U.S. Department of Energy
Hanford Site

October 9, 2020

21-SGD-0002

Ms. Alexandra K. Smith, Program Manager
Nuclear Waste Program
Washington State Department of Ecology
3100 Port of Benton Boulevard
Richland, Washington 99354

Dr. Laura Buelow, Remedial Project Manager
Office of Environmental Cleanup
Site Cleanup Unit 4
U.S. Environmental Protection Agency
825 Jadwin Avenue, Suite 210
Richland, Washington 99352

Dear Addressees:

GROUNDWATER MONITORING SAMPLING AND ANALYSIS PLAN FOR THE 100-HR-3 GROUNDWATER OPERABLE UNIT, DOE/RL-2017-13-ADD1, DRAFT A

This letter transmits the Groundwater Monitoring Sampling and Analysis Plan for the 100-HR-3 Groundwater Operable Unit, DOE/RL-2017-13-ADD1, Draft A, for your review. Please submit your comments within 45 days of receipt of this letter. The Data Quality Objective (DQO) meeting for this document was held on February 27, 2020, with both regulatory agencies participating.

If you have any questions, please contact me, or your staff may contact John Sands, of my staff, on (509) 372-2282.

Sincerely,

Michael W. Cline Digitally signed by Michael W. Cline Date: 2020.10.09 08:27:26 -07'00'

Michael W. Cline, Director,
Soil and Groundwater Division
Richland Operations Office

SGD:JPS

cc: See page 2

Attachment:
DOE/RL-2017-13-ADD1, Draft A

cc: w/attach
J. Bell, NPT
A. L. Boyd, Ecology
R. Buck, Wanapum
L. Contereras, YN
D. R. Einan, EPA
S. Leckband, HAB
N. M. Menard, Ecology
N. Murphy, CTUIR
S. N. Schleif, Ecology
K. R. Welsch, Ecology
M. Woods, ODOE
Administrative Record (100-HR-3)
Environmental Portal

cc w/o attach:
T. B. Bergman, CHPRC
S. L. Brasher, MSA
S. W. Davis, MSA
R. T. Evans, CHPRC
R. E. Fox, CHPRC
L. K. O'Mara, CHPRC

DOE/RL-2017-13-ADD1
Draft A

Groundwater Monitoring Sampling and Analysis Plan for the 100-HR-3 Groundwater 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
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2017-13-ADD1
Draft A

Groundwater Monitoring Sampling and Analysis Plan for the 100-HR-3 Groundwater 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
P.O. Box 550
Richland, Washington 99352

APPROVED
By Janis D. Aardal at 8:19 am, Sep 24, 2020

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Title: *Groundwater Monitoring Sampling and Analysis Plan for the 100-HR-3 Groundwater Operable Unit*

Print Name U.S. Department of Energy, Richland Operations Office	Signature	Date
Print Name U.S. Environmental Protection Agency	Signature	Date
Print Name Washington State Department of Ecology	Signature	Date

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Terms

COC	contaminant of concern
DoD/DOE QSM	U.S. Department of Defense/U.S. Department of Energy Consolidated Quality System Manual
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
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
EB	equipment blank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FSO	Field Sample Operation
FTB	full trip blank
FWS	Field Work Supervisor
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Documents*
HEIS	Hanford Environmental Information System
IATA	International Air Transportation Association
MB	method blank
MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
NTU	nephelometric turbidity unit
O&M	operation and maintenance
OU	operable unit
P&T	pump and treat
PSQ	principal study question
QA	quality assurance

QAPjP	quality assurance project plan
QC	quality control
RAO	remedial action objective
RCT	radiological control technician
RD/RAWP	remedial design/remedial action work plan
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RS&I	Remedy Selection and Implementation
RUM	Ringold Formation upper mud unit
Rwie	Ringold Formation member of Wooded Island — unit E
SAF	sample authorization form
SAP	sampling and analysis plan
SME	subject matter expert
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) presents the groundwater monitoring plan for the 100-HR-3 Groundwater Operable Unit (OU). The 100-HR-3 OU comprises groundwater contaminated by releases from facilities and waste sites associated with past operation of the D, DR, and H Reactors. It includes the 100-D and 100-H operational areas and the area between them known as the Horn (Figure 1-1). In July 2018, the 100-D/H record of decision (ROD; EPA et al., 2018, *Record of Decision Hanford 100 Area Superfund Site 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*) was issued, which included the remedy for the 100-HR-3 Groundwater OU. The 100-D/H ROD selected pump and treat (P&T) as the remedy for total chromium and hexavalent chromium (Cr(VI)). Monitored natural attenuation (MNA) of groundwater was selected for nitrate and strontium-90 (Sr-90). Performance monitoring of the P&T system remedy, and as part of the MNA remedy, will be performed as described in this SAP. Performance monitoring of the contaminants of concern (COCs) in the groundwater as a component of the MNA remedy will be performed until cleanup levels are met. The compliance and attainment monitoring approaches for groundwater continue to be developed. Attainment monitoring demonstrates that groundwater cleanup levels have been achieved for contaminants remediated through MNA. Once approved compliance and attainment monitoring approaches and networks have been identified, they will be added to this SAP through a revision or Tri-Party Agreement change notice per the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement; Ecology et al., 1989a).

Upon approval of DOE/RL-2017-13, *Remedial Design/Remedial Action Work Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*, to which this document is an addendum, this SAP will supersede DOE/RL-2013-30, *Sampling and Analysis Plan for 100-HR-3 Groundwater Operable Unit Monitoring*.

This SAP consists of the following five chapters and two appendices:

- Chapter 1 addresses the project scope and objectives, background, groundwater contaminants, and project schedule.
- Chapter 2 presents the quality assurance project plan (QAPjP).
- Chapter 3 provides the field sampling plan.
- Chapter 4 addresses waste management.
- Chapter 5 addresses health and safety requirements.
- Appendix A provides the data quality objectives (DQOs) and sampling design.
- Appendix B provides the summary sampling table.

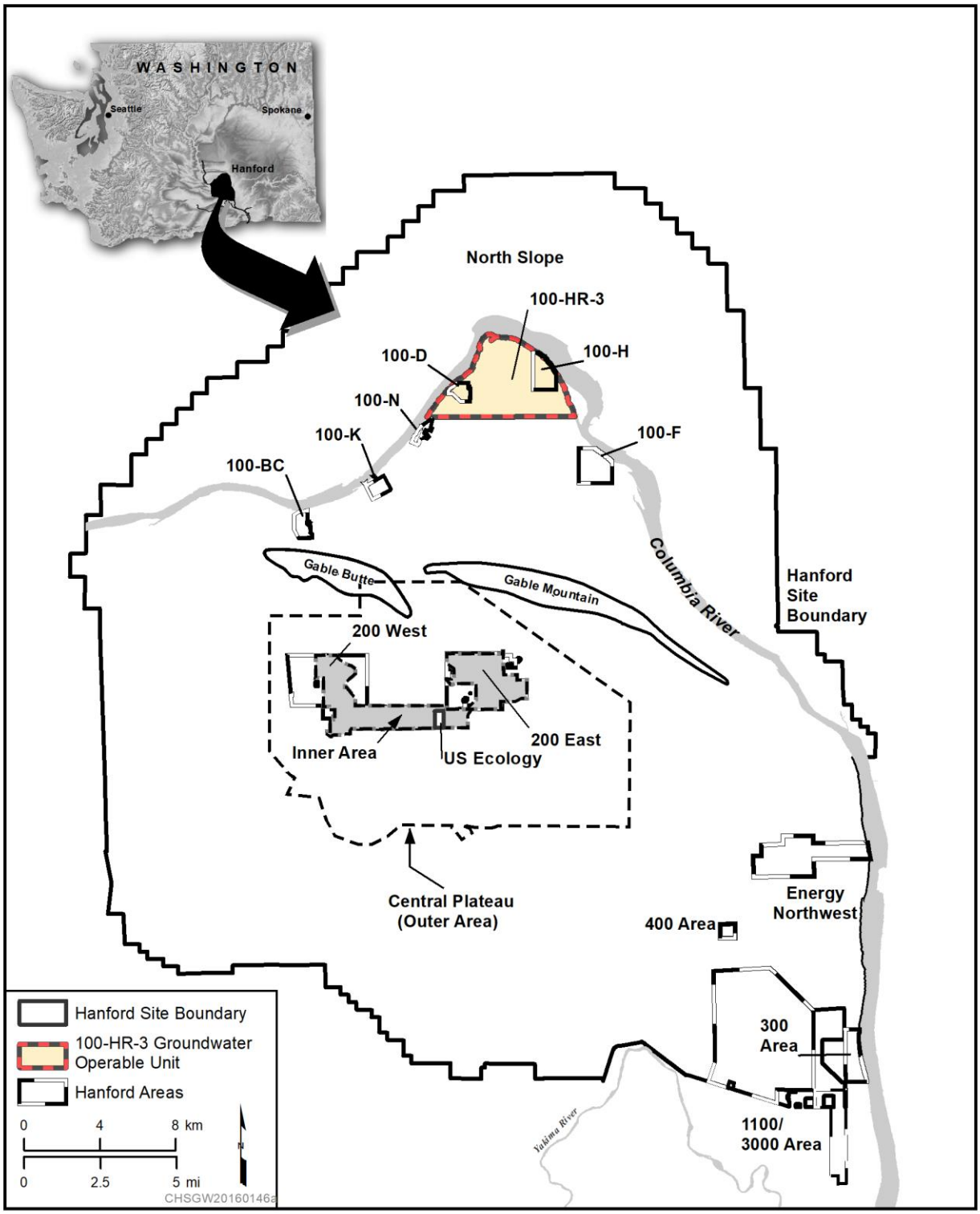


Figure 1-1. Location of the 100-HR-3 Groundwater OU

1.1 Project Scope and Objective

The monitoring presented in this plan satisfies the requirements of performance and attainment monitoring of the P&T and MNA remedies as identified in the 100-D/H ROD (EPA et al., 2018) and described in DOE/RL-2017-13. This includes identification of the groundwater monitoring network, installation of new monitoring wells, periodic sampling of new and existing wells and aquifer tubes, laboratory analysis, and data evaluation. The monitoring locations identified in this SAP are designed to collect groundwater data sufficient to evaluate the P&T operations, natural attenuation processes, rates of attenuation, and overall protectiveness with respect to the following 100-HR-3 OU remedial action objectives (RAOs) identified in the 100-D/H ROD (EPA et al., 2018):

- RAO 1: Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.
- RAO 2: Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.
- RAO 7: Restore groundwater in 100-HR-3 OU to cleanup levels, which include drinking water standards, within a timeframe that is reasonable given the particular circumstances of the site.

Remedial action performance monitoring for Cr(VI) and total chromium is included in this SAP. The monitoring locations are designed to collect groundwater data sufficient to track the extent, movement, and concentrations of Cr(VI) to evaluate performance of the remedy. In addition, sampling data collected under this SAP will be used to conduct remedial process optimization, which is described in SGW-58690, *Remedial Process Optimization Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units Interim Action*. The performance monitoring component includes installing new monitoring wells, periodic sampling, laboratory analysis, and data evaluation. Data evaluated during performance monitoring include analytical results from aquifer tubes, monitoring wells, extraction wells, and the effluent from the treatment facilities. Extraction and injection wells are also evaluated for well performance and run-time. The performance monitoring for the P&T system will assess whether the remedial action is achieving the RAOs for protectiveness and the progress of cleanup. Groundwater analytical results are used to evaluate concentration trends, plume boundaries, and plume capture. Results from operational monitoring, such as Cr(VI) concentrations in extraction wells and water-level data, are also included in the remedy performance assessment. Operational monitoring data will also be used to assess and confirm the natural attenuation processes, concentration trends, rates of attenuation, and overall protectiveness.

Performance monitoring data are used in conjunction with treatment system data to obtain the following information:

- Evaluate concentration trends, monitor geochemical changes, plume boundaries, and plume capture
- Determine if there are continuing sources or transformation products
- Optimize the treatment system

Concentration trends and contaminant plume interpretations and analyses are used to confirm and predict progress toward performance goals. Hydraulic monitoring includes water-level data collected hourly through the automated water-level network. The data are supplemented with localized dynamic water-level data from each of the P&T system extraction and injection wells, and manual depth-to-groundwater measurements collected routinely during groundwater sampling and during specified, synoptic events within the monitoring well network. The combined data are used to evaluate

the effect of the P&T systems on the water table and to evaluate groundwater flow direction and gradient. The hydraulic effects of the P&T systems are superimposed on seasonal fluctuations in river levels and inland groundwater elevations to evaluate the effectiveness of hydraulic containment and capture of Cr(VI) plumes.

The MNA remedy includes performance monitoring to determine the progress and effectiveness of natural attenuation to meet cleanup levels. A DQO process was used to select monitoring locations and frequencies and is included as Appendix A. Since the P&T system impacts groundwater hydraulics and natural attenuation, performance monitoring during active remediation will be used to demonstrate that Sr-90 is continuing to attenuate through radioactive decay as expected, and nitrate concentrations will be evaluated to ensure decreasing contaminant trends.

Attainment monitoring for Sr-90 and nitrate MNA will be conducted during the rebound study and compliance monitoring phase of Cr(VI) compliance monitoring (as described in Table 4-3 and Section 7.2 of DOE/RL-2017-13). Monitoring will continue until COCs have attained the cleanup levels, the COCs are expected to continue to meet cleanup levels, and U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) approve termination of the monitoring.

1.2 Background

This section summarizes the hydrogeology, groundwater flow, contaminant sources, and contaminant plumes within the 100-HR-3 Groundwater OU.

1.2.1 Site Geology/Hydrology

A description of the 100-D/H Area site history and hydrogeologic conditions is included in the 100-D/H remedial investigation/feasibility study (RI/FS) report (DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*). The generalized hydrogeology for the 100-HR-3 OU is provided in Figure 1-2. The following primary stratigraphic units controlling groundwater flow in the unconfined aquifer in the 100-D, 100-H, and Horn Areas are, from shallowest to deepest:

- Hanford formation — A sand and gravel-dominated deposit encountered at the ground surface and extending down to the vicinity of the current water table at the 100-H Area. The unconfined aquifer is primarily within the Hanford formation in 100-H.
- Ringold Formation member of Wooded Island — unit E (Rwie) — A sand and gravel-dominated deposit that exhibits variable cementation. The unconfined aquifer is primarily within the Rwie in the 100-D Area.
- Ringold Formation upper mud unit (RUM) — A fine-textured silt-dominated deposit exhibiting very low hydraulic conductivity and effectively defining the bottom of the unconfined aquifer. Within RUM, thin sand-to-gravel layers form zones with variable hydraulic conductivities, with some water-bearing units. The uppermost water-bearing unit of the RUM constitutes the first saturated sand-to-gravel layer encountered below the silty RUM aquitard.

Deposits making up the unconfined aquifer at the 100-HR-3 OU include the Hanford formation and Rwie. The Hanford formation facies consists of moderately to very poorly sorted, large to very large, cobble- to boulder-sized clasts in open framework gravels that include discrete sand lenses, with little or no silt and clay-sized material. Rwie is a denser, more compact, and well graded formation versus the looser, coarser-grained Hanford formation gravel-dominated facies. The Rwie is composed of fluvial matrix supported gravels and sands with intercalated fine- to coarse-grained sand and silt layers. The thickness of

the unconfined aquifer is determined by the difference between the water table and the surface of the RUM, which forms the base of the unconfined aquifer.

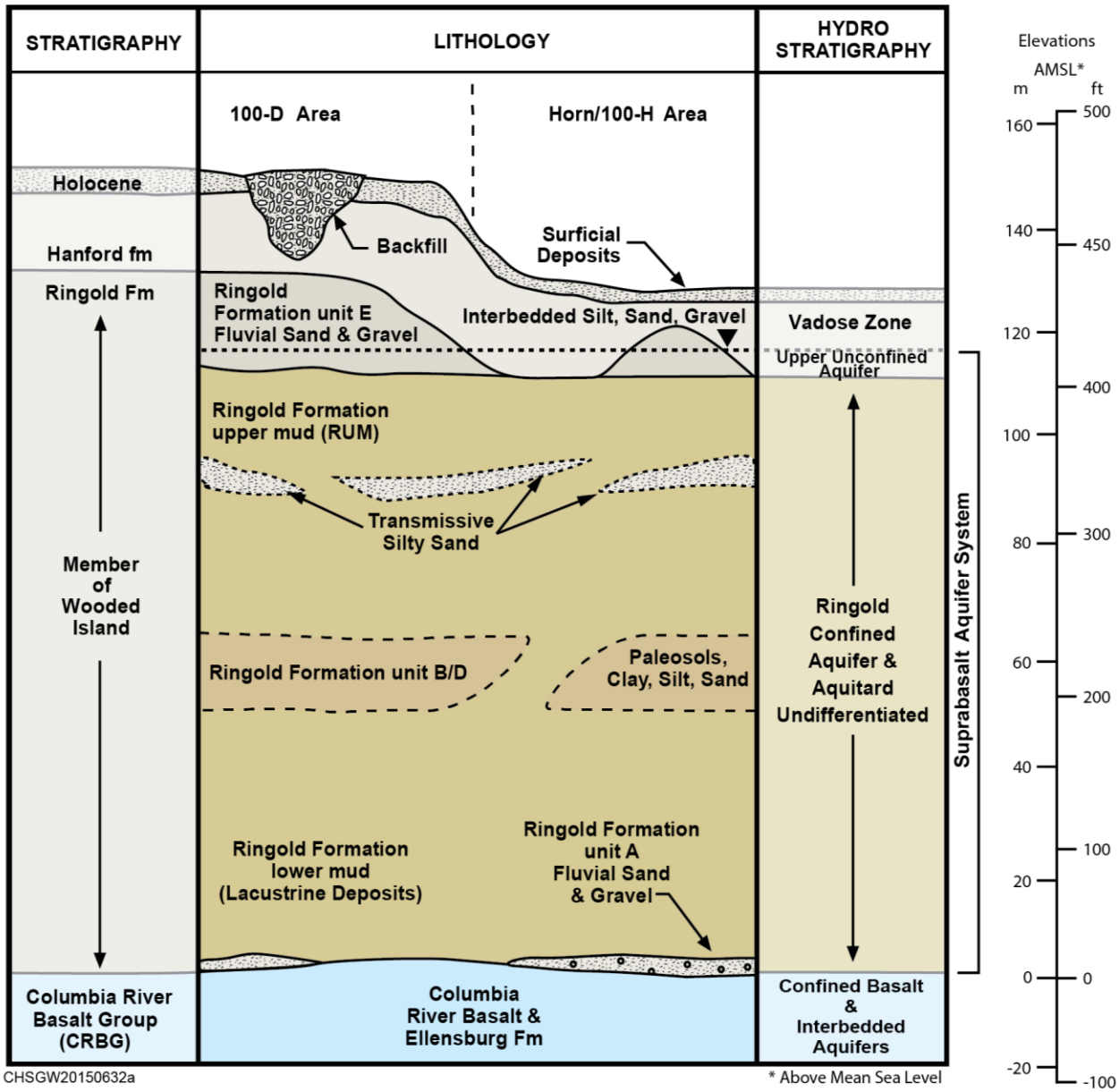


Figure 1-2. Conceptual Hydrogeologic Cross Section from West to East of the 100-HR-3 OU

The unconfined aquifer thickness at the 100-HR-3 OU generally thins from west to east, from the 100-D Area toward the 100-H Area, with the thinnest areas found in the northeastern area of the Horn. Thickness of the unconfined aquifer ranges from near 0 to 12 m (39 ft) across the OU. The thickness of the unconfined aquifer mimics the RUM surface topography (DOE/RL-2008-42, *Hydrogeological Summary Report for 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit*). Further details on the unconfined aquifer are provided in Section 3.6 of the 100-D/H RI/FS (DOE/RL-2010-95).

At 100-D, the unconfined aquifer is primarily within the Rwie, overlain by the Hanford formation, with the water table at the approximate location of the geologic contact between the two formations. During historical reactor operations, the cooling water recharge mounds raised the water table above the top of the Rwie and into the more hydraulically conductive Hanford formation, allowing rapid, widespread distribution of contamination. Across the Horn, the Hanford formation becomes the primary aquifer, with only pockets of Rwie present. At 100-H, Rwie was thought to be absent (WHC-SD-EN-TI-132, *Geologic Setting of the 100-HR-3 Operable Unit, Hanford Site, South-Central Washington*; WHC-SD-EN-TI-155, *Geology of the 100-K Area, Hanford Site, South-Central Washington*; WHC-SD-ER-TI-003, *Geology and Hydrology of the Hanford Site: A Standardized Text for use in Westinghouse Hanford Company Documents and Reports*; DOE/RL-2010-95). However, with additional wells and boreholes placed across the Horn and 100-H over the years, it was noted that pockets of Rwie are present in small areas of 100-H (ECF-HANFORD-13-0020, *Process for Constructing a Three-dimensional Geologic Framework Model of the Hanford Site's 100 Area*). Therefore, while the dominant geologic unit of the unconfined aquifer is the Hanford formation in the Horn and 100-H, areas are present where the unconfined aquifer is within the Rwie.

The RUM is a distinctly less permeable material that generally forms the base of the unconfined aquifer. RUM material is dominated by a fine-grained overbank paleosol facies association that is up to 61 m (200 ft) thick (WHC-SD-EN-TI-132). The upper part of the RUM sometimes contains gravel in a silt/clay matrix that represents a transition zone (reworked interval) above the more massive silt or clay. The RUM surface is typically encountered between 9 and 33 m (30 to 110 ft) below ground surface at 100-D, and between 11 and 20 m (37 and 60 ft) bgs in the 100-H Area, due to the change in the ground surface elevation between the two areas. The silt- and clay-rich RUM generally has low hydraulic conductivity values relative to the Hanford formation and Rwie. In 100-H Area, data from borehole logs indicate that the uppermost water-bearing unit in the RUM material contains more sand than elsewhere at the 100-HR-3 OU. This may result in a less competent barrier between the unconfined aquifer and the uppermost water-bearing unit in the RUM below, possibly contributing to a hydraulic connection between the two units.

Within the RUM, thin sand-to-gravel layers form zones with variable hydraulic conductivities form a confined or semiconfined (leaky) aquifer (DOE/RL-2010-95). Wells currently drilled and completed within the RUM have been capable of using these sand and gravel zones for extraction of sufficient water for P&T operations. These zones of higher hydraulic conductivity typically start between 3 to 5 m (9 to 16 ft) below the initial RUM surface contact and can be tens of meters thick in some areas, especially in 100-D, although thicknesses are highly variable by location. These water-bearing RUM units vary in thickness, capacity, degree of apparent confinement, spatial continuity, and the presence of contamination.

The uppermost water-bearing unit in the RUM is bounded by the silt and clay of RUM material to the top. The presence of a nontransmissive layer consisting of silt or clay material defines the lower boundary. This water-bearing unit may occur as a discontinuous or continuous sandy layer across the 100-HR-3 OU, but the connectivity has not yet been determined. At 100-H, observations of the piezometric head in this unit during local pumping and during injection into the shallow unit indicate that it is not fully isolated from the overlying unconfined aquifer in the area inland of the H Reactor (SGW-47776, *Aquifer Testing and Rebound Study in Support of the 100-H Deep Chromium Investigation*).

1.2.2 Groundwater Flow

As discussed briefly above, there are two aquifers present within the 100-HR-3 OU. These two aquifers are the unconfined and the uppermost water-bearing unit within the RUM, which appears to be a semiconfined aquifer.

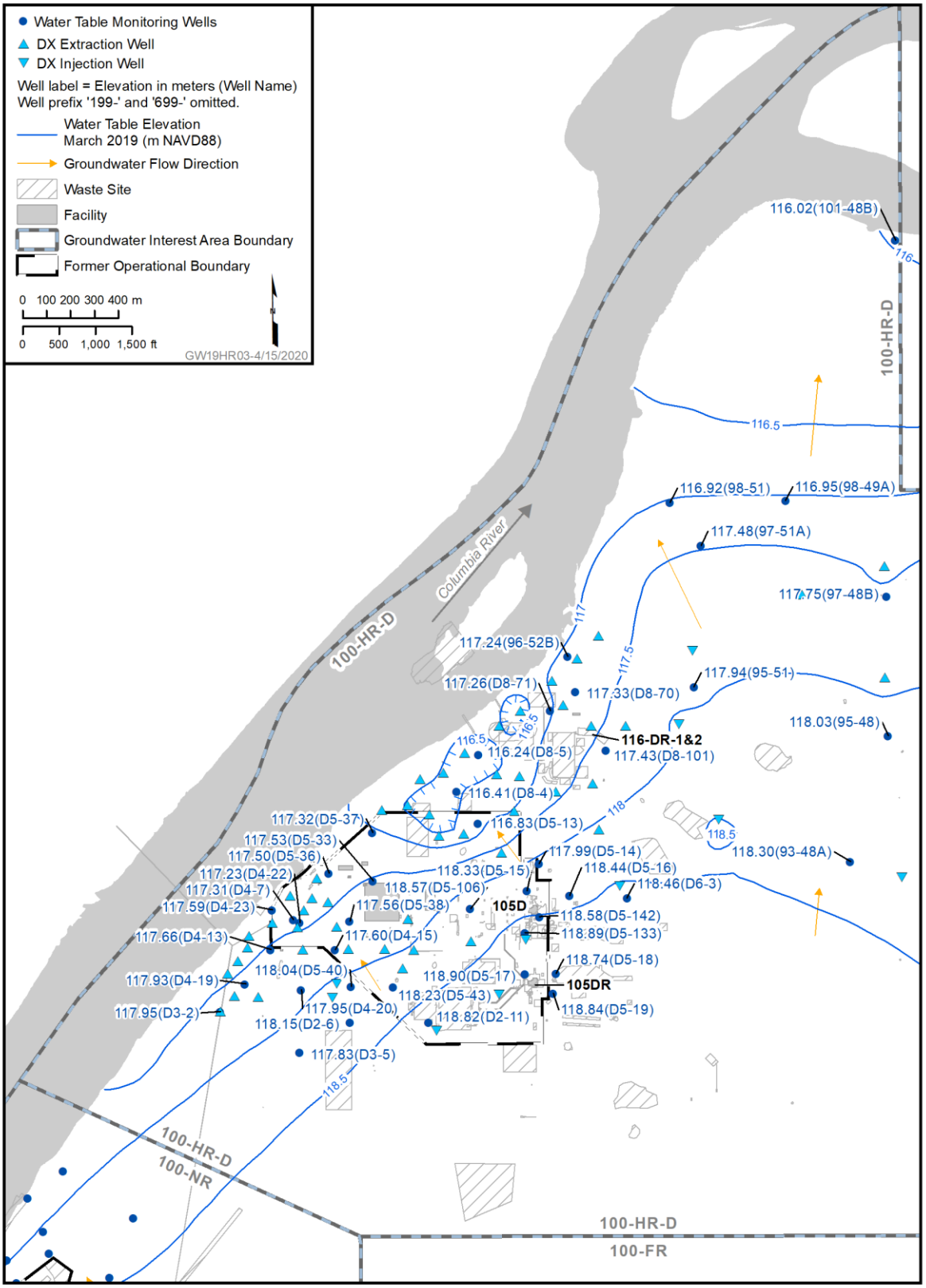
1.2.2.1 Unconfined aquifer

Under natural gradient conditions, the groundwater in the southern portion of 100-D generally flows to the west toward the Columbia River, with some seasonal variation where flow is more southwesterly. In the northern 100-D Area, the gradient changes to a northwesterly direction, with groundwater flow inland being more westerly, moving across the Horn toward the 100-H Area. In 100-H, the natural groundwater gradient is toward the east and southeast and the Columbia River on the eastern side of the Horn. Groundwater flow entering the southern portion of the 100-HR-3 OU tends to flow toward the 100-H Area.

Figures 1-3 and 1-4 present March 2019 groundwater flow maps showing a mid-period river stage developed using concurrent measurements collected near the end of the low river stage period. Hydraulic effects of P&T systems at the 100-HR-3-OU (i.e., formation of depressions at extraction wells and mounds at injection locations) are superimposed onto the seasonal fluctuations. Small groundwater mounds are due to the injection of treated groundwater from P&T systems. The effect of the P&T system is noticeable where groundwater depressions are present around some P&T system extraction wells, and mounding is present around injection wells.

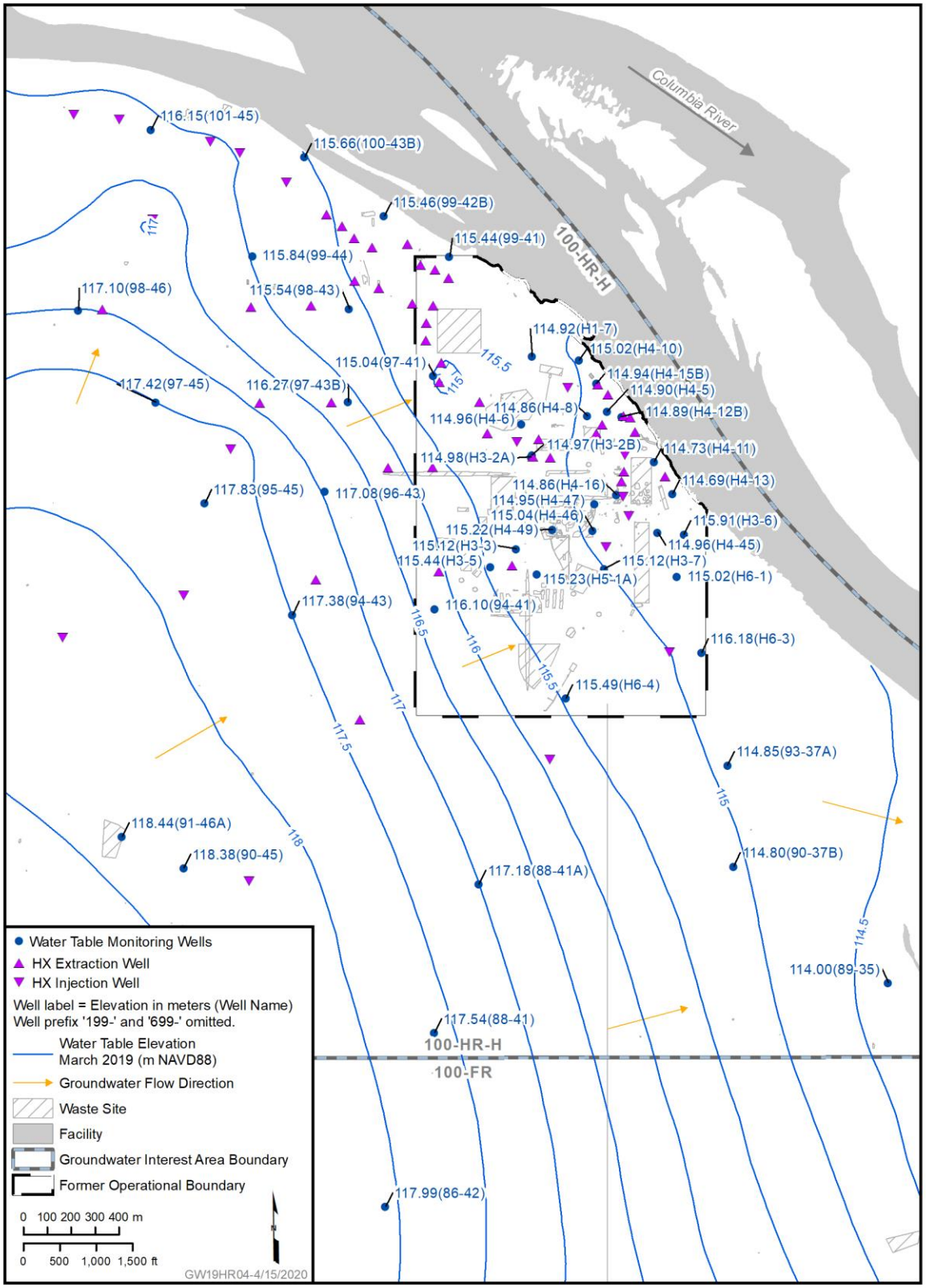
During high river stage periods, the local groundwater gradient magnitude is reduced near the river; the vicinity very near the river may actually exhibit a flow direction reversal, with river water intruding slowly into the aquifer (i.e., seasonal bank storage). This increased elevation of the boundary condition causes the groundwater inland of the river to back up during high river stage, creating the seasonal rise in groundwater elevation typically observed inland of the river. As the river stage declines following the seasonal freshet, the boundary condition again adjusts, groundwater gradient steepens toward the river and velocity increases. This condition continues until the groundwater head again equilibrates with the low river stage condition. Seasonal groundwater elevation transients are observed up to several kilometers inland from the river as the water table and river stage equilibrate, although the magnitude of the increase progressively decreases with distance from the river.

