DOE/RL-2013-30
Revision 0

Sampling and Analysis Plan for 100-HR-3 Groundwater Operable Unit Monitoring

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

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Contents

1 Introduction 1-1

1.1 Project Scope and Objectives 1-2
1.2 Background 1-5
1.2.1 Site Hydrogeology 1-5
1.2.2 Groundwater Flow 1-10
1.2.3 Sources of Groundwater Contamination 1-11
1.2.4 Contaminant Plumes 1-18
1.3 Data Quality Objective Summary 1-18
1.4 Contaminants 1-18
1.5 Project Schedule 1-18

2 Quality Assurance Project Plan 2-1

2.1 Project Management 2-1
2.1.1 Project/Task Organization 2-1
2.1.2 DOE Lead Agency (Richland Operations Office) 2-1
2.1.3 Lead Regulatory Agency (Ecology) 2-2
2.1.4 Remediation Contractor 2-2
2.2 Quality Objectives and Criteria 2-7
2.2.1 Special Training/Certification 2-7
2.2.2 Documents and Records 2-11
2.3 Data Generation and Acquisition 2-14
2.3.1 Analytical Methods Requirements 2-14
2.3.2 Field Analytical Methods 2-14
2.3.3 Quality Control 2-14
2.3.4 Measurement Equipment 2-23
2.3.5 Instrument and Equipment Testing, Inspection, and Maintenance 2-24
2.3.6 Instrument/Equipment Calibration and Frequency 2-24
2.3.7 Inspection/Acceptance of Supplies and Consumables 2-24
2.3.8 Nondirect Measurements 2-24
2.3.9 Data Management 2-24
2.4 Assessment and Oversight 2-25
2.4.1 Assessments and Response Actions 2-25
2.4.2 Reports to Management 2-25
2.5 Data Validation and Usability 2-25
2.5.1 Data Review and Verification 2-25
2.5.2 Data Validation 2-26
2.5.3 Reconciliation with User Requirements 2-26

3 Field Sampling Plan 3-1

3.1 Sampling Objectives 3-1

3.2 Sample Location, Frequency, and Constituents to be Monitored 3-2

3.2.1 PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L? 3-2

3.2.2 PSQ 2: Is the remedy effectively reducing the groundwater Cr(VI) plume? 3-2

3.2.3 PSQ 3: Are other contaminant plumes that exceed risk-based/ARAR levels decreasing as predicted? 3-2

3.2.4 PSQ 4: What are the direction and magnitude of groundwater hydraulic gradients in the confined and unconfined aquifers? 3-3

3.2.5 PSQ 5a: Are infrequently detected analytes confirmed not to be contaminants of potential concern? 3-6

3.2.6 PSQ 5b: Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern? 3-6

3.2.7 PSQ 5c: Are potential source areas confirmed not to be continuing sources of COPCs in groundwater? 3-6

3.3 Operational Sampling 3-6

3.3.1 Strontium-90 Sampling 3-6

3.3.2 Uranium Sampling 3-45

3.4 Sampling Methods 3-48

3.4.1 Decontamination of Sampling Equipment 3-49

3.4.2 Water Levels 3-49

3.5 Documentation of Field Activities 3-50

3.5.1 Corrective Actions and Deviations for Sampling Activities 3-51

3.6 Calibration of Field Equipment 3-51

3.7 Sample Handling 3-52

3.7.1 Containers3-52

3.7.2 Container Labeling 3-52

3.7.3 Sample Custody 3-53

3.7.4 Sample Transportation 3-53

4 Management of Waste 4-1

5 Health and Safety 5-1

6 References 6-1

Appendices

A Data Quality Objectives ..... A-i

B Sampling Location Information for the 100-HR-3 Groundwater Operable Unit ..... B-i

C Example Forms ..... C-i

Figures

Figure 1-1. Location of the 100-HR-3 Groundwater Operable Unit 1-1
Figure 1-2. 100-D/H Area and Operable Units 1-3
Figure 1-3. Conceptual Hydrogeologic Cross-Section from West to East of the 100-HR-3 Operable Unit 1-6
Figure 1-4. RUM Surface Contours 1-7
Figure 1-5. 100-HR-3 Operable Unit, 100-D Area Overview Map and Water Table 1-12
Figure 1-6. 100-HR-3 Operable Unit, 100-H Area Overview Map and Water Table 1-13
Figure 1-7. 100-HR-3 Operable Unit, 100-D Area Groundwater Contours and Hexavalent Chromium Concentrations at High River Stage 1-14
Figure 1-8. 100-HR-3 Operable Unit, 100-H Area Groundwater Contours and Hexavalent Chromium Concentrations at High River Stage 1-15
Figure 1-9. 100-HR-3 Operable Unit, 100-D Area Groundwater Contours and Hexavalent Chromium Concentrations at Low River Stage 1-16
Figure 1-10. 100-HR-3 Operable Unit, 100-H Area Groundwater Contours and Hexavalent Chromium Concentrations at Low River Stage 1-17
Figure 1-11. Locations in the 100-D Area Where Sodium Dichromate was Handled 1-19
Figure 1-12. Locations in the 100-H Area Where Sodium Dichromate was Handled 1-20
Figure 1-13. Potential Strontium-90 Sources in the 100-H Area 1-21
Figure 1-14. Potential Nitrate Sources in the 100-D Area 1-22
Figure 1-15. Potential Nitrate Sources in the 100-H Area 1-23
Figure 1-16. Strontium-90 Plumes in the 100-D Area 1-24
Figure 1-17. Strontium-90 Plumes in the 100-H Area 1-25
Figure 1-18. Nitrate Plumes in the 100-D Area 1-26
Figure 1-19. Nitrate Plumes in the 100-H Area 1-27
Figure 2-1. Project Organization 2-3
Figure 3-1. Wells with Historical Strontium-90 Detections at 100-D 3-46
Figure 3-2. Wells with Historical Strontium-90 Detections at 100-H 3-47

Tables

Table 1-1. Analytes for 100-HR-3 Groundwater Operable Unit Monitoring 1-28
Table 2-1. Data Quality Indicators....2-8
Table 2-2. Change Control for Sampling Projects 2-12
Table 2-3. Performance Requirements for Groundwater Analysis 2-15
Table 2-4. Project Quality Control Requirements....2-19
Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria....2-20
Table 2-6. Sample Container, Preservation, and Holding Time Guidelines for Groundwater Samples by Analytical Method....2-23
Table 3-1. Status of 100-HR-3 Interim Action Compliance Wells....3-1
Table 3-2. Monitoring Wells, Analytes, and Frequencies for Surveillance Groundwater Monitoring[a] 3-4
Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents....3-7
Table 3-4. Treatment Process Water Monitoring....3-45

Terms

AEA	*Atomic Energy Act of 1954*
ALARA	as low as reasonably achievable
AWLN	automated water level network
BTR	Buyer's Technical Representative
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
DUP	field duplicate sample
DWS	drinking water standard
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESHR	Environmental, Safety, Health, and RadCon
FSO	Field Sampling Operations
FTB	full trip blank
FWS	Field Work Supervisor
FY	fiscal year
G/P	glass/plastic
HASP	health and safety plan

HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
HEIS	Hanford Environmental Information System
HHE	human health and the environment
IC	ion chromatography
ICP/AES	inductively coupled plasma/atomic emission spectroscopy
ICP/MS	inductively coupled plasma/mass spectrometry
ISMS	Integrated Safety Management System
ISRM	in situ redox manipulation
LCS	laboratory control sample
LRA	lead regulatory agency
MB	method blank
MDL	method detection limit
MS	matrix spike
MSA	Mission Support Alliance
MSD	matrix spike duplicate
NA	not applicable
NCO	nuclear chemical operator
NTU	nephelometric turbidity unit
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
OU	operable unit
P&T	pump and treat
PPE	personal protective equipment
PSQ	principal study question
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*

RCT	radiological control technician
RD/RAWP	remedial design/remedial action work plan
RDR	request for data review
RI	remedial investigation/feasibility study
ROD	record of decision
RPD	relative percent difference
RUM	Ringold Formation upper mud
S&GRP	Soil and Groundwater Remediation Project
SAF	Sampling Authorization Form
SAP	sampling and analysis plan
SIR	sample issue resolution
SMILE	*Sample Management Integrated Lifecycle Environment*
SMR	Sample Management and Reporting
SPLIT	field split sample
SUR	surrogate
TPA	Tri-Party Agreement
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VC	vertical characterization
WAC	*Washington Administrative Code*
ZVI	zero valent iron

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1 Introduction

This sampling and analysis plan (SAP) presents the groundwater monitoring program for the 100-HR-3 Groundwater Operable Unit (OU). The remedial design/remedial action work plan (RD/RAWP) (DOE/RL-2013-31, *Remedial Design/Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit*) describes how the interim remedial actions are to be designed, installed, and operated to meet the interim remedial action objectives (RAOs). Groundwater monitoring set forth in this document is designed to track changing conditions, performance of the remedy, and effectiveness of interim remedial actions in meeting performance criteria required by the interim 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*) and interim action ROD amendment (EPA/AMD/R10-00/122, *Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington*). Treatment system monitoring is presented in DOE/RL-2013-49, *100-HR-3 Pump and Treat System Operations and Maintenance Plan*.

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 reactor areas and the area between them known as the Horn (Figure 1-1). The interim action ROD (EPA/ROD/R10-96/134) identified hexavalent chromium (Cr(VI)) released from facilities and waste sites as a risk to human health and the environment (HHE). The interim action ROD identified Cr(VI) as a contaminant of concern (COC) for groundwater in the 100-HR-3 OU.

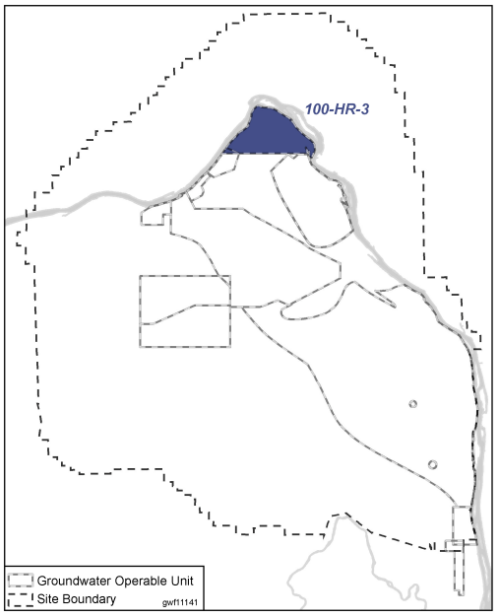

Figure 1-1. Location of the 100-HR-3 Groundwater Operable Unit

In April 1996, the interim action ROD (EPA/ROD/R10-96/134) that was issued for the 100-HR-3 Groundwater OU selected pump and treat (P&T) technology as the interim remedy for river protection and institutional controls to restrict groundwater use. These actions, together with the collection of monitoring information, were identified to meet the interim action ROD RAOs. The interim action ROD amendment (EPA/AMD/R10-00/122) selected in situ chemical treatment through installation of an in situ redox manipulation (ISRM) barrier as an additional interim remedy for a Cr(VI) groundwater plume west of the 100-D and 100-DR reactors. EPA et al., 2009, *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site Benton County, Washington*, selected an increased P&T system, based on expanded Cr(VI) plume dimensions and different directions of migration. Evaluation of the ISRM barrier performance identified breakthrough of Cr(VI) contaminated groundwater in the northern portion of the barrier. 11-AMCP-0002, "Non-Significant Change for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Washington July 2010, Memo to File Regarding: Supplemental Actions for the In-Site Reduction/Oxidation Manipulation Barrier Performance for the 100-HR-3 Groundwater Operable Unit Interim Remedy," authorized no further replenishment of the ISRM barrier and identified the expanded P&T system as the replacement remedy. The interim actions are intended to meet the interim action ROD RAOs to protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River, protect human health by preventing exposure to contaminants in the groundwater, and provide information that will lead to a final remedy. This SAP consolidates

requirements from and supersedes previous *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) groundwater sampling and analysis documents as identified in Section 2.4.2 of the associated RD/RAWP (DOE/RL-2013-31). New wells for extraction, injection, or monitoring purposes will be added to this SAP through their specific drilling SAPs; however, changes in monitoring schedule or analytes will be made through a Tri-Party Agreement (TPA) (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*) Change Notice or revision to this document.

This plan does not address sitewide surveillance (*Atomic Energy Act of 1954* [AEA]) groundwater monitoring programs. Groundwater monitoring under AEA is implemented primarily through DOE O 435.1, *Radioactive Waste Management*. Through the AEA, the U.S. Department of Energy (DOE) regulates control of radioactive materials under its authority. DOE determines the frequency and location of groundwater monitoring for radionuclides according to standards established to protect HHE from potential radioactive material risks. AEA monitoring is addressed in DOE/RL-2012-59, *Surveillance Groundwater Monitoring on the Hanford Site*.

Additionally, this plan does not address riverbank seep water monitoring. Sampling of riverbank seeps is conducted as a component of Hanford Site environmental reporting (MSA-1303832, "Contract Deliverable CD0063, Hanford Site Annual Environmental Report September 30, 2013"). Riverbank seep grab samples are collected annually in the 100-D and 100-H Areas, with no seep sampling along the Horn. These samples are analyzed for alpha, beta, technitium-99, tritium, isotopic uranium (uranium-234, uranium-235, and uranium-238), metals (filtered and unfiltered), anions, and strontium-90 in the 100-D Area and alpha, beta, anions, tritium, strontium-90, technetium-99, metals (filtered and unfiltered), anions, and tritium in the 100-H Area. Monitoring of seeps and springs (consisting of sampling and analysis water discharged from the seepage face near the river) started historically during reactor operations. During reactor operations, persistent seeps and/or springs developed along the shore of the Columbia River in areas adjacent to the substantial recharge mounds associated with high volume cribs and trenches receiving contaminated reactor cooling water. Since the cessation of reactor operations, seeps continue to be observed seasonally during the period of declining river stage following the freshet. The number, location, and frequency of seep and spring occurrence along the reactor areas have changed over the years; in general, they have become ephemeral and less persistent as groundwater elevation in the recharge areas returned to a more natural level. Seeps and springs remain of interest for two primary reasons: they represent potential exposure points for human and ecological receptors to contaminants in the riparian zone, and they are surface expressions of groundwater and provide additional opportunity to measure contaminant concentrations at locations that may not be otherwise available for sampling. However, data collected from seeps need to be kept in the context of the nature of the seeps along the Hanford Reach, where seeps may be ephemeral and migratory (i.e., they may not appear in the same location year to year), and it is not always apparent exactly what portion of the aquifer is being represented by a particular seep. Results of riverbank seep sampling are provided annually (for example, DOE/RL-2013-47, *Hanford Site Environmental Report for Calendar Year 2013* [Section 7.4]).

This SAP consists of five chapters. The remainder of this chapter addresses project scope and objectives, background, data quality objectives (DQOs), groundwater contaminants, and project schedule. Chapter 2 presents the quality assurance project plan (QAPjP), and Chapter 3 provides the field sampling plan. Chapters 4 and 5 address waste management and health and safety requirements, respectively. Chapter 6 is a listing of all references cited in this SAP. Appendix A is the DQOs, and Appendix B is the sampling location information.

1.1 Project Scope and Objectives

The scope of monitoring presented in this plan is to satisfy the requirements in the interim action ROD (EPA/ROD/R10-96/134) and the interim action ROD amendment (EPA/AMD/R10-00/122). The primary

COC at 100-HR-3 is Cr(VI), with the potential co-contaminants including nitrate, strontium-90, tritium, uranium, and technetium-99. The monitoring locations identified in this SAP are designed to collect groundwater data sufficient to track the extent, movement, and concentration of Cr(VI) to evaluate performance with respect to the RAOs to protect HHE (EPA/ROD/R10-96/134), as follows:

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

Remedial action performance monitoring for Cr(VI), the COC identified in the interim remedial action ROD, is included in this SAP. Protection of Columbia River aquatic receptors is evaluated using data collected to track Cr(VI) plumes and hydraulic capture of Cr(VI) contaminated groundwater. Human health is protected by preventing exposure through implementing institutional controls to restrict groundwater use. Data collected will assist in evaluating the final remedy decision, which is pending.

A remedial investigation/feasibility study (RI/FS) (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*, hereinafter called the 100-D/H RI/FS report) was completed to support selection of a final remedy. The 100-D/H Area includes the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 OUs (Figure 1-2). The 100-D/H RI/FS report risk assessment used a data set collected between 2006 and 2012. The screening completed for contaminants of potential concern (COPCs) in the baseline risk assessment identified strontium-90 and nitrate as contaminants in groundwater meeting the criteria of final COPCs. The scope of monitoring in this plan includes these COPCs to support selection of a final remedy.

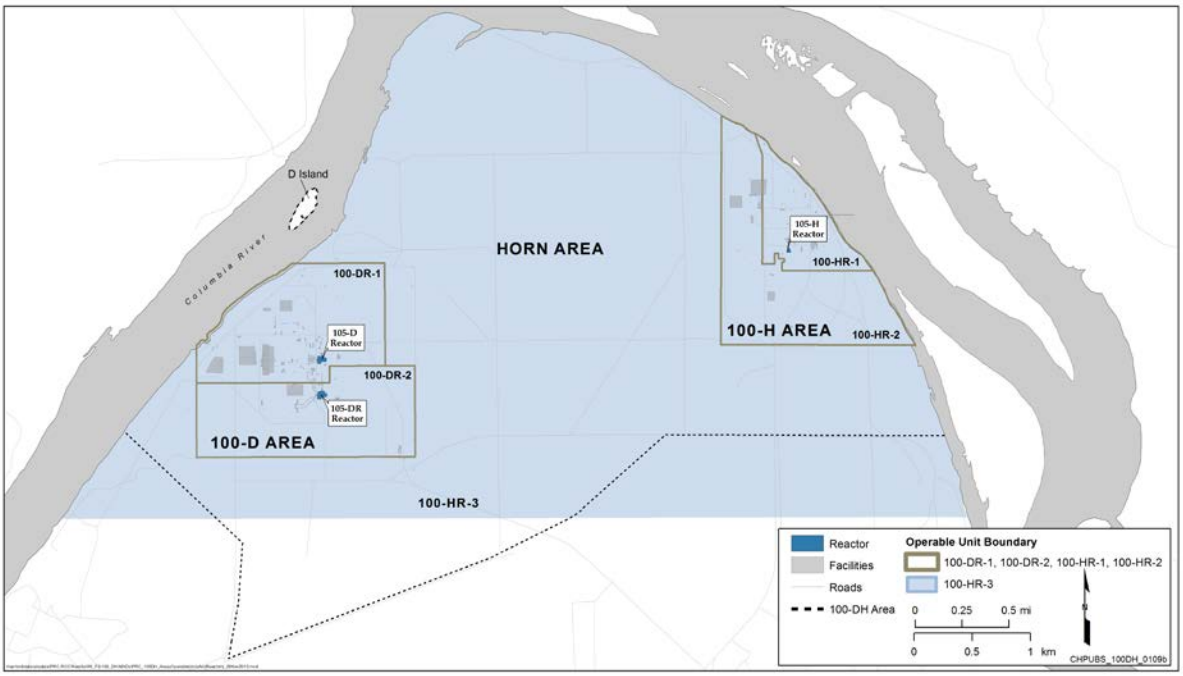

Figure 1-2. 100-D/H Area and Operable Units

During comment resolution for the 100-D/H RI/FS report (DOE/RL-2010-95), DOE agreed with the Washington State Department of Ecology (Ecology) to collect data to assess specific uncertainties. These analytes were identified as having been detected on an infrequent basis or having been detected

historically at concentrations above their respective action levels but with no specific associated location or trend. This list of analytes included those where the analytical test method used historically had a detection limit above the action level, as described in detail in Section 6.3 of 100-D/H RI/FS report (DOE/RL-2010-95). This SAP identifies collection of the data to address specific uncertainties, and the following objectives are included:

- Monitor to identify performance in meeting the RAOs in the interim action ROD (EPA/ROD/R10-96/134).
- Identify automated water level network (AWLN) wells to assist in determining local flow conditions.
- Identify locations and analytes for uncertainty sampling resulting from negotiations between the DOE Richland Operations Office (DOE-RL) and Ecology, which includes confirmation of the following determinations:
  - Infrequently detected analytes are not COPCs.
  - Analytes with method detection limits (MDLs) above action levels are not COPCs.
  - Potential source areas are not continuing sources of COPCs in groundwater.

Implementation of this plan provides routine groundwater monitoring data for use in the Hanford Site groundwater annual reports. Monitoring under this plan for Cr(VI), co-contaminants identified in the interim action ROD (EPA/ROD/R10-96/134), and COPCs identified in the 100-D/H RI/FS report (DOE/RL-2010-95) will continue until a final remedial decision is implemented. Data gathered under this plan help satisfy the requirements of CERCLA (40 CFR 300.430(b), "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy").

The DQO process included evaluation of the locations of monitoring wells with respect to the 2013 Cr(VI), strontium-90, and nitrate plume configurations. Historical sampling locations and analytical results generated during groundwater monitoring in 100-HR-3 from January 2009 through December 2013 were reviewed. The objective of the evaluation was to select a representative monitoring network and identify sampling requirements to answer the principal study questions (PSQs) and meet data needs. The analysis was directed at defining locations needed for contaminant monitoring and determining an appropriate sampling frequency. The criteria applied to identify monitoring locations and to select an appropriate sampling frequency are provided in Appendix A (Sections A8.3 and A8.4, respectively). Appendix B presents a list of the available monitoring locations.

The Hanford Site annual groundwater monitoring program collects synoptic water level measurements in March, which represents a mid-river stage period, as a component of the program. These measurements are collected under SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*, and are not included as part of this plan. In the River Corridor, water level monitoring during high river stage, low river stage, and transitional river stages better represents the conditions affecting contaminant transport in 100-HR-3, as discussed in Sections 1.2.2 and 3.2. AWLN and transducer data from P&T system wells provide additional, more frequent water levels for use in the evaluation of contaminant transport, concentration trends, and plume capture.

Programmatic requirements for other sampling within the 100-D/H Area (e.g., *Resource Conservation and Recovery Act of 1976* [RCRA]) will continue to be performed pursuant to other sampling plans, and those requirements are not included or affected by changes made to this SAP. RCRA groundwater monitoring is conducted for the 183-H Solar Evaporation Basins under a separate plan (DOE/RL-97-48,

183-H Solar Evaporation Basins Postclosure Plan). Data collected under DOE/RL-97-48 are considered supplementary groundwater quality information to the CERCLA OU process.

Issued in November 2013, DOE/RL-2012-59 includes monitoring of the upper basalt-confined aquifer and Ringold-confined aquifers. Confined aquifer sampling will continue under DOE/RL-2012-59; it is separate from this SAP and will not be affected by changes made to this SAP. Monitoring wells located within 100-HR-3 that are sampled to meet the requirements of DOE/RL-2012-59 are 199-H4-15CP, 199-D5-141, 199-H2-1, 199-H3-2C, 199-H3-9, 199-H3-10, 199-H4-12C, 199-H4-15CQ, 199-H4-15CR, 199-H4-15CS, 699-97-43C, 699-97-45B, and 699-97-48C. Well 199-H4-2, completed in the upper basalt, is not included in surveillance monitoring. Section 3.2 identifies analytes and sampling frequencies for the wells identified in this paragraph for the Surveillance Monitoring Program. Wells screened in the upper basalt-confined and Ringold Unit A aquifers are not needed to meet the DQOs of this SAP and are not part of this monitoring program.

Monitoring of wells in the confined or semiconfined aquifers in 100-HR-3 will be conducted, as needed, to meet the DQOs of this SAP, as described in Chapter 3 and presented in Table 3-3. Wells 199-H4-2 and 199-H4-15CP monitor groundwater within the upper basalt-confined aquifer in 100-HR-3. The confined to semiconfined aquifer within Ringold Unit A is present beneath most of the Hanford Site and is monitored by Well 199-H4-15CR. Ringold Unit B is monitored by Well 199-H4-15CQ. Wells screened in the confined or semiconfined aquifers within the Ringold Formation upper mud (RUM) unit within 100-HR-3 include 199-D5-141, 199-D8-54B, 199-D5-134, 199-H2-1, 199-H3-2C, 199-H3-9, 199-H3-10, 199-H4-12C, 199-H4-15CS, 199-H4-90, 199-H4-91, 699-97-43C, 699-97-45B, and 699-97-48C. Section 3.2 identifies the analytes and sampling frequencies for these wells.

Contaminant plumes that originate in other OUs could encroach into the 100-HR-3 Area. These plumes are monitored by the OUs where they originate and are not part of the scope of this SAP.

1.2 Background

This section summarizes hydrogeology, groundwater flow, contaminant sources, and contaminant plumes.

1.2.1 Site Hydrogeology

A description of the 100-D/H Area site history and hydrogeologic conditions is included in the 100-D/H RI/FS report (DOE/RL-2010-95). The generalized hydrogeology for the 100-HR-3 OU is provided in Figure 1-3. The 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 100-H. The unconfined aquifer is primarily within the Hanford formation in 100-H.
- Ringold Formation unit E—a sand and gravel-dominated deposit that exhibits variable cementation. The unconfined aquifer is primarily within the Ringold Formation unit E in 100-D.
- 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.

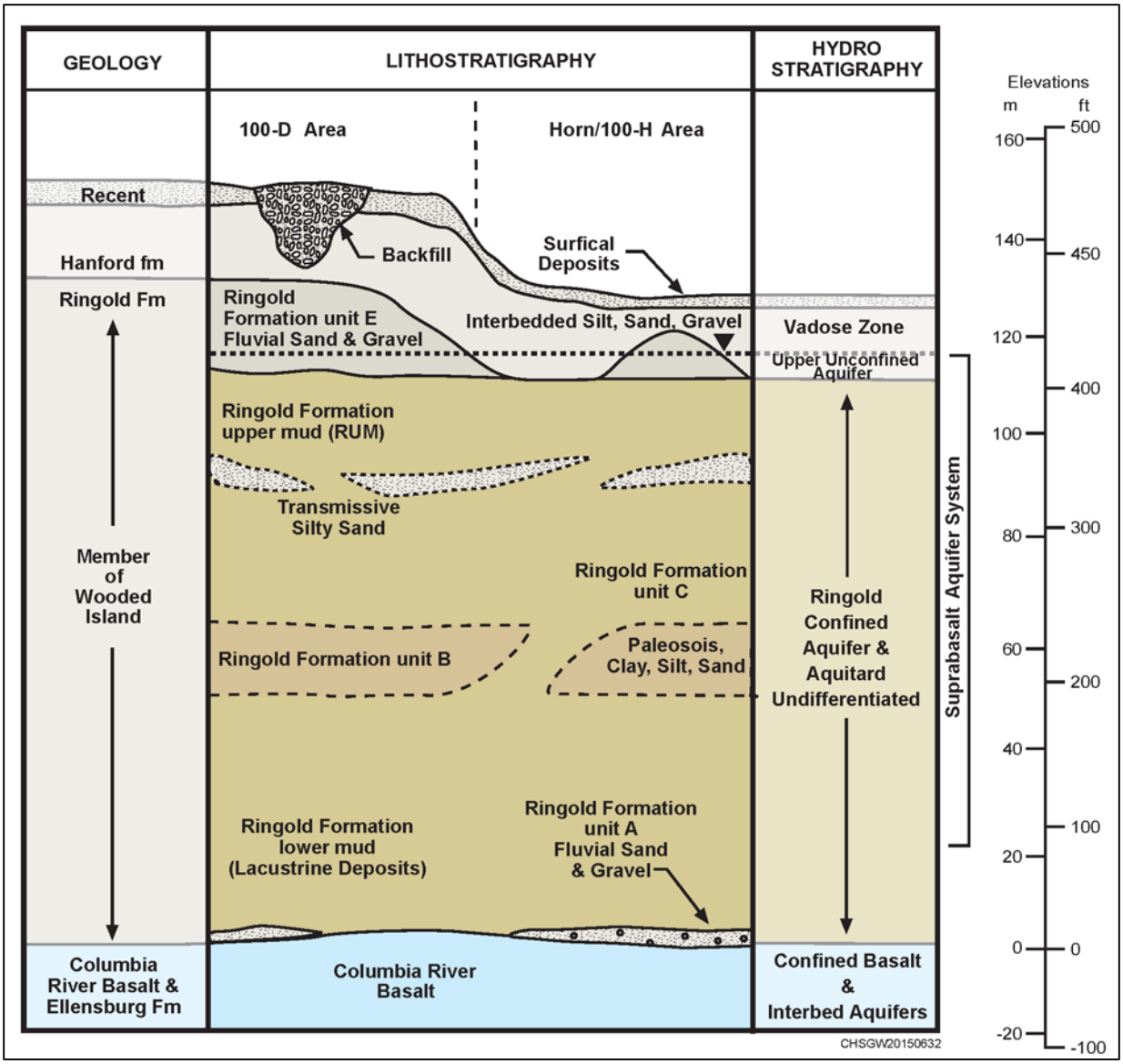

Figure 1-3. Conceptual Hydrogeologic Cross-Section from West to East of the 100-HR-3 Operable Unit

Deposits making up the unconfined aquifer at 100-HR-3 include the Hanford formation and Ringold Formation unit E. 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. Ringold Formation unit E is a denser, compact, and well graded formation versus the looser, coarser-grained Hanford gravel-dominated facies. Ringold Formation unit E 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 elevation and the surface of the RUM, which forms the base of the unconfined aquifer. Aquifer thickness is greatest where the RUM surface has dips, forming what appear to be scour channels (Figure 1-4).

