U.S. Department of Energy
Hanford Site

21-SGD-000863 March 24, 2021

Dr. Laura C. Buelow, Project Manager
Superfund and Emergency Management Division
Site Cleanup Section 4
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Richland, Washington 99352

Dear Dr. Buelow:

PARENT REBOUND STUDY SAMPLING AND ANALYSIS PLAN FOR THE 100-KR-4 OPERABLE UNIT, DOE/RL-2020-42, REVISION 0

This letter transmits the approved Parent Rebound Study Sampling and Analysis Plan (SAP) for the 100-KR-4 Operable Unit, DOE/RL-2020-42, Revision 0, to the U.S. Environmental Protection Agency (EPA). This SAP outlines groundwater sampling requirements for hexavalent chromium rebound studies within the 100-KR-4 Operable Unit (OU). The monitoring is focused on gathering data to assess remedy completion and to determine whether the current interim action, as identified in the interim action record of decision (ROD) EPA/ROD/R10-96/134, for the 100-HR-3 and 100-KR-4 OU Interim Remedial Actions, Hanford Site, Benton County, Washington, has met the remedial action objectives.

The U.S. Department of Energy at Hanford has worked closely with EPA to incorporate comments and revise the document.

If there are any questions please contact me, or you may contact Ellwood Glossbrenner, of my staff, on (509) 376-5828.

Sincerely,

Michael W. Cline Digitally signed by Michael W. Cline
Date: 2021.03.24 07:42:47 -07'00'

Michael W. Cline, Director
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SGD:ETG

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DOE/RL-2020-42 Rev 0

cc: See page 2

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DOE/RL-2020-42
Revision 0

Parent Rebound Study Sampling and Analysis Plan for the 100-KR-4 Operable Unit

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
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DOE/RL-2020-42
Revision 0

Parent Rebound Study Sampling and Analysis Plan for the 100-KR-4 Operable Unit

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office
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APPROVED
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Title: *Parent Rebound Study Sampling and Analysis Plan for the 100-KR-4 Operable Unit*

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Terms

ALARA	as low as reasonably achievable
AWLN	automated water level network
COC	contaminant of concern
DOE	U.S. Department of Energy
DOE/CAP-AP	U.S. Department of Energy Consolidated Audit-Accreditation Program
DOE-RL	U.S. Department of Energy, Richland Operations Office
DOT	U.S. Department of Transportation
DQI	data quality indicator
DUP	laboratory sample duplicate
DQO	data quality objective
EB	equipment blank
Ecology	Washington State Department of Ecology
ESD	explanation of significant difference
FSO	Field Sample Operations
FTB	full trip blank
FWS	Field Work Supervisor
FXR	field transfer blank
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Documents*
HEIS	Hanford Environmental Information System
IATA	International Air Transportation Association
LCS	laboratory control sample
LRA	lead regulatory agency
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
OU	operable unit
P&T	pump and treat
PRZ	periodically rewetted zone

PSQ	principal study question
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
QSM	Quality Systems Manual
RAO	remedial action objective
RCT	radiological control technician
RD/RAWP	remedial design/remedial action work plan
ROD	record of decision
RUM	Ringold Formation upper mud
Rwie	Ringold Formation member of Wooded Island – unit E
S&GRP	Soil and Groundwater Remediation Project
SAF	sample authorization form
SAP	sampling and analysis plan
SMR	Sample Management and Reporting
SPLIT	field split sample
SUR	surrogate
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VOC	volatile organic compound

1 Introduction

This sampling and analysis plan (SAP) outlines groundwater sampling requirements for hexavalent chromium (Cr(VI)) rebound studies within the 100-KR-4 Operable Unit (OU). The monitoring is focused on gathering data to assess remedy completion and to determine if the current interim action, as identified in the interim action record of decision (ROD) EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington* (hereinafter referred to as the 100-KR-4 interim remedial action ROD), has met the remedial action objectives (RAOs). The RAOs for the 100-KR-4 OU are as follows:

- RAO 1: Protect aquatic receptors in the river bottom substrate from contaminants in the groundwater entering the Columbia River.
- RAO 2: Protect human health by preventing exposure to contaminants in groundwater.
- RAO 3: Provide information that will lead to a final remedy.

The 100-KR-4 OU contains groundwater contaminated by releases from facilities and waste sites associated with past operation of the 105KE and 105KW Reactors (Figure 1-1). The Cr(VI) released from these facilities and waste sites poses a risk to human health and/or the environment and was identified in 100-KR-4 interim remedial action ROD (EPA/ROD/R10-96/134) as the primary groundwater contaminant of concern (COC) in the 100-KR-4 OU. In documents for 100-KR-4, remedial concentration levels for Cr(VI) are referred to as cleanup levels, standards, remedial action goals, and cleanup targets, often interchangeably. Table 1-1 highlights the origins and applicability of these terms. For the purposes of this document, the term "target" will apply to the 20 µg/L interim action ROD value that will be used to determine when a rebound study might be appropriate for a given area.

Table 1-1. Cr(VI) Remediation Terms and Levels for the 100-KR-4 Operable Unit

Cr(VI) Concentration	Term	Applicability	Source and Year
48 µg/L	Cleanup level or standard	Inland areas of 100-KR-4	Interim action ROD (EPA/ROD/R10-96/34), 1996
20 µg/L	Target	Inland areas of 100-KR-4	Interim action ROD amendment (EPA/AMD/R10-00/122), 1999
			100-KR-4 RD/RAWP (Section 6.2 in DOE/RL-2013-33)
	Remedial action goal	Inland areas of 100-KR-4	100-KR-4 RD/RAWP (Section 2.3 in DOE/RL-2013-33)
10 µg/L	Cleanup level or standard	At the Columbia River	Ambient water quality standard (WAC 173-201A), 1996

Note: Complete reference citations are provided in Chapter 6.
ROD = record of decision

As described in DOE/RL-2013-33, *Remedial Design/Remedial Action Work Plan for the 100-KR-4 Groundwater Operable Unit* (as modified by TPA-CN-0858), hereinafter referred to as the 100-KR-4 remedial design/remedial action work plan (RD/RAWP), once groundwater Cr(VI) concentrations are at or below the interim remedial action target, a rebound study will be initiated to determine if contaminant concentrations will remain below cleanup levels when the aquifer is no longer under the influence of active remedial processes. If Cr(VI) concentrations remain at or below the cleanup levels, then active remediation may be terminated in these areas. However, if results of the rebound study indicate the presence of continuing sources of groundwater contamination in the periodically rewetted zone (PRZ) and in the

overlying vadose zone, then the site will return to active remediation, and the potential secondary source should be evaluated for further action. The PRZ is the portion of the deep vadose zone between the seasonal high and low groundwater elevations. In areas of known or suspected deep vadose zone contamination, daily and seasonal fluctuations in river stage can mobilize contaminants in the PRZ into groundwater.

The U.S. Department of Energy, Richland Operations Office (DOE-RL) has undertaken preparation of this parent rebound study SAP because as of January 1, 2020, several areas within the 100-KR-4 OU are starting to exhibit Cr(VI) concentrations below the interim action groundwater remedial target concentration of 20 µg/L. This remedial target concentration was established in the 2009 explanation of significant differences (ESDs) to the interim remedial action ROD (EPA et al., 2009, *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site Benton County, Washington*) to ensure discharges to the Columbia River did not exceed the 10 µg/L surface water quality standard. This parent rebound study SAP has been prepared to describe requirements for implementing Cr(VI) rebound studies. This plan also describes the monitoring of additional contaminants of interest for which no remedy has been defined and groundwater parameters that are used to establish groundwater quality. These contaminants are collocated within the current and historical extent of Cr(VI) groundwater contamination and have been identified as contaminants of potential concern in the ongoing remedial investigation and feasibility study for 100-K. The additional information will help inform future groundwater predictions in the absence of the current interim remedial action.

This SAP is a parent document developed to provide flexibility in implementing future rebound studies for the 100-KR-4 OU. These rebound studies are meant to support the 100-KR-4 OU final action. As the 100-KR-4 OU remedy continues to progress, any changes necessary will follow the requirements identified in Section 2.1.6, as appropriate. Subsequent addenda will provide details for area-specific rebound studies and will require the same approvals as this parent document.

1.1 Project Scope and Objective

This parent rebound study SAP was developed to detail the groundwater sampling and analysis activities associated with rebound studies within the 100-KR-4 OU. Area-specific rebound study addenda will be developed over time that provide more specific detail (i.e., wells and sampling frequency). The objective of the SAP is to develop and document the principal study questions (PSQs) and the associated data needs to be addressed during a rebound study, as documented in Appendix A. As rebound studies are implemented, if additional data needs are identified within a given rebound study area, they will be included in the specific SAP addenda and as appropriate will be incorporated into this SAP through a *Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a; Tri-Party Agreement) change notice or SAP revision. Routine groundwater monitoring will continue to be implemented under DOE/RL-2013-29, *Sampling and Analysis Plan for the 100-KR-4 Groundwater Operable Unit Monitoring*, as amended by applicable Tri-Party Agreement change notices, and will not be affected by this SAP.

1.2 Background

The 100-KR-4 OU is located in the northern portion of the Hanford Site, along the Columbia River (Figure 1-1). Groundwater in the 100-KR-4 OU was contaminated by waste releases associated with past operations of the 105KE and 105KW plutonium production reactors and associated support facilities, which operated from 1955 to 1971. The soil OUs that contributed to the 100-KR-4 groundwater plumes have been designated as 100-KR-1 and 100-KR-2. Discharges from those OUs included contaminated wastewater and chemical solutions. As identified in the interim remedial action ROD (EPA/ROD/R10-96/134), the primary COC in groundwater for the 100-KR-4 OU is Cr(VI). Other groundwater co-contaminants include tritium, nitrate, carbon-14, strontium-90, and trichloroethene (TCE) (DOE/RL-96-84, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and*

100-KR-4 Groundwater Operable Units' Interim Action). To mitigate risks associated with Cr(VI) contamination in groundwater discharging to the river, groundwater remediation efforts started at the 100-KR-4 OU in 1997 under the interim action RD/RAWP (DOE/RL-96-84) with the installation of the KR4 pump and treat (P&T) system, which used a series of extraction wells located within the plume, an ion exchange system to remove Cr(VI), and injection wells to return treated water to the aquifer.

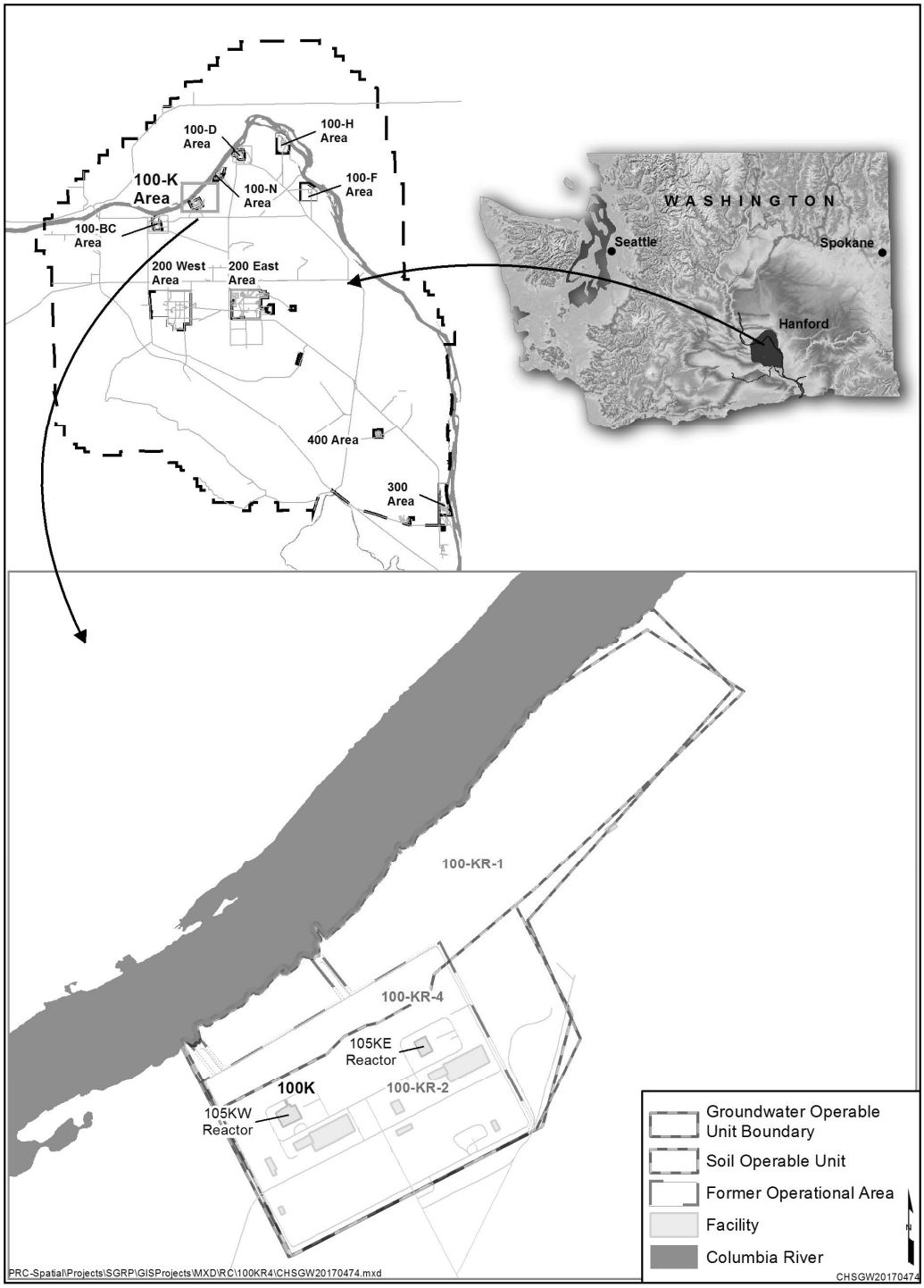

Figure 1-1. 100-K Source and Groundwater Operable Units

Since 1997, the initial KR4 P&T system has been expanded as well as the area of groundwater under active remediation. The first expansion was conducted under the remedial RD/RAWP supplement to the interim remedial action ROD (DOE/RL-2006-52, *The KW Pump and Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action*) in 2007 with the addition of the KW P&T system. The second expansion was conducted in accordance with an ESD to the interim remedial action ROD (EPA et al., 2009), which added the KX P&T system. In 2015, the 100-KR-4 RD/RAWP (DOE/RL-2013-33) was approved and superseded the previous work plan and combined the requirements into one document. The KR4, KW, and KX P&T systems continue to operate in the 100-KR-4 OU under the interim remedial action ROD (EPA/ROD/R10-96/134) as revised by applicable ESDs.

With the addition of the KX P&T system in 2009, the maximum observed Cr(VI) concentration in groundwater dropped from 2,220 µg/L in 2009, to 348 µg/L in 2015. In some areas, like in the vicinity of the 105KW Reactor, Cr(VI) concentrations had dropped below the groundwater interim action remediation target of 20 µg/L. In 2016, DOE-RL initiated a Cr(VI) rebound study specific to the 105KW Reactor Area, to evaluate the potential for contaminant concentrations to remain below cleanup levels once active groundwater extraction was discontinued. The KW P&T system was temporarily shut down from May 16, 2016, through March 31, 2017 for the rebound study in accordance with DOE/RL-2016-42, *Sampling and Analysis Plan for KW Pump and Treat System Rebound Study.*

Based on the results of the rebound study (SGW-62061, *KW Rebound Study Summary Report and Assessment*), the extraction well network associated with the KW P&T was optimized to focus on the area between the 105KW Reactor and the 183.1KW Headhouse. Subsequently, documentation was written to support the implementation of a treatability test to address the confirmed continuing source of groundwater continuation located near the 183.1KW Headhouse.

1.2.1 Site Geology/Hydrology

The Ringold Formation lies directly above the basalt in the 100-K Area. Within the 100-K Area, the formation ranges from as shallow as 86.4 m (284 ft) below ground surface to approximately 110 m (371 ft) below ground surface in contact with the basalt group. The Ringold Formation is composed of loose to semi-hardened clay, silt, fine- to coarse-grained sand, or granule- to cobble-sized gravel that are grouped into five sediment layers. One of those layers, Ringold Formation member of Wooded Island – unit E (Rwie), which typically consists of fluvial gravels with lesser amounts of sand, silt, and clay, as well as areas of local cementation, comprises most of the unconfined aquifer unit at the 100-K Area. Rwie is the most important Ringold Formation unit when evaluating the nature and extent of groundwater contamination at the 100-K Area. The Rwie at the 100-K Area is underlain by the Ringold Formation upper mud (RUM) unit. The RUM unit, a massive silt and clay unit in this area, exhibits very low hydraulic conductivity and delineates the bottom of the unconfined aquifer in the 100-K Area.
The Hanford formation overlies the Ringold Formation in the 100-K Area and consists of boulders, gravel, sand, and silt deposited by cataclysmic Ice Age floodwaters that drained out of glacial Lake Missoula during the Pleistocene epoch. The Hanford formation is the dominant material in the 100 Area vadose zone (unsaturated zone), which ranges in thickness from less than 1 m (3.3 ft) near the river shoreline to approximately 30 m (100 ft) near the southeastern boundary of the 100-K Area. The Hanford formation underlying the 100-K Area is essentially a sand and gravel wedge that increases in thickness away from the river. The geology and hydrogeology of the 100-K Area are described in detail in DOE/RL-2010-97, *Remedial Investigation for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft B.