Daily and seasonal fluctuations in the river stage also impact groundwater flow in the 100-HR-3 OU. Long-term changes in the river stage produce more extensive and long-lived changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer. 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. Due to the effect that the seasonal river stage changes have on contaminant concentrations in the100-HR-3 OU, both low river and high river stage monitoring data, including water-level data, are used to evaluate capture of the contaminant plume.



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

Figure 1-3. 100-D Area Overview Map and March 2019 Water Table



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

Figure 1-4. 100-H Area Overview Map and March 2019 Water Table

Horizontal gradients and groundwater velocities are detailed in the 100-D/H RI/FS (DOE/RL-2010-95). Results of the three-point gradient analysis suggest geographic variations in average hydraulic gradients that can be broadly grouped in the following three general areas:

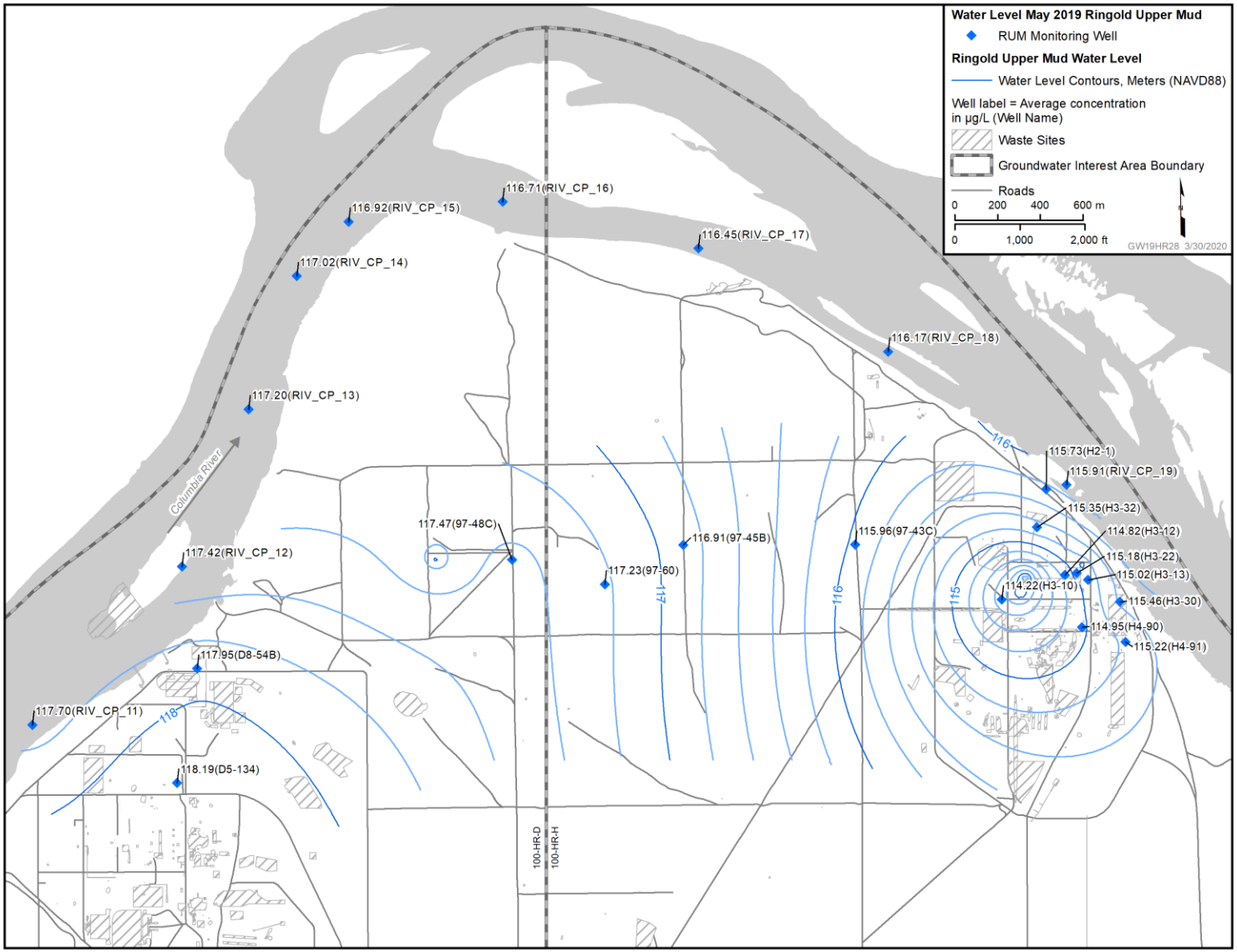
- Near the 100-D southern plume
- Near 100-H
- Between 100-D and 100-H, referred to as the Horn (which includes the northern portion of 100-D)

In the area near the 100-D southern plume during 2019, hydraulic gradients were between 0.0035 m/m and 0.0045 m/m with a consistent north-northwest direction. In 100-D north, gradients were between 0.004 m/m and 0.005 m/m over most of the year, with gradients in July and December of 0.002 m/m and 0.0025 m/m, respectively. Groundwater flow direction in the northern portion of 100-D during 2019 was also to the north/northwest. The gradients in the Horn were between 0.0014 m/m and 0.0017 m/m at an easterly or east/northeasterly direction. Gradients in 100-H were slightly steeper than in the Horn, as expected for a near-river area, and varied from about 0.002 m/m to 0.003 m/m. Flow direction was generally to the east/northeast except during high river stage when the gradient shifted to southeasterly.

1.2.2.2 RUM Aquifer

The uppermost water-bearing unit in the RUM (also referred to as the RUM aquifer) is approximately 0.5 to 7 m (1.6 to 23 ft) thick and occurs at elevations ranging from approximately 95 to 115 m (312 to 377 ft) above mean sea level (NAVD88, *North American Vertical Datum of 1988*). Groundwater levels in this unit respond to changes in river stage across the operable unit. When the river stage is moderate to low, this unit shows slightly higher pressure head than the unconfined aquifer near the river. The lack of lag time between Columbia River stage changes and water table fluctuations in the nearby wells completed in RUM indicates a hydraulic connection between these units in 100-H Area.

Groundwater flow in the uppermost water-bearing unit in the RUM is shown in Figure 1-5. While the representation is based on a limited number of wells, it appears to mimic the flow regime of the unconfined aquifer, shown in Figures 1-3 and 1-4.



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

Figure 1-5. Uppermost Water-Bearing Unit in the RUM, May 2019 Groundwater Contours

1.2.3 Sources of Contamination

Three plutonium production reactors (D, DR, and H) operated in the 100-D/H Area. The operation of these reactors required a continuous supply of high quality cooling water during operations. Each reactor used on average (during the reactor operating lifetime) about 95,000 L/min (25,000 gal/min) of cooling water (100-D/H RI/FS [DOE/RL-2010-95]). The cooling water source was the Columbia River. Water from the Columbia River was filtered and treated chemically prior to use as cooling water, including the addition of sodium dichromate as a corrosion inhibitor. The addition of sodium dichromate included both dry and highly concentrated liquid stock solution.

As discussed in SGW-64372, *100-D/H Continuing Hexavalent Chromium Source Evaluation*, there are several suspected areas where source material is known or suspected to remain in the lower vadose. These areas may be monitored at a higher frequency, if needed, to help determine contaminant trends or source area locations.

1.2.3.1 Unconfined Aquifer Contamination

Spills and leaks of water treatment chemicals, including sodium dichromate solution, particularly in the reactor areas, occurred in the water treatment and chemical storage areas and from cooling water conveyance. The treated cooling water passed through the reactors in a single pass and was released to the environment during operations. Large quantity cooling water discharges to the environment under normal operating conditions were directed to retention basins. During upset conditions, such as fuel element failures, cooling water was diverted from the regularly used retention basins to other disposal areas, such as ditches, cribs, trenches, or other engineered structures, and was allowed to infiltrate directly into the soil column. These practices and leaks in the retention basins resulted in extensive groundwater recharge mounds, consisting primarily of contaminated cooling water and wide distribution of contamination in the unconfined aquifer (HW-77170, *Status of the Ground Water Beneath Hanford Reactor Areas January, 1962 to January, 1963*; BNWL-CC-1352, *Ground Disposal of Reactor Coolant Effluent*).

Cooling water picked up other contaminants during passage through the reactors, including Sr-90. Fuel cladding failures occurred when corrosion or swelling of the aluminum cladding covering a uranium fuel slug caused the cladding to break open, releasing uranium oxide particles that contained plutonium isotopes and fission products (cesium-137 and Sr-90) into the cooling water. Fuel cladding failures also occurred within the fuel storage basins. Some leakage was reported for the 100-D and 100-H fuel storage basins (WHC-SD-EN-TI-181, *100-D Area Technical Baseline Report*; BHI-00127, *100-H Area Technical Baseline Report*). Sr-90 has been historically detected near the reactors and retention basins.

Sanitary liquid waste was routed by sewer lines to septic systems. Additional information on the septic systems is presented in the 100-D/H RI/FS (DOE/RL-2010-95). Historically, septic systems contributed to local nitrate contamination in the vadose zone and groundwater. The historical use of fertilizer on pre-Hanford Site agricultural lands likely contributed to nitrate contamination in 100-HR-3 OU groundwater. There is currently only a small area with nitrate present above 45 mg/L, located at the former 183-H Solar Evaporation Basins.

1.2.3.2 Contamination in the Uppermost Water-Bearing Unit in the RUM

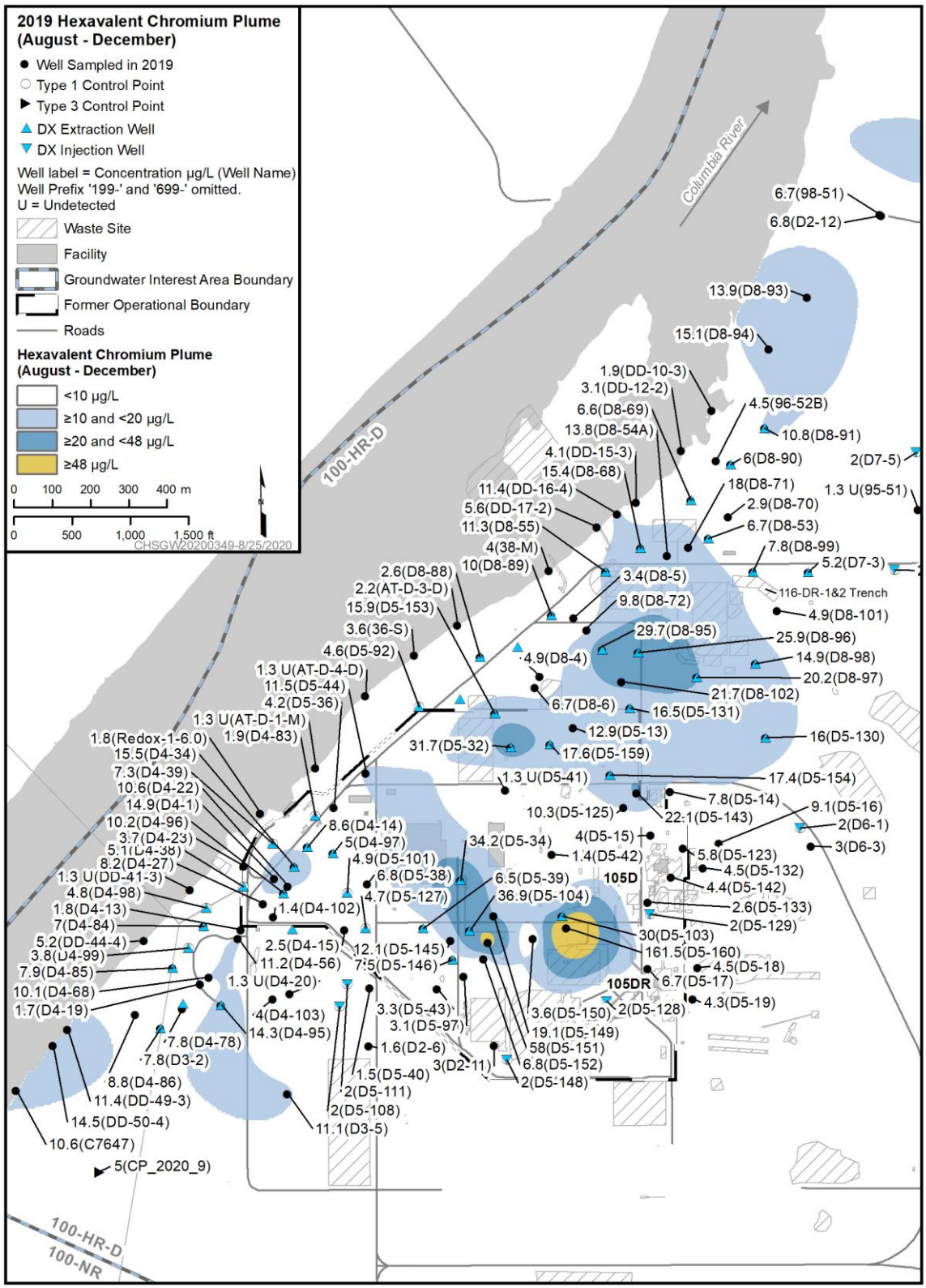
Cr(VI) contamination is present in the uppermost water-bearing unit in the RUM at the 100-H Area and in the Horn. The source of contamination is hypothesized to be Cr(VI)-contaminated groundwater in the overlying unconfined aquifer being forced into the lower aquifer by high hydraulic heads within the overlying shallow unconfined aquifer during reactor operations (HW-77170), and during the 1967 infiltration test (BNWL-CC-1352).

At 100-H, this theory is supported by the fact that the RUM material at 100-H exhibits a relatively thin zone of silt and clay material separating the two aquifers. This material also exhibits a substantial sand and gravel fraction, making the competency of the RUM material as a confining unit questionable. At other locations (e.g., within the 100-D and 100-K Areas), this analogous portion of the RUM exhibits a much finer texture and correspondingly lower apparent hydraulic conductivity, indicating that it is an effective confining unit at those locations. The uppermost water-bearing unit in the RUM in the 100-H Area exhibits slightly higher head relative to the unconfined aquifer, indicating a small upward vertical gradient; however, this gradient has decreased through time (DOE/RL-2010-95).

In the Horn, well 699-97-60 is located between two pockets of Rwie located laterally to each side of the well. It is presumed that the elevated water table during operations would have been channeled into the zone between the two pockets, causing a high pressure head in the area where Cr(VI) contamination is noted at well 699-97-60 (SGW-54332, *Software for Support of Groundwater Contaminant Fate and Transport Analysis -13345*). Groundwater maps during the 1967 infiltration test (BNWL-CC-1352) and during normal operations (HW-77170) indicate that contaminated cooling water spread across the Horn.

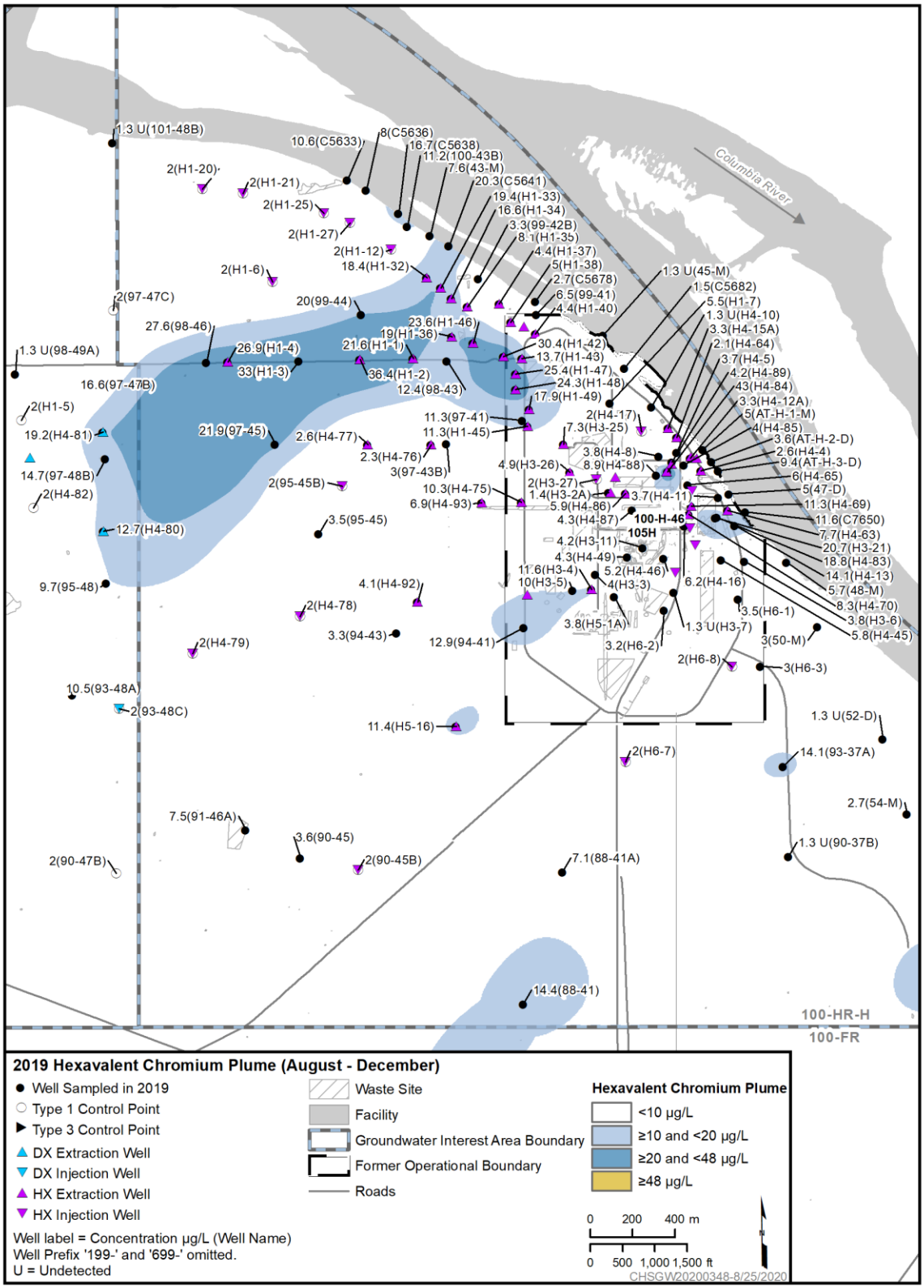
1.2.4 Contaminant Plumes

The current contaminant plume configurations result from both the behavior of the historical recharge mounds and from groundwater movement since the cessation of cooling water discharges. The most widely distributed contaminant is Cr(VI). The 2019 Cr(VI) plumes in the unconfined aquifer are depicted during low river stage in Figures 1-6 through 1-8. The Sr-90 plumes in 100-D and 100-H are shown in Figures 1-9 and 1-10, respectively. Natural attenuation of nitrate, along with the effects of the P&T system, have reduced nitrate to a small area at 100-H, as show in Figure 1-11. The Cr(VI) plume within the uppermost water-bearing unit in the RUM is presented in Figure 1-12. Sr-90 has not been identified in the RUM aquifer. A nitrate plume for the uppermost water-bearing unit in the RUM has not been developed since it is limited to a small area near the 183-H Solar Evaporation Basins at 100-H. The Hanford Site annual groundwater reports (e.g., DOE/RL-2018-66, *Hanford Site Groundwater Monitoring Report for 2018*) contain annual interpretations of contaminant plumes in groundwater.



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

Figure 1-6. 100-D Area Groundwater Contours and Cr(VI) Concentrations, Low River Stage, 2019



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

Figure 1-7. 100-H Area Groundwater Contours and Cr(VI) Concentrations, Low River Stage, 2019

