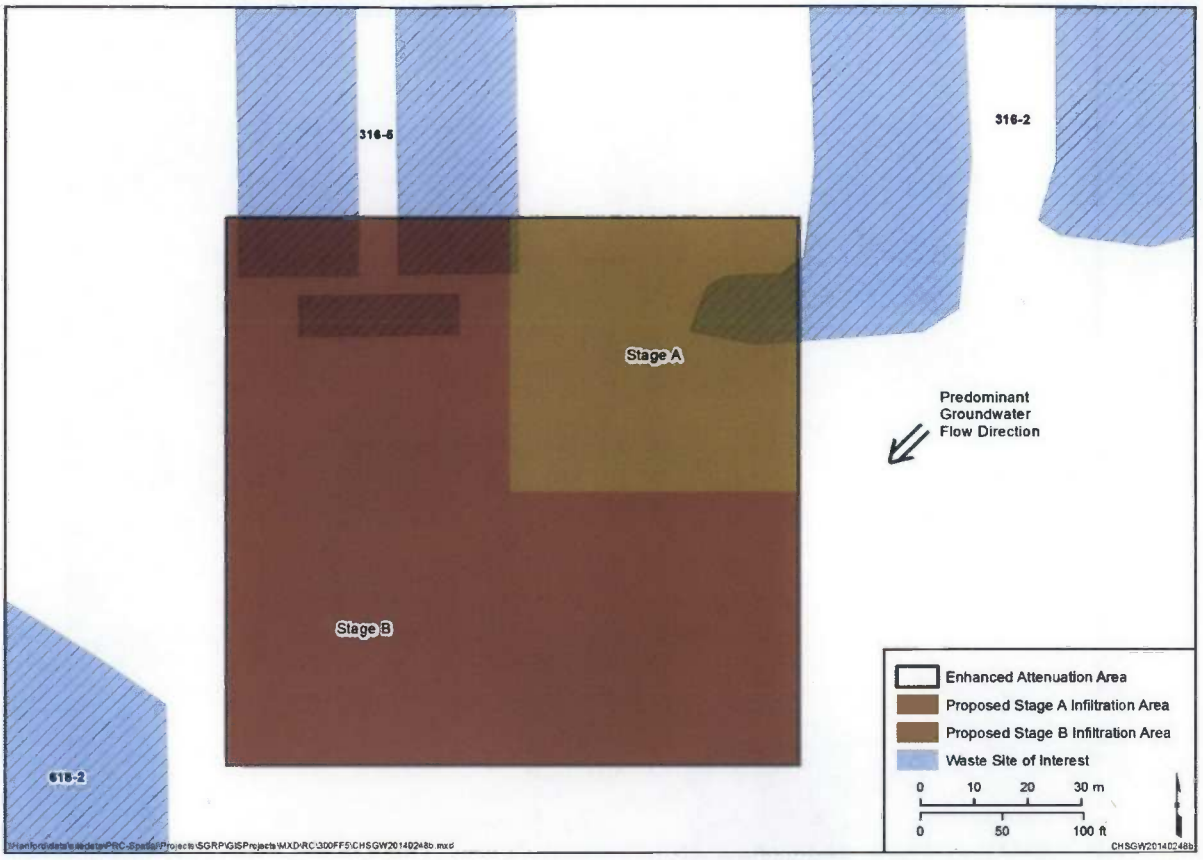
Completion of the cleanup is being accomplished under the *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1* (EPA and DOE, 2013) (hereafter referred to as the 300 Area Record of Decision [ROD]/ROD Amendment). Uranium is identified as a contaminant of concern in the 300 Area ROD/ROD Amendment. 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. Uranium sequestration will be used to reduce the leachability of uranium in the soil that is the primary source of uranium entering the groundwater.

Remedies selected in the 300 Area ROD/ROD Amendment are implemented through the remedial design report/remedial action work plan (RDR/RAWP) (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]*). Further details about the site description, process information, and previous investigations are provided in the RDR/RAWP.

1.1 Scope

This sampling instruction (SI) provides the design for the supplemental post- ROD field investigation to be undertaken in support of the enhanced attenuation using uranium sequestration in in a region of high uranium groundwater concentrations. Uranium sequestration will be achieved by injecting phosphate solutions into the vadose zone and periodically rewetted zone (PRZ) to reduce the leachability of uranium that is the primary source of contamination in groundwater. Uranium sequestration will also be used in the top of the aquifer to reduce the leachability of uranium that may be mobilized during the vadose zone and PRZ treatment process. The uranium sequestration activities are discussed in the RDR/RAWP and DOE/RL-2014-13, ADD 2, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater* (referred to hereafter as the Groundwater Addendum).

The Groundwater Addendum describes the major components of the selected groundwater remedies, one of which is enhanced attenuation of uranium using sequestration by phosphate infiltration and injection into the subsurface. Implementation of the uranium sequestration remediation design will be performed using a staged approach. The proposed infiltration/injection areas for Stages A and B are shown in Figure 1. Together, the Stage A and Stage B infiltration areas (approximately 1 ha [3 ac]) are referred to as the "enhanced attenuation area." The enhanced attenuation area location and implementation of the Stage A uranium sequestration remediation design will be refined based on the results of this supplemental post-ROD field investigation task.



Note: Predominant groundwater flow direction is representative of high-water conditions.

Figure 1. Stage A and Stage B Infiltration/Injection Enhanced Attenuation Area

1.2 Purpose

The purpose of the supplemental post-ROD field investigation sampling activities in this SI is to collect uranium soil concentration and uranium leachability data that will be used to refine the location of the enhanced attenuation area and provide information to refine and evaluate the Stage A enhanced attenuation remediation design. The sampling activities in this SI will provide information on the distribution and leachability of uranium within the vadose zone and the PRZ from boreholes drilled within, and in the vicinity of, the proposed enhanced attenuation area. The data will also be used to refine the conceptual site model.

1.3 Site Description and Process Information

Figure 2 shows the location of the proposed supplemental post-ROD field investigation boreholes. The enhanced attenuation area is located within the influence of four major waste disposal facilities that operated in the 300 Area. Although these sites have been remediated, deeper residual uranium is thought to contribute to the high uranium concentrations detected in the groundwater in this area.

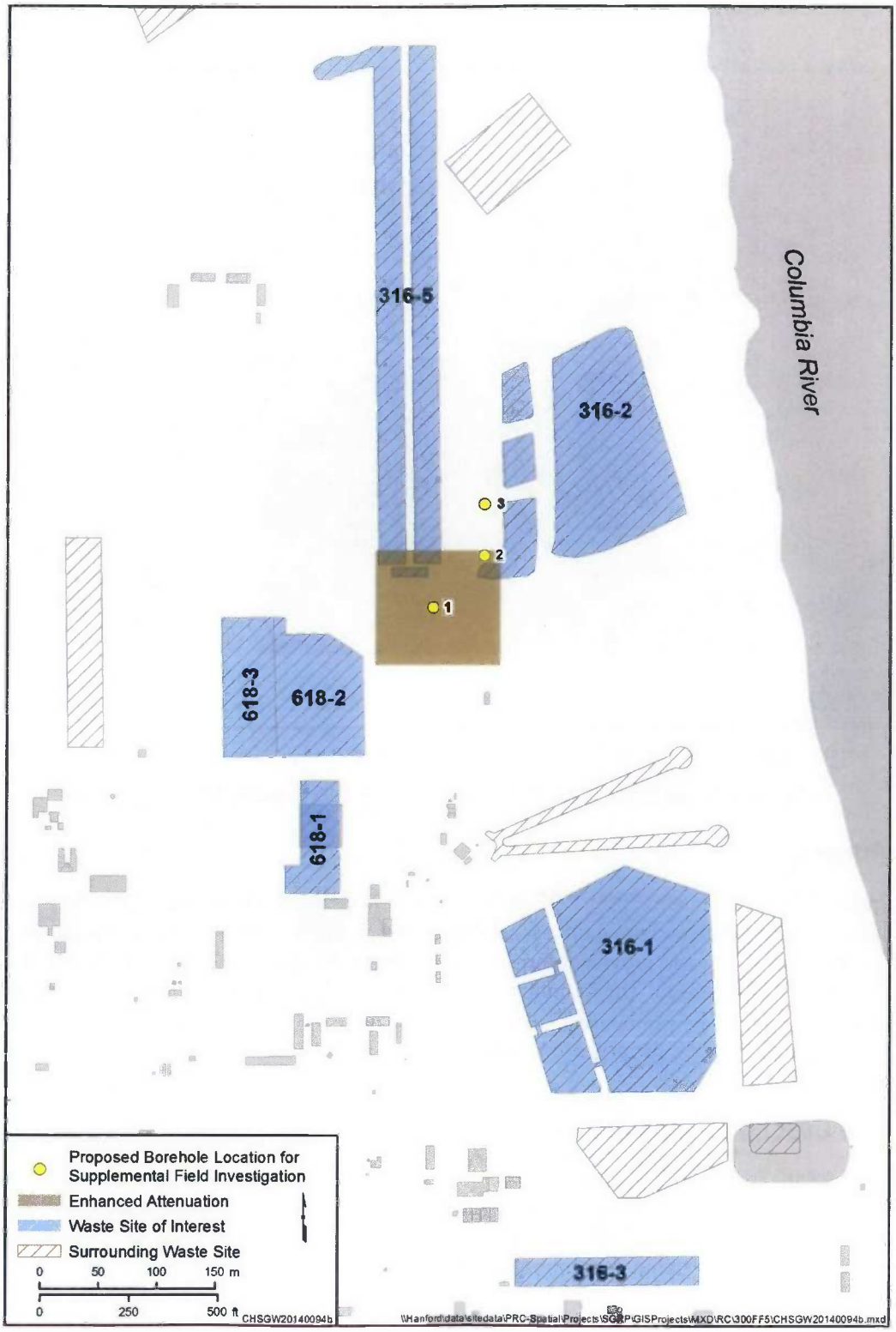


Figure 2. Location of Proposed Boreholes for Supplemental Post-ROD Field Investigation

The Solid Waste Burial Ground No. 2 (waste site 618-2) and the Dry Waste Burial Ground No. 3 (waste site 618-3) sites were located to the southwest of the proposed enhanced attenuation area. From 1951 through 1955, these waste sites were used to dispose of uranium-contaminated solid waste from 300 Area facilities. This included contaminated equipment and contaminated metal wastes. The sites were remediated from September 2004 through August 2006. Remediation involved excavation and removal of buried waste and contaminated soil to a maximum depth of 6.1 m (19.7 ft) below ground surface (bgs). The sites were backfilled with clean fill to grade level.