1.2.2 Groundwater Flow

Both natural and artificial hydrologic processes have influenced groundwater flow patterns and contaminant distribution at the 100-K Area. The effects of natural processes on contaminant migration (infiltration of precipitation and changes in river stage) are ongoing. During reactor operations, artificial recharge from effluent disposal caused the water table to rise. Those effects diminished after reactor operations ceased. However, some effects from reactor operations have not completely dissipated, as observed in continued elevated Cr(VI) concentration at inland wells (e.g., 199-K-193), and other artificial processes continue to influence contaminant migration (particularly ongoing P&T operations).

Groundwater in the 100-K Area flows generally to the northwest toward the Columbia River, which forms a discharge boundary for the unconfined aquifer. Operation of P&T systems at 100-KR-4 OU creates changes in groundwater flow direction and velocity. These changes are expressed as depressions and mounds in the water table, affecting the flow direction (Figure 1-2). Larger mounds (e.g., those produced by the combined discharges from KR4 and KX systems near the middle of the 116-K-2 Trench) create conditions of radial flow away from the mound. This creates local diversion of groundwater flow direction away from the natural patterns. Groundwater farther inland of the 100-K Area generally flows to the north and northeast toward the 100-N Area. The flow direction and apparent velocity in this inland area are somewhat uncertain due to sparse groundwater elevation measurements in the area.

The daily and seasonal fluctuations in the river stage also affect groundwater flow at the 100-KR-4 OU. The longer-term (seasonal) changes in river stage produce more extensive and longer observed changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer. During high river-stage periods, the local groundwater gradient magnitude is reduced near the river; the area very near the river may actually exhibit a flow direction reversal, with river water intruding slowly into the aquifer (i.e., seasonal bank storage). In addition, the increased elevation at the river causes the groundwater inland to backup during high river stage, thus creating the seasonal rise in groundwater elevation observed inland of the river. As the river stage declines following the seasonal freshet, the boundary condition adjusts, the groundwater gradient steepens toward the river, and velocity increases. This condition continues until the groundwater head equilibrates with the low river-stage condition. Typically, as a result of the change in gradient and velocity as the river stage changes, contaminant concentrations are lower during high river stage and greater during low river stage.

1.2.3 Sources of Contamination

Historical operations of the 105KE and 105KW Reactors and their support systems (e.g., cooling water conditioning and wastewater discharge) resulted in discernible groundwater contamination.
The Columbia River was the cooling water source for the reactors. Water from the Columbia River was filtered and chemically treated prior to use as cooling water, which included the addition of sodium dichromate as a corrosion inhibitor. The sodium dichromate was added to the cooling water as a highly concentrated liquid solution prior to the water passing through the reactors.

Spills and leaks of water treatment chemicals, including a 70% by weight aqueous solution of sodium dichromate dihydrate ($Na_2Cr_2O_7{\cdot}2H_2O$), occurred in the water treatment and chemical storage areas, and from chemical conveyance lines. The treated cooling water passed through the reactors in a single pass and was then released to the Columbia River after aging in retention basins during normal operations. During reactor upset conditions (e.g., fuel element failures), the cooling water was diverted from the retention basins to the 116-K-1 Crib (for a brief period) and later to the 116-K-2 Trench and was allowed to infiltrate directly into the soil column (Figure 1-2). These practices resulted in extensive groundwater recharge mounds consisting primarily of contaminated cooling water, as well as widespread distribution of contamination in the unconfined aquifer (HW-77170, *Status of Ground Water Beneath*

Hanford Reactor Areas, January, 1962 to January, 1963; BNWL-CC-1352, *Ground Disposal of Reactor Cooling Effluent*). Cooling water picked up other contaminants as it passed through the reactors, including strontium-90.

Other discrete source areas include the 116-KE-1 and 116-KW-1 Cribs, which received reactor gas dryer condensate containing elevated tritium, carbon-14, and ammonia. Ammonia discharged to these sites was oxidized to nitrate (Figure 1-3). The 116-KE-3 and 116-KW-2 Cribs/reverse wells received drainage of fuel storage basin water that leaked from the bottom of the basins. This water contained elevated strontium-90, tritium, and plutonium isotopes. The 105-KE Fuel Storage Basin additionally exhibited leakage over its service life, resulting in additional releases to the vadose zone and underlying groundwater. The 118-K-1 Burial Ground received various contaminated solid wastes, resulting in substantial contamination of the vadose zone and underlying unconfined aquifer by tritium.

TCE is also observed in groundwater near the 105KW Reactor. However, a specific source and release point has not been identified. The source is assumed to be associated with the use of the solvent during maintenance and repair of reactor components.

1.2.4 Contaminant Plumes

The current contaminant plume configurations result from the behavior of the historical recharge mounds and from groundwater movement since the cessation of cooling water discharges. Chromium, primarily as soluble Cr(VI), is the most widespread contaminant in groundwater beneath the 100-K Area (Figure 1-2). Other groundwater contaminants are strontium-90, carbon-14, nitrate, tritium, and TCE (Figure 1-3). Strontium-90 and carbon-14 are present in the groundwater in localized areas associated with select cribs and trenches with vadose zone contamination. Nitrate and tritium are present over larger areas than strontium-90 and carbon-14, but within the boundaries of the Cr(VI) plumes. TCE is localized near the 105KW Reactor. These contaminants are collocated with Cr(VI) contamination throughout the 100-K Area, and while the interim remedial action has not specifically targeted these contaminants, it has impacted their movement and behavior in groundwater. Groundwater contaminant plumes in Figures 1-2 and 1-3 represent the 2019 plume distributions as documented in DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*.

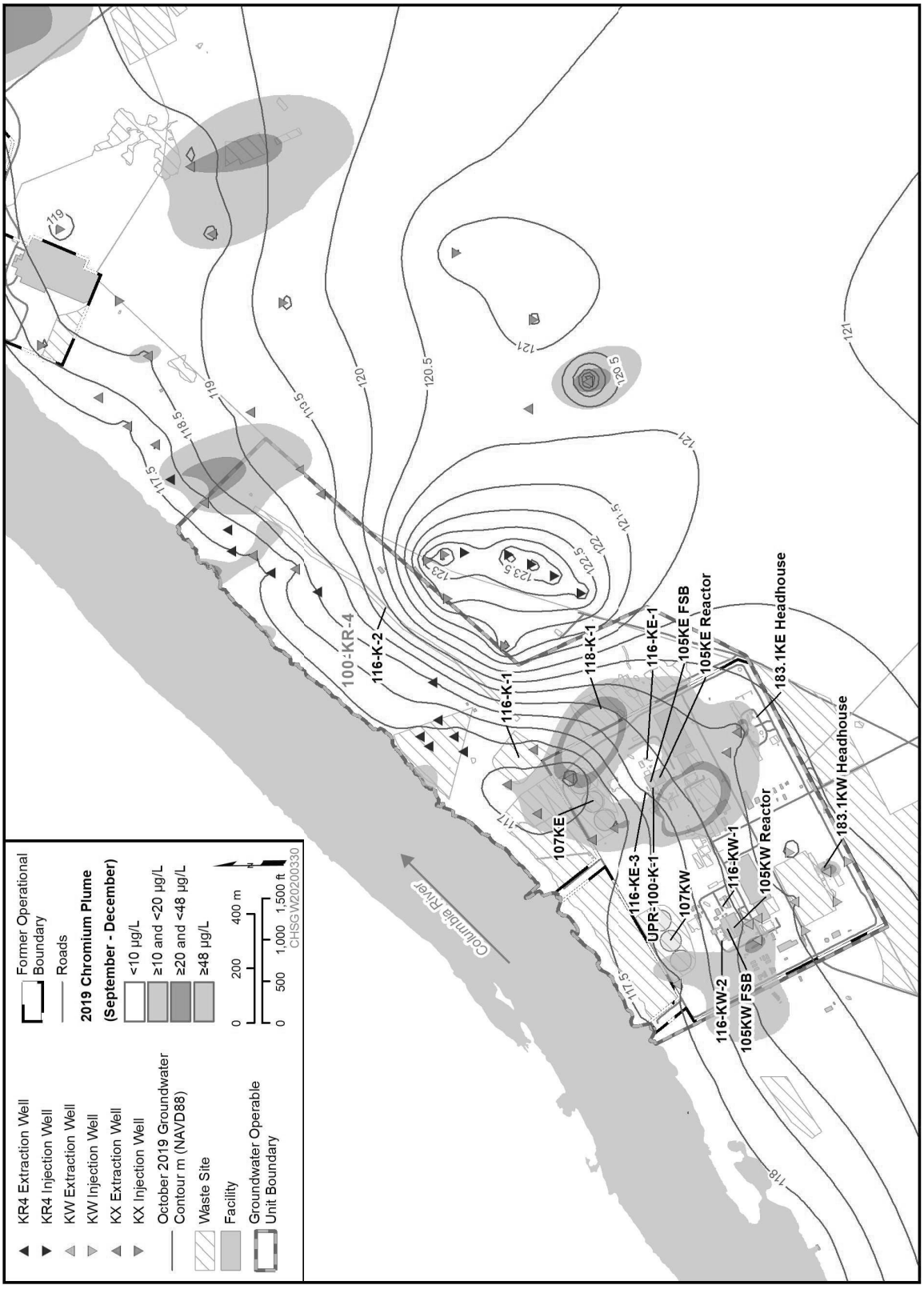

Figure 1-2. Cr(VI) Distribution in Groundwater at the 100-KR-4 Operable Unit (Low River Stage, 2019)

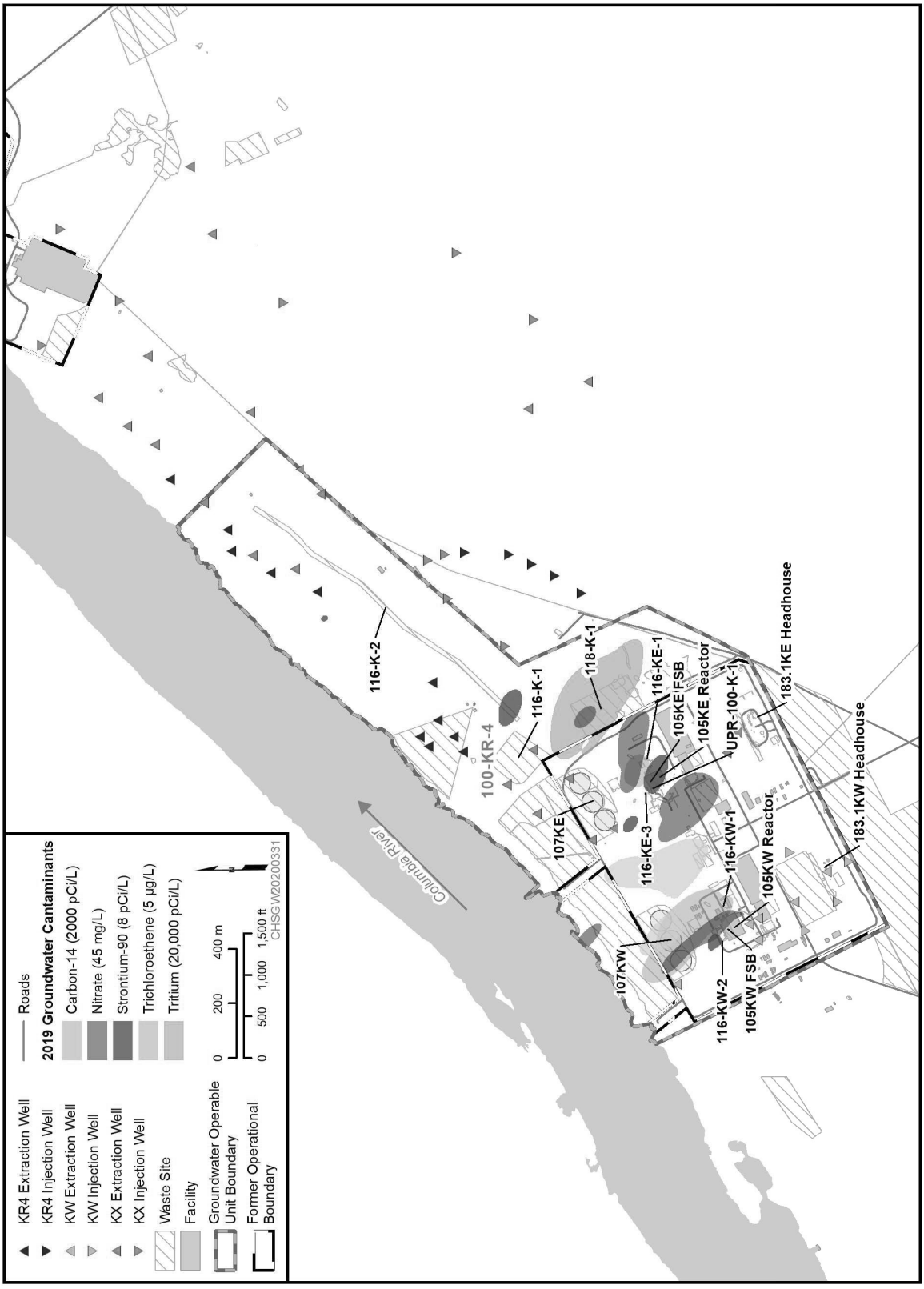

Figure 1-3. 100-KR-4 Carbon-14, Nitrate, Strontium-90, Tritium, and TCE Plumes (2019)

1.3 Data Quality Objective Summary

Appendix A of this SAP provides the details of the data quality objectives (DQO) process that was implemented to ensure that the data collected as part of this SAP can be used to support decision making for 100-KR-4 rebound tests. The data needs, alternative outcomes and actions, and decision rules were developed collaboratively between the U.S. Department of Energy (DOE) and EPA, and are based on lessons learned from previous rebound study sampling approaches (i.e., DOE/RL-2016-42). Table 1-2 lists the PSQs that will be addressed through the collection of groundwater data associated with this SAP and addenda. As indicated in Section 1.1, if additional data needs are identified within a given rebound study area they will be included in the area specific SAP addenda.

Table 1-2. Principal Study Questions

Principal Study Question		Data Need
PSQ 1	In the absence of P&T operations, have Cr(VI) concentrations reached concentrations below the interim action remediation target of 20 µg/L and expected to remain stable or decrease?	Increased frequency of Cr(VI) concentration measurements in groundwater in the absence of P&T operations
PSQ 2a	If rebound of Cr(VI) is observed, does it originate from known or suspected continuing sources of groundwater contamination?	High frequency Cr(VI) concentration measurements in groundwater collected at the top of the unconfined aquifer in the absence of P&T operations
PSQ 2b	If rebound of Cr(VI) is observed, does it originate from areas outside of known or suspected continuing sources of groundwater contamination?	Increased frequency of Cr(VI) concentration measurements in groundwater collected at the top of the unconfined aquifer in the absence of P&T operations
PSQ 2c	If rebound of Cr(VI) is observed, does it originate from previously unmonitored inland areas associated with historical operations?	Increased frequency of Cr(VI) concentration measurements in groundwater collected at the top of the unconfined aquifer in the absence of P&T operations
PSQ 3	What is the vertical distribution of Cr(VI) within the unconfined aquifer in the absence of P&T operations?	Cr(VI) concentration measurements in groundwater collected vertically through the saturated screen interval in the absence of P&T operations
PSQ 4	What is the magnitude, gradient, and flow direction of groundwater in the absence of P&T operations?	Manual water level and AWLN measurements collected in the absence of P&T operations
PSQ 5	What are the seasonal effects of changing river stage on Cr(VI) concentrations and groundwater flow in the absence of P&T operations?	• High frequency Cr(VI) concentration measurements in groundwater • Manual water level and AWLN measurements
PSQ 6	In the absence of P&T operations, has groundwater reestablished natural conditions?	• Increased frequency of major ions (calcium, chloride, magnesium, nitrate, potassium, sodium, and sulfate), alkalinity, specific conductance, and other field parameter measurements in groundwater in the absence of P&T operations • Manual water level and AWLN measurements
PSQ 7	In the absence of P&T operations, what are the effects on other 100-KR-4 groundwater contaminants of interest?	Increased frequency of carbon-14, nitrate, strontium-90, tritium, and trichloroethene concentration measurements in groundwater in the absence of P&T operations

AWLN = automated water level network
P&T = pump and treat
PSQ = principal study question

1.3.1 Role of the Sampling and Analysis Plan and Addenda

To avoid duplicating Chapters 2 through 5 of this SAP, and to simplify the documentation process, this SAP will act as the main body of information that supports the creation of area-specific rebound SAP addenda. This SAP contains the overall sampling and analysis objectives to support groundwater monitoring activities associated with rebound studies performed in the 100-KR-4 OU. The SAP addenda, which will be published as needed, include the well-specific sampling requirements. Future SAP addenda will be developed using the DQOs as defined in Appendix A.