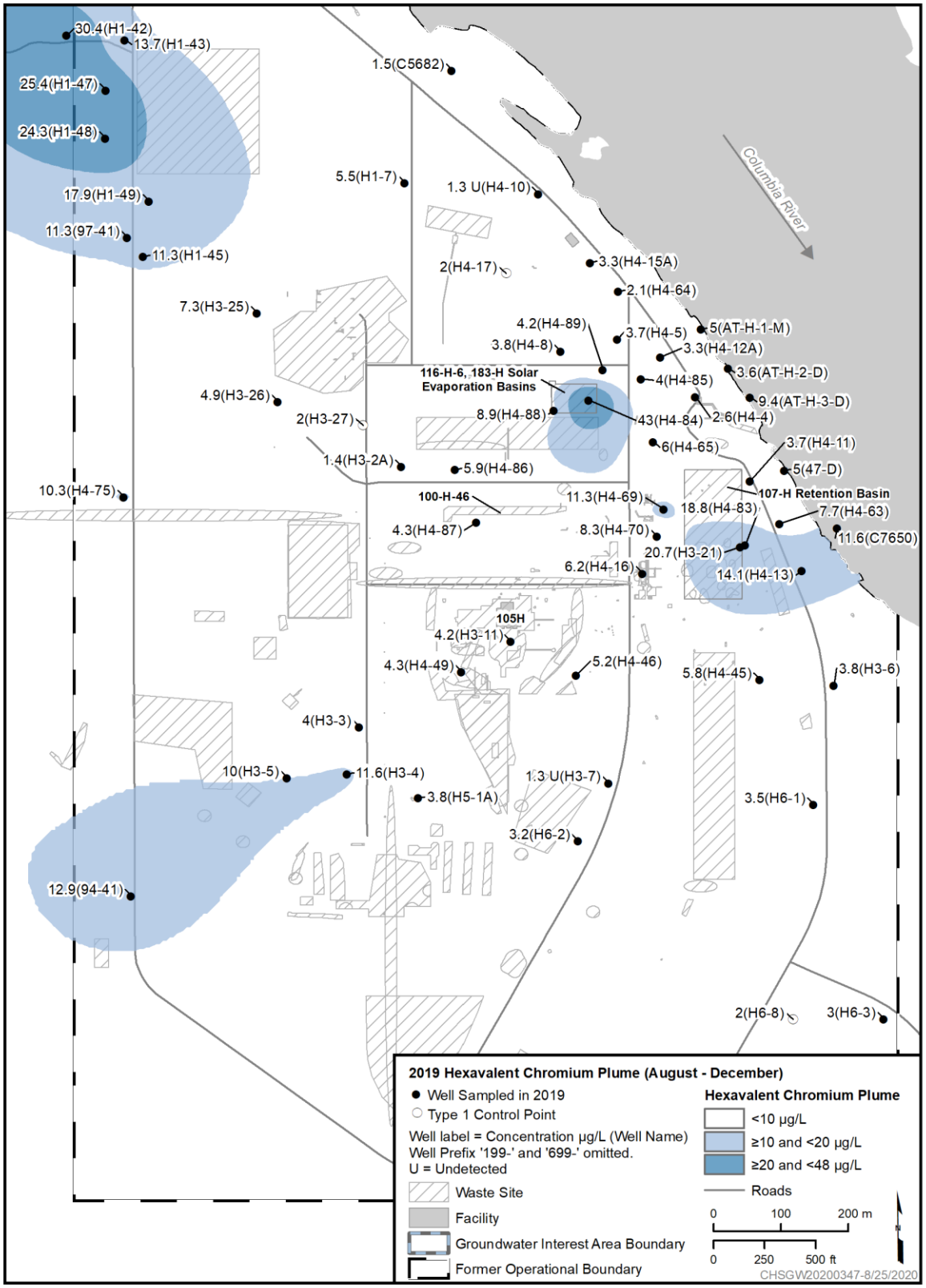


Figure 1-8. 100-H Operational Area Cr(VI) Plume, Low River Stage 2019

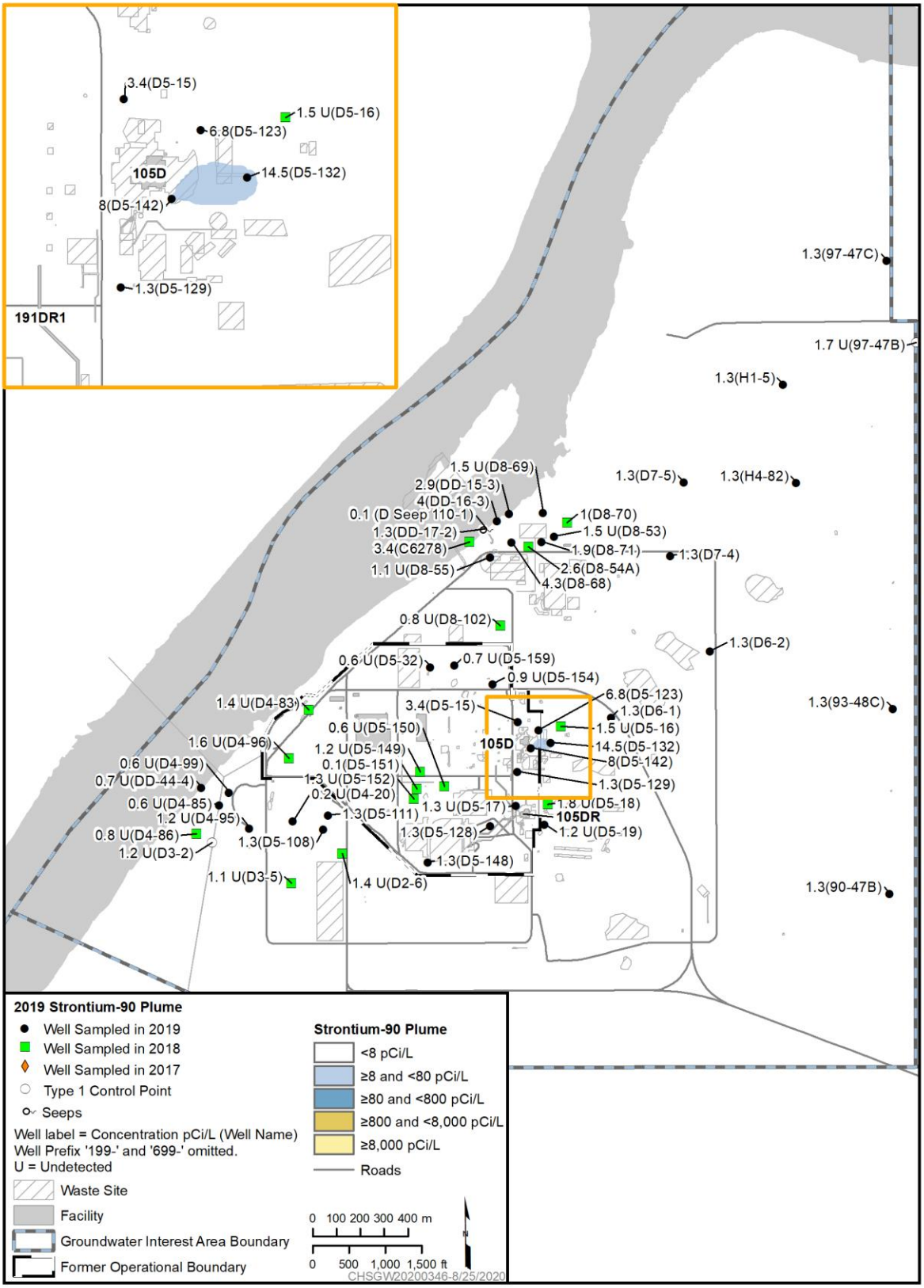


Figure 1-9. Sr-90 Plume at the 100-D Area, 2019

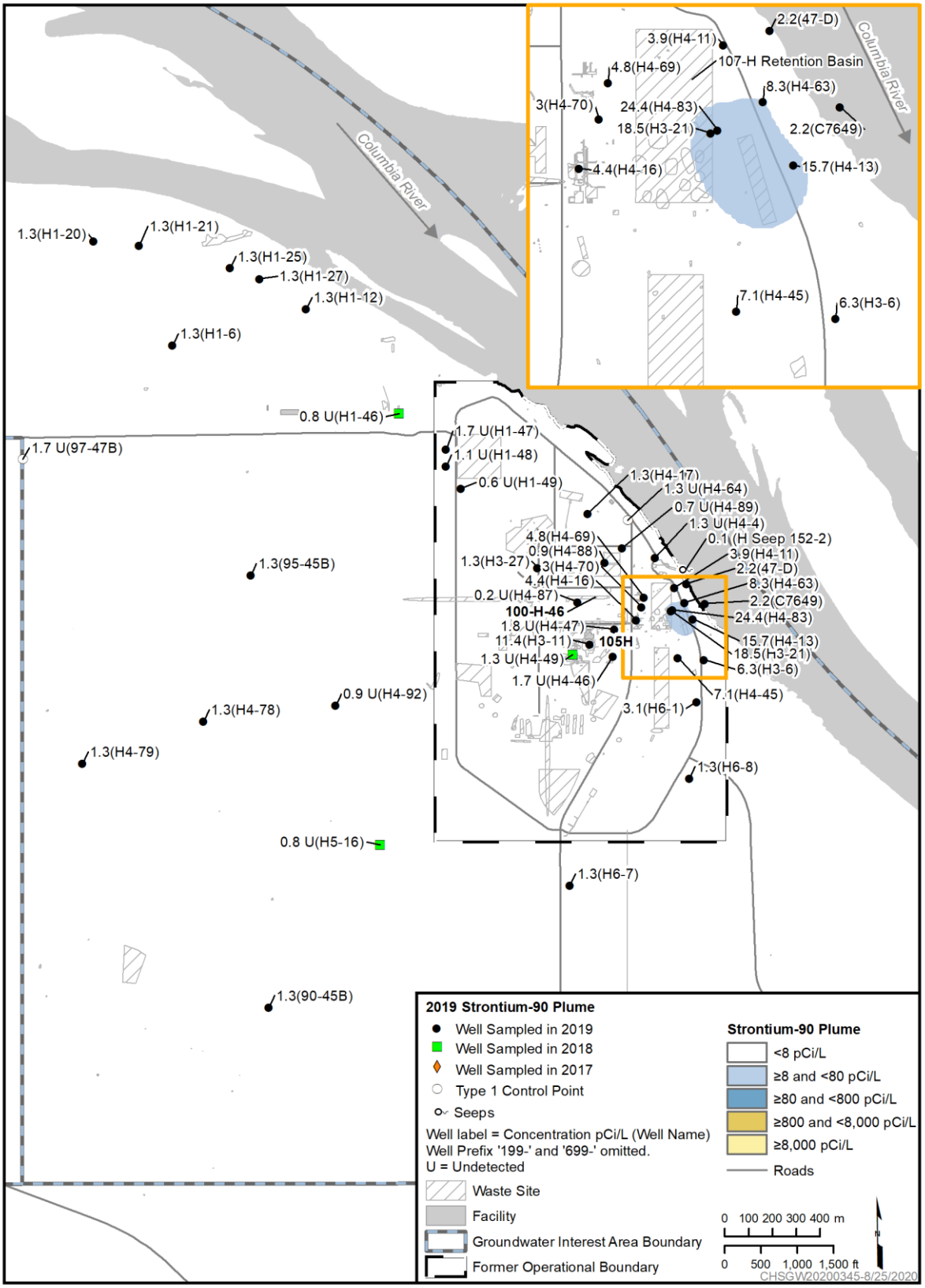


Figure 1-10. Sr-90 Plume at the 100-H Area, 2019

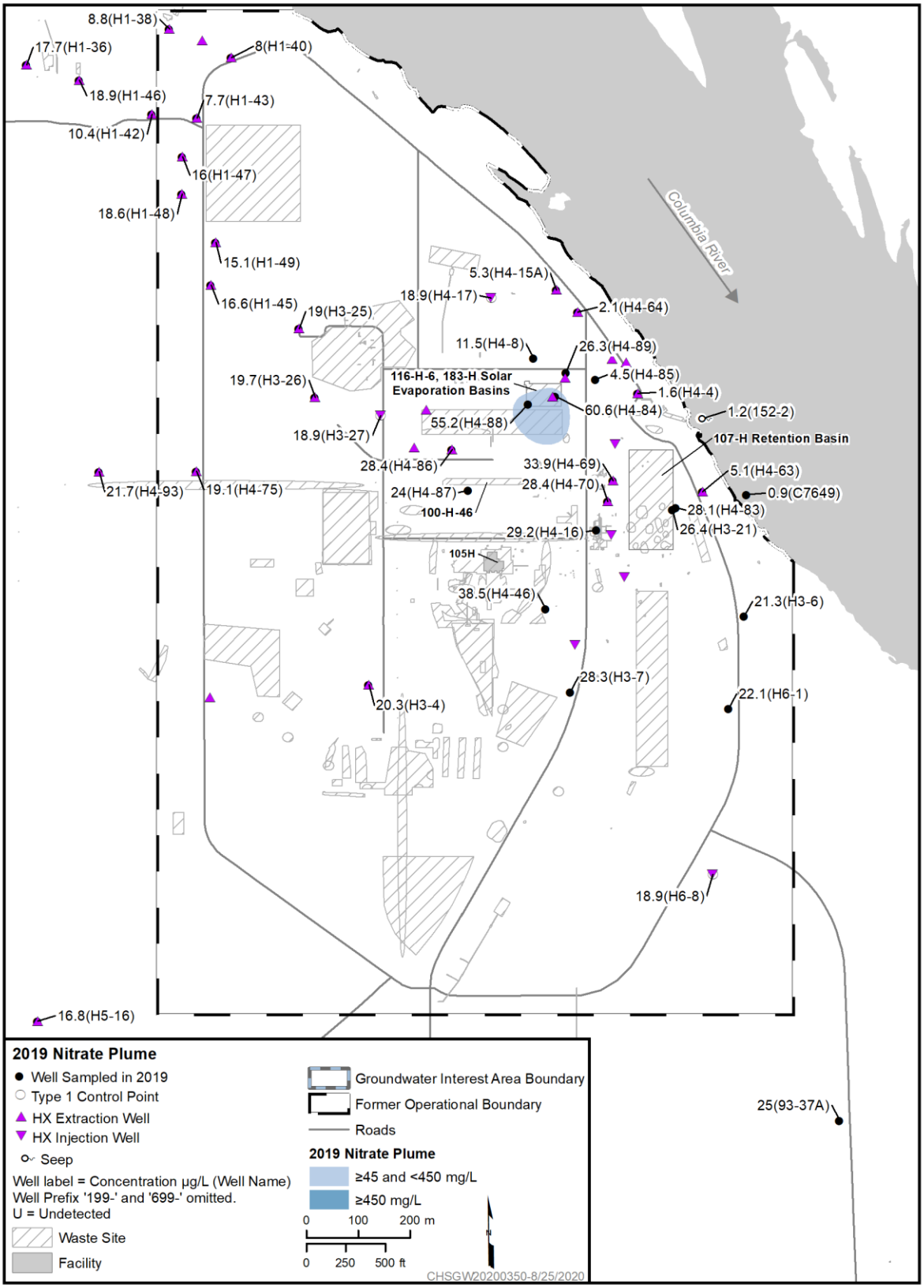


Figure 1-11. Nitrate Plume for Unconfined Aquifer, 2019

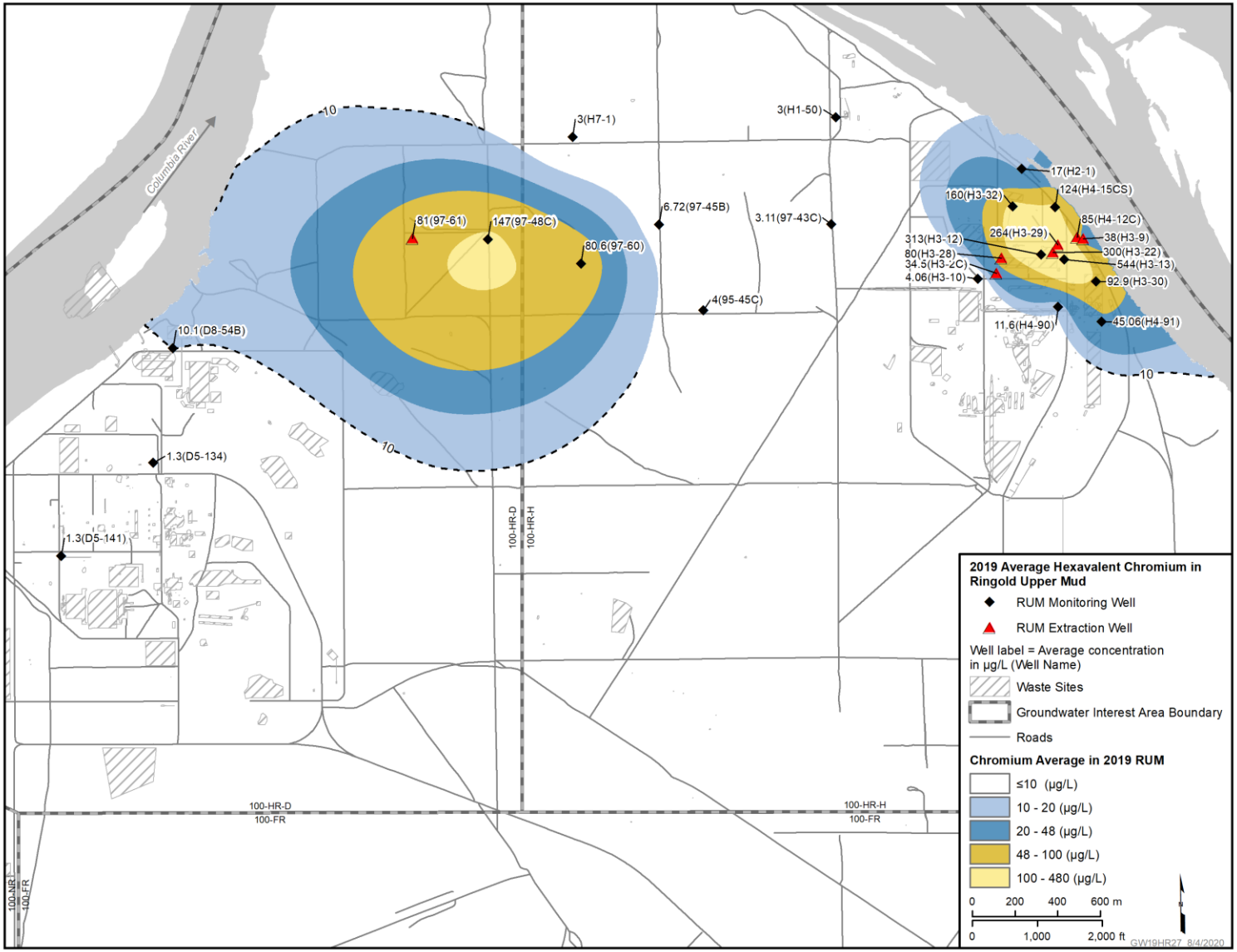


Figure 1-12. Cr(VI) Plume for Uppermost Water-Bearing Unit in the RUM, 2019

1.3 Data Quality Objective Summary

A site-specific DQO process was performed to identify the data needs for the 100-HR-3 OU remedy performance monitoring. The groundwater monitoring network for each COC and for both the unconfined aquifer and the uppermost water-bearing unit in the RUM was identified during the DQO process. Locations were identified to monitor COC concentrations, detect changes in the plume area, and refine the understanding of local hydraulic gradients. The DQO is included as Appendix A and includes the DQO meeting notes and final sampling plan.

1.4 Contaminants of Concern/Target Analytes

Table 1-1 lists the COCs and general chemistry parameters that may be sampled for within the 100-HR-3 OU. The known levels of contamination are discussed in Section 1.2.4, and shown in Figures 1-6 through 1-12. Quality assurance (QA), quality control (QC), and sampling criteria for these analytes are presented in Section 2.

Table 1-1. Analytes for the 100-HR-3 OU Sampling

Analyte	Rationale	CAS Number*
General Chemical Parameters		
Alkalinity	General chemistry	ALKALINITY
Inorganics (Anions)		
Chloride	General chemistry	16887-00-6
Fluoride	General chemistry	16984-48-8
Nitrate	COC	14797-55-8
Phosphate	General chemistry	14265-44-2
Sulfate	P&T byproduct	14808-79-8
Inorganics (Metals)		
Calcium	General chemistry	7440-70-2
Chromium (total)	COC	7440-47-3
Chromium (hexavalent)	COC	18540-29-9
Magnesium	General chemistry	7439-95-4
Potassium	General chemistry	7440-09-7
Sodium	General chemistry	7440-23-5
Uranium (total)	Present at 183-H, tracking	7440-61-1
Radionuclides		
Gross alpha	Indicator	12587-46-1
Gross beta	Indicator	12587-47-2
Strontium-90	COC	10098-97-2

Table 1-1. Analytes for the 100-HR-3 OU Sampling

Analyte	Rationale	CAS Number*
Technetium-99	Present at 183-H, tracking	14133-76-7
Field Measurements		
Depth to groundwater		Not applicable
Dissolved oxygen		DO
pH		PH
Specific conductance		CONDUCT
Temperature		TEMPERATURE
Turbidity		TURBIDITY

*Value in this column is either the CAS number or the constituent identifier if no CAS number exists.

CAS = Chemical Abstracts Service
COC = contaminant of concern
OU = operable unit
P&T = pump and treat

1.5 Project Schedule

Implementation of the 100-HR-3 OU performance monitoring in this SAP will start upon approval of the remedial design/remedial action work plan (RD/RAWP; DOE/RL-2017-13). Groundwater P&T for Cr(VI) contamination is expected to achieve cleanup within 12 years of implementation. Total chromium in groundwater is primarily present as Cr(VI). The treatment of Cr(VI) groundwater contamination will result in attaining cleanup levels for total chromium in less time than Cr(VI), since the total chromium cleanup levels are 65 µg/L and 100 µg/L where groundwater discharges to surface water and in upland groundwater, respectively, as opposed to the Cr(VI) cleanup levels of 10 µg/L and 48 µg/L.

The duration of the MNA performance monitoring period is based on the model-estimated timeframes for nitrate and Sr-90 to achieve cleanup levels. The estimated timeframes for nitrate and Sr-90 to achieve cleanup levels are 6 years and 44 years, respectively. The duration of the performance monitoring period is based on the estimated timeframe for each COC to achieve its cleanup level, as follows:

- Cr(VI) and total chromium (P&T): Year = 2032
- Nitrate (MNA): Year = 2026
- Sr-90 (MNA): Year = 2064

Attainment and compliance monitoring will be performed when cleanup levels for each COC are achieved.

2 Quality Assurance Project Plan

A 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 QSM, 2019, *Department of Defense (DoD), Department of Energy (DOE), Consolidated Quality System Manual (QSM) for Environmental Laboratories* (hereinafter called the DoD/DOE QSM), 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 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.

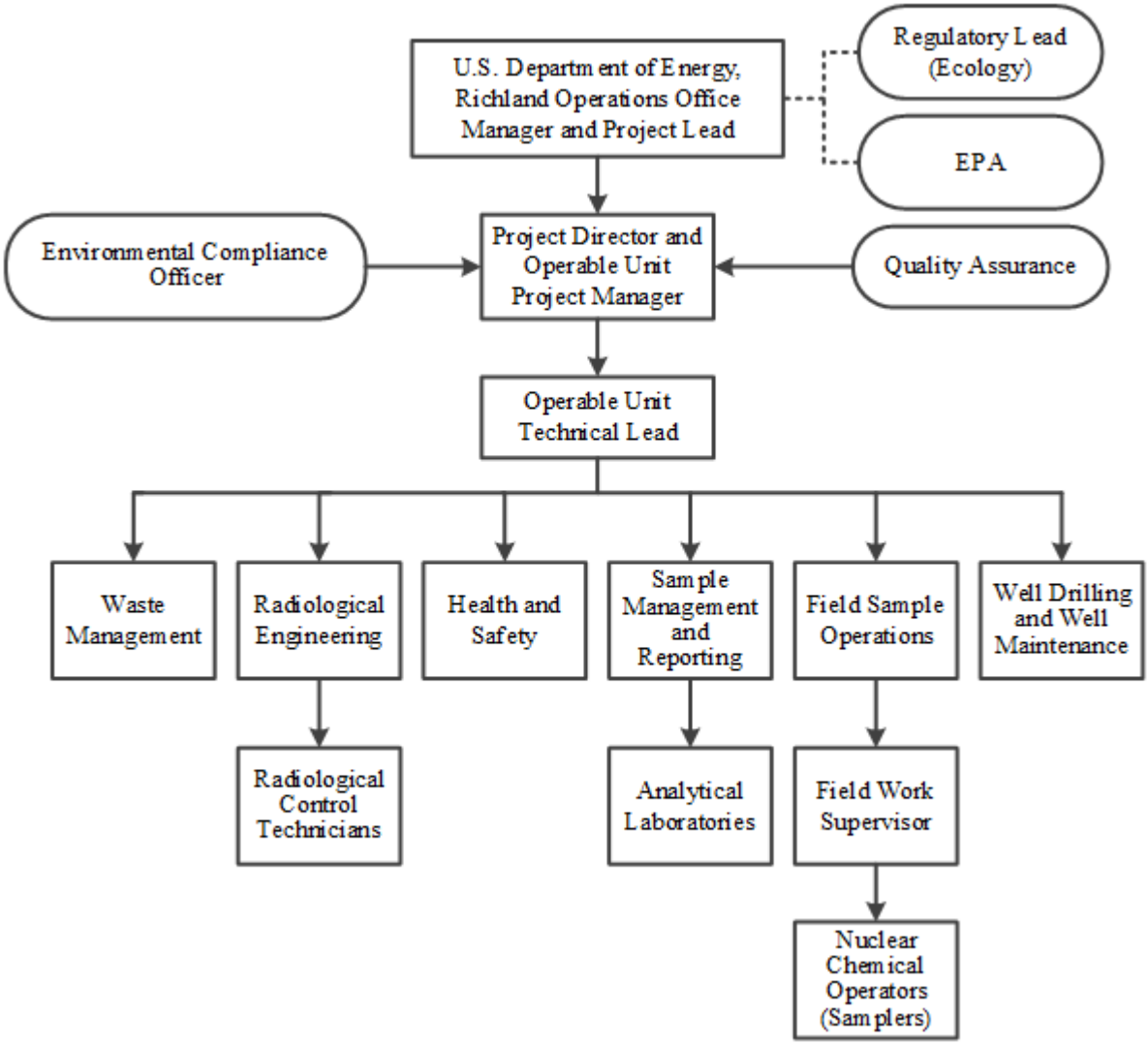


Figure 2-1. Project Organization

2.1.1.1 Regulatory Lead

The lead regulatory agency for the 100-HR-3 Groundwater OU is Ecology. They are responsible for regulatory oversight of cleanup projects and activities. EPA retains approval authority for all SAPs. Ecology works with EPA and the DOE, Richland Operations Office (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-HR-3 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).

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 Project Director

The Project Director provides oversight and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The Project 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 contractor 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, and 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. The OU Technical Lead works closely with the Environmental Compliance Officer (ECO), 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.

Prejob 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 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 as low as reasonably achievable trend 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 HASQARD (DOE/RL-96-68). The laboratories are evaluated under the DOE Consolidated Audit - Accreditation Program (DOE/CAP-AP) or its successor programs to the DoD/DOE QSM requirements. HASQARD requirements, beyond those within the DoD/DOE QSM, 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

2.1.2 Coordinating Well Decommissioning with DOE-RL 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 Section 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.

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 remeasurement. • Qualify the data before use.
Accuracy (laboratory control samples, matrix spikes, SURs, 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 SURs.	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 remeasurement.
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 on 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 to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's 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.

Table 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Bias (equipment blanks, 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.
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 remeasurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

Reference: 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

SUR = surrogate

2.1.4 Analytical Priority

If sample volume is insufficient to analyze for all analytes listed for a given waste site, the highest priority analytes critical for supporting remedy decisions are required to be analyzed. While insufficient sample volume is not expected to be a concern, priority is normally given first to volatile organic compounds (VOCs), second to chemicals that may be immediately dangerous to life or health, and third to substances that are readily mobile in the immediate environment. Since the COCs do not contain VOCs or immediately dangerous to life or health, priority will be given to the most mobile chemicals and transuranic radionuclides. Attempts will be made to collect at least every other sample of the lesser priority analytes that are important for supporting decisions. Lowest priority analytes not critical for supporting decisions will be analyzed only if sufficient sample volumes are collected.

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.

Regarding "minor field changes," the project scientist in coordination with the soil and groundwater subject matter expert (SME) will approve deviations from the SAP that do not have an adverse effect on the technical integrity or adequacy of the sampling activity. Below are examples of minor field changes:

- During groundwater sampling, most groundwater samples will be pumped, although use of another method may be authorized by the OU Project Technical Lead.
- The sample depths provided in this SAP are estimated based on known characterization data and geology collected from nearby wells. For this reason, adjustments to the sample depths are anticipated. The sample depths may be altered during drilling in consultation with the OU Project Technical Lead.
- Groundwater samples may not be collected before a minimum of three well casing volumes have been purged and water chemistry (e.g., temperature, pH, and conductivity) has stabilized within 10% variance over three consecutive measurements unless approved by the OU Project Technical Lead.

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. The lead regulatory agency and 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. The lead regulatory agency and 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. Tri-Party Agreement Action Plan, Section 9.3, 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 changes," the project scientist in coordination with the soil and groundwater SMEs will consult with DOE-RL and the regulatory lead when deviations from the SAP do not affect the overall intent of the plan. Below are examples of minor changes:

- Changing the type of sample being collected (e.g., collecting continuous grab samples instead of continuous cores)
- Selecting a different well construction material and/or well design
- Changing to a different drilling method

The OU Technical Lead, in coordination with the soil and groundwater SME, will inform DOE-RL and Ecology of deviations from the SAP that do affect the overall intent and schedule of the approved plan.

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 will be controlled in accordance with internal work requirements and processes.

The FWS and SMR 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 SMR)
- 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 and field 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 provides information regarding analytical method requirements for samples collected. Updated EPA methods and nationally recognized standard methods may be substituted for the analytical methods identified in Table 2-3 in order to follow changed requirements in the method update. The new method shall achieve project DQOs as well as 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 or Quantitation Limit for Water (µg/L)[d]
General Chemical Parameters (µg/L)				
Alkalinity	ALKALINITY	N/A	EPA/600 Method 310.1 or Standard Method 2320	5,250
Anions (µg/L)				
Chloride	16887-00-6	250,000	EPA/600 Method 300.0 or 9056	400
Fluoride	16984-48-8	4,000		525
Nitrate	14797-55-8	10,000		525
Phosphate	14265-44-2	--		787.5
Sulfate	14808-79-8	250,000		1,050
Metals (µg/L)				
Calcium	7440-70-2	N/A	SW-846 Method 6010 (preferred method)	1,050
Chromium (total)	7440-47-3	100	SW-846 Method 6020 (preferred method)	10.5
Hexavalent chromium	18540-29-9	48/10	SW-846 Method 7196	10.5
			SW-846 Method 7196, low level	5
Magnesium	7439-95-4	N/A	SW-846 Method 6010 (preferred method)	1050
Potassium	7440-09-7	N/A	SW-846 Method 6010 (preferred method)	5,250
Sodium	7440-23-5	N/A	SW-846 Method 6010 (preferred method)	1,050
Uranium (total)	7440-61-1	30	SW-846 Method 6020	1.05

Table 2-3. Performance Requirements for Sample Analysis

Constituent	CAS Number[a]	MCL or WAC[b]	Analytical Method[c]	Required PQL or Quantitation Limit for Water (µg/L)[d]
Radionuclides (pCi/L)				
Gross alpha	12587-46-1	15	Gas proportional counting	3
Gross beta	12587-47-2	50 (or 4 mrem)		4
Strontium-90	10098-97-2	8		2
Technetium-99	14133-76-7	900		50
Field Measurements				
Dissolved oxygen	DO	N/A	Field measurement instrument/meter	N/A
pH	PH			
Specific conductance	CONDUCT			
Temperature	TEMPERATURE			
Turbidity	TURBIDITY			

a. Value in this column is either the CAS number or the constituent identifier if no CAS number 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 300.0, 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, Third Edition; Final Update V*. For Standard Methods, see APHA/AWWA/WEF, *Standard Methods for the Examination of Water and Wastewater*. Equivalent methods may be substituted.

d. Required quantitation limits are specified in contracts with analytical laboratories. Actual PQLs achieved vary by laboratory and sample 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.

CAS	=	Chemical Abstracts Service	N/A	=	not applicable
EPA	=	U.S. Environmental Protection Agency	PQL	=	practical quantitation limit
MCL	=	maximum contaminant level	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 for field measurements.

2.2.3 Quality Control

The QC requirements specified in the SAP 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	As needed[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 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
Laboratory Batch Quality Control[d]		
Carrier	Recovery/yield for radioanalytes	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 for radioanalytes	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 10 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 Site groundwater).

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

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

TSD = treatment, storage, and disposal

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

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

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

Analyte	Quality Control Element	Acceptance Criteria	Corrective Action
	Field duplicate[b]	≤20% RPD	Review data[d]
Hexavalent chromium	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Uranium (total) by ICP-MS	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Radionuclides			
Gross alpha	MB	<MDC <5% sample activity concentration	Flag with "B"
	LCS	80% to 120% recovery or statistically derived limits[e]	Flag with "o"[a]
	DUP[b]	≤20% RPD	Review data[d]
	EB, FTB	<MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Gross beta	MB	<MDC <5% sample activity concentration	Flag with "B"
	LCS	80% to 120% recovery or statistically derived limits[e]	Flag with "o"[a]
	DUP[b]	≤20% RPD	Review data[d]
	EB, FTB	<MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Strontium-90	MB	<MDC	Flag with "B"

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

Analyte	Quality Control Element	Acceptance Criteria	Corrective Action
		<5% sample activity concentration	
	LCS	80% to 120% recovery or statistically derived limits[e]	Flag with "o"[a]
	DUP[b]	≤20% RPD	Review data[d]
	Tracer	30% to 105% recovery	Review data[d]
	Carrier	40% to 110% recovery	Review data[d]
	EB, FTB	<MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Technetium-99	MB	<MDC <5% sample concentration	Flag with "B"
	LCS	80% to 120% recovery or statistically derived limits[e]	Flag with "o"[a]
	DUP[b]	≤20% RPD	Review data[d]
	MS	75% to 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 EPA requirements but is intended solely as guidance. The table is consistent with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document*.

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

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

c. Either a sample duplicate or a MS/MSD is to be analyzed to determine measurement precision (if there is insufficient sample volume, an LCSD is analyzed with the acceptance criteria defaulting to the DUP or MS/MSD criteria as appropriate for the media).

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.

DUP = laboratory sample duplicate
EB = equipment blank
EPA = U.S. Environmental Protection Agency
FTB = full trip 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
LCSD = laboratory control sample duplicate
MB = method blank
MDC = minimum detectable activity
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PQL = practical quantitation limit
QC = quality control
RPD = relative percent difference
SMR = Sample Management and Reporting

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

Analyte	Quality Control Element	Acceptance Criteria	Corrective Action

Data flags:

B, C = possible laboratory contamination: analyte was detected in the associated MB.

N = result may be biased: associated matrix spike result was outside the acceptance limits.

o = result may be biased: associated laboratory control sample result was outside the acceptance limits – laboratory applied.

Q = problem with associated field QC blank: results were out of limits.

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.

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 two types of field blanks (equipment blanks [EBs] and full trip blanks [FTBs]). Field blanks are typically prepared using high-purity reagent water[1]. QC sample definitions and their required frequency for collection are described below. Required frequencies are provided in Table 2-4.

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: 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: 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.

Full trip blanks: Bottles prepared by the sampling team before travel to the sampling site. The preserved bottle set is either for VOC 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.

[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).

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 laboratory control samples, laboratory sample duplicates, matrix spikes (MSs), matrix spike duplicates (MSDs), method blanks (MBs), surrogates (SURs), carriers, and tracers (for certain radionuclides). These QC analyses are required by EPA methods (e.g., those in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*), 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: 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: An intra-laboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

Matrix spike: 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: 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: 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, SURs 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.

Laboratories are required to analyze samples within the holding times specified 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
General Chemistry Parameters, Anions		
Alkalinity	Cool ≤6°C	14 days[b]
Chloride, fluoride, sulfate	Cool ≤6°C	28 days[b,c,d]
Nitrate, nitrite, phosphate	Cool ≤6°C	48 hours[c,d]
Metals		
ICP-AES metals/ ICP-MS metals	Nitric acid to pH <2	6 months[b,c,d]
Hexavalent chromium	Cool ≤6°C	24 hours[b,d]
Radionuclides		
Gross alpha/gross beta	Nitric acid to pH <2	6 months[d]
Strontium-90	Nitric acid to pH <2	6 months[e]
Technetium-99	Nitric acid to pH <2	6 months[e]

Notes: Holding times and preservation methods are dependent on the constituent and are consistent with EPA 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. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, Table 3-2.

c. 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants," Table II.

d. SW-846, Table 2-40(B).

e. DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document, Volume 2, Sampling Technical Requirements*, Appendix A.

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 requirements.

2.2.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Section 3.6. 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 the analytical test method 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, 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 may be performed for the identified SAP 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, 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 the following:

- Verification of instrument calibrations
- Evaluation of analytical results based on MBs
- 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 may be performed to Level C, which 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, MB results, MS/MSD results, SUR 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 data quality assessment (DQA) 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 DQA 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 DQA 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, representativeness, comparability, completeness, bias, 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 both the statistical DQA data evaluation process and the DQI evaluation process. Results of the DQA or DQI processes will be used by the contractor OU Project Manager to interpret the data and determine if the DQOs for this activity have been met.

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3 Field Sampling Plan

This chapter identifies the groundwater wells (including P&T wells) and aquifer tubes to be sampled, the sampling frequency, and the constituents to be analyzed. Details of the DQO process for determining sampling frequency, location, and constituents are presented in Appendix A of this SAP. Table B-1 shows the sample design for the 100-HR-3 OU on a "per well" basis.

3.1 Sampling Objectives/Design

As stated in Section 1.1, the monitoring presented in this plan satisfies the requirements of performance and attainment monitoring of the P&T and MNA remedies as identified in the 100-D/H ROD (EPA et al., 2018) and described in DOE/RL-2017-13. The objectives of groundwater monitoring in this OU were defined using the DQO process (Appendix A) to identify data needs to ensure the RAOs identified in the 100-D/H ROD (EPA et al., 2018) are met. As a result of this process, groundwater monitoring was identified as needed within the 100-HR-3 OU for both the unconfined and RUM aquifers, the deeper confined units, and shoreline aquifer tubes.

The terminology used in this plan, adopted as part of updated guidance (e.g., EPA 230-R-92-014, *Methods for Evaluating The Attainment Of Cleanup Standards Volume 2: Ground Water*), identifies a period of active remediation with performance monitoring, followed by the end of remediation with a rebound study, followed by compliance monitoring to demonstrate attainment of cleanup levels. More information is provided in the RD/RAWP (DOE/RL-2017-13).

The sampling design is judgmental, as described below, and presented in Appendix A.

Judgmental sampling. 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. Therefore, conclusions about the target population are limited and depend entirely on the validity and accuracy of professional judgment. Probabilistic statements about parameters are not possible.

Well locations are judgmental sampling. Statistical analysis may be performed on collected groundwater samples to assess trends and evaluate data.

3.2 Sample Location, Frequency, and Constituents to be Monitored

The DQO process was used to identify sample locations, frequencies for collection, and constituents for monitoring. During the team meetings, a total of seven principal study questions (PSQs) were agreed upon for current monitoring. Additional PSQs for consideration as cleanup criteria are met, along with potential additional studies, were also discussed but not adopted. Appendix A identifies the sampling locations within the 100-HR-3 OU that addresses the PSQs. Not all of the sampling locations identified for potential use in the monitoring network within the 100-HR-3 OU are needed to answer PSQs.

Samples are to be collected as outlined in Appendix A and Table B-1 in Appendix B. Monitoring wells, aquifer tubes, and P&T system extraction wells have been identified as available for monitoring to meet the data needs identified for each PSQ. If current P&T extraction wells are converted to injection use, the change will be made to Table B-1 per the Tri-Party Agreement process and the location will no longer be identified as a potential monitoring location. Changes to the P&T extraction system configuration will also be identified through a Tri-Party Agreement change notice, with the monitoring in Table B-1 adjusted as needed to meet the PSQs.

Monitoring of P&T system extraction wells will be conducted at the DX or HX facility. If an extraction well is not in operation during the planned sampling event, the sample will be collected at the well head, by other means. Aquifer tubes selected for monitoring during high river stage will be modified as needed to facilitate sampling. Wells that are not accessible for safety reasons or due to other well maintenance concerns will have these issues addressed prior to sampling. Wells that have been identified as "to be decommissioned" will be placed on the decommissioning list and will not be sampled.

Sample collection will include measurement of field parameters (dissolved oxygen, pH, specific conductance, temperature, turbidity, and depth to groundwater). Monitoring conducted for the PSQs also uses data generated for P&T system operations and maintenance (O&M). The O&M monitoring is described in DOE/RL-2013-49, *100-HR-3 Pump and Treat System Operations and Maintenance Plan*. These data include monthly (or more frequent) Cr(VI) measurements from extraction wells, which are collected to monitor P&T system performance.

3.3 Operational Sampling

Samples are collected from the P&T facilities and analyzed for Cr(VI) to monitor system performance. Process sampling is conducted on a routine basis as described in the O&M plan (Table 4-2 in DOE/RL-2013-49, Rev. 1) and is not included herein. Additional samples are collected from the influent and effluent tanks. Treatment process water monitoring is presented in Table 3-1. Sampling for Sr-90 was limited to those areas near known plumes, as described in the following sections.

Table 3-1. Operational Monitoring Requirements

Parameters	Location	Data Use	Frequency
DX P&T System			
Nitrate, total chromium, Cr(VI)	Influent/effluent tanks, extraction wells	Monitor remedial action effects on contaminant concentrations in treatment water	Quarterly
Field Parameters: pH, turbidity, temperature, dissolved oxygen, specific conductance, Cr(VI)	Influent/effluent tanks	Monitor water quality	Quarterly
HX P&T System			
Nitrate, total chromium, Cr(VI)	Influent/effluent tanks, extraction wells	Monitor remedial action effects on contaminant concentrations in treatment water	Quarterly
Strontium-90	Selected extraction wells*	Monitor contaminant concentrations	Quarterly
Field Parameters: pH, turbidity, temperature, dissolved oxygen, specific conductance, Cr(VI)	Influent/effluent tanks	Monitor water quality	Quarterly

Note: A complete list of system wells is provided in DOE/RL-2013-49, Rev. 1, *100-HR-3 Pump and Treat System Operations and Maintenance Plan*.

*HX extraction wells for strontium-90 analysis include wells 199-H3-21 and 199-H4-63.