The 300 Area North Process Pond (waste site 316-2) was located to the northeast of the proposed enhanced attenuation area. This waste site consisted of several separate sections separated by dikes. From 1948 to May 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, as 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. Remediation involved excavating and removing the contaminated soil to a maximum depth of 7.5 m (25 ft) bgs. The site was backfilled with clean fill to grade level.

The 300 Area Process Trenches (waste site 316-5) were located north of the proposed enhanced attenuation area. This site consisted of two trenches, each 152.4 m (500 ft) long, operating 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 the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* was completed from July 1997 through February 1998. Remediation involved excavating and removing the contaminated soil to a maximum depth of 4.3 m (14 ft) bgs. The site was backfilled with clean fill to grade level.

Soil samples from a borehole (A8069) on the west side of the 316-2 waste site (Figure 3) detected elevated concentrations of uranium as deep as 6.1 m (20 ft) bgs. Soil samples from a borehole (C7654) near the south end of the 316-5 waste site detected elevated concentrations of uranium as deep as 10.7 m (35 ft) bgs. In 2011-2012, groundwater samples from a well located near the center of the proposed enhanced attenuation area (well 399-1-17A) had high groundwater uranium concentrations (maximum of 4,030 µg/L). In 2012-2013, groundwater samples from a well located to the northeast of the proposed enhanced attenuation area (well 399-1-55) also had high uranium concentrations (maximum 571 µg/L). Groundwater levels in the enhanced attenuation area can fluctuate about 2 m (7 ft), with a depth to groundwater during high river stage of about 8 m (26 ft) bgs and a depth to groundwater during low river stage of about 10 m (33 ft) bgs.

1.4 Target Analyte

Groundwater contaminants of concern are identified in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013). The uranium sequestration component of the groundwater remedy seeks to sequester residual labile uranium; therefore, the target analyte for this SI is uranium.

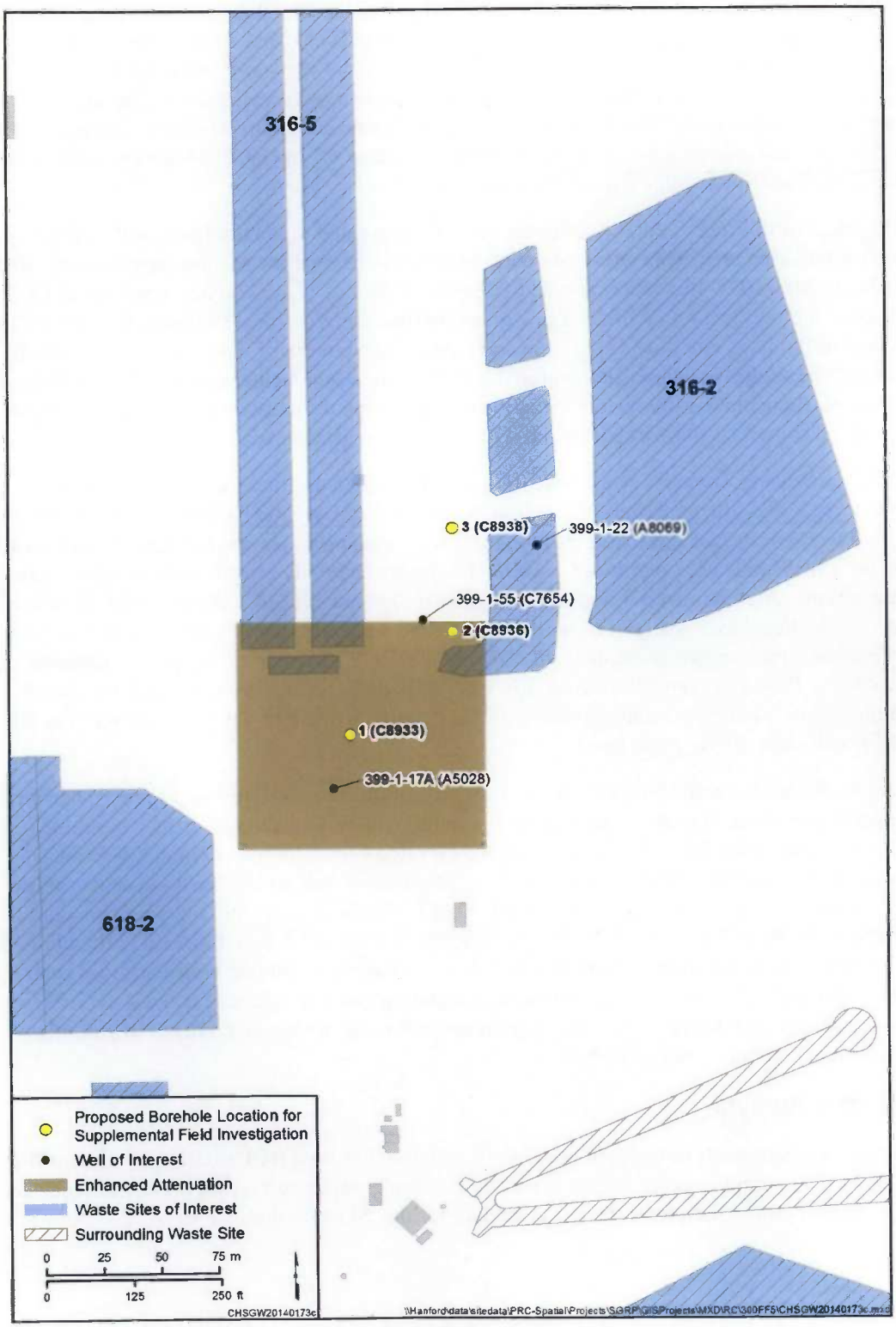


Figure 3. Location of Existing Groundwater Wells 399-1-17A and 399-1-55 and Proposed Boreholes

1.5 Systematic Planning

A data quality objectives (DQO) process, as described in EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4), was used to develop the sampling and analytical design for the supplemental post-ROD field investigation. Using the DQO process, two problem statements were identified. The data collected during the post-ROD field investigation are targeted to resolve these problem statements.

Problem Statement 1 involves locating the enhanced attenuation area over the region of highest uranium concentration in groundwater in order to maximize the effectiveness of the uranium sequestration. As stated in the previous section, recent groundwater data indicate a region of higher uranium concentration may be located to the northeast of the proposed enhanced attenuation area. Table 1 provides specific information on the principal study questions to be resolved, data needs, measurements, and data use for Problem Statement 1. Sampling to resolve Principal Study Question 1a will provide vertical profile uranium soil concentrations in the vadose zone and PRZ to confirm the location of higher uranium concentrations in the soil. Sampling to resolve Principal Study Question 1b will provide uranium leachability characteristics to determine the region of greater mobility of the uranium. Together, data collected to resolve these principal study questions will be used to focus the position of the enhanced attenuation area, orienting it around more leachable and higher uranium-contaminated soil.

Table 1. Summary of Problem Statement 1

Problem Statement 1	The enhanced attenuation area (approximately 1 ha [3 ac]), as defined in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013), represents a region centered on the highest concentration of uranium in the groundwater.	
Principal Study Question 1a	Does the enhanced attenuation area (approximately 1 ha [3 ac]), as defined in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013), represent a region centered on higher concentration of uranium in the vadose zone and PRZ?	
Discussion	Data obtained in 2011 from well 399-1-17A indicated that the high groundwater uranium concentration was near the southern end of the 300 Area Process Trenches (waste site 316-5) and were used to locate the enhanced attenuation area. More recent data from well 399-1-55 indicates higher groundwater uranium concentration may be located northeast of the enhanced attenuation area.	
Data Need	**Measurement/Observation and Location/Frequency**	**Data Use**
Vertical profile and lateral distribution of uranium soil concentrations and lithology in the vadose zone and PRZ that corresponds to regions of higher groundwater uranium.	Conduct total uranium measurements and lithology observations from vertical profile samples collected in the vadose zone and PRZ at the following locations (Figure 3): • Proximity of well 399-1-17A (borehole location 1) • Proximity of well 399-1-55 (borehole location 2) • Region north of well 399-1-55 (borehole location 3)	This information will be combined with existing total uranium data to refine the three-dimensional model of uranium soil concentrations in the study area. The total uranium data will be used to select the samples for additional analysis to resolve Problem Statement 2. The refined uranium model will also be used, in combination with data from Principal Study Question 1b, to select the optimal location of the enhanced attenuation area.