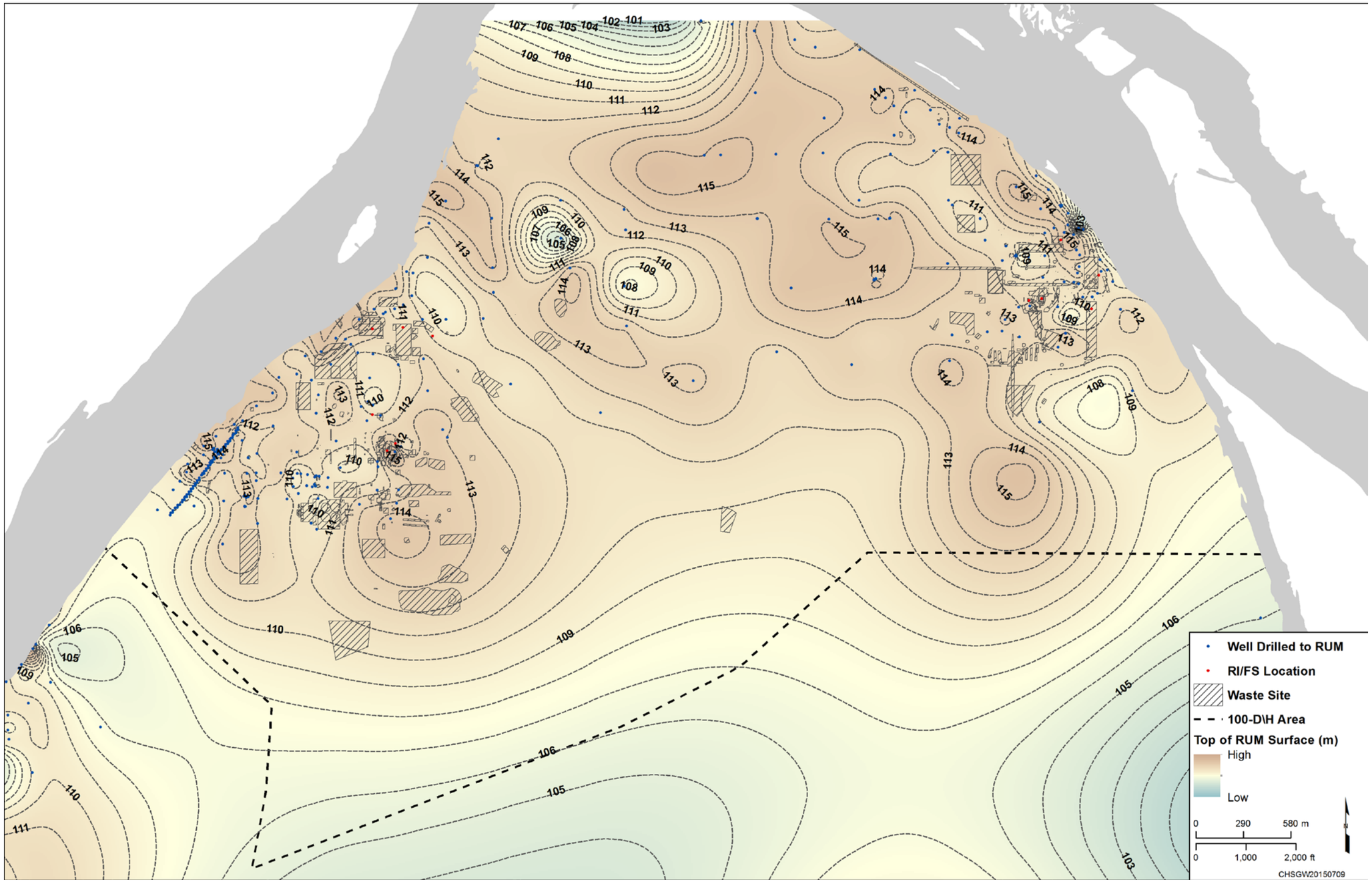

Figure 1-4. RUM Surface Contours

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The unconfined aquifer thickness at 100-HR-3 generally thins from west to east, from 100-D toward 100-H, with the thinnest areas found in the northern area of the Horn. Thickness of the unconfined aquifer ranges from near 0 to 12 m (39 ft) across the area. The thickness of the unconfined aquifer mimics the RUM 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 report (DOE/RL-2010-95).

At 100-D, the unconfined aquifer is primarily within the Ringold unit E, overlain by the Hanford formation. During historical reactor operations, the cooling water recharge mounds raised the water table above the top of the Ringold unit E 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 Ringold unit E present. At 100-H, Ringold unit E 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). More recent geologic information has indicated that Ringold unit E is present in small areas of 100-H (ECF-HANFORD-13-0020, *Process for Constructing a Three-dimensional Geologic Framework Model of the Hanford Site 100 Area*). Therefore, while the dominant geologic unit of the unconfined aquifer is the Hanford formation, small areas are present where the unconfined aquifer is within the Ringold unit E.

RUM 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 silt- and clay-rich RUM has low hydraulic conductivity values relative to the Hanford formation and Ringold Formation unit E. RUM is considered an aquitard and forms the base of the unconfined aquifer. Within RUM, thin sand-to-gravel layers form zones with variable hydraulic conductivities that range from low to high and form confined or semiconfined aquifers. This confined or semiconfined aquifer is the first water bearing RUM unit, bounded by the silt and clay of RUM to the top, and by either a continuation of the RUM or Ringold lower mud unit at the bottom. The presence of a nontransmissive layer consisting of silt or clay material defines the lower boundary of the aquifer.

The RUM first water bearing unit is confined to semiconfined and described as a very fine to fine grained sand unit (100-D/H RI/FS report [DOE/RL-2010-95]). This unit may occur as a discontinuous or continuous sand layer across 100-HR-3, 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 unit in the area inland of the H Reactor (SGW-47776, *Aquifer Testing and Rebound Study in Support of the 100-H Deep Chromium Investigation*). Near the river, the RUM first water bearing unit appears to be semiconfined to confined and isolated from the overlying unit. In wells completed in this unit near the river, the groundwater exhibits rapid, nearly simultaneous head changes that coincide directly with river stage fluctuations. The inland wells do not exhibit simultaneous responses to river stage changes but are responsive to head changes in the overlying unconfined unit, indicating that the unit identified as the first water bearing RUM unit in the inland area of 100-H may not be in direct hydraulic communication with the similar unit near the river.

The RUM first water bearing unit is approximately 0.5 to 7 m (1.6 to 23 ft) thick and occurs at elevations ranging from approximately 95 to 105 m (312 to 345 ft) above mean sea level (NAVD88, *North American Vertical Datum of 1988*). Groundwater levels in this unit respond to changes in river stage. 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.

Three wells (699-97-48C, 699-97-45B, and 699-97-43C) are completed within the first water bearing RUM unit near the Horn. The first water bearing unit within RUM in this area is semiconfined to confined, based on its observed piezometric head being higher than the overlying shallow unconfined unit in some areas. The first water bearing unit within the RUM is otherwise not well defined in this area.

1.2.2 Groundwater Flow

Under natural gradient conditions, groundwater in the southern portion of 100-D generally flows to the west toward the Columbia River. In northern 100-D, the gradient changes to a northwesterly direction, with groundwater flow inland being more westerly, moving across the Horn Area towards 100-H. In 100-H, the natural groundwater gradient is towards 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 towards the 100-H Area.

Figures 1-5 and 1-6 present March groundwater flow maps showing a mid-period river stage period, 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 groundwater gradients and Cr(VI) plumes during low and high river stage are presented on Figures 1-7 through 1-10. The effect of the P&T system is noticeable where groundwater depressions are present around some DX 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 affect groundwater flow in 100-HR-3. Longer term changes in the river stage produce more extensive and longer lived changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer. During 2013, the higher river stage during the summer months was less pronounced than in the previous two years, resulting in little to no groundwater flow reversal effect during higher river conditions (Figures 1-7 and 1-8). During high river stage, the effect of river water migrating into the aquifer can cause lower contaminant concentrations in aquifer tubes and in some near river wells. However, since the groundwater flow reversal effect was muted during 2013, seasonal changes in contaminant concentrations due to near-shore mixing also were muted. The result was higher concentrations near the river for more of the year in comparison to previous years. Groundwater flow directions at lower river conditions are shown in Figures 1-9 and 1-10.

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 affect that the seasonal river stage changes have on contaminant concentrations in 100-HR-3, both low river and high river stage monitoring data, including water level data, are used to evaluate capture of the contaminant plume.

Horizontal gradients and groundwater velocities are detailed in the 100-D/H RI/FS report (DOE/RL-2010-95). Results of the three-point gradient analysis suggest geographic variations in average hydraulic gradients that can be broadly grouped in 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 2011, hydraulic gradients varied in magnitude from approximately 0.0014 to 0.0023 for the period May through August, and from approximately 0.0017 to 0.0031 for September through April. The gradient direction was to the north/northwest toward the Columbia River for most of the year; however, gradients shifted to the north/northeast from May through August 2011, coinciding with high stage in the Columbia River.

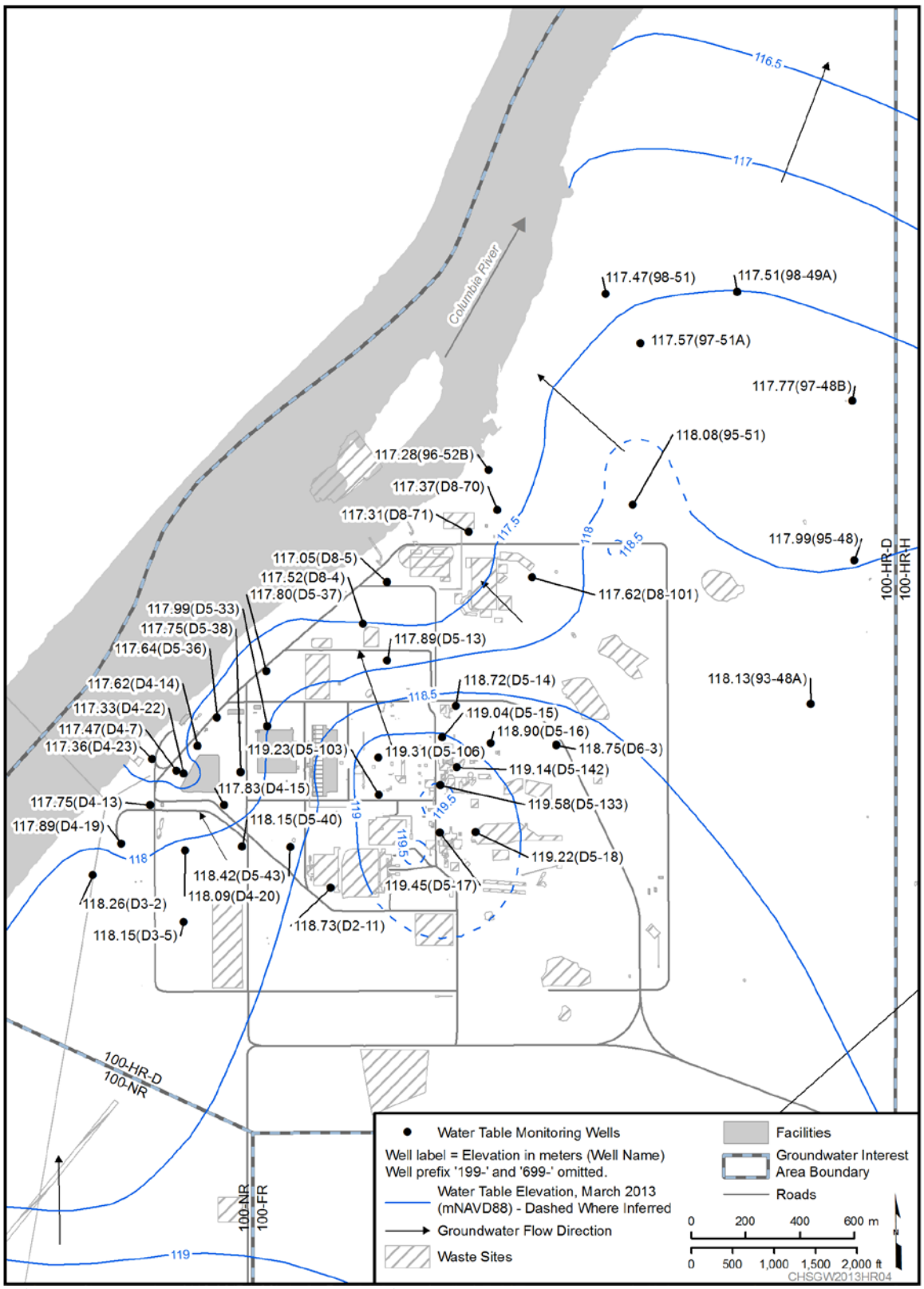
In the area near 100-H during 2011, hydraulic gradients varied in magnitude from about 0.0014 to 0.0036, for the period of May through August, and from approximately 0.0015 to 0.0046 for September through April. The gradient direction was generally north/northeast toward the Columbia River; however, gradients shifted to the south/southeast from May through August 2011, coinciding with high stage in the Columbia River.

During 2011 in the Horn Area, hydraulic gradients were difficult to enumerate because of widely varying monitoring frequencies at the wells that formed the boundaries of the gradient elements. Available data indicate that areas relatively close to the shore of the Columbia River varied in azimuth depending on river stage. The azimuth ranged from north/northwest during times of very low river stage (that is, toward the Columbia River at the northern side of 100-D), to south/southeast (that is, away from the Columbia River) during times of very high river stage, with periods of relatively flatter gradients to the west and west/southwest at times of intermediate river stage. At locations farther from the Columbia River, gradients appear to be more systematically to the west across the Horn.

1.2.3 Sources of Groundwater Contamination

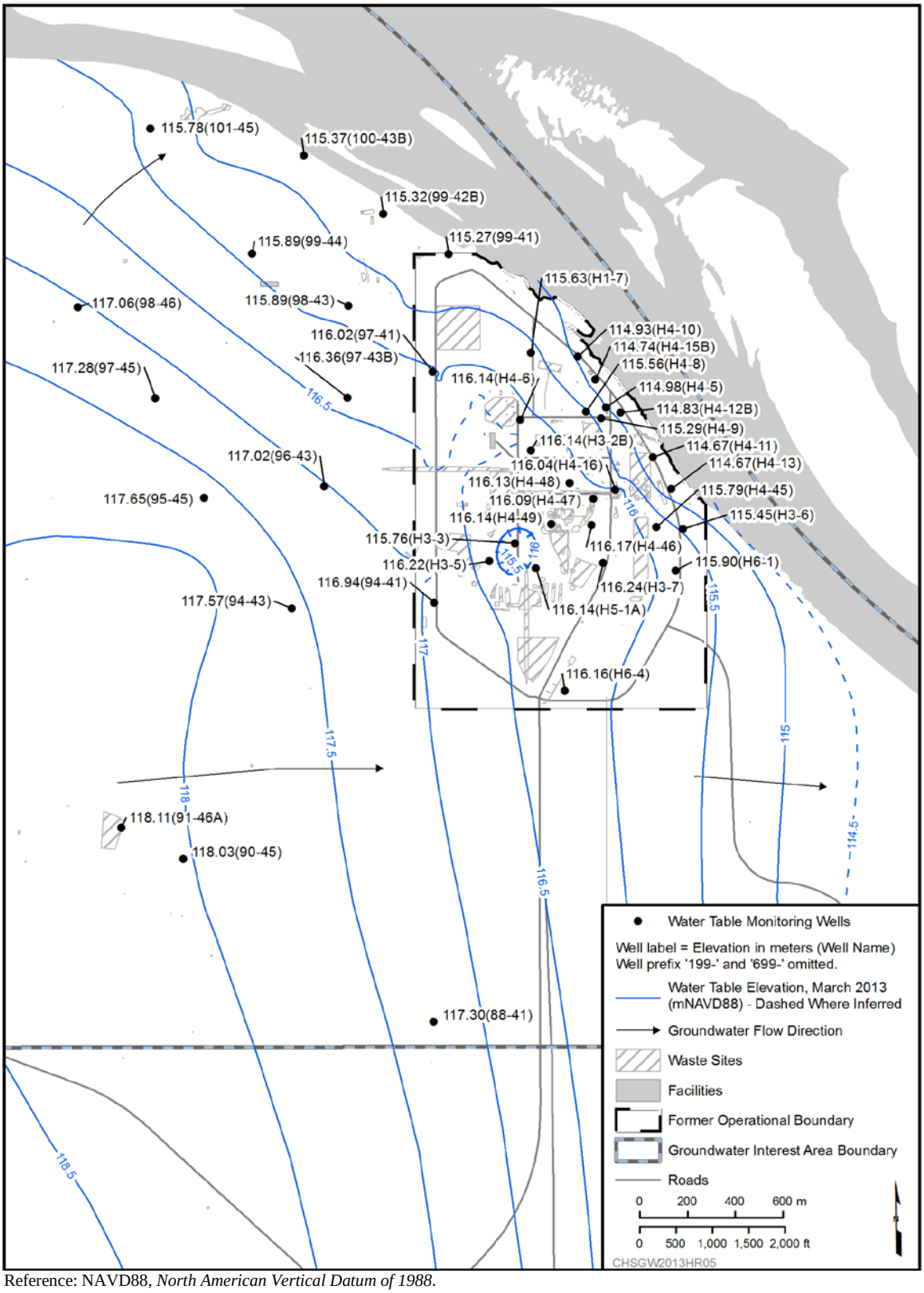
Three plutonium production reactors (105-D, 105-DR, and 105-H) operated in the 100-D/H Area (Figure 1-2). The operation of these reactors required a continuous supply of high quality cooling water during operations. Each reactor used on average (over reactor operating lifetime) about 95,000 L/min (25,000 gal/min) of cooling water (100-D/H RI/FS report [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. Locations where sodium dichromate was handled during operations in the 100-D and 100-H Areas are shown on Figures 1-11 and 1-12, respectively.

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, cribs, and trenches. 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 or other engineered structures, and was allowed to infiltrate directly into the soil column. These practices 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*).



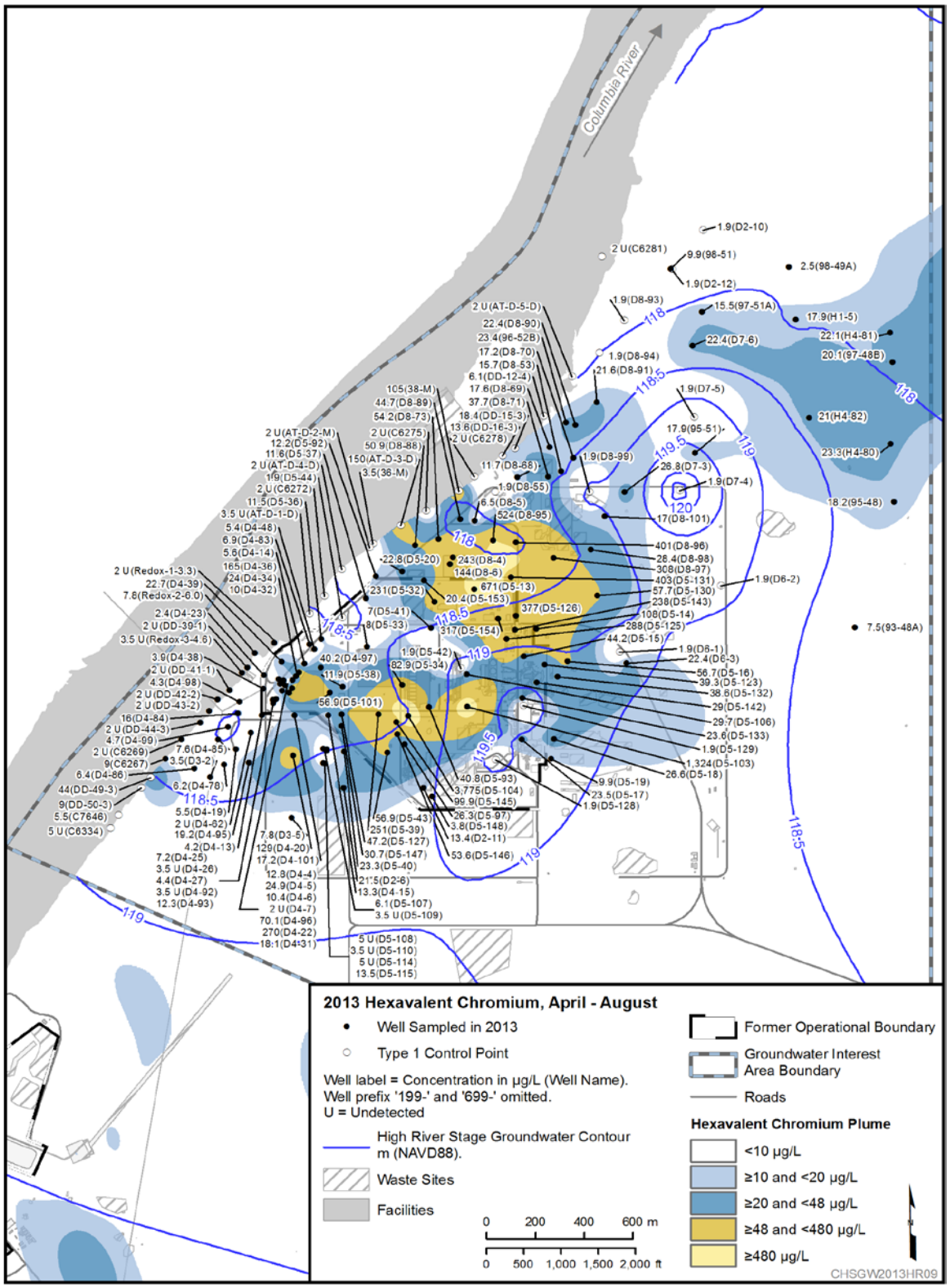
Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 1-5. 100-HR-3 Operable Unit, 100-D Area Overview Map and Water Table



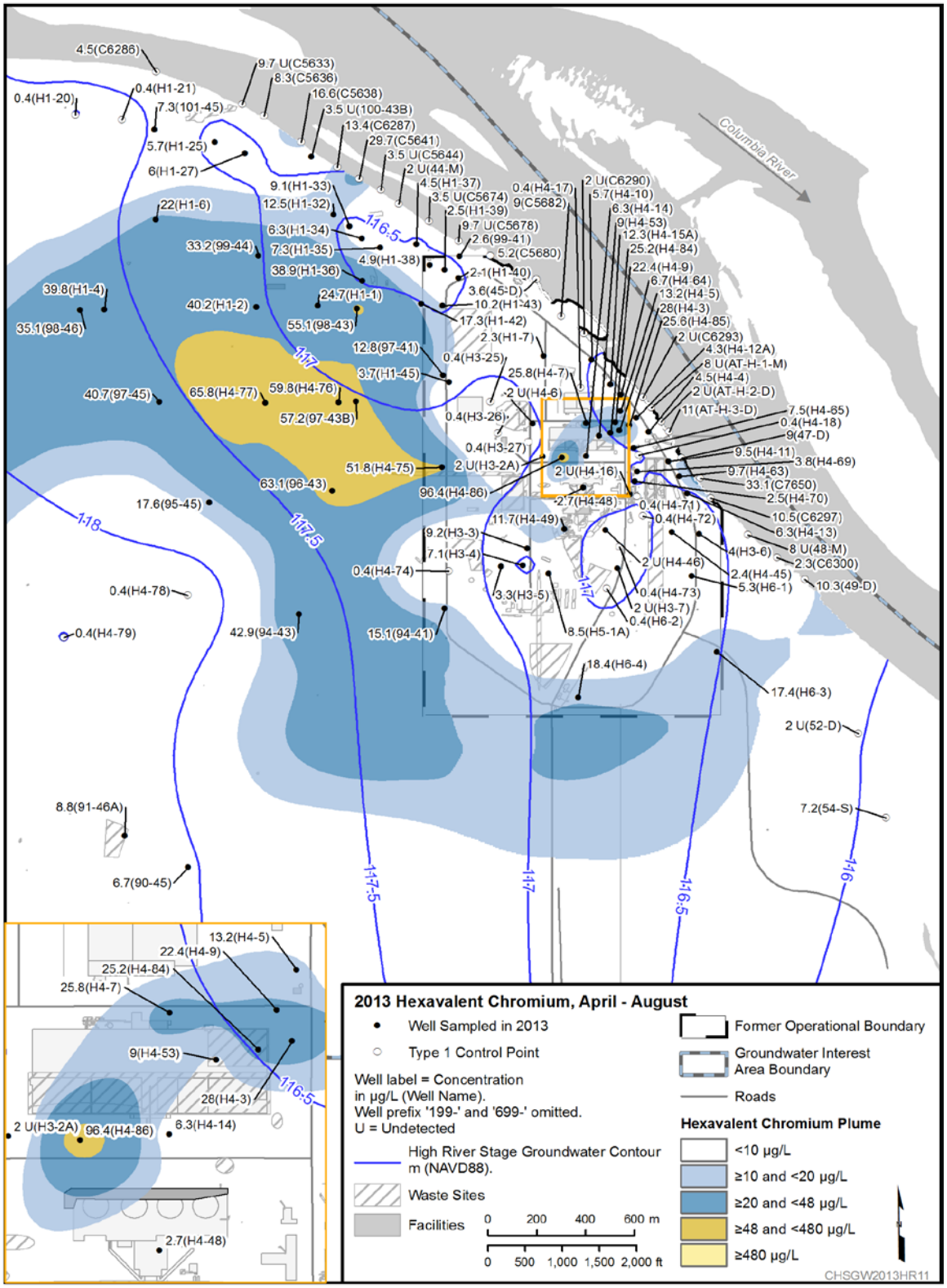
Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 1-6. 100-HR-3 Operable Unit, 100-H Area Overview Map and Water Table



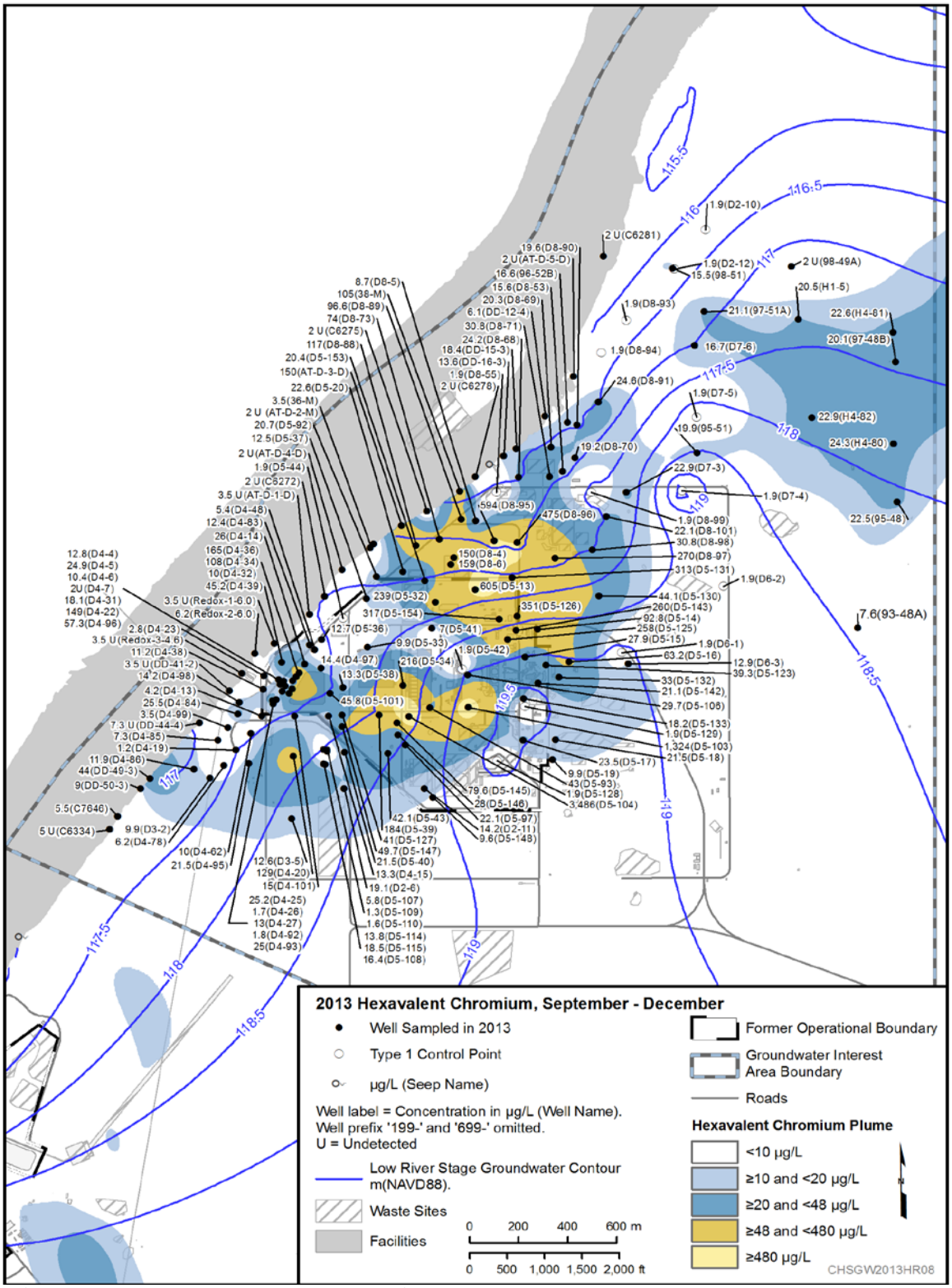
Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 1-7. 100-HR-3 Operable Unit, 100-D Area Groundwater Contours and Hexavalent Chromium Concentrations at High River Stage