P&T = pump and treat

3.3.1 Strontium-90 Sampling

No extraction wells are currently located within the Sr-90 groundwater plume at 100-D. Sampling within the plume is being conducted as described in Appendix A. In the 100-H Area, the known Sr-90 plume is located near the 116-H-7 retention basin. Concentrations of Sr-90 were as high as 26 pCi/L (well 199-H4-13) as recently as March 2014. Extraction wells (199-H4-63 and 199-H3-21) are located near or within the plume and were selected for monitoring to track HX system influent concentrations. The Sr-90 plume at 100-H is shown in Figure 1-10.

3.4 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. Groundwater samples as follows 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 – <5 nephelometric turbidity units (NTUs) prior to sampling (or OU Technical Lead's recommendation)

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

Unless special requirements are requested from the OU Technical Lead, wells are typically purged using the equivalent volume as that of three borehole diameters multiplied by the length of the saturated portion of the well screen. Stable field readings are also required (as specified above). The default pumping rate is 7.6 to 45.4 L/min (2 to 12 gal/min) depending on the pump, although this is not practical at every well. On occasions when the purge volume is extraordinarily large, wells are purged for a minimum of 1 hour and are then sampled once stable field readings are obtained.

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 >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 the collection of 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 on the order of 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.

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 or surface water 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 the purpose of 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, *Standard Methods for the Examination of Water and Wastewater*, and SW-846. Recommended holding times are also provided in HASQARD (DOE/RL-96-68).

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

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

3.4.1 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.

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, four rinse cycles are performed to decontaminate sampling equipment: a detergent rinse, an acid rinse, a water rinse, and a hexane 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 50ºC (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 the equipment is 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
- Signature of person performing decontamination

3.4.2 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 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.

3.4.3 Water Levels

Groundwater levels are measured annually across the Hanford Site to construct water-table maps that are used to determine the direction and rate of groundwater flow in the unconfined aquifer (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). In addition, the river gauges located at 100-D and 100-H are utilized to calibrate water table maps.

Water levels are also measured in wells that are screened in confined or partially confined aquifers to help determine horizontal and vertical hydraulic gradients. The collection of additional water-level measurements, including the use of the automated water-level network is described in Appendix A.

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.

3.5 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). Also, 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, MSs, 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.

3.5.1 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.

3.6 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 requirements (DOE/RL-96-68).

Field instrument 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 Hanford Site services 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.

3.7 Sample Handling

Sample handling and transfer will be in accordance with established methods to preclude loss of identity, damage, deterioration, and loss of sample. 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.

3.7.1 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 precleaned 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.

3.7.2 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 preprinted or handwritten in indelible or waterproof ink.

3.7.3 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.

3.7.4 Sample Transportation

Packaging and transportation instructions shall comply with applicable transportation regulations and DOE requirements. Sample transportation will comply with U.S. Department of Transportation (DOT) regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastesCarrier-specific requirements defined in the current edition of International Air Transportation Association (IATA), *Dangerous Goods Regulations*, shall also be used when preparing sample shipments conveyed by air freight 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 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, the samples 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.

4 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with DOE/RL-2017-13. For waste designation purposes, wells listed in Table B-1 in this SAP 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. Table B-1 will be updated annually to reflect changes in P&T system configuration, new well installations, and well decommissioning.

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 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, and site visitors; and incident reporting are governed by the health and safety program. Hanford Site-specific health and safety plans will be used to supplement the general health and safety program.

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6 References

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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
FS	feasibility study
MTCA	“Model Toxics Control Act—Cleanup” (WAC 173-340)
OU	operable unit
P&T	pump and treat
PSQ	principal study question
RAO	remedial action objective
RI	remedial investigation
ROD	record of decision
RUM	Ringold Formation upper mud
UCL	upper confidence limit
UCL-95	95 percent upper confidence limit

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A1 Introduction

The 100-HR-3 Groundwater Operable Unit (OU) specific data quality objectives (DQOs) were developed to support a groundwater monitoring plan that addresses multiple data needs and uses. The monitoring is focused on meeting the remedial action objectives (RAOs) that are identified in the record of decision (ROD) from July 2018 (EPA et al., 2018, *Record of Decision Hanford 100 Area Superfund Site 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*). The RAOs for the 100-HR-3 Groundwater OU are as follows:

- RAO 1: Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater-containing contaminant concentrations above federal and state standards, and risk-based thresholds.
- RAO 2: Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water-containing contaminant concentrations above federal and state standards, and risk-based thresholds.
- RAO 7: Restore groundwater in the 100-HR-3 OU to cleanup levels, which include drinking water standards, within a timeframe that is reasonable given the particular circumstances of the site.

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* (EPA QA/G-4). 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 the groundwater monitoring plan is to collect spatially and temporally distributed measurements and observations on contaminant plumes. These measurements and observations are used to support operation of the remedial actions and evaluation of performance against RAOs. Operation of the system is based on the conceptual site model (CSM), which identifies the nature and extent of contamination, as presented in detail in the 100-D/H remedial investigation (RI)/feasibility study (FS) report (DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*). The CSM is also presented in Section 1.4 of DOE/RL-2017-13, *Remedial Design/Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit*. Data collected under the groundwater monitoring plan will continue to inform the CSM and guide optimization of the remedial processes.

A2 Evaluation of the Data Needs

During the evaluation of the data needs, data which already exists from computational or sampling and analysis methods was compiled and reviewed. The 100-D/H RI/FS (DOE/RL-2010-95) 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-D/H Area. The updated understanding of contaminant extent is provided in annual groundwater

monitoring reports (e.g., DOE/RL-2018-66, *Hanford Site Groundwater Monitoring Report for 2018*; DOE/RL-2017-66, *Hanford Site Groundwater Monitoring Report for 2017*). Over the past few years, additional wells installed in the uppermost water-bearing unit of the Ringold Formation upper mud (RUM), groundwater monitoring data, pump and treat (P&T) system data, and pumping tests in the uppermost water-bearing unit of the RUM have helped improve understanding of the uppermost water-bearing unit of the RUM; however, more information is needed to understand contaminant fate and transport in this unit.

Representatives from the U.S. Department of Energy (DOE), the primary groundwater contractor, and the Washington State Department of Ecology participated in facilitated meetings to support the DQO process and the evaluation of ongoing sampling requirements. During these meetings, the participants discussed the available information and remaining data needs. A summary of the meetings is included at the end of this appendix. The meeting summary includes a list of individuals who represent the planning team members for this DQO, a summary of the data needs discussions held during the meeting, and a table representing the agreed DQO elements which are incorporated into this DQO.

Principle study questions (PSQs) and data needs were identified for the following problem statements, which define the problems to be addressed by the groundwater monitoring plan:

- **Problem Statement 1:** There is a need to determine if RAO 2, preventing discharge of contaminants to the Columbia River, is being met.
- **Problem Statement 2:** There is a need to determine if RAO 7, restoring groundwater conditions, is being achieved. There is a need to monitor the performance of the P&T remedy for total chromium and hexavalent chromium (Cr(VI)).
- **Problem Statement 3:** There is a need to monitor the performance of the natural attenuation remedy for nitrate and strontium-90 (Sr-90).
- **Problem Statement 4:** There is a need to understand the groundwater flow in both the unconfined and uppermost water-bearing unit of the RUM under pumping and ambient flow conditions.
- **Problem Statement 5:** There is a need to understand the impact of secondary sources.
- **Problem Statement 6:** There is a need to understand the nature and extent of Cr(VI) contamination in the uppermost water-bearing unit of the RUM .
- **Problem Statement 7:** There is a need to understand the physical and hydraulic characteristics of the uppermost water-bearing unit of the RUM .

The goals of the study are addressed through PSQs identified for each problem statement. Data needs 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 for each problem statement are captured in Table A-1.[1] Decision rules and the alternative outcomes, which will determine actions to be completed based on the information collected, are also included in Table A-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.

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

Data Need(s)		Measurements or Observations	Identify the Decision Statements or Estimation Statements Needed to Address the PSQs	Define Alternative Outcomes or Actions that can Occur upon Answering PSQs
Problem Statement 1: There is a need to determine if RAO 2, preventing discharge of contaminants to the Columbia River, is being met. **PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?** **PSQ 1a: From the unconfined aquifer?** **PSQ 1b: From the uppermost water-bearing unit of the RUM?** **PSQ 1c: Are aquifer tubes where Cr(VI) is typically detected above 10 µg/L representative of the aquifer?**				
PSQ 1(a)	Unconfined aquifer Cr(VI) concentrations.	Measurements taken from unconfined aquifer monitoring wells within 100 m of the river during low river stage (typically September to December). Measurements taken from unconfined aquifer P&T wells within 100 m of the river during low river stage.* Measurements taken at aquifer tubes in areas with inadequate well coverage potentially impacted by Cr(VI) plumes, used for qualitative evaluation, during low river stage. Measurements taken during high river stage in aquifer tubes where Cr(VI) is typically detected above 10 µg/L.	Determine whether unconfined aquifer groundwater is discharging Cr(VI) to the river at concentrations greater than 10 µg/L.	If data from aquifer tubes or near river unconfined aquifer wells indicates Cr(VI) may be discharging to the river at concentrations greater than 10 µg/L, then evaluate P&T optimization and maintain monitoring at established frequency.
				If data from aquifer tubes and near river unconfined aquifer wells indicates Cr(VI) is not discharging to the river at concentrations greater than 10 µg/L, then re-evaluate P&T system configuration and monitoring configuration. Consider modeled impacts of migration from inland plumes and possibly plan and implement a rebound test and compliance monitoring.
PSQ 1(b)	RUM aquifer Cr(VI) concentrations.	Measurements taken from uppermost water-bearing unit of the RUM monitoring wells within 100 m of the river during low river stage (typically September to December) and high river stage. Where monitoring well concentrations are nondetected for 2 consecutive years, the wells will be sampled every other year. Measurements taken from the uppermost water-bearing unit of the RUM P&T wells within 100 m of the river during low river stage* and high river stage. Additional wells or other monitoring points near the river in areas where there is a potential for discharge from the RUM to the Columbia River (i.e., shoreline of 100-H).	Determine whether uppermost water-bearing unit of the RUM groundwater is discharging Cr(VI) to the river at concentrations greater than 10 µg/L.	If data from near river wells in the uppermost water-bearing unit of the RUM indicates Cr(VI) may be discharging to the river at concentrations greater than 10 µg/L, then evaluate P&T optimization and maintain monitoring at established frequency.
				If data from near river wells in the uppermost water-bearing unit of the RUM indicates Cr(VI) is not discharging to the river at concentrations greater than 10 µg/L, then re-evaluate P&T system configuration and monitoring configuration. Consider modeled impacts of migration from inland plumes and possibly plan and implement a rebound test and compliance monitoring.
PSQ 1(c)	Aquifer tube Cr(VI) concentrations.	Measurements taken during high river stage at aquifer tubes in areas where Cr(VI) is typically detected above 10 µg/L.	Determine whether aquifer tube data in areas where Cr(VI) is typically detected above 10 µg/L are representative of the aquifer.	If aquifer tube data for areas where Cr(VI) is typically detected above 10 µg/L are representative of the aquifer, then maintain aquifer tube monitoring.
				If aquifer tube data for areas where Cr(VI) is typically detected above 10 µg/L are not representative of the aquifer, then evaluate alternative sampling methods for PSQ 1(a).
Problem Statement 2: There is a need to monitor the performance of the P&T remedy for total chromium and Cr(VI). **PSQ 2: Are the contaminant mass, concentrations, and plume areas reducing as expected?** **PSQ 2a: In the unconfined aquifer?** **PSQ 2b: In the uppermost water-bearing unit of the RUM?**				
PSQ 2(a)	Unconfined aquifer Cr(VI) concentrations.	Measurements taken annually during low river stage at unconfined aquifer monitoring wells within the plume or that define plume boundaries, and at P&T extraction wells. Measurements will be taken every other year where concentrations have been nondetected for 2 consecutive years.	Determine whether the remedy is removing mass and reducing the Cr(VI) plume in the unconfined aquifer as expected.	If Cr(VI) unconfined aquifer concentrations and plume area are reducing at or faster than the rate necessary to meet remedial action expectations, then evaluate if monitoring should continue at established or decreasing frequencies for specific locations.
				If Cr(VI) unconfined aquifer concentrations and plume area are reducing more slowly than the rate necessary to meet remedial action expectations, then evaluate P&T optimization to improve the rate of reduction or consider an alternate response.
				Nonbounding wells where concentrations have been nondetected for 2 consecutive years will be reviewed at the time of each 5-year review to determine if ongoing sampling is necessary.

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

Data Need(s)		Measurements or Observations	Identify the Decision Statements or Estimation Statements Needed to Address the PSQs	Define Alternative Outcomes or Actions that can Occur upon Answering PSQs
PSQ 2(b)	RUM aquifer Cr(VI) concentrations.	Measurements taken annually during low river stage at the uppermost water-bearing unit of the RUM wells within the plume or that define plume boundaries, and at P&T extraction wells. Measurements will be taken every other year where concentrations have been nondetected for 2 consecutive years.	Determine whether the remedy is removing mass and reducing the Cr(VI) plume in the uppermost water-bearing unit of the RUM as expected.	If Cr(VI) uppermost water-bearing unit of the RUM concentrations and plume area are reducing at or faster than the rate necessary to meet remedial action expectations, then evaluate if monitoring should continue at established or decreasing frequencies for specific locations.
				If Cr(VI) uppermost water-bearing unit of the RUM concentrations and plume area are reducing more slowly than the rate necessary to meet remedial action expectations, then evaluate P&T optimization to improve the rate of reduction or consider an alternate response.
				Nonbounding wells where concentrations have been nondetected for 2 consecutive years will be reviewed at the time of each 5-year review to determine if ongoing sampling is necessary.
Problem Statement 3: There is a need to monitor the performance of the natural attenuation remedy for nitrate and Sr-90. **PSQ 3: Are concentrations of nitrate and Sr-90 attenuating as expected?** **PSQ 3a: In the unconfined aquifer?** **PSQ 3b: In the uppermost water-bearing unit of the RUM?**				
PSQ 3(a)	Unconfined aquifer nitrate and Sr-90 concentrations.	Measurements of nitrate taken once every 5 years at wells with historically high nitrate concentrations. Measurements of nitrate taken annually at wells with occasional exceedances of nitrate. Measurements of Sr-90 taken once every 5 years at wells within the Sr-90 plume and at locations that define the Sr-90 plume boundaries.	Determine whether the nitrate and Sr-90 concentrations and plume areas in the unconfined aquifer are decreasing as expected.	If nitrate plumes in the unconfined aquifer are attenuating at the expected rate or faster, then continue performance monitoring.
				If nitrate plumes in the unconfined aquifer are attenuating more slowly than the expected rate, then consider a secondary source investigation or an alternate response.
				If Sr-90 plumes in the unconfined aquifer are attenuating at the expected rate or faster, then continue performance monitoring.
				If Sr-90 plumes in the unconfined aquifer are attenuating more slowly than the expected rate, then consider a secondary source investigation or an alternate response.
PSQ 3(b)	RUM aquifer nitrate concentrations.	Measurements of nitrate taken semiannually at wells with exceedances of nitrate and at wells adjacent to those with exceedances, since no plume has been developed. (Note: Sr-90 has not been detected in the uppermost water-bearing RUM.)	Determine whether nitrate concentrations and plume areas in the uppermost water-bearing unit of the RUM are decreasing as expected.	If nitrate plumes in the uppermost water-bearing unit of the RUM are attenuating at the expected rate or faster, then continue performance monitoring.
				If nitrate plumes in the uppermost water-bearing unit of the RUM are attenuating more slowly than the expected rate, then consider a secondary source investigation or an alternate response.
Problem Statement 4: There is a need to understand the groundwater flow in both the unconfined and RUM aquifers under pumping and ambient flow conditions. **PSQ 4: What are the direction and magnitude of groundwater hydraulic gradients?** **PSQ 4a: In the unconfined aquifer under operational conditions?** **PSQ 4b: In the unconfined aquifer under ambient conditions?** **PSQ 4c: In the uppermost water-bearing unit of the RUM under operational conditions?** **PSQ 4d: In the uppermost water-bearing unit of the RUM under ambient conditions?**				
PSQ 4(a)	Unconfined aquifer water levels under operational conditions.	Manual water-level measurements from unconfined aquifer monitoring wells taken annually as part of the groundwater monitoring program (SGW-38815). Additional measurements taken more frequently at unconfined aquifer P&T system wells and from AWLN station wells. Manual water-level measurements collected during sampling events.	Determine the direction and magnitude of unconfined aquifer groundwater flow under operational conditions.	If groundwater hydraulic gradient information is sufficient, then retain the water-level monitoring network, including manual measurements, P&T, and AWLN system measurements.
				If groundwater hydraulic gradient information collected is sufficient to inform the fate and transport modeling, continue current water-level monitoring, including manual measurements, P&T, and AWLN system measurements.
				If groundwater hydraulic gradient information collected is not sufficient to inform the fate and transport modeling, then evaluate changes to the AWLN and determine if more frequent manual measurements are needed.
				If the P&T system configuration changes, then evaluate changes to the AWLN.

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

Data Need(s)		Measurements or Observations	Identify the Decision Statements or Estimation Statements Needed to Address the PSQs	Define Alternative Outcomes or Actions that can Occur upon Answering PSQs
PSQ 4(b)	Unconfined aquifer water levels under ambient conditions.	Manual water-level measurements from unconfined aquifer monitoring wells during a widespread P&T system shut off period. Additional measurements taken more frequently at unconfined aquifer P&T system wells and from AWLN station wells during a widespread P&T system shut off period.	Determine the direction and magnitude of unconfined aquifer groundwater flow under ambient conditions.	If groundwater hydraulic gradient information is sufficient, then retain the water-level monitoring network, including manual measurements, P&T, and AWLN system measurements.
				If groundwater hydraulic gradient information collected is sufficient to inform the fate and transport modeling, continue current water-level monitoring, including manual measurements, P&T, and AWLN system measurements.
				If the P&T system configuration changes, then evaluate changes to the AWLN.
PSQ 4(c)	Uppermost water-bearing unit of the RUM water levels under operational conditions.	Manual water-level measurements from the uppermost water-bearing unit of the RUM monitoring wells taken annually as part of the groundwater monitoring program (SGW-38815). Additional measurements taken more frequently at the uppermost water-bearing unit of the RUM P&T system wells and from AWLN station wells. Manual water-level measurements collected during sampling events.	Determine the direction and magnitude of the uppermost water-bearing unit of the RUM groundwater flow under operational conditions.	If groundwater hydraulic gradient information is sufficient, then retain the water-level monitoring network, including manual measurements, P&T, and AWLN system measurements.
				If groundwater hydraulic gradient information collected is sufficient to inform the fate and transport modeling, continue current water level monitoring, including manual measurements, P&T, and AWLN system measurements.
				If the P&T system configuration changes, then evaluate changes to the AWLN and determine if more frequent manual measurements are needed.
PSQ 4(d)	RUM aquifer water levels under ambient conditions.	Manual water-level measurements from RUM aquifer monitoring wells during a widespread P&T system shut off during high river, low river, and a transitional river stage period. P&T wells in the unconfined aquifer are to be held at a steady-state during the water-level measurement period (including shut down and recovery timeframes). The steady-state conditions needed will be determined on a case by case basis and may include turning off the unconfined aquifer P&T system or limiting flow at the unconfined aquifer P&T system wells. Additional measurements taken at the RUM aquifer P&T system wells and from AWLN wells during a widespread P&T system shut off during high river, low river, and a transitional river stage. P&T wells in the unconfined aquifer are to be held at a steady-state during the water-level measurement period (including shut down and recovery timeframes). The steady-state conditions needed will be determined on a case by case basis and may include turning off the unconfined aquifer P&T system or limiting flow at the unconfined aquifer P&T system wells.	Determine the direction and magnitude of the uppermost water-bearing unit of the RUM groundwater flow under ambient conditions.	If groundwater hydraulic gradient information is sufficient, then retain the water-level monitoring network, including manual measurements, P&T, and AWLN system measurements.
				If groundwater hydraulic gradient information collected is sufficient to inform the fate and transport modeling, continue current water-level monitoring, including manual measurements, P&T, and AWLN system measurements.
				If the P&T system configuration changes, then evaluate changes to the AWLN and determine if more frequent manual measurements are needed.
				If groundwater flow in the uppermost water-bearing unit of the RUM is influenced by (or influencing) the unconfined aquifer flow regime, then update the conceptual site model and re-evaluate remedy operations to achieve RAOs.
Problem Statement 5: There is a need to understand the impact of secondary sources. **PSQ 5: Are there areas that require additional sampling to evaluate the impacts of secondary sources?** **PSQ 5a: In the unconfined aquifer?** **PSQ 5b: In the uppermost water-bearing unit of the RUM?**				
PSQ 5(a)	Additional sampling of the unconfined aquifer wells.	Monitor select wells near the 183-H Solar Evaporation Basins for uranium, nitrate, and Cr(VI). Measurements will be taken annually during high river stage at unconfined aquifer monitoring wells within the source area. Measurements will be taken annually during low river stage at unconfined aquifer monitoring wells downgradient from the source area. Monitor select wells near the 107-H Retention Basin for Cr(VI). Measurements will be taken annually during high river stage at unconfined aquifer monitoring wells within the source area. Measurements will be taken annually during low river stage at unconfined aquifer monitoring wells downgradient from the source area.	Estimate the impacts of secondary sources on remedial timeframes.	If data collected demonstrate that secondary sources do not extend the remedial timeline, then continue monitoring.
				If data collected demonstrate that a secondary source may extend the remedial timeframe, then evaluate the need for additional targeted investigation or remedial actions.
PSQ 5(b)	Additional sampling of RUM aquifer wells.	Monitor select wells near the 183-H Solar Evaporation Basins for nitrate, Cr(VI), and Tc-99. Measurements will be taken annually during high river stage at unconfined aquifer monitoring wells within the source area. Measurements will be taken annually during low river stage at unconfined aquifer monitoring wells downgradient from the source area.	Estimate the impacts of secondary sources on remedial timeframes.	If data collected demonstrate that secondary sources do not extend the remedial timeline, then continue monitoring.
				If data collected demonstrate a secondary source may extend the remedial timeframe, then evaluate the need for additional targeted investigation or remedial actions.

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

Data Need(s)		Measurements or Observations	Identify the Decision Statements or Estimation Statements Needed to Address the PSQs	Define Alternative Outcomes or Actions that can Occur upon Answering PSQs
Problem Statement 6: There is a need to understand the nature and extent of Cr(VI) contamination in the RUM aquifer. **PSQ 6: What are the nature and extent of Cr(VI) concentrations within the uppermost water-bearing unit of the RUM?**				
PSQ 6	RUM aquifer Cr(VI) concentrations.	Install groundwater monitoring wells as needed to delineate the Cr(VI) plume. Sample new wells quarterly to establish baseline conditions. Following the eighth sampling event, data will be reviewed to determine the appropriate sampling frequency.	Determine whether groundwater Cr(VI) concentrations indicate additional evaluation or remediation is needed.	If Cr(VI) is present in the uppermost water-bearing unit of the RUM at concentrations exceeding cleanup levels, then continue evaluation under PSQ 2(b).
				If Cr(VI) is not present in the uppermost water-bearing unit of the RUM at concentrations greater than cleanup levels, then evaluate need for monitoring under other PSQs.
Problem Statement 7: There is a need to understand the physical and hydraulic characteristics of the RUM aquifer. **PSQ 7: What are the physical and hydraulic characteristics of the uppermost water-bearing unit of the RUM?**				
PSQ 7	Physical and hydraulic characteristics of the uppermost water-bearing unit of the RUM.	Conduct aquifer testing on new and existing wells and obtain physical property information on the aquifer from new wells to determine: • Spatial distribution of hydraulic properties • Uppermost water-bearing unit of the RUM thickness • Porosity and hydraulic conductivity of the uppermost water-bearing unit of the RUM and overlying material • Storativity of the uppermost water-bearing unit of the RUM • Groundwater linear velocity Additional hydrogeologic observations in near river areas where there is a potential for discharge from the RUM. Information from PSQs 4(c) and 4(d) will inform the assessment of communication with the river. Additional wells and monitoring may be needed to define the connection with the river at the 100-H Area.	Determine the supporting geoframework and fate and transport of contaminants in the uppermost water-bearing of the RUM.	If the physical and hydraulic characteristics data collected are not sufficient to inform the geoframework or fate and transport modeling, then conduct additional aquifer testing and obtain hydraulic property information from new or existing wells.
				If the physical and hydraulic characteristics data collected is sufficient to inform the geoframework or fate and transport modeling, use the existing data.
			Determine if there are geologic connections between the uppermost water-bearing unit of the RUM and the Columbia River.	If a hydrogeologic connection exists between the uppermost water-bearing unit of the RUM and Columbia River, then continue monitoring for PSQ 1(b).
				If no hydrogeologic connection exists between the uppermost water-bearing unit of the RUM and Columbia River, then evaluate the uppermost water-bearing unit of the RUM points of compliance and remedy operations to achieve RAOs.

Reference: SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*.

*P&T system operations will determine the best practice for collecting well samples in low-water conditions, including removing well pumps to collect manual samples.

AWLN = automatic water-level network
P&T = pump and treat
PSQ = principal study question
RAO = remedial action objective
RUM = Ringold Formation upper mud unit

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-HR-3 Groundwater OU and were discussed during the DQO meetings.

A3.1 Spatial Boundaries of the Study

The monitoring program physical boundaries constrain the data collection in three dimensions. The areal limits include the 100-HR-3 Groundwater OU area of interest, 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-HR-3 Groundwater OU. If the extent of contamination was identified in an additional area, the study area boundaries would be expanded to include the additional area. The working hypothesis is that contaminant migration in the 100-HR-3 Groundwater OU follows groundwater flow paths toward discharge boundaries. The study domain includes both the unconfined aquifer and the confined to semiconfined aquifer in the first water-bearing unit of the RUM, and groundwater within the hyporheic zone at the groundwater discharge boundary with the Columbia River.

The unconfined aquifer extends from the top of the periodically rewetted zone to the top surface of the RUM material, and is the shallowest aquifer. Below the unconfined aquifer is the RUM material, which consists primarily of silt and clay, but contains more sand in the 100-H Area. Within the RUM material, contamination has been identified in the uppermost water-bearing unit. This semiconfined to confined water-bearing unit is bounded by the silt and clay of the RUM to the top, and by either a continuation of the RUM material or the Ringold Formation member of Wooded Island — lower mud unit at its base. This lower boundary is defined by the presence of a nontransmissive layer consisting of silt or clay type material. While several other water-bearing units have been identified in the RUM material, contamination has not been found in these lower units. Groundwater contamination has been identified within the uppermost water-bearing unit of the RUM. The monitoring plan is designed to gather data that will be used for further definition of contamination and evaluate effects of contaminants within the uppermost water-bearing unit of the RUM.

Groundwater from the unconfined aquifer in the 100-HR-3 Groundwater 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. Discharge from the uppermost water-bearing unit in the RUM to the Columbia River has not yet been quantified.

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. Historical trends were evaluated to identify changes in conditions that are related to seasonal changes in order to provide an understanding of how any particular measurement may be affected. Time-series plots of concentrations, groundwater elevations, and river stage were used to identify relationships with the purpose of developing the appropriate measurement schedules to satisfy data needs.

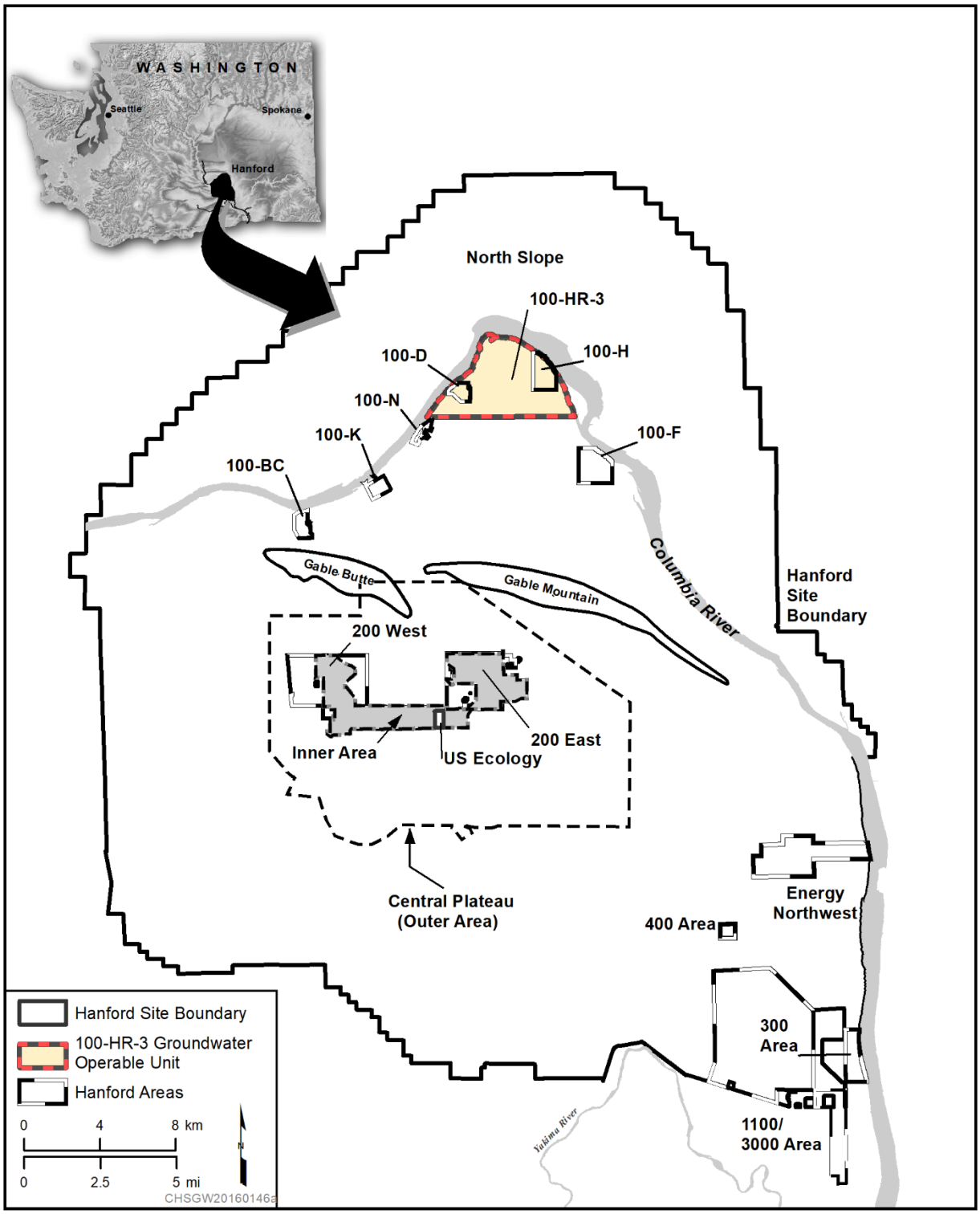

Figure A-1. 100-D/H Area and 100-HR-3 Groundwater OU Area of Interest

The Columbia River functions as a discharge boundary for the shallow unconfined aquifer beneath the 100-HR-3 Groundwater 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 and high river stage, the magnitude of the groundwater gradient is reduced, and in portions of the shallow aquifer near the river, the 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 greater-than-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. While not yet definitively determined, it is possible that portions of the uppermost water-bearing unit of the RUM also discharges to the river. A hydraulic head response to river stage changes has been noted in the uppermost water-bearing unit of the RUM in several locations (SGW-60571, *Aquifer Testing of the First Water-Bearing Unit in the RUM at 100-H*).