Table 1. Summary of Problem Statement 1

Principal Study Question 1b	Does the enhanced attenuation area (approximately 1 ha [3 ac]), as defined in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013), represent a region of higher leachability of uranium in the vadose zone and PRZ?	
Discussion	Use uranium and lithographic profile data from Principal Study Question 1a to determine the location and soil horizons for uranium leachability tests.	
Data Need	**Measurement/Observation and Location/Frequency**	**Data Use**
Leachability of uranium in the vadose zone and PRZ that corresponds to regions of higher groundwater uranium.	Conduct semi-selective sequential uranium leach tests on sediments collected from each borehole to determine the amount of uranium released under variable conditions. Conduct labile uranium leach test on sediments collected from each borehole to estimate the readily leachable (labile) uranium fraction. Leach tests will be conducted on one vadose zone sample and one PRZ sample.	Confirm the region of greater leachability of uranium in the vadose zone and PRZ. The leachability of uranium will be used in combination with the three-dimensional model of uranium soil concentrations as refined by Principal Study Question 1a to select the optimal location of the enhanced attenuation area.
	Conduct grain-size and pH analyses on samples selected for the leachability study.	Determine the physical characteristics of the substrate material that may affect leachability.

Note: 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.*

PRZ = periodically rewetted zone

ROD = Record of Decision

The following decision rule will be used to determine if sufficient information has been collected to resolve Problem Statement 1:

- If the new and existing total uranium soil concentration data and the new leachable uranium information do not change the current conceptual site model (centroid of the 10 times uranium background is within the enhanced attenuation area boundaries), then the location of the enhanced attenuation area will remain as defined. Otherwise, the location of the enhanced attenuation area will be revised to align with the revised conceptual site model.

Problem Statement 2 involves determining the leachability characteristics of samples from specific regions of the vadose zone and PRZ in order to evaluate the potential phosphate infiltration and injection treatment effectiveness as a result of Stage A. Table 2 provides specific information on the principal study question to be resolved, data needs, measurements, and data use for Problem Statement 2. Two principal study questions were identified to resolve Problem Statement 2. Sampling activities to resolve Principal Study Question 2a will provide pre-treatment uranium leachability characteristics using uranium leachability data collected to support Principal Study Question 1b. In addition, samples will be selected to provide information on the uranium mineral composition and soil transport characteristics, which will be used to refine the conceptual site model.

Table 2. Summary of Problem Statement 2

Problem Statement 2	Leachability characteristics, within the enhanced attenuation area, as refined by Principal Study Questions 1a and 1b, are necessary to evaluate the potential treatment effectiveness in the vadose zone and PRZ.
Principal Study Question 2a	What are the pre-treatment leachability characteristics of the vadose zone and PRZ in the refined location of the enhanced attenuation area?
Discussion	Leachability test results obtained for Principal Study Question 1b from boreholes within the refined enhanced attenuation area are used to resolve Principal Study Question 2a. Samples are available for mineral testing and flow-through column tests to support the conceptual site model.

Data Need	Measurement/Observation and Location/Frequency	Data Use
Leachability of uranium in the vadose zone and PRZ prior to application of phosphate in order to refine the remediation design and evaluate treatment effectiveness.	Use results from semi-selective sequential uranium leach tests and from labile uranium leach tests (obtained to resolve Principal Study Question 1b) on sediments collected from each borehole within the refined enhanced attenuation area to determine the amount of uranium released under variable conditions, as well as to estimate the readily leachable uranium fraction.	This information will be used to refine the Stage A strategy for the phosphate injection and infiltration. The data will also be used to determine the leachability characteristics of uranium in the enhanced attenuation area prior to application of phosphate.
Support the conceptual site model and refine the uranium transport model.	Perform analysis to identify primary uranium-bearing mineral phase from at least one borehole within the refined enhanced attenuation area. Mineral analysis will be conducted on samples selected for the leachability study. Perform two flow-through column tests using sediment samples from a borehole within the refined enhanced attenuation area. One flow-through column test will be conducted on the field-textured sediments (by removing very large cobbles) while the other test will be performed just on the <2 mm size fraction. Estimate the total uranium content associated with the field texture and <2 mm size sediments.	Determine the dominant uranium-bearing mineral phase. Determine the leachability of uranium using flow-through column tests under field texture conditions and compare to conditions that represent standard laboratory collection protocol (<2 mm size fraction). Data will be used to determine the scaling of transport parameters from the <2 mm size fraction to field-textured sediments and to estimate the total uranium content associated with the field-textured sediments as well as the <2 mm size fraction.

Table 2. Summary of Problem Statement 2

Principal Study Question 2b	What are the post-treatment uranium leachability characteristics of the vadose zone and PRZ in the refined enhanced attenuation area?	
Discussion	Stage A post-treatment data from a new borehole, co-located with a PSQ 2a borehole, will provide data to evaluate treatment effectiveness and support Stage B design.	
Data Need	**Measurement/Observation and Location/Frequency**	**Data Use**
Vertical profile and lateral distribution of uranium soil concentrations, lithology, and leachability of uranium in the vadose zone and PRZ after application of phosphate during Stage A.	Conduct total uranium measurements and lithology observations on one vadose zone sample and at least one PRZ sample collected from one new borehole within the refined enhanced attenuation area.	Determine the leachability characteristics of uranium (relative fraction leachable compared to the total uranium) in the Stage A remediation area after application of phosphate.
	Conduct labile uranium leach tests on sediments collected from one new borehole within the refined enhanced attenuation area to estimate the readily leachable uranium fraction. Leach tests will be conducted on one vadose zone sample and one PRZ sample.	
	Conduct grain-size and pH analyses on samples selected for the leachability study.	Determine the physical characteristics of the substrate material that may affect leachability.
Support the conceptual site model and refine the uranium transport model.	Perform analysis to identify primary uranium-bearing mineral phase from one borehole within the refined enhanced attenuation area. Mineral analysis should be conducted on samples selected for the leachability study.	Determine the extent of phosphate phase precipitation (rind formation) on the uranium-bearing mineral phase.

PRZ = periodically rewetted zone

Sampling activities to resolve Principal Study Question 2b will provide Stage A post-treatment vertical profile uranium soil concentrations in the vadose zone and PRZ and uranium leachability characteristics data. The data approach and methods will be the same as the pre-treatment data. Evaluating Stage A post-treatment conditions will provide information for the Stage B uranium sequestration design and treatment effectiveness.

The following decision rule will be used to determine if sufficient information has been collected to resolve Principal Study Question 2a:

- If the pre-treatment vadose zone and PRZ uranium leachability characteristics, predominant uranium-bearing mineral phase, and uranium travel times are consistent with the conceptual site model used to design the enhanced attenuation remediation, then proceed with the remediation as designed. Otherwise revise the enhanced attention design to align with the revised conceptual site model.

1.6 Project Schedule

Table 3 provides the approximate durations of major project activities that follow approval of this SI.

Table 3. Project Activity Durations

Activity	Comment	Approximate Duration
Planning: Includes subcontract preparation, preparation and issuance of statement(s) of work, and request(s) for proposal to drilling subcontractor(s) through award of contract(s).		110 days
Cultural and ecological review: Includes 140 days preparation of cultural and ecological forms/reports/approval, plus 2 days DOE-RL turnaround, plus 7 days for notification of Tribes.	Concurrent with planning activity.	149 calendar days[a]
Roads and pads: If needed.	Commences once planning and cultural and ecological review activities are completed.	20 days
Mobilization: Includes submittals and subcontractor training and medical processes.	Concurrent with roads and pads activity.	30 days
Field support, drilling, and sampling: Field support includes supporting personnel, geologist, and BTRs; drilling activity[b] includes drilling three boreholes with a 3-day turnaround time for preliminary results on total uranium samples.	Field support activities are concurrent with roads and pads, mobilization, and demobilization activities; drilling and sampling commences upon completion of mobilization.	45 days
Demobilization	Concurrent with end of field support, drilling, and sampling.	10 days
Analysis of samples: Includes 3-day turnaround time for preliminary results on total uranium samples from three boreholes through final laboratory report after the samples have been analyzed from the last drilled borehole. Leach tests are assumed to take 42 days.	Concurrent with drilling and sampling; last analyses and laboratory report complete approximately 65 days after completion of sampling.	86 days
Closeout and borehole summary preparation: Includes quality assurance inspection, final surveys, closeout of subcontractor reports, and preparation and approval of borehole summary.	Commences once demobilization is complete.	40 days
Supplemental post-ROD field investigation summary report[c]		40 days

a. Based on full cultural review. Actual duration maybe shorter if information from previous cultural reviews can be used.

b. Borehole decommissioning may occur upon determination that borehole will no longer be needed and with operable unit project manager approval. The decision to decommission boreholes is assumed to occur 2 months after the final uranium leach test sample has been delivered to Pacific Northwest National Laboratory to allow for sampling results to be available for consideration in decision making.

c. Report will not include post-treatment sampling to resolve Principal Study Question 2b.

Table 3. Project Activity Durations

Activity	Comment	Approximate Duration

BTR = buyer's technical representative
DOE-RL = U.S. Department of Energy, Richland Operations Office
ROD = Record of Decision

1.7 Project Management

Project management for the post-ROD field investigation will be as described in 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* (300 Area remedial investigation/feasibility study [RI/FS] sampling analysis plan [SAP]). The project team contains the personnel necessary to perform the SI activities in a safe, efficient, and compliant manner.

2 Sampling Design

The locations of the proposed boreholes for this post-ROD field investigation were chosen due to their proximity to wells 399-1-17A and 399-1-55 (Figure 3), where elevated uranium concentrations within the groundwater have been previously noted.