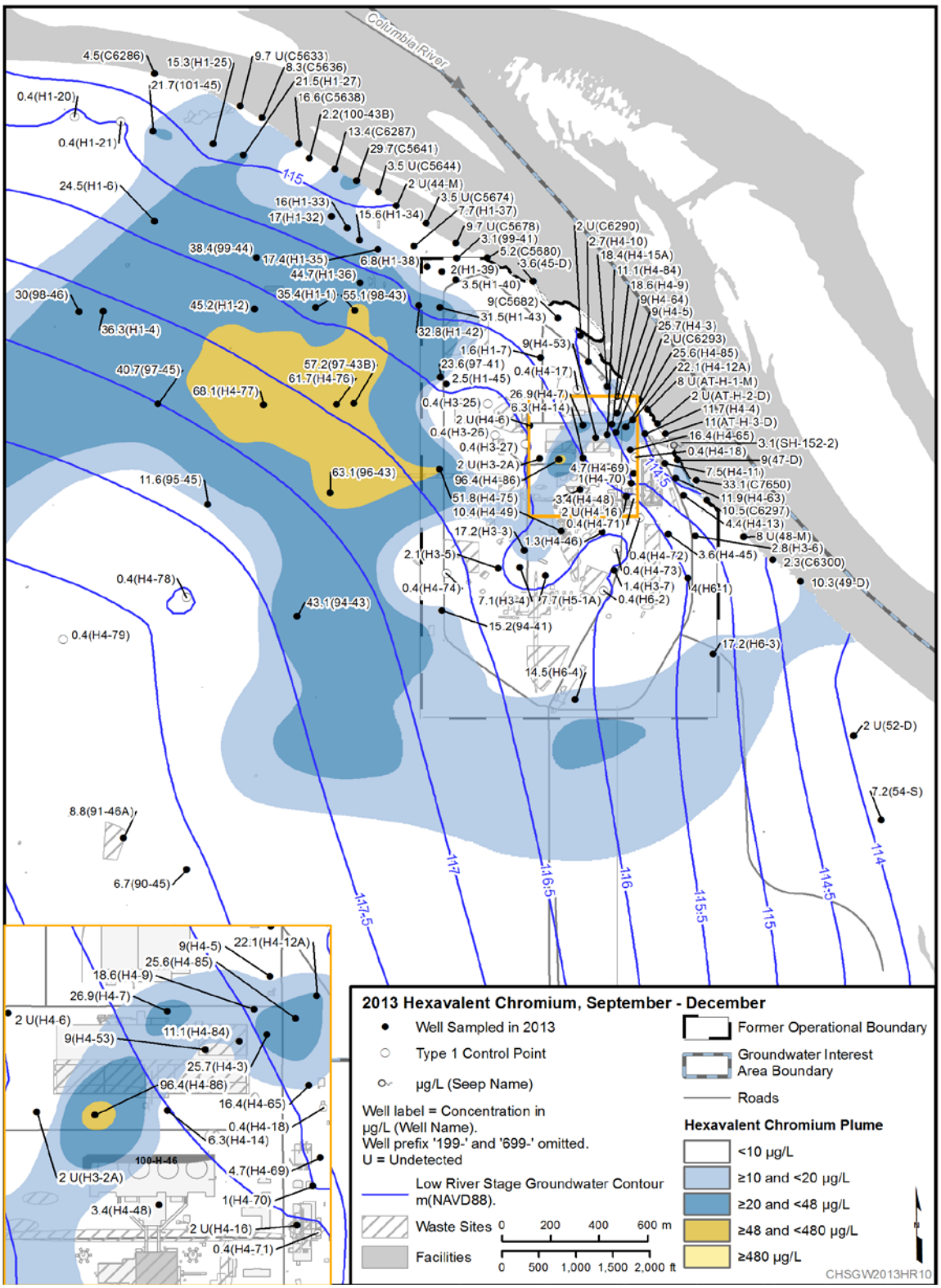
Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 1-8. 100-HR-3 Operable Unit, 100-H Area Groundwater Contours and Hexavalent Chromium Concentrations at High River Stage



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

Figure 1-9. 100-HR-3 Operable Unit, 100-D Area Groundwater Contours and Hexavalent Chromium Concentrations at Low River Stage



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

Figure 1-10. 100-HR-3 Operable Unit, 100-H Area Groundwater Contours and Hexavalent Chromium Concentrations at Low River Stage

Cooling water picked up other contaminants during passage through the reactors, including strontium-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 strontium-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*; and BHI-00127, *100-H Area Technical Baseline Report*); however, the leak rate was small, and the leak location was never identified. Locations that discharged water to the vadose zone in the 100-D Area represent potential strontium-90 sources (Figure 1-11). Figure 1-13 presents potential strontium-90 source locations in the 100-H Area.

Sanitary liquid waste was routed by sewer lines to septic systems. Five septic systems were in 100-D, and four were in 100-H. There are no records of radiological waste being disposed to these systems; however, detergents, cleaning compounds, and solvents may have been disposed to these systems. 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 local 100-D/H nitrate contamination in groundwater. The facilities and pre-Hanford Site agricultural lands where nitrate was known to be present at 100-D and 100-H, based on historical information, are presented on Figures 1-14 and 1-15.

Contaminant sources in the vadose zone have primarily been remediated through excavation activities. Cr(VI) in groundwater is being actively remediated by the P&T systems. Nitrate contamination in the groundwater remains only in small localized areas and is also captured by the P&T systems. Other contaminants in groundwater include strontium-90, tritium, and uranium.

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) (DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). Cr(VI) plumes are depicted during 2013 high and low river stage on Figures 1-7 to 1-10. Strontium-90 and nitrate plumes are smaller and reside within the footprint of the Cr(VI) plumes. Figures 1-16 to 1-19 show strontium-90 and nitrate plumes for the 100-D and 100-H Areas.

1.3 Data Quality Objective Summary

The DQO process was conducted to support identification of sampling requirements. Participants included a DOE appointed panel, DOE representatives, and the primary groundwater contractor. Ecology was not a participant during the DQO process. Appendix A presents the DQO process followed for this SAP and its resulting application to refine the well network and focus the sampling requirements. This DQO process was to support optimization of the groundwater monitoring network for the 100-HR-3 OU for the interim action ROD (EPA/ROD/R10-96/134) until a final ROD is obtained.

1.4 Contaminants

Table 1-1 identifies specific contaminants identified in the 100-HR-3 OU for CERCLA groundwater monitoring. The contaminants listed are those identified in the interim action ROD (EPA/ROD/R10-96/134) and 100-D/H RI/FS report (DOE/RL-2010-95). Table 1-1 also identifies additional field parameters that will be measured concurrent with contaminant sampling.

1.5 Project Schedule

This SAP will direct CERCLA monitoring activities needed for the 100-HR-3 OU until a final ROD is approved. Upon issuance of a final ROD for the 100-HR-3 OU, a new SAP will be developed and issued in association with preparation of the RAWP. The sampling schedule will be established through *Sample*

Management Integrated Lifecycle Environment (SMILE), which optimizes the overall number of well trips and limits schedule redundancy. SMILE allows for the tracking of overlapping requirements so single well trips can co-sample wells and optimize schedules.