As defined in the 100-KR-4 RD/RAWP (DOE/RL-2013-33), a statistical trend analysis to confirm that the groundwater concentrations are expected to continue to decline from their current levels will be performed and included as an appendix to each SAP addendum. Each addendum will also include how the DQOs as defined in this SAP are being addressed through the sampling scheme.

1.4 Contaminants of Concern/Target Analytes

Table 1-3 lists Cr(VI), other contaminants of interest, and general chemistry parameters that may be analyzed during a rebound study. The specific wells, analytes, and frequency will be identified in area specific rebound SAP addenda. Quality assurance (QA), quality control (QC), and sampling criteria for any additional analytes that are identified will be included in rebound specific SAP addenda.

Table 1-3. Analytes for 100-KR-4 Operable Unit Rebound Study Sampling

Analyte	CAS Number or Constituent ID
General Chemical Parameters	
Alkalinity	ALKALINITY
Inorganics (Anions)	
Chloride	16887-00-6
Fluoride	16984-48-8
Nitrate	14797-55-8
Phosphate	14265-44-2
Sulfate	14808-79-8
Inorganics (Metals)	
Calcium	7440-70-2
Chromium	7440-47-3
Hexavalent chromium	18540-29-9
Magnesium	7439-95-4
Potassium	7440-09-7
Sodium	7440-23-5
Volatile Organic Compounds	
Trichloroethene	79-01-6
Radionuclides	
Carbon-14	14762-75-5
Strontium-90	10098-97-2

Table 1-3. Analytes for 100-KR-4 Operable Unit Rebound Study Sampling

Analyte	CAS Number or Constituent ID
Tritium	10028-17-8
Field Measurements	
Dissolved oxygen	DO
pH measurement	PH
Specific conductance	CONDUCT
Temperature	TEMPERATURE
Turbidity	TURBIDITY

CAS = Chemical Abstracts Service
N/A = not applicable

1.5 Project Schedule

The first SAP addendum will be finalized in 2021 and will focus on the 183.1KW Headhouse. Other addenda will follow.

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2 Quality Assurance Project Plan

A Quality Assurance Project Plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the QA elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5), and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). DoD/DOE, 2019, *Department of Defense (DoD) Department of Energy (DOE) Consolidated Quality System Manual (QSM) for Environmental Laboratories*, is also discussed. Section 7.8 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b; hereinafter called the Tri-Party Agreement Action Plan) requires the QA/QC and sampling and analysis activities to specify the QA requirements for Past-Practice Processes. This QAPjP also describes applicable requirements and controls based on guidance in Washington State Department of Ecology (Ecology) Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies,* and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP supplements the contractor's environmental QA program plan.

The QAPjP references are included in Chapter 6. The QAPjP includes the following sections, which describe the quality requirements and controls applicable to Hanford Site OU sampling activities:

- Section 2.1, "Project Management"
- Section 2.2, "Data Generation and Acquisition"
- Section 2.3, "Assessment and Oversight"
- Section 2.4, "Data Review and Usability"

2.1 Project Management

This section includes project goals, planned management approaches, and planned output documentation.

2.1.1 Project/Task Organization

The project organization is described in the following sections and illustrated in Figure 2-1.

2.1.1.1 Regulatory Lead

The lead regulatory agency (LRA) for the 100-KR-4 OU is EPA. The LRA is responsible for regulatory oversight of cleanup projects and activities. EPA retains approval authority for all SAPs. EPA works with DOE-RL to resolve concerns over the work described in this SAP in accordance with the Tri-Party Agreement (Ecology et al., 1989a).

2.1.1.2 DOE-RL Manager

Hanford Site cleanup in the 100-KR-4 OU is the responsibility of DOE-RL. The DOE-RL Manager is responsible for authorizing the contractor to perform activities described within this SAP at the Hanford Site under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; *Resource Conservation and Recovery Act of 1976*; *Atomic Energy Act of 1954*; and the Tri-Party Agreement (Ecology et al., 1989a).

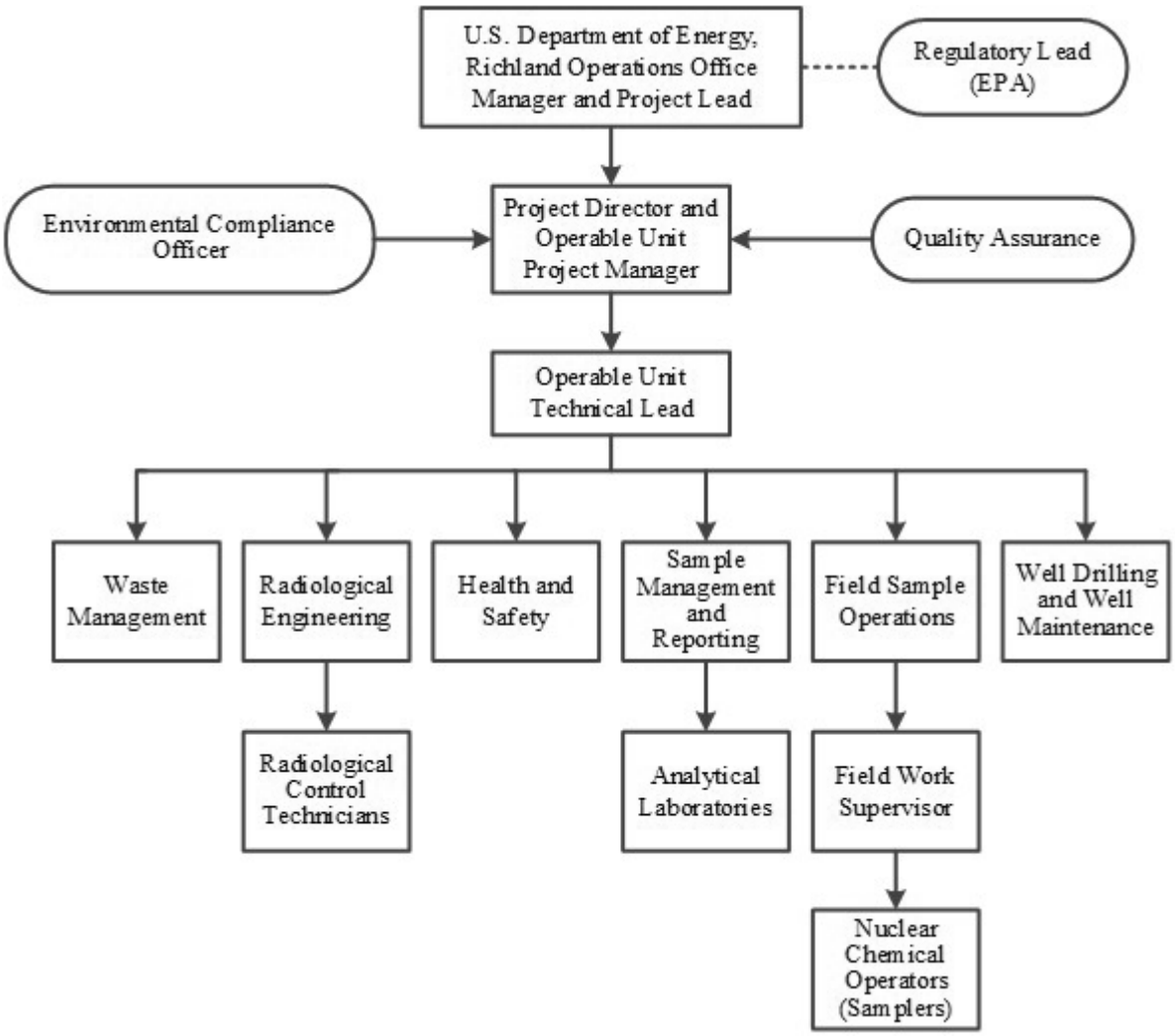

Figure 2-1. Project Organization

2.1.1.3 DOE-RL Project Lead

The DOE-RL Project Lead is responsible for providing day-to-day oversight of the contractor's performance of the work scope, working with the contractor to identify and work through issues, and providing technical input to the DOE-RL management.

2.1.1.4 Soil and Groundwater Remediation Project Director

The Soil and Groundwater Remediation Project (S&GRP) Director provides oversight and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The S&GRP Director also provides support to the OU Project Manager to ensure that work is performed safely and cost effectively.

2.1.1.5 Operable Unit Project Manager

The OU Project Manager (or designee) is responsible and accountable for project-related activities including coordinating with DOE-RL, regulators, and contactor management in support of sampling activities to ensure work is performed safely, compliantly, and cost effectively. In addition, the

OU Project Manager (or designee) is also responsible for managing sampling documents and requirements, field activities, subcontracted tasks, and for ensuring the project file is properly maintained.

2.1.1.6 Operable Unit Technical Lead

The OU Technical Lead is responsible for developing specific sampling design, analytical requirements, and QC requirements, either independently or as defined through a systematic planning process. The OU Technical Lead ensures that sampling and analysis activities as delegated by the OU Project Manager are carried out in accordance with the SAP, and works closely with the Environmental Compliance Officer, QA, Health and Safety, the Field Work Supervisor (FWS), and the Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope.

2.1.1.7 Sample Management and Reporting

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. The SMR group generates field sampling documents, labels, and instructions for field sampling personnel and develops the sample authorization form (SAF), which provides information and instruction to the analytical laboratories. The SMR group ensures that field sampling documents are revised to reflect approved changes. The SMR group receives analytical data from the laboratories, ensures the data are appropriately reviewed, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation and recordkeeping. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. The SMR group is responsible for informing the OU Project Manager of any issues reported by the analytical laboratories.

2.1.1.8 Field Sampling Operations

FSO is responsible for planning and coordinating field sampling resources. The FWS directs the nuclear chemical operators (samplers), who collect samples in accordance with this sampling plan and corresponding standard methods and work packages. The FWS ensures that deviations from field sampling documents or issues encountered in the field are documented appropriately (e.g., in the field logbook). The FWS ensures that samplers are appropriately trained and available. Samplers collect samples in accordance with sampling requirements. Samplers also complete field logbooks, data forms, and chain-of-custody forms, including any shipping paperwork, and enable delivery of the samples to the analytical laboratory.

Pre-job briefings are conducted by FSO, in accordance with work management and work release requirements, to evaluate activities and associated hazards by considering the following factors:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required

2.1.1.9 Quality Assurance

The QA point of contact provides independent oversight and is responsible for addressing QA issues on the project, overseeing implementation of the project QA requirements. Responsibilities include reviewing project documents including the QAPjP, and participating in QA assessments on sample collection and analysis activities, as appropriate.

2.1.1.10 Environmental Compliance Officer

The Environmental Compliance Officer provides technical oversight, direction, and acceptance of project and subcontracted environmental work and also develops appropriate mitigation measures with the goal of minimizing adverse environmental impacts.

2.1.1.11 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulation or internal primary contractor work requirements.

2.1.1.12 Radiological Engineering

Radiological Engineering is responsible for the following:

- Radiological engineering and project health physics support
- Conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization
- Identifying radiological hazards and ensuring appropriate controls are implemented to maintain worker exposures to hazards at ALARA levels
- Interfacing with the project Health and Safety representative and other appropriate personnel, as needed, to plan and direct project radiological control technician (RCT) support

2.1.1.13 Waste Management

Waste Management is responsible for identifying waste management sampling/characterization requirements to ensure regulatory compliance and for interpreting data to determine waste designations and profiles. Waste Management communicates policies and practices and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner.

2.1.1.14 Analytical Laboratories

The analytical laboratories accept, manage, prepare, and analyze samples in accordance with established methods and the requirements of their subcontract, and provide necessary data packages containing analytical and QC results. Laboratories provide explanations of results to support data review and in response to resolution of analytical issues. Laboratory quality requirements are consistent with the HASQARD (DOE/RL-96-68). The laboratories are evaluated under the U.S. Department of Energy Consolidated Audit-Accreditation Program (DOE/CAP-AP) or its successor programs to DoD/DOE, 2019, Quality Systems Manual (QSM) requirements. Beyond those within the DoD/DOE QSM, HASQARD requirements are also evaluated under the DOE/CAP-AP. Laboratories are accredited by Ecology for the analyses performed under this SAP.

2.1.1.15 Well Drilling and Well Maintenance

The well drilling and maintenance and well coordination and planning managers are responsible for the following:

- Planning, coordinating, and executing drilling construction
- Well maintenance activities
- Coordinating with the OU Technical Lead about field constraints that could affect sampling design
- Coordinating well decommissioning with DOE-RL in accordance with the substantive standards of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

2.1.2 Quality Objectives and Criteria

The QA objective of this plan is to ensure the generation of analytical data of known and appropriate quality is acceptable and useful in order to meet the evaluation requirements stated in the sampling plan. Data descriptors known as data quality indicators (DQIs) help determine the acceptability and usefulness of data to the user. The principal DQIs (precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity) are defined for the purposes of this document in Table 2-1.

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. DQIs are evaluated during a process to assess data usability (Section 2.4.3).

2.1.3 Methods-Based Analysis

Laboratory testing for analytes described in Sections 1.4 and 2.2.1 may include nontarget analytes that are part of the analytical method (i.e., methods-based reporting). The additional constituents that are part of the method and reported by the laboratory are for informational purposes. Analytical performance requirements will be applicable only to the analytes specific to this SAP. Poor QC-related to nontarget analyte results would not result in any required corrective action by the laboratory, except for the application of proper result qualification flags.

2.1.4 Analytical Priority

If sample volume is insufficient to analyze for all analytes listed for a given well, the sampling priority will be determined by the OU Technical Lead. In general, the highest priority analytes critical for supporting groundwater decisions are required to be analyzed. While insufficient sample volume is not expected to be a concern, priority is first given to Cr(VI) and analytes linked to a particular continuing source of groundwater contamination (e.g., carbon-14 downgradient of the 116-KW-1 gas condensate crib) , second to other 100-KR-4 OU contaminants of interest, and finally analytes typically associated with groundwater geochemistry. Additional analytical prioritization may be provided in the individual addenda to this SAP.

Table 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Precision (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	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 (laboratory control samples, matrix spikes, surrogates, carriers, and tracers)	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include 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 (field duplicates)	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 results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.

Table 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one dataset 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 QA protocols.	If data are not comparable to other datasets: • 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 (no QC element; addressed in data usability assessment)	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered 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 quality criteria (data quality objectives or performance/acceptance criteria).	If datasets do not meet the completeness objective: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future completeness.
Bias (equipment blanks, field transfer blanks *[only with VOCs]*, full trip blanks, laboratory control samples, matrix spikes, and method blanks)	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 practices to limit preferential selection or loss of sample media. • Use sample handling practices, 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.

Table 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	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[b] 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.

Reference: Chapter 1, "Quality Control," of SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium.*

a. Acceptance criteria for QC elements are provided in Table 2-5.

b. For purposes of this sampling plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

QA = quality assurance
QC = quality control
VOC = volatile organic compound

2.1.5 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting samples and compliant with applicable DOE orders and government regulations. The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Training has been instituted by the contractor management team to meet training and qualification programs that satisfy multiple training drivers imposed by applicable DOE, *Code of Federal Regulations*, and *Washington Administrative Code* requirements.

Training records are maintained for each employee in an electronic training record database. The contractor's training organization maintains the training records system. Line management confirms that an employee's training is appropriate and up to date prior to performing work under this SAP.

2.1.6 Documents and Records

The OU Project Manager (or designee) is responsible for ensuring the current version of the SAP is being used and providing any updates to field personnel. Version control is maintained by the administrative document control process. Table 2-2 defines the types of changes that may impact the sampling and the associated approvals, notifications, and documentation requirements.

Table 2-2. Change Control for Sampling Projects

Type of Change[a]	Action	Documentation
Minor Field Change. Changes that have no adverse effect on the technical adequacy of the sampling activity or the work schedule.	The field personnel recognizing the need for a field change will consult with the OU Project Manager (or designee) prior to implementing the field change.	Minor field changes will be documented in the field logbook. The logbook entry will include the field change, the reason for the field change, and the names and titles of those approving the field change.
Minor Change. Changes to approved plans that do not affect the overall intent of the plan or schedule.	The OU Project Manager will inform DOE-RL and the Regulatory Lead of the change. EPA determines there is no need to revise the document.	Documentation of this change approval would be in the Unit Manager's Meeting minutes or comparable Tri-Party Agreement Change Notice.[b]
Revision Necessary. Lead regulatory agency determines changes to approved plans require revision to document.	If it is anticipated that a revision is necessary, the OU Project Manager will inform DOE-RL and the Regulatory Lead. EPA determines the change requires a revision to the document.	Formal revision of the sampling document.

References: DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents*.

Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*.

Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*.

a. Consistent with DOE/RL-96-68 and Sections 9.3 and 12.4 of Ecology et al., 1989b.

b. Section 9.3 of Ecology et al., 1989b defines the minimum elements of a change notice.