Three boreholes are proposed to be drilled approximately 0.76 m (2.5 ft) into the top of the aquifer (i.e., one split-spoon sampler length into the aquifer). The top of the aquifer is expected to be at approximately 105 m (344 ft) (NAVD88, *North American Vertical Datum of 1988*). Ground surface elevation in this region is approximately 115 m (377 ft) (NAVD88). The ground surface elevation at each borehole location will be measured prior to initiating drilling activities, and the actual expected depth intervals to be examined and/or sampled will be confirmed based on actual ground surface elevation.

Sampling at the three boreholes will be conducted to obtain total uranium soil concentration data throughout the length of the boreholes from the vadose zone, PRZ and the top portion of the aquifer. The total uranium soil concentration results will be used to refine the existing three-dimensional model of uranium soil concentrations in the region where the investigation site is located. Together, the refined three-dimensional conceptual site model and the uranium leachability characteristic tests (identified in Section 2.3.2) will be used to refine the enhanced attenuation area location. The uranium leachability characteristic tests will also be used to refine the treatment design and to document the pre-treatment leachability characteristics of the vadose zone and PRZ. Samples will also be used to conduct predominant uranium-bearing mineral phase analyses and flow-through column tests.

General requirements for training and certifications, documentation, field documentation, equipment/instrumentation maintenance and calibration, sample handling, custody, labeling and transportation are similar to those described in the 300 Area RI/FS SAP (DOE/RL-2009-45).

2.1 Sampling Objectives

Sampling activities for this post-ROD field investigation are intended to provide soil samples that are representative of conditions in the vadose zone and PRZ at the investigation site. Laboratory analysis of these samples for total uranium soil concentration and for uranium leachability characteristics will provide data to refine the location of the enhanced attenuation area and to refine the phosphate

infiltration/injection strategy for Stage A of the uranium sequestration remediation design. In addition, mineral phase testing and flow-through column tests on samples collected from at least one borehole will be performed for the purposes of refining the conceptual site model.

2.2 Borehole Drilling

The boreholes are proposed to be drilled with resonant sonic technology at the post-ROD field investigation site (Figure 3) to collect soil samples. Resonant sonic drilling is preferred over conventional drilling methods because this technique is faster and has the capacity to sample the larger gravel/cobbles found in the 300 Area, while providing the sample volumes needed. Alternative drilling methods may be used with approval of the OU technical lead in consultation with the well maintenance and drilling manager. To avoid potential impact to the representativeness of vadose zone and PRZ soil samples, all efforts must be made to drill without the use of slurry makeup water. In the event that drilling slurry makeup water is needed, the situation must be discussed with project technical staff before proceeding.

Boreholes will be drilled to approximately 105.6 m (346.5 ft) (NAVD88), which is expected to be at approximately10.8 m (35.3 ft) bgs (depth does not include additional drilling pad thickness, if any). The final total depth of the boreholes will be confirmed by the drilling buyer's technical representative and site geologist and may change depending on the actual ground surface elevation or subsurface conditions encountered. In the event that subsurface conditions prevent completion of the borehole to its intended depth, the OU project manager will be consulted to determine the path forward (e.g., re-drill the borehole at another location or accept the modified final depth for that borehole).

Proposed borehole locations are shown on Figure 3, with the estimated NAD83, *North American Datum of 1983* coordinates provided in Table 4.

Table 4. Estimated Location Coordinates for Proposed Boreholes (NAD83 State Plane)

Location	Borehole Identification	Northing (m)	Easting (m)
1	C8933	116437	594120
2	C8936	116482	594165
3	C8938	116527	594165

Source: NAD83, *North America Datum of 1983.*

2.3 Sampling Methods

To ensure sample and data usability, the sampling associated with this SI will be performed in accordance with DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD), pertaining to sample collection, collection equipment, and sample handling. Soil samples will be collected throughout the length of the borehole, initiating at approximately 3 m (10 ft) bgs into the the top of the aquifer at approximately 105.6 m (346.5 ft) (NAVD88) which is anticipated to be approximately one split-spoon sampler length into the aquifer (Figure 4). Sampling will be performed using a 10.2 cm (4 in.) diameter, 0.76 m (2.5 ft) long split-spoon sampler. The split-spoon samplers will be equipped with four separate polycarbonite liners that are each 15.2 cm (6 in.) long. If sufficient sample recovery is not achieved, soil from the split-spoon drive shoe may be used to supplement the sample mass of the split-spoon liners. Site personnel will not overdrive the sampling device.

Upon retrieval of the split-spoon sampler, each split-spoon liner will be labeled at the top and bottom with the appropriate depths (e.g., 6.1 m [20 ft] and 6.2 m [20.5 ft]) and labeled according to borehole number (i.e., C8933). Each split-spoon liner will also be labeled regarding its position in the split spoon (i.e., A, B, C, or D; with the bottom/deepest liner being "A" to the uppermost liner being "D"). Figure 5 provides a diagram of the labeling convention. A continuous line will be drawn the length of the split-spoon liner with an arrow pointing to the shallowest end of the liner (i.e., with an "up" arrow indicating core orientation). Once the split-spoon liners have been appropriately labeled, photos will be taken of each split-spoon liner as described in Section 2.3.4. Collection of samples will have the following priority: samples for determining total uranium, samples for performing uranium leachability characteristic tests, and the samples for performing the mineral phase and flow-through column tests.

2.3.1 Grab Samples for Total Uranium Analysis

At the three boreholes (Figure 3), soil grab samples will be collected from one liner of each split-spoon sampler, at approximately 0.8 m (2.5 ft) intervals, for laboratory analysis of total uranium. Results from total uranium analyses of samples obtained in the vadose zone and PRZ will provide information on the uranium concentration in the vadose zone and PRZ. The results will be used to refine the three-dimensional model of uranium soil concentrations in the region of the investigation. The refined three-dimensional model, along with the uranium leachability characteristics (Section 2.3.2), will be used to refine the location of the enhanced attenuation area. Figure 4 shows a diagram of the soil grab samples intervals. Figure 5 provides a diagram of the four polycarbonite liners within each split spoon and their intended uses for the samples collected from the vadose zone and PRZ. Soil from the split-spoon liner in position B (Figure 5) from each split-spoon sampler used within the vadose zone and PRZ will be transferred (while in the field) to a clean, stainless-steel mixing bowl and homogenized. A 20 g grab sample (<2 mm sediment size) from the homogenized soil in the bowl will be collected and containerized as described in Section 2.4.1. The remaining soil will be retained for further sampling for uranium leachability characteristics, mineral phase tests, or flow-through column analyses/tests, as described later in this SI.

In addition, one grab sample for total-uranium analysis will be collected from a split-spoon sampler driven into the top of the aquifer (see Figure 4). The grab sample may be collected from either liner A, B, or C. A 20 g grab sample (<2 mm sediment size) will be collected from the homogenized soil in a clean, stainless-steel mixing bowl and containerized as described in Section 2.4.1. There is no need to retain any remaining soil from this split-spoon sampler. The purpose of these samples is to compare the total uranium concentrations found in the saturated sediments with the sediments in the vadose zone and PRZ.

For each of the boreholes, approximately 10 total uranium grab samples are anticipated. Adjustments to the sample collection depth intervals may be made with input from the OU technical lead after field screening results (Section 2.3.5) are evaluated. For each borehole, additional grab samples for total uranium analysis may be collected based on conditions observed in the field. These conditions of interest include zones of elevated radiological contamination (observed by field screening) or significant changes in lithology as noted by the site geologist..

Results from analysis of the total uranium grab samples taken from the three boreholes will be used to determine what samples (location and soil horizon) to use for the uranium leachability characteristic tests. A summary of the total uranium grab samples is provided in Table 5.