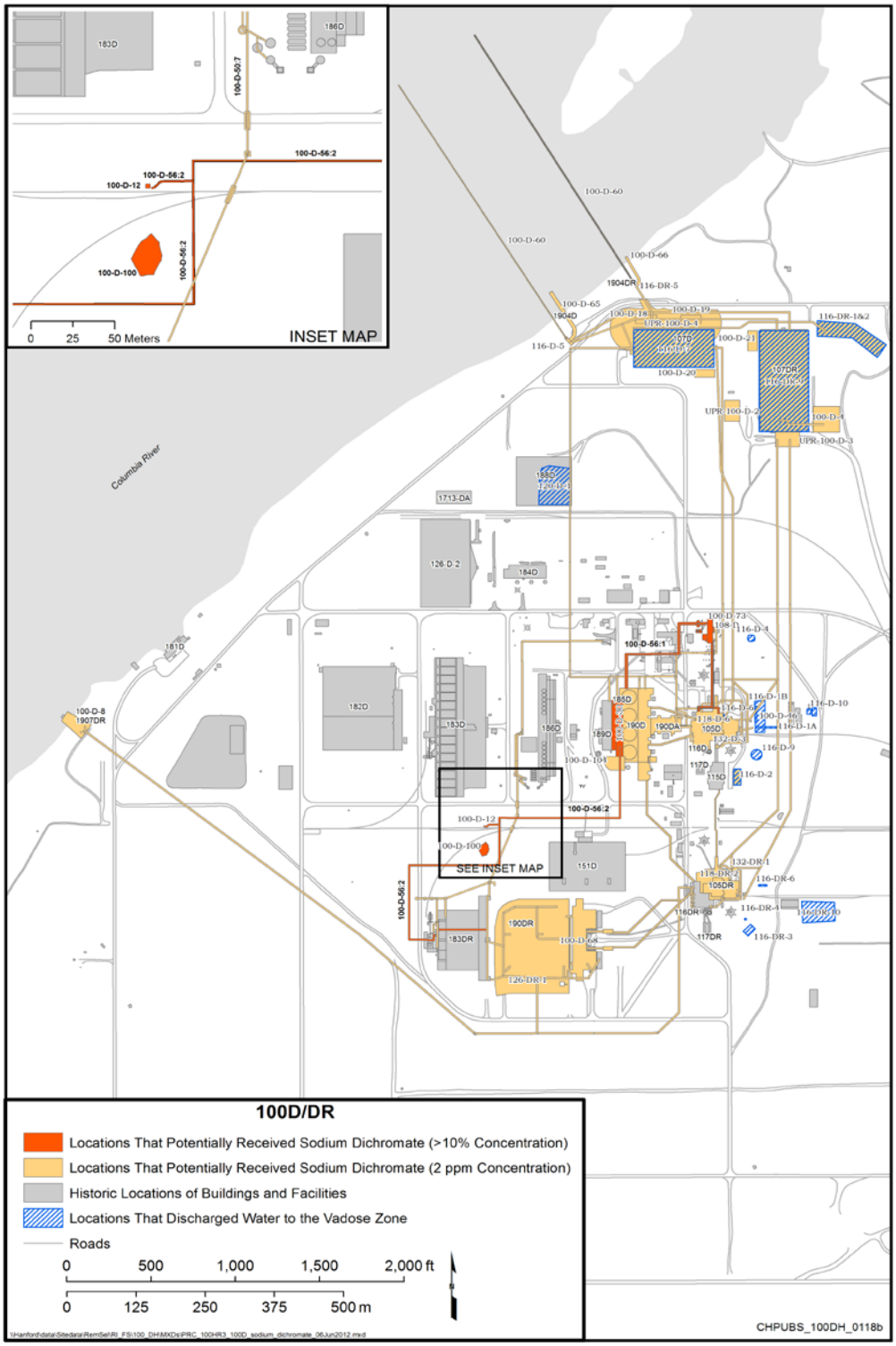


Figure 1-11. Locations in the 100-D Area Where Sodium Dichromate was Handled

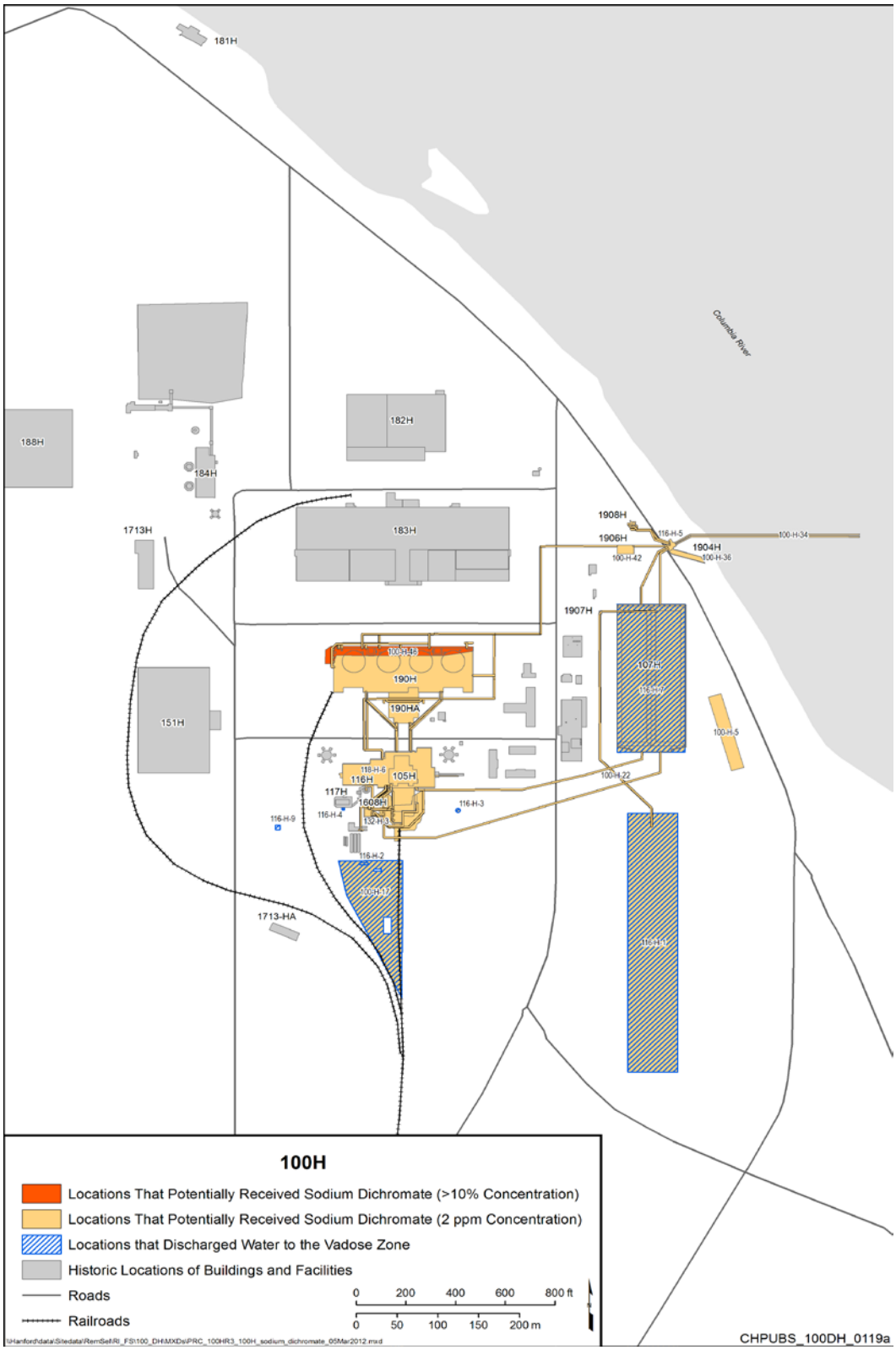


Figure 1-12. Locations in the 100-H Area Where Sodium Dichromate was Handled

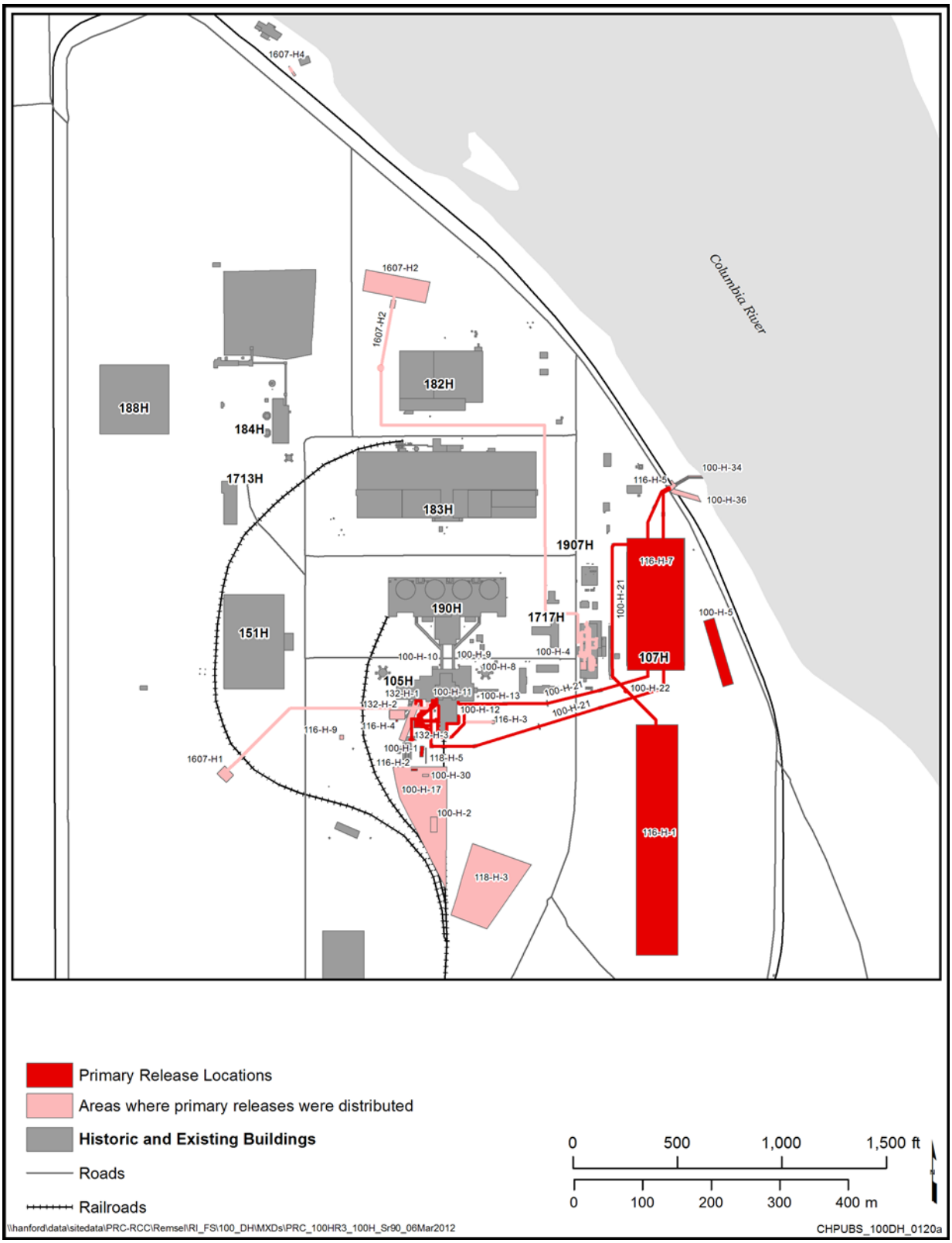


Figure 1-13. Potential Strontium-90 Sources in the 100-H Area

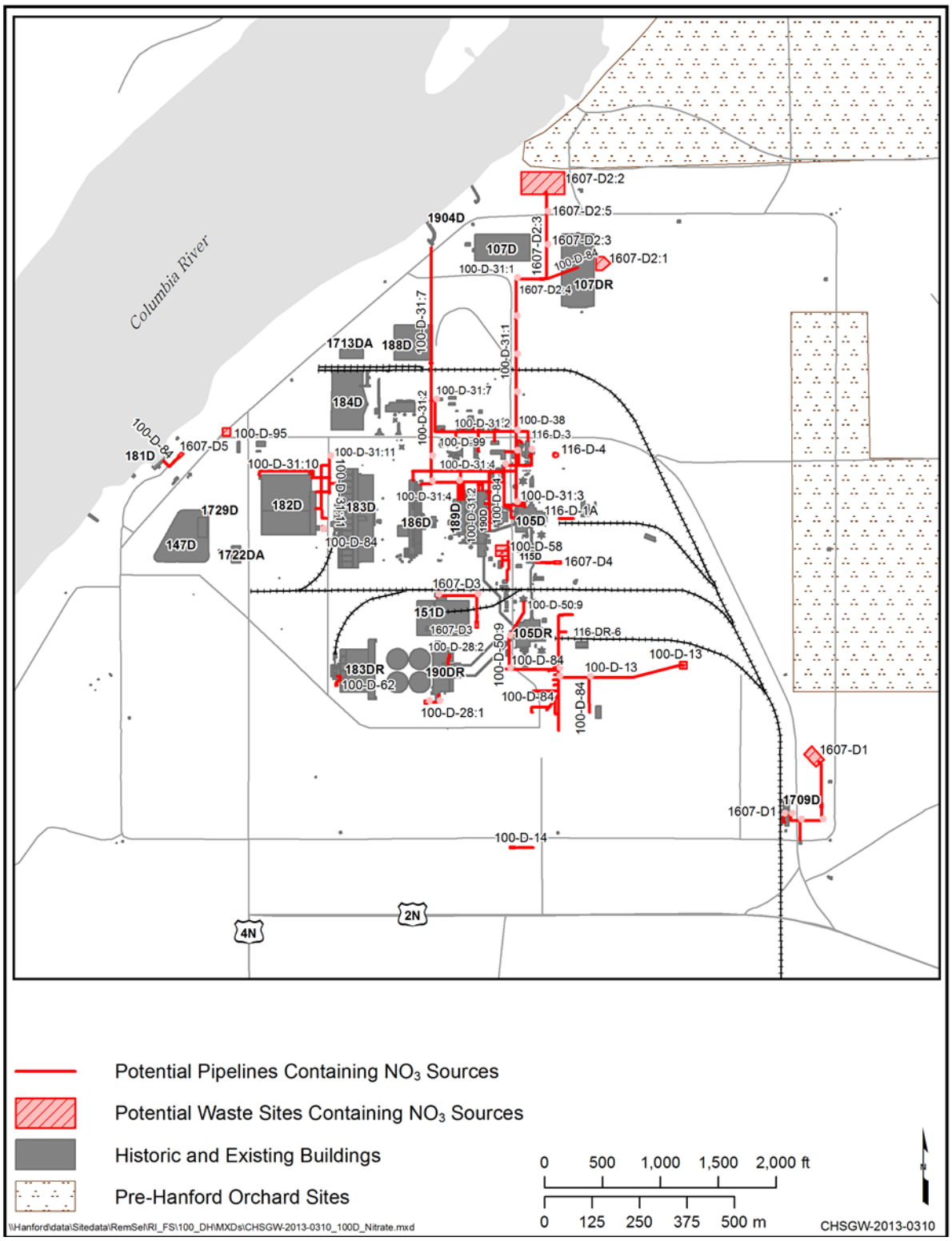


Figure 1-14. Potential Nitrate Sources in the 100-D Area

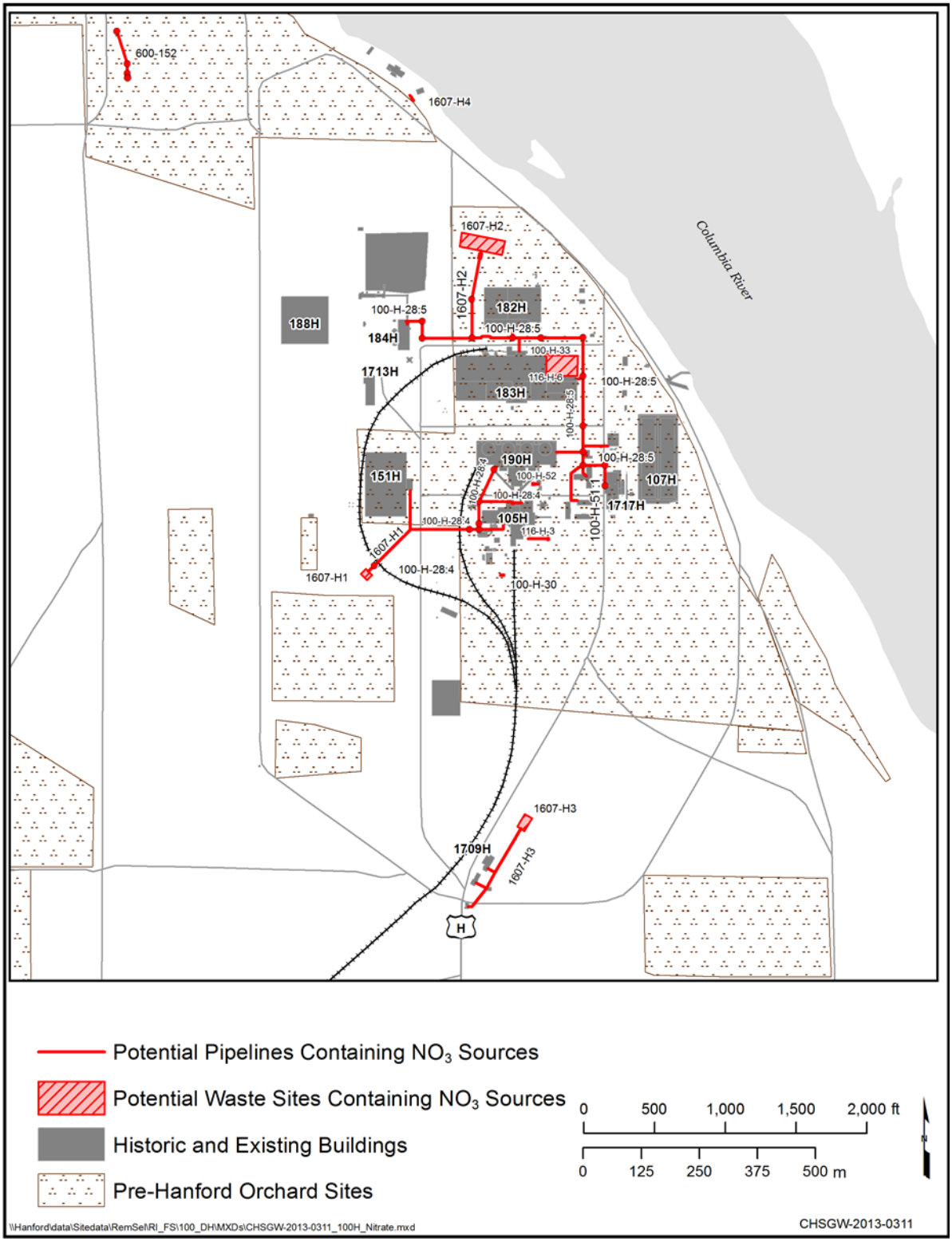


Figure 1-15. Potential Nitrate Sources in the 100-H Area

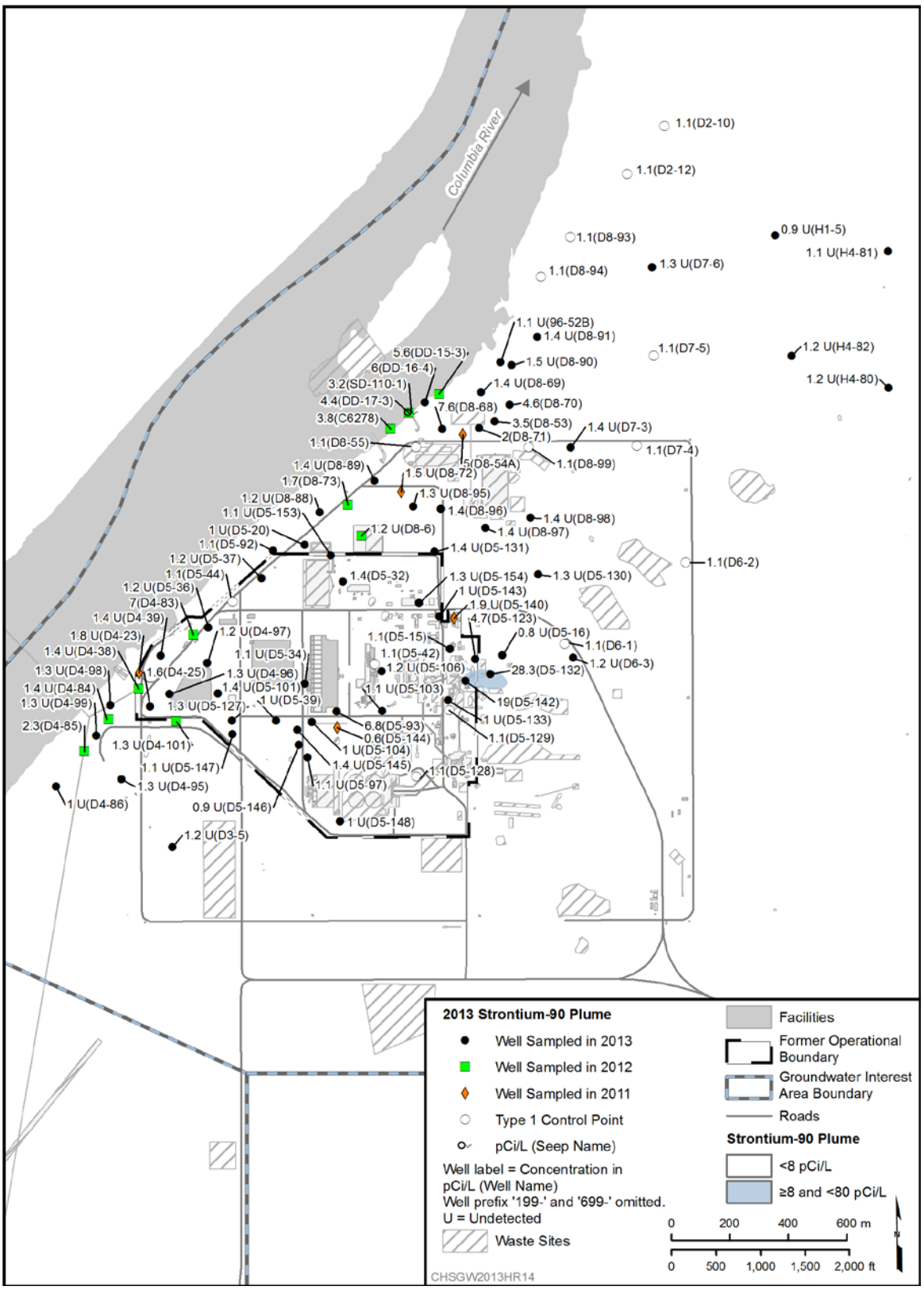


Figure 1-16. Strontium-90 Plumes in the 100-D Area

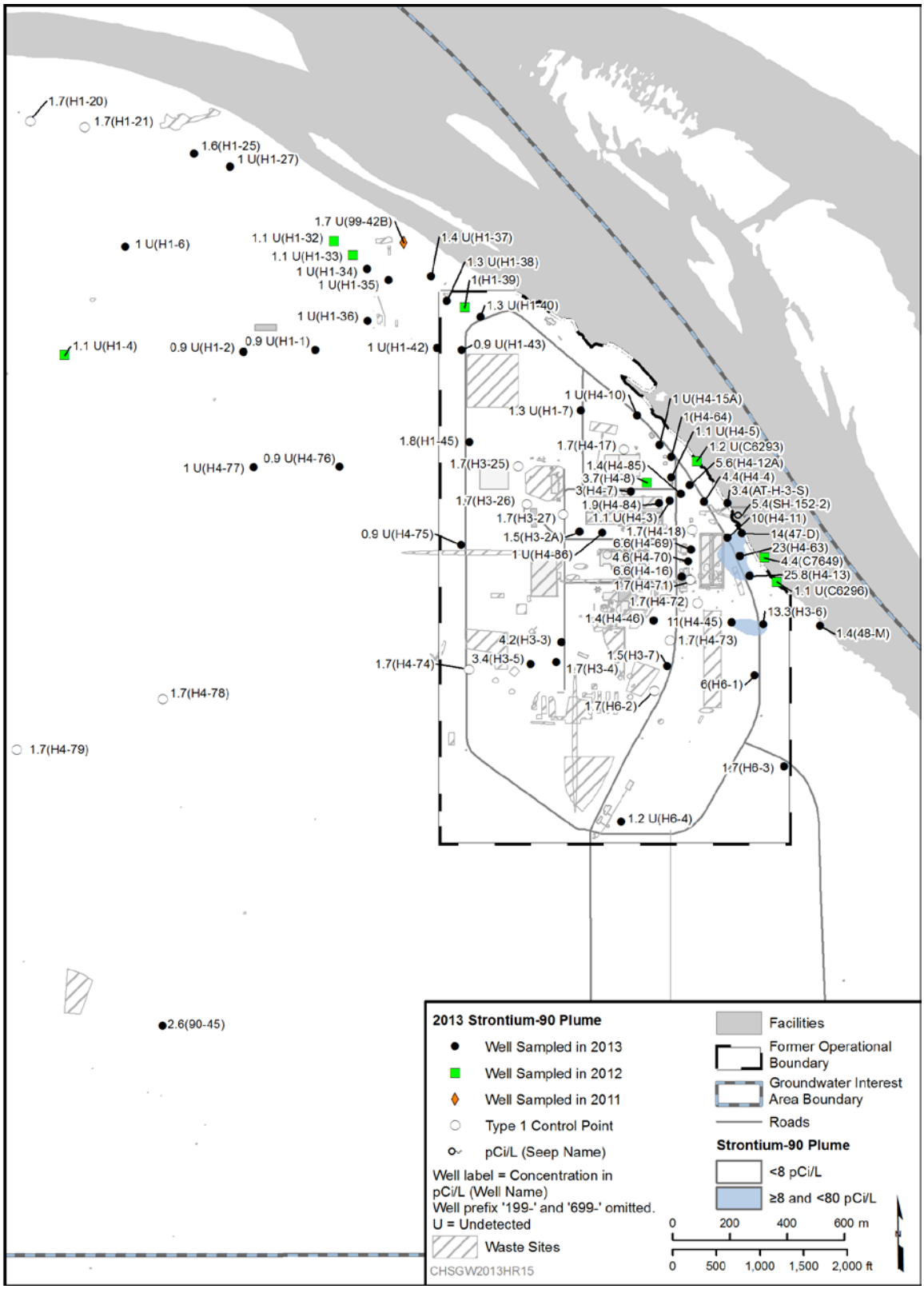


Figure 1-17. Strontium-90 Plumes in the 100-H Area

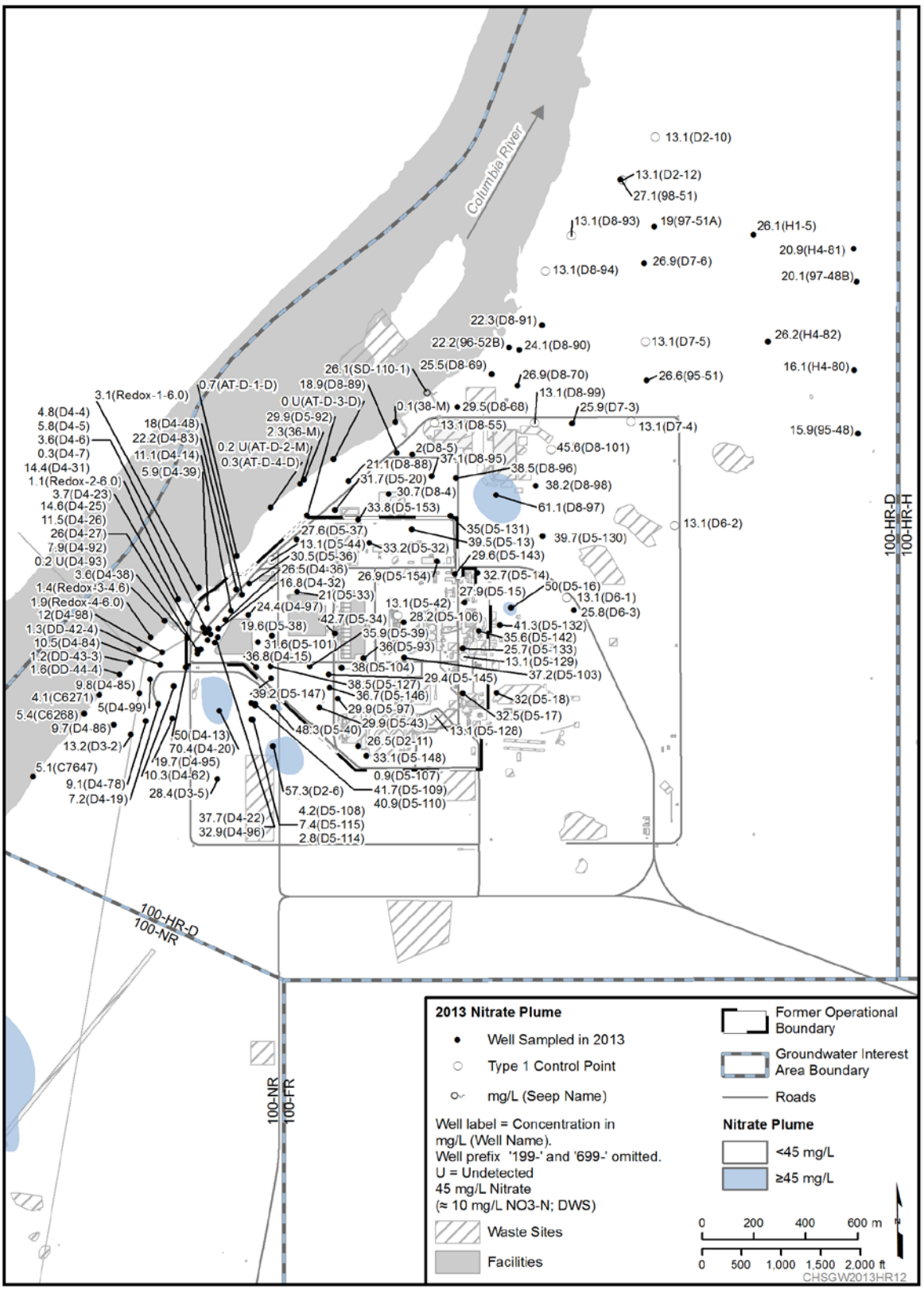


Figure 1-18. Nitrate Plumes in the 100-D Area

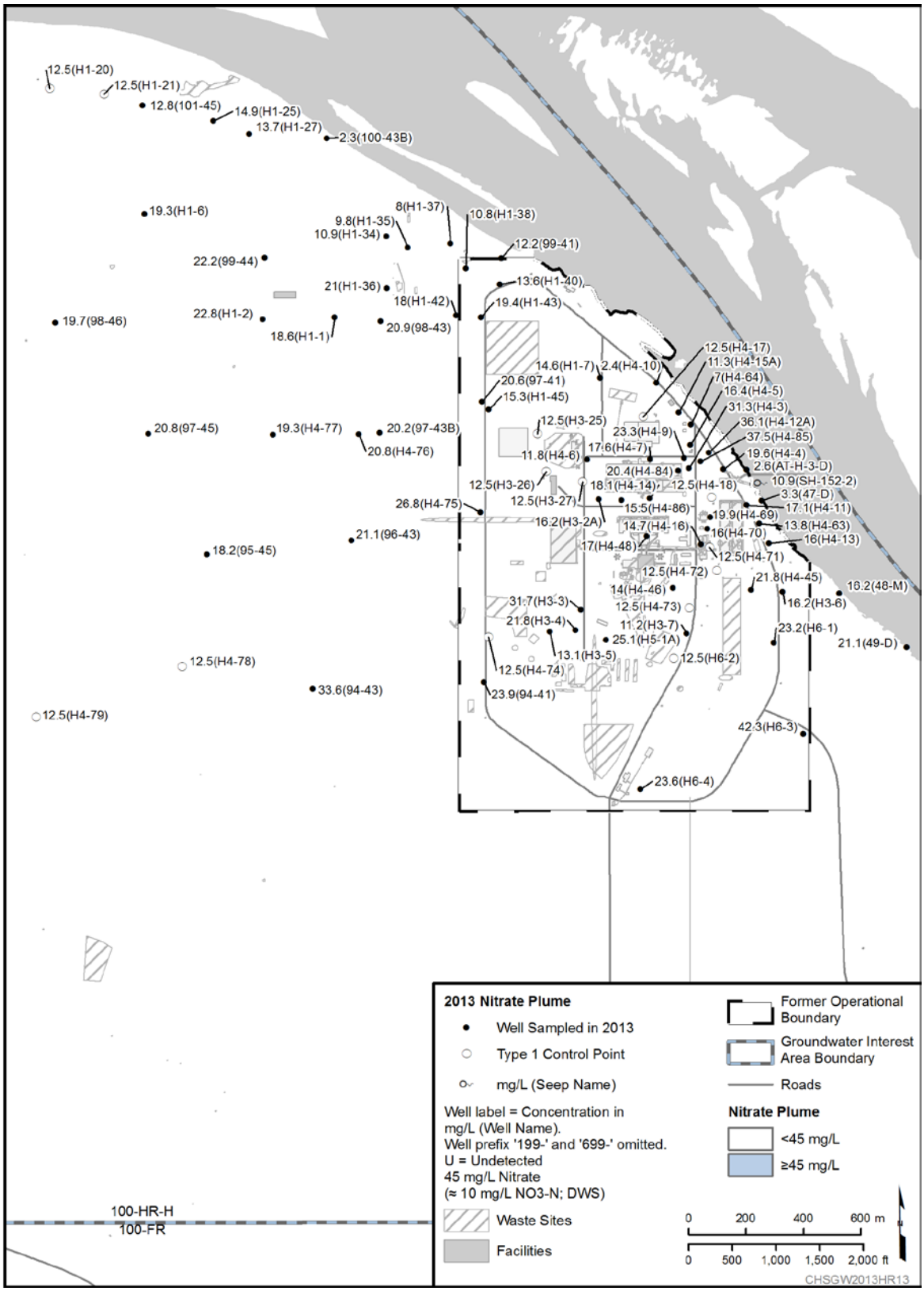


Figure 1-19. Nitrate Plumes in the 100-H Area

Table 1-1. Analytes for 100-HR-3 Groundwater Operable Unit Monitoring

Contaminant	Chemical Abstracts Service Number
Inorganics – Metals	
Antimony	7440-36-0
Cadmium	7440-43-6
Chromium (Total)	7440-47-3
Chromium (Hexavalent)	18540-29-9
Cobalt	7440-48-4
Copper	7440-50-8
Iron	7439-89-6
Lead	7439-92-1
Manganese	7439-96-5
Silver	7440-22-4
Uranium	7440-61-1
Zinc	7440-66-6
Inorganics – Anions	
Fluoride	16984-48-8
Nitrate	14797-55-8
Nitrite	14797-65-0
Sulfate	14808-79-8
Radionuclides	
Strontium-90	10098-97-2
Technetium-99	14133-76-7
Tritium	10028-17-8

Table 1-1. Analytes for 100-HR-3 Groundwater Operable Unit Monitoring

Contaminant	Chemical Abstracts Service Number
Field Measurements	
Dissolved Oxygen	Not Applicable
Oxidation Reduction Potential	Not Applicable
pH	Not Applicable
Specific Conductance	Not Applicable
Temperature	Not Applicable
Turbidity	Not Applicable
Depth to Groundwater	Not Applicable

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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, and laboratory analysis. This QAPjP complies with requirements from the following documents:

- DOE O 414.1D Admin Chg 1, *Quality Assurance*
- 10 CFR 830, "Nuclear Safety Management," Subpart A, "Quality Assurance Requirements"
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5)
- EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5)
- Ecology Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*
- TPA Action Plan (Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*, Sections 6.5 and 7.8)

This chapter describes applicable quality requirements and controls. Sections 6.5 and 7.8 of the TPA Action Plan (Ecology et al., 1989b) require quality assurance (QA)/quality control (QC) and sampling and analysis activities to specify QA requirements for treatment, storage, and disposal units, as well as for past practice processes. Therefore, this QAPjP follows the QA elements of EPA/240/B-01/003 and EPA/240/R-02/009. This QAPjP demonstrates conformance to Part B requirements of ANSI/ASQC E4-1994, *Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs*, and complies with Ecology guidance on QAPjPs (Ecology Publication No. 04-03-030).

This QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to Hanford Site OU groundwater monitoring activities: Project Management, Data Generation and Acquisition, Assessment and Oversight, and Data Validation and Usability.

2.1 Project Management

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

2.1.1 Project/Task Organization

The contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, and shipping samples to the laboratory. The project organization is illustrated in Figure 2-1. The project organization related directly to sampling and analysis is described in the following subsections. The remaining areas of the organization, including the P&T system operation and drilling operations, are described in the operations and maintenance (O&M) plan (DOE/RL-2013-49) and RD/RAWP (DOE/RL-2013-31).

2.1.2 DOE Lead Agency (Richland Operations Office)

DOE is the lead agency under CERCLA (delegated by Executive Order 12580, *Superfund Implementation*, the primary authority under Section 104, "Response Authorities," and Section 121, "Cleanup Standards") to conduct removal and remedial actions at DOE facilities. DOE-RL is responsible for remedial actions throughout the Hanford Site and for managing the assigned activities including scope, budget, schedule, quality, personnel, communication, risk/safety, contracts, and regulatory interface. DOE works under regulatory oversight in accordance with CERCLA Section 120, "Federal

Facilities," as implemented through the TPA (Ecology et al., 1989a). DOE obtains Congressional funding for these functions.

2.1.3 Lead Regulatory Agency (Ecology)

Ecology is the lead regulatory agency (LRA) for CERCLA remediation activities at the 100-HR-3 OU, as described in the TPA (Ecology et al., 1989a). The LRA is responsible for regulatory oversight of cleanup projects and activities. The LRA has SAP approval authority for the OUs they manage. The LRA works with DOE-RL to resolve concerns over the work described in this SAP in accordance with the TPA.

2.1.4 Remediation Contractor

CH2M HILL Plateau Remediation Company is the prime contractor responsible for implementing CERCLA remediation activities at the 100-HR-3 OU. Company organizations that provide functional and operational support for remediation activities are described in the following subsections.

2.1.4.1 Environmental Program and Strategic Planning and Environmental Compliance Officer

The Environmental Compliance Officer (ECO), within the Soil and Groundwater Remediation Project (S&GRP) is part of the Environmental, Safety, Health, and RadCon (ESHR) group and is responsible for the following tasks:

- Providing technical oversight, direction, and acceptance of project and subcontracted environmental work
- Reviewing plans, protocols, and technical documents to ensure that environmental requirements have been addressed
- Identifying environmental issues affecting operations and developing cost effective solutions
- Developing appropriate mitigation measures to minimize adverse environmental impacts
- Responding to environmental/regulatory issues or concerns
- Overseeing project implementation for compliance with applicable internal and external environmental requirements

The Environmental Program and Strategic Planning QA Engineer is responsible for providing independent support for programmatic QA issues on the project. The Environmental Program and Strategic Planning organization is separate from S&GRP, and its general organization structure is presented in Figure 2-1. Responsibilities of the Environmental Compliance and QA group include overseeing implementation of project QA requirements, reviewing project documents, and participating in QA assessments on sample collection and analysis activities, as appropriate.

2.1.4.2 Soil and Groundwater Remediation Project

S&GRP is responsible for management and implementation of remediation activities at the 100-HR-3 OU and coordinating with DOE-RL, Ecology, and Remediation Contractor personnel. The following organizations within S&GRP provide functional and operational support for the remediation activities.

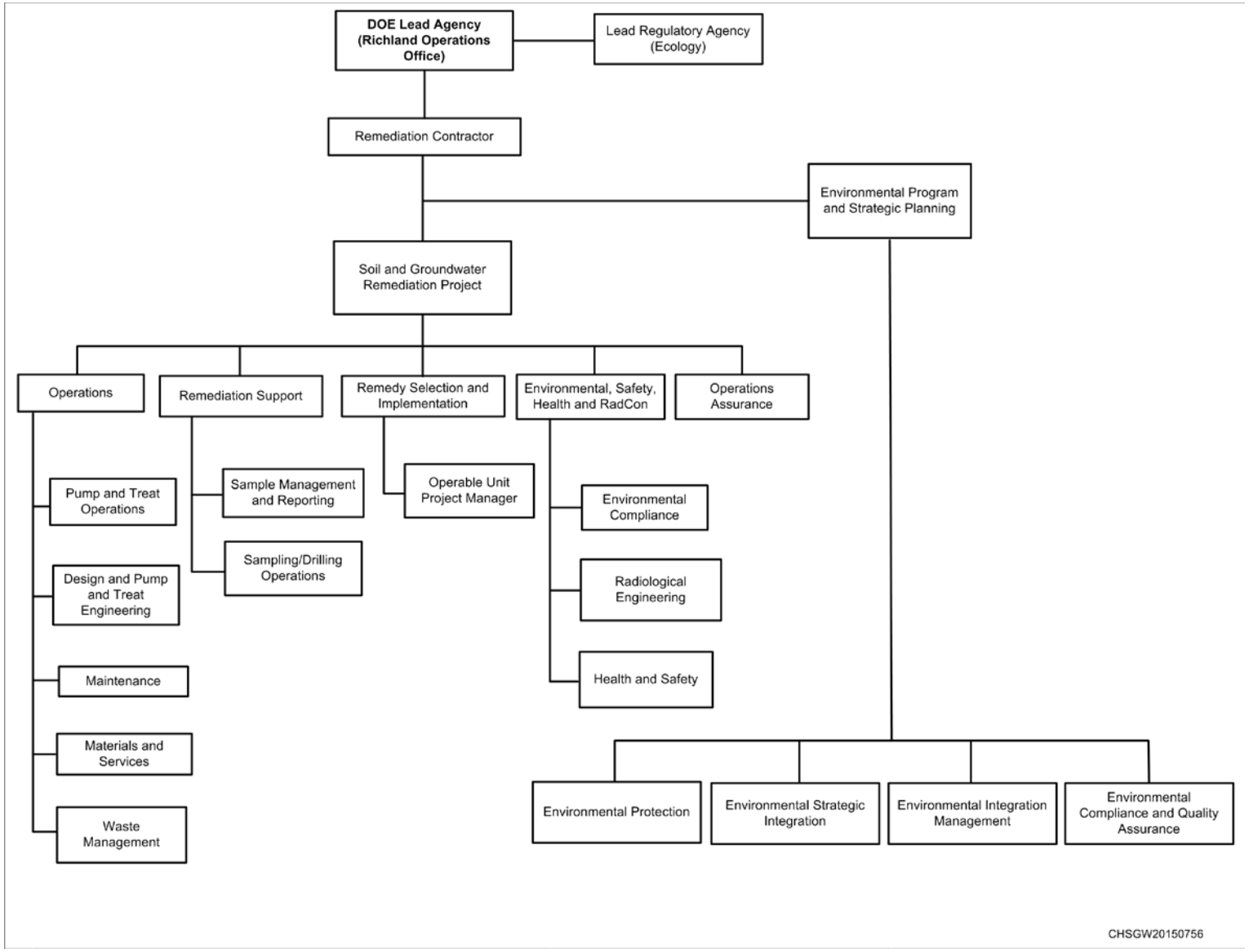

Figure 2-1. Project Organization

2.1.4.3 Operations

The Operations organization is responsible for O&M of P&T systems which includes ensuring that appropriate operations support functions (e.g., radiological protection and safety) are available to support operations activities and verifying that O&M procedures have been prepared, approved (as necessary), and implemented. The Operations organization is provided in the O&M plan (DOE/RL-2013-49).

2.1.4.4 Remediation Support

The Remediation Support organization provides field and technical support to S&GRP. These field activities include groundwater well and investigative borehole drilling, well and borehole decommissioning, environmental sampling, and groundwater well maintenance. The organization also provides environmental sample planning, sample and data management, sample analytical support, and data quality assessment (DQA) services.

2.1.4.5 Sample Management and Reporting Organization

The Sample Management and Reporting (SMR) organization supports three primary work areas: sample data planning, sample and data management, and analytical support. Sample and data planning includes assistance in planning, generating, and reviewing DQO processes and reports, SAPs, sampling instructions, and DQA reports. SMR provides well trip scheduling and optimization using SMILE. The SMR organization also coordinates laboratory analytical work and ensures that laboratories conform to DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD) or equivalent, as approved by DOE and the regulatory agencies. SMR receives analytical data from the laboratories, enters the data into the Hanford Environmental Information System (HEIS) database, and arranges for and oversees data validation. SMR is responsible for informing the OU Project Manager and/or OU technical lead of any issues reported by the analytical laboratories.

2.1.4.6 Sampling/Drilling Operations

The Sampling and Drilling Operations organization provides field sampling, well maintenance, drilling and decommissioning, and well planning support to S&GRP. The field sampling group provides trained and certified personnel to conduct sampling in accordance with HASQRD (DOE/RL-96-68). The well maintenance group is responsible for ensuring that wells remain operable during the life of the well. The well planning group is responsible for preparing and coordinating key documents needed to execute drilling projects safely and provide technical support.

2.1.4.7 Remedy Selection and Implementation

Remedy Selection and Implementation provides direction and oversight for remediation activities and coordinates with DOE-RL, Ecology, and remediation contractor personnel. Remedy Selection and Implementation is responsible for coordinating and evaluating remediation data and ensuring compliance with state and federal laws. The group is also responsible for collecting P&T data and tracking trends to show cleanup performance.

2.1.4.8 Operable Unit Project Manager

The OU Project Manager provides direction and oversight and coordinates with DOE, regulatory, and contractor personnel to support remediation activities. The OU Project Manager is responsible for sampling documents and requirements, field activities, and subcontracted tasks. The OU Project Manager works closely with the Operations, Remediation Support, ESHR, and Operations Assurance organizations to integrate the disciplines in planning and implementing the work scope.

2.1.4.9 Environmental, Safety, Health, and RadCon

The ESHR organization supports S&GRP by providing a safe work environment. The organization is responsible for protection of employees, the public, and the environment and it provides assistance in compliance with company, DOE, and Occupational Safety and Health Administration (OSHA) standards and requirements. Safe operations are achieved by applying the Integrated Safety Management System (ISMS) and Voluntary Protection Program.

2.1.4.10 Environmental Compliance

The Environmental Compliance organization reviews plans, procedures, and technical documents to ensure that environmental requirements have been addressed; identifies environmental issues that affect operations and develops cost effective solutions; and responds to environmental/regulatory issues. The Environmental Compliance organization also oversees project implementation for compliance with environmental requirements.

2.1.4.11 Radiological Engineering

The Radiological Engineering organization is responsible for radiological support within S&GRP. Specific responsibilities include conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, work planning, and optimizing radiological controls. The Radiological Engineering organization identifies radiological hazards and implements appropriate controls to maintain worker exposures ALARA. The Radiological Control organization plans and directs radiological control technician (RCT) support for all activities. The Radiological Engineering organization coordinates with the Health and Safety organization to determine personal protective equipment (PPE) requirements.

2.1.4.12 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within S&GRP in accordance with 10 CFR 851, “Worker Safety and Health Program,” health and safety requirements. This is implemented through hazards analysis, job hazard analyses, and other pertinent safety documents. The Health and Safety organization assists project personnel in complying with applicable health and safety standards and requirements and coordinates with the Radiological Engineering organization to determine PPE requirements.

2.1.4.13 Operations Assurance

The Operations Assurance organization provides support to S&GRP to execute project activities in a manner that improves operational efficiency and performance. Operations Assurance responsibilities include training, procedures, lessons learned, issues management, and emergency preparedness.

2.1.4.14 Quality Assurance

The QA point-of-contact, with the Operations Assurance organization, is responsible for the following tasks:

- Addressing QA issues on the project
- Overseeing implementation of project QA requirements
- Reviewing project documents (including DQO summary report, QAPjP, and SAP)
- Reviewing data validation reports from third-party data validation contractors, as appropriate
- Participating in QA assessments on sample collection and analysis activities, as appropriate

2.1.4.15 Operable Unit Technical Lead

The OU Technical Lead, with Remedy Selection and Implementation, is responsible for the following tasks:

- Developing specific sampling design, analytical requirements, and QC requirements either independently or as defined through a systematic planning process
- Developing technical basis and recommendations regarding well usage for extraction, injection, or monitoring purposes, as well as changes in the well use, in coordination with DOE-RL and the OU Project Delivery Manager
- Ensuring that sampling and analysis activities, as delegated by the OU Project Delivery Manager, are carried out in accordance with the SAP
- Working closely with the ECO, QA, Health and Safety, Field Work Supervisor (FWS), and SMR organization to integrate these and other technical disciplines in planning and implementing the work scope

2.1.4.16 Analytical Laboratories

Analytical laboratories are responsible for the following tasks:

- Analyzing samples in accordance with established methods
- Providing data packages containing analytical and QC results
- Providing explanations in response to resolution of analytical issues
- Meeting HASQARD (DOE/RL-96-68) QA requirements
- Being on the Mission Support Alliance (MSA) Evaluated Suppliers List
- Being accredited by Ecology for the analyses performed for S&GRP
- Maintaining compliance with the DOE Consolidated Audit Program

2.1.4.17 Waste Management

Waste Management is responsible for the following tasks:

- Communicating policies and protocols for waste management, transportation, and disposal per the waste management plan (DOE/RL-97-01)
- Ensuring compliance for waste storage, transportation, disposal, and tracking in a safe and cost effective manner, per the waste management plan
- Identifying waste management sampling/characterization requirements to ensure regulatory compliance
- Interpreting data to determine waste designations and profiles

2.1.4.18 Field Sampling Operations

Field Sampling Operations (FSO) is responsible for the following tasks:

- Planning, coordinating, and conducting field sampling activities
- Ensuring that samplers are appropriately trained and available

- Ensuring that the field sampling plan is understood and can be performed as specified by the nuclear chemical operators (NCOs), which is achieved by directing NCO training, performing mock-ups, and holding practice sessions with field personnel
- Developing and publishing field sampling procedures used by NCOs
- Directing NCOs and ensuring that they collect all salient samples in accordance with sampling documentation
- Completing field logbook entries, chain-of-custody forms, and shipping paperwork and ensuring delivery of the samples to the analytical laboratory in a timely manner
- Acting as a technical interface between the OU Project Manager and FWSs (such as the Drilling Buyer's Technical Representative [BTR], and Geologist-BTR) and ensuring that technical aspects of the field work are met
- Reviewing the SAP for field sample collection concerns, analytical requirements, and special sampling requirements
- Resolving issues regarding implementing technical requirements to field operations and coordinating resolution of sampling issues through consultation with the OU Project Manager and SMR

2.1.4.19 Well Maintenance

The Well Maintenance Manager is responsible for the following tasks:

- Completing well maintenance activities
- Coordinating with the OU Technical Lead to identify field constraints that could affect groundwater sampling

2.2 Quality Objectives and Criteria

The QA objective of this plan is to ensure the generation of analytical data of known and appropriate quality that are acceptable and useful for decision making. In support of this objective, statistics and data descriptors, known as data quality indicators (DQIs), help determine the acceptability and utility of data to the user. Principal DQIs are precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. The analytical methods, detection limits, and precision and accuracy requirements for each analysis to be performed are summarized in Table 2-1.