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

EPA = U.S. Environmental Protection Agency

OU = operable unit

Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order*

Regarding minor field changes, the OU technical lead (in coordination with the S&GRP subject matter expert) will approve deviations from the SAP and SAP addenda that do not have an adverse effect on the technical integrity or adequacy of the sampling activity. Examples of minor field changes are as follows:

- During groundwater sampling, most groundwater samples will be pumped, although use of another method may be authorized by the OU technical lead.

- The sample depths provided in the SAP addenda are based on well specific construction information. In the event that a groundwater sample cannot be completed due to excessive buildup of fine material in the sump of the well, the sample depth may be altered during sampling in consultation with the OU technical lead. In the event this occurs, wells will be submitted to the well drilling and well maintenance organization for inspection and cleaning.

Regarding minor changes, the OU technical lead (in coordination with the S&GRP subject matter expert) will consult with DOE-RL and the lead regulatory agency when deviations from the SAP do not affect the overall intent of the plan. Examples of minor changes are as follows:

- The addition of monitoring wells to the sampling program
- The modification of groundwater sampling frequency

The OU technical lead (in coordination with the S&GRP subject matter expert) will inform DOE-RL and EPA of deviations from the SAP that affect the overall intent and schedule, which may require revision to the approved plan (Table 2-2).

Logbooks and data forms are required for field activities. The logbook must be identified with a unique project name and number. Only authorized individuals may make entries into the logbooks. Logbooks and data forms will be controlled in accordance with internal work requirements and processes.

The FWS and SMR group are responsible for ensuring that the field instructions are maintained and aligned with any revisions or approved changes to the SAP. The SMR group will ensure that any deviations from the SAP are reflected in revised field sampling documents for the samplers and the analytical laboratory. The FWS will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook).

The OU Project Manager, FWS, or designee, is responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities.
The OU Project Manager is also responsible for ensuring that project files are appropriately set up and maintained. The project files will contain project records or references to their storage locations.
Project files may include the following information:

- Operational records and logbooks
- Data forms
- Global positioning system data (a copy will be provided to the SMR group)
- Inspection or assessment reports and corrective action reports
- Field summary reports
- Interim progress reports
- Final reports
- Photographs

The following records are managed and maintained by SMR personnel:

- Completed field sampling logbooks
- Field drilling and analytical data
- Groundwater sample reports
- Completed chain-of-custody forms

- Sample receipt records
- Laboratory data packages
- Analytical data verification and validation reports
- Analytical data "case file purges" (i.e., raw data purged from laboratory files) provided by the offsite analytical laboratories

Convenience copies of laboratory analytical results are maintained in the HEIS database. Records may be stored in either electronic (e.g., in the managed records area of the Integrated Document Management System) or hard copy format (e.g., DOE Records Holding Area). Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed per Tri-Party Agreement requirements.

2.2 Data Generation and Acquisition

This section addresses data generation and acquisition to ensure that the project's methods for sampling measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented. Requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

2.2.1 Analytical Methods Requirements

Table 2-3 presents a master list of information regarding constituents and analytical method requirements for samples collected as part of rebound studies; the constituents and analytical requirements for each area-specific rebound study will be provided in addenda to this document. Updated EPA methods and nationally recognized standard methods may be substituted for the analytical methods identified in Table 2-3 to follow changed requirements in the method update. The new method shall achieve project DQOs as well or better than the replaced method.

Table 2-3. Performance Requirements for Sample Analysis

Constituent	CAS Number[a]	MCL or WAC[b]	Analytical Method[c]	Required PQL for Water[d]
General Chemical Parameters (µg/L)				
Alkalinity	ALKALINITY	N/A	310.1, 2320	5,250
Inorganics – Anions (µg/L)				
Chloride	16887-00-6	250,000	300, 9056	400
Fluoride	16984-48-8	4,000	300, 9056	525
Nitrate	14797-55-8	45,000[e]	300, 9056	525
Phosphate	14265-44-2	N/A	300, 9056	787.5
Sulfate	14808-79-8	250,000	300, 9056	1,050
Inorganics – Metals (µg/L)				
Calcium	7440-70-2	N/A	6010	1,050
Chromium	7440-47-3	100	6020	10.5
Hexavalent chromium	18540-29-9	48/10	7196 (low level)	5

Table 2-3. Performance Requirements for Sample Analysis

Constituent	CAS Number[a]	MCL or WAC[b]	Analytical Method[c]	Required PQL for Water[d]
Magnesium	7439-95-4	N/A	6010	1,050
Potassium	7440-09-7	N/A	6010	5,250
Sodium	7440-23-5	N/A	6010	1,050
Volatile Organic Compounds (µg/L)				
Trichloroethene	79-01-6	4	8260	2.1
Radionuclides (pCi/L)				
Carbon-14	14762-75-5	2,000	Liquid scintillation counter	50
Strontium-90	10098-97-2	8	Gas proportional counting	2
Tritium	10028-17-8	20,000	Liquid scintillation	700
Field Measurements				
Dissolved oxygen	DO	N/A	Field measurement instrument/meter	N/A
pH measurement	PH			
Specific conductance	CONDUCT			
Temperature	TEMPERATURE			
Turbidity	TURBIDITY			

a. Value identified is either the CAS number or the constituent identifier if no CAS numbers exists.

b. WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards," Method B or WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington," or 40 CFR 141, "National Primary Drinking Water Regulations."

c. For EPA Method 310.1, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 300, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium*. Equivalent methods may be substituted.

d. Required PQLs are specified in contracts with analytical laboratories. Actual practical quantitation limits vary by laboratory and may be lower. Method detection limits are three to five times lower than quantitation limits. For radionuclides, values in this column are the required minimum detectable concentrations in pCi/L for water.

e. The federal drinking water standard for nitrate is 10 mg/L, expressed as nitrogen. This equates to 45,000 µg/L when expressed as NO_3.

CAS = Chemical Abstracts Service
EPA = U.S. Environmental Protection Agency
MCL = maximum contaminant level
N/A = not applicable
PQL = practical quantitation limit
WAC = *Washington Administrative Code*

2.2.2 Field Analytical Methods

Field screening and survey data will be measured consistent with HASQARD (DOE/RL-96-68). Field analytical methods are performed in accordance with the manufacturers' manuals. Table 2-3 provides the parameters (if any) for field measurements. Section 3.3 further discusses field measurements.

2.2.3 Quality Control

The QC requirements specified in the SAP and supporting SAP addenda must be followed in the field and analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC samples are summarized in Table 2-4. Acceptance criteria for field and laboratory QC are shown in Table 2-5. Data will be qualified and flagged in HEIS, as appropriate.

Table 2-4. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field Quality Control		
Equipment blank	Contamination from nondedicated sampling equipment	1 in 20 samples when nondedicated equipment is used.[a,b]
Full trip blank	Contamination from containers, preservative reagents, storage, or transportation	1 per 20 sampling events (well trips[c] or other media samples)
Field transfer blank	Contamination from sampling site	1 per day; VOCs are sampled; additional field transfer blanks are collected if VOC samples are acquired on the same day for multiple laboratories (wells or other media samples)
Field duplicate samples	Reproducibility/sampling precision	1 in 20 sampling events (well trips or other media samples[c])
Field split samples	Inter-laboratory comparability	As needed. When needed, the minimum is one for every analytical method, for analyses performed.
Laboratory Batch Quality Control[d]		
Carrier	Recovery/yield	Added to each sample and quality control sample[e]
Method blanks	Laboratory contamination	1 per analytical batch[e]
Laboratory sample duplicate	Laboratory reproducibility and precision	1 per analytical batch[e]
Matrix spikes	Matrix effect/laboratory accuracy	1 per analytical batch[e]
Matrix spike duplicate	Laboratory reproducibility, and method accuracy and precision	1 per analytical batch[e]
Surrogates	Recovery/yield for organic compounds	Added to each sample and quality control
Tracers	Recovery/yield	Added to each sample and quality control
Laboratory control	Method accuracy	1 per analytical batch[e]

Note: The information in this table does not represent U.S. Environmental Protection Agency or Washington State Department of Ecology requirements; it is intended solely as guidance.

a. For portable Grundfos® pumps, equipment blanks are collected 1 per 20 well trips. Whenever a new type of nondedicated equipment is used, an equipment blank shall be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination procedure for the nondedicated equipment.

b. Vendor provided borehole equipment is considered dedicated equipment and equipment blanks are not typically acquired in this instance.

c. A 'well trip' is defined as any time a well is accessed for sampling. For groundwater monitoring, field duplicates and full trip blanks are run at a frequency of 1 in 20 well trips (i.e., 5% of the well trips) for all groundwater monitoring wells sampled within any given month (not just those restricted to a single TSD unit). For example, if a month has 181 wells scheduled, then 10 field duplicates will be collected.

d. Batching across projects is allowed for similar matrices (e.g., Hanford groundwater).

e. Unless not required by, or different frequency is called out, in laboratory analysis method.

®Grundfos is a registered trademark of Grundfos Corporation, Bjerringbro, Denmark.

TSD = treatment, storage, and disposal

VOC = volatile organic compound

Table 2-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte	Quality Control Element	Acceptance Criteria (Water)	Corrective Action
General Chemical Parameters			
Alkalinity	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80–120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75–125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Inorganics - Anions			
Anions by IC	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80–120% recovery	Flag with "o"[a]
	DUP [b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75–125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Inorganics - Metals			
ICP-AES metals	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80–120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD [c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75–125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
ICP-MS metals	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80–120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75–125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]

Table 2-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte	Quality Control Element	Acceptance Criteria (Water)	Corrective Action
Hexavalent chromium	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80–120% recovery	Flag with "o"[a]
	DUP [b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75–125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Volatile Organic Compounds			
Volatile organics by GC-MS	MB	<MDL[f] <5% sample concentration	Flag with "B"
	LCS	70–130% recovery or % recovery statistically derived[e]	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	70–130% recovery	Flag with "T"
	SUR	70–130% recovery	Review data[d]
	EB, FTB, FXR	<MDL[f] <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Radionuclides			
Carbon-14	MB	<MDC <5% sample concentration	Flag with "B"
	LCS	80–120% recovery or statistically derived limits[e]	Flag with "o"[a]
	DUP[b]	≤20% RPD	Review data[d]
	MS	75–125% recovery	Flag with "N"
	EB, FTB	<MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Strontium-90	MB	<MDC <5% sample concentration	Flag with "B"
	LCS	80–120% recovery or statistically derived limits[e]	Flag with "o" [a]
	DUP[b]	≤20% RPD	Review data[d]
	Tracer	30–105% recovery	Review data[d]
	Carrier	40–110% recovery	Review data[d]
	EB, FTB	<MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]

Table 2-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte	Quality Control Element	Acceptance Criteria (Water)	Corrective Action
Tritium	MB	<MDC <5% sample concentration	Flag with "B"
	LCS	80–120% recovery or statistically derived limits[f]	Flag with "o"[a]
	DUP[b]	≤20% RPD	Review data[d]
	MS	75–125% recovery	Flag with "N"
	EB, FTB	<MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]

Notes: The information in this table does not represent U.S. Environmental Protection Agency requirements but is intended solely as guidance. The table is consistent with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium*, and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document*.

a. The reporting laboratory will apply the "o" flag with SMR concurrence.

b. Applies when at least one result is greater than the laboratory practical quantitation limit (chemical analyses) or greater than five times the MDC (radiochemical analyses).

c. Either a sample duplicate or a MSD is to be analyzed to determine measurement precision (if there is insufficient sample volume, a laboratory control sample duplicate is analyzed with the acceptance criteria defaulting to the DUP/MSD criteria

d. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data.

e. Laboratory-determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.

f. For the common laboratory contaminants acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criterion is less than five times the MDL.

This table only applies to laboratory analyses. Depth to groundwater, dissolved oxygen, pH, specific conductance, temperature, and turbidity are not listed because they are measured in the field.

DUP = laboratory sample duplicate
EB = equipment blank
FTB = full trip blank
FXR = field transfer blank
GC-MS = gas chromatography – mass spectrometry
IC = ion chromatography
ICP-AES = inductively coupled plasma – atomic emission spectroscopy
ICP-MS = inductively coupled plasma – mass spectrometry
LCS = laboratory control sample
MB = method blank
MDC = minimum detectable activity
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
RPD = relative percent difference
SUR = surrogate

Data Flags:

B, C = possible laboratory contamination: analyte was detected in the associated method blank
o = result may be biased: associated laboratory control sample result was outside the acceptance limits – laboratory applied.
N = result may be biased: associated matrix spike result was outside the acceptance limits
Q = problem with associated field QC blank: results were out of limits
T = result may be biased: associated matrix spike result was outside the acceptance limits (GC-MS only)

Samples are analyzed within the holding time guidelines provided in Table 2-6. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilization, decomposition, or by other chemical changes. Data from samples analyzed outside of the holding times are flagged in the HEIS database with an "H."

Table 2-6. Holding Time Guidelines for Laboratory Analytes

Constituent/Parameter	Preservation[a]	Holding Time[b]
General Chemistry Parameters		
Alkalinity	Cool ≤6°C	14 days
Inorganics – Anions		
Chloride, fluoride, sulfate	Cool ≤6°C	28 days
Nitrate, phosphate	Cool ≤6°C	48 hours
Inorganics – Metals		
ICP-AES metals/ICP-MS metals	HNO_3 to pH <2	6 months
Hexavalent chromium	Cool ≤6°C	24 hours
Volatile Organic Compounds		
Volatile organics by GC-MS	HCl or H_2SO_4 to pH <2 Cool ≤6°C	7 days unpreserved 14 days preserved
Radionuclides		
Carbon-14	None	6 months
Strontium-90	HNO_3 to pH <2	6 months
Tritium	None	6 months

Notes: Holding times and preservation methods are dependent on the constituent, and are consistent with U.S. Environmental Protection Agency guidance and approved analytical methods.

Container types and volumes will be identified on the chain of custody form.

This table only applies to laboratory analyses. Depth to groundwater, dissolved oxygen, pH, specific conductance, temperature, and turbidity are not listed because they are measured in the field.

a. For preservation identified as stored at <6°C, the sample should be protected against freezing unless it is known that freezing will not impact the sample integrity.

b. Additional information regarding holding times can be found in the current version of CHPRC-00189, *Environmental Quality Assurance Program Plan*, Appendix B.

GC-MS = gas chromatography – mass spectrometry
ICP-AES = inductively coupled plasma – atomic emission spectroscopy
ICP-MS = inductively coupled plasma – mass spectrometry

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation studies. Audit results are used to improve performance.

2.2.3.1 Field Quality Control Samples

Field QC samples are collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability and laboratory performance to help ensure reliable data are obtained. Field QC samples include field duplicates, field split (SPLIT) samples, and three types of field blanks (equipment blanks [EBs], full trip blanks [FTBs], and field transfer blanks [FXRs]). Field blanks are typically prepared using high-purity reagent water.[1] QC sample definitions are described below. The frequency of required collection is provided in Table 2-4.

[1] Reagent water is high-purity water that is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques (DOE/RL-96-68).

Field duplicates: independent samples collected as close as possible to the same time and same location as the schedule sample, and intended to be identical. Field duplicates are placed in separate sample containers and analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.

Field splits (SPLITs): two samples collected as close as possible to the same time and same location and intended to be identical. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are inter-laboratory comparison samples used to evaluate comparability between laboratories.

Equipment blanks (EBs): high-purity water passed through or poured over decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. EB sample bottles are placed in the storage containers with samples from the associated sampling event and are analyzed for the same constituents as samples from the sampling event. EBs are used to evaluate decontamination process effectiveness; these samples are not required for disposable sampling equipment.

Field transfer blanks (FXRs): preserved volatile organic analysis sample vials filled with high-purity water at the sample collection site where volatile organic compounds (VOCs) samples are collected. FXR samples are prepared during sampling to evaluate potential contamination attributable to field conditions. After collection, FXR sample vials are sealed and placed into the same storage containers with samples collected the same day for the associated sampling event. FXR samples are analyzed for VOCs only.

Full trip blanks (FTBs): bottles prepared by the sampling team before travel to the sampling site. The preserved bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. It is filled with high-purity water and the bottles are sealed and transported (unopened) to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential sample contamination from the sample bottles, preservative, handling, storage, and transportation.

2.2.3.2 Laboratory QC Samples

Internal QA/QC programs are maintained by laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of carriers, laboratory control samples (LCSs), laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), method blanks (MBs), surrogates (SURs), and tracers. These QC analyses are required by EPA methods (e.g., those in the SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Compendium*), and will be run at the frequency specified in the respective references unless superseded by agreement. QC checks outside of control limits are documented in analytical laboratory reports during data usability assessments, if performed. Laboratory QC checks and their typical frequencies are listed in Table 2-4. Acceptance criteria are shown in Table 2-5. Following are descriptions of the various types of laboratory QC samples.

Carrier: a known quantity of nonradioactive isotope that is expected to behave similarly and is added to an aliquot of sample. Sample results are generally corrected based on carrier recovery.

Laboratory control sample (LCS): a control matrix (e.g., reagent water) spiked with analytes representing the target analytes or certified reference material used to evaluate laboratory accuracy.