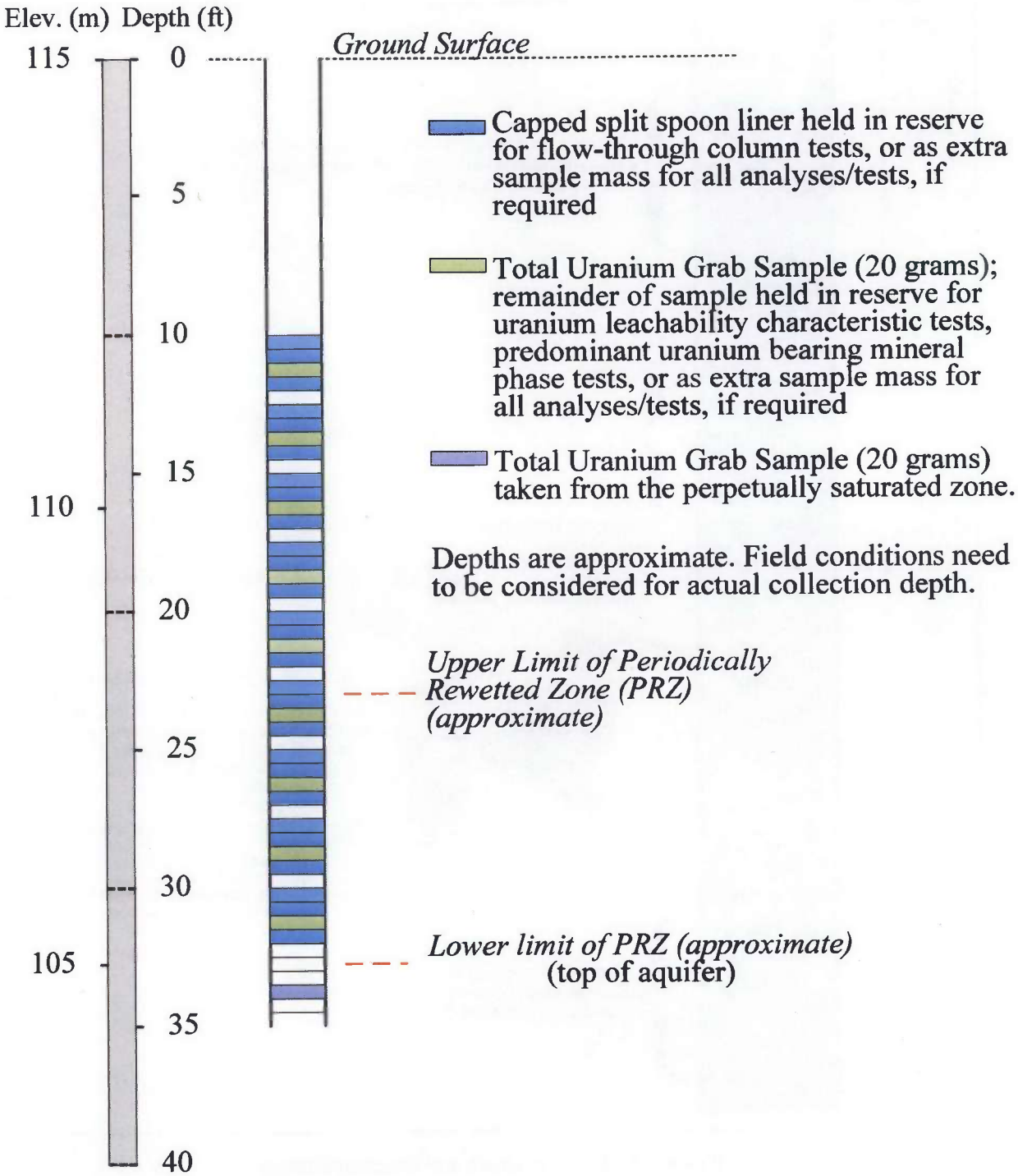


Figure 4. Target Sample Intervals for Proposed Boreholes

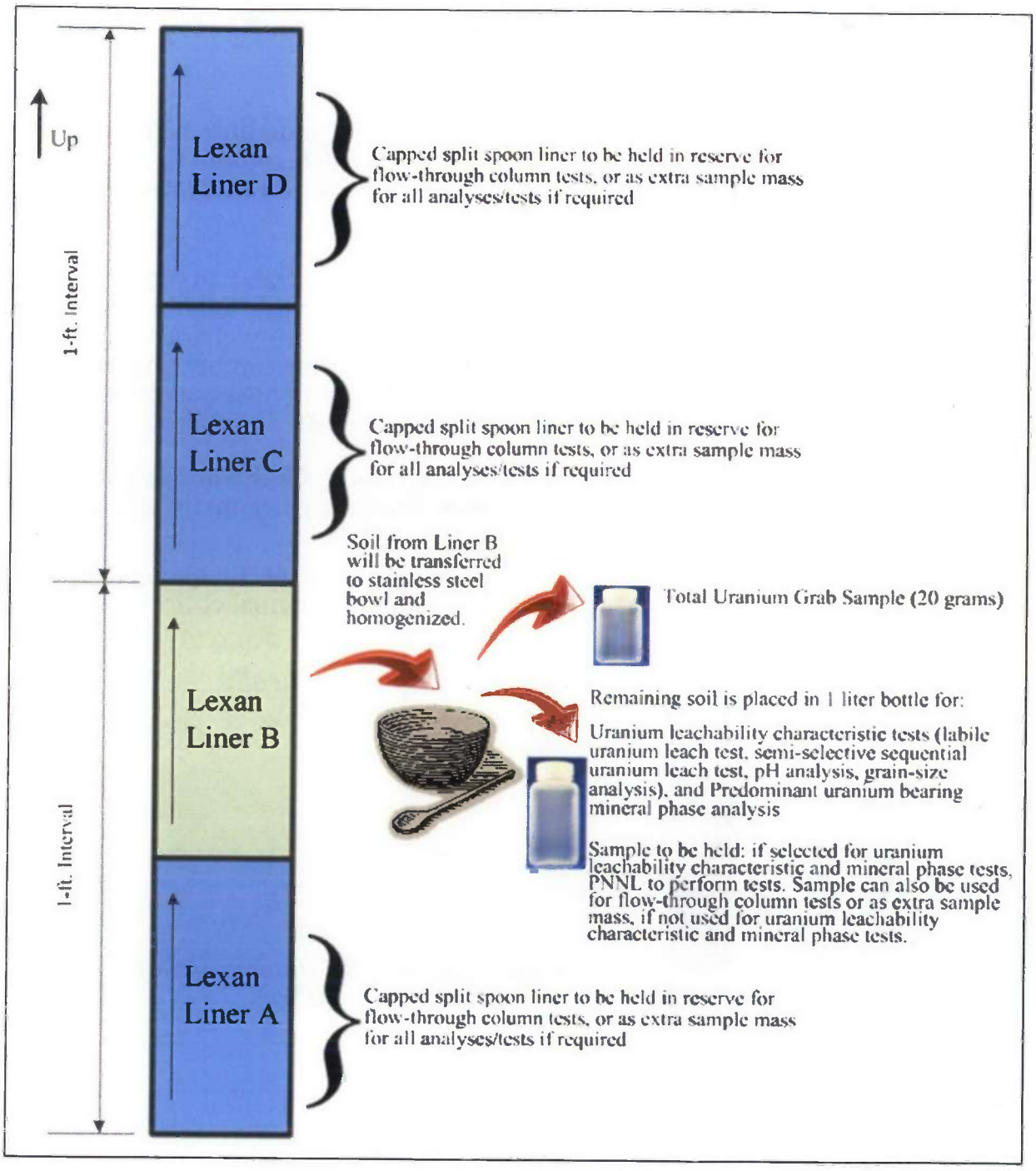


Figure 5. Split-Spoon Liners and Sampling Strategy

1

Table 5. Borehole Locations and Depths

Sample Location		C8933, C8936, C8938	
Estimated Depth to Water		7 to 10 m (23 to 32.8 ft) bgs	
Projected Total Depth		Approximately 10.8 m (35.3 ft) bgs	
Media	**Sample Type** [a]	**Estimated Depth**	**Analytes**
Soil	Grab sample from split-spoon liners in position B [b]	Sample collected at approximately 0.8 m (2.5 ft) intervals from split-spoon liners in position B. Split-spoon sampler to collect samples beginning at 3 m (10 ft) bgs to approximately 0.76 m (2.5 ft) into the aquifer.	Total uranium (<2 mm grain-size fractions)
	Grab sample from split-spoon liners in position B and/or intact split-spoon liners from positions A, C, and D.	Sample location and soil horizon to be selected based on combination of total uranium soil concentration data with the three-dimensional model of uranium soil concentrations. One sample from within the vadose zone and one from within the PRZ.	Uranium using semi-selective chemical extraction (<2 mm grain-size fractions)
			Labile uranium using sodium bicarbonate/ carbonate extraction (<2 mm grain size fractions)
			pH analysis
			Grain size (laboratory analysis)
			Predominant uranium-bearing mineral phase (<2 mm grain-size fractions)
	Intact split-spoon liners from positions A, C, and D	Split-spoon sampler to collect samples beginning at 3 m (10 ft) bgs to lower limit of the PRZ. Sample location and soil horizon to be determined by project team.	Field texture sediment flow-through column test
			<2 mm grain-size fractions flow-through column test
	All split-spoon liners	Continuous	Lithology description Core photographs

Note: Depths are approximate; field conditions need to be considered for actual collection depth.

a. Does not include samples for quality assurance/quality control.

b. Grab sample from split spoon liners in position A, B, or C may be used for samples collected from within the saturated zone (aquifer).

bgs = below ground surface

PRZ = periodically rewetted zone

2.3.2 Samples for Uranium Leachability Characteristic Tests

At the three boreholes, uranium leachability characteristic tests will provide information about the leachability characteristics of the uranium in the vadose zone and PRZ. The results from the uranium leachability characteristic tests, along with the refined three-dimensional model of uranium soil concentrations, will be used to refine the location of the enhanced attenuation area.

Once the 20 g total uranium analysis grab samples from each split-spoon sampler (from split-spoon liners in position B from the vadose zone and PRZ, as mentioned in Section 2.3.1) have been taken from the stainless-steel mixing bowls, the remaining homogenized soil (approximately 1 L [0.3 gal]) will be collected and containerized, as detailed in Section 2.4.1. For each of the boreholes, approximately nine 1 L (0.3 gal) containerized grab samples from the vadose zone and PRZ are anticipated to be held/stored until a decision is made whether the samples will be used for uranium leachability characteristic tests. The sample mass may be used for other analyses/tests, if not used for the leachability tests.

In addition, soil from split-spoons liners in positions A, C, and D from the vadose zone and PRZ may also be used for uranium leachability characteristic tests. The sample location and soil horizons where the uranium leachability characteristic tests will be performed will be determined by the project team, based on the three-dimensional model of uranium soil concentrations. Each of the three boreholes will have two uranium leachability characteristics samples analyzed: one sample from within the vadose zone, and the another sample from within the PRZ.