Data quality is defined by the degree of rigor in the acceptance criteria assigned to DQIs. Typically, acceptance criteria are set by the analytical method itself; however, project specific requirements, as indicated by DQOs, may result in more stringent acceptance criteria. 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 the DQA process (Section 2.4).

2.2.1 Special Training/Certification

A graded approach is used to ensure that workers receive a level of training commensurate with their responsibilities 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.

Table 2-1. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Precision	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/ replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity) • Request reanalysis or remeasurement • Qualify the data before use
Representativeness	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and is satisfied by ensuring the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for them not being representative • 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

DQI	Definition	Determination Methodologies	Corrective Actions
Comparability	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and is 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 data sets: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability
Completeness	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered 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 (DQOs or performance/ acceptance criteria).	If data set does not meet 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

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

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

Typical training requirements or qualifications have been instituted by the contractor management team to meet training and qualification programs to satisfy multiple training drivers imposed by applicable *Code of Federal Regulations* (CFR) and *Washington Administrative Code* (WAC) requirements. For example, the environmental, safety, and health training program provides workers with the knowledge and skills necessary to execute assigned duties safely. Field personnel complete the following training before starting work:

- OSHA 40 Hour Hazardous Waste Worker Training and supervised 24-hour hazardous waste site experience
- 8 Hour Hazardous Waste Worker Refresher Training (as required)
- Hanford General Employee Training (including Hanford General Employee Radiation Training)
- Radiological worker training

Project-specific training, focused specifically to project activities, may include the following:

- Qualifications needed to comply with QA requirements
- Sampler training and certifications specific to the type of sampling being performed
- RCT qualifications established by the Radiation Protection Program (RCTs assigned to projects will be qualified through the prescribed training program and will undergo ongoing training and qualification activities)

Pre-job briefings, in accordance with work management and work release document evaluation activities and associated hazards, include the following:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in the area in which the job will be performed
- Facility where the job will be performed
- Equipment and material required
- Safety protocols applicable to the job
- Training requirements for individuals assigned to perform work
- Level of management control
- Proximity of emergency contacts

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

2.2.2 Documents and Records

The OU Project Manager (or delegate) is responsible for ensuring that the current version of the SAP is being used and providing updates to field personnel. Version control is maintained by the administrative document control process. Changes to the sampling document are handled consistent with HASQARD (DOE/RL-96-68) and the TPA Action Plan (Ecology et al., 1989b). The OU Project Manager is

responsible for tracking all SAP changes, obtaining appropriate review, and alerting DOE-RL of these changes. Appropriate documentation will follow, in accordance with the requirements for the type of change. Table 2-2 summarizes the changes that may be made and the corresponding documentation requirements.

Table 2-2. Change Control for Sampling Projects

Type of Change[a]	Type of Change (TPA Action Plan[b])	Action	Documentation
Minor Change. Change has no impact on the sample or field analytical result, and little or no impact on performance or cost. Further, the change does not affect the DQOs specified in the SAP.	**Minor Field Change.** Changes that have no adverse effect on the technical adequacy of the job or the work schedule.	The field personnel recognizing the need for a field change will consult with the OU Project Manager prior to implementing the field change.	Minor field changes will be documented in the field logbook. The logbook entry will include the field change, the reason for the field change, and the names and titles of those approving the field change.
Significant Change. Change has a considerable effect on performance or cost, but still allow for meeting the DQOs specified in the SAP.	**Minor Change**. Changes to approved plans that do not affect the overall intent of the plan or schedule.	The OU Project Manager will inform the DOE-RL Project Manager and the Regulatory Lead of the change and seek concurrence at a Unit Manager's Meeting or comparable forum. LRA determines there is no need to revise the document.	Change approval will be documented in the Unit Manager's Meeting minutes or comparable record such as a change notice[c].
Fundamental Change. Change has significant effect on the sample or the field analytical result, performance, or cost, and the change does not meet the requirements specified in the DQOs in the sampling document.	**Revision Necessary.** LRA determines changes to approved plans require revision to document.	If it is anticipated that a fundamental change will require the approval of the Regulatory Lead, the applicable DOE-RL Project Manager will be notified by the OU Project Manager and will be involved in the decision prior to implementation of a fundamental change. The LRA determines if the change requires a revision to the document.	Formal revision of the sampling document.

Table 2-2. Change Control for Sampling Projects

Type of Change[a]	Type of Change (TPA Action Plan[b])	Action	Documentation

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

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

c. The TPA Action Plan, Section 9.3, defines the minimum elements of a change notice.

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

DQO = data quality objective

LRA = lead regulatory agency

OU = operable unit

SAP = sampling and analysis plan

The FWS, SMR, and appropriate BTR are responsible for ensuring that field instructions are maintained and aligned with any revisions or approved changes to the SAP. SMR will ensure that any deviations from the SAP are reflected in revised paperwork for the samplers and analytical laboratory. The FWS or appropriate BTR will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook or on nonconformance report forms) in accordance with corrective action protocols.

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 also is responsible for ensuring that project files are maintained. Project files will contain project records or references to their storage locations. Project files may include, as appropriate, 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
- Forms required by WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells,” and the master drilling contract

SMR personnel manage and maintain the following records:

- Field sampling logbooks
- Groundwater sample reports and field sample reports
- 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 offsite analytical laboratories

The laboratory is responsible for maintaining, and having available upon request, the following items:

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Instrument calibration information
- Current state accreditation documentation
- Laboratory audit records
- Training records of personnel conducting the analyses

Records may be stored in either electronic or hard copy format. Documentation and records, regardless of medium or format, are controlled in accordance with work requirements and processes to ensure that stored records are accurate and can be retrieved. Records required by the TPA (Ecology et al., 1989a) will be managed in accordance with the requirements therein.

2.3 Data Generation and Acquisition

The following subsections present the requirements for analytical methods, measurement and analysis, data collection or generation, data handling, and field and laboratory QC. Requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

2.3.1 Analytical Methods Requirements

Analytical method performance requirements for samples collected are presented in Table 2-3. Laboratory operations and analytical services must comply with HASQARD (DOE/RL-96-68). In consultation with the laboratory and OU Project Manager, SMR can approve changes to analytical methods as long as the new method is based upon a nationally recognized standard method (e.g., EPA or ASTM International), and it delivers analytical data that are comparable to those provided by the old method. The new method must achieve project DQOs as well or better than the replaced method, and it is required due to the nature of the sample (e.g., high radioactivity). The laboratory using the new method must be accredited by Ecology to perform that method. Issues that may affect analytical results are resolved by SMR in coordination with the OU Project Manager.

2.3.2 Field Analytical Methods

Chemical field screening and radiological field survey data used for site characteristics will be measured in accordance with HASQARD (DOE/RL-96-68) approved methods (as applicable). Field analytical methods are also performed in accordance with manufacturer specifications and standard EPA methods. Table 2-3 identifies the parameters for field survey analyses.

2.3.3 Quality Control

QC requirements specified in this 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 provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Table 2-4 summarizes field and laboratory QC sample requirements. Table 2-5 shows acceptance criteria for field QC.

Table 2-3. Performance Requirements for Groundwater Analysis

Constituent	Chemical Abstracts Service Number	Action Level[a]	Analytical Method[b]	Required Detection Limit	Accuracy[c]	Precision[c]
Inorganics – Metals (µg/L)						
Alkalinity	NA	NA	EPA 310.1 – Titration	5,000	80-120[d]	≤20[d]
Antimony	7440-36-0	6.0	EPA 6020 – ICP/MS	5	80-120[d]	≤20[d]
Cadmium	7440-43-6	0.25	EPA 6020 – ICP/MS	2	80-120[d]	≤20[d]
Calcium	7440-70-2	NA	EPA 6010 – ICP/AES	1,000	80-120[d]	≤20[d]
Chromium (Total)	7440-47-3	65	EPA 6020 – ICP/MS	10	80-120[d]	≤20[d]
Chromium (Hexavalent)	18540-29-9	10	EPA 7196 – Colorimetric	10	80-120[d]	≤20[d]
Cobalt	7440-48-4	4.8	EPA 6020 – ICP/MS	2.6	80-120[d]	≤20[d]
Copper	7440-50-8	9.0	EPA 6020 – ICP/MS	8	80-120[d]	≤20[d]
Iron	7439-89-6	1,000	EPA 6010 – ICP/AES	50	80-120[d]	≤20[d]
Lead	7439-92-1	2.1	EPA 6020 – ICP/MS	2	80-120[d]	≤20[d]
Manganese	7439-96-5	384	EPA 6020 – ICP/MS	5	80-120[d]	≤20[d]
Magnesium	7439-95-4	NA	EPA 6010 – ICP/AES	750	80-120[d]	≤20[d]
Potassium	7440-09-07	NA	EPA 6010 – ICP/AES	4,000	80-120[d]	≤20[d]
Silver	7440-22-4	2.6	EPA 6020 – ICP/MS	2	80-120[d]	≤20[d]
Sodium	7440-23-5	NA	EPA 6010 – ICP/AES	500	80-120[d]	≤20[d]
Uranium	7440-61-1	30	EPA 6020 – ICP/MS	15	80-120[d]	≤20[d]
Zinc	7440-66-6	91	EPA 6020 – ICP/MS	10	80-120[d]	≤20[d]

Table 2-3. Performance Requirements for Groundwater Analysis

Constituent	Chemical Abstracts Service Number	Action Level[a]	Analytical Method[b]	Required Detection Limit	Accuracy[c]	Precision[c]
Inorganics – Anions (µg/L)						
Bromide	24959-67-9	NA	EPA 300.0 – IC Anions	250	80-120[d]	≤20[d]
Chloride	16887-00-6	NA	EPA 300.0 – IC Anions	400	80-120[d]	≤20[d]
Fluoride	16984-48-8	960	EPA 300.0 – IC Anions	500	80-120[d]	<20[d]
Nitrate	14797-55-8	10,000 (as N)	EPA 300.0 – IC Anions	250	80-120[d]	<20[d]
Nitrite	14797-65-0	3,300	EPA 300.0 – IC Anions	250	80-120[d]	<20[d]
Sulfate	14808-79-8	250,000	EPA 300.0 – IC Anions	550	80-120[d]	<20[d]
Phosphate	14265-44-2	NA	EPA 300.0 – IC Anions	500	80-120[d]	≤20[d]
Radionuclides (pCi/L)						
Strontium-90	10098-97-2	8	Sr-90 Chemical Separation/Gas Proportional Counting Laboratory Specific	2.0	80-120[e]	≤20[e]
Tritium	10028-17-8	20,000	Tritium – Liquid Scintillation Counting	400	70-130[e]	≤20[e]
Field Measurements						
Dissolved Oxygen	7782-44-7	NA	EPA Method 360.1 Dissolved Oxygen Probe	0.05 mg/L	+/- 0.05 mg/L	<0.06 mg/L[e]
Oxidation Reduction Potential	NA	NA	Probe	NA	+/- 0.1 mV[e]	<0.2 mV
pH	13967-14-1	NA	EPA Method 150.1 pH Probe	2.0 pH unit	+/- 0.1 pH unit	<0.2 pH unit

Table 2-3. Performance Requirements for Groundwater Analysis

Constituent	Chemical Abstracts Service Number	Action Level[a]	Analytical Method[b]	Required Detection Limit	Accuracy[c]	Precision[c]
Specific Conductance	NA	NA	EPA Method 120.1 Conductivity Meter	1 µS/cm	80-120[d]	<20[d]
Temperature	NA	NA	EPA Method 170.1 Temperature Probe	NA	+/- 0.2°C	<0.2°C
Turbidity	NA	NA	EPA Method 180.1 Turbidity Meter	0.01 NTU	+/- 0.01 NTU	<0.01 NTU
Depth to Groundwater	NA	NA	Electrical Tape	NA	+/- 0.001 m	<0.006 m

a. Action level as presented in 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*. Sources include:

40 CFR 131, "Water Quality Standards.

40 CFR 141, "National Primary Drinking Water Regulations."

WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington."

WAC 173-340-720(4)(b)(ii)(A) and (B), "Groundwater Cleanup Standards," "Noncarcinogens and Carcinogens."

b. Equivalent methods may be substituted. For EPA Method 200.8, see EPA-600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For EPA Methods 150.1 and 300.0, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*. Field measurements are carried out using various probes in accordance with manufacturer specifications and standard methods.

c. Percent unless otherwise indicated as value.

d. The accuracy criterion shown is the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike, and surrogate recoveries as appropriate to the method. The precision criterion shown is for batch laboratory replicate matrix spike analysis RPDs.

e. For radionuclides, the accuracy criterion shown is for associated batch laboratory control sample percent recoveries. Additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criterion shown is for batch laboratory replicate sample RPDs.

Table 2-3. Performance Requirements for Groundwater Analysis

Constituent	Chemical Abstracts Service Number	Action Level[a]	Analytical Method[b]	Required Detection Limit	Accuracy[c]	Precision[c]

EPA = U.S. Environmental Protection Agency
NA = not applicable
IC = ion chromatography
ICP/AES = inductively coupled plasma/atomic emission spectroscopy
ICP/MS = inductively coupled plasma/mass spectrometry
NTU = nephelometric turbidity unit
RPD = relative percent difference

Data will be qualified and assigned a data qualifier in HEIS, as appropriate.

Table 2-4. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
Field Quality Control		
Field Duplicates	1 in 20 well trips	Precision, including sampling and analytical variability
Field Splits	As needed When needed, the minimum is one for every analytical method, for analyses performed where detection limit and precision and accuracy criteria have been defined in the Analytical Performance Requirements table	Precision, including sampling, analytical, and interlaboratory
Full Trip Blanks	1 per 20 well trips	Cross-contamination from containers or transportation
Equipment Blanks	As needed If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment blank is not required Otherwise, one for every 20 samples for each media[a,b]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical Quality Control[d]		
Laboratory Control Samples	1 per analytical batch[c]	Evaluate Laboratory Accuracy
Method Blanks	1 per analytical batch[d]	Laboratory Contamination
Laboratory Duplicates	1 per analytical batch[d]	Laboratory Reproducibility and Precision
Matrix Spikes	1 per analytical batch[d]	Matrix Effect/Laboratory Accuracy
Matrix Spike Duplicates	1 per analytical batch[d]	Laboratory Accuracy and Precision
Tracers	1 per analytical batch[d]	Recovery/Yield

a. For portable pumps, equipment blanks are collected one for every 10 well trips. Whenever a new type of nondedicated equipment is used, an equipment blank will be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination methods for the nondedicated equipment.

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

c. As defined in laboratory analysis methods.

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

Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria

Analysis[a]	Quality Control Element	Acceptance Criteria	Corrective Action
Anions			
Ion Chromatography	MB	<MDL <5% Sample Concentration	Flagged with "C"
	LCS	80 – 120% Recovery[a]	Data Reviewed[b]
	DUP or MS/MSD	≤20% RPD	Data Reviewed[b]
	MS	75 – 125% Recovery[a]	Flagged with "N"
	EB, FTB	<2 Times MDL	Flagged with "Q"
	DUP (Field)	≤20% RPD[c]	Flagged with "Q"
Metals			
ICP/AES or ICP/MS or Colorimetric	MB	<Required Detection Limit <5% Sample Concentration	Flagged with "C"
	LCS	80 – 120% Recovery[a]	Data Reviewed[b]
	MS	75 – 125% Recovery[a]	Flagged with "N"
	MSD	75 – 125% Recovery[a]	Flagged with "N"
	MS/MSD	≤20% RPD	Data Reviewed[b]
	EB, FTB	<2 Times MDL	Flagged with "Q"
	DUP (field)	≤20% RPD[c]	Flagged with "Q"
Radiochemical Analyses			
Strontium-90 and Tritium	MB	<Minimum Detectable Concentration <5% Sample Concentration	Flagged with "B"
	LCS	70 – 130% recovery	Data Reviewed[b]
	DUP	≤20% RPD[c]	Data Reviewed[b]

Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria

Analysis[a]	Quality Control Element	Acceptance Criteria	Corrective Action
	Tracer (Where Applicable)	20 – 105% Recovery	Data Reviewed[b]
	Carrier (Where Applicable)	30 – 105% Recovery	Data Reviewed[b]
	EB, FTB	<2 Times MDL	Flagged with "Q"
	DUP (Field)	≤20% RPD/30% RPD[c]	Flagged with "Q"

a. Determined by the laboratory based on historical data or statistically derived control limits. Limits are reported with the data. Where specific acceptance criteria are listed, those acceptance criteria may be used in place of statistically derived acceptance criteria.

b. After review, corrective actions are determined on a case-by-case basis.

c. Applies only in cases where both results are greater than 5 times the minimum detectable concentration.

DUP = field duplicate samples
EB = equipment blank
FTB = full trip blank
ICP/AES = inductively coupled plasma/atomic emission spectroscopy
ICP/MS = inductively coupled plasma/mass spectrometry
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
RPD = relative percent difference

Data Flags:

B (organics)/C (inorganics/wetchem) = Analyte was detected in both the associated quality control blank and the sample.
N = All except gas chropmatography/mass spectrometry – matrix spike outlier.
Q = Associated quality control sample is out of limits.

2.3.3.1 Field QC 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 that reliable data are obtained. Field QC samples include field duplicates, split samples, and three types of field blanks (full trip, field transfer, and equipment). Field blanks are typically prepared using high-purity reagent water. QC sample definitions and their required frequency for collection are described in this section.

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

Field Splits (SPLITs): two samples collected as close as possible to the same time and location and intended to be identical. SPLITs will be stored in separate containers and analyzed by different

laboratories for the same analytes. SPLITs are interlaboratory comparison samples used to evaluate comparability between laboratories.

Full Trip Blanks (FTBs): bottles prepared by the sampling team prior to traveling to the sampling site. The preserved bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. It is filled with high-purity reagent water (or dead water from Well 699-S11-E12AP for low-level tritium FTBs[1]) 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 contamination of the samples attributable to the sample bottles, preservative, handling, storage, and transportation.

Equipment Blanks (EBs): reagent water passed through or poured over the decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the Sampling Authorization Form (SAF). EB sample bottles are placed in the same storage containers with the samples from the associated sampling event. EB samples will be analyzed for the same constituents as the samples from the associated sampling event. EBs are used to evaluate the effectiveness of the decontamination process. EBs are not required for disposable sampling equipment.

2.3.3.2 Laboratory QC Samples

Internal QA/QC programs are maintained by the laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of matrix spikes (MSs), DUPs, matrix spike duplicates (MSDs), laboratory control samples (LCSs), surrogates (SURs), tracers, and method blanks (MBs). These samples are recommended in the guidance documents and are required by EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. QC checks outside of control limits are documented in analytical laboratory reports during DQAs. Table 2-4 lists laboratory QC methods and their typical frequencies. Table 2-5 shows laboratory QC acceptance criteria. The following text describes the various laboratory QC samples.

DUP: an intralaboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

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

MSD: a replicate spiked aliquot of a sample 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.

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

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

SUR: a compound added to all samples in the analysis batch (field samples and QC samples) prior to preparation. The SUR is typically similar in chemical composition to the analyte being determined, yet is not normally encountered. SURs are expected to respond to the preparation and measurement systems in a

[1] Because of the low detection levels achieved in the low-level tritium analysis, special low-level tritium water must be used. This low-level tritium water, known as dead water, is collected yearly, or as needed, from Well 699-S11-E12AP or other approved source.

manner similar to the analytes of interest. Because SURs are added to all standards, samples, and QC samples, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.

Tracer: a tracer is a known quantity of radioactive isotope that is different from that of the isotope of interest but is expected to behave similarly and is added to an aliquot of sample. Sample results are generally corrected based on tracer recovery.

Sample Storage Blanks: are used as appropriate. Storage blanks are used to monitor potential cross-contamination of samples due to improper storage conditions. This type of monitoring is described in laboratory-specific standard operating procedures.

The laboratories are required to analyze samples within the holding time specified in Table 2-6. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilizing, decomposing, or by other chemical changes. Data from samples analyzed outside the holding times are flagged in the HEIS database with an "H."

Table 2-6. Sample Container, Preservation, and Holding Time Guidelines for Groundwater Samples by Analytical Method

Method Name	Number of Bottles	Bottle Type	Volume (mL)	Preservation Requirement	Holding Time
EPA 300.0 – IC Anions	1	G/P	500	Cool ≤6°C	28 days/ 48 hours*
EPA 310.1 – Titration	1	G/P	500	Cool ≤6°C	14 days
EPA 6010 – ICP/AES	1	G/P	500	Nitric Acid to pH <2	6 months
EPA 6020 – ICP/MS	1	G/P	500	Nitric Acid to pH <2	6 months
EPA 7196 – Colorimetric	1	Amber Glass	500	Cool ≤6°C	24 hours
Strontium-90 Chemical Separation/Gas Proportional Counting	1	G/P	1,000	Nitric Acid to pH <2	6 months

Notes: For EPA Methods 300.0 and 310.1, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*.

For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.

* Holding time of 28 days applies to fluoride, chloride, and sulfate; 48 hour holding time applies to nitrate.

EPA = U.S. Environmental Protection Agency
G/P = glass/plastic
IC = ion chromatography
ICP/AES = inductively coupled plasma atomic emission spectroscopy
ICP/MS = inductively coupled plasma/mass spectrometry

2.3.4 Measurement Equipment

Each user of the measuring equipment is responsible for ensuring that equipment is functioning as expected, properly handled, and properly calibrated at required frequencies in accordance with methods governing control of the measuring 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 manufacturer specifications and other approved methods.

2.3.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM International) 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 maintenance requirements specified in HASQARD (DOE/RL-96-68) and applicable Hanford Site requirements.

2.3.6 Instrument/Equipment Calibration and Frequency

Specific field equipment calibration information is provided in Section 3.5. Analytical laboratory instruments are calibrated in accordance with the laboratory QA plan and HASQARD (DOE/RL-96-68).

2.3.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, 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. Necessary responsibilities and interfaces must be in place to ensure that items procured/acquired for the contractor meet specific technical and quality requirements. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

2.3.8 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 the data generated as part of any sampling and analysis QA/QC effort. All data used in evaluations will be identified by source.

2.3.9 Data Management

The SMR organization, in coordination with the OU Project Manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable EPA and DOE QA programmatic requirements.

When appropriate, electronic data will be accessed through a Hanford Site database (e.g., HEIS) or a project specific database, whichever is applicable, for the data being stored. Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the TPA Action Plan (Ecology et al., 1989b).

Laboratory errors are reported to the SMR organization within 24 hours of discovery. For reported laboratory errors, a sample issue resolution (SIR) form will be initiated, as described in Section 2.3. The SIR form is used to document analytical errors and establish their resolution with the OU Project Manager. SIR forms become a permanent part of the analytical data package for future reference and records management.

2.4 Assessment and Oversight

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

2.4.1 Assessments and Response Actions

Random surveillances and assessments verify compliance with the requirements outlined in this SAP, OU specific addenda, project field instructions, the project quality management plan, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates the corrective actions/deficiencies 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).

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

2.4.2 Reports to Management

Management will be made aware of deficiencies identified by self assessments, corrective actions from ECOs, and findings from QA assessments and surveillances. Issues with samples received by the laboratories are communicated to the SMR organization, within 24 hours of discovery, using an SIR form. This process is used to document analytical or sample issues and establish resolution with the OU Project Manager.

2.5 Data Validation and Usability

This section addresses the 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.

2.5.1 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, reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times have been met, and reviewing QC data 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.

Errors identified by laboratories are reported to the SMR organization project coordinator, who initiates an SIR form. This process is used to document analytical errors and to establish resolution with the OU Technical Lead.

Relative to analytical data in sample media, field screening results are of lesser importance in making inferences regarding risk. Field QA/QC results will be reviewed to ensure they are usable.

The OU Technical Lead data review will help determine if observed changes reflect improved/degraded groundwater quality or potential data errors and may submit a request for data review (RDR) on questionable data. The laboratory may be asked to check calculations or reanalyze the sample, or the well may be resampled. Results of the RDR process are used to flag the data appropriately in the HEIS database and/or to add comments.

2.5.2 Data Validation

Data validation is an independent assessment to ensure that the reliability of data is known. Analytical data validation provides a level of assurance that an analyte is present or absent. Validation might also include verification of instrument calibrations, evaluation of analytical results based upon MBs, recovery of various internal standards, correctness of uncertainty calculations, correctness of identification and quantification of analytes, and the effect of quality deficiencies on the reliability of the data. Data validation will be based on EPA functional guidelines. The criteria for data validation are based on a graded approach. The primary contractor has defined five levels of validation: A through E. Level A is the lowest level and is the same as verification. Level E is a 100 percent review of all data (e.g., calibration data and calculations of representative samples from the data set).

Data validation will be performed to contractor Level C. Level C validation consists of a review of the QC data and specifically requires verification of deliverables, requested versus reported analytes, and qualification of the results based on evaluation of analytical holding times, MB results, MS/MSD results, SUR recoveries, and duplicate sample results. Level C data validation will be performed on at least 5 percent of the data by matrix and analyte group. Analyte group refers to categories, such as radionuclides, volatile chemicals, semivolatiles, polychlorinated biphenyls, metals, and anions. The goal is to cover the various analyte groups and matrices during the data validation process.

2.5.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the DQA is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to meet the project DQOs. For routine groundwater monitoring undertaken through this SAP, the DQA is captured in QC associated with the annual groundwater report (e.g., DOE/RL-2014-32), evaluating field and laboratory QC, and the usability of data. Further DQAs will be performed at the discretion of the OU Project Manager and documented in a report overseen by SMR.

3 Field Sampling Plan

This chapter lists the groundwater wells (including P&T wells) and aquifer tubes to be monitored, sampling frequency, and constituents to be analyzed.

3.1 Sampling Objectives

The objectives of groundwater monitoring in this OU are to define the extent and track the movement of groundwater contaminant plumes in the unconfined aquifer and RUM unit. The interim action ROD (EPA/ROD/R10-96/134) included compliance monitoring for river protection as part of a compliance monitoring plan in the Remedial Design Report/RAWP (DOE/RL-96-84). The interim action ROD amendment (EPA/AMD/R10-00/122) identified requirements for compliance monitoring for ISRM barrier performance. Table 3-1 identifies compliance wells identified based on these interim action decisions. The sampling objectives are accomplished in the field by sampling groundwater at designated wells and aquifer tubes, and analyzing the samples for COCs and COPCs.

The performance monitoring identified for evaluating Cr(VI) discharge to the Columbia River is designed to fulfill the requirements of compliance monitoring designated under the interim action decisions. The terminology used in this plan, adopted as part of updated guidance (for example, 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 Chapter 6 of the RD/RAWP (DOE/RL-2013-31).

Table 3-1. Status of 100-HR-3 Interim Action Compliance Wells

Well Number	Original Use	Status (September 30, 2014)
199-D8-58[a]	100-D Area Interim Action Compliance Well	Decommissioned (2/28/06)
199-D8-69[a]	100-D Area Interim Action Compliance Well	DX Extraction Well
199-D8-70[a]	100-D Area Interim Action Compliance Well	Monitoring Well
199-H4-4[a]	100-H Area Interim Action Compliance Well	HX Extraction Well
199-H4-5[a]	100-H Area Interim Action Compliance Well	Monitoring Well
199-H4-63[a]	100-H Area Interim Action Compliance Well	HX Extraction Well
199-H4-64[a]	100-H Area Interim Action Compliance Well	HX Extraction Well
199-D4-23[b]	ISRM Barrier Interim Action Compliance Well	Monitoring Well
199-D4-38[b]	ISRM Barrier Interim Action Compliance Well	DX Extraction Well
199-D4-39[b]	ISRM Barrier Interim Action Compliance Well	DX Extraction Well
199-D4-83[b]	ISRM Barrier Interim Action Compliance Well	DX Extraction Well
199-D4-84[b]	ISRM Barrier Interim Action Compliance Well	DX Extraction Well
199-D4-85[b]	ISRM Barrier Interim Action Compliance Well	DX Extraction Well
199-D4-86[b]	ISRM Barrier Interim Action Compliance Well	Monitoring Well

Table 3-1. Status of 100-HR-3 Interim Action Compliance Wells

Well Number	Original Use	Status (September 30, 2014)

a. Compliance well is identified in DOE/RL-96-84, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action.*

b. Compliance well is identified in DOE/RL-99-51, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation*.