Laboratory sample duplicate (DUP): an intra-laboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

Matrix spike (MS): an aliquot of a sample spiked with a known concentration of target analyte(s). The MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to sample preparation and analysis.

Matrix spike duplicate (MSD): a replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.

Method blank (MB): an analyte-free matrix to which the same reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the sample preparations and analytical procedure and is used to quantify contamination resulting from the analytical process.

Surrogate (SUR): a compound added to every sample in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined, but they are not normally encountered. SURs are expected to respond to the preparation and measurement systems in a manner similar to the analytes of interest. Because SURs are added to every standard, sample, and QC sample, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.

Tracer: a known quantity of radioactive isotope that is different from that of the isotope of interest but is expected to behave similarly and is generally added to an aliquot of sample prior to the sample preparation step. A tracer does not chemically interfere with the target radioisotope during radiochemical preparation, separation, and counting. Sample results are generally corrected based on tracer recovery.

2.2.4 Measurement Equipment

Each measuring equipment user is responsible to ensure the equipment is functioning as expected, properly handled, and properly calibrated at required frequencies per methods governing control of the equipment. Onsite environmental instrument testing, inspection, calibration, and maintenance will be recorded in accordance with approved methods. Field screening instruments will be used, maintained, and calibrated in accordance with the manufacturer's specifications and other approved methods.

2.2.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or have been evaluated as acceptable and valid in accordance with instrument-specific methods, requirements, and specifications. Software applications will be acceptance tested prior to use in the field.

Measurement and testing equipment used in the field or in the laboratory will be subject to preventive maintenance measures to ensure minimization of downtime. Laboratories must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and onsite organization's QA plan or operating protocols, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with HASQARD (DOE/RL-96-68) requirements.

2.2.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Section 3.5. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford Site requirements.

2.2.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with applicable analytical test method (Table 2-3) requirements and will be appropriate for their use. Supplies and consumables used in

support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

2.2.8 Nondirect Measurements

Data obtained from sources such as computer databases, programs, literature files, and historical databases will be technically reviewed to the same extent as data generated as part of any sampling and analysis QA/QC effort. Data used in evaluations will be identified by source.

2.2.9 Data Management

The SMR group, in coordination with the OU Project Manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements governing data management methods.

Electronic data access, when appropriate, will be through a Hanford Site database (e.g., HEIS). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

Laboratory errors are reported to the SMR group through an established process. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with applicable methods. This process is used to document analytical errors and to establish their resolution with the OU Project Manager. The sample issue resolution forms become a permanent part of the analytical data package for future reference and for records management.

2.3 Assessment and Oversight

Assessment and oversight activities address the effectiveness of project implementation and associated QA/QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

2.3.1 Assessments and Response Actions

Assessments may be performed to verify compliance with the requirements outlined in this SAP and supporting SAP addenda, project field instructions, the QAPjP, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project line management chain coordinates the corrective actions/deficiency resolutions in accordance with the QA program, the corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the OU Project Manager (or designee). A data usability assessment will be performed for the identified SAP and SAP addendum activities. The data usability assessment results will be provided to the OU Project Manager. No other planned assessments have been identified. If circumstances arise in the field dictating the need for additional assessments, then additional assessments will be performed.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratories' QA plans. The SMR group oversees offsite analytical laboratories and verifies the laboratories are qualified to perform Hanford Site analytical work.

2.3.2 Reports to Management

Program and project management (as appropriate) will be made aware of deficiencies identified by assessments and oversight. Issues reported by the laboratories are communicated to SMR group, which then initiates a sample issue resolution form. The process is used to document analytical or sample issues and to establish resolution with the OU Project Manager. If an assessment finding results in sampling issues that affect a regulatory requirement, DOE would be informed and the matter discussed with the regulatory agencies.

2.4 Data Review and Usability

This section addresses QA activities that occur after data collection. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives.

2.4.1 Data Review and Verification

Data review and verification are performed to confirm that sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, and reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times, if any, have been met. Furthermore, review of QC data is used to determine whether analyses have met the data quality requirements specified in this SAP.

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Field QA/QC results will be reviewed to ensure they are usable.

The OU Technical Lead performs data reviews to help determine if observed changes reflect potential data errors, which may result in submitting a request for data review on questionable data. The laboratory may be asked to check calculations or reanalyze the sample. In extreme cases, another sample may be collected. Results of the request for the data review process are used to flag the data appropriately in the HEIS database and/or to add comments.

2.4.2 Data Validation

Data validation is an independent assessment to ensure the reliability of the data. Analytical data validation provides a level of assurance that an analyte is present or absent. Validation may also include:

- Verification of instrument calibrations
- Evaluation of analytical results based on method blanks
- Recovery of various internal standards
- Correctness of uncertainty calculations
- Correctness of identification and quantification of analytes
- The effect of quality deficiencies on data reliability

The contractor follows the data validation process described in EPA-540-R-2017-001, *National Functional Guidelines for Inorganic Superfund Methods Data Review*; and EPA-540-R-2017-002, *National Functional Guidelines for Organic Superfund Methods Data Review*, adjusted for use with SW-846, HASQARD (DOE/RL-96-68), and radiochemistry methods. The criteria for data validation are based on a graded approach, using five levels of validation: Levels A through E. Level A is the lowest level and is the same as verification. Level E is a 100% review of all data (e.g., calibration data and calculations of representative samples from the dataset). Data validation will be performed to Level C,

which is a review of the QC data. Level C validation consists of a review of the QC data and specifically requires verification of deliverables; requested versus reported analytes; and qualification of the results based on evaluation of analytical holding times, method blank results, MS/MSD results, surrogate recoveries, and duplicate sample results. Level C data validation is generally equivalent to Level 2A in EPA 540-R-08-005, *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*. Level C data validation will be performed on at least 5% of the data by matrix and analyte group under the direction of SMR. Analyte group refers to categories such as radionuclides, volatile chemicals, semivolatiles, metals, and anions. The goal is to include each of the various analyte groups and matrices during the data validation process. The DOE-RL Project Lead or OU Project Manager may specify a higher percentage of data to be validated or that data validation be performed at higher levels.

2.4.3 Reconciliation with User Requirements

The purpose of reconciliation with user requirements is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. The DUA process is the scientific and statistical evaluation of previously verified and validated data to determine if information obtained from environmental data operations are of the right type, quality, and quantity to support their intended use (usability). The DUA process uses the entirety of the collected data to determine usability for decision making. If a statistical sampling design was used during field sampling activities, then the DUA will be performed following guidance in EPA/240/B-06/003, *Data Quality Assessment: Statistical Methods for Practitioners* (EPA QA/G-9S). When judgmental (focused) sampling designs are implemented in the field, DQIs such as precision, accuracy/bias, representativeness, comparability, completeness, and sensitivity for the specific datasets (individual data packages) will be evaluated in accordance with EPA/240/R-02/004, *Guidance on Environmental Data Verification and Data Validation* (EPA QA/G8). Data verification and data validation are integral to the statistical data quality assessment process and the DQI evaluation process. Results of the DUA processes will be used by the OU project manager to interpret the data and determine if the DQOs for this activity have been met.

3 Field Sampling Plan

This field sampling plan identifies activities associated with groundwater sampling and analysis for rebound studies performed in the 100-KR-4 OU. This field sampling plan provides the general overview and requirements to support groundwater sampling activities, while the specific wells and sampling frequency will be included in SAP addenda.

3.1 Sampling Objectives/Design

As discussed in Appendix A, the objectives for collecting groundwater samples during a rebound study in the 100-KR-4 OU are to assess remedial action completion, confirm or identify areas that may require additional action to remediate a secondary source, and/or identify opportunities for P&T optimization. In general, a judgement sampling approach will be used and documented in the SAP addenda.

In judgmental sampling, the selection of sampling units (i.e., the number and location and/or timing of collecting samples) is based on knowledge of the feature or condition under investigation and on professional judgment. Judgmental sampling is distinguished from probability-based sampling in that inferences are based on professional judgment, not statistical scientific theory.

3.2 Sample Location, Frequency, and Constituents to be Monitored

As previously stated, the purpose of this parent rebound SAP is to compile the necessary requirements to implement rebound studies at locations within the 100-KR-4 OU. Appendix A contains the selection criteria to evaluate potential sampling locations. The SAP addenda will specify the specific sampling locations, frequency, and constituents to be monitored to meet the data needs summarized in Table 3-1.

Table 3-1. Summary of PSQs, Measurements, and Applied Frequency

PSQ	Measurement	Filtered or Unfiltered	Frequency
PSQ 1	Cr(VI)	Filtered	Bimonthly
PSQ 2a	Cr(VI)	Filtered	Monthly
PSQ 2b	Cr(VI)	Filtered	Bimonthly
PSQ 2c	Cr(VI)	Filtered	Bimonthly
PSQ 3	Cr(VI)	Filtered	Bimonthly to river stage*
PSQ 4a	Water levels	--	To be collected during sampling events; AWLN (hourly)
PSQ 5	Cr(VI) Water levels	Filtered --	Bimonthly To be collected during sampling events
PSQ 6	Major ions (calcium, chloride, magnesium, nitrate, potassium, sodium, and sulfate) Alkalinity Field parameters (i.e., specific conductance, dissolved oxygen, pH, etc.)	Cations – filtered Anions – unfiltered Alkalinity – unfiltered	Bimonthly
PSQ 7	Carbon-14, nitrate, strontium-90, tritium, and trichloroethene	Unfiltered	Monthly to quarterly

*Locations identified for "river stage" sampling under PSQ 3 will target collecting groundwater samples during the seasonal high (May/June) and low (September/October) river stage periods.

AWLN = automated water level network

PSQ = principal study question

3.2.1 Vertical Distribution of Groundwater Contamination

As discussed in Appendix A, PSQ 3 identified a need to evaluate the vertical distribution of groundwater contamination in the absence of P&T operations. Wells will be evaluated based on the criteria in Appendix A to determine the number of samples needed to evaluate adequately the vertical distribution of groundwater contamination with the available saturated screen length to provide a quantitative evaluation of contamination. The sample depths will be included in the SAP addenda.

3.3 Sampling Methods

Sampling may include but is not limited to the following methods:

- Field screening measurements
- Radiological screening
- Groundwater sampling
- Aquifer tube sampling
- Water level measurements

Groundwater samples will be collected in accordance with the current revision of applicable operating methods. To meet the PSQs listed in Table 3-1, groundwater samples will be collected from the top 1.5 m (5 ft) of the water table, unless otherwise specified. Groundwater samples are collected after field measurements of purged groundwater have stabilized:

- pH: two consecutive measurements agree within 0.2 pH units
- Temperature: two consecutive measurements agree within 0.2°C (32.3°F)
- Conductivity: two consecutive measurements agree within 10% of each other
- Turbidity: Less than 5 nephelometric turbidity units prior to sampling (or OU Technical Lead's recommendation)

Dissolved oxygen will also be measured in the field under this SAP but is not required to be stable prior to sample collection.

Field measurements (except for turbidity) are obtained using a flow-through cell. Groundwater is pumped directly from the well to the flow-through cell. At the beginning of the sample event, field crews attach a clean, stainless-steel sampling manifold to the riser discharge. The manifold has two valves and two ports: one port is used only for purgewater and the other port is used to supply water to the flow-through cell. Probes are inserted into the flow-through cell to measure pH, temperature, conductivity, and dissolved oxygen. Turbidity is measured by inserting a sample vial into a turbidimeter. The purgewater is then discharged to the purgewater truck.

Once field measurements have stabilized, the hose supplying water to the flow-through cell is disconnected and a clean, stainless-steel drop leg is attached for sampling. The flow rate is reduced during sampling to minimize loss of volatiles (if any) and prevent over filling the bottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles (if any). Filtered samples are collected after collection of the unfiltered samples. For some constituents (e.g., metals), both filtered and unfiltered samples are collected. If additional samples require filtration (e.g., at turbidity greater than 5 nephelometric turbidity units), an inline, disposable 0.45 μm filter is used.

Typically, three traditional types (i.e., Grundfos®, Hydrostar®, and submersible electrical pumps) of environmental-grade sampling pumps are used for groundwater sampling at Hanford Site monitoring wells. In addition, low-purge-volume, adjustable-rate bladder pumps may be used. Individual pumps are selected based on the unique characteristics of the well and the sampling requirements.

A small number of wells will not support sample collection via pumping because of low yield or the physical characteristics of the well. In these cases, a grab sample may be obtained. In cases where there is not sufficient yield, purgewater activities are not performed.

Low-purge-volume sampling methodology for collecting groundwater samples is also being implemented at the Hanford Site. Low-flow purging and sampling uses a low-purge-volume, adjustable-rate bladder pump with flow rates typically approximately 0.1 to 0.5 L/min (0.26 to 0.13 gal/min). This methodology is intended to minimize excessive movement of water from the soil formation into the well. The objective is to pump in a manner that minimizes stress (drawdown) to the system. Purge volumes for wells using low-purge bladder pumps are determined on a well-specific basis based on drawdown, pumping rate, pump and sample line volume, and volume required to obtain stable field conditions prior to collecting samples.

Collecting groundwater samples vertically throughout the aquifer will also be performed using low-flow purging techniques. To meet PSQ 3, groundwater samples will be collected at specified depths as identified in the SAP addenda.

For certain types of samples, preservatives are required. Preservatives, based on the media type and analytical methods, are added to the collection bottles before their use in the field. Groundwater samples may require filtering in the field, as noted on the chain-of-custody form.

To ensure sample and data usability, the sampling associated with this SAP will be performed in accordance with HASQARD (DOE/RL-96-68) requirements for sample collection, collection equipment, sample handling, and sample shipment to the laboratory.

Sample preservation and holding time requirements are specified for groundwater samples in Table 2-6. These requirements are in accordance with the analytical method specified in Table 2-3. The container types, preservatives, and volumes will be identified on the SAF and chain-of-custody form. This SAP defines a “sample” as a set of filled sample bottles for beginning holding-time restrictions.

Holding times are the maximum periods allowed between sample collection and lab analysis summarized in Table 2-6. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the constituent and are listed in analytical method compilations such as APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*; and SW-846. Recommended holding times are also provided in HASQARD (DOE/RL-96-68).

3.3.1 Decontamination of Sampling Equipment

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

® Grundfos is a registered trademark of Grundfos Holding A/S Corporation, Bjerringbro, Denmark.

® Hydrostar is a registered trademark of KYB Corporation, Tokyo, Japan.

Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

Decontamination of sampling equipment is performed using high-purity water in each step. In general, three rinse cycles are performed to decontaminate sampling equipment: a detergent rinse, an acid rinse, and a water rinse. During the detergent rinse, the equipment is washed in a phosphate-free detergent solution, followed by rinsing with high-purity water in three sequential containers. After the third high-purity water rinse, equipment that is stainless-steel or glass is rinsed in a 1M nitric acid solution (pH <2). Equipment is then rinsed with high-purity water in three sequential containers (the high-purity water rinses following the acid rinse are conducted in separate water containers that are not used for detergent rinse). Following the final high-purity water rinse, equipment is rinsed in hexane and then placed on a rack to dry. Dry equipment is loaded into a drying oven. The oven is set at 50°C (122°F) for items that are not metal or glass or at 100°C (212°F) for metal or glass. Once reaching temperature, equipment is baked for 20 minutes and then cooled. The equipment is then removed from the oven and wrapped in clean, unused aluminum foil using surgeon's gloves. The wrapped equipment is stored in a custody-locked, controlled-access area.

To decontaminate sampling pumps that are not permanently installed, the pump cowling is first removed, washed (if needed) in phosphate-free detergent solution, and then reinstalled on the pump. The pump is then submerged in phosphate-free detergent solution, and 11.4 L (3 gal) of solution is pumped through the unit and disposed. Detergent solution is then circulated through the submerged pump for 5 minutes. The pump is removed from solution and rinsed with high-purity water. The pump is submerged in high-purity water and 30.3 L (8 gal) of high-purity water is pumped through the unit and disposed. The pump is removed from the high-purity water and the intake and housing are covered with plastic sleeving. The cleaning is documented on a tag affixed to the pump, which includes the following information: date pump cleaned, pump identification, comments, and signature of person performing decontamination.

3.3.2 Radiological Field Data

Alpha and beta/gamma data collection in the field will be used as needed to support sampling and analysis efforts. Radiological screening will be performed by the RCT or other qualified personnel. The RCT will record field measurements, noting the depth of the sample and the elevated instrument reading. Elevated measurements will be relayed to the field geologist for daily inclusion in the Field Activity Report or operational records, as applicable.

The following information will be provided to field personnel performing work in support of this SAP:

- Instructions to RCTs on the methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, as appropriate.
- Information regarding the portable radiological field instrumentation including a physical description of the instruments, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. These instruments

are commonly used on the Hanford Site to obtain measurements of removable surface contamination measurements and direct measurements of the total surface contamination.

- Instructions regarding the minimum requirements for documenting radiological controls information in accordance with 10 CFR 835, "Occupational Radiation Protection."
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of radiological information.
- The minimum standards and practices necessary for preparing, performing, and retaining radiological-related information.
- The requirements associated with preparing and transporting regulated material.
- Daily reports of radiological surveys and measurements collected during conduct of field investigation activities. Data will be cross-referenced between laboratory analytical data and radiation measurements to facilitate interpreting the investigation results.