Response of the Cr(VI) plume in the unconfined aquifer at 100-HR-3 Groundwater 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-2018-66). 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. With the addition of new wells in the uppermost water-bearing unit of the RUM , the changes in plume configuration in the RUM can now also be tracked, and changes in plume geometry in response to river stage can be evaluated.

The Cr(VI) plume boundaries in the unconfined aquifer have also been tracked as a component of groundwater monitoring since implementation of the interim remedial action 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*). The expansion of the groundwater P&T system through the addition of the DX and HX extraction and injection networks has provided a system of wells that is adequate to identify and track plume boundaries. Additional wells may be added periodically for system operations, to target mass removal, and to track plume boundaries as the plumes shift in response to ongoing remediation.

The understanding of Cr(VI) flux to the river and plume geometry supports identification of an annual sampling frequency for PSQ 1. The areal extent requiring monitoring will shrink over time, commensurate with groundwater cleanup. As RAOs are achieved and verified, monitoring needs will change. As plume geometry changes in response to the ongoing remediation, wells which no longer provide mass reduction or plume bounding services may be evaluated to determine if ongoing sampling frequencies should be reduced.

A3.3 Resource Limitations and Constraints

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

- Limitations due to DOE baseline budget priorities and available funding
- Number and type of new wells to be installed, which is limited by funding, priorities, and identified needs at a point in time
- 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 limitations
- Further remedial actions (i.e., waste site excavation) near wells that may result in removal of a well included in the monitoring plan
- 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 the adequacy of spatial and temporal coverage of the monitoring network. 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). 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. Decision statements for each PSQ are included in Table A-1.

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 (UCL) for comparison to the cleanup level, is recommended. Data will be expressed and reported as individual measurements for each COC as a 95% UCL (UCL-95), using the well monitoring dataset. Using UCL-95 to determine whether a site 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” (MTCA) guidance. A comparison to the cleanup level will be performed using the UCL-95 for each COC. The UCL-95 calculation will be 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 MTCA (WAC 173-340-720(9)(d)(i), "Groundwater Cleanup Standards").

Table A-2 provides a summary of the information used to support the selection between a statistical versus a nonstatistical sampling design for each PSQ. Factors that were taken into consideration in making this selection included the timeframe over which each of the PSQs applies, qualitative consequences of an inadequate sampling design, and accessibility of the site if resampling is required.

Table A-2. Statistical Versus Nonstatistical Sampling Design

PSQ	Evaluation (Years)	Qualitative Consequences of Inadequate Sampling Design (Low/Moderate/Severe)	Resampling Access (Accessible/Inaccessible)	Proposed Sampling Design (Statistical/Nonstatistical)
1	Annual	Low	Accessible	Nonstatistical
2	Annual	Low	Accessible	Nonstatistical
3	Annual	Low	Accessible	Nonstatistical
4	Annual	Low	Accessible	Nonstatistical
5	Annual	Low	Accessible	Nonstatistical
6	Annual	Low	Accessible	Nonstatistical
7	Annual	Low	Accessible	Nonstatistical

PSQ = principal study question

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

Monitoring locations and frequencies were selected to address the problem statements. The following sections provide the methodology used to select the groundwater monitoring locations and sampling frequencies that meet the data needs associated with the PSQs.

A5.1 Identification of Available Monitoring Locations

All available monitoring locations (e.g., wells, aquifer tubes, and treatment process streams) were identified within the groundwater OU and surrounding area of interest. Available locations are listed in Table B-1 in this SAP, and Figure B-1.

A5.2 Evaluation of Available Locations Against the Data Needs

Existing and potential locations were evaluated against the data needs for each PSQ to identify locations that potentially fulfill the data need. The following rationale was generally used for identifying potential locations:

- Location – Distance to a receptor, contaminant plume, or source

- Screened interval for monitoring wells – Unconfined aquifer, uppermost water-bearing unit in the RUM
- Historical sample results – Contaminant detections at existing monitoring locations

Well locations and construction information were extracted from the Environmental Dashboard Application at https://ehs.hanford.gov/eda. This provided physical information for the monitoring locations (e.g., relative position of screened intervals). Historical measurements and observations recorded in the Hanford Environmental Information System were used to identify historical sample results, including detection of contaminants of interest, contaminant concentration time series, and water-level measurements. Columbia River gauging stations at both 100-D and 100-H are also used to calibrate the water-table maps. Contaminant plumes were generated based on DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*.

A Hanford Site base map was generated that showed the following:

- Groundwater contaminant plumes and water-level contours
- Potential monitoring locations available for the 100-HR-3 OU

The available monitoring locations that can be used to fulfill at least one data need for each PSQ were then plotted. The resulting figures were used to provide a spatial depiction of monitoring locations that could address each individual PSQ. These visualization tools were used to examine specific areas during systematic evaluations and identify locations that meet a data need.

A5.3 Monitoring Location Retained/Excluded

Available monitoring locations were systematically evaluated to determine the suitability in fulfilling the data need. To support this activity, location information derived from ArcGIS® (e.g., proximity to contaminant plumes and potential exposure points) and selection criteria were systemically applied. This evaluation included criteria for retaining and excluding specific monitoring locations. Table A-3 identifies the qualitative evaluation criteria for each PSQ and data need. The following criteria were considered in the evaluation for retention and exclusion.

Criteria for retention included locations that meet the following requirements:

- Define known contaminant groundwater plumes
- Exhibit temporal trends
- Define the apparent vertical distribution of contaminants within the affected aquifer(s), with monitoring locations in both the unconfined and confined aquifers separately
- Monitor the apparent migration pathway of defined contaminant plumes
- Monitor potential exposure points (e.g., groundwater discharge to surface water, aquifer tubes, and wells within 100 m [328 ft] of the river shore)
- Monitor hydraulic 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)

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

Table A-3. 100-HR-3 Groundwater OU Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
Problem Statement 1: There is a need to determine if RAO 2, preventing discharge of contaminants to the Columbia River, is being met. **PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?** **PSQ 1a: From the unconfined aquifer?** **PSQ 1b: From the uppermost water-bearing unit of the RUM?** **PSQ 1c: Are aquifer tubes where Cr(VI) is typically detected above 10 µg/L representative of the aquifer?**				
Wells: Near-river locations that provide indication of real or potential exposure point concentrations.	Provide information that represents groundwater conditions at locations of discharge to surface water.	1. Monitoring well proximal to river completed in either aquifer. (Select if within 100 m (328 ft) of the river.) 2. If distance parallel to river between wells at 100 m (328 ft) from river leaves plume segments unmonitored, then add wells within 200 m (656 ft) of the river to provide spatial coverage. 3. Additional wells may be required to determine if there is a hydrogeologic connection between the RUM aquifer and the river.	1. Distance from the river indicates the well may not be representative of exposure point concentration. 2. Plume segment is adequately represented by another well or measurement location. Locations within 50 m (164 ft) of a similar monitoring location generally may be excluded. 3. Locations with no historical Cr(VI) contamination greater than 5 µg/L and hydraulic gradients indicate a low potential for future contamination (i.e., well is not located downgradient of plume).	**Analyte:** Cr(VI) filtered. **Unconfined aquifer frequency:** Annually at low/declining river stage. **RUM aquifer frequency:** Semiannually at low and high river stage. **Unconfined aquifer basis:** Historical trends of contaminants in the unconfined aquifer are well documented; this sampling frequency and timing best represents groundwater contaminant discharge. **RUM aquifer basis:** Historical trends of contaminants in the RUM aquifer need additional measurements to evaluate contaminant discharge. A potential for a hydrogeologic connection between the river and the RUM aquifer needs to be determined.
		4. Extraction wells proximal to river completed in either aquifer.	4. Distance from the river indicates the well may not be representative of exposure point concentration. 5. Plume segment is adequately represented by another well or measurement location. Locations within 50 m (164 ft) of a similar monitoring location generally may be excluded. 6. Locations with no historical Cr(VI) contamination greater than 5 µg/L and hydraulic gradients indicate a low potential for future contamination (i.e., well is not located downgradient of plume).	**Analyte:** Cr(VI) filtered. **Unconfined aquifer frequency:** Annual at low river stage; sample extraction wells regardless of operational condition. **RUM aquifer frequency:** Semiannual at low and high river stage; sample extraction wells regardless of operational condition. **Unconfined aquifer basis:** Historical trends of contaminants are well documented; this sampling frequency and timing best represents groundwater contaminant discharge. Near shore extraction wells may need additional efforts to collect the required samples. **RUM aquifer basis:** Historical trends of contaminants in the RUM aquifer need additional measurements to evaluate contaminant discharge.
Aquifer tubes: Locations that provide measurement data in areas without near-river well coverage.	Provide information that represents qualitative exposure point concentrations at locations of groundwater discharge to surface water.	1. Aquifer tubes greater than 200 m (656 ft) downgradient of a selected monitoring well. 2. Aquifer tubes having Cr(VI) detections within 5 years. 3. Aquifer tubes located within Cr(VI) plume boundaries and/or within a projection of the plume to the river. 4. Aquifer tubes exhibiting specific conductance consistent with groundwater.[a]	1. Aquifer tube(s) within a nested group of aquifer tubes and specific conductance of the individual tube is consistent with river water.[b] 2. Aquifer tube(s) is downgradient of a selected near-river monitoring well. 3. Recent data (within 5 years) do not show Cr(VI) detections and the local hydraulic gradients indicate a low potential for future contamination (i.e., aquifer tube is not located downgradient of plume).	**Analyte:** Cr(VI) filtered. **Frequency:** Annual (low/declining river stage); semiannual in select locations where the representativeness of the aquifer tube is in question. **Basis:** Historical trends of contaminants are well documented and recorded; aquifer tubes are generally only available during low river stage; aquifer tubes are to be extended to allow for high river monitoring in select locations.
Aquifer tubes: Locations that provide qualitative information.	Provide information to support the definition of plume capture and hydraulic containment.	1. Aquifer tube(s) in a location downgradient of an extraction well that shows data from an upgradient well are not able to define the plume 2. Specific conductance data indicate an area of groundwater discharge.[a]	1. Aquifer tube(s) within a nested group of aquifer tubes and specific conductance of the individual tube is consistent with river water.[b] 2. Aquifer tube(s) is downgradient of a selected near-river monitoring well. 3. Recent data (within 5 years) do not show Cr(VI) detections and local hydraulic gradients indicate a low potential for future contamination.	**Analyte:** Cr(VI) filtered. **Frequency:** Annual (low/declining river stage); semiannual in select locations where the representativeness of the aquifer tube is in question. **Basis:** Historical trends of contaminants are documented; aquifer tubes are generally only available during low river stage and need to sample concurrent with upgradient well(s); aquifer tubes are to be extended to allow for high river monitoring in select locations.

Table A-3. 100-HR-3 Groundwater OU Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
Problem Statement 2: There is a need to monitor the performance of the P&T remedy for total chromium and Cr(VI). **PSQ 2: Are the Cr(VI) mass, concentrations, and plume areas reducing as expected?** **PSQ 2a: In the unconfined aquifer?** **PSQ 2b: In the uppermost water-bearing unit of the RUM?**				
Wells: Wells located within and adjacent to current and historically defined contaminant plume segments.	Provide information that supports the definition of plume geometry and estimation of residual mass.	1. Wells that define the boundaries of plume segments. a. Concentrations below RAOs located along the periphery of the plume segment. b. Generally within 100 m (328 ft) of the inferred 10 µg/L contour. 2. Wells located within the 48 µg/L contour. 3. Closest well outside the periphery of the plume boundary.	1. Remedial system injection wells. 2. Wells located within 50 m (164 ft) of a selected monitoring location that do not provide unique local information (e.g., preferential flow pathways, measurement of conditions in a discrete aquifer unit).	**Analyte:** Cr(VI) filtered. **Unconfined and Uppermost water-bearing unit in the RUM frequency:** Annual at wells within the plume; once every 2 years for wells that have had concentrations below detection for 2 years. **Basis:** This sampling frequency supports definition of plume boundaries that, when combined with the operations data, will provide mass removal in order to determine whether the remedy performance is effective
Aquifer tubes: Within and adjacent to current and historically defined contaminant plume.	Provide information that supports definition of plume geometry.	1. Aquifer tubes that define the boundary of a plume segment. 2. Specific conductance data indicate an area of groundwater.[a]	1. Aquifer tube(s) within a nested group of aquifer tubes.[b] 2. Specific conductance of the individual tube is consistent with river water.[a] 3. Recent data (within 5 years) do not show Cr(VI) detections and local hydraulic gradients indicate a low potential for future contamination.	**Analyte:** Cr(VI) filtered. **Unconfined and Uppermost water-bearing unit in the RUM frequency:** Annual. **Basis:** This sampling frequency supports definition of plume boundaries.
Problem Statement 3: There is a need to monitor the performance of the natural attenuation remedy for nitrate and Sr-90. **PSQ 3: Are concentrations of nitrate and Sr-90 attenuating as expected?** **PSQ 3a: In the unconfined aquifer?** **PSQ 3b: In the uppermost water-bearing unit of the RUM?**				
Wells: Wells at locations that historically exhibited the selected contaminants.	Provide information that supports definition of plume geometry and assessment of concentration trends.	1. Wells with recent data (within the past 5 years) that show nitrate or Sr-90 concentrations that are greater than the cleanup level. 2. Wells located downgradient to wells exhibiting contamination that may exhibit migrating contamination in the future.	1. Remedial system injection wells. 2. Wells located within 50 m (164 ft) of a selected monitoring location that do not provide unique local information (e.g., preferential flow pathways, measurement of conditions in a discrete aquifer unit).	**Analytes:** Nitrate and Sr-90 (both unfiltered). **Unconfined aquifer frequency:** Once every 5 years at wells with historically high nitrate concentrations. Measurements taken semiannually at wells with occasional exceedances of nitrate. Measurements taken once every 5 years at wells within the Sr-90 plume and at locations that define the plume boundaries. **Uppermost water-bearing unit in the RUM frequency (nitrate only):** Measurements taken semiannually at wells with exceedances of nitrate and at those that define the plume boundaries. **Basis:** This sampling frequency supports the definition of plume boundaries and tracking of natural attenuation of contaminants.

Table A-3. 100-HR-3 Groundwater OU Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
Problem Statement 4: There is a need to understand the groundwater flow in both the unconfined and RUM aquifers under pumping and ambient flow conditions. **PSQ 4: What are the direction and magnitude of groundwater hydraulic gradients?** **PSQ 4a: In the unconfined aquifer under operational conditions?** **PSQ 4b: In the unconfined aquifer under ambient conditions?** **PSQ 4c: In the uppermost water-bearing unit of the RUM under operational conditions?** **PSQ 4d: In the uppermost water-bearing unit of the RUM under ambient conditions?**				
Wells: P&T system wells with operating transducers; monitoring wells equipped with AWLN systems; manual measurements of groundwater elevation. Applicable to unconfined aquifer and RUM aquifer during operating conditions.	Provide quantitative measurements to support determination of direction and magnitude of groundwater flow, hydraulic gradients, and verify plume hydraulic capture	1. P&T system wells with operating transducers. 2. Monitoring wells selected for placement of AWLN system units, based on the examination of historical water-level data and data gaps in the flow regime. 3. Wells specifically identified as completed within discrete aquifer units 4. Wells that provide spatial distribution of groundwater elevation (e.g., located inland from the river and outside the operable unit boundaries). 5. Wells to examine aquifer connectivity (e.g., pump tests).	1. Wells exhibiting nonrepresentative conditions based on the examination of data. 2. Wells completed in discrete, hydraulically separated aquifer units will not be combined for gradient analysis, but evaluated separately.	**Analyte:** Water levels. **Frequency:** Hourly – automated network (i.e., AWLN and remedial system wells). Semiannual synoptic measurements in select wells. Annual water-level measurements are also collected for a select set of wells under a different sampling program. **Basis:** The basis of these frequencies is to demonstrate hydraulic containment of the plume and be able to track plume movement.
Wells: P&T system wells with operating transducers; monitoring wells equipped with AWLN systems; manual measurements of groundwater elevation. Applicable to unconfined aquifer and RUM aquifer during ambient flow conditions.	Provide quantitative measurements to support determination of direction and magnitude of groundwater flow, hydraulic gradients, and verify plume hydraulic capture.	1. P&T system wells with operating transducers when the well is in "off" condition. 2. Monitoring wells selected for placement of AWLN system units, based on the examination of historical water-level data and data gaps in the flow regime. 3. Wells specifically identified as completed within discrete aquifer units 4. Wells that provide spatial distribution of groundwater elevation (e.g., located inland from the river and outside the operable unit boundaries). 5. Wells to examine aquifer connectivity (e.g., pump tests).	1. Wells exhibiting nonrepresentative conditions based on the examination of data. 2. Wells completed in discrete, hydraulically separated aquifer units will not be combined for gradient analysis, but evaluated separately.	**Analyte:** Water levels. **Unconfined aquifer frequency:** Water-level measurements from unconfined aquifer monitoring wells during a widespread P&T system shut off period. Additional measurements taken at unconfined aquifer P&T system wells and from AWLN wells during a widespread P&T system shut off period. **Uppermost water-bearing unit in the RUM frequency:** Water-level measurements from RUM aquifer monitoring wells during a widespread P&T system shut off during high river, low river, and a transitional river stage period. P&T wells in the unconfined aquifer are to be held at a steady-state during testing. Additional measurements taken at RUM aquifer P&T system wells and from AWLN wells during a widespread P&T system shut off during high river, low river, and a transitional river stage. P&T wells in the unconfined aquifer are to be held at a steady-state during testing. **Unconfined aquifer basis:** As the remedy reaches completion, the conditions of the unconfined aquifer under nonpumping conditions will be needed to determine if the RAO will continue to be met once the remedy is no longer operating. **Uppermost water-bearing unit in the RUM basis:** As the remedy reaches completion, the conditions of the unconfined aquifer under nonpumping conditions will be needed to determine if the RAO will continue to be met once the remedy is no longer operating. Different flow conditions need to be evaluated to determine if groundwater flow in the RUM is influenced by (or influencing) the unconfined aquifer flow regime, or the river. Data will be available to improve remedy performance in the RUM aquifer.

Table A-3. 100-HR-3 Groundwater OU Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
Problem Statement 5: There is a need to understand the impact of secondary sources. **PSQ 5: Are there areas that require additional sampling to evaluate the impacts of secondary sources?** **PSQ 5a: In the unconfined aquifer?** **PSQ 5b: In the uppermost water-bearing unit of the RUM?**				
Wells within or downgradient of a continuing source.	Provide information to evaluate the remediation timeframe impacts of secondary sources	1. Select wells within or downgradient of the 183-H Solar Evaporation Basin secondary source area. 2. Select wells within or downgradient of the 107-H Retention Basin secondary source area.	1. Remedial system injection wells.	**Unconfined aquifer analytes:** Cr(VI) filtered, nitrate unfiltered, uranium (total) filtered, and unfiltered at select wells. Uppermost water-bearing unit of the **RUM analytes:** Cr(VI) filtered, nitrate, Tc-99 at select wells. **Frequency:** Annually at high river stage for wells within the source area; annually at low river stage for wells downgradient of the source area. **Basis:** The sampling frequency will support the evaluation of remedial timeframes for COCs and the monitoring needs of other constituents with concentrations near the DWS.
Problem Statement 6: There is a need to understand the nature and extent of Cr(VI) contamination in the RUM aquifer. **PSQ 6: What are the nature and extent of Cr(VI) concentrations within the uppermost water-bearing unit of the RUM?**				
Wells: Installed as needed to delineate the Cr(VI) plume.	Provide information that represents groundwater conditions in the RUM and near shore areas	1. Wells completed in the RUM aquifer as needed to delineate the Cr(VI) plume. 2. Sample new wells quarterly to establish baseline conditions. Following the 8th sampling event, data will be reviewed to determine the appropriate sampling frequency.	1. Remedial system injection wells. 2. Wells exhibiting nonrepresentative conditions based on the examination of data.	**Analyte:** Cr(VI) filtered. **Frequency:** As installed, new wells are to be sampled quarterly for 2 years to establish baseline conditions. **Basis:** The sampling frequency will support the delineation of the Cr(VI) plume in the RUM aquifer.
Problem Statement 7: There is a need to understand the physical and hydraulic characteristics of the RUM aquifer. **PSQ 7: What are the physical and hydraulic characteristics of the uppermost water-bearing unit of the RUM?**				
Wells: Completed in the RUM aquifer; new wells as installed in RUM aquifer.	Provide information that represents physical and hydraulic characteristics of the RUM aquifer in areas with contamination, or near areas of contamination.	1. Wells completed in the RUM aquifer.	1. Remedial system injection wells. 2. Wells exhibiting nonrepresentative conditions based on the examination of data.	**Analyte:** Hydraulic properties, porosity, hydraulic connectivity across the unit, hydraulic conductivity, aquifer thickness. **Frequency:** As needed. **Basis:** The data will be collected based on professional judgement and as new wells become available to determine the spatial distribution and connectivity of the RUM aquifer across the 100-HR-3 OU. Testing of an individual well will not need to be repeated once aquifer parameters are established.

Notes: Selected wells may include monitoring wells and/or remedial system extraction wells (data collected during remedial system operations may be used). Initial conditions for well selection were based on inferred 2018/2019 contaminant distributions.

Total chromium (filtered and unfiltered) will be analyzed at approximately 20% of the locations where Cr(VI) is collected on an annual basis for quality control purposes. Wells will be randomly selected.

PSQ 4: Selection of monitoring locations for the unconfined aquifer AWLN will use locations selected using professional judgment, based on experience at the Hanford Site. Extraction and injection wells are identified based on P&T system configuration as of December 31, 2014. AWLN wells are identified based on a system status on a periodic basis to ensure adequate coverage to conduct the capture analysis for the calendar year, as described in ECF-Hanford-15-0001, *Description of Groundwater Modeling Calculations and Assessments for the Calendar Year 2014 (CY2014) 100 Areas Pump and Treat Report*. The selection of wells, which is also based on evaluation of river protection, uses the methodology described in SGW-54209, *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River Shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)*. Groundwater elevation data are also collected during sample collection.

PSQ 4: Additional wells are to be selected for specific geographic area tests.

PSQ 6: The year of well currently scheduled installation is noted for wells planned for FY 2020 and FY 2021.

PSQ 7: See DQO Meeting Notes for a description of the various testing to be conducted.

a. The specific conductance or conductivity in the Columbia River is typically lower (130 to 145 µS/cm) than groundwater (400 to 600 µS/cm).

b. The aquifer tube with the highest historic concentrations would be monitored to determine the greatest impact to the river.

AWLN = automated water level network
COC = contaminant of concern
DQO = data quality objective
DWS = drinking water standard
FY = fiscal year
OU = operable unit
P&T = pump and treat
PSQ = principle study question
RAO = remedial action objective
RAO = remedial action objective
RUM = Ringold Formation upper mud

Criteria for exclusion included locations that meet the following requirements:

- Redundant (i.e., are located within 50 m [164 ft] of another monitoring location) and do not provide supplemental or definitive input to a data need
- P&T injection wells (these wells are not available for monitoring due to their piping configurations)
- Do not provide representative measurements, e.g., wells with poor seals, undefined open intervals, or unconventional well constructions (note that no wells are currently known to meet this condition; however, if discovered, they are decommissioned and not included in the sampling program)
- Have not exhibited historical detections of contaminants of interest
- Do 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 is sampling locations that meet the identified data needs for each PSQ.

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 agreed to during the DQO meetings and are captured in Table A-1.

A6 Final Sample Design

The resulting sample design is a list of selected representative monitoring locations and the recommended frequency for data collection for each data type identified for those locations. Table B-1 in this SAP presents a summary of monitoring locations, frequencies, and constituents. The PSQ addressed at each location is also included.

Figures A-2 through A-9 show the monitoring locations for each PSQ, as follows:

- Figure A-2: PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?
- Figure A-3, 100-D Area: PSQ 2: Are the Cr(VI) mass, concentrations, and plume areas reducing as expected?
- Figure A-4, 100-H Area: PSQ 2: Are the Cr(VI) mass, concentrations, and plume areas reducing as expected?
- Figure A-5: PSQ 3: Are concentrations of nitrate and Sr-90 attenuating as expected?
- Figure A-6: PSQ 4: What are the direction and magnitude of groundwater hydraulic gradients?
- Figure A-7: PSQ 5: Are there areas that require additional sampling to evaluate the impacts of secondary sources?
- Figure A-8: PSQ 6: What are the nature and extent of Cr(VI) concentrations within the uppermost water-bearing unit of the RUM?
- Figure A-9: PSQ 7: What are the physical and hydraulic characteristics of the uppermost water-bearing unit of the RUM?

For PSQ 4, additional wells may be needed for ambient and pumping conditions, depending on the geographic location of the testing proposed.

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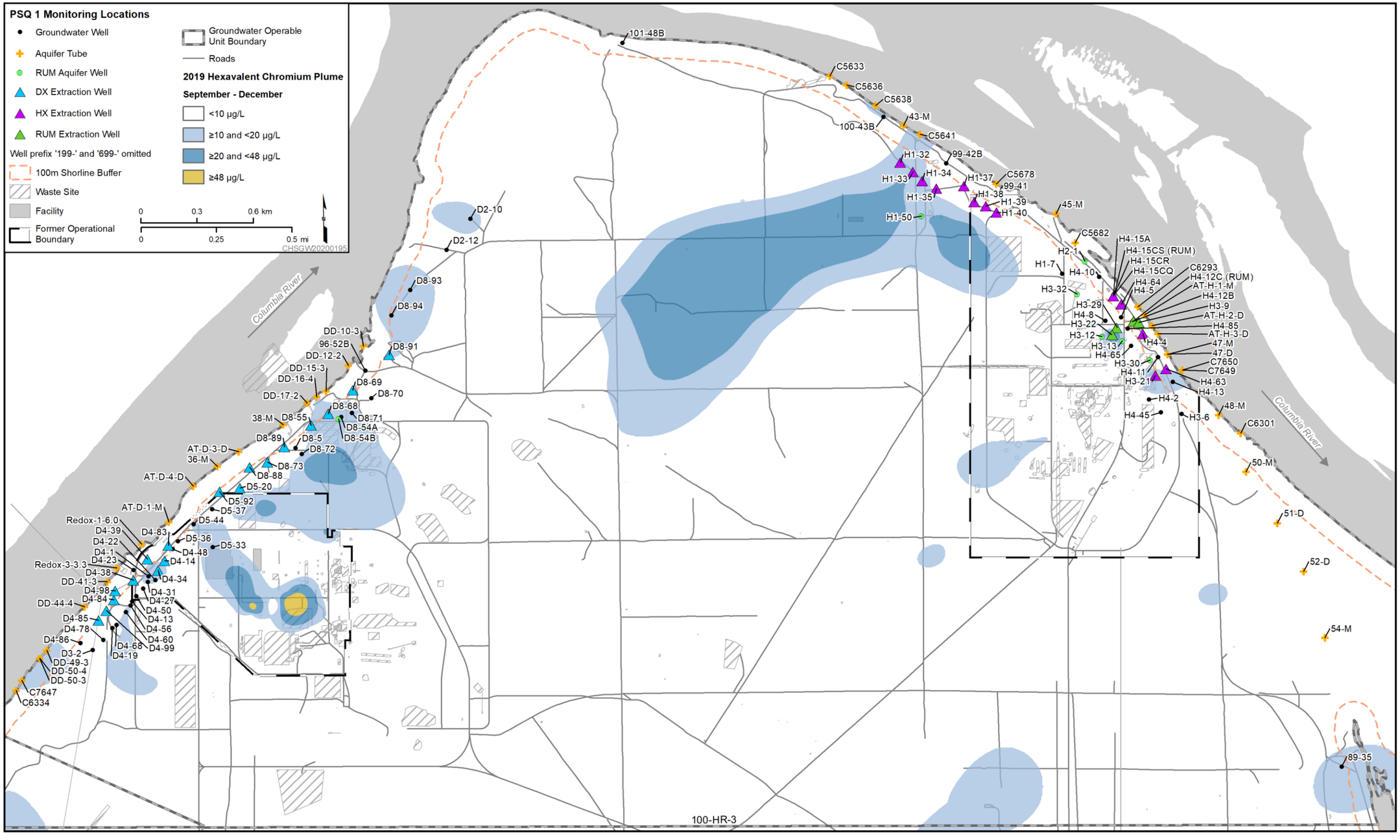

Figure A-2. Monitoring Locations for PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?

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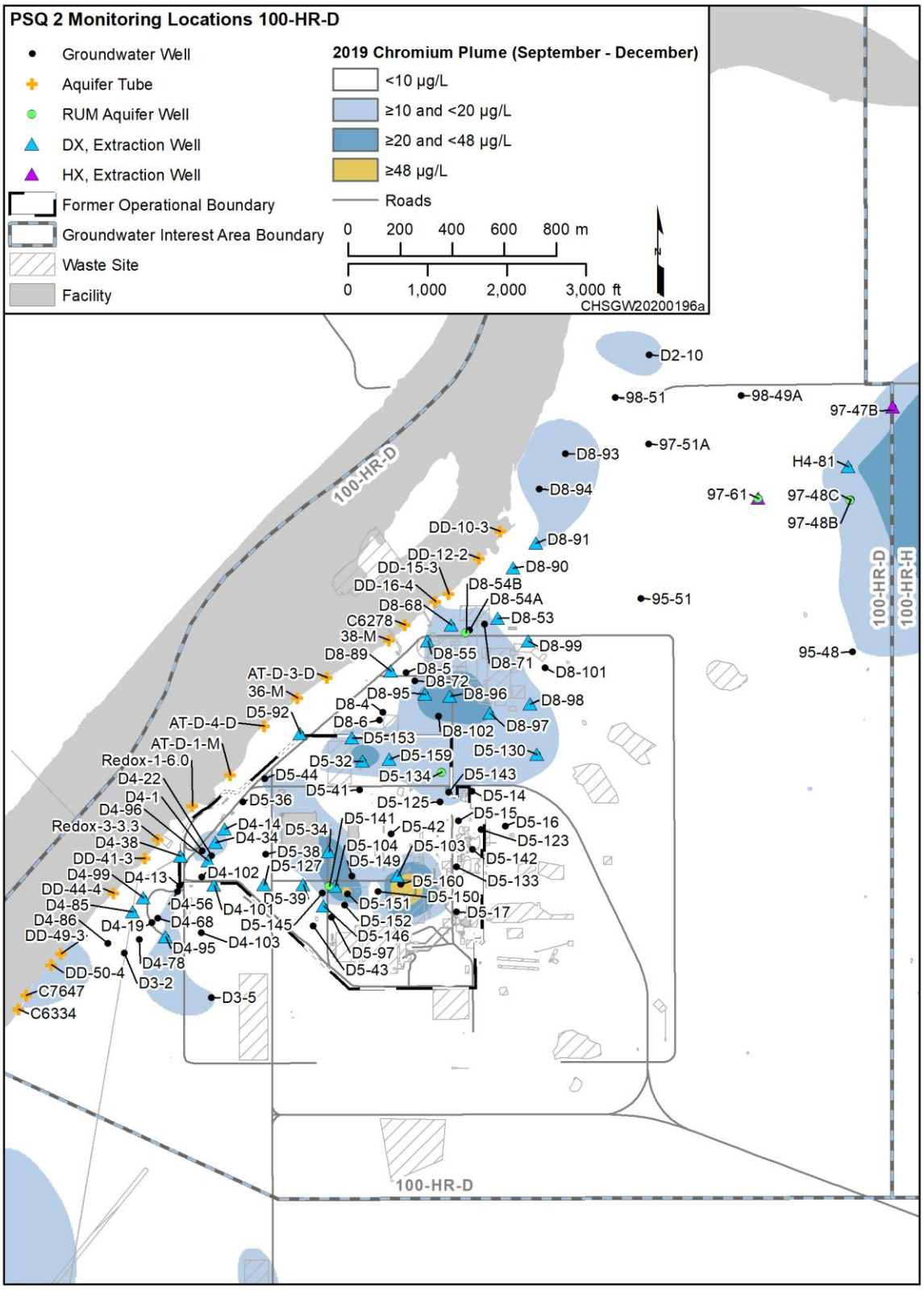

Figure A-3. 100-D Area; Monitoring Locations for PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?