ISRM = in situ redox manipulation

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. The detailed process is presented in Appendix A. Five problem statements were used to identify PSQs that can be answered using data inputs to satisfy specific data needs. Available groundwater monitoring locations within the 100-HR-3 OU are shown on Figures A-2 and A-3 (Appendix A).

The following subsections present a brief summary of the criteria used in the DQO process for each PSQ, with the results of the DQO selection process presented in Table 3-3. Sample collection will include measurement of field parameters (dissolved oxygen, oxidation reduction potential, pH, specific conductance, temperature, turbidity, and depth to groundwater).

Monitoring conducted for the PSQs also use data generated for P&T system O&M. O&M monitoring is described in DOE/RL-2013-49. These data include monthly (or more frequent) Cr(VI) measurements from extraction wells, which are collected to monitor P&T system performance; quarterly effluent tank co-contaminant and Cr(VI) samples; quarterly influent tank samples; and water level measurements in system wells.

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

Wells for monitoring were selected based on proximity to the Columbia River, distance between wells, and historical Cr(VI) distribution. Aquifer tubes for sampling were selected based on distance downgradient from a well, Cr(VI) distribution, and specific conductance data indicating the location represents groundwater. Historical groundwater data and evaluation of Cr(VI) discharge relative to river stage indicate the highest concentrations are observed during low river stage in wells near the river. Low river stage, which typically occurs from September to December, was identified for annual Cr(VI) sampling.

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

Wells for monitoring were selected based on calendar year 2013 Cr(VI) plume geometry and concentration contours. Data from P&T system monitoring, which provides monthly Cr(VI) concentration data, also will be used in the evaluation of plume geometry and mass reduction. Aquifer tubes for sampling were selected based on Cr(VI) distribution and specific conductance data indicating the location represents groundwater. An annual sampling frequency was selected for Cr(VI) remedy evaluation.

3.2.3 PSQ 3: Are other contaminant plumes that exceed risk-based/ARAR levels decreasing as predicted?

Wells for monitoring were selected based on recent strontium-90 and nitrate concentrations that were greater than action levels (8 pCi/l and 45,000 µg/L [10,000 µg/L for nitrate-N], respectively). Limited downgradient locations were selected to delineate plume boundaries.

An annual sampling frequency was selected for nitrate. This sampling is supplemented with P&T system monitoring for nitrate, which is conducted quarterly at wells with nitrate contamination (Section 3.3). The nitrate plumes are currently within the capture zone of the P&T system, and concentrations are expected to continue current declining trends.

A triennial (once every three years) sampling frequency was selected for strontium-90. Sampling is supplemented with P&T system monitoring for strontium-90, which is conducted quarterly at wells with strontium-90 contamination (Section 3.3). Strontium-90 is a relatively immobile constituent and does not migrate at a rapid rate. Although concentrations are greater than the 8 pCi/L drinking water standard (DWS) at some locations, protection of human health is achieved through implementation of institutional controls that restrict groundwater withdrawal and use. The reported concentrations also are less than ecological protection concentrations.

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

Transducer data from operating extraction and injection wells, along with the transducer data from monitoring wells within the AWLN system, will be collected and utilized in plume tracking and evaluation of capture zones. As of December 31, 2014, there were 43 extraction and 14 injection wells at DX and 31 extraction and 14 injection wells at HX, for a total of 98 wells connected to the P&T systems. Water levels will also be collected during groundwater sampling events, at each well or sampling location. In total, 243 monitoring wells were available for use at 100-HR-3 as of December 31, 2014, which includes piezometers but does not include the 170 aquifer tubes located within the OU. Synoptic water level measurements will be collected twice per year, once during low river stage and once during high river stage. The treatment system and AWLN measurements will be recorded hourly. The data will be used to evaluate plume capture and migration (as described in ECF-Hanford-15-0001, *Description of Groundwater Calculations and Assessments for the Calendar Year 2014 (CY2014) 100 Areas Pump and Treat Report*, and annual P&T reports, such as DOE/RL-2015-05, *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations, and 100-NR-2 Groundwater Remediation*).

The monitoring network identified in Table 3-3 and shown on Figure A-8 in Appendix A indicates wells where low river and a high river stage water level measurement will be collected. The evaluation of groundwater gradients will include both the unconfined aquifer and the aquifer in the first water bearing unit of the RUM. An additional groundwater contour evaluation is collected as part of the annual groundwater monitoring program under a different SAP.

Table 3-2. Monitoring Wells, Analytes, and Frequencies for Surveillance Groundwater Monitoring[a]

Well Name	Geologic Unit Monitored	Sampling Frequency	Monitoring Objectives	Analytes						
				Field Parameters[b]	Alkalinity	Anions[c]	Metals[d] (Filtered/ Unfiltered)	Hexavalent Chromium	Gross Alpha/Beta	Tritium
199-H4-15CP	Upper Saddle Mountain basalt	B–FY 2013	VC, co-sample	B	B	B	B	B	B	
199-D5-141	RUM	B–FY 2014	VC, co-sample	B	B	B	B	B	B	
199-H2-1	RUM	A	Co-sample	A	A	A	A	A	A	
199-H3-2C	RUM	A	VC, co-sample	A	A	A	A	A	A	
199-H3-9	RUM	A	Co-sample	A	A	A	A	A	A	
199-H3-10	RUM	A	Co-sample	A	A	A	A	A	A	
199-H4-12C	RUM	A	VC, co-sample; HX extraction well	A	A	A	A	A	A	A
199-H4-15CQ	Ringold A	B–FY 2014	VC, co-sample	B	B	B	B	B	B	
199-H4-15CR	Ringold B	B–FY 2014	VC, co-sample	B	B	B	B	B	B	
199-H4-15CS	RUM	B–FY 2014	VC, co-sample	B	B	B	B	B	B	
699-97-43C	RUM	B-FY 2013	VC, co-sample	B	B	B	B	B	B	B
699-97-45B	RUM	B-FY 2013	VC, co-sample	B	B	B	B	B	B	B
699-97-48C	RUM	B-FY 2013	VC, co-sample	B	B	B	B	B	B	B

Note: To avoid duplication of costs and effort on a monthly basis, multiple sample events scheduled for the same well and month are combined into one well trip and are referred to co-sample events.

a. Details are provided in DOE/RL-2012-59, *Surveillance Groundwater Monitoring on the Hanford Site*.

b. Field parameters include dissolved oxygen, oxidation reduction potential, pH, specific conductance, temperature, turbidity, and depth to groundwater.

c. Anions include fluoride, nitrate, and sulfate.

d. Metals include antimony, cadmium, chromium (total), chromium (hexavalent), cobalt, copper, iron, lead, manganese, silver, uranium, and zinc.

Table 3-2. Monitoring Wells, Analytes, and Frequencies for Surveillance Groundwater Monitoring[a]

Well Name	Geologic Unit Monitored	Sampling Frequency	Monitoring Objectives	Analytes						
				Field Parameters[b]	Alkalinity	Anions[c]	Metals[d] (Filtered/ Unfiltered)	Hexavalent Chromium	Gross Alpha/Beta	Tritium

A = annual
B = biennial (every other year)
FY = fiscal year
RUM = Ringold upper mud unit
VC = vertical characterization

3.2.5 PSQ 5a: Are infrequently detected analytes confirmed not to be contaminants of potential concern?

and

3.2.6 PSQ 5b: Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?

Infrequently detected analytes and analytes, with detection limits above action levels, are referred to as "analytes with uncertainty." The monitoring locations for the analytes with uncertainty were selected to provide spatial representativeness, based on the highest number of previous detections of the identified analytes within the exposure area (Section A.7.1, Appendix A). The analytes for monitoring include antimony, cadmium, cobalt, copper, fluoride, iron, lead, manganese, nitrite, silver, sulfate, and zinc. A triannual sampling frequency, until nine samples are collected at each monitoring location, was selected.

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

Wells for monitoring potential source areas were selected from downgradient locations. Analytes for monitoring are Cr(VI) at 100-D-100 and Cr(VI), nitrate, and uranium at 183-H. A triannual sampling frequency, until nine samples are collected at each monitoring location, was selected. Monitoring results will be evaluated to identify whether there is a potential continuing source and if additional sampling is warranted.

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 (DOE/RL-2013-49, Table 4-2) and is not included herein. Additional samples are collected from the influent and effluent tanks. Treatment process water monitoring is presented in Table 3-4. Sampling for co-contaminants strontium-90 and uranium was limited to those areas near known plumes or downgradient of those areas with historical detections, as described in the following subsections.

3.3.1 Strontium-90 Sampling

No extraction wells are currently located within the strontium-90 groundwater plume at 100-D. Strontium-90 is present above the 8 pCi/L DWS at Wells 199-D5-132 and 199-D5-142, located near the 105-D Reactor (Figure 3-1). To evaluate if strontium-90 is migrating from that area and extracted downgradient, samples will be collected for strontium-90 analysis from the nearest downgradient extraction wells (199-D5-32, 199-D5-154 and 199-D5-159) from the known plume. Strontium-90 was detected historically near the 116-DR-1&2 trench and in downgradient aquifer tubes. In downgradient aquifer tubes C6278, DD-15-3, and DD-16-4, concentrations increased following the startup of DX. Extraction wells near the 116-DR-1&2 trench (Wells 199-D8-68, 199-D8-69, and 199-D8-55) were, therefore, included in the sampling for strontium-90 to ensure that concentrations in the DX system influent remained below 8 pCi/L. Figure 3-1 presents the wells that have, at one time in their history, had a detection of strontium-90 at 100-D.

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D2-6	Unconfined Aquifer		A		A	TE						X	X					
199-D2-10	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D2-11	Unconfined Aquifer		A					Yes	SO4			X		X				
199-D2-12	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D3-2	Unconfined Aquifer	ISRM well/no injection	A			TE		Yes	SO4	TA	X	X	X	X				
199-D3-3	Unconfined Aquifer	ISRM well																
199-D3-4	Unconfined Aquifer	ISRM well																
199-D3-5	Unconfined Aquifer		A									X						
199-D4-1	Unconfined Aquifer	ISRM well/no injection	A						beta emitters (once)	A			X					
199-D4-2	Unconfined Aquifer	ISRM well/no injection																
199-D4-3	Unconfined Aquifer	ISRM well/no injection																

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D4-4	Unconfined Aquifer	ISRM well/no injection																
199-D4-5	Unconfined Aquifer	ISRM well/no injection	A						beta emitters (once)	A		X	X					
199-D4-6	Unconfined Aquifer	ISRM well/no injection	A									X						
199-D4-7	Unconfined Aquifer	ISRM well																
199-D4-8	Unconfined Aquifer	ISRM well/no injection																
199-D4-9	Unconfined Aquifer	ISRM well																
199-D4-10	Unconfined Aquifer	ISRM well																
199-D4-11	Unconfined Aquifer	ISRM well																
199-D4-12	Unconfined Aquifer	ISRM well																
199-D4-13	Unconfined Aquifer	ISRM well/no injection			A	A		Yes	beta emitters (once)	A			X	X				

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D4-14	Unconfined Aquifer	DX Extraction/ISRM	A			A					X	X	X					
199-D4-15	Unconfined Aquifer		TA			A		Yes	TA (Sb, Cd, Co, Cu, Pb, Ag)				X	X		X	X	
199-D4-16	Unconfined Aquifer	ISRM well																
199-D4-17	Unconfined Aquifer	ISRM well																
199-D4-18	Unconfined Aquifer	ISRM well																
199-D4-19	Unconfined Aquifer	ISRM well/no injection	A					Yes	beta emitters (once)	TA			X	X				
199-D4-20	Unconfined Aquifer		A		A	TA		Yes				X	X	X				
199-D4-21	Unconfined Aquifer	ISRM well						Yes						X				
199-D4-22	Unconfined Aquifer	ISRM well/no injection			A	TA							X					
199-D4-23	Unconfined Aquifer	ISRM compliance	A					Yes			X	X		X				

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D4-24	Unconfined Aquifer	ISRM well																
199-D4-25	Unconfined Aquifer	ISRM well/ZVI test	A						beta emitters (once)	A			X					
199-D4-26	Unconfined Aquifer	ISRM well/ZVI test																
199-D4-27	Unconfined Aquifer	ISRM well/ZVI test																
199-D4-28	Unconfined Aquifer	ISRM well																
199-D4-29	Unconfined Aquifer	ISRM well																
199-D4-30	Unconfined Aquifer	ISRM well																
199-D4-31	Unconfined Aquifer	ISRM well																
199-D4-32	Unconfined Aquifer	ISRM well																
199-D4-33	Unconfined Aquifer	ISRM well																
199-D4-34	Unconfined Aquifer	DX Extraction/ISRM	A									X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D4-35	Unconfined Aquifer	ISRM well																
199-D4-36	Unconfined Aquifer	ISRM well																
199-D4-37	Unconfined Aquifer	ISRM well																
199-D4-38	Unconfined Aquifer	DX Extraction/ISRM compliance	A						A -SO4		X	X						
199-D4-39	Unconfined Aquifer	DX Extraction/ISRM compliance	A						A -SO4		X	X						
199-D4-40	Unconfined Aquifer	ISRM well																
199-D4-41	Unconfined Aquifer	ISRM well																
199-D4-42	Unconfined Aquifer	ISRM well																
199-D4-43	Unconfined Aquifer	ISRM well																
199-D4-44	Unconfined Aquifer	ISRM well																
199-D4-45	Unconfined Aquifer	ISRM well																

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D4-46	Unconfined Aquifer	ISRM well																
199-D4-47	Unconfined Aquifer	ISRM well																
199-D4-48	Unconfined Aquifer	ISRM well																
199-D4-49	Unconfined Aquifer	ISRM well																
199-D4-50	Unconfined Aquifer	ISRM well																
199-D4-51	Unconfined Aquifer	ISRM well																
199-D4-52	Unconfined Aquifer	ISRM well																
199-D4-53	Unconfined Aquifer	ISRM well																
199-D4-54	Unconfined Aquifer	ISRM well																
199-D4-55	Unconfined Aquifer	ISRM well																
199-D4-56	Unconfined Aquifer	ISRM well																

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D4-57	Unconfined Aquifer	ISRM well																
199-D4-58	Unconfined Aquifer	ISRM well																
199-D4-59	Unconfined Aquifer	ISRM well																
199-D4-60	Unconfined Aquifer	ISRM well																
199-D4-61	Unconfined Aquifer	ISRM well																
199-D4-62	Unconfined Aquifer	ISRM well																
199-D4-63	Unconfined Aquifer	ISRM well																
199-D4-64	Unconfined Aquifer	ISRM well																
199-D4-65	Unconfined Aquifer	ISRM well																
199-D4-66	Unconfined Aquifer	ISRM well																
199-D4-67	Unconfined Aquifer	ISRM well																

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D4-68	Unconfined Aquifer	ISRM well																
199-D4-69	Unconfined Aquifer	ISRM well																
199-D4-70	Unconfined Aquifer	ISRM well																
199-D4-71	Unconfined Aquifer	ISRM well																
199-D4-72	Unconfined Aquifer	ISRM well																
199-D4-73	Unconfined Aquifer	ISRM well																
199-D4-74	Unconfined Aquifer	ISRM well																
199-D4-75	Unconfined Aquifer	ISRM well																
199-D4-76	Unconfined Aquifer	ISRM well																
199-D4-77	Unconfined Aquifer	ISRM well																
199-D4-78	Unconfined Aquifer	ISRM well																

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D4-79	Unconfined Aquifer	ISRM well																
199-D4-80	Unconfined Aquifer	ISRM well																
199-D4-81	Unconfined Aquifer	ISRM well																
199-D4-82	Unconfined Aquifer	ISRM well																
199-D4-83	Unconfined Aquifer	DX Extraction/ISRM compliance	A			TE			A -SO4		X	X	X					
199-D4-84	Unconfined Aquifer	DX Extraction/ISRM compliance	A			A					X	X	X					
199-D4-85	Unconfined Aquifer	DX Extraction/ISRM compliance	A			TE			A-SO4		X	X	X					
199-D4-86	Unconfined Aquifer	ISRM compliance	A			TE		Yes	A-SO4		X	X	X	X				
199-D4-87	Unconfined Aquifer	ISRM well																
199-D4-88	Unconfined Aquifer	ISRM well																
199-D4-89	Unconfined Aquifer	ISRM well																

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D4-90	Unconfined Aquifer	ISRM well																
199-D4-91	Unconfined Aquifer	ISRM well																
199-D4-92	Unconfined Aquifer	ISRM well/ZVI test																
199-D4-93	Unconfined Aquifer	ISRM well/ZVI test																
199-D4-94	Unconfined Aquifer	ISRM well																
199-D4-95	Unconfined Aquifer	DX Extraction	A									X						
199-D4-96	Unconfined Aquifer	DX Extraction	A			A						X	X					
199-D4-97	Unconfined Aquifer	DX Extraction	A									X						
199-D4-98	Unconfined Aquifer	DX Extraction	A								X	X						
199-D4-99	Unconfined Aquifer	DX Extraction	A								X	X						
199-D4-101	Unconfined Aquifer	DX Extraction	A			TA						X	X					

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D5-13	Unconfined Aquifer		A									X						
199-D5-14	Unconfined Aquifer		A		A			Yes	TA (Sb, Cd, Co, Cu, Pb, Ag)			X	X	X		X	X	
199-D5-15	Unconfined Aquifer																	
199-D5-16	Unconfined Aquifer		A		A	A						X	X					
199-D5-17	Unconfined Aquifer		A		A			Yes				X	X	X				
199-D5-18	Unconfined Aquifer		A			TE						X	X					
199-D5-19	Unconfined Aquifer		A			A		Yes				X	X	X				
199-D5-20	Unconfined Aquifer	DX Extraction	A								X	X						
199-D5-32	Unconfined Aquifer	DX Extraction	A	A	A							X	EXT					
199-D5-33	Unconfined Aquifer							Yes						X				

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D5-34	Unconfined Aquifer	DX Extraction	TA		A							X	X					X
199-D5-36	Unconfined Aquifer		A					Yes			X			X				
199-D5-37	Unconfined Aquifer							Yes						X				
199-D5-38	Unconfined Aquifer		A					Yes				X		X				
199-D5-39	Unconfined Aquifer	DX Extraction	TA		A	A						X	X					X
199-D5-40	Unconfined Aquifer		A		A	A						X	X					
199-D5-41	Unconfined Aquifer		A									X						
199-D5-42	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D5-43	Unconfined Aquifer		A			A		Yes					X	X				
199-D5-44	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D5-92	Unconfined Aquifer	DX Extraction	A								X	X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D5-97	Unconfined Aquifer		TA					Yes				X		X				X
199-D5-101	Unconfined Aquifer	DX Extraction	A			A						X	X					
199-D5-103	Unconfined Aquifer		TA					Yes				X		X				X
199-D5-104	Unconfined Aquifer	DX Extraction	TA									X						X
199-D5-106	Unconfined Aquifer							Yes						X				
199-D5-107	Unconfined Aquifer	Molasses Inj Test/ Injection Well																
199-D5-108	Unconfined Aquifer	Vegetable Oil Inj Test/Injection Well																
199-D5-109	Unconfined Aquifer	Molasses Inj Test																
199-D5-110	Unconfined Aquifer	Molasses Inj Test																
199-D5-111	Unconfined Aquifer	Molasses Inj Test																
199-D5-112	Unconfined Aquifer	Molasses Inj Test																

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D5-113	Unconfined Aquifer	Molasses Inj Test																
199-D5-114	Unconfined Aquifer	Vegetable Oil Inj Test																
199-D5-115	Unconfined Aquifer	Vegetable Oil Inj Test																
199-D5-116	Unconfined Aquifer	Vegetable Oil Inj Test																
199-D5-117	Unconfined Aquifer	Vegetable Oil Inj Test																
199-D5-118	Unconfined Aquifer	Vegetable Oil Inj Test																
199-D5-123	Unconfined Aquifer		A	A		A							X					
199-D5-125	Unconfined Aquifer		A									X						
199-D5-126	Unconfined Aquifer							Yes						X				
199-D5-127	Unconfined Aquifer	DX Extraction	TA		A							X	X					X
199-D5-128	Unconfined Aquifer	DX Injection	Eff									Eff						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D5-129	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D5-130	Unconfined Aquifer	DX Extraction	A		A							X	X					
199-D5-131	Unconfined Aquifer	DX Extraction	A		A							X	X					
199-D5-132	Unconfined Aquifer		A	TA	A							X	X					
199-D5-133	Unconfined Aquifer		TA					Yes				X		X				X
199-D5-134	Unconfined Aquifer							Yes						X				
199-D5-141	Unconfined Aquifer																	
199-D5-142	Unconfined Aquifer		A	TA	A				TA (Sb, Cd, Co, Cu, Pb, Ag)			X	X			X	X	
199-D5-143	Unconfined Aquifer		A															
199-D5-145	Unconfined Aquifer		TA									X						X

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D5-146	Unconfined Aquifer	DX Extraction	TA									X						X
199-D5-147	Unconfined Aquifer																	
199-D5-148	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D5-153	Unconfined Aquifer	DX Extraction	A		A							X	X					
199-D5-154	Unconfined Aquifer	DX Extraction	A	A								X	EXT					
199-D5-159	Unconfined Aquifer	DX Extraction	A	A								X	EXT					
199-D6-1	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D6-2	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D6-3	Unconfined Aquifer		A									X						
199-D7-3	Unconfined Aquifer	DX Extraction	A									X						
199-D7-4	Unconfined Aquifer	DX Injection	Eff									Eff						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D7-5	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D7-6	Unconfined Aquifer	DX Extraction	A									X						
199-D8-4	Unconfined Aquifer		TA		A							X	X					
199-D8-5	Unconfined Aquifer		A					Yes			X	X		X				
199-D8-6	Unconfined Aquifer																	
199-D8-53	Unconfined Aquifer	DX Extraction	A									X						
199-D8-54A	Unconfined Aquifer		A	A				Yes			X		X	X				
199-D8-55	Unconfined Aquifer	DX Extraction	A	A							X	X	EXT					
199-D8-68	Unconfined Aquifer	DX Extraction	A	A	A	TE					X	X	EXT					
199-D8-69	Unconfined Aquifer	DX Extraction	A	A							X	X	EXT					
199-D8-70	Unconfined Aquifer		A					Yes			X	X		X				

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D8-71	Unconfined Aquifer		A					Yes			X	X		X				
199-D8-72	Unconfined Aquifer		A															
199-D8-73	Unconfined Aquifer	DX Extraction	A								X	X						
199-D8-88	Unconfined Aquifer	DX Extraction	A								X	X						
199-D8-89	Unconfined Aquifer	DX Extraction	A								X	X						
199-D8-90	Unconfined Aquifer	DX Extraction	A									X						
199-D8-91	Unconfined Aquifer	DX Extraction	A								X	X						
199-D8-93	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D8-94	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D8-95	Unconfined Aquifer	DX Extraction	A									X						
199-D8-96	Unconfined Aquifer	DX Extraction	A		A							X	X					

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D8-97	Unconfined Aquifer	DX Extraction	A		A							X	X					
199-D8-98	Unconfined Aquifer	DX Extraction	A		A							X	X					
199-D8-99	Unconfined Aquifer	DX Injection	Eff									Eff						
199-D8-101	Unconfined Aquifer		A		A							X	X					
199-H1-1	Unconfined Aquifer	HX Extraction	A									X						
199-H1-2	Unconfined Aquifer	HX Extraction	A									X						
199-H1-3	Unconfined Aquifer	HX Extraction																
199-H1-4	Unconfined Aquifer	HX Extraction	A									X						
199-H1-5	Unconfined Aquifer	DX Extraction	A									X						
199-H1-6	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H1-7	Unconfined Aquifer		A					Yes			X			X				

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H1-20	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H1-21	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H1-25	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H1-27	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H1-32	Unconfined Aquifer	HX Extraction	A								X	X						
199-H1-33	Unconfined Aquifer	HX Extraction	A								X	X						
199-H1-34	Unconfined Aquifer	HX Extraction	A								X	X						
199-H1-35	Unconfined Aquifer	HX Extraction	A								X	X						
199-H1-36	Unconfined Aquifer	HX Extraction	A									X						
199-H1-37	Unconfined Aquifer	HX Extraction	A								X	X						
199-H1-38	Unconfined Aquifer	HX Extraction	A								X	X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H1-39	Unconfined Aquifer	HX Extraction	A								X	X						
199-H1-40	Unconfined Aquifer	HX Extraction	A								X	X						
199-H1-42	Unconfined Aquifer	HX Extraction	A									X						
199-H1-43	Unconfined Aquifer	HX Extraction	A									X						
199-H1-45	Unconfined Aquifer	HX Extraction	A									X						
199-H1-46	Unconfined Aquifer		A									X						
199-H3-2A	Unconfined Aquifer		A						TA (Sb, Cd, Co, Cu, Pb, Ag)							X	X	
199-H3-2B	Unconfined Aquifer							Yes						X				
199-H3-3	Unconfined Aquifer		A									X						
199-H3-4	Unconfined Aquifer	HX Extraction	A									X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H3-5	Unconfined Aquifer																	
199-H3-6	Unconfined Aquifer		A	TA	A						X	X	X					
199-H3-7	Unconfined Aquifer		A		A							X	X					
199-H3-11	Unconfined Aquifer		A									X						
199-H3-25	Unconfined Aquifer	HX Extraction	A									X						
199-H3-26	Unconfined Aquifer	HX Extraction	A									X						
199-H3-27	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H4-2	Unconfined Aquifer																	
199-H4-4	Unconfined Aquifer	HX Extraction	A	A	A		A			TE	X	X	EXT					X
199-H4-5	Unconfined Aquifer		A					Yes			X	X		X				
199-H4-6	Unconfined Aquifer																	

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H4-8	Unconfined Aquifer	RCRA	A		A			Yes			X	X	X	X				X
199-H4-10	Unconfined Aquifer		A					Yes			X	X		X				
199-H4-11	Unconfined Aquifer		A	TA				Yes			X	X	X	X				
199-H4-12A	Unconfined Aquifer	RCRA	TA		A		TA				X	X	X	X				X
199-H4-12B	Unconfined Aquifer							Yes						X				
199-H4-13	Unconfined Aquifer		A	TA				Yes	TA (Sb, Cd, Co, Cu, Pb, Ag)	A	X	X	X	X		X	X	
199-H4-15A	Unconfined Aquifer	HX Extraction	A								X	X						
199-H4-15B	Unconfined Aquifer							Yes						X				
199-H4-16	Unconfined Aquifer																	
199-H4-17	Unconfined Aquifer	HX Injection	Eff									Eff						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H4-18	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H4-45	Unconfined Aquifer		A	A							X	X	X					
199-H4-46	Unconfined Aquifer		A		A							X	X					
199-H4-47	Unconfined Aquifer																	
199-H4-49	Unconfined Aquifer		A									X						
199-H4-63	Unconfined Aquifer	HX Extraction	A	TA			A			A	X	X	EXT					
199-H4-64	Unconfined Aquifer	HX Extraction	A				A				X	X	EXT					
199-H4-65	Unconfined Aquifer		A								X	X						X
199-H4-69	Unconfined Aquifer	HX Extraction	A	A								X	X					
199-H4-70	Unconfined Aquifer	HX Extraction	A									X						
199-H4-71	Unconfined Aquifer	HX Injection	Eff									Eff						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H4-72	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H4-73	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H4-74	Unconfined Aquifer	HX Extraction	A									X						
199-H4-75	Unconfined Aquifer	HX Extraction	A		A							X	X					
199-H4-76	Unconfined Aquifer	HX Extraction	A									X						
199-H4-77	Unconfined Aquifer	HX Extraction	A									X						
199-H4-78	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H4-79	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H4-80	Unconfined Aquifer	DX Extraction	A									X						
199-H4-81	Unconfined Aquifer	DX Extraction	A									X						
199-H4-82	Unconfined Aquifer	DX Extraction	A									X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H4-83	Unconfined Aquifer		A	TA				Yes	beta emitters (once)	TA		X	X	X				
199-H4-84	Unconfined Aquifer	RCRA	TA		TA		TA	Yes	TA (Sb, Cd, Co, Cu, Pb, Ag)	A		X	X	X		X	X	X
199-H4-85	Unconfined Aquifer		TA		TA		TA		beta emitters (once)	A	X	X	X	X				X
199-H4-86	Unconfined Aquifer	HX Extraction	A									X						
199-H4-92	Unconfined Aquifer		A															
199-H4-93	Unconfined Aquifer	HX Extraction	A									X						
199-H5-1A	Unconfined Aquifer	ISRM Field Test Piezometer	A					Yes				X		X				
199-H5-2	Unconfined Aquifer	ISRM Field Test/ Injection Well																
199-H5-3O	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-3P	Unconfined Aquifer	ISRM Field Test Piezometer																

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H5-4O	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-4P	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-5O	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-5P	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-6	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-7	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-8	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-9	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-10	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-11	Unconfined Aquifer	ISRM Field Test Piezometer																
199-H5-12	Unconfined Aquifer																	