3.3.3 Water Levels

Using a calibrated depth measurement tape, the depth to water is also recorded in each well prior to sampling. When two consecutive measurements are taken that agree within 6 mm (0.24 in.), the final determined measurement is recorded, along with the date and time for the specific event. The depth to groundwater is subtracted from the elevation of a reference point (usually the top of the casing) to obtain the water-level elevation. The top of the casing is a known elevation reference point because it has been surveyed to local reference data.

The automated water level network (AWLN) is an array of remote monitoring stations connected by a telemetry network to a central base station (SGW-53543, *Automated Water Level Network Functional Requirements Document*). Each monitoring station consists of a pressure transducer connected to a data collection telemetry unit. Hourly pressure data from the AWLN are used to calculate water levels, which are used to estimate the level of hydraulic containment achieved by P&T systems, determine hydraulic gradients in areas with variable conditions, and measure changes in the stage of the Columbia River. Applicable AWLN station will be identified in the SAP addenda. Unless otherwise stated in the specific addendum, hourly measurements should be sufficient.

3.4 Documentation of Field Activities

Logbooks and data forms are required for field sampling activities and will be used in accordance with HASQARD (DOE/RL-96-68) requirements. A logbook must be identified with a unique project name and number. Only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the FWS, cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms may be used to collect field information; however, information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks.

A summary of information to be recorded in logbooks or on the data forms is as follows:

- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task.
- Purpose of visit to the task area.
- Site activities in specific detail (e.g., maps and drawings) or the forms used to record such information (e.g., soil boring log or well completion log). In addition, details of any field tests that were conducted, reference to any forms that were used, other data records, and methods followed in conducting the activity.
- Details of any field calibrations and surveys that were conducted. Reference any forms that were used, other data records, and the methods followed in conducting the calibrations and surveys.
- Details of any samples collected and the preparation (if any) of splits, duplicates, matrix spikes, or blanks. Reference the methods followed in sample collection or preparation; list location of sample collected, sample type, each label or tag numbers, sample identification, sample containers and volume, preservation method, packaging, chain-of-custody form number, and analytical request form number pertinent to each sample or sample set; and note the time and the name of the individual to whom custody of samples was transferred.
- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed. Reference the page number(s) of any logbook where detailed information is recorded.
- Any equipment failures or breakdowns that occurred, with a brief description of repairs or replacements.

3.4.1 Corrective Actions and Deviations for Sampling Activities

The OU Project Manager, FWS, appropriate field crew supervisors, and SMR personnel must document deviations from protocols, issues pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected due to field conditions.

As appropriate, such deviations or issues will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The OU Project Manager, FWS, field crew supervisors, or SMR personnel will be responsible for communicating field corrective action requirements and for ensuring corrective actions are applied to field activities as soon as practical.

Changes in sample activities that require notification, approval, and documentation will be performed as specified in Table 2-2.

3.5 Calibration of Field Equipment

Onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. Calibration records shall include the raw calibration data, identification of the standards used, associated reports, date of analysis, and analyst's name or initials. The results from all instrument calibration activities are recorded in accordance with HASQARD (DOE/RL-96-68) requirements.

Field instrumentation calibration and QA checks will be performed as follows:

- Prior to initial use of a field analytical measurement system.
- At the frequency recommended by the manufacturer or methods, or as required by regulations.
- Upon failure to meet specified QC criteria.
- Calibration of radiological field instruments on the Hanford Site is performed by the Mission Support Alliance prime contractor, as specified by their calibration program.
- Daily calibration checks will be performed and documented for each instrument used. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.
- Using standards for calibration that are traceable to a nationally recognized standard agency source or measurement system. Manufacturer's recommendations for storage and handling of standards (if any) will be followed. Expired standards will not be used for calibration.

3.6 Sample Handling

Sample handling and transfer will be in accordance with established methods to preclude loss of sample identity, damage, deterioration, and loss of sample material. Custody seals or custody tape will 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. If during the chain-of-custody process it is discovered that the custody tape has been tampered with or broken on the sample bottle, the sample will be analyzed but the results will include a flag to indicate that custody was broken. If the custody tape has been tampered with or broken on the cooler, the sample custodian shall note this on the sample receiving documentation.

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

3.6.1 Containers

Samples shall be collected, where and when appropriate, in break-resistant containers. The field sample collection record shall indicate the lot number of the bottles used in sample collection.
When commercially pre-cleaned containers are used in the field, lot identification shall be retained for documentation.

Containers shall be capped and stored in an environment that minimizes the possibility of sample container contamination. If contamination of the stored sample containers occurs, corrective actions shall be implemented to prevent reoccurrences. Contaminated sample containers cannot be used for a sampling event. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. Container types and sample amounts/volumes are identified on the chain-of-custody form.

If required, the Radiological Control organization will measure both the contamination levels and 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 FWS (in consultation with the SMR organization), can send smaller sample volumes to the laboratory.

3.6.2 Container Labeling

Each sample is identified by affixing a standardized label or tag to the container. This label or tag shall contain the sample identification number. The label shall identify or provide reference to associate the sample with the date and time of collection, preservative used (if applicable), analysis required, and collector's name or initials. Sample labels may be either pre-printed or handwritten in indelible or waterproof ink.

3.6.3 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 sample integrity is maintained.
A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each sample or set of samples shipped to any laboratory.

Shipping requirements will determine how sample shipping containers are prepared for shipment.
The analyses requested for each sample will be indicated on the accompanying chain-of-custody form.
Each time the responsibility for the custody of the sample changes, new and previous custodians will sign the record and note the date and time. The field sampling team will make a copy of the signed record before sample shipment and transmit the copy to the SMR group.

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

- Project name
- Collectors' names
- Unique sample number
- Date, time, and location (or traceable reference thereto) of sample collection
- Matrix
- Preservatives
- Chain-of-possession information (i.e., signatures and printed names of each individual involved in the transfer of sample custody and storage locations, and dates/times of receipt and relinquishment)
- Requested analyses (or reference thereto)
- Number of sample containers per unique sample identification number
- Shipped-to information (i.e., analytical laboratory performing the analysis)

Samplers should note any anomalies with the samples. If anomalies are found, samplers should inform the SMR group so special direction for analysis can be provided to the laboratory if deemed necessary.

3.6.4 Sample Transportation

Packaging and transportation instructions shall comply with applicable transportation regulations and DOE 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 (DOT) as described in 49 CFR 171, "Transportation," "General

Information, Regulations, and Definitions," through 177, "Carriage by Public Highway."[2] Carrier-specific requirements defined in the current edition of International Air Transportation Association (IATA), 2020, *Dangerous Goods Regulations*, shall also be used when preparing sample shipments conveyed by airfreight providers.

Samples containing hazardous constituents above regulated amounts shall be considered hazardous material in transportation and transported according to DOT/IATA requirements. If the sample material is known or can be identified, then it will be packaged, marked, labeled, and shipped according to the specific instructions for that material. Appropriate laboratory notifications will be made, if necessary, through the SMR project coordinator.

Materials are classified by DOT/IATA as radioactive when the isotope specific activity concentration and the exempt consignment limits described in 49 CFR 173, "Shippers—General Requirements for Shipments and Packagings," are exceeded. Samples shall be screened or relevant historical data will be used to determine if these values are exceeded. When screening or historical data indicate samples are radioactive, they shall be properly classified, described, packaged, marked, labeled, and transported according to DOT/IATA requirements.

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

[2] Transportation regulations 49 CFR 174, "Carriage by Rail," and 49 CFR 176, "Carriage by Vessel," are not applicable, as these two transportation methods are not used.

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4 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Miscellaneous solid waste that has contacted suspect dangerous waste will be managed as dangerous waste. Purgewater, decontamination fluids, and other wastes generated will be collected and managed in accordance with DOE/RL-97-01, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Unit.* Packaging and labeling during waste storage and transportation will meet the applicable substantive federal and/or state requirements. Waste materials requiring collection will be placed in containers appropriate for the material and the receiving facility in accordance with the applicable waste management or waste control plan and applicable substantive federal and/or state requirements. For waste designation purposes, wells identified in subsequent SAP addenda may be surveyed in HEIS, and the maximum concentration for each analyte within the most recent 5 years will be evaluated for use in creating a waste profile, if required. Offsite analytical laboratories are responsible for the disposal of unused sample quantities and wastes from analytical processes.

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5 Health and Safety

DOE established the hazardous waste operations safety and health program pursuant to the *Price-Anderson Amendments Act of 1988* to ensure the safety and health of workers involved in mixed-waste site activities. The program was developed to comply with the requirements of 10 CFR 851, "Worker Safety and Health Program," which incorporates the standards of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response"; 10 CFR 830, "Nuclear Safety Management"; and 10 CFR 835. The health and safety program defines the chemical, radiological, and physical hazards and specifies the controls and requirements for daily work activities on the overall Hanford Site. Personnel training; control of industrial safety and radiological hazards; personal protective equipment; site control and general emergency response to spills, fire, accidents, injury, site visitors; and incident reporting are governed by the health and safety program. Site-specific health and safety plans will be used to supplement the general health and safety program.

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Appendix A

Data Quality Objectives

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Terms

CSM	conceptual site model
DOE	U.S. Department of Energy
DQO	data quality objective
ESD	explanation of significant difference
OU	operable unit
P&T	pump and treat
PSQ	principal study question
RAO	remedial action objective
ROD	record of decision
SAP	sampling and analysis plan
UCL-95	95 percent upper confidence limit

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A1 Introduction

The 100-KR-4 Operable Unit (OU) specific data quality objectives (DQOs) were developed to support groundwater monitoring associated with hexavalent chromium (Cr(VI)) rebound studies within the OU. The monitoring is focused on gathering data to assess remedy completion and to determine if the current interim action, as identified in the interim action record of decision (ROD) EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington* (hereinafter referred to as the 100-KR-4 interim remedial action ROD), has met the remedial action objectives (RAOs), which for the 100-KR-4 OU are as follows:

RAO 1: Protect aquatic receptors in the river bottom substrate from contaminants in the groundwater entering the Columbia River.

RAO 2: Protect human health by preventing exposure to contaminants in groundwater.

RAO 3: Provide information that will lead to a final remedy.

To mitigate risks associated with Cr(VI) contamination in groundwater from discharging to the river, groundwater remediation efforts started at the 100-KR-4 OU in 1997 under the interim action remedial design/remedial action work plan (DOE/RL-96-84, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*).

Using ion exchange resins, the initial pump and treat (P&T) system has been expanded over the years. The first expansion was conducted under the remedial design/remedial action work plan supplement to the interim remedial action ROD (DOE/RL-2006-52, *The KW Pump and Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action*) in 2007 with the addition of the KW P&T system. The second expansion was conducted in accordance with an explanation of significant differences (ESD) to the interim remedial action ROD (EPA et al., 2009, *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site Benton County, Washington*). In 2015, DOE/RL-2013-33, *Remedial Design/Remedial Action Work Plan for the 100-KR-4 Groundwater Operable Unit Interim Action* (as modified by TPA-CN-0858), was approved and superseded the previous work plan and combined the requirements into one document.

The KR4, KW, and KX P&T systems operate in the 100-KR-4 OU under the interim remedial action ROD (EPA/ROD/R10-96/134) as revised by applicable ESDs. The interim action continues to operate based on the conceptual site model (CSM), which identifies the nature and extent of contamination, as presented in detail in the DOE/RL-2010-97, *Remedial Investigation for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft B, hereinafter referred to as the 100-K remedial investigation. The CSM is also present in Section 1.4 of DOE/RL-2013-33. Data collected under this sampling and analysis plan (SAP) will continue to inform the CSM, guide interim action optimization, and potentially support implementation of additional remedial actions for waste sites or known or suspected secondary sources that continue to feed groundwater contamination above cleanup standards.

The DQO process was conducted to support identification of sampling requirements. This document follows the DQO guidance identified in EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objective Process*. The following steps are used for DQO development:

1. State the problem.
2. Identify the goal of the study.
3. Identify information inputs.
4. Define the boundaries of the study.

5. Develop the analytical approach.
6. Specify performance or acceptance criteria.
7. Develop the detailed plan for obtaining data.

The purpose of this SAP is to identify spatially and temporally distributed measurements and observations for Cr(VI) contamination, aquifer proprieties (i.e., water levels and groundwater chemistry), and other known 100-KR-4 OU groundwater contaminants of interest (i.e., carbon-14, nitrate, strontium-90, tritium, and trichloroethene). This SAP will also act as the main body of information with subsequent SAP addenda to identify wells and sampling frequency to meet the identified principal study questions (PSQs) developed in Chapter A2. These measurements and observations will be used to assess remedy completion for Cr(VI) while the unconfined aquifer is no longer under the influence of ongoing P&T operations.

A2 Evaluation of the Data Needs

During the data needs evaluation, data that already exist from computational or sampling and analysis methods were compiled and reviewed. Also, the PSQs identified in the previous rebound study (DOE/RL-2016-42, *KW Rebound Study Sampling and Analysis Plan*), were used to inform this DQO. The 100-K remedial investigation (DOE/RL-2010-97, Draft B) summarizes information on constituent concentrations (both vertically and spatially), water level, river impacts within the unconfined aquifer, flow direction, and transport characteristics for the unconfined aquifer underlying the 100-K Area. The updated understanding of contaminant extent is provided in the annual groundwater monitoring reports (e.g., DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*; DOE/RL-2019-67, *Calendar Year 2019 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations, and 100-NR-2 Groundwater Remediation*). Based on the Cr(VI) contaminant distribution identified in DOE/RL-2019-66, many areas within the 100-KR-OU Area are reaching Cr(VI) concentrations less than the groundwater interim remediation target of 20 µg/L.

Representatives from the U.S. Department of Energy (DOE), primary groundwater contractor, and U.S. Environmental Protection Agency (EPA) participated in a facilitated meeting to support the DQO process. During this meeting, which was held on July 21, 2020, the participants discussed the types of data required to assess remedy completion under the interim action. SGW-65230-VA, *Date Quality Objective for the 100-KR-4 Rebound Study Sampling and Analysis Plan*, includes a copy of the presentation discussed during the meeting as well as a meeting summary. The meeting summary includes a list of individuals who represent the planning team members for this DQO. SGW-65230-VA contains the agreed to DQO elements that are incorporated into this DQO.

PSQs and data needs were identified for the following problem statement, which define the problem to be addressed by this SAP and subsequent SAP addenda:

Problem Statement: Groundwater data are needed to support the following evaluations:

- Assess remedy completion
- Confirm or identify areas that require additional action to remediate secondary sources
- Optimize P&T

The goal of this study is addressed through PSQs identified for the problem statement. Data needs identified for each PSQ identify the information inputs necessary to address each PSQ. The PSQs and data needs for each PSQ, as well as the measurement or observations needed and data uses are captured in Table A-1.[1]

[1] Table A-1 mirrors the agreed DQO elements table prepared for the DQO meeting summary with minor format changes, updated PSQ numbering, and the exclusion of preliminary PSQs discussed but not retained.

Decision rules and the alternative outcomes that will determine actions to be completed based on the information collected are also included in Table A-1.

A3 Defining the Boundaries of the Study

The DQO process identifies the target population(s) of interest and the spatial and temporal features pertinent for decision making. Specific spatial and temporal boundaries are identified for groundwater monitoring at the 100-KR-4 OU and were discussed during the DQO meeting. However, the specific areas for which future rebound studies will be performed will be identified in subsequent addenda to the 100-KR-4 Parent Rebound SAP.

A3.1 Spatial Boundaries of the Study

The monitoring program physical boundaries constrain the data collection in three dimensions. The areal limits includes those areas affected by the 100-KR-4 interim action P&T systems as shown in Figure A-1. The current boundaries of the study area are constrained by the areal and vertical extent of contamination associated with the 100-KR-4 OU. If contamination were identified in an additional area, the study area boundaries would be expanded to include the additional area. With the exception of a few extraction wells located between the 100-K and 100-N Areas to provide hydraulic containment between the 100-KR-4 and 100-NR-4 OUs, the working hypothesis is that contaminant migration in the 100-KR-4 OU follows groundwater flow paths toward discharge boundaries. The study domain includes the unconfined aquifer, which is constrained by the Ringold Formation upper mud, and groundwater within the hyporheic zone at the groundwater discharge boundary with the Columbia River.

Groundwater from the 100-KR-4 OU discharges to the Columbia River through the hyporheic zone. The interface of the groundwater and surface water represents a boundary of the study area based on regulatory levels for groundwater discharge to surface water.