The uranium leachability characteristics will be determined through a set of tests that include a semi-selective sequential uranium leach test, labile uranium leach test, pH analysis, and a grain-size analysis. These tests are collectively referred to as the uranium leachability characteristics analyses in this SI. Figure 4 shows a diagram of the uranium leachability characteristic sample intervals to be collected. Figure 5 provides a diagram of the liner positions and of the sampling strategy. A summary of the uranium leachability characteristics samples is provided in Table 5.

2.3.3 Samples for Uranium-Bearing Mineral Phase Analysis and Flow-Through Column Tests

A predominant uranium-bearing mineral phase analysis will be performed on samples selected for the uranium leachability characteristic tests (Section 2.3.2). The flow-through column tests will be performed on vadose zone and PRZ samples collected from the three boreholes. The flow-through column tests will be conducted in pairs; one with field-textured sediments (remove ≥128 mm cobbles) and one with <2 mm size fraction from the same split-spoon liner location(s). Both the mineral phase analysis and the column tests will be used to support the conceptual site model and to refine the uranium transport model.

For the flow-through column tests, intact split-spoon liners will be collected from each split spoon from liner positions A, C, and D (Figure 5) from the vadose zone and PRZ. For each of the three boreholes, approximately 27 intact split-spoon liners from the vadose zone and PRZ are anticipated to be collected. Upon retrieving the split-spoon sampler and labeling and photographing each split-spoon liner, end caps will be placed on the intact liners from liner positions A, C, and D and securely taped to prevent the caps from coming off during transport or storage. If sufficient sample recovery is not achieved for the liners from positions A, C, and D, soil from the split-spoon drive shoe may be used to supplement the sample mass of the split-spoon liner. If soil from one split-spoon liner is not adequate to conduct the flow-through column tests, then the nearest samples held in reserve for other tests, if not needed, may be used as long as the entire sample mass comes from the same split spoon. Soil immediately adjacent to the liner selected for the column tests is preferred to soil from a liner that is positioned further away in the split spoon.

All split-spoon liners from the vadose zone and PRZ will be held/stored until a decision is made by the project team regarding which samples intervals (location and soil horizons) will be used. Unused split-spoon liners will be maintained until final intervals are selected for all of the analyses/tests for this SI (i.e., uranium soil concentration, leachability tests, pH analysis, grain-size measurements, mineral phase analysis, and flow-through column tests). Unused split-spoon liners will be archived until tests are complete. A summary of the mineral analysis and flow-through column tests samples are provided in Table 5.

2.3.4 Additional Data Collection Activities

The site geologist will provide a lithologic description of each split-spoon liner, noting the soil size fractions and capturing a sample photo log. The ends of each split-spoon liner will be photographed in the field prior to capping or transfer to the stainless-steel bowl. Decommissioning of boreholes will occur once approved by the OU project manager and will be conducted in accordance with *Washington Administrative Code* (WAC) 173-160, "Minimum Standards for Construction and Maintenance of Wells."

2.3.5 Field Screening

Radiological field screening data, visual observation of lithologies, or site geologist professional judgment may be used to adjust borehole locations, select sample locations in split-spoon liners, assist in determining sample shipping requirements, and support worker health and safety monitoring. Section 2.3.7 describes radiological field screening methods.

2.3.6 Decontamination of Sampling Equipment

Sampling equipment shall be decontaminated in accordance with the sampling equipment decontamination methods. To prevent potential contamination of samples, care should be taken to use decontaminated equipment for each sampling activity.

2.3.7 Radiological Field Data

Radiological screening will be performed by the radiological control technician or other qualified personnel in accordance with approved methods and with HASQARD (DOE/RL-96-68), as applicable. The radiological control technician will record field measurements, noting the depth of the sample and the instrument reading. Measurements will be relayed to the site geologist for inclusion in the field logbook or operational records daily, as applicable.

2.4 Sample Handling

Sample handling and transfer shall be in accordance with established methods to preclude loss of identity, damage, deterioration, and loss of sample. Custody seals or custody tape shall be used to verify that sample integrity has been maintained during sample transport. The custody seal will be inscribed with the sampler's initials and date.

A sampling and data tracking database is used to track the samples from the point of collection through the laboratory analysis process.

2.4.1 Containers

Pre-cleaned sample containers with certificates of analysis denoting compliance with EPA 540/R-93/051, *Specifications and Guidance for Contaminant-Free Sample Containers*, for the intended analyses will be used for soil samples collected for chemical analysis. The Radiological Engineering organization will measure the contamination levels and the dose rates associated with the filled sample containers. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received by the analytical laboratory in

accordance with the laboratory's radioactivity acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, the field work supervisor (in consultation with the Sample Management and Reporting [SMR] organization) may send smaller volumes to the laboratory. Suggested sample container, preservation, and holding time requirements are specified in Table 6. These requirements are in accordance with the analytical method specified. The final container type and volumes will be identified on the sampling authorization form (SAF) and chain-of-custody form.

Table 6. Sample Preservation, Container, and Holding Time Guidelines

Analytes	Bottle Size/Type	Minimum Sample Size	Preservation	Holding Time
Total uranium	60 mL glass/plastic	20 g	N/A	6 months
Uranium using semi-selective chemical extraction (<2 mm grain-size fractions)	1,000 mL glass/plastic	Split-spoon liner sediment that remains in stainless-steel bowl after removal of 20 g total uranium sample	N/A	6 months
Labile uranium using sodium bicarbonate/ carbonate extraction (<2 mm grain-size fractions)				
pH				
Grain size				
Predominant uranium-bearing mineral phase (<2 mm grain-size fractions)				
Field-textured sediment flow-through column test	Polycarbonate liner	10.2 cm (4 in.) diameter by 15.2 cm (6 in.) long liner	N/A	6 months
<2 mm grain-size fractions flow-through column test				

N/A = not applicable

2.4.2 Container Labeling

Each sample container will be labeled with the following information on firmly affixed, water-resistant labels:

- SAF number
- Sampler's name
- Sample collection date and time
- Analysis required
- Chain-of-custody number
- Bottle type and size
- Laboratory performing the analyses
- Sample location

- Hanford Environmental Information System (HEIS) number
- Preservation method (if applicable)

Sample records must include the following information:

- Analysis required
- Source of sample
- Matrix (e.g., water or soil)
- Field data (e.g., radiological readings)

2.4.3 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure that sample integrity is maintained throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory.

The following information is required on a completed chain-of-custody form:

- Project name
- Printed name of sampler
- Unique sample number
- Date and time of collection
- Signatures of individual involved in sample transfer
- Matrix
- Preservative
- Requested analyses (or reference thereto)
- Date and time of transfer

2.4.4 Sample Transportation

All packaging and transportation instructions shall be in compliance with applicable transportation regulations and U.S. Department of Energy requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation as described in 49 *Code of Federal Regulations* (CFR) 171, "General Information, Regulations, and Definitions," through 177, "Carriage by Public Highway." Carrier-specific requirements, defined in *Dangerous Goods Regulations* (IATA, 2014), shall also be used when preparing sample shipments conveyed by air freight providers.

Prior to shipping radioactive samples to the laboratory, the organization responsible for shipping shall notify the laboratory of the approximate number and radiological levels of the samples. This notification is conducted through the SMR project coordinator. The laboratory is responsible for ensuring that the applicable license limits are not exceeded. The laboratory shall provide the SMR organization with written acceptance for samples with elevated radioactive contamination or dose.

2.5 Analytical Methods

Analytical method performance requirements for soil samples collected from the three boreholes are presented in Table 7. Total uranium analytical results (grab samples) from the three boreholes will be provided within a 3-day turnaround period (for preliminary results), with final results provided within 15 days. The quick-turnaround times are required to support the selection of location and soil horizons of samples for the uranium leachability characteristic tests.

Deviations from the analytical methods noted in Table 7 must be approved in accordance with Section 2.8.3 and in accordance with the HASQARD (DOE/RL-96-68). The SMR organization, in consultation with the OU project manager, shall take the lead in ensuring that deviations from the

analytical methods noted in Table 7 are properly approved. Issues that may affect analytical results are to be resolved by the SMR organization in coordination with the OU project manager.

2.5.1 Semi-Selective Sequential Uranium Leach Test

Semi-selective sequential uranium leach testing uses a semi-selective chemical extraction technique as described in PNNL-14022, *300 Area Uranium Leach and Adsorption Project*, and PNNL-21733, *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediments*, on 300 Area uranium-contaminated sediments. The test will be used to determine the percentage of uranium present in the extractable phases of carbonate coatings, carbonate solid-bearing compounds, amorphous hydrous oxides, crystalline iron (III) oxides, and strong acid leachable compounds. Each extractant solution will be collected and analyzed for calcium, aluminum, iron, and manganese via inductively coupled plasma-optical emission spectroscopy and uranium content via inductively coupled plasma-mass spectrometry.

Table 7. Analytical Performance Requirements

Analyte	Matrix	Analytical Method[a]	PQL[b]	Precision Requirement (%)[c]	Accuracy Requirement (%)[c]
Nonradiological					
Uranium (total)	Soil	ICP-MS 6020	150 µg/kg	≤30	70-130
Uranium (total)	Sodium bicarbonate/ carbonate leachate[d]	ICP-MS	N/A	N/A	N/A
Uranium (total)	Semi-selective chemical extraction leachate[e]	ICP-OES/ICP-MS	N/A	N/A	N/A
Predominant uranium-bearing mineral phase	Soil	SEM/EDS	N/A	N/A	N/A
Uranium (total)	Soil	Flow-through column tests	N/A	N/A	N/A
pH analysis	Water leachate from leach tests	EPA Method 150.1 or EPA 9040	0.1 pH unit	≤20	90-110
Physical Properties					
Grain-size (sieve) analysis	Soil	ASTM D422-63	N/A	N/A	N/A
Lithology	Soil	Geologic description	N/A	This method has no quantitative requirements beyond adherence to the laboratory methodology.	