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H5-13	Unconfined Aquifer																	
199-H5-14	Unconfined Aquifer																	
199-H5-16	Unconfined Aquifer																	
199-H6-1	Unconfined Aquifer		A	A	A							X	X					
199-H6-2	Unconfined Aquifer	HX Extraction	A									X						
199-H6-3	Unconfined Aquifer		A		A							X	X					
199-H6-4	Unconfined Aquifer																	
199-H6-7	Unconfined Aquifer	HX Injection	Eff									Eff						
199-H6-8	Unconfined Aquifer	HX Injection	Eff									Eff						
699-88-41	Unconfined Aquifer		A									X						
699-89-35	Unconfined Aquifer																	

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
699-90-34	Unconfined Aquifer																	
699-90-37B	Unconfined Aquifer		A									X						
699-90-38	Unconfined Aquifer																	
699-90-45	Unconfined Aquifer		A									X						
699-91-46A	Unconfined Aquifer		A									X						
699-92-49	Unconfined Aquifer																	
699-93-48A	Unconfined Aquifer		A									X						
699-93-48C	Unconfined Aquifer	DX Injection	Eff									Eff						
699-93-50	Unconfined Aquifer																	
699-94-41	Unconfined Aquifer		A									X						
699-94-43	Unconfined Aquifer		A									X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
699-95-45	Unconfined Aquifer		A									X						
699-95-45B	Unconfined Aquifer	HX Injection	Eff									Eff						
699-95-48	Unconfined Aquifer		A									X						
699-95-51	Unconfined Aquifer		A					Yes				X		X				
699-96-43	Unconfined Aquifer																	
699-96-44	Unconfined Aquifer																	
699-96-45	Unconfined Aquifer																	
699-96-52B	Unconfined Aquifer		A					Yes			X	X		X				
699-97-41	Unconfined Aquifer		A					Yes				X		X				
699-97-43B	Unconfined Aquifer		A						TA (Sb, Cd, Co, Cu, Ag)			X				X	X	
699-97-45	Unconfined Aquifer		A					Yes				X		X				

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
699-97-47B	Unconfined Aquifer																	
699-97-48B	Unconfined Aquifer		A					Yes				X		X				
699-97-51A	Unconfined Aquifer		A									X						
699-98-43	Unconfined Aquifer		A					Yes				X		X				
699-98-46	Unconfined Aquifer		A						TA (Sb, Cd, Co, Cu, Ag)			X				X	X	
699-98-49A	Unconfined Aquifer		A									X						
699-98-51	Unconfined Aquifer							Yes						X				
699-99-41	Unconfined Aquifer		A					Yes			X			X				
699-99-42B	Unconfined Aquifer		A					Yes	TA (Sb, Cd, Co, Cu, Ag)		X	X		X		X	X	
699-99-44	Unconfined Aquifer		A					Yes				X		X				

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
699-100-43B	Unconfined Aquifer		A					Yes			X	X		X				
699-101-45	Unconfined Aquifer							Yes						X				
699-101-48B	Unconfined Aquifer		TE								X							
C7647	Aquifer Tube – 100-D Area		A								X	X						
DD-10-3	Aquifer Tube – 100-D Area		A								X	X						
DD-12-2	Aquifer Tube – 100-D Area		A								X	X						
DD-15-3	Aquifer Tube – 100-D Area		A	A							X	X	X					
DD-16-4	Aquifer Tube – 100-D Area		A	A							X	X	X					
DD-17-2	Aquifer Tube – 100-D Area		A								X							
C6278	Aquifer Tube – 100-D Area		A	A									X					
DD-41-3	Aquifer Tube – 100-D Area		A								X	X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
DD-44-4	Aquifer Tube – 100-D Area		A								X	X						
DD-49-3	Aquifer Tube – 100-D Area		A			TE					X	X	X					
DD-50-3	Aquifer Tube – 100-D Area		A			A							X					
DD-50-4	Aquifer Tube – 100-D Area		A			TE					X	X	X					
Redox-1-6.0	Aquifer Tube – 100-D Area		A								X	X						
Redox-3-3.3	Aquifer Tube – 100-D Area		A								X	X						
36-M	Aquifer Tube – 100-D Area		A								X	X						
38-M	Aquifer Tube – 100-D Area		A								X	X						
AT-D-1-M	Aquifer Tube – 100-D Area		A								X	X						
AT-D-3-D	Aquifer Tube – 100-D Area		A								X	X						
AT-D-4-D	Aquifer Tube – 100-D Area		A								X	X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
43-M	Aquifer Tube – 100-H Area		A								X	X						
45-M	Aquifer Tube – 100-H Area		A								X	X						
47-D	Aquifer Tube – 100-H Area		A	A									X					
47-M	Aquifer Tube – 100-H Area		A								X	X						
48-M	Aquifer Tube – 100-H Area		A								X	X						
50-M	Aquifer Tube – 100-H Area		A								X	X						
51-D	Aquifer Tube – 100-H Area		A								X	X						
52-D	Aquifer Tube – 100-H Area		A								X	X						
54-M	Aquifer Tube – 100-H Area		A								X	X						
AT-H-1-M	Aquifer Tube – 100-H Area		A								X	X						
AT-H-2-D	Aquifer Tube – 100-H Area		A								X	X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
AT-H-3-D	Aquifer Tube – 100-H Area		A								X	X						
C5633	Aquifer Tube – 100-H Area		A								X	X						
C5636	Aquifer Tube – 100-H Area		A								X	X						
C5638	Aquifer Tube – 100-H Area		A								X	X						
C5641	Aquifer Tube – 100-H Area		A								X	X						
C5678	Aquifer Tube – 100-H Area		A								X	X						
C5682	Aquifer Tube – 100-H Area		A								X							
C6293	Aquifer Tube – 100-H Area		A								X	X						
C6301	Aquifer Tube – 100-H Area		A								X	X						
C7649	Aquifer Tube – 100-H Area		A	A									X					
C7650	Aquifer Tube – 100-H Area		A								X	X						

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-D5-134	RUM First Water Bearing Unit		A									X			X			
199-D5-141	RUM First Water Bearing Unit		A									X			X			
199-D8-54B	RUM First Water Bearing Unit		A					Yes			X	X			X			
199-H2-1	RUM First Water Bearing Unit		TA		TA			Yes			X	X	X		X			
199-H3-10	RUM First Water Bearing Unit		A					Yes				X			X			
199-H3-2C	RUM First Water Bearing Unit	HX Extraction	A		TA	TE						X	X		X			
199-H3-9	RUM First Water Bearing Unit	HX Extraction	A						beta emitters (once)	TE	X	X	X		X			
199-H4-12C	RUM First Water Bearing Unit	HX Extraction/RCRA	A		TA						X	X	X		X			X

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

											PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
Monitoring Location	**Well Type or Aquifer Tube**	**Treatment System[a]**	**Hexavalent Chromium**	**Strontium-90**	**Nitrate**	**Tritium**	**Uranium**	**AWLN[b]**	**Other[c]**	**Gross Beta**	**Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**	**Is the remedy effectively reducing the groundwater Cr(VI) plume?**	**Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?**	**What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?**	**What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**	**Are infrequently detected analytes confirmed not to be contaminants of potential concern?**	**Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**	**Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?**
199-H4-90	RUM First Water Bearing Unit		TA		TA							X	X		X			
199-H4-91	RUM First Water Bearing Unit		TA		TA							X	X		X			
699-97-43C	RUM First Water Bearing Unit		TA			TE						X	X		X			
699-97-45B	RUM First Water Bearing Unit		TA			TE						X	X		X			
699-97-48C	RUM First Water Bearing Unit		TA			TE		Yes				X	X		X			
699-97-60	RUM First Water Bearing Unit		TA			TE						X	X		X			
699-97-61	RUM First Water Bearing Unit		TA			TE			beta emitters (once)	TE		X	X		X			
D River Gauge								Yes						X				
H River Gauge								Yes						X				

Table 3-3. Summary of Monitoring Locations, Frequencies, and Constituents

Monitoring Location	Well Type or Aquifer Tube	Treatment System[a]	Hexavalent Chromium	Strontium-90	Nitrate	Tritium	Uranium	AWLN[b]	Other[c]	Gross Beta	PSQ Addressed[d]							
											1	2	3[e]	4a	4b	5a	5b	5c
											Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?	Is the remedy effectively reducing the groundwater Cr(VI) plume?	Are other contaminant plumes that exceed risk-based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?	What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?	What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?	Are infrequently detected analytes confirmed not to be contaminants of potential concern?	Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?	Are potential source areas confirmed not to be continuing sources of contaminants of potential concern in groundwater?

a. Data for extraction and injection wells will be collected as identified in DOE/RL-2013-49, *100-HR-3 Pump and Treat System Operations and Maintenance Plan*, and Table 3-4.

b. AWLN = automated water level network; yes = transducers at these locations are set up to collect measurements hourly.

c. Other - analytes are as follows: Sb - antimony; Cd – cadmium; Co – cobalt; Cu – copper; F – fluoride; Fe – iron; PB – lead; Mn – manganese; NO2 – nitrite; Ag – silver; SO4 – sulfate; Zn – zinc.

d. Field parameters will be collected from sample location when a laboratory sample is collected. Field parameters include pH, temperature, conductivity, and turbidity. Additional field parameters that may be included are dissolved oxygen and oxygen reduction potential.

e. PSQ 3 includes operational sampling from extraction wells

Note: total chromium will be collected in conjunction with Cr(VI) on a periodic basis.

A = annual monitoring
Eff = Effluent
RUM = Ringold Formation upper mud
Sr-90 = strontium-90
TA = triannual monitoring (three times per year)
TE = triennial monitoring (once every three years)
Yes = location is part of the automated water level network
X = location selected to address PSQ

Table 3-4. Treatment Process Water Monitoring

Parameters	Location	Data Use	Frequency
DX P&T System			
Nitrate, Total Chromium, Hexavalent Chromium	Influent/effluent tanks, extraction wells	Monitor remedial action effects on co-contaminant concentrations in treatment water	Quarterly
Strontium-90	Selected extraction wells[a]	Monitor co-contaminant concentrations	Quarterly
Field Parameters: pH, Turbidity, Temperature, Dissolved Oxygen, Specific Conductance, Hexavalent Chromium	Influent/effluent tanks	Monitor water quality	Quarterly
Method 300.0 Anion List Including Chloride, Fluoride, Nitrate, Nitrite, Phosphate, Sulfate	Influent/effluent tanks	Monitor water quality	Monthly for 2 years, then re-evaluate
HX P&T System			
Nitrate, Total Chromium, Hexavalent Chromium	Influent/effluent tanks, extraction wells	Monitor remedial action effects on co-contaminant concentrations in treatment water	Quarterly
Strontium-90	Selected extraction wells[b]	Monitor co-contaminant concentrations	Quarterly
Uranium	Selected extraction wells[c]	Monitor co-contaminant concentrations	Semiannually
Field Parameters: pH, Turbidity, Temperature, Dissolved Oxygen, Specific Conductance, Hexavalent Chromium	Influent/effluent tanks	Monitor water quality	Quarterly
Method 300.0 Anion List Including Chloride, Fluoride, Nitrate, Nitrite, Phosphate, Sulfate	Influent/effluent tanks	Monitor water quality	Monthly for 2 years, then re-evaluate

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

a. DX extraction wells for strontium-90 analysis include 199-D5-32, 199-D5-154, 199-D5-159, 199-D8-68, 199-D8-69, and 199-D8-55.

b. HX extraction wells for strontium-90 analysis include 199-H4-4 and 199-H4-63.

c. HX extraction wells for uranium analysis include 199-H4-4, 199-H4-63, and 199-H4-64.

In the 100-H Area, the known strontium-90 plume is located near the 116-H-7 retention basin. Concentrations of strontium-90 were as high as 26 pCi/L (Well 199-H4-13) as recent as March 2014. Extraction wells (199-H4-63 and 199-H4-4) are located near or within the plume and were selected for monitoring to track HX system influent concentrations. Figure 3-2 presents the wells that have, at one time in their history, had a detection of strontium-90 at 100-H.

3.3.2 Uranium Sampling

Uranium has not been detected above 5 µg/L in 100-D and is not considered a COC in that area. As a result, uranium is not included in the process water sampling for 100-D extraction wells.

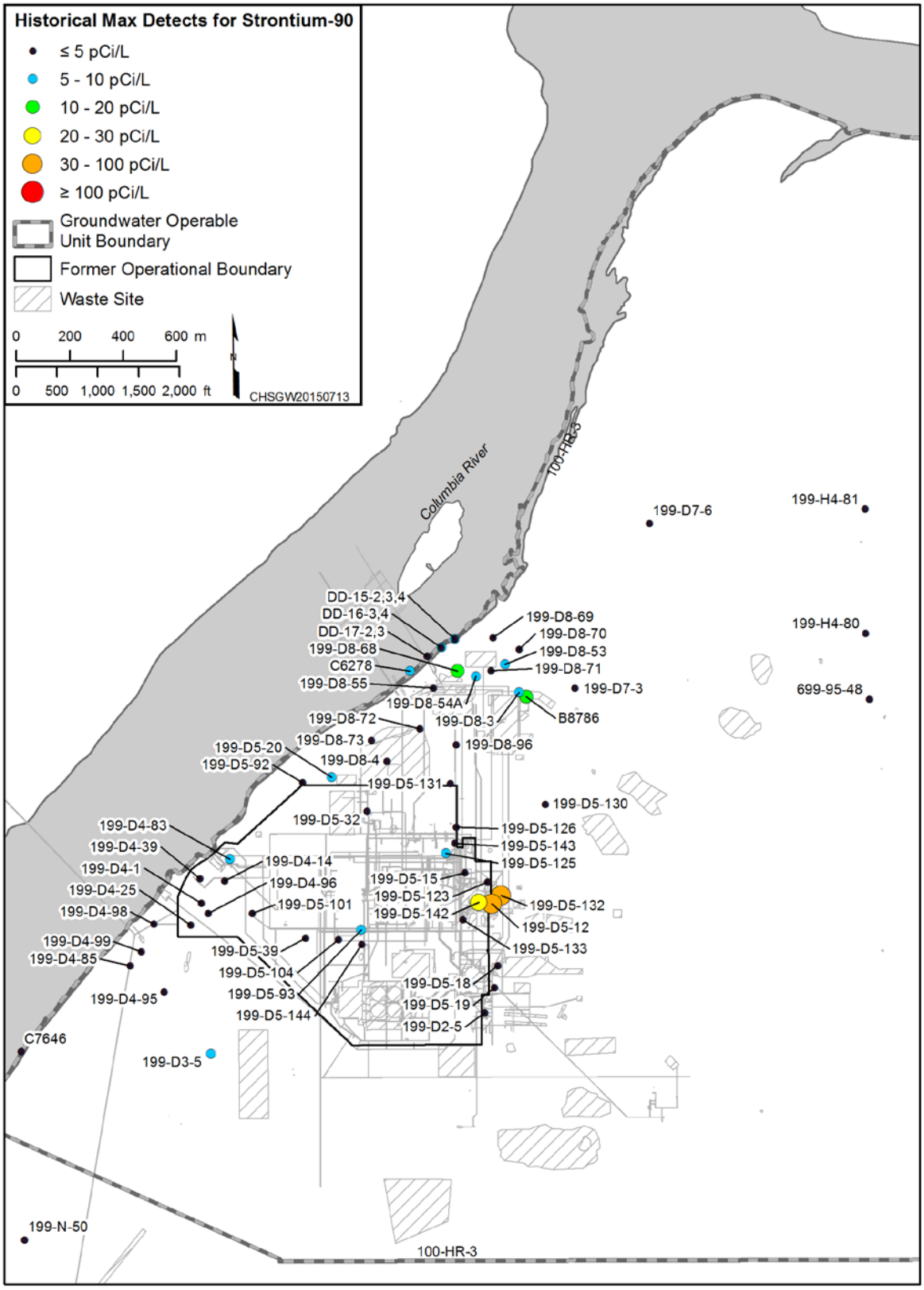

Figure 3-1. Wells with Historical Strontium-90 Detections at 100-D

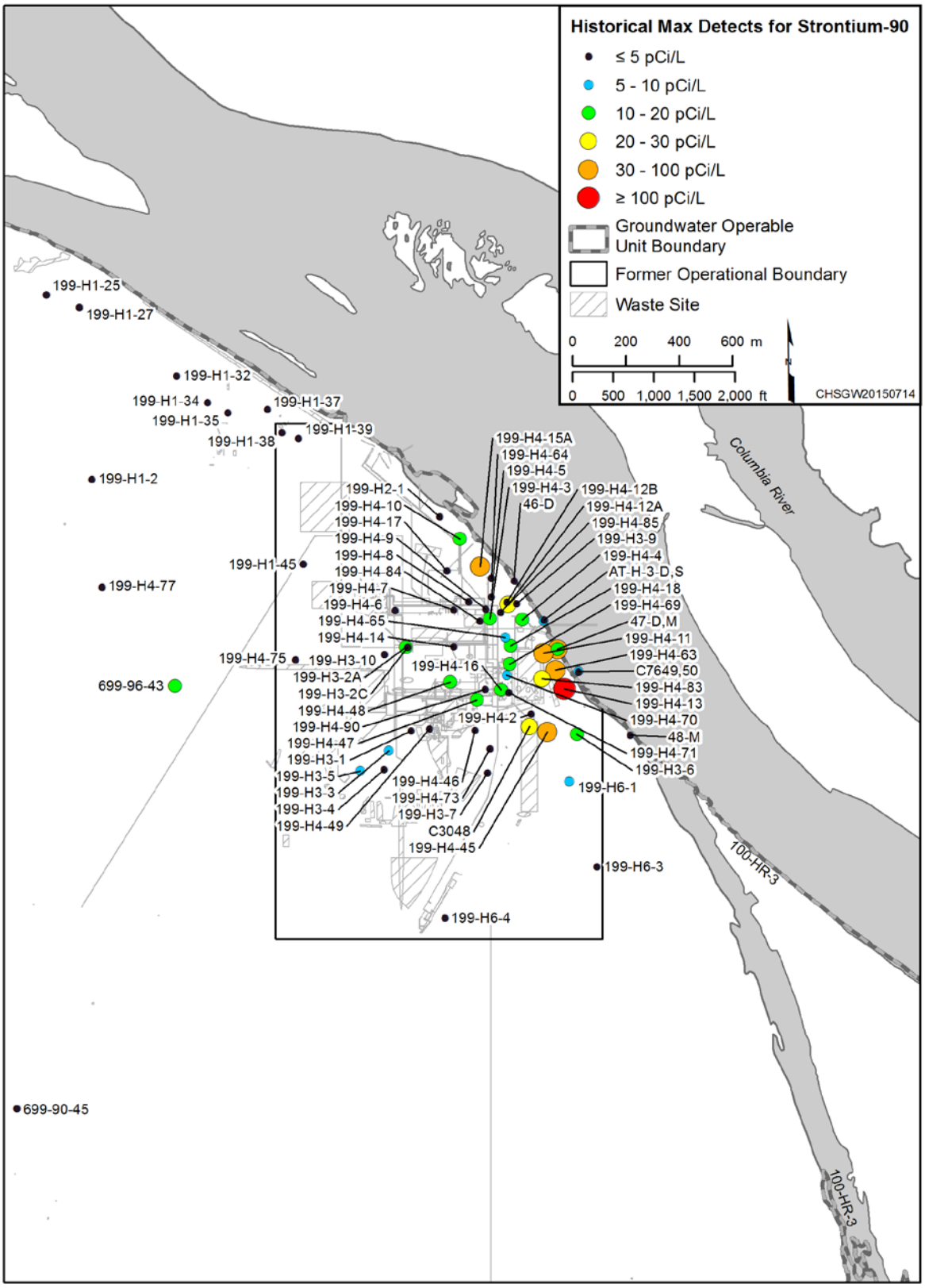

Figure 3-2. Wells with Historical Strontium-90 Detections at 100-H

In 100-H, uranium has been historically detected near the 183-H solar evaporation basins. Extraction wells (199-H4-4, 199-H4-63, and 199-H4-64), selected for system monitoring, are located near the basins.

3.4 Sampling Methods

Sampling activities may include collection of specific types of samples and performance of field measurements. Samples and measurements performed may include, but are not limited to, the following types:

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

All individuals performing groundwater sampling activities are trained in the proper handling of defensible samples, paperwork, and related documentation necessary to fulfill established requirements (see Section 2.2.1 for training and certification requirements). Groundwater well and aquifer tube samples will be collected in accordance with the current revision of applicable operating procedures, using dedicated sampling pumps, precleaned bailers, or precleaned portable pumps. Aquifer tubes will be inspected prior to sampling and those with compromised integrity will be scheduled for repair or removed from the sampling list. DOE will be notified of concerns regarding aquifer tube integrity. Replacement locations will be considered on a case-by-case basis.

Calibrated field screening equipment is used for collection of all field measurements. Water samples are collected after field measurements of purged groundwater have stabilized:

- pH – two consecutive measurements agree within 0.2 pH units
- Temperature – two consecutive measurements agree within 0.2°C
- Conductivity – two consecutive measurements agree within 10 percent of each other
- Turbidity – less than 5 nephelometric turbidity units (NTUs) prior to sampling (or project scientist's recommendation)

For certain types of samples, preservatives are required. While the preservative may be added to collection bottles before their use in the field, it is allowable to add the preservative at the sampling vehicle immediately after collection. Samples may require filtering in the field, as noted on the chain-of-custody forms.

To ensure sample and data usability, sampling associated with this SAP will be performed according to HASQARD (DOE/RL-96-68) pertaining to sample collection, collection equipment, and sample handling.

Suggested sample container, preservation, and holding time requirements are specified in Table 2-6 for groundwater samples. These requirements are in accordance with the analytical method specified. The final container type and volumes for each sampling event are identified on the SAF and chain-of-custody forms. Example SAF and chain-of-custody forms are included in Appendix C. This SAP defines a sample as a filled sample bottle for starting the clock for holding time restrictions.

Holding time is the elapsed period between sample collection and analysis. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other

chemical alterations. Required holding times (Table 2-6) depend on the analytical method, as specified for appropriate EPA methods (EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*; SW-846).

3.4.1 Decontamination of Sampling Equipment

Sampling equipment will be decontaminated in accordance with sampling equipment decontamination methods. To prevent potential contamination of samples, care should be taken to use decontaminated equipment for each sampling activity. Most wells are equipped with dedicated pumps and sampling valves. Nondedicated equipment could include, but is not limited to, portable Grundfos pumps, Kabis bailers, split-spoons, or liners. EBs are required when nondedicated sampling equipment is used (both new and decontaminated). The SMR group will transmit a request for the collection of EBs to the sampling group. Equipment decontamination is performed in accordance with FSO procedures. In general, sampling decontamination includes the following activities:

- Remove visible particulate matter by wiping and scraping, using a stiff nylon brush or equivalent, into the waste container.
- Wash equipment with a stiff nylon brush or equivalent.
- Rinse equipment with high purity water a minimum of three times.
- Allow equipment to dry.
- Wrap in aluminum foil and stored in a poly bag.
- Mark poly bag with the words Field Decontaminated Equipment, and label the date that the equipment was decontaminated.

Radiological decontamination may include additional cleaning and screening based on the contamination levels encountered and under the direction of the RCT.

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

3.4.2 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 levels also are measured in wells that are screened in confined or partially confined aquifers to help determine horizontal and vertical hydraulic gradients.

A measurement of depth to water also is recorded in each well prior to sampling, using calibrated depth measurement tapes. Two consecutive measurements are taken that agree within 6 mm (0.02 ft). These are recorded along with the date, time, measuring tape number, and other pertinent details. The depth to groundwater is subtracted from the elevation of a reference point (usually the top of casing) to obtain the

water level elevation. Tops of casings are known elevation reference points because they have been surveyed to local reference data. Well elevation details, including the screen interval, are presented in Appendix B (Table B-1).

Groundwater elevation data are collected from the system well network during specified synoptic measurement times, as discussed in Sections 1.1 and 3.2.4, in addition to being measured during sampling events. Manual water level measurements are collected with clean, nonstretch, laminated steel electric sounding tapes graduated in metric units. Measurements are recorded using the Field Logging and Electronic Data Gathering system and/or a Water Level Measurement Form and entered into HEIS.

Select wells in the AWLN are equipped with pressure transducers that provide water levels within the wells, as indicated by the calculated height of water above the transducer. These measurements are electronically recorded on an hourly basis. Pressure transducers are also used at all wells being operated through the P&T system.

Groundwater elevation is measured during regularly scheduled groundwater sampling events, during focused events to collect elevation measurements from many wells over a short period of time, and in selected wells by automated data logging pressure transducers placed in the wells (AWLN). The 100-HR-3 AWLN system was refurbished and expanded during 2014 with the addition of 15 new measurement stations. By December 2014, the AWLN recorded data from pressure transducers at 53 locations. The increase in number and location of monitoring wells increases certainty to the hydraulic monitoring system and, therefore, the ability to determine hydraulic capture. Additional localized dynamic water level data are collected at each of the P&T extraction and injection wells. Manual depth-to-groundwater measurements are collected routinely during groundwater sampling missions. All of the available data are used, where applicable, to assemble groundwater elevation maps.

Finally, although advanced interpolation techniques are used in developing water level maps, confidence in these maps is heavily dependent on the density of the monitoring well network and the quality of the available data. During 2014, data from AWLN monitoring locations were not always available or deemed usable for the entire time frame. Due to station technology improvements and additional AWLN stations, the data network at 100-HR-3 was improved in 2014 as compared to 2013; therefore, the data set was again not as extensive as in previous years. Although the interpolated water level maps are consistent with observations and qualitative interpretations of aquifer conditions and resulting flow fields during the year, improvements to the monitoring network are required to increase confidence in these interpretations. Maintenance and data checks are being conducted on a regular basis to improve the system reliability and data quality. Periodic review of the transducer data is conducted to compare the output against the trend of previous data. This is accomplished by first reviewing the data file and then loading the data into the Virtual Library for comparison against previous data. If needed, field crews are sent out to the remote locations to diagnose and repair/replace equipment.

3.5 Documentation of Field Activities

Logbooks or data forms are required for field activities. A logbook must be identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook and only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the FWS, or other responsible manager within FSO, and 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, the information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks. The following information is to be recorded in logbooks:

- Purpose of activity
- Day, date, time, and weather conditions
- Names, titles, and organizations of personnel present
- Deviations from the QAPjP due to field conditions
- All site activities, including field tests
- Materials quality documentation (e.g., certifications)
- Details of samples collected (e.g., preparation, splits, DUPs, MS, and EBs)
- Location and types of samples
- Chain-of-custody details and variances relating to chain-of-custody
- Field measurements
- Field calibrations testing, inspections, maintenance and surveys, and equipment identification numbers, as applicable
- Equipment decontaminated, number of decontaminations, and variations to decontamination methods
- Equipment failures or breakdowns and descriptions of any corrective actions
- Telephone calls relating to field activities

3.5.1 Corrective Actions and Deviations for Sampling Activities

The OU Project Manager, FWS, appropriate BTR (or designee), and SMR personnel must document deviations from protocols, problems pertaining to sample collection, chain-of-custody forms, sample transport, or noncompliant (not sampled according to the sampling plan or other procedural/compliance document) monitoring. Examples of deviations include samples not collected because of field conditions, changes in sample locations because of physical obstructions, or additions of sample depth(s).

As appropriate, such deviations or problems will be documented in field logbook or on nonconformance report forms in accordance with internal corrective action methods. The OU Project Manager, FWS, appropriate BTR (or designee), or SMR personnel will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities.

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

Construction management, the appropriate BTR, or the FWS is responsible for ensuring that field equipment is calibrated appropriately. Onsite environmental instruments are calibrated in accordance with manufacturer operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. Results from all instrument calibration activities are recorded in accordance with HASQARD Volume 3 (DOE/RL-96-68).

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

- Prior to initial use of field analytical measurement systems.
- 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 MSA prime contractor, as specified by their calibration program.
- Daily calibration checks will be performed and documented for each applicable instrument used to collect environmental measurements. 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.
- Standards used for calibration will be traceable to nationally or internationally recognized standard agency source or measurement system, if available.

3.7 Sample Handling

Sample handling and transfer will be in accordance with requirements established in HASQARD Volume 2 (DOE/RL-96-68) 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.

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

3.7.1 Containers

Precleaned sample containers with certificates of analysis denoting compliance with EPA specifications (EPA 540/R-93/051, *Specifications and Guidance for Contaminant-Free Sample Containers*) for the intended analyses will be used for samples collected for chemical analysis. Container sizes may vary, depending on laboratory specific volumes/requirements for meeting analytical detection limits. The Radiological Engineering 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 laboratory radioactivity acceptance criteria. Container types and sample amounts/volumes are identified in Table 2-6.

3.7.2 Container Labeling

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

- SAF
- HEIS number
- Sample collection date and time
- Collector's name or initials
- Analysis required
- Preservation method (if applicable)
- Chain-of-custody number

- Bottle type and size
- Laboratory performing the analyses
- Sample location

Sample records must include the following information:

- Analysis required
- Source of sample
- Matrix (water, including indication if sample is field filtered)
- Field data (pH, temperature, turbidity, and conductivity)
- Radiological readings

Dissolved oxygen and redox potential information may be specified by the project. An example SAF and chain-of-custody form are included in Appendix C.