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Table A-1. Compilation of Data Needs and Alternative Outcomes

PSQ		Data Need	Measurements or Observations and Data Use	Sample/Measurement Type and Frequency	Define Alternative Outcomes and Actions that can Occur upon Answering PSQs
PSQ 1	In the absence of P&T operations, have Cr(VI) concentrations reached concentrations below the interim action remediation target of 20 µg/L and expected to remain stable or decrease?	Increased frequency of Cr(VI) concentration measurements in groundwater in the absence of P&T operations	Measurements taken from existing unconfined aquifer wells within a given 100-KR-4 OU remedy area to determine if Cr(VI) concentration will remain below the interim action remediation target of 20 µg/L.	Analysis of representative groundwater samples on filtered aliquots, collected from the top 1.5 m (5 ft) of the water table, every other month from identified locations.	Alternative outcome: No rebound in groundwater Cr(VI) concentrations exceeding the interim action of 20 µg/L is observed. Action: Assess monitoring network and frequency for sufficiency and continue the rebound study.
					Alternative outcome: Rebound in groundwater Cr(VI) concentrations exceeding the interim action cleanup level target of 20 µg/L is observed. Action: Assess monitoring network and frequency for sufficiency and evaluate the need to restart the interim action P&T in the affected area(s).
PSQ 2a	If rebound of Cr(VI) is observed, does it originate from known or suspected continuing sources of groundwater contamination?	High frequency Cr(VI) concentration measurements in groundwater collected at the top of the unconfined aquifer in the absence of P&T operations	Measurements taken from existing unconfined aquifer wells at or immediately downgradient from known or suspected continuing sources within a given 100-KR-4 OU remedy area. Assess apparent rebound compared to the seasonal effect from river stage primarily through comparative trend analysis.	Analysis of representative groundwater samples on filtered aliquots, collected from the top 1.5 m (5 ft) of the water table, monthly from identified locations.	Alternative outcome: Rebound of Cr(VI) concentrations in groundwater above applicable standards is not observed coming from known or suspected sources. Action: Assess monitoring network and frequency for sufficiency and continue the rebound study.
					Alternative outcome: Rebound of Cr(VI) concentrations in groundwater above applicable standards is observed coming from known or suspected sources in the vicinity of historical releases. Action: Assess the magnitude of the observed rebound and determine if additional actions are needed to address the secondary source and evaluate the need to restart and optimize P&T operations.
PSQ 2b	If rebound of Cr(VI) is observed, does it originate from areas outside of known or suspected continuing sources of groundwater contamination?	Increased frequency of Cr(VI) concentration measurements in groundwater collected at the top of the unconfined aquifer in the absence of P&T operations	Measurements taken from existing unconfined aquifer wells downgradient from known or suspected secondary sources within a given 100-KR-4 OU remedy area. Assess apparent rebound compared to the seasonal effect from river stage primarily through comparative trend analysis.	Analysis of representative groundwater samples on filtered aliquots, collected from the top 1.5 m (5 ft) of the water table, every other month from identified locations.	Alternative outcome: Rebound of Cr(VI) concentrations in groundwater above applicable standards is not observed coming from areas outside known or suspected continuing sources. Action: Assess monitoring network and frequency for sufficiency and continue the rebound study.
					Alternative outcome: Rebound of Cr(VI) concentrations in groundwater above applicable standards is observed coming from areas outside known or suspected continuing sources. Action: Evaluate if rebound is coming from areas of known or suspected sources of contamination or previously unmonitored inland areas. Assess the magnitude of the observed rebound and evaluate if the groundwater sampling frequency needs to be increased to monthly and/or evaluate the need to restart and optimize P&T operations.
PSQ 2c	If rebound of Cr(VI) is observed, does it originate from previously unmonitored inland areas associated with historical operations?	Increased frequency of Cr(VI) concentration measurements in groundwater collected at the top of the unconfined aquifer in the absence of P&T operations	Measurements taken from existing unconfined aquifer wells located inland of known secondary source or wells that have historically bounded the lateral extent of the Cr(VI) plume within a given 100-KR-4 OU remedy area.	Analysis of representative groundwater samples on filtered aliquots, collected from the top 1.5 m (5 ft) of the water table, every other month from identified locations.	Alternative outcome: Rebound of Cr(VI) concentrations in groundwater exceeding the inland cleanup level of 48 µg/L is not observed coming from previously unmonitored inland areas caused by historical operations. Action: Assess monitoring network and frequency for sufficiency and continue the rebound study.
					Alternative outcome: Rebound of Cr(VI) concentrations in groundwater exceeding the inland cleanup level of 48 µg/L is observed coming from previously unmonitored inland areas caused by historical operations. Action: Assess the magnitude of the observed rebound and evaluate if the groundwater sampling frequency needs to be increased to monthly, evaluate the need to restart and optimize P&T operations, and/or evaluate the need for additional monitoring wells but continue the rebound study.
PSQ 3	What is the vertical distribution of Cr(VI) within the unconfined aquifer in the absence of P&T operations?	Cr(VI) concentration measurements in groundwater collected vertically through the saturated screen interval in the absence of P&T operations	Depth discrete measurements taken from existing unconfined aquifer wells within a given 100-KR-4 OU remedy area. Data will be used to assess the vertical distribution of Cr(VI) contamination and determine adequacy of existing monitoring wells and sampling scheme.	Analysis of representative groundwater samples on filtered aliquots, collected vertically through available well screens and aquifer thickness. • For wells located at or immediately downgradient of known or suspected secondary sources, vertical sampling will occur every other month. • For wells located inland from or downgradient of known or suspected secondary source, vertical sampling will occur during seasonal high and seasonal low river stage.	Alternative outcome: Vertical distribution of Cr(VI) contamination is not observed within existing well screens. Action: Assess the timing of the sampling event and potentially reduce sampling depending on current frequency, but continue rebound study.
					Alternative outcome: Vertical distribution of Cr(VI) contamination is observed within existing well screens. Action: Assess monitoring frequency and sample depth for other PSQs for sufficiency and continue rebound study.
					Alternative outcome: Vertical distribution of Cr(VI) contamination is observed within existing well screens, but well screen is relatively shallow. Action: Assess monitoring frequency for sufficiency, evaluate the need for a new deeper monitoring well, and continue rebound study.
					Alternative outcome: Vertical distribution of Cr(VI) contamination is observed within existing well screens located inland from or downgradient of known or suspected secondary source. Action: Assess monitoring frequency and potential increase to every other month and continue rebound study.

Table A-1. Compilation of Data Needs and Alternative Outcomes

PSQ		Data Need	Measurements or Observations and Data Use	Sample/Measurement Type and Frequency	Define Alternative Outcomes and Actions that can Occur upon Answering PSQs
PSQ 4	What is the magnitude, gradient, and flow direction of groundwater in the absence of P&T operations?	Manual water level and AWLN measurements collected in the absence of P&T operations	Water level measurements collected during groundwater sampling events, and AWLN measurements from existing stations Data will be used to update flow and transport models, and interpolate groundwater plumes.	Water level measurements will be collected from identified monitoring locations over a relatively short time frame during groundwater sampling activities. AWLN measurement collected hourly from existing station.	Alternative outcome: Hydraulic gradient is established at expected direction and anticipated apparent velocity. Action: Assess monitoring network and frequency for sufficiency and continue rebound monitoring.
					Alternative outcome: Hydraulic gradient is established in an unexpected direction or unexpected apparent velocity. Action: Assess monitoring network and frequency for sufficiency, revise if necessary, and continue rebound monitoring.
PSQ 5	What are the seasonal effects of changing river stage on Cr(VI) concentrations and groundwater flow in the absence of P&T operations?	High frequency Cr(VI) concentration measurements in groundwater Manual water level and AWLN measurements	Measurements and water levels taken from existing unconfined aquifer wells within a given 100-KR-4 OU remedy area to determine the seasonal effect on Cr(VI) contamination. Data will be used to update groundwater flow and transport models and interpolate groundwater plumes to inform the conceptual site model. Water levels and Cr(VI) concentration data will be used for comparative trend analysis.	Analysis of representative groundwater samples on filtered aliquots, collected from the top 1.5 m (5 ft) of the water table, every other month from identified locations for a full river stage cycle (e.g., 12 months). Water level measurements collected during sampling events.	Alternative outcome: The seasonal effects on Cr(VI) contamination exhibit Cr(VI) concentration below the interim action groundwater remediation target of 20 µg/L. Action: Assess monitoring network and frequency for sufficiency, revise if necessary, and continue rebound monitoring.
					Alternative outcome: The seasonal effects on Cr(VI) contamination exhibits Cr(VI) concentrations above the interim action groundwater remediation target of 20 µg/L. Action: Evaluate the need to restart the interim action P&T depending on the magnitude of the increase and proximity to the river.
PSQ 6	In the absence of P&T operations, has groundwater reestablished natural conditions?	Increased frequency of major ions (calcium, chloride, magnesium, nitrate, potassium, sodium, and sulfate), alkalinity, specific conductance and other field parameter measurements in groundwater in the absence of P&T operations Manual water level and AWLN measurements	Measurements taken from existing unconfined aquifer wells within a given 100-KR-4 OU remedy area to determine if the groundwater has returned to natural conditions and flow directions after the cessation of P&T operations. Data will be used to assess natural flow directions as well as perform comparative trend analysis of general groundwater chemistry.	Analysis of representative groundwater samples on filtered aliquots of major cations and unfiltered aliquots of major anions, and alkalinity collected from the top 1.5 m (5 ft) of the water table every other month from identified locations for a minimum 6 months. Water level measurements collected during sampling events.	Alternative outcome: Groundwater conditions have returned to natural flow conditions and reestablishment of inland groundwater geochemistry in the absence of P&T operations. Action: Assess monitoring network and frequency for sufficiency, revise if necessary, and continue rebound monitoring.
					Alternative outcome: Groundwater conditions have not returned to natural flow conditions and reestablishment of inland groundwater geochemistry in the absence of P&T operations. Action: Evaluate the groundwater velocities and potential sources of major anions and cations in the identified area, revise sampling frequency if necessary, and continue rebound monitoring.
PSQ 7	In the absence of P&T operations, what are the effects on other 100-KR-4 groundwater contaminants of interest?	Increased frequency of carbon-14, nitrate, strontium-90, tritium, and trichloroethene concentration measurements in groundwater in the absence of P&T operations	Measurements taken from existing unconfined aquifer wells within a given 100-KR-4 OU remedy area to determine extent of groundwater contamination of other 100-KR-4 groundwater contaminants of interest in the absence of P&T.	Analysis of representative groundwater samples collected unfiltered aliquots as follows: • For wells located at or immediately downgradient of known or suspected secondary sources, every other month. • For wells located inland from or downgradient of known or suspected secondary source, once every quarter.	Alternative outcome: Groundwater concentrations of other 100-KR-4 contaminants of interest do not change in the absence of P&T. Action: Assess monitoring network and frequency for sufficiency, revise if necessary, and continue rebound monitoring.
					Alternative outcome: Groundwater concentrations of other 100-KR-4 contaminants of interest increase above applicable standards in the absence of P&T. Action: Assess monitoring network and frequency for sufficiency, revise if necessary, and continue rebound monitoring.

AWLN = automatic water level network
OU = operable unit
P&T = pump and treat
PSQ = principal study question

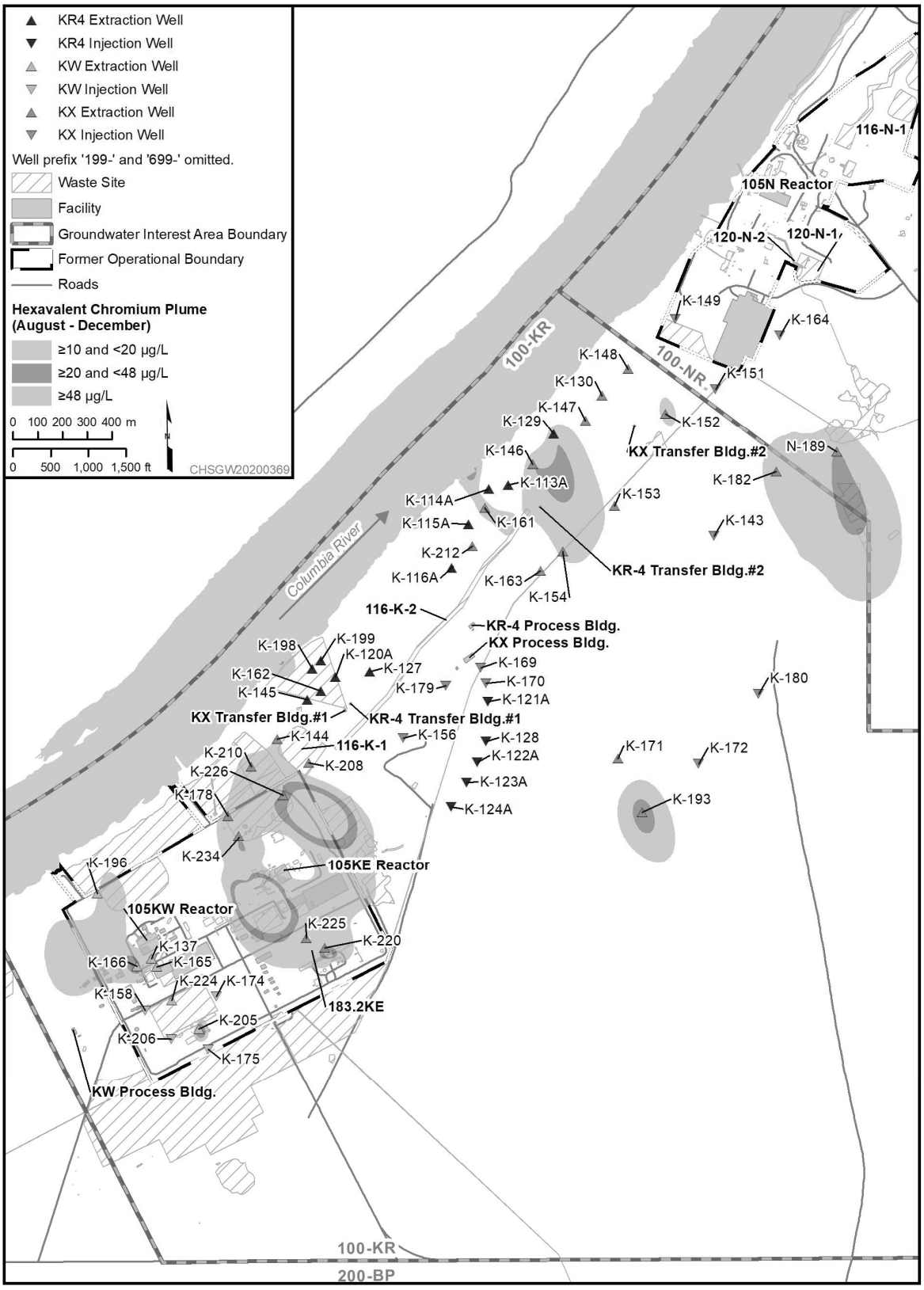

Figure A-1. 100-KR-4 2019 Cr(VI) Plume and P&T Well Network

A3.2 Temporal Boundaries of the Study

Temporal boundaries are related to timing, frequency, and duration of measurements and observations. Timing is driven by river stage seasonal variation and the associated changes in groundwater flow direction and flow velocity. Frequency is the number of times per year a sample is collected from a monitoring location. Previous experience from the 100K West rebound study (DOE/RL-2016-42) helped to identify the appropriate measurement frequency to satisfy data needs.

The Columbia River functions as a discharge boundary for the shallow unconfined aquifer beneath the 100-KR-4 OU. During periods of low river stage, groundwater in the unconfined aquifer flows toward the river and discharges into the river along the shore. During periods of rising level and high river stage, the magnitude of the groundwater gradient is reduced, and in portions of the shallow aquifer near the river, gradient may actually reverse and river water may enter the aquifer. As the river stage remains elevated, groundwater from inland continues to flow toward the river and backs up against the boundary head provided by the elevated river stage; groundwater elevation inland of the river shore rises accordingly. As the river stage declines after the freshet, groundwater again flows toward the river, typically under above average gradient. Because of the hydraulic lag that occurs between high river stage and maximum groundwater elevation inland, high river stage does not directly coincide with high groundwater elevation. Data generally indicate that the river stage begins to climb in April, while May through July have historically remained above the annual mean river stage. Periods of high and low river stage change from year to year. However, the period of high river stage is generally from April through August, and low river stage is generally observed from September through December.

Response of the Cr(VI) plume in the unconfined aquifer at 100-KR-4 OU to the change in river stage has been tracked and is reported as part of the Hanford Site annual groundwater report (e.g., DOE/RL-2019-66). The dimensions and changes in plume geometry in the unconfined aquifer with changes in river stage are well understood under pumping conditions. The plume boundaries are generally farther inland from the river during high river stage in comparison to low river stage. The greatest flux of contaminants to the river occurs as the river transitions from seasonal high to seasonal low.

The timing of when a rebound study may be implemented will be documented in the SAP addenda. Each rebound study is assumed to last a full river stage cycle (i.e., 12 months) to ensure adequate understanding of contaminate migration effects during high and low river stage as well as during seasonal transition periods.