Table 7. Analytical Performance Requirements

Analyte	Matrix	Analytical Method[a]	PQL[b]	Precision Requirement (%)[c]	Accuracy Requirement (%)[c]

Sources:

ASTM D422-63, *Standard Test Method for Particle Size Analysis of Soils.*

EPA Method 150.1, "pH (Electrometric)."

SW-846, Method 6020, "Inductively Coupled Plasma-Mass Spectrometry."

SW-846, Method 9040, "pH Electrometric Measurement."

a. Analytical method selection is based on available methods by laboratories currently contracted to the Hanford Site. However, equivalent methods may be substituted. For the three-digit EPA methods, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes.* For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

b. The PQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The PQL is generally 5 to 10 times the method detection limit. For many analytes, the PQL analyte concentration is selected as the lowest non-zero standard in the calibration curve. Contract required detection limits are equivalent to the PQLs.

c. Precision and accuracy requirements as defined in EPA procedures and implemented by laboratory analysis and quality assurance procedures. Precision criteria for batch laboratory replicate sample analyses. Accuracy criteria for associated batch laboratory control sample percent with additional evaluations also performed for matrix spikes, tracers, and carriers as appropriate to the method.

d. Leach test (<2 mm grain-size sediment) will use sodium bicarbonate/carbonate solution as recommended in "Methods for Estimating Adsorbed Uranium (VI) and Distribution Coefficients of Contaminated Sediments" (Kohler et al., 2004), and will be performed as described in PNNL-22032, *Uranium in Hanford Site 300 Area: Extraction Data on Borehole Sediments.*

e. Semi-selective sequential uranium leach test will use a semi-selective chemical extraction technique as described in PNNL-14022, *300 Area Uranium Leach and Adsorption Project*, and PNNL-21733, *Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediments.*

ASTM = American Society for Testing Materials
EPA = U.S. Environmental Protection Agency
ICP-MS = inductively coupled plasma-mass spectrometer
ICP-OES = inductively coupled plasma- optical emission spectroscopy
N/A = not applicable
PQL = practical quantitation limit
SEM/EDS = scanning electron microscope/energy dispersive x-ray spectroscopy

2.5.2 Labile Uranium Leach Test

The labile uranium leach test is a second measure of readily leachable uranium to estimate the percent of total uranium that is leachable during the river-stage dynamics observed in the PRZ. The method is described in detail in "Methods for Estimating Adsorbed Uranium (VI) and Distribution Coefficients of Contaminated Sediments" (Kohler et al., 2004), and uses a sodium bicarbonate (1.44×10^{-2} M) sodium carbonate (2.8×10^{-3} M) extraction solution at a pH of 9.45. The batch leach test is performed for 1,000 hours with the pH monitored to ensure that it does not drop below 8.8, and total dissolved uranium is measured periodically until a steady-state concentration is attained.

2.5.3 Scanning Electron Microscope/Energy Dispersive X-Ray Spectroscopy and/or Cryogenic Laser Fluorescence Spectroscopy

In this test, a small amount of the sediment is exposed to an electron beam using a scanning electron microscope. Dispersed x-ray signals generated during scanning provide analysis of the elemental composition of the sample material. The cryogenic laser fluorescence instrument can identify the

sediment phases to which uranium is associated. Both techniques may be considered for use on <2 mm size fraction particles once the total uranium concentrations are known.

2.5.4 Flow-Through Column Leach Tests

Flow-through column leach tests are performed in order to determine the amount of uranium that can be removed from the sediment. For field-sized sediment, one of the split-spoon liners is used as received (10.2 cm [4 in.] diameter by 15.2 cm [6 in.] long). For the <2 mm particle size columns, the column size is chosen to minimize wall effects and to ensure uniform influent coverage inside the column (length of column must be greater than four times the diameter). The <2 mm particle size columns are filled in increments and tamped as they were filled in order to minimize void space and channelized flow within the columns. The weight of the water-saturated, sediment-filled apparatus and the weight of the dry sediment placed in the <2 mm particle size columns, along with the known volume of the columns, are used to calculate the column pore volume and sediment bulk density of each column, respectively. In addition, a conservative tracer bromide anion is used to aid in determining travel times.

Column leach tests are performed by slowly percolating air-saturated upgradient groundwater or Columbia River water in an upflow direction in order to remove as much trapped air as possible, thus creating near water saturation conditions. Twice during the flow-through column tests, the flow are stopped for periods of time between 48 and 72 hours and then restarted to allow release kinetics to be determined from the increased uranium concentrations found immediately after flow is resumed.

2.6 Quality Control Requirements

2.6.1 Field Quality Control Samples

Field quality control (QC) samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to field sampling variability. One field duplicate and one equipment blank sample will be collected for every borehole. Field duplicates are independent samples collected as close as possible to the same point in space and time and should be collected generally from an area expected to have some contamination so valid comparisons between the samples can be made. Field duplicates will be collected from the stainless-steel bowl of homogenized soil used for the grab samples. Field duplicate results can be an indication of sample error. Equipment blanks will be collected from any sampling device that is reused. The equipment blanks will be collected using either silica sand or distilled water and will be analyzed for the target analyte. If disposable (i.e., single-use) equipment is used, equipment blanks are not required. Equipment blank results greater than two times the method detection limit are identified as containing suspected contamination.

2.6.2 Laboratory Quality Control Samples

Laboratory QC samples (e.g., method blanks, laboratory control samples/blank spikes, and matrix spikes) are defined for the three-digit U.S. Environmental Protection Agency (EPA) methods (EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*) and for the four-digit EPA methods (SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*) and are also defined in HASQARD (DOE/RL-96-68). The QC samples will be run at the frequency specified in the respective reference, unless superseded by agreement between the primary contractor and the laboratory.

2.6.3 Data Usability

In order to determine whether data collected conform to specified criteria and satisfy the objectives of the field investigation, data review and verification activities are performed. The data review and verification activities include a review for completeness (all samples were analyzed as requested, chain-of-custody documentation is complete, and scientific studies were conducted as requested); use of the correct

analytical method/procedure; review for transcription errors; correct application of dilution factors; appropriate reporting of dry weight versus wet weight; and correct application of conversion factors. Laboratory personnel may perform data verification.

In addition, the OU project manager may determine that a data quality assessment (DQA) is necessary to compare completed field sampling activities to those proposed in corresponding sampling documents and to evaluate the resulting data. This is applicable to the analytical data obtained for total uranium and the pH analyses. The purpose of the data evaluation is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project's needs. The DQA (if performed) with be in accordance with the EPA/240/B-06/002, *Data Quality Assessment: A Reviewer's Guide* (QA/G-9R), and EPA/240/B-06/003, *Data Quality Assessment: Statistical Tools for Practitioners* (EPA QA/G-S). The responses to data quality defects identified through the DQA process will vary and may be data-specific or measurement-specific. Some pre-identified corrective actions for total uranium and pH analyses are identified in Table 8.

2.7 Instrument and Equipment

Field and analytical instruments will be calibrated and maintained as described in the 300 Area RI/FS SAP (DOE/RL-2009-45).

2.8 Documentation

The OU project manager is responsible for ensuring that a project file is properly maintained as described in the 300 Area RI/FS SAP (DOE/RL-2009-45).

2.8.1 Documentation of Field Activities

Field activities will be documented as described in the 300 Area RI/FS SAP (DOE/RL-2009-45).

2.8.2 Corrective Actions and Deviations for Sampling Activities

The OU project manager, field team lead, or designee must document deviations from procedures or other issues related to sample collection, chain-of-custody, analytes, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected due to field conditions, changes in sample locations due to physical obstructions, or additional samples taken.

As appropriate, such deviations or issues will be documented in the field logbook or on nonconformance report forms in accordance with internal corrective action procedures. The OU project manager, field team lead, or designee will be responsible for communicating field corrective action requirements and for ensuring that immediate corrective actions are applied to field activities.

The field team lead or designee (e.g., site geologist) will use the following criteria during borehole drilling to evaluate whether the planned sample depths and intervals are still accurate and to make adjustments as needed to the depths and quantities of samples to be obtained:

- Radiological field screening data
- Visual observation of lithology and moisture conditions, specifically noting the amount of gravel
- Visual observation of contamination
- Changes in drilling rate
- Site geologist professional judgment
- Changes in project requirements

Table 8. Data Quality Indicators for Total Uranium pH Analyses

Data Quality Indicator	Definition*	Determination Methodologies	Corrective Actions
Precision	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity) • Request reanalysis or re-measurement • Qualify the data before use
Accuracy	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. Quality control analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use • Request reanalysis or re-measurement
Representativeness	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring that the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for them not being representative • Reject the data, or, if data are otherwise usable, qualify the data for limited use and define the portion of the system that the data represent • Redefine sampling and measurement requirements and protocols • Resample and reanalyze, if needed

Table 8. Data Quality Indicators for Total Uranium pH Analyses

Data Quality Indicator	Definition*	Determination Methodologies	Corrective Actions
Comparability	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and quality assurance protocols.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable. • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability
Completeness	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's data needs	If data set does not meet completeness objective: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability

Table 8. Data Quality Indicators for Total Uranium pH Analyses

Data Quality Indicator	Definition*	Determination Methodologies	Corrective Actions
Bias	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike).	For sampling bias: • Properly select and use sampling tools • Institute correct sampling and subsampling procedures to limit preferential selection or loss of sample media • Use sample handling procedures, including proper sample preservation, that limit the loss or gain of constituents to the sample media Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias. Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation • Qualify/reject the data before use

* Source: SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition, Final Update V*, as amended.