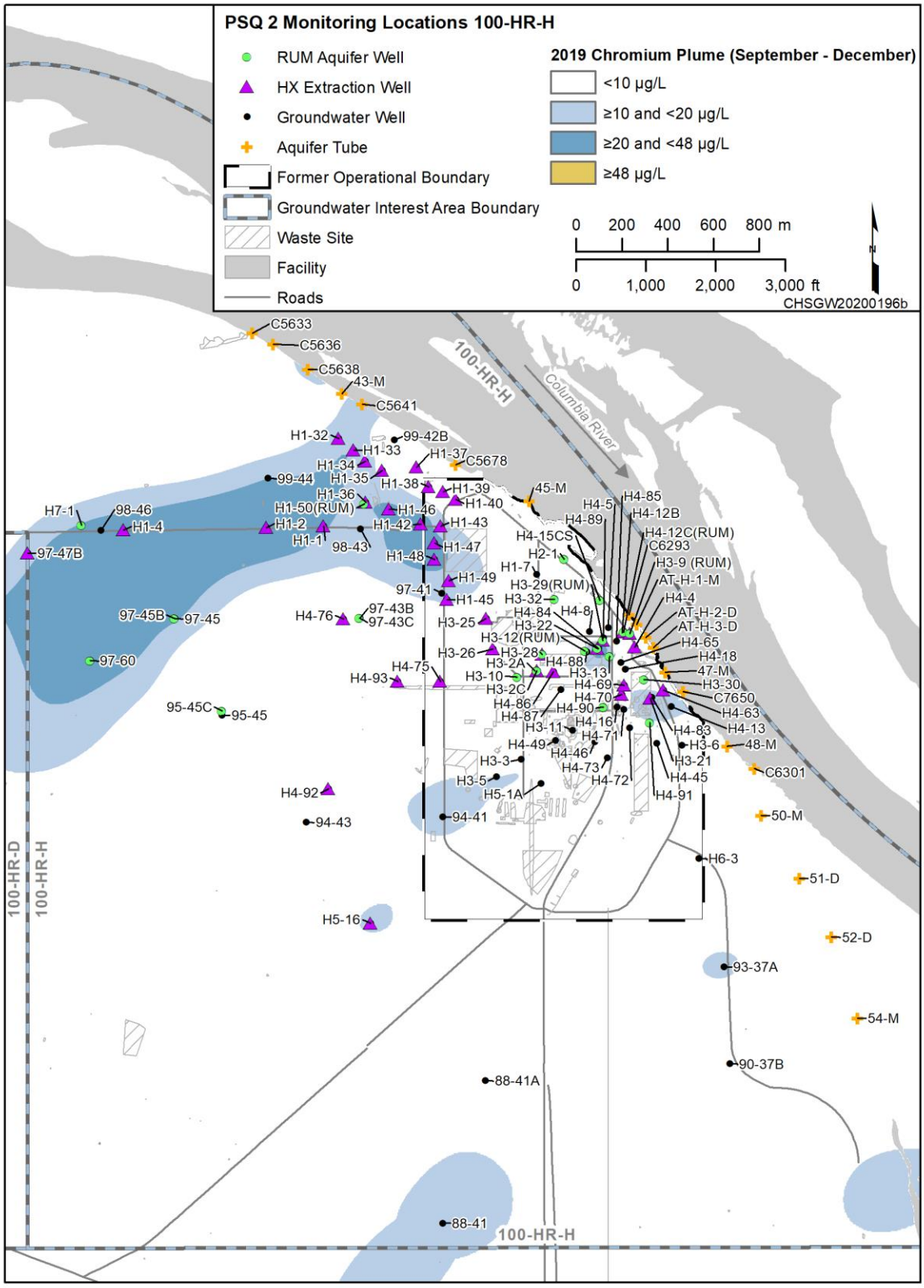

Figure A-4. 100-H Area; Monitoring Locations for PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?

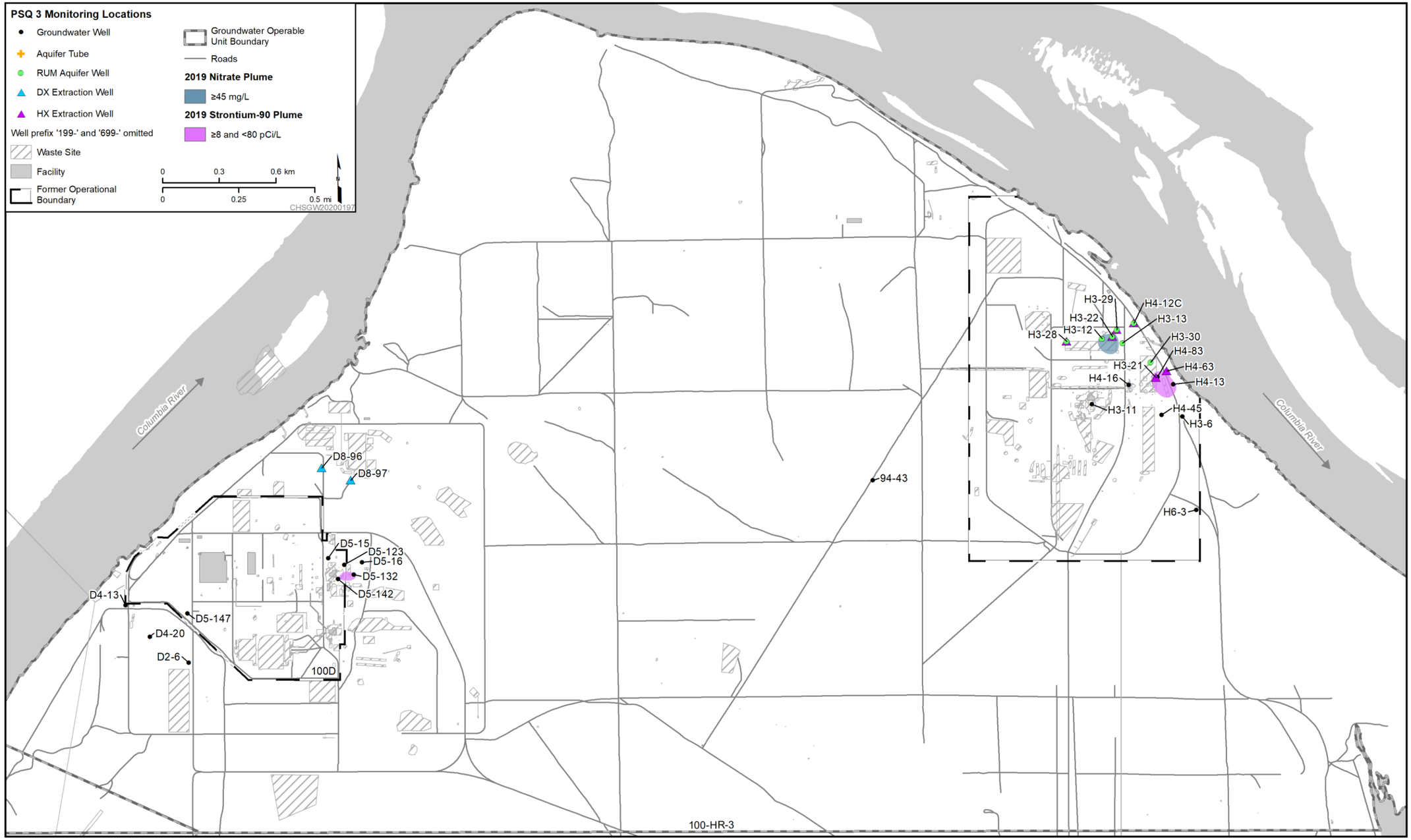

Figure A-5. Monitoring Locations for PSQ 3: Are Concentrations of Nitrate and Sr-90 Attenuating as Expected?

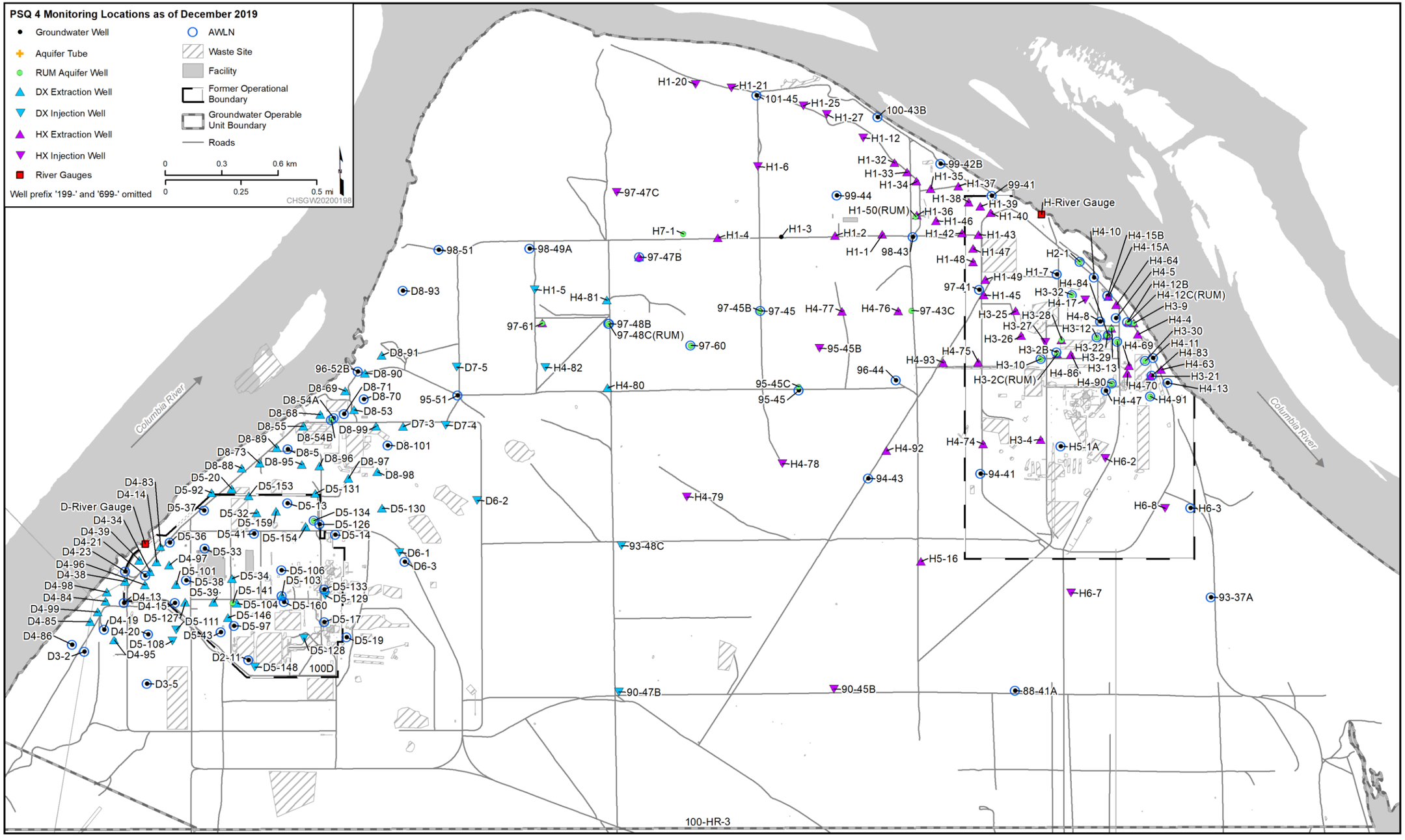

Figure A-6. Monitoring Locations for PSQ 4: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?

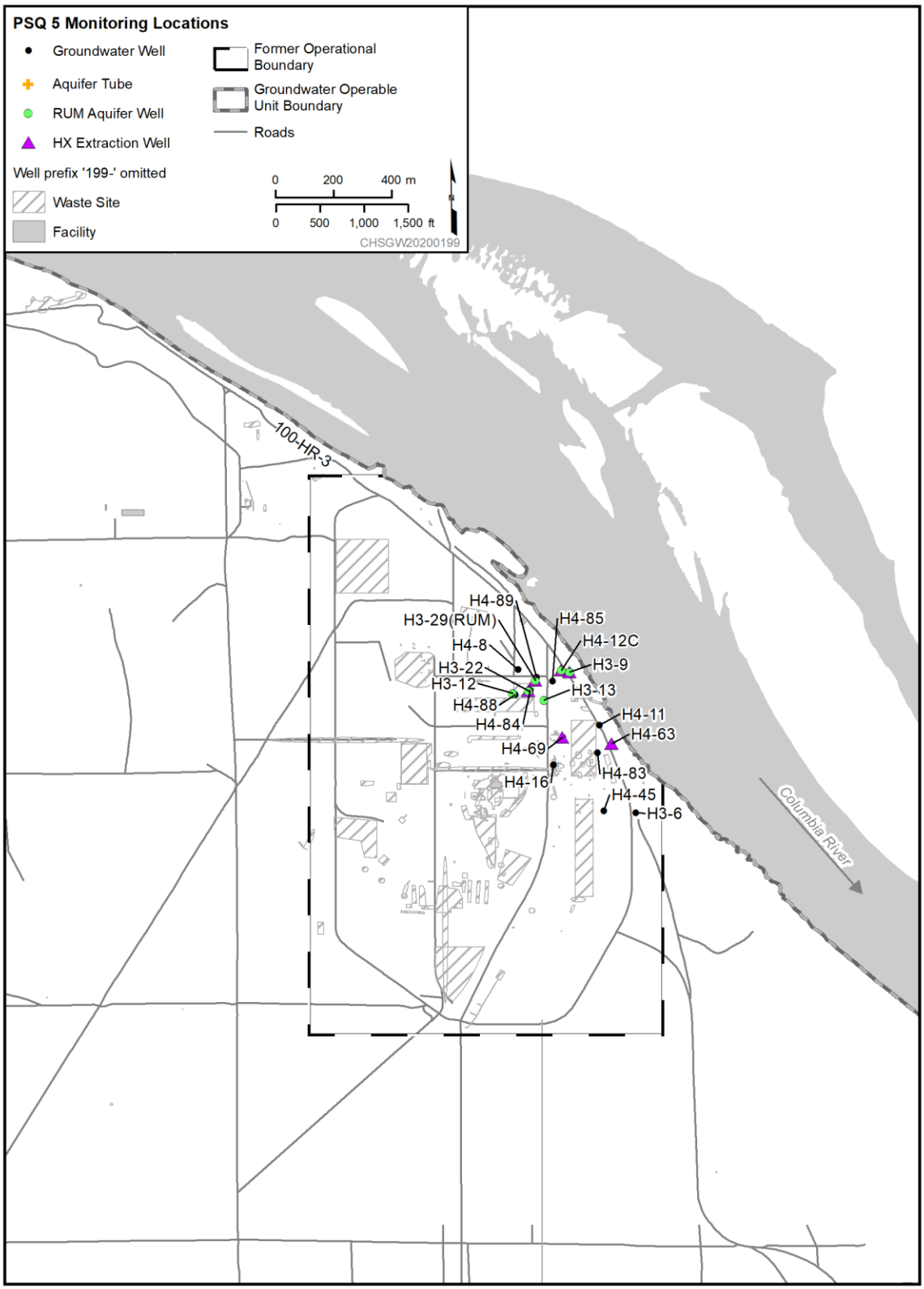

Figure A-7. Monitoring Locations for PSQ 5: Are There Areas that Require Additional Sampling to Evaluate the Impacts of Secondary Sources?

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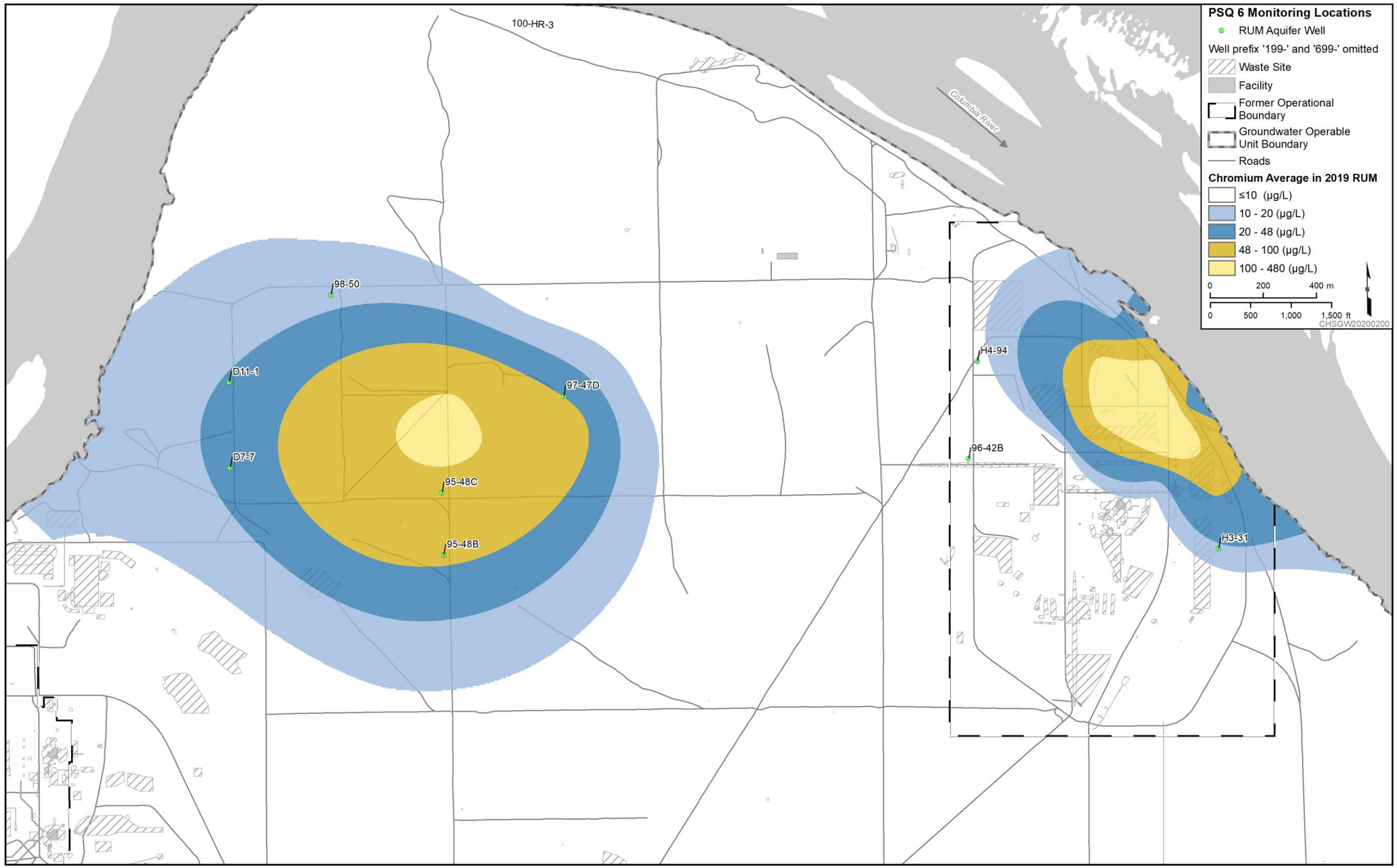

Figure A-8. Monitoring Locations for PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost Water-Bearing Unit of the RUM?

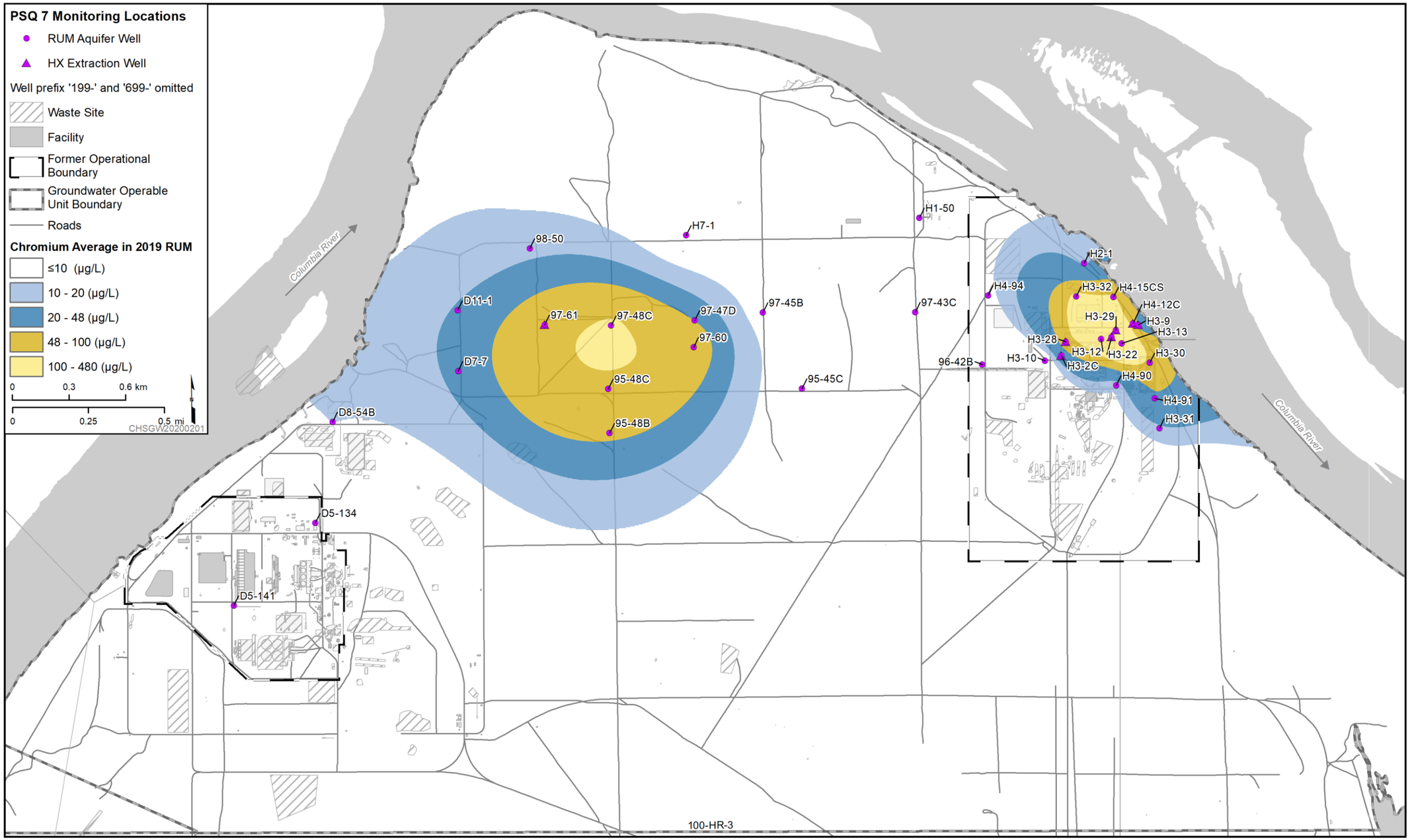

Figure A-9. Monitoring Locations for PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost Water-Bearing Unit of the RUM?

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DQO Meeting Summary

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100-HR-3 Groundwater OU DQO Meeting: Richland, WA
February 27, 2020
Meeting Summary

Background

On February 27, 2020, the individuals listed in **Appendix A** met to define the Data Quality Objectives (DQOs) for the 100-HR-3 post-ROD groundwater monitoring. The meeting agenda is attached as **Appendix B**. A follow-up meeting was held on April 13, 2020. The following summarizes discussion outcomes and defines the agreed path forward for the development of a Sampling and Analysis Plan (SAP) to replace the existing 2013 interim action SAP (DOE/RL-2013-30, Rev. 0) and addendums, and update the 2017 DQO for the Ringold Upper Mud (RUM) aquifer, which has been implemented through the Remedial Design/ Remedial Action Work Plan (RD/RAWP) (DOE/RL-2017-13, Appendix B).

The attendees discussed the existing PSQs to determine where data needs have changed or are no longer necessary. Additional PSQs were proposed and discussed. A summary of the DQO elements discussed is captured in the table attached as **Appendix C**. The DQO elements will be used to develop the updated groundwater monitoring SAP, as an addendum to the RD/RAWP (DOE/RL-2017-13).

PSQs 1-6 referenced in this meeting summary refer to the existing PSQ numbers from the 2013 groundwater monitoring SAP and 2017 DQO for the RUM, with the exception of adding subparts where separate PSQs were defined for the unconfined aquifer and uppermost RUM aquifer or additional data needs were identified for the PSQ. PSQs 7-11 were proposed and discussed during the meeting. The updated SAP resulting from this DQO will update the PSQs retained with consecutive numbering and include footnotes to identify the prior PSQ numbers where appropriate.

PSQ 1

New PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/l?

a) From the unconfined aquifer?
b) From the uppermost RUM aquifer?
c) Are aquifer tubes where Cr(VI) is typically detected above 10 µg/l representative of the aquifer?
d) Is the uppermost RUM aquifer hydrologically connected to the Columbia River?

Prior PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/l?

PSQ 1 was separated into subparts 1(a) and 1(b) to address the differing data needs for the unconfined and uppermost RUM aquifers.

Some near-river extraction wells cannot be sampled during low-river conditions when the wells do not have sufficient head for pumps to function. The attendees discussed the feasibility of removing pumps to collect manual samples during low water conditions. The decision to remove pumps is a Pump and Treat Operations decision. Operators are currently in the process of evaluating well sampling approaches during low-water conditions and will determine the appropriate sampling methods during low-water conditions, which may include pump removal, if necessary, to conduct sampling.

Aquifer tubes are currently only sampled during low-river stage. To obtain representative samples during sampling events at high-river stage for select locations, aquifer tubes would need to be extended above the river stage surface. Locations where this is needed include those where Cr(VI) is typically

1

detected above 10 µg/L. These data may be used to inform plume mapping, but not be used for evaluating compliance. Collecting aquifer tube samples during both the high and low river stages may provide data to allow project scientists to better understand the representativeness of aquifer tube samples for estimating unconfined aquifer discharges into the river. Aquifer tube representativeness of the aquifer will be evaluated through subpart 1(c).

The attendees discussed the need to understand the connection between the uppermost RUM aquifer and the river. Prior sampling and testing identified a potential connection, with a confirmed head response, but more data are needed to improve the understanding of RUM aquifer groundwater discharge (flux) to the river. Subpart 1(d) was added to the PSQ to address the data need.

The Columbia River Component (CRC) study collected samples that suggested upwelling within the river. The attendees suggested that the CRC study's information related to the RUM interface with the river should be reviewed. Additional wells at the shoreline may be necessary to further define the connection to the river at 100-HR-3. A tracer test focused on near-river uppermost RUM wells will be considered to provide data for the geo-framework and hydraulic connection with the river. Special studies to identify geochemical or microbial signatures between the unconfined and uppermost RUM aquifers and the river will also be considered (see Additional Studies below).

PSQ 2

New PSQ 2: Are the contaminant mass, concentrations and plume areas reducing as expected?

a) From the unconfined aquifer?
b) From the uppermost RUM aquifer?

Prior PSQ 2: Is the remedy effectively reducing the groundwater Cr(VI) plume?

The existing PSQ was amended to address the unconfined and uppermost RUM aquifers separately.

Samples for PSQ 2 will be collected annually at low river stage from wells in both aquifers within the plume boundaries or which define the plume boundaries. Locations where more frequent samples may be needed will be addressed in PSQ 5. Ecology agreed that annual sampling was appropriate, given that modeling informed by low-river stage data is likely to be more conservative than high-river stage data and is preferred by stakeholders. Wells which have Cr(VI) concentrations below 10 µg/L for two consecutive years and are not bounding wells for plume modeling will be sampled every other year. The need for ongoing sampling of these wells will be reviewed at the time of each 5-year review.

The RD/RAWP or drilling SAP (DOE/RL-2013-35 with addenda) may have a requirement to establish two years of ambient conditions. If it is not included elsewhere, quarterly monitoring for 2 years following drilling will be included in this SAP. During this period, sampling to evaluate the effectiveness of the remedy will not be necessary, but sampling to evaluate plume mass and extent will continue to be collected under other PSQs.

PSQ 3

New PSQ 3: Are concentrations of nitrate and strontium-90 attenuating as expected?

a) From the unconfined aquifer?
b) From the uppermost RUM aquifer?

Prior PSQ 3: Are other contaminant plumes that exceed risk based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?

Nitrate and Sr-90 concentrations have continued to attenuate. The 100-H Sr-90 plume shape varies from year to year due to the concentrations at bounding locations having concentrations very close to the clean-up levels. As concentrations continue to attenuate and decrease below the clean-up levels, the plume shape should become more consistent. The attendees agreed Sr-90 sampling should continue at 100-H area wells 199-H3-6, 199-H3-11, 199-H4-13, 199-H4-16, 199-H4-45, 199-H4-63, and 199-H4-83. The Sr-90 plume at 100-D is unchanged in shape. Wells with detections of Sr-90 at or near 8 pCi/L will be sampled. The attendees agreed to continue sampling for Sr-90 at 100-D area wells 199-D5-123, 199-D5-132, 199-D5-142, and 199-D5-15. These wells are included in the **Appendix D** Well Sampling Frequency tables.

For the unconfined aquifer, the primary sampling frequency for both nitrate and Sr-90 should be reduced to once every five years to inform the five-year review cycle. Sample collection will target year two or three of each 5-year review cycle. The attendees agreed that the Hanford Site Annual Groundwater Report which uses a 3-year data window for plume mapping purposes may use data collected outside the data window with appropriate notations, i.e. the once every 5-year data can be included. Kris Ivarson agreed to provide a list of wells for nitrate sampling based on areas with historic elevated concentrations. These wells are included in the **Appendix D** Well Sampling Frequency tables.

Sr-90 has not been detected above clean-up levels in the uppermost RUM aquifer. Accordingly, samples will not be collected for Sr-90 in the RUM aquifer.

Nitrate is not present above cleanup levels in the 100-D uppermost RUM aquifer and is only present above cleanup levels in the 100-H area uppermost RUM aquifer in the area of the Solar Evaporation Basins footprint. The attendees agreed that sampling for nitrate in the area of the 183-H Solar Evaporation Basins should continue at the current frequency (twice annually) in the RUM aquifer. (See Appendix D for proposed wells).

PSQ 4

New PSQ 4: What are the direction and magnitude of groundwater hydraulic gradients?

a) In the unconfined aquifer under operational conditions?
b) In the unconfined aquifer under ambient conditions?
c) In the uppermost RUM aquifer under operational conditions?
d) In the uppermost RUM aquifer under ambient conditions?

Prior PSQ 4: What are the direction and magnitude of groundwater hydraulic gradients in the unconfined and confined aquifers?

Well water-level data collected under PSQ 4 are necessary for the assessment of current pumping conditions, plume mapping, evaluating river protection, and Remedial Process Optimization. Data needed under PSQ 4 includes both operational conditions (i.e., under the influence of the pump and treat system) and ambient conditions (i.e., not under the influence of the pump and treat system). Data will continue to be collected under operating conditions. In addition, ambient conditions need to consider the possible influence of pumping in the other aquifer and adjustments in the pumping scheme will need to be considered prior to data collection. Going forward, a pump-and-treat system shut down over a large area that captures aquifer conditions during low-river, high-river, and transitional stages over a year may be needed to collect ambient water-level data. Additionally, rebound tests will be coordinated with the pump-and-treat shutdown to measure contaminants of concern (COC) responses

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to ambient conditions. COC monitoring during these rebound tests will be addressed through a separate SAP.

Once an anticipated groundwater model is developed and calibrated based on data collected, PSQ 4 may be re-evaluated to determine if the sampling frequency should be modified or the PSQ should be retired.