A3.3 Resource Limitations and Constraints

A number of known and potential constraints may interfere with implementation of the groundwater rebound studies. The following constraints are identified at this time:

- Limitations due to DOE baseline budget priorities and available funding
- Extent of testing to be conducted at new and existing wells, which is limited by funding, priorities, and identified needs at a point in time
- Project and field operation personnel availability
- Groundwater sampling of current P&T wells assumes that all downhole equipment from operating extraction and injection wells has been removed
  - An evaluation is underway to determine if sampling can be performed with P&T equipment installed

- Rebound studies may impact yearly treatment goals for gallons treated and mass removed. This situation needs to be discussed and documented with the DOE as part of the yearly remedial process optimization.
- The vertical flow within completed monitoring wells remains uncertain. The vertical samples collected under this SAP provide a limited interpretation of the vertical distribution of contamination. Further hydraulic testing could be performed on wells that indicated full thickness contamination to confirm the results.
- Further remedial actions (i.e., waste site excavation) near wells that may result in removal of a well included in the monitoring plan
  - Extensive use of dust suppression water may affect localized hydraulic gradients or increase contaminant concentrations. Ongoing or planned waste site remediation activities should be evaluated prior to a rebound study.
- Unforeseen circumstances such as extended site closures

A4 Specification of Performance or Acceptance Criteria

This step in the evaluation is intended to specify performance criteria expressed as probability limits on potential errors in decision making. The probability limits specify the level of confidence desired for conclusions drawn from site data.

Primary decisions for monitoring DQOs involve adequacy of spatial and temporal coverage of the monitoring network. In general, spatial coverage will be defined in the SAP addenda but includes monitoring wells that adequately describe a given rebound area with consideration to contaminant distribution (i.e., upgradient, downgradient, and bounding) and hydraulic flow in the absence of P&T operations.

Analytical data and field measurements can only estimate the true condition of the site under investigation, and decisions that are made based on measurement data could potentially be in error (i.e., decision error). Based on the PSQs established in Table A-1, Table A-2 includes the applicable method, practical quantitation limits, and acceptable analytical performance ranges to ensure data collected are of sufficient quality for their intended purpose.

Table A-2. Constituent Methods and Analytical Performance Requirements

Constituent	CAS Number[a]	MCL or WAC[b]	Analytical Method[c]	Required PQL for Water[d]	Precision Requirement[e,f]	Accuracy Requirement[e,f]
General Chemical Parameters (µg/L)						
Alkalinity	ALKALINITY	N/A	310.1, 2320	5,250	≤20%	80–120%
Inorganics – Anions (µg/L)						
Chloride	16887-00-6	250,000	300, 9056	400	≤20%	80–120%
Fluoride	16984-48-8	4,000	300, 9056	525	≤20%	80–120%
Nitrate	14797-55-8	45,000[g]	300, 9056	525	≤20%	80–120%
Phosphate	14265-44-2	N/A	300, 9056	787.5	≤20%	80–120%
Sulfate	14808-79-8	250,000	300, 9056	1,050	≤20%	80–120%
Inorganics – Metals (µg/L)						
Calcium	7440-70-2	N/A	6010	1,050	≤20%	80–120%
Chromium	7440-47-3	100	6020	10.5	≤20%	80–120%

Table A-2. Constituent Methods and Analytical Performance Requirements

Constituent	CAS Number[a]	MCL or WAC[b]	Analytical Method[c]	Required PQL for Water[d]	Precision Requirement[e,f]	Accuracy Requirement[e,f]
Hexavalent chromium	18540-29-9	48/10	7196 (low level)	5	≤20%	80–120%
Magnesium	7439-95-4	N/A	6010	1,050	≤20%	80–120%
Potassium	7440-09-7	N/A	6010	5,250	≤20%	80–120%
Sodium	7440-23-5	N/A	6010	1,050	≤20%	80–120%
Volatile Organic Compounds (µg/L)						
Trichloroethene	79-01-6	4	8260	2.1	≤20%	70–130%
Radionuclides (pCi/L)						
Carbon-14	14762-75-5	2,000	Liquid scintillation counter	50	≤20%	80–120%
Strontium-90	10098-97-2	8	Gas proportional counting	2	≤20%	80–120%
Tritium	10028-17-8	20,000	Liquid scintillation	700	≤20%	80–120%
Field Measurements						
Dissolved oxygen	DO	N/A	Field measurement instrument/meter	N/A	N/A	N/A
pH measurement	PH					
Specific conductance	CONDUCT					
Temperature	TEMPERATURE					
Turbidity	TURBIDITY					

a. Value identified is either the CAS number or the constituent identifier if no CAS numbers exists.

b. WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards," Method B or WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington," or 40 CFR 141, "National Primary Drinking Water Regulations."

c. For EPA Method 310.1 see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 300, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium*. Equivalent methods may be substituted.

d. Required PQLs are specified in contracts with analytical laboratories. Actual practical quantitation limits vary by laboratory and may be lower. Method detection limits are three to five times lower than quantitation limits. For radionuclides, values in this column are the required minimum detectable concentrations in pCi/L for water.

e. Precision and accuracy requirements are identified and defined in CHPRC-00189, *Environmental Quality Assurance Program Plan*

f. Accuracy criteria are the minimum for associated batch laboratory control sample percent recoveries. Laboratories may use statistically derived control limits. Additional analyte-specific evaluations are also performed for matrix spikes and surrogates as appropriate to the method. Precision criteria are for batch laboratory replicate matrix spike analyses.

g. The federal drinking water standard for nitrate is 10 mg/L, expressed as nitrogen. This equates to 45,000 µg/L when expressed as NO_3.

CAS = Chemical Abstracts Service
EPA = U.S. Environmental Protection Agency
MCL = maximum contaminant level
PQL = practical quantitation limit
WAC = *Washington Administrative Code*

Because of the potential for error, the primary objective of step 6 of the DQO process is to determine which decision statements (if any) require a statistically based sample design. For those decision statements requiring a statistically based sample design, DQO step 6 identifies tolerable limits on the probability of making a decision error. While decision statements are included in Table A-1 for each PSQ, the current sample design approach will primarily rely on a judgmental sampling and potentially qualitative trend analysis to determine potential outcomes.

A4.1 Statistical Versus Nonstatistical Sampling Design

Resolving the PSQs is dependent on evaluating different datasets, including historical and current analytical data and field measurements. These data will be used for scientific calculations and statistical analyses. The limits on analytical data are specified within the analytical method quality assurance/quality control criteria, as identified in Chapter 2 of the main document.

Traditional statistical sampling designs were not identified for the groundwater monitoring for PSQs. OSWER Directive 9283.1-44, *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*, identifies nonstatistical or visual review that may be appropriate when groundwater data are all nondetected, or data are a combination of nondetect, and all detected contaminant of concern concentrations are less than the cleanup level. For groundwater data that are not appropriate for nonstatistical review, a mean test or trend test, using the upper confidence limit for comparison to the cleanup level, is recommended. Data may be expressed and reported as individual measurements for each analyte as a 95 percent upper confidence limit (UCL-95), using the well monitoring dataset. Using UCL-95 to determine whether an area can be declared clean is suggested in both the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* and WAC 173-340, "Model Toxics Control Act—Cleanup" guidance. A comparison to the action level may be performed using UCL-95 for each analyte. The UCL-95 calculation completed using the recommended methodologies found in U.S. Environmental Protection Agency guidance (EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*) and WAC 173-340-720(9)(d)(i), "Groundwater Cleanup Standards."

The data collected will be used to optimize the remedial action and evaluate RAOs. Consequences of inadequate sampling design may impact the period to achieve cleanup or the ability to achieve RAOs. All monitoring locations are accessible for resampling, though the time of collection will differ and may introduce variability in the dataset.

A5 Development of the Detailed Plan for Obtaining Data

The following sections provide the methodology to select groundwater monitoring locations and sampling frequencies that adequately meet the data needs associated with the PSQs.

A5.1 Identification of Available Monitoring Locations

When an area within the 100-KR-4 OU has been identified for a rebound study, all available monitoring locations (e.g., wells, aquifer tubes, and treatment process streams) should be identified and reviewed. Figure A-2 shows the 100-KR-4 well network at the end of fiscal year 2020 as well as the groundwater plumes from the 2019 Hanford Annual Groundwater Report (DOE/RL-2019-66).

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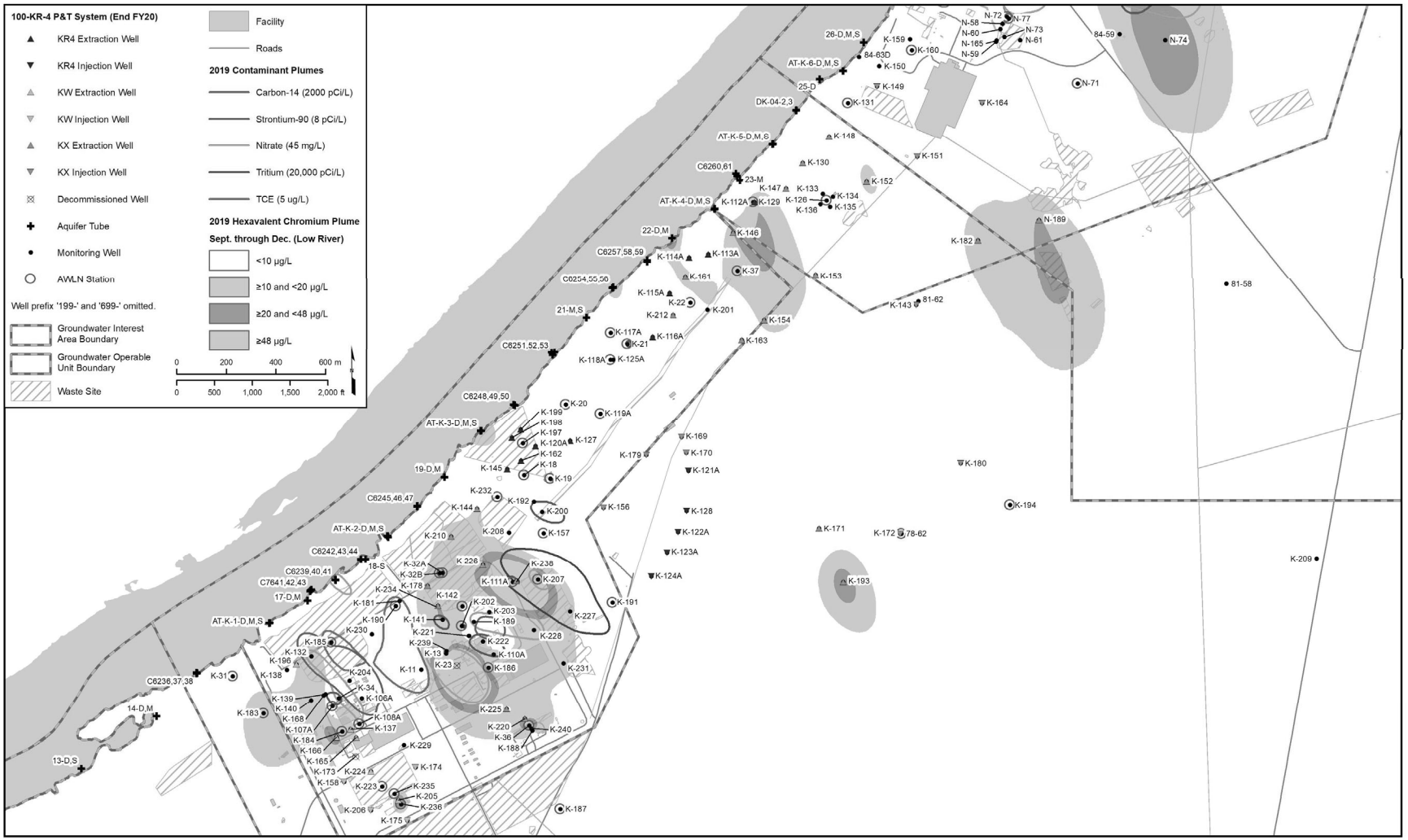

Figure A-2. 100-KR-4 Well Network, September 2020

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A5.2 Evaluation of Available Locations Against the Data Needs

Each potential monitoring location within a proposed rebound study area will be evaluated against the data needs for each PSQ to identify locations that potentially fulfill the data need. The available monitoring locations that can be used to fulfill each PSQ will be plotted on maps and provided in specific rebound SAP addenda. The following rationale should be used for identifying potential locations:

- Location – understanding of contaminant plumes (both current and historic) and proximity to known or suspect sources
- Screened interval for monitoring wells
- Historical sample results – Contaminant detections at existing monitoring locations

Well locations and construction information will be extracted from the Environmental Dashboard Application, which provides physical information for the monitoring locations (e.g., relative position of screened intervals). Historical measurements and observations recorded in the Hanford Environmental Information System will also be used to identify historical sample results, including detection of contaminants of interest, contaminant concentration time series, and water-level measurements.

A5.3 Monitoring Location Retained/Excluded

Each available monitoring location near to and within an identified rebound study area should be systematically evaluated to determine the suitability in fulfilling the data needs identified in Table A-1. This evaluation includes criteria for retaining and excluding specific monitoring locations. The following criteria should be considered in the evaluation (criteria for retention include locations that meet the following requirements):

- Defined contaminant groundwater plumes
- Proximity to known or suspected continuing sources of Cr(VI) contamination (SGW-64284, *100-K Area Continuing Hexavalent Chromium Sources*)
- Proximity to known or suspected continuing sources of other contaminates of interest (DOE/RL-2018-22, *Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft B)
- Recent and historical temporal trends
- Historic vertical distribution of contaminants within the unconfined aquifer
- Apparent migration pathway of defined contaminant plumes
- Recent and historic hydraulic head conditions
- Monitor performance and aquifer impact of ongoing operation of remedial action systems (e.g., P&T extraction wells and specifically identified performance monitoring wells)

Criteria for exclusion include locations that meet the following requirements:

- Redundant (i.e., are located within approximately 10 m [30 ft] of another monitoring location) and does not provide supplemental or definitive input to a data need
- Does not provide useful bounding condition measurements (i.e., not located in a downgradient area where the plume may be migrating)

The result of this evaluation will be sampling locations that meet the identified data needs for each PSQ in Table A-1.

As part of the sampling activities associated with this SAP, groundwater samples will be collected from wells to determine the vertical distribution of groundwater contamination in the absence of P&T operations. Wells should be evaluated based on the following:

- Proximity to known or suspected continuing sources of contamination
- Screen design
- Saturated thickness
- Stratigraphy
- Previously collected vertical groundwater characterization samples collected during drilling

At a minimum, two samples will be collected per well; one sample will be collected at the top of the unconfined aquifer and a second collected from the bottom of the screened interval. The specific depths will be identified in the SAP addenda. These samples will be used for a qualitative evaluation of the vertical distribution of contamination and may be used to optimize extraction well pump placement, in the future. In the event a well indicates full thickness contamination, it is recommended the vertical flow within the completed well be determined.

A5.4 Data Collection Frequency

Historical groundwater monitoring and P&T system performance monitoring provide a well understood CSM of contaminant distribution and groundwater movement. The appropriate data collection frequencies for each PSQ were discussed briefly during the DQO meetings. Using the previous 100K West Rebound Study (DOE/RL-2016-42) as a starting point, sampling frequencies were developed to meet the identified PSQs.

Groundwater samples will be collected on a schedule based on the relative proximity of monitoring locations to the apparent secondary source areas, with the monitoring locations within the source areas being sampled most frequently (e.g., monthly) and locations more distant from the source areas sampled less frequently (e.g., bimonthly, quarterly). Groundwater elevation will be measured manually during each groundwater sampling event; existing automated water level network stations will remain in service and will record hourly groundwater elevation measurements. Each rebound study is anticipated to last a minimum of 12 months to evaluate fully the seasonal river stage effects on a given area. A rebound study may be shortened if Cr(VI) concentrations increase to greater than 48 µg/L at a location downgradient of a rebound study area or close to an exposure point.

A6 Final Sample Design

The final sampling design will be included in the rebound SAP addenda and will include wells identified to meet each PSQ and the recommended frequency for data collection for each data type identified for those locations. Table A-3 summarizes PSQs, measurements to be collected, and the identified frequency that will be applied based on the identified PSQs.

Table A-3. Summary of PSQs, Measurements, and Applied Frequency

PSQ	Measurement	Filtered or Unfiltered	Frequency
PSQ 1	Cr(VI)	Filtered	Bimonthly
PSQ 2a	Cr(VI)	Filtered	Monthly
PSQ 2b	Cr(VI)	Filtered	Bimonthly
PSQ 2c	Cr(VI)	Filtered	Bimonthly
PSQ 3	Cr(VI)	Filtered	Bimonthly to river stage*
PSQ 4a	Water levels	--	To be collected during sampling events AWLN
PSQ 5	Cr(VI) Water levels	Filtered --	Bimonthly To be collected during sampling events
PSQ 6	Major ions (calcium, chloride, magnesium, nitrate, potassium, sodium, and sulfate) Alkalinity Field parameters (i.e., specific conductance, dissolved oxygen, pH, etc.)	Cations – filtered Anions – unfiltered Alkalinity – unfiltered	Bimonthly
PSQ 7	Carbon-14, nitrate, strontium-90, tritium, and trichloroethene	Unfiltered	Monthly to quarterly

*Locations identified for "River Stage" sampling under PSQ 3 will target collecting groundwater samples during the seasonal high (May/June) and low (September/October) river stage periods.

AWLN = automated water level network

PSQ = principal study question

A7 References

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