These criteria may also be used by other field personnel, as necessary, to assist in determining sample shipping requirements and to support worker health and safety monitoring.

Changes in sample locations not affecting the SI objectives will require notification and approval of the OU project manager. Changes to sample locations affecting the SI objectives will require concurrence from U.S. Department of Energy, Richland Operations Office (DOE-RL) and the lead regulatory agency.

2.8.3 Change Control

The OU project manager is responsible for tracking all changes and obtaining appropriate reviews by contractor staff. The OU project manager will discuss the change with DOE-RL. DOE-RL will then discuss with the lead regulatory agency significant and fundamental changes, as described in Sections 9.3 and 12.4 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989a) Action Plan (*Hanford Federal Facility Agreement and Consent Order Action Plan* [Ecology et al., 1989b]). Appropriate documentation will follow, in accordance with the requirements for the type of change. Changes to this SI are handled consistent with HASQARD (DOE/RL-96-68) and the Tri-Party Agreement Action Plan. Table 9 summarizes the changes that may be made and their documentation requirements.

Table 9. Change Control for Sampling Projects

Type of Change[a]	Type of Change (Tri-Party Agreement Action Plan[b])	Action	Documentation
Minor change: Change has no impact on the sample or field analytical result, and little or no impact on performance or cost. Further, the change does not affect the SI objectives.	**Minor field change:** Changes have no adverse effect on the technical adequacy of the job or the work schedule.	The field personnel recognizing the need for a field change will consult with the OU project manager prior to implementing the field change.	Minor field changes will be documented in the field logbook. The logbook entry shall include the field change, the reason for the field change, and the names and titles of those approving the filed change.
Significant change: Change has a considerable effect on performance or cost but still allows for meeting the SI objectives.	**Minor change:** Changes to approved plans that do not affect the overall intent of the plan or schedule.	The OU project manager will inform the DOE-RL project manager and the regulatory lead of the change and seek concurrence at a unit managers' meeting or comparable forum. The lead regulatory agency determines there is no need to revise the document.	Documentation of this change approval would be made in the unit managers' meeting minutes or comparable record such as a change notice.[c]

Table 9. Change Control for Sampling Projects

Type of Change[a]	Type of Change (Tri-Party Agreement Action Plan[b])	Action	Documentation
Fundamental change: Change has significant effect on the sample or the field analytical result, performance, or cost, and the change does not meet the requirements specified in the SI objectives.	**Revision necessary:** Lead regulatory agency determines changes to approved plans require revision to document.	If it is anticipated that a fundamental change will require approval of the regulatory lead, the applicable DOE-RL project manager will be notified by the OU project manager and will be involved in the decision prior to implementation of a fundamental change. The lead regulatory agency determines the change requires a revision to the document.	Formal revision of the sampling document.

a. Consistent with DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD).

b. Consistent with Sections 9.3 and 12.4 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b).

c. The Tri-Party Agreement Action Plan (Ecology et al., 1989b), Section 9.3, defines the minimum elements of a change notice.

DOE-RL = U.S. Department of Energy, Richland Operations Office

OU = operable unit

SI = sampling instruction

Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)

3 Waste Management

Waste materials are generated during sample collection and processing. The method of identification, storage, and disposition of hazardous, radioactive, or mixed waste materials and unused samples (including unexpected waste) generated by sampling activities will be managed in accordance with DOE/RL-2000-56, *Waste Management Plan for the 300-FF-5 Operable Unit*, and must be characterized to the extent necessary to meet the requirements of DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*, and the waste acceptance criteria for the relevant disposal facility.

Offsite analytical laboratories are responsible for disposal of unused sample quantities. If generated, unused samples or waste from offsite laboratories will not be returned without prior approval of the DOE-RL project manager pursuant to 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions."

Between 2006 and 2011, 38 wells or boreholes (identified in Table 10) were previously drilled within 100 m (328 ft) of the post-ROD field investigation site described in this SI. As sufficient waste characterization knowledge exists and these previously drilled wells are both spatially and temporally relevant, no additionally sampling and analysis is expected in order to characterize drilling wastes from

the boreholes (C8933, C8936, and C8938) of this SI. Instead, a waste profile will be created for disposal at the Environmental Restoration Disposal Facility (ERDF) that includes the highest detected results from soil samples in these previously drilled wells. To generate this list, the HEIS database was queried for all soil results in the 38 previously drilled wells.

Table 10. Wells/Boreholes Drilled Within 100 m (328 ft) of Study Area Between 2006 and 2011

C5000	C5357	C5627	C7118	C7125	C7654
C5351	C5358	C5628	C7119	C7126	C8027
C5352	C5359	C5629	C7120	C7127	C8028
C5353	C5387	C5630	C7121	C7128	
C5354	C5388	C5631	C7122	C7129	
C5355	C5389	C7116	C7123	C7130	
C5356	C5626	C7117	C7124	C7653	

The data set generated as a result of this query was rather large, including 4,811 unique results for chemical and radionuclide constituents in previous sampling and analysis activities. The data set was then pared by removing all nondetect results, all radiological results below ERDF's 1 pCi/g reporting limit, all chemical and geophysical results that are not a waste management concern (e.g., total/inorganic carbon, bulk density, and particle size), and all but the highest result for each chemical or radiological constituent. The data are summarized in Table 11. For waste management purposes during these sampling activities, these constituents will be noted for possible inclusion on the ERDF waste stream profile. If field conditions indicate a potential anomaly, analyses for the identified constituents may be conducted when field readings indicate contamination levels significantly higher than expected.

Table 11. Waste Characterization Estimates

1,2-Dichloroethene (total)	20 µg/kg	Magnesium	5,490 mg/kg
2-Butanone	1.5 µg/kg	Manganese	907 mg/kg
2-Ethylhexyl aldehyde	200 µg/kg	Mercury	0.104 mg/kg
3-Heptanone	69 µg/kg	Methylene chloride	3.3 µg/kg
4-Methyl-2-pentanone	1.2 µg/kg	Molybdenum	2.41 mg/kg
Acetone	68.3 µg/kg	n-Heptane	11 µg/kg
Aluminum	10,800 mg/kg	Nickel	54.5 mg/kg
Antimony	1.35 mg/kg	Nitrate	54.7 mg/kg
Aroclor-1254	5.99 µg/kg	Nitrogen in nitrite and nitrate	11.5 mg/kg
Aroclor-1260	22.8 µg/kg	n-Octane	8.3 µg/kg
Arsenic	4.87 mg/kg	Phosphate	113 mg/kg
Barium	221 mg/kg	Phosphorus	1,280 mg/kg
Beryllium	1.68 mg/kg	Potassium	1,370 mg/kg

Table 11. Waste Characterization Estimates

Bis(2-ethylhexyl) phthalate	1,140 µg/kg	Potassium-40	12.2 pCi/g
Bismuth	0.978 mg/kg	Selenium	2.29 mg/kg
Boron	1.43 mg/kg	Silicon	1,030 mg/kg
Bromide	1.2 mg/kg	Silver	1.45 mg/kg
Butyraldehyde	8.7 µg/kg	Sodium	903 mg/kg
Cadmium	1.49 mg/kg	Strontium	46.4 mg/kg
Calcium	7,940 mg/kg	Sulfate	40.7 mg/kg
Carbon disulfide	3.7 µg/kg	Thallium	1.54 mg/kg
Carbon tetrachloride	2.6 µg/kg	Tin	4.39 mg/kg
Chloride	158 mg/kg	Toluene	0.967 µg/kg
Chromium	99.7 mg/kg	Total petroleum hydrocarbons – gasoline range	1,400 µg/kg
cis-1,2-Dichloroethylene	32 µg/kg	Tritium	12.9 pCi/g
Cobalt	11.9 mg/kg	Uranium	67.6 mg/kg
Copper	112 mg/kg	Uranium-233/234	35.6 pCi/g
Fluoride	9.6 mg/kg	Uranium-235	2.91 pCi/g
Hexane	9.6 µg/kg	Uranium-238	38.6 pCi/g
Iron	30,400 mg/kg	Vanadium	97.1 mg/kg
Lead	8.24 mg/kg	Zinc	58.1 mg/kg
Lithium	7.67 mg/kg		

4 Health and Safety

The hazardous waste operations safety and health program is implemented for employees involved in hazardous waste site activities. The program was developed to comply with the requirements of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response," and 10 CFR 835, "Occupational Radiation Protection," to ensure the safety and health of workers during hazardous waste operations.

The health and safety program was developed to define the chemical, radiological, and physical hazards, and to specify the controls and requirements for day-to-day work activities on the overall Hanford Site. The program incorporates applicable core functions and guiding principles outlined in the Integrated Safety Management System and governs minimal personal training; control of industrial safety and radiological hazards; personal protective equipment; site control; and general emergency response to spills, fire, accidents, injury, and incident reporting.

Project field staff will be required to comply with the health and safety program at all times. Unescorted site visitors must have completed the required health and safety training before entering the work area. Escorted visitors are briefed on health and safety concerns and must be escorted by the site superintendent (or designee) at all times when they are in the work area.

During operations, emergency response will be covered by the health and safety program. The health and safety program specifies primary emergency response actions for site personnel, area alarms, implementation of the emergency action plan and emergency equipment at the task site, emergency coordinators, emergency response, and spill containment.

5 References

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