PSQs 5(a) and 5(b)

Prior 5(a): Are infrequently detected analytes confirmed not to be contaminants of potential concern (COPCs)?

Prior 5(b): Are analytes with detection limits above action levels confirmed not to be COPCs?

The attendees agreed to retire PSQ 5(a) and 5(b). Both have been addressed and no further data needs were identified.

PSQ 5(c):

New PSQ 5(c): Are there areas that require additional sampling to evaluate the impacts of secondary sources?

a) From the unconfined aquifer?

b) From the uppermost RUM aquifer?

Prior PSQ 5(c): Are potential source areas confirmed not to be continuing sources of COPCs in groundwater?

The PSQ addresses locations where data needs may require a more robust sampling strategy than surrounding areas due to the potential presence of secondary sources. A technical paper related to 100-D/H secondary source waste sites is currently under development and will be shared with Ecology (targeting April 2020). The following sites were discussed as they relate to PSQ 5(c). Wells proposed for sampling under PSQ 5(c) are included at Appendix D.

100-D-100/100-D-56:2

The vadose zone near the water table at this site is a likely secondary source of Cr(VI) to groundwater. No additional sampling is necessary. Current monitoring is sufficient to address data needs.

100-D North

A secondary source of Cr(VI) to groundwater is possible in this area. No additional sampling is necessary. Current monitoring is sufficient to address data needs. A rebound test will likely be needed to evaluate whether potential sources, if present, cause groundwater to exceed cleanup concentrations. Sampling during a rebound test will be covered under a separate SAP.

107-H Retention Basin

The vadose zone beneath this site is a likely secondary source of Sr-90 and Cr(VI). Data needs must address the seasonal variation as it applies to the continuing source determination. Semi-annual sampling will continue for two years, followed by a re-evaluation to determine whether the vadose zone beneath the 107-H Retention Basin is a continuing source. The two years of semi-annual sampling will include samples collected during high-river stage.

Following the meeting, existing data were reviewed by CHPRC staff and discussed at the follow-up meeting. Each 107-H Sr-90 sampling location has several years (or in some case decades) of existing

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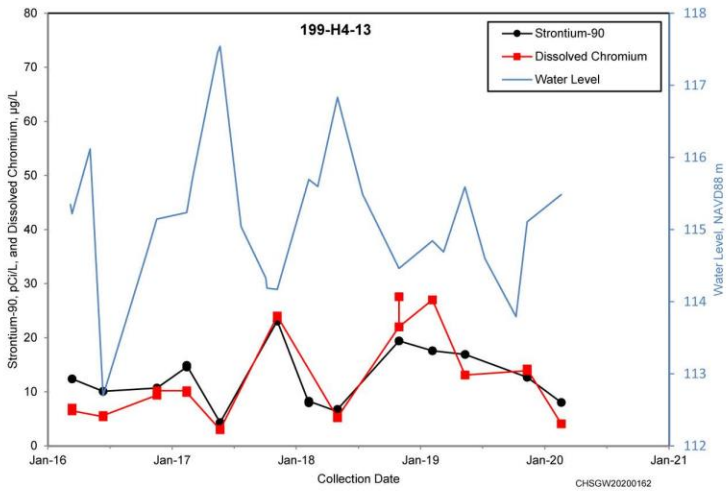
data. The newest well was installed in 2015. Given the length of time that sampling has taken place, and the amount of data available, no further sampling for Sr-90 under PSQ 5 is necessary at the 107-H Retention Basin. Data from well 199-H4-13 indicates that both Sr-90 and Cr(VI) respond to seasonal fluctuations, with concentrations increasing as water levels decline, consistent with a well location downgradient from a secondary source. Future sampling frequencies will be reduced and used to inform the impacts of the secondary source on remedial timeframes. There is currently no well located within the potential source area at the retention basin. Sampling will continue for Sr-90 as specified in PSQ 3. Samples for Cr(VI) will be collected annually at high-river stage in select wells adjacent to the source areas, since there is not currently a well in the footprint of the retention basin, and annually at low-river stage in select wells downgradient of the source area (H4-63 and H4-13).

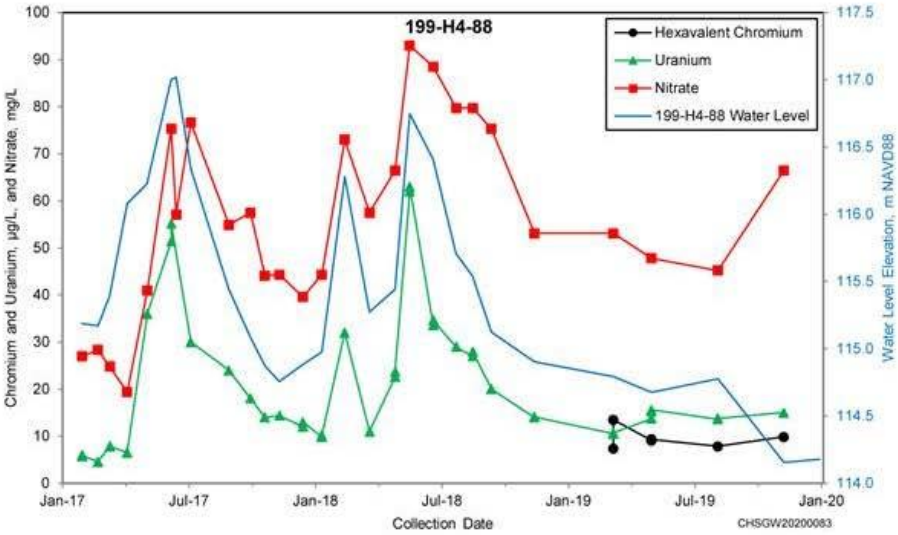


183-H Solar Evaporation Basins

The vadose zone beneath this site is a likely secondary source of Cr(VI), nitrate, and uranium to the unconfined aquifer. Uranium was not identified as a COC in the Record of Decision (ROD), however subsequent monitoring has indicated a periodic exceedance above the DWS at this location. Technetium-99 is also present in the uppermost RUM aquifer, but no potential continuing source has been identified. Technetium-99 was determined not to be a COC in the ROD, but currently rising concentrations will continue to be monitored to determine if further evaluation is warranted. Concentrations of Tc-99 are not currently above the DWS. The attendees agreed at the February meeting to continue semi-annual sampling for both the unconfined and uppermost RUM aquifers unless sufficient data existed to establish seasonal variations of COC concentrations and the correlation between constituents.

Following the meeting, previously collected data were reviewed by CHPRC to determine if the data needs were sufficiently addressed. The following figure contains the last three years of concentration data for COCs (Nitrate and Cr(VI)) at well 199-H4-88 and demonstrates the seasonal variations and

correlations between constituents and water levels based on existing data. The seasonal fluctuation contaminant response is also present in well 199-H4-84.



The existing data was discussed at the follow up meeting. The attendees agreed that the data collected to date is sufficient to establish seasonal constituent variations and correlations with river stage at the 183-H Solar Evaporation Basins. Future sampling frequencies will be reduced to annual sampling and used to inform the impacts on remedial timeframes.

PSQ 6(a)

New PSQ 6(a): What are the nature and extent of Cr(VI) concentrations within the uppermost RUM aquifer?

Prior PSQ 6(a): What are the nature and extent of Cr(VI) concentrations within the uppermost RUM aquifer?

This PSQ informs the compliance timeframe for attainment of the RAOs, and Remedial Process Optimization. Additional groundwater wells are planned for installation in FY2020 and FY2021. New wells will be sampled per the existing drilling SAP for two years following installation. Additional data needs will be assessed after the currently planned wells are installed and sample data has been evaluated.

Additional hydraulic characteristics may be evaluated through an ambient conditions evaluation under PSQ 4 or an additional SAP discussed below.

PSQ 6(b)

Prior 6(b): What are the direction and magnitude of groundwater gradients in the uppermost RUM aquifer?

The attendees agreed to retire 6(b), as the data needs will be addressed by the new PSQ 4(b).

PSQ 6(c)

New PSQ 6(c): What are the physical and hydraulic characteristics of the uppermost RUM aquifer?

Prior PSQ 6(c): What are the physical and hydraulic characteristics of the uppermost RUM aquifer?

Further aquifer testing is necessary to evaluate the hydraulic characteristics of the uppermost RUM aquifer. Additional wells may be needed to provide physical characteristics of the RUM aquifer for conducting hydraulic tests. Uppermost RUM aquifer well installations are currently planned for FY20 and FY21. Following evaluation of data collected from the FY20 and FY21 wells, additional well installation needs may be evaluated.

Proposed PSQ 7

Proposed PSQ 7: Are COCs at concentrations less than groundwater protection standards?

The attendees discussed the proposed PSQ 7, which was intended to provide a remedy completion focused PSQ related to groundwater in the inland plume. The objectives of PSQ 7 will be addressed through PSQs 9-11. PSQ 7 was not adopted.

Proposed PSQ 8

Proposed PSQ 8: Are Cr(VI) concentrations at near river wells < 10 µg/l (i.e. protective of river)?

The attendees discussed a proposed PSQ 8, which was intended to provide a remedy completion focused PSQ related to river protection. The resulting decision statements would guide the shift from performance monitoring to rebound testing and compliance monitoring. The objectives of PSQ 8 will be addressed through PSQs 9-11. PSQ 8 was not adopted.

Proposed PSQs 9-11

New PSQ 9: Do contaminant trends indicate COCs are approaching cleanup levels?

New PSQ 10: Does modeling indicate that COC concentrations will remain below cleanup levels?

New PSQ 11: Do COC concentrations within a spatially appropriate area indicate a Phase 2 shutdown evaluation study in preparation for a Phase 3 attainment evaluation is appropriate?

These PSQs were proposed during the meeting to provide indicators to guide the evaluation and selection of areas ready for rebound testing in preparation for attainment evaluations. As the remedy continues to reduce the plumes, areas demonstrating achievement of the RAOs may be evaluated for attainment. As these areas are determined to have met the RAOs, the pump and treat system may be optimized to focus on remaining plume areas. The data needs for PSQs 9-11 will be addressed through PSQs 1-6. At the follow up meeting, the attendees agreed that the objectives of PSQ 9-11 will be incorporated into the RD/RAWP, rather than added to the SAP.

The Phase 2 shutdown evaluation and Phase 3 attainment evaluations refer to pump-and-treat cleanup strategy phases described in the RA/RDRA (DOE/RL-2017-13, Draft A at pg. 3-11).

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Additional Studies

Some data needs discussed during the meeting were determined to be best addressed through separate investigations or studies, rather than inclusion in the SAP.

Well Corrosion

While well corrosion has not been an issue for the 100-D/H pump and treat systems, degrading wells could contribute additional contaminants to groundwater, resulting in un-representative sampling data, or reduced system effectiveness. Following discussion, the attendees agreed that the issue of well degradation was best addressed as an operational concern or through special studies and is not a regulatory data need.

Geochemistry Data

The Geochemistry data would assist in evaluating where the aquifers communicate with each other and with the river through the use of geochemical or microbial signatures. If necessary, geochemistry or microbial signatures may be assessed through special studies.

Operational Data

Previously, operational data needs associated with pump and treat effluent (e.g., re-injection criteria and associated aquifer impacts from re-injection) were driven by the SAP and Operations and Maintenance Plan. CHPRC has proposed updating the O&M plan to address the appropriate monitoring and reducing the monitoring frequency from quarterly to semi-annually.

Rebound Tests

Rebound tests may be used to evaluate ambient aquifer conditions, remedy effectiveness, and potential secondary sources. CHPRC proposed the development of a separate overarching rebound test SAP, which will outline the general processes and information necessary for conducting rebound tests during the active remedy timeframe. As specific rebound tests are identified, a more detailed addendum will be added to that overarching Rebound Test SAP for each area to be tested.

Next steps

Additional tasks necessary for the development of the SAP include:

- Kris Ivarson will provide a list of wells to be sampled for PSQ 3 (completed – see Appendix D),
- John Virgin will determine whether the RD/RAWP contains language sufficient to address the data needs discussed with proposed PSQ 8,
- The CRC upwelling evaluation will be reviewed to determine whether the information presented is relevant to the interconnection between the uppermost RUM aquifer and the Columbia river,
- River protection points of compliance will be further evaluated,
- DOE-RL and Ecology will review and comment on the included DQO language and well sampling proposals for PSQs 3 and 5 (completed),
- A secondary sources evaluation will be presented to Ecology (est. April 2020), and
- A decisional draft of the SAP will be provided for Ecology review (est. June 2020).

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Appendix A: List of Attendees

Representatives from the following organizations were in attendance:

First	Last	Representing	2/27/20	4/13/20
Craig	Arola	CHPRC	X	X
Steven	Balone	DOE/RL	X	
Alicia	Boyd	Ecology	X	X
Robert	Evans	CHPRC	X	X
Ellwood	Glossbrenner	DOE/RL	X	X
Dib	Goswami	Ecology		X
Travis	Hammond	CHPRC	X	X
Jason	Hulstrom	CHPRC	X	
Kristine	Ivarson	CHPRC	X	X
Brian	Johnson	Ecology	X	
Kevin	Kytola	Sapere	X	X
Stuart	Luttrell	Ecology	X	
Rob	Mackley	PNNL	X	X
Heather	Medley	CHPRC	X	X
Darrell	Newcomer	CHPRC	X	X
Chris	Parsons	Sapere	X	X
John	Sands	DOE/RL	X	X
John	Virgin	CHPRC	X	X
Jerel	Yokel	Ecology	X	X

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Appendix B: Meeting Agenda

(The agenda is included as a representation of topics discussed. The order and content were modified as agreed by attendees.)

AGENDA

DQO Workshop for 100-HR-3 Groundwater Monitoring

Date: **February 27, 2020**
Time: **8:00 am – 2:30 pm**
Location: **2420 Stevens** – Room 176

Objective: Update Principle Study Questions, data needs, and monitoring approaches for 100-HR-3 unconfined and confined aquifers to align with post-ROD activities.

8:00 am – 8:10 am	**Review agenda and objective**
8:10 am – 8:30 am	**Background** ▪ Prior sampling and analysis planning ▪ Remedial Action Objectives from ROD ▪ Post-ROD activities ▪ "Statement of the Problem"
8:30 am – 9:15 am	**PSQ Review and Update:** Review existing PSQs and discuss modifications, deletions, and additions.
9:15 am – 11:30 am	**PSQ-specific Discussion** For each PSQ we will discuss the current understanding of site conditions using the most recent data and decide if and how the current monitoring network and sampling approach should be modified going forward.
11:30 am – 12:30 pm	**BREAK**
12:30 pm – 2:00 pm	**PSQ-specific Discussion - continued**
2:00 pm – 2:30 pm	**Wrap Up** • Summary of Agreements • Plan for review of systematic planning record (DQO summary)

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Appendix C: Data Quality Objectives Summary[1]

Principle Study Question Sub-Parts		Data Needs Summary	Identify the decision statements or estimation statements needed to address the PSQs.	Define alternative outcomes or actions that can occur upon answering PSQs.
PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/l?				
PSQ 1(a)	From the unconfined aquifer?	– Measurements taken from unconfined aquifer monitoring wells within 100 m of the river during low river stage (typically September to December). – Measurements taken from unconfined aquifer P&T wells within 100 m of the river during low river stage.[2] – Measurements taken at aquifer tubes in areas with inadequate well coverage potentially impacted by Cr(VI) plumes, used for qualitative evaluation, during low river stage. – Measurements taken during high river stage[3] in aquifer tubes where Cr(VI) is typically detected above 10 µg/L.	Determine whether unconfined aquifer groundwater is discharging Cr(VI) to the river at concentrations greater than 10 µg/l.	If data from aquifer tubes or near river unconfined aquifer wells indicates Cr(VI) may be discharging to the river at concentrations greater than 10 µg/l, then evaluate pump-and-treat optimization and maintain monitoring at established frequency. If data from aquifer tubes and near river unconfined aquifer wells indicates Cr(VI) is not discharging to the river at concentrations greater than 10 µg/l, then re-evaluate pump-and-treat system configuration and monitoring configuration. Consider modeled impacts of migration from inland plumes and possibly plan and implement a rebound test and compliance monitoring.
PSQ 1(b)	From the uppermost RUM aquifer?	– Measurements taken from uppermost RUM aquifer monitoring wells within 100 m of the river during low river stage (typically September to December) and high river stage. Where monitoring well concentrations are non-detect for two consecutive years, the wells will be sampled every other year. – Measurements taken from uppermost RUM aquifer P&T wells within 100 m of the river during low river stage[2] and high river stage. – Additional wells or other monitoring points near the river in areas where there is a potential for discharge from the RUM to the Columbia River (i.e., shoreline of 100-H)	Determine whether uppermost RUM aquifer groundwater is discharging Cr(VI) to the river at concentrations greater than 10 µg/l.	If data from near river uppermost RUM aquifer wells indicates Cr(VI) may be discharging to the river at concentrations greater than 10 µg/l, then evaluate pump-and-treat optimization and maintain monitoring at established frequency. If data from near river uppermost RUM aquifer wells indicates Cr(VI) is not discharging to the river at concentrations greater than 10 µg/l, then re-evaluate pump-and-treat system configuration and monitoring configuration. Consider modeled impacts of migration from inland plumes and possibly plan and implement a rebound test and compliance monitoring.
PSQ 1(c)	Are aquifer tubes where Cr(VI) is typically detected above 10 µg/l representative of the aquifer?	– Measurements taken during high river stage[3] at aquifer tubes in areas where Cr(VI) is typically detected above 10 µg/L.	Determine whether aquifer tube data in areas where Cr(VI) is typically detected above 10 µg/l are representative of the aquifer.	If aquifer tube data for areas where Cr(VI) is typically detected above 10 µg/l are representative of the aquifer, then maintain aquifer tube monitoring. If aquifer tube data for areas where Cr(VI) is typically detected above 10 µg/l are not representative of the aquifer, then evaluate alternative sampling methods for PSQs 1(a).
PSQ 2: Are the contaminant mass, concentrations and plume areas reducing as expected?				
PSQ 2(a)	In the unconfined aquifer?	– Measurements taken annually during low river stage at unconfined aquifer monitoring wells within the plume or that define plume boundaries, and at pump-and-treat extraction wells. – Measurements will be taken every other year where concentrations have been non-detect for two consecutive years.	Determine whether the remedy is removing mass and reducing the Cr(VI) plume in the unconfined aquifer as expected.	If Cr(VI) unconfined aquifer concentrations and plume area are reducing at or faster than the rate necessary to meet remedial action expectations, then evaluate if monitoring should continue at established or decreasing frequencies for specific locations. If Cr(VI) unconfined aquifer concentrations and plume area are reducing slower than the rate necessary to meet remedial action expectations, then evaluate pump-and-treat optimization to improve rate of reduction or consider alternate response. Non-bounding wells where concentrations have been non-detect for two consecutive years will be reviewed at the time of each 5-year review to determine if ongoing sampling is necessary.
PSQ 2(b)	In the uppermost RUM aquifer?			If Cr(VI) uppermost RUM aquifer concentrations and plume area are reducing at or faster than the rate necessary to meet remedial action expectations, then evaluate if

[1] Decision statement and alternative outcome language was not discussed during the meeting. The included language is intended for review by the attendees to aid in the development of the SAP.
[2] Operations will determine the best practice for collecting well samples in low-water conditions, including removing well pumps to collect manual samples.
[3] The conditions which define high-river stage for the purpose of aquifer tube sampling will be developed in the SAP.

Principle Study Question Sub-Parts		Data Needs Summary	Identify the decision statements or estimation statements needed to address the PSQs.	Define alternative outcomes or actions that can occur upon answering PSQs.
		– Measurements taken annually during low river stage at uppermost RUM aquifer wells within the plume or that define plume boundaries, and at pump-and-treat extraction wells. – Measurements will be taken every other year where concentrations have been non-detect for two consecutive years.	Determine whether the remedy is removing mass and reducing the Cr(VI) plume in the uppermost RUM aquifer as expected.	monitoring should continue at established or decreasing frequencies for specific locations.
				If Cr(VI) uppermost RUM aquifer concentrations and plume area are reducing slower than the rate necessary to meet remedial action expectations, then evaluate pump-and-treat optimization to improve rate of reduction or consider alternate response.
				Non-bounding wells where concentrations have been non-detect for two consecutive years will be reviewed at the time of each 5-year review to determine if ongoing sampling is necessary.
PSQ 3: Are concentrations of nitrate and strontium-90 attenuating as expected?				
PSQ 3(a)	In the unconfined aquifer?	– Measurements of nitrate taken once every five years at wells with historically high nitrate concentrations. – Measurements of nitrate taken annually at wells with occasional exceedances of nitrate. – Measurements of strontium-90 taken once every five years at wells within the strontium-90 plume and at locations that define the strontium-90 plume boundaries.	Determine whether the nitrate and strontium-90 concentrations and plume areas in the unconfined aquifer are decreasing as expected	If nitrate plumes in the unconfined aquifer are attenuating at the expected rate or faster, then continue performance monitoring.
				If nitrate plumes in the unconfined aquifer are attenuating slower than the expected rate, then consider secondary source investigation or alternate response.
				If strontium-90 plumes in the unconfined aquifer are attenuating at the expected rate or faster, then continue performance monitoring.
				If strontium-90 plumes in the unconfined aquifer are attenuating slower than the expected rate, then consider secondary source investigation or alternate response.
PSQ 3(b)	In the uppermost RUM aquifer?	– Measurements of nitrate taken semi-annually at wells with exceedances of nitrate and at wells that define the nitrate plume boundaries. (Note: Sr-90 has not been detected in the uppermost RUM aquifer)	Determine whether nitrate concentrations and plume areas in the uppermost RUM aquifer are decreasing as expected.	If nitrate plumes in the uppermost RUM aquifer are attenuating at the expected rate or faster, then continue performance monitoring.
				If nitrate plumes in the uppermost RUM aquifer are attenuating slower than the expected rate, then consider secondary source investigation or alternate response.
PSQ 4: What are the direction and magnitude of groundwater hydraulic gradients?				
PSQ 4(a)	In the unconfined aquifer under operational conditions?	– Manual water level measurements from unconfined aquifer monitoring wells taken annually as part of the groundwater monitoring program (SGW-38815, Rev.2). – Additional measurements taken more frequently at unconfined aquifer P&T system wells and from AWLN station wells. – Manual water level measurements collected during sampling events.	Determine the direction and magnitude of unconfined aquifer groundwater flow under operational conditions.	If groundwater hydraulic gradient information is sufficient, then retain the water-level monitoring network, including manual measurements, P&T, and AWLN system measurements.
				If groundwater hydraulic gradient information collected is sufficient to inform the fate and transport modeling, continue current water level monitoring, including manual measurements, P&T, and AWLN system measurements.
				If groundwater hydraulic gradient information collected is not sufficient to inform the fate and transport modeling, then evaluate changes to the automated water level network and determine if more frequent manual measurements are needed.
				If the pump-and-treat system configuration changes, then evaluate changes to the automated water level network.
PSQ 4(b)	In the unconfined aquifer under ambient conditions?	– Manual water level measurements from unconfined aquifer monitoring wells during a large-area P&T system shut off period. – Additional measurements taken more frequently at unconfined aquifer P&T system wells and from AWLN station wells during a wide-spread P&T system shut off period.	Determine the direction and magnitude of unconfined aquifer groundwater flow under ambient conditions.	If groundwater hydraulic gradient information is sufficient, then retain the water-level monitoring network, including manual measurements, P&T, and AWLN system measurements.
				If groundwater hydraulic gradient information collected is sufficient to inform the fate and transport modeling, continue current water level monitoring, including manual measurements, P&T, and AWLN system measurements.
				If the pump-and-treat system configuration changes, then evaluate changes to the automated water level network.
PSQ 4(c)	In the uppermost RUM aquifer under operational conditions?	– Manual water level measurements from uppermost RUM aquifer monitoring wells taken annually as part of the groundwater monitoring program (SGW-38815, Rev.2). – Additional measurements taken more frequently at RUM aquifer P&T system wells and from AWLN station wells.	Determine the direction and magnitude of uppermost RUM aquifer groundwater flow under operational conditions.	If groundwater hydraulic gradient information is sufficient, then retain the water-level monitoring network, including manual measurements, P&T, and AWLN system measurements.
				If groundwater hydraulic gradient information collected is sufficient to inform the fate and transport modeling, continue current water level monitoring, including manual measurements, P&T, and AWLN system measurements.
				If the pump-and-treat system configuration changes, then evaluate

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Principle Study Question Sub-Parts		Data Needs Summary	Identify the decision statements or estimation statements needed to address the PSQs.	Define alternative outcomes or actions that can occur upon answering PSQs.
		– Manual water level measurements are collected during sampling events.		changes to the automated water level network and determine if more frequent manual measurements are needed.
PSQ 4(d)	In the uppermost RUM aquifer under ambient conditions?	– Manual water level measurements from RUM aquifer monitoring wells during a wide-spread P&T system shut off during high river, low river and a transitional river stage period. P&T wells in the unconfined aquifer are to be held at a steady state during the water-level measurement period (including shut down, and recovery time frames). The steady state conditions needed will be determined on a case by case basis and may include turning off the unconfined aquifer P&T system or limiting flow at the unconfined aquifer P&T system wells. – Additional measurements taken at RUM aquifer P&T system wells and from AWLN wells during a wide-spread P&T system shut off during high river, low river, and a transitional river stage. P&T wells in the unconfined aquifer are to be held at a steady state during the water-level measurement period (including shut down, and recovery time frames). The steady state conditions needed will be determined on a case by case basis and may include turning off the unconfined aquifer P&T system or limiting flow at the unconfined aquifer P&T system wells.	Determine the direction and magnitude of uppermost RUM groundwater flow under ambient conditions.	If groundwater hydraulic gradient information is sufficient, then retain the water-level monitoring network, including manual measurements, P&T, and AWLN system measurements. If groundwater hydraulic gradient information collected is sufficient to inform the fate and transport modeling, continue current water level monitoring, including manual measurements, P&T, and AWLN system measurements. If the pump-and-treat system configuration changes, then evaluate changes to the automated water level network and determine if more frequent manual measurements are needed. If groundwater flow in the uppermost RUM aquifer is influenced by (or influencing) the unconfined aquifer flow regime, then update conceptual site model and re-evaluate remedy operations to achieve RAOs.
PSQ 5(c): Are there areas that require additional sampling to evaluate the impacts of secondary sources?				
PSQ 5(c)(i)	In the unconfined aquifer?	– Monitor select wells near the 183-H Solar Evaporation Basins for uranium, nitrate, and Cr(VI). Measurements will be taken annually during high river stage at unconfined aquifer monitoring wells within the source area. Measurements will be taken annually during low river stage at unconfined aquifer monitoring wells downgradient from the source area. – Monitor select wells near the 107-H Retention Basin for Cr(VI). Measurements will be taken annually during high river stage at unconfined aquifer monitoring wells within the source area. Measurements will be taken annually during low river stage at unconfined aquifer monitoring wells downgradient from the source area.	Estimate the impacts of secondary sources on remedial timeframes.	If data collected demonstrate that secondary sources do not extend the remedial timeline, then continue monitoring. If data collected demonstrates that a secondary source may extend the remedial timeframe, then evaluate the need for additional targeted investigation or remedial actions.
PSQ 5(c)(ii)	In the uppermost RUM aquifer?	– Monitor select wells near the 183-H Solar Evaporation Basins for nitrate, Cr(VI), and Tc-99. Measurements will be taken annually during high river stage at unconfined aquifer monitoring wells within the source area. Measurements will be taken annually during low river stage at unconfined aquifer monitoring wells downgradient from the source area.	Estimate the impacts of secondary sources on remedial timeframes.	If data collected demonstrate that secondary sources do not extend the remedial timeline, then continue monitoring. If data collected demonstrates a secondary source may extend the remedial timeframe, then evaluate the need for additional targeted investigation or remedial actions.
PSQ 6(a): What are the nature and extent of Cr(VI) concentrations within the uppermost RUM aquifer? (No change from previous DQO)				
PSQ 6(a)	N/A			If Cr(VI) is present in the uppermost RUM aquifer at concentrations exceeding cleanup levels, then continue evaluation under PSQ 2(b).

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Principle Study Question Sub-Parts		Data Needs Summary	Identify the decision statements or estimation statements needed to address the PSQs.	Define alternative outcomes or actions that can occur upon answering PSQs.
		– Install groundwater monitoring wells as needed to delineate the Cr(VI) plume. – Sample new wells quarterly to establish baseline conditions. Following the 8th sampling event, data will be reviewed to determine the appropriate sampling frequency.	Determine whether groundwater Cr(VI) concentrations indicate additional evaluation or remediation is needed.	If Cr(VI) is not present in the uppermost RUM aquifer at concentrations greater than cleanup levels, then evaluate need for monitoring under other PSQs.
PSQ 6(c): What are the physical and hydraulic characteristics of the uppermost RUM aquifer? (No change from previous DQO)				
PSQ 6(c)	N/A	– Conduct aquifer testing on new and existing wells and obtain physical property information on the aquifer from new wells to determine: o Spatial distribution of hydraulic properties, o Uppermost RUM aquifer thickness, o Porosity and hydraulic conductivity of the uppermost RUM aquifer and overlying material, o Storativity of uppermost RUM aquifer, and o Groundwater linear velocity – Additional hydrogeologic observations in near river areas where there is a potential for discharge from the RUM.[4] – Information from PSQs 4(c) and 4(d) will inform assessment of communication with river. Additional wells and monitoring may be needed to define connection with river at H.	Determine the geo-framework and fate and transport of contaminants in the RUM aquifer.	If the physical and hydraulic characteristics data collected is not sufficient to inform the geo-framework or fate and transport modeling, then conduct additional aquifer testing and obtain hydraulic property information from new and/or existing wells.
				If the physical and hydraulic characteristics data collected is sufficient to inform the geo-framework or fate and transport modeling, use the existing data.
			Determine if there are geologic connections between the RUM aquifer and the Columbia River.	If a geologic connection exists between the uppermost RUM aquifer and Columbia River exist, then continue monitoring for PSQ 1(b).
				If no geologic connection exists between the uppermost RUM aquifer and Columbia River, then evaluate uppermost RUM aquifer points of compliance and remedy operations to achieve RAOs.
PSQ 9: Do contaminant trends indicate COCs are approaching cleanup levels at and near points of compliance?				
PSQ 9	N/A	– Information collected pursuant to PSQs 1, 2, 3, 5, and 6(a).	Determine whether COC concentrations and trends are approaching cleanup levels at and near points of compliance.	If COC concentrations and trends are approaching cleanup levels, evaluate modeling under PSQ 10.
				If COC concentrations and trends are not yet approaching cleanup levels, continue remedy and performance monitoring.
PSQ 10: Does modeling indicate that COC concentrations will remain below cleanup levels at or near points of compliance?				
PSQ 10	N/A	– Fate and transport modeling.	Determine whether modeling indicates concentrations will remain below cleanup levels at or near points of compliance.	If modeling indicates that COC concentrations will remain below cleanup levels, evaluate appropriate spatial areas under PSQ 11.
				If modeling does not indicate COC concentrations will remain below cleanup levels, continue remedy and performance monitoring.
PSQ 11: Do COC concentrations within a spatially appropriate area indicate a Phase 2 shutdown evaluation study in preparation for a Phase 3 attainment evaluation is appropriate?				
PSQ 11	N/A	– Evaluations pursuant to PSQs 9 and 10.	Determine whether COC concentrations for a spatially appropriate area are demonstrating readiness rebound testing.	If an appropriate spatial area can be defined which satisfies PSQs 9 and 10, then plan and conduct a shutdown evaluation.
				If a spatially appropriate area cannot be defined, continue remedy and evaluate if monitoring should continue at established or decreasing frequencies for specific locations.

[4] Additional hydrogeologic observations were proposed by CHPRC as an additional data need for PSQ 6(c) following the meeting.

Appendix D: Well Sampling Frequencies

PSQ 3(a) – Unconfined aquifer

Well	Sr-90 Sampling Frequency	Nitrates Sampling Frequency	Notes
199-D2-6		Once each 5 years	
199-D4-13		Once each 5 years	
199-D4-20		Once each 5 years	
199-D5-123	Once each 5 years		
199-D5-132	Once each 5 years		
199-D5-142	Once each 5 years		
199-D5-147		Once each 5 years	
199-D5-15	Once each 5 years	Once each 5 years	
199-D5-15		Once each 5 years	
199-D5-16		Once each 5 years	
199-D8-96		Once each 5 years	
199-D8-97		Once each 5 years	
199-H3-11	Once each 5 years		
199-H3-6	Once each 5 years		
199-H4-13	Once each 5 years		
199-H4-16	Once each 5 years		
199-H4-45	Once each 5 years		
199-H4-63	Once each 5 years		
199-H4-83	Once each 5 years		
199-H6-3		Once each 5 years	No nitrate concentrations above 45 mg/l in 100-H since before 2009
699-94-43		Once each 5 years	No nitrate concentrations above 45 mg/l in 100-H since before 2009

PSQ 3(b) – Uppermost RUM aquifer

Well	Sr-90 Sampling Frequency	Nitrates Sampling Frequency	Notes
199-H3-13		Semi-Annually	
199-H3-22		Semi-Annually	
199-H3-29		Semi-Annually	
199-H3-12		Semi-Annually	
199-H3-28		Semi-Annually	
199-H4-12C		Semi-Annually	
199-H3-30		Semi-Annually	

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PSQ 5(c)(i) – Unconfined aquifer

Well	Sr-90 Sampling Frequency	Nitrates Sampling Frequency	Uranium and Cr(VI) Sampling Frequency	Notes
199-H3-6			Annually	
199-H4-8		Annually	Annually	
199-H4-11			Annually	
199-H4-16			Annually	
199-H4-45			Annually	
199-H4-63			Annually	
199-H4-69			Annually	
199-H4-83			Annually	
199-H4-84		Annually	Annually	
199-H4-85		Annually	Annually	
199-H4-88		Annually	Annually	
199-H4-89		Annually	Annually	

PSQ 5(c)(ii) – Uppermost RUM aquifer

Well	Sr-90 Sampling Frequency	Nitrates Sampling Frequency	Tc-99 and Cr(VI) Sampling Frequency	Notes
199-H3-9		Annually	Cr(VI) – Annually	
199-H3-12		Annually	Cr(VI) – Annually	
199-H3-13		Annually	Cr(VI) & Tc-99 – Annually	
199-H3-22		Annually	Cr(VI) & Tc-99 – Annually	
199-H3-29		Annually	Cr(VI) & Tc-99 – Annually	
199-H4-12C		Annually	Cr(VI) – Annually	

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Appendix B

Sample Summary Table

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Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
Unconfined Aquifer Wells																	
199-D2-10				A							1a	2a					
199-D2-11									YES					4a, 4b			
199-D2-12				A							1a						
199-D2-6					5								3a				
199-D3-2				A					YES		1a	2a		4a, 4b			
199-D3-3	To be decommissioned																
199-D3-4	To be decommissioned																
199-D3-5				A					YES			2a		4a, 4b			
199-D4-1				A							1a	2a					
199-D4-10	To be decommissioned																
199-D4-101[c]				A								2a					
199-D4-102				A								2a					
199-D4-103				A								2a					
199-D4-11	To be decommissioned																
199-D4-12	To be decommissioned																
199-D4-13				A	5				YES		1a	2a	3a	4a, 4b			
199-D4-14		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D4-15									YES					4a, 4b			
199-D4-16	To be decommissioned																
199-D4-17	To be decommissioned																
199-D4-18	To be decommissioned																
199-D4-19				A					YES		1a	2a		4a, 4b			

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-D4-2	To be decommissioned																
199-D4-20					5				YES				3a	4a, 4b			
199-D4-21									YES					4a, 4b			
199-D4-22				A							1a	2a					
199-D4-23				A					YES		1a			4a, 4b			
199-D4-24	To be decommissioned																
199-D4-25	To be decommissioned																
199-D4-26	To be decommissioned																
199-D4-27				A							1a						
199-D4-28	To be decommissioned																
199-D4-29	To be decommissioned																
199-D4-3	To be decommissioned																
199-D4-30	To be decommissioned																
199-D4-31				A							1a						
199-D4-32	To be decommissioned																
199-D4-33	To be decommissioned																
199-D4-34		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D4-35	To be decommissioned																
199-D4-36	To be decommissioned																
199-D4-37	To be decommissioned																
199-D4-38		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D4-39		DX-EXT		A						YES	1a			4a, 4b			
199-D4-4	To be decommissioned																

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-D4-40	To be decommissioned																
199-D4-41	To be decommissioned																
199-D4-42	To be decommissioned																
199-D4-43	To be decommissioned																
199-D4-44	To be decommissioned																
199-D4-45	To be decommissioned																
199-D4-46	To be decommissioned																
199-D4-47	To be decommissioned																
199-D4-48				A							1a						
199-D4-49	To be decommissioned																
199-D4-5	To be decommissioned																
199-D4-50				A							1a						
199-D4-51	To be decommissioned																
199-D4-52	To be decommissioned																
199-D4-53	To be decommissioned																
199-D4-54	To be decommissioned																
199-D4-55	To be decommissioned																
199-D4-56				A							1a	2a					
199-D4-57	To be decommissioned																
199-D4-58	To be decommissioned																
199-D4-59	To be decommissioned																
199-D4-6	To be decommissioned																
199-D4-60				A							1a						

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Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-D4-61	To be decommissioned																
199-D4-62	To be decommissioned																
199-D4-63	To be decommissioned																
199-D4-64	To be decommissioned																
199-D4-65	To be decommissioned																
199-D4-66	To be decommissioned																
199-D4-67	To be decommissioned																
199-D4-68				A							1a	2a					
199-D4-69	To be decommissioned																
199-D4-7	To be decommissioned																
199-D4-70	To be decommissioned																
199-D4-71	To be decommissioned																
199-D4-72	To be decommissioned																
199-D4-73	To be decommissioned																
199-D4-74	To be decommissioned																
199-D4-75	To be decommissioned																
199-D4-76	To be decommissioned																
199-D4-77	To be decommissioned																
199-D4-78				A							1a	2a					
199-D4-79	To be decommissioned																
199-D4-8	To be decommissioned																
199-D4-80	To be decommissioned																
199-D4-81	To be decommissioned																

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Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-D4-82	To be decommissioned																
199-D4-83		DX-EXT		A						YES	1a			4a, 4b			
199-D4-84		DX-EXT		A						YES	1a			4a, 4b			
199-D4-85		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D4-86				A					YES		1a	2a		4a, 4b			
199-D4-87	To be decommissioned																
199-D4-88	To be decommissioned																
199-D4-89	To be decommissioned																
199-D4-9	To be decommissioned																
199-D4-90	To be decommissioned																
199-D4-91	To be decommissioned																
199-D4-92	To be decommissioned																
199-D4-93	To be decommissioned																
199-D4-94	To be decommissioned																
199-D4-95		DX-EXT		A						YES		2a		4a, 4b			
199-D4-96		DX-EXT		A						YES		2a		4a, 4b			
199-D4-97		DX-EXT								YES				4a, 4b			
199-D4-98		DX-EXT		A						YES	1a			4a, 4b			
199-D4-99		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D5-101		DX-EXT								YES				4a, 4b			
199-D5-103		DX-EXT		A						YES		2a		4a, 4b			
199-D5-104		DX-EXT		A						YES		2a		4a, 4b			
199-D5-106									YES					4a, 4b			

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Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-D5-107																	
199-D5-108		DX-INJ								YES				4a, 4b			
199-D5-109																	
199-D5-110																	
199-D5-111		DX-INJ								YES				4a, 4b			
199-D5-112																	
199-D5-113																	
199-D5-114																	
199-D5-115																	
199-D5-116																	
199-D5-117																	
199-D5-118																	
199-D5-123				A		5						2a	3a				
199-D5-125				A								2a					
199-D5-126									YES					4a, 4b			
199-D5-127		DX-EXT		A						YES		2a		4a, 4b			
199-D5-128		DX-INJ								YES				4a, 4b			
199-D5-129		DX-INJ								YES				4a, 4b			
199-D5-13									YES					4a, 4b			
199-D5-130		DX-EXT		A						YES		2a		4a, 4b			
199-D5-131		DX-EXT								YES				4a, 4b			
199-D5-132						5							3a				
199-D5-133				A					YES			2a		4a, 4b			

Table B-1. Sample Summary Table

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199-D5-14				A					YES			2a		4a, 4b			
199-D5-142				A		5						2a	3a				
199-D5-143				A								2a					
199-D5-145				A								2a					
199-D5-146		DX-EXT		A						YES		2a		4a, 4b			
199-D5-147					5								3a				
199-D5-148		DX-INJ								YES				4a, 4b			
199-D5-149				A								2a					
199-D5-15				A	5	5						2a	3a				
199-D5-150				A								2a					
199-D5-151				A								2a					
199-D5-152				A								2a					
199-D5-153		DX-EXT		A						YES		2a		4a, 4b			
199-D5-154		DX-EXT								YES				4a, 4b			
199-D5-159		DX-EXT		A						YES		2a		4a, 4b			
199-D5-16				A	5							2a	3a				
199-D5-160[d]		DX-EXT		A						YES		2a		4a, 4b			
199-D5-17				A					YES			2a		4a, 4b			
199-D5-18																	
199-D5-19									YES					4a, 4b			
199-D5-20		DX-EXT		A						YES	1a			4a, 4b			
199-D5-32		DX-EXT		A						YES		2a		4a, 4b			
199-D5-33				A					YES		1a			4a, 4b			

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-D5-34		DX-EXT		A						YES		2a		4a, 4b			
199-D5-36				A					YES		1a	2a		4a, 4b			
199-D5-37				A					YES		1a			4a, 4b			
199-D5-38				A					YES			2a		4a, 4b			
199-D5-39		DX-EXT		A						YES		2a		4a, 4b			
199-D5-40																	
199-D5-41				A					YES			2a		4a, 4b			
199-D5-42				A								2a					
199-D5-43				A					YES			2a		4a, 4b			
199-D5-44				A							1a	2a					
199-D5-92		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D5-97				A					YES			2a		4a, 4b			
199-D6-1		DX-INJ								YES				4a, 4b			
199-D6-2		DX-INJ								YES				4a, 4b			
199-D6-3									YES					4a, 4b			
199-D7-3		DX-EXT								YES				4a, 4b			
199-D7-4		DX-INJ								YES				4a, 4b			
199-D7-5		DX-INJ								YES				4a, 4b			
199-D7-6																	
199-D8-101				A					YES			2a		4a, 4b			
199-D8-102				A								2a					
199-D8-4				A								2a					
199-D8-5				A					YES		1a	2a		4a, 4b			

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Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-D8-53		DX-EXT		A						YES		2a		4a, 4b			
199-D8-54A				A					YES		1a	2a		4a, 4b			
199-D8-55		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D8-6				A								2a					
199-D8-68		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D8-69		DX-EXT		A						YES	1a			4a, 4b			
199-D8-70				A					YES		1a			4a, 4b			
199-D8-71				A					YES		1a	2a		4a, 4b			
199-D8-72				A							1a	2a					
199-D8-73		DX-EXT		A						YES	1a			4a, 4b			
199-D8-88		DX-EXT		A						YES	1a			4a, 4b			
199-D8-89		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D8-90		DX-EXT								YES		2a		4a, 4b			
199-D8-91		DX-EXT		A						YES	1a	2a		4a, 4b			
199-D8-93				A					YES		1a	2a		4a, 4b			
199-D8-94				A							1a	2a					
199-D8-95		DX-EXT		A						YES		2a		4a, 4b			
199-D8-96		DX-EXT		A	5					YES		2a	3a	4a, 4b			
199-D8-97		DX-EXT		A	5					YES		2a	3a	4a, 4b			
199-D8-98		DX-EXT		A						YES		2a		4a, 4b			
199-D8-99		DX-EXT								YES		2a		4a, 4b			
199-H1-1		HX- EXT		A						YES		2a		4a, 4b			
199-H1-12		HX-INJ								YES				4a, 4b			

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-H1-2		HX- EXT		A						YES		2a		4a, 4b			
199-H1-20		HX-INJ								YES				4a, 4b			
199-H1-21		HX-INJ								YES				4a, 4b			
199-H1-25		HX-INJ								YES				4a, 4b			
199-H1-27		HX-INJ								YES				4a, 4b			
199-H1-3[e]		HX-INJ								YES				4a, 4b			
199-H1-32		HX- EXT		SA						YES	1a	2a		4a, 4b			
199-H1-33		HX- EXT		SA						YES	1a	2a		4a, 4b			
199-H1-34		HX- EXT		A						YES	1a	2a		4a, 4b			
199-H1-35		HX- EXT		A						YES	1a	2a		4a, 4b			
199-H1-36		HX- EXT		A						YES		2a		4a, 4b			
199-H1-37		HX- EXT		SA						YES	1a	2a		4a, 4b			
199-H1-38		HX- EXT		SA						YES	1a	2a		4a, 4b			
199-H1-39		HX- EXT		SA						YES	1a	2a		4a, 4b			
199-H1-4		HX- EXT		SA						YES		2a		4a, 4b			
199-H1-40		HX- EXT		SA						YES	1a	2a		4a, 4b			
199-H1-42		HX- EXT		SA						YES		2a		4a, 4b			
199-H1-43		HX- EXT		A						YES		2a		4a, 4b			
199-H1-45		HX- EXT		A						YES		2a		4a, 4b			
199-H1-46		HX- EXT		A						YES		2a		4a, 4b			
199-H1-47		HX- EXT		A						YES		2a		4a, 4b			
199-H1-48		HX- EXT		A						YES		2a		4a, 4b			
199-H1-49		HX- EXT		A						YES		2a		4a, 4b			

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-H1-5		DX-INJ								YES				4a, 4b			
199-H1-6		HX-INJ								YES				4a, 4b			
199-H1-7				A					YES		1a	2a		4a, 4b			
199-H3-11				A		5						2a	3a				
199-H3-21		HX- EXT		A		5				YES	1a	2a	3a	4a, 4b			
199-H3-25		HX- EXT								YES		2a		4a, 4b			
199-H3-26		HX- EXT								YES		2a		4a, 4b			
199-H3-27		HX-INJ								YES				4a, 4b			
199-H3-2A				A								2a					
199-H3-2B									YES					4a, 4b			
199-H3-3				A								2a					
199-H3-4[e]		HX-INJ								YES				4a, 4b			
199-H3-5				A								2a					
199-H3-6				A		5					1a	2a	3a		5a		
199-H3-7																	
199-H4-10				A					YES		1a			4a, 4b			
199-H4-11				A					YES		1a			4a, 4b	5a		
199-H4-12A																	
199-H4-12B				A					YES		1a	2a		4a, 4b			
199-H4-13				A		5			YES		1a	2a	3a	4a, 4b			
199-H4-15A		HX- EXT		A						YES	1a			4a, 4b			
199-H4-15B									YES					4a, 4b			
199-H4-16				A		5						2a	3a		5a		

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-H4-17		HX-INJ								YES				4a, 4b			
199-H4-18[c]				A								2a					
199-H4-4		HX- EXT		A						YES	1a	2a		4a, 4b			
199-H4-45				A		5					1a	2a	3a		5a		
199-H4-46				A								2a					
199-H4-47									YES					4a, 4b			
199-H4-49				A								2a					
199-H4-5				A					YES		1a	2a		4a, 4b			
199-H4-6																	
199-H4-63		HX- EXT		A		5				YES	1a	2a	3a	4a, 4b	5a		
199-H4-64		HX- EXT		A						YES	1a			4a, 4b			
199-H4-65				A							1a	2a					
199-H4-69		HX- EXT		A						YES		2a		4a, 4b	5a		
199-H4-70		HX- EXT		A						YES		2a		4a, 4b			
199-H4-71[c]				A								2a					
199-H4-72[c]				A								2a					
199-H4-73[c]				A								2a					
199-H4-74		HX- EXT								YES				4a, 4b			
199-H4-75		HX- EXT		A						YES		2a		4a, 4b			
199-H4-76		HX- EXT		A						YES		2a		4a, 4b			
199-H4-77[e]		HX-INJ								YES				4a, 4b			
199-H4-78		HX-INJ								YES				4a, 4b			
199-H4-79		HX-INJ								YES				4a, 4b			

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-H4-8				A	A		A		YES		1a	2a		4a, 4b	5a		
199-H4-80[e]		DX-INJ								YES				4a, 4b			
199-H4-81		DX-EXT		A						YES		2a		4a, 4b			
199-H4-82		DX-INJ								YES				4a, 4b			
199-H4-83				A		5			YES			2a	3a	4a, 4b	5a		
199-H4-84				A	A		A		YES			2a		4a, 4b	5a		
199-H4-85				A	A		A				1a	2a			5a		
199-H4-86		HX- EXT		A						YES		2a		4a, 4b			
199-H4-87				A								2a					
199-H4-88				A	A		A					2a			5a		
199-H4-89				A	A		A					2a			5a		
199-H4-92		HX- EXT		A						YES		2a		4a, 4b			
199-H4-93		HX- EXT		A						YES		2a		4a, 4b			
199-H5-10																	
199-H5-11																	
199-H5-12																	
199-H5-13																	
199-H5-14																	
199-H5-16		HX- EXT		A						YES		2a		4a, 4b			
199-H5-1A				A					YES			2a		4a, 4b			
199-H5-2																	
199-H5-3O																	
199-H5-3P																	

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-H5-4O																	
199-H5-4P																	
199-H5-5O																	
199-H5-5P																	
199-H5-6																	
199-H5-7																	
199-H5-8																	
199-H5-9																	
199-H6-1																	
199-H6-2		HX-INJ								YES				4a, 4b			
199-H6-3				A	5				YES			2a	3a	4a, 4b			
199-H6-4																	
199-H6-7		HX-INJ								YES				4a, 4b			
199-H6-8		HX-INJ								YES				4a, 4b			
699-100-43B				A					YES		1a			4a, 4b			
699-101-45									YES					4a, 4b			
699-101-48B				A							1a						
699-88-41				A								2a					
699-88-41A				A					YES			2a		4a, 4b			
699-89-35				A							1a						
699-90-34	To be decommissioned																
699-90-37B				A								2a					
699-90-38	To be decommissioned																

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
699-90-45																	
699-90-45B		HX-INJ								YES				4a, 4b			
699-90-47B		DX-INJ								YES				4a, 4b			
699-91-46A																	
699-92-49																	
699-93-37A				A					YES			2a		4a, 4b			
699-93-48A																	
699-93-48C		DX-INJ								YES				4a, 4b			
699-93-50																	
699-94-41				A					YES			2a		4a, 4b			
699-94-43				A	5				YES			2a	3a	4a, 4b			
699-95-45				A					YES			2a		4a, 4b			
699-95-45B		HX-INJ								YES				4a, 4b			
699-95-48				A								2a					
699-95-51				A					YES			2a		4a, 4b			
699-96-43																	
699-96-44									YES					4a, 4b			
699-96-45																	
699-96-52B				A					YES		1a			4a, 4b			
699-97-41				A					YES			2a		4a, 4b			
699-97-43B				A								2a					
699-97-45				A					YES			2a		4a, 4b			
699-97-47B				A					YES			2a		4a, 4b			

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
699-97-47C		HX-INJ								YES				4a, 4b			
699-97-48B				A					YES			2a		4a, 4b			
699-97-51A				A								2a					
699-98-43				A					YES			2a		4a, 4b			
699-98-46				A								2a					
699-98-49A				A					YES			2a		4a, 4b			
699-98-51				A					YES			2a		4a, 4b			
699-99-41				A					YES		1a			4a, 4b			
699-99-42B				A					YES		1a	2a		4a, 4b			
699-99-44				A					YES			2a		4a, 4b			
Uppermost Water-bearing Unit of the RUM Aquifer																	
199-D5-134	RUM - First water-bearing unit			A					YES			2b		4c, 4d			7
199-D5-141	RUM - First water-bearing unit			A								2b		4c, 4d			7
199-D7-7	RUM - First water-bearing unit; scheduled for installation		A	Q												6	7
199-D8-54B	RUM - first water-bearing unit			SA					YES		1b	2b		4c, 4d			7
199-D11-1	RUM - First water-bearing unit; scheduled for installation		A	Q												6	7
699-95-45C	RUM - First water-bearing unit			A					YES			2b		4c, 4d			7
699-95-48B	RUM - First water-bearing unit; scheduled for installation		A	Q												6	7
699-95-48C	RUM - First water-bearing unit; scheduled for installation		A	Q												6	7
699-96-42B	RUM - First water-bearing unit; scheduled for installation		A	Q												6	7
699-97-43C	RUM - First water-bearing unit			A								2b		4c, 4d			7

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
699-97-47D	RUM - First water-bearing unit; scheduled for installation		A	Q												6	7
699-97-45B	RUM - First water-bearing unit			A								2b		4c, 4d			7
699-97-48C	RUM - First water-bearing unit			A					YES			2b		4c, 4d			7
699-97-60	RUM - First water-bearing unit			A					YES			2b		4c, 4d			7
699-97-61	RUM - First water-bearing unit	DX-EXT		A						YES		2b		4c, 4d			7
699-98-50	RUM - First water-bearing unit; scheduled for installation		A	Q												6	7
199-H1-50	RUM - First water-bearing unit			SA					YES		1b	2b		4c, 4d			7
199-H2-1	RUM - First water-bearing unit			SA					YES		1b	2b		4c, 4d			7
199-H3-10	RUM - First water-bearing unit			A					YES			2b		4c, 4d			7
199-H3-12	RUM - First water-bearing unit			SA	SA				YES		1b	2b	3b	4c, 4d	5b		7
199-H3-13	RUM - First water-bearing unit			SA	SA			A	YES		1b	2b	3b	4c, 4d	5b		7
199-H3-22	RUM - First water-bearing unit	HX- EXT		SA	SA			A		YES	1b	2b	3b	4c, 4d	5b		7
199-H3-28	RUM - First water-bearing unit	HX- EXT		SA	SA					YES		2b	3b	4c, 4d			7
199-H3-29	RUM - First water-bearing unit	HX- EXT		SA	SA			A		YES	1b	2b	3b	4c, 4d	5b		7
199-H3-2C	RUM - First water-bearing unit	HX- EXT		SA						YES		2b		4c, 4d			7
199-H3-30	RUM - First water-bearing unit			SA	A				YES		1b	2b	3b	4c, 4d			7
199-H3-31	RUM - First water-bearing unit; scheduled for installation		A	Q												6	7
199-H3-32	RUM - First water-bearing unit			SA					YES		1b	2b		4c, 4d			7
199-H3-9	RUM - First water-bearing unit	HX- EXT		SA	A					YES	1b	2b		4c, 4d	5b		7
199-H4-12C	RUM - First water-bearing unit	HX- EXT		SA	SA					YES	1b	2b	3b	4c, 4d	5b		7
199-H4-15CS	RUM - First water-bearing unit			SA							1b	2b					7
199-H4-90	RUM - First water-bearing unit			A					YES			2b		4c, 4d			7

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
199-H4-91	RUM - First water-bearing unit			A					YES			2b		4c, 4d			7
199-H4-94	RUM - First water-bearing unit; scheduled for installation		A	Q												6	7
199-H7-1	RUM - First water-bearing unit			A					YES			2b		4c, 4d			7
Aquifer Tubes																	
36-M	100-D Area			A							1c	2a					
38-M	100-D Area			A							1c	2a					
AT-D-1-M	100-D Area			A							1c	2a					
AT-D-3-D	100-D Area			A							1c	2a					
AT-D-4-D	100-D Area			A							1c	2a					
C6278	100-D Area			A								2a					
C6334	100-D Area			A							1c	2a					
C7647	100-D Area			SA							1c	2a					
DD-10-3	100-D Area			A							1c	2a					
DD-12-2	100-D Area			A							1c	2a					
DD-15-3	100-D Area			A							1c	2a					
DD-16-4	100-D Area			SA							1c	2a					
DD-17-2	100-D Area			A							1c						
DD-41-3	100-D Area			A							1c	2a					
DD-44-4	100-D Area			A							1c	2a					
DD-49-3	100-D Area			SA							1c	2a					
DD-50-3	100-D Area			SA							1c						
DD-50-4	100-D Area			SA							1c	2a					
Redox-1-6.0	100-D Area			A							1c	2a					

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
Redox-3-3.3	100-D Area			A							1c	2a					
43-M	100-H Area			SA							1c	2a					
45-M	100-H Area			A							1c	2a					
47-D	100-H Area			A							1c						
47-M	100-H Area			A							1c	2a					
48-M	100-H Area			A							1c	2a					
50-M	100-H Area			A							1c	2a					
51-D	100-H Area			A							1c	2a					
52-D	100-H Area			A							1c	2a					
54-M	100-H Area			A							1c	2a					
AT-H-1-M	100-H Area			A							1c	2a					
AT-H-2-D	100-H Area			A							1c	2a					
AT-H-3-D	100-H Area			SA							1c	2a					
C5633	100-H Area			SA							1c	2a					
C5636	100-H Area			SA							1c	2a					
C5638	100-H Area			SA							1c	2a					
C5641	100-H Area			SA							1c	2a					
C5678	100-H Area			A							1c	2a					
C5682	100-H Area			A							1c						
C6293	100-H Area			A							1c	2a					
C6301	100-H Area			A							1c	2a					
C7649	100-H Area			A							1c						
C7650	100-H Area			SA							1c	2a					

Table B-1. Sample Summary Table

Monitoring Location	Notes	Remediation System	Total Chromium (Filtered and Unfiltered)[a]	Cr(VI) (Filtered)	Nitrate (Unfiltered)	Sr-90 (Unfiltered)	Uranium (Total) (Filtered and Unfiltered	Tc-99 (Unfiltered)	Automated Water-Level Network	P&T System Data	PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater Than 10 µg/L?	PSQ 2: Are the Cr(VI) Mass, Concentrations, and Plume Areas Reducing as Expected?	PSQ 3: Are Concentrations of Nitrate and Strontium-90 Attenuating as Expected?	PSQ 4[b]: What are the Direction and Magnitude of Groundwater Hydraulic Gradients?	PSQ 5: Are There Areas That Require Additional Sampling to Evaluate the Impacts of Secondary Sources?	PSQ 6: What are the Nature and Extent of Cr(VI) Concentrations Within the Uppermost water-bearing unit of the RUM?	PSQ 7: What are the Physical and Hydraulic Characteristics of the Uppermost water-bearing unit of the RUM?
Lower Confined Units																	
199-H4-15CP	Basalt confined		5	5							1c						
199-H4-15CQ	Rwia confined		5	5							1c						
199-H4-15CR	Rwie confined		5	5							1c						
199-H4-2	Basalt confined		5	5							1c						
River Gauges																	
D Gauge									YES					4a, 4b, 4c, 4d			
H Gauge									YES					4a, 4b, 4c, 4d			

a. Approximately 20% of aquifer tubes and wells sampled for Cr(VI) will be sampled for total chromium per year, on a random basis.

b. Additional wells are to be selected for specific geographic area tests.

c. Well is being converted to a monitoring well in FY 2020. Sampling and P&T system configuration reflect post-realignment conditions. Monitoring is needed to confirm conditions relative to PSQ 2.

d. Well is being converted to an extraction well in FY 2020. Sampling and P&T system configuration reflect post-realignment conditions.

e. Well is being converted to an injection well in FY 2020. Sampling and P&T system configuration reflect post-realignment conditions.

FY = fiscal year
P&T = pump and treat
PSQ = principle study question
Rwia = Ringold Formation member of Wooded Island — unit A
Rwie = Ringold Formation member of Wooded Island — unit E
RUM = Ringold Formation upper mud

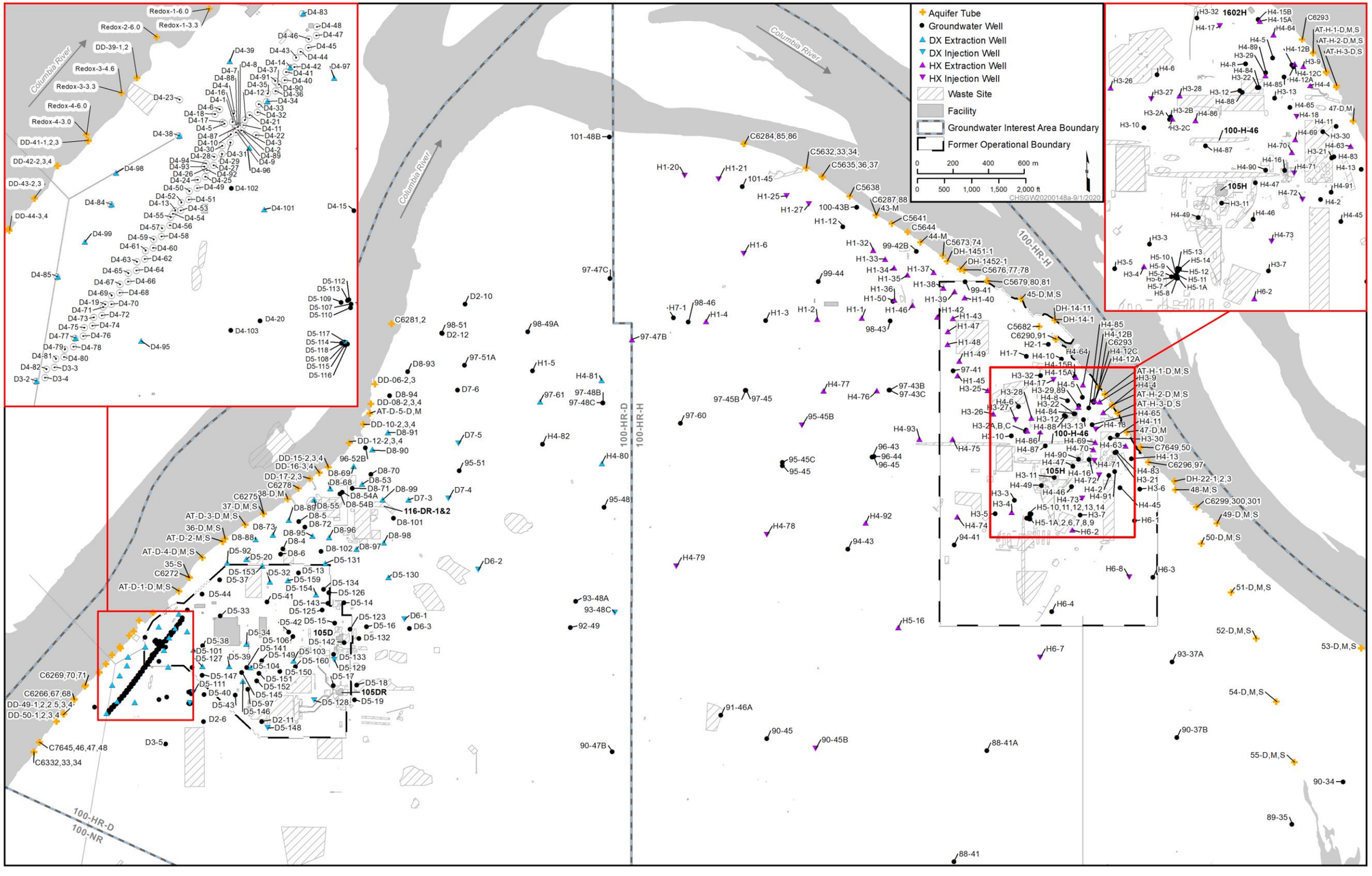

Figure B-1. Available Monitoring Locations as of December 31, 2019

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