3.7.3 Sample Custody

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

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 sample custody changes, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to the SMR organization within 48 hours of shipping. The following information is required on a completed chain-of-custody form:

- Project name
- Signature of sampler
- HEIS sample number
- Date and time of collection
- Matrix (including indication if groundwater sample is field filtered)
- Preservatives
- Signatures of individual involved in sample transfer
- Requested analyses
- Number of containers associated with each analysis, if greater than one
- Company contact information (e.g., phone number and email)

3.7.4 Sample Transportation

All packaging and transportation instructions will comply with applicable transportation regulations and DOE requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, “Transportation,” “General Information, Regulations, and Definitions,” 49 CFR through 177, “Carriage by Public Highway.” Carrier specific requirements defined in the current edition of International Air Transportation Association *Dangerous Goods Regulations* also should be considered when preparing sample shipments conveyed by air freight providers.

Samples containing hazardous constituents will be considered hazardous material in transportation and transported according to DOT (49 CFR) 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.

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

4 Management of Waste

Details on the specific requirements for waste identification, characterization, segregation, packaging, labeling, storage, and inspection for waste generation activities associated with the 100-HR-3 OU groundwater monitoring activities are provided in DOE/RL-97-01, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units*. The following activities are likely to generate waste:

- Construction, operation, maintenance, and decommissioning of groundwater remediation systems
- Groundwater well or aquifer tube installation
- Groundwater well or aquifer tube development, sampling, maintenance, and decommissioning
- Water level and other in situ groundwater measurements
- Process sampling and screening/analysis of samples
- Decontamination of equipment and material
- Aquifer testing, geophysical logging, and treatability studies

Resin will be sampled and analyzed for waste characterization prior to change of resin and disposal. Disposal and transportation of waste resin are described in DOE/RL-97-01.

Waste will be designated in accordance with WAC 173-303, “Dangerous Waste Regulations,” using process knowledge, historical analytical data, and/or analyses of samples identified in the referenced documents or SAPs, as appropriate. The waste management plan (DOE/RL-97-01) includes waste stream specific management practices.

Offsite analytical laboratories are responsible for disposal of unused sample quantities. Pursuant to 40 CFR 300.440, “National Oil and Hazardous Substances Pollution Contingency Plan,” “Procedures for Planning and Implementing Off-Site Response Actions,” approval from the DOE Remedial Project Manager is required before returning unused samples or waste from offsite laboratories.

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5 Health and Safety

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

The health and safety program was developed to define chemical, radiological, and physical hazards and specify the controls and requirements for day-to-day work activities on the overall Hanford Site. The program incorporates applicable core functions and guiding principles outlined in ISMS and governs minimal personal training, control of industrial safety and radiological hazards, PPE, site control, and general emergency response to spills, fire, accidents, injury, and incident reporting. Monitoring locations identified for biostimulation test area sampling also require industrial hygiene measurements of annular space lower explosive limit, hydrogen sulfide, sulfur dioxide, and methane as a component of health and safety.

Work activities will be conducted in accordance with all applicable health and safety programs. The health and safety program addresses the health and safety hazards of each phase of site operation and includes the requirements for hazardous waste operations and/or construction activities, as specified in 29 CFR 1910.120.

Project field staff will be required to comply with the health and safety plan (HASP) at all times. Unescorted site visitors are required to read and sign the HASP before entering the construction area and must have completed the required training outlined in the HASP. Escorted visitors are briefed on health and safety concerns and must be escorted by the site superintendent (or designee) at all times when they are in the construction area. Construction areas may include P&T system or monitoring well locations.

During P&T operations, emergency response for 100-HR-3 OU interim remedial activities will be covered by the health and safety program. The health and safety program specifies primary emergency response actions for site personnel, area alarms, implementation of the emergency action plan and emergency equipment at the task site, emergency coordinators, emergency response procedures, and spill containment procedures.

Emergency contact numbers are 911 or the Hanford Site Emergency number (373-0911) from a mobile phone.

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6 References

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Appendix A

Data Quality Objectives

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Contents

A1 Introduction A-1
A2 Step 1: State the Problem A-1
A3 Step 2: Identify the Goal of the Study A-1
A4 Step 3: Identify Information Inputs A-2
A5 Step 4: Define the Boundaries of the Study A-3
A5.1 Spatial Boundaries of the Study A-3
A5.2 Temporal Boundaries of the Study A-34
A5.3 Resource Limitations and Constraints A-35
A6 Step 5: Develop the Analytic Approach A-35
A7 Step 6: Specify Performance or Acceptance Criteria A-36
A7.1 Statistical Versus Nonstatistical Sampling Design A-36
A8 Step 7: Develop the Detailed Plan for Obtaining Data A-37
A8.1 Identify Available Monitoring Locations A-37
A8.2 Evaluate Available Locations Against the Data Needs A-38
A8.3 Monitoring Location Evaluations A-38
A8.3.1 Monitoring Locations Retained/Excluded A-38
A8.3.2 Monitoring Locations for Analytes with Uncertainty A-47
A8.4 Data Collection Frequency A-47
A9 Final Sample Design A-54
A10 References A-63

Supporting Information

SGW-54542 ..... A-65

Figures

Figure A-1. 100-D/H Area and 100-HR-3 Groundwater Operable Unit Area of Interest A-6
Figure A-2. Available Monitoring Locations for 100-D Area A-39
Figure A-3. Available Monitoring Locations for 100-H Area A-40
Figure A-4. Monitoring Locations for PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater than 10 µg/L? A-55
Figure A-5. Monitoring Locations for PSQ 2: Is the Remedy Effectively Reducing the Groundwater Cr(VI) Plume? A-56
Figure A-6. Nitrate Monitoring Locations for PSQ 3: Are other Contaminant Plumes that Exceed Risk Based/Applicable or Relevant and Appropriate Requirements (ARAR) Levels Decreasing as Predicted? A-57
Figure A-7. Strontium-90 Monitoring Locations for PSQ 3: Are other Contaminant Plumes that Exceed Risk Based/Applicable or Relevant and Appropriate Requirement Levels Decreasing as Predicted? A-58
Figure A-8. Automated Water Level Network Monitoring Locations for PSQ 4a: What are the Direction and Magnitude of Groundwater Hydraulic Gradients in the Confined and Unconfined Aquifers? A-59
Figure A-9. Monitoring Locations for PSQ 5a: Are Infrequently Detected Analytes Confirmed not to be Contaminants of Potential Concern? and PSQ 5b: Are Analytes with Detection Limits above Action Levels Confirmed not to be Contaminants of Potential Concern? A-60
Figure A-10. Monitoring Locations for PSQ 5c: Are Potential Source Areas Confirmed not to be Continuing Sources of Contaminants of Potential Concern in Groundwater? A-61

Tables

Table A-1. Specific Data Needs to Address the Problem Statements and Principal Study Questions A-4
Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a] A-7
Table A-3. Decision Rules A-35
Table A-4. Statistical Versus Nonstatistical Sampling Design A-37
Table A-5. 100-HR-3 Groundwater Operable Unit Monitoring Location Evaluation A-41
Table A-6. Summary of Data Evaluation for PSQ 5a and PSQ 5b[d] A-51

Terms

ARAR	applicable or relevant and appropriate requirement
AWLN	automated water level network
CCC	criteria continuous concentration
COC	contaminant of concern
COPC	contaminant of potential concern
Cr(VI)	hexavalent chromium
CSM	conceptual site model
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
HEIS	Hanford Environmental Information System
ISRM	in situ redox manipulation
MCL	maximum contaminant level
MTCA	“Model Toxics Control Act—Cleanup” (WAC 173-340)
O&M	operations and maintenance
OU	operable unit
PSQ	principal study question
RAG	remedial action goal
RAO	remedial action objective
RI	remedial investigation
ROD	record of decision
RUM	Ringold Formation upper mud
UCL	upper confidence limit
WIDL	Well Information and Document Lookup
ZVI	zero valent iron

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A1 Introduction

The 100-HR-3 Groundwater Operable Unit (OU) specific data quality objectives (DQOs) are developed to support a groundwater monitoring plan that addresses multiple data needs and uses. The DQO process was conducted to support identification of sampling requirements. Participants included a DOE appointed panel, DOE representatives, and the primary groundwater contractor. Ecology was not a participant during the DQO process. 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 analytic approach.
6. Specify performance or acceptance criteria.
7. Develop the detailed plan for obtaining data.

A2 Step 1: State the Problem

A series of individual problem statements has been developed to focus the scope of the data collection. Each problem statement identifies a condition (or conditions) that requires measurement and observation data to meet specific data needs. In some instances, the same data may fill data needs for more than one problem statement. Problem Statements 1, 2, and 3 identify conditions for measurement based on the interim action record of decision (ROD) (EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington*). Problem Statement 4 identifies a condition for measurements to enhance and evaluate the pump-and-treat system effectiveness. Problem Statement 5 identifies a condition for collecting measurements to reduce uncertainties identified during the remedial investigation (RI)/feasibility study (FS). The following problem statements define the problems that need to be addressed by the groundwater monitoring plan:

1. Problem Statement 1 – The interim action ROD identifies protection of aquatic receptors as a remedial action objective (RAO).

2. Problem Statement 2 – The interim action ROD identifies pump-and-treat as the remedy for treating hexavalent chromium (Cr(VI)).

3. Problem Statement 3 – The interim action ROD identifies an RAO to provide information that will lead to a final remedy.

4. Problem Statement 4 – Water level data are needed to optimize the pump-and-treat system and verify hydraulic containment of contaminant plumes.

5. Problem Statement 5 – Through comment resolution with the Washington State Department of Ecology (Ecology) during the RI/FS process, the U.S. Department of Energy (DOE)-Richland Operations Office agreed to collect data to address specific uncertainties.

A3 Step 2: Identify the Goal of the Study

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 existing interim remedial actions and evaluation of performance against remedial action goals (RAGs). 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 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 CSM is also present in Section 1.4 of DOE/RL-2013-31, *Remedial Design/Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit*.

Step 2 of the DQO process involves identifying key principal study questions (PSQs) that the study attempts to address. Each PSQ corresponds to a problem statement identified in Step 1. The following PSQs are identified for this study:

- **PSQ 1:** Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?
- **PSQ 2:** Is the remedy effectively reducing the groundwater Cr(VI) plume?
- **PSQ 3**: Are other contaminant plumes that exceed risk based/applicable or relevant and appropriate requirement (ARAR) levels decreasing as predicted?
- **PSQ 4a:** What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?
- **PSQ 4b:** What are the direction and magnitude of groundwater hydraulic gradients in the confined[1] aquifer?
- **PSQ 5a:** Are infrequently detected analytes confirmed not to be contaminants of potential concern (COPCs)?
- **PSQ 5b:** Are analytes with detection limits above action levels confirmed not to be COPCs?
- **PSQ 5c:** Are potential source areas confirmed not to be continuing sources of COPCs in groundwater?

A4 Step 3: Identify Information Inputs

Step 3 of the DQO process identifies the types and sources of information needed to resolve each of the PSQs developed in Step 2. Data may already exist or may be derived from computational or sampling and analysis methods. The 100-D/H RI/FS report (DOE/RL-2010-95) summarizes information on constituent concentrations (both vertically and spatially), water level, river effects within the aquifer, flow direction, and transport characteristics for the aquifer(s) underlying the 100-D/H Area. The CSM presents current understanding of groundwater in the 100-HR-3 Groundwater OU.

The problem statements and accompanying PSQs are associated with specific data needs. Table A-1 identifies the data needs, measurement or observation needed, and data uses for each problem statement and PSQ.

[1] References to the confined aquifer are for wells screened in the first water bearing unit of the Ringold Formation upper mud unit, unless otherwise noted. This aquifer includes both confined and semiconfined areas.

A5 Step 4: Define the Boundaries of the Study

Step 4 of 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.

A5.1 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 Ringold Formation upper mud (RUM), and groundwater within the hyporheic zone at the groundwater discharge boundary with the Columbia River.

There are two distinct vertical boundaries. The uppermost unit is the unconfined aquifer, which extends from the top of the periodically rewetted zone to the top surface of the RUM. The second unit is the first water bearing unit within the RUM. 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 or the Ringold lower mud unit. This lower boundary is defined by the presence of a nontransmissive layer consisting of silt or clay type material.

Groundwater contamination has been identified within the RUM in this discrete water bearing unit. The monitoring plan is designed to gather data that will be used for further definition of contamination and evaluate effects of contaminants within the first water bearing unit of the RUM.

Groundwater from 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.

Table A-2 lists existing wells and aquifer tubes that may be used for 100-HR-3 Groundwater OU monitoring.

Table A-1. Specific Data Needs to Address the Problem Statements and Principal Study Questions

Data Need	Measurement or Observation	Data Use
Problem Statement 1: The interim action ROD identifies protection of aquatic receptors as an RAO. **PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**		
Cr(VI) Concentrations	Measurements taken annually with groundwater moving toward the river and approaching low river stage at wells closest to the river (typically September to December). Evaluate targeted period annually. Measurements taken at aquifer tubes limited to areas with inadequate well coverage potentially impacted by Cr(VI) plumes, used for qualitative evaluation.	Determine whether Cr(VI) is discharging to the river at concentrations greater than 10 µg/L.
Problem Statement 2: The interim action ROD identifies pump-and-treat as the remedy for treating Cr(VI). **PSQ 2: Is the remedy effectively reducing the groundwater Cr(VI) plume?**		
Cr(VI) Concentrations	Measurements taken annually at wells within the plume, at pump-and-treat system wells, and at wells that define the plume boundaries. Aquifer tube locations were selected to verify plume boundary conditions. Sampling will be conducted during the timeframe where the Cr(VI) concentrations are highest for that well location.	Determine that the remedy is removing mass and reducing the Cr(VI) plume.
Problem Statement 3: The interim action ROD identifies an RAO to provide information that will lead to a final remedy. **PSQ 3: Are other contaminant plumes that exceed risk based/ARAR levels decreasing as predicted?***		
Nitrate and Strontium-90 Concentrations	Measurements taken annually at wells within the nitrate plumes and at locations that define the plume boundaries. Measurements taken triennially at wells within the strontium-90 plume and at locations that define the plume boundaries.	Track the nitrate and strontium-90 plumes to identify and verify natural attenuation processes and inform a final remedy decision.
Problem Statement 4: Water level data are needed to optimize the pump-and-treat system and verify hydraulic containment of contaminant plumes. **PSQ 4a: What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?** **PSQ 4b: What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**		
Water Levels	Measurements for monitoring wells taken annually during the groundwater monitoring program and semiannually during low and river stages. Additional measurements taken hourly at pump-and-treat system wells and AWLN wells.	Determine direction and magnitude of groundwater flow. Verify plume capture and hydraulic containment.

Table A-1. Specific Data Needs to Address the Problem Statements and Principal Study Questions

Data Need	Measurement or Observation	Data Use
Problem Statement 5 – Through comment resolution with Ecology during the RI/FS process, DOE agreed to collect data to address specific uncertainties. **PSQ 5a: Are infrequently detected analytes confirmed not to be contaminants of potential concern?** **PSQ 5b: Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?**		
Additional COPCs	Collection of nine (total) measurements, on a triannual basis, for constituents with uncertainty. These constituents are: **100-D Area** – antimony, cadmium, cobalt, copper, lead, and silver **100-H Area** – antimony, cadmium, cobalt, copper, lead, and silver **Horn Area** – antimony, cadmium, cobalt, copper, and silver **ISRM Area** – antimony, cadmium, cobalt, copper, fluoride, iron, lead, manganese, nitrite, silver, sulfate, and zinc	Confirm the expectation that the additional analytes are not COPCs and do not require action or continued monitoring.
PSQ 5c: Are potential source areas confirmed not to be continuing sources of COPCs in groundwater?		
Site Specific Contaminants	Measurements for Cr(VI) taken at wells downgradient of the 100-D-100 and 100-D-30/100-D-104 waste sites, and uranium at the 183-H waste site. Collect up to nine (total) measurements at the 100-D-100, 100-D-30/100-D-104 waste sites, on a triannual basis. Monitoring for uranium at 183-H will continue until compliance with the MCL can be demonstrated.	Confirm the expectation that the potential source areas are not a continuing source of a COC or COPC in groundwater.

* Other contaminants, such as uranium and tritium, are not specifically identified in this PSQ since they may change over time.

ARAR = applicable or relevant and appropriate requirement
AWLN = automated water level network
COC = contaminant of concern
COPC = contaminant of potential concern
Cr(VI) = hexavalent chromium
DOE = U.S. Department of Energy
ISRM = in situ redox manipulation
MCL = maximum contaminant level
PSQ = principal study question
RAO = remedial action objective
RI/FS = remedial investigation/feasibility study
ROD = record of decision

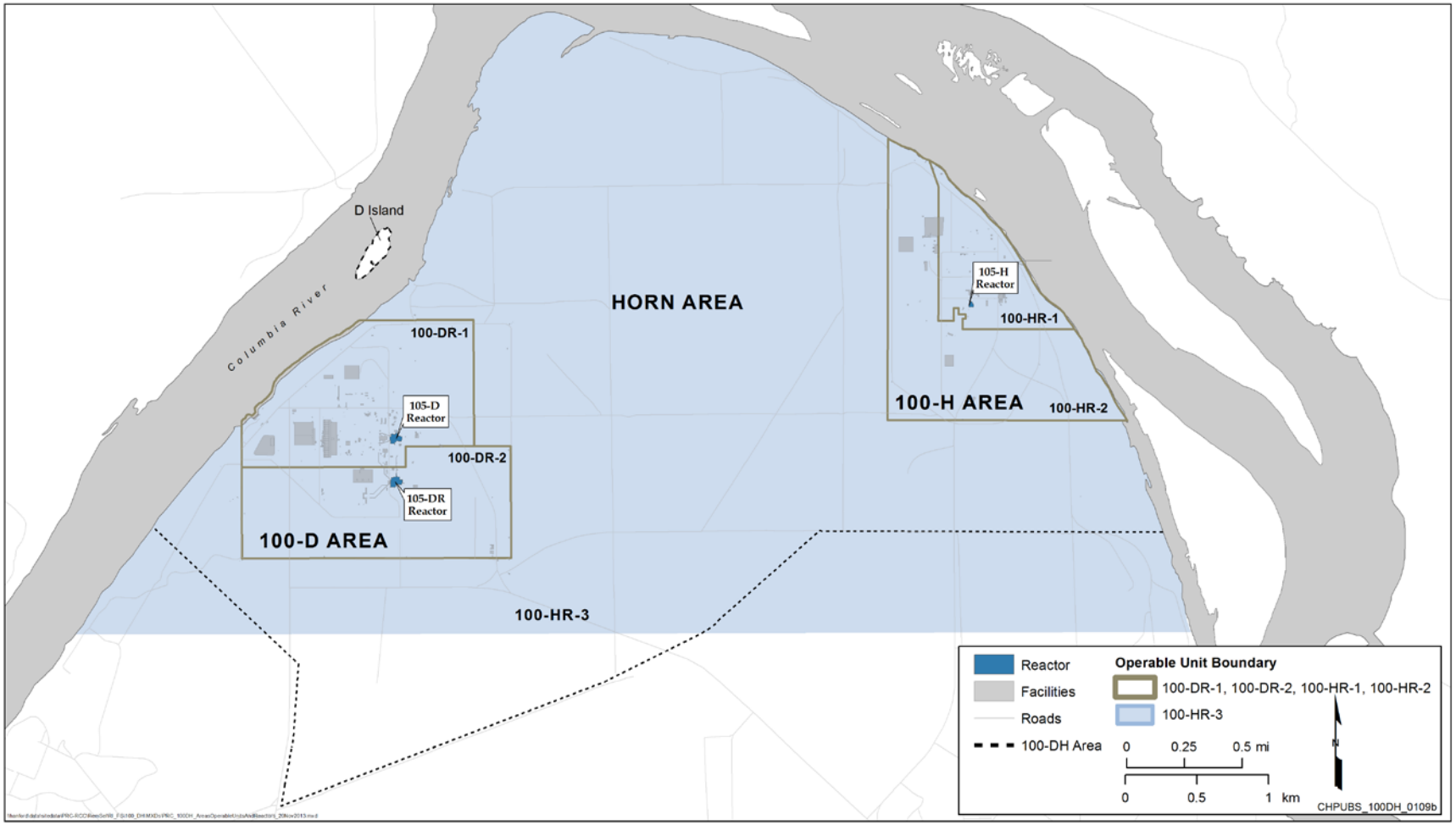

Figure A-1. 100-D/H Area and 100-HR-3 Groundwater Operable Unit Area of Interest

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D2-10	Unconfined Aquifer Well	Injection	574470.87	153465.19
199-D2-11	Unconfined Aquifer Well		573328.16	151120.73
199-D2-12	Unconfined Aquifer Well	Injection	574343.45	153300.01
199-D2-6	Unconfined Aquifer Well		573000.21	151119.86
199-D3-2	Unconfined Aquifer Well	ISRM treatment zone monitoring well	572453.955	151165.653
199-D3-3	Unconfined Aquifer Well	ISRM Barrier	572482.542	151186.957
199-D3-4	Unconfined Aquifer Well	ISRM Barrier	572468.159	151170.973
199-D3-5	Unconfined Aquifer Well		572787.66	150994.54
199-D4-1	Unconfined Aquifer Well	ISRM treatability test monitoring well	572752.848	151558.893
199-D4-10	Unconfined Aquifer Well	ISRM Barrier	572750.247	151540.441
199-D4-101	Unconfined Aquifer Well	Extraction	572800.1	151425.94
199-D4-11	Unconfined Aquifer Well	ISRM Barrier	572768.94	151554.139
199-D4-12	Unconfined Aquifer Well	ISRM Barrier	572771.583	151562.084
199-D4-13	Unconfined Aquifer Well	ISRM treatment zone monitoring well	572665.855	151424.474
199-D4-14	Unconfined Aquifer Well	Extraction	572839.812	151641.64
199-D4-15	Unconfined Aquifer Well		572936.636	151424.862
199-D4-16	Unconfined Aquifer Well	ISRM treatability test monitoring well	572756.742	151555.323
199-D4-17	Unconfined Aquifer Well	ISRM treatability test monitoring well	572738.089	151558.433
199-D4-18	Unconfined Aquifer Well	ISRM treatability test monitoring well	572726.336	151570.93
199-D4-19	Unconfined Aquifer Well	ISRM treatment zone monitoring well	572559.349	151282.037

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D4-2	Unconfined Aquifer Well	ISRM treatability test monitoring well	572768.371	151543.963
199-D4-20	Unconfined Aquifer Well		572794.042	151257.474
199-D4-21	Unconfined Aquifer Well	ISRM Barrier	572778.845	151569.801
199-D4-22	Unconfined Aquifer Well	ISRM treatability test monitoring well	572788.453	151539.293
199-D4-23	Unconfined Aquifer Well		572672.455	151592.87
199-D4-24	Unconfined Aquifer Well	ISRM Barrier	572699.894	151471.431
199-D4-25	Unconfined Aquifer Well	ISRM Barrier	572711.441	151476.238
199-D4-26	Unconfined Aquifer Well	ISRM Barrier/ZVI injection well	572712.326	151488.878
199-D4-27	Unconfined Aquifer Well	ISRM Barrier	572724.228	151493.48
199-D4-28	Unconfined Aquifer Well	ISRM Barrier	572725.087	151506.073
199-D4-29	Unconfined Aquifer Well	ISRM Barrier	572736.858	151510.687
199-D4-3	Unconfined Aquifer Well	ISRM treatability test monitoring well	572766.075	151546.12
199-D4-30	Unconfined Aquifer Well	ISRM Barrier	572737.443	151523.215
199-D4-31	Unconfined Aquifer Well	ISRM Barrier	572749.468	151527.997
199-D4-32	Unconfined Aquifer Well	ISRM Barrier	572790.871	151573.746
199-D4-33	Unconfined Aquifer Well	ISRM Barrier	572792.629	151585.936
199-D4-34	Unconfined Aquifer Well	Extraction	572804.601	151590.028
199-D4-35	Unconfined Aquifer Well	ISRM Barrier	572806.305	151602.279
199-D4-36	Unconfined Aquifer Well	ISRM treatment zone monitoring well	572818.193	151606.215
199-D4-37	Unconfined Aquifer Well	ISRM Barrier	572820.293	151618.582

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D4-38	Unconfined Aquifer Well	Extraction	572671.317	151537.856
199-D4-39	Unconfined Aquifer Well	Extraction	572747.453	151650.84
199-D4-4	Unconfined Aquifer Well	ISRM Barrier	572754.612	151571.609
199-D4-40	Unconfined Aquifer Well	ISRM Barrier	572832.346	151622.634
199-D4-41	Unconfined Aquifer Well	ISRM Barrier	572834.105	151634.658
199-D4-42	Unconfined Aquifer Well	ISRM Barrier	572847.129	151642.441
199-D4-43	Unconfined Aquifer Well	ISRM Barrier	572849.647	151656.21
199-D4-44	Unconfined Aquifer Well	ISRM Barrier	572856.117	151665.631
199-D4-45	Unconfined Aquifer Well	ISRM Barrier	572868.006	151671.796
199-D4-46	Unconfined Aquifer Well	ISRM Barrier	572868.854	151684.937
199-D4-47	Unconfined Aquifer Well	ISRM Barrier	572880.483	151690.132
199-D4-48	Unconfined Aquifer Well	ISRM Barrier	572881.3	151703.459
199-D4-49	Unconfined Aquifer Well	ISRM Barrier	572699.115	151458.694
199-D4-5	Unconfined Aquifer Well	ISRM treatability test monitoring well	572740.543	151556.5
199-D4-50	Unconfined Aquifer Well	ISRM Barrier	572687.3	151454.007
199-D4-51	Unconfined Aquifer Well	ISRM Barrier	572686.611	151441.402
199-D4-52	Unconfined Aquifer Well	ISRM Barrier	572674.91	151436.734
199-D4-53	Unconfined Aquifer Well	ISRM Barrier	572674.099	151424.628
199-D4-54	Unconfined Aquifer Well	ISRM Barrier	572662.428	151419.728
199-D4-55	Unconfined Aquifer Well	ISRM Barrier	572659.029	151414.635

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D4-56	Unconfined Aquifer Well	ISRM Barrier	572657.655	151402.283
199-D4-57	Unconfined Aquifer Well	ISRM Barrier	572645.941	151397.862
199-D4-58	Unconfined Aquifer Well	ISRM Barrier	572644.812	151385.354
199-D4-59	Unconfined Aquifer Well	ISRM Barrier	572633.324	151380.821
199-D4-6	Unconfined Aquifer Well	ISRM treatability test monitoring well	572733.34	151577.919
199-D4-60	Unconfined Aquifer Well	ISRM Barrier	572632.367	151368.255
199-D4-61	Unconfined Aquifer Well	ISRM Barrier	572620.657	151363.701
199-D4-62	Unconfined Aquifer Well	ISRM Barrier	572619.521	151351.066
199-D4-63	Unconfined Aquifer Well	ISRM Barrier	572607.636	151346.844
199-D4-64	Unconfined Aquifer Well	ISRM Barrier	572606.946	151333.911
199-D4-65	Unconfined Aquifer Well	ISRM Barrier	572594.767	151329.737
199-D4-66	Unconfined Aquifer Well	ISRM Barrier	572594.28	151316.861
199-D4-67	Unconfined Aquifer Well	ISRM Barrier	572581.859	151312.779
199-D4-68	Unconfined Aquifer Well	ISRM Barrier	572581.324	151299.838
199-D4-69	Unconfined Aquifer Well	ISRM Barrier	572568.997	151295.692
199-D4-7	Unconfined Aquifer Well	ISRM treatability test monitoring well	572760.866	151551.254
199-D4-70	Unconfined Aquifer Well	ISRM Barrier	572568.789	151282.677
199-D4-71	Unconfined Aquifer Well	ISRM Barrier	572556.286	151278.503
199-D4-72	Unconfined Aquifer Well	ISRM Barrier	572554.432	151265.778
199-D4-73	Unconfined Aquifer Well	ISRM Barrier	572542.167	151262.724

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D4-74	Unconfined Aquifer Well	ISRM Barrier	572539.801	151249.798
199-D4-75	Unconfined Aquifer Well	ISRM Barrier	572527.758	151246.947
199-D4-76	Unconfined Aquifer Well	ISRM Barrier	572526.06	151234.236
199-D4-77	Unconfined Aquifer Well	ISRM Barrier	572513.333	151231.008
199-D4-78	Unconfined Aquifer Well	ISRM Barrier	572511.284	151218.263
199-D4-79	Unconfined Aquifer Well	ISRM Barrier	572498.237	151214.024
199-D4-8	Unconfined Aquifer Well	ISRM treatability test monitoring well	572763.298	151552.647
199-D4-80	Unconfined Aquifer Well	ISRM Barrier	572496.869	151202.591
199-D4-81	Unconfined Aquifer Well	ISRM Barrier	572484.362	151199.64
199-D4-82	Unconfined Aquifer Well	ISRM Barrier	572470.262	151183.894
199-D4-83	Unconfined Aquifer Well	Extraction	572859.432	151723.418
199-D4-84	Unconfined Aquifer Well	Extraction	572568.043	151433.521
199-D4-85	Unconfined Aquifer Well	Extraction	572486.163	151324.202
199-D4-86	Unconfined Aquifer Well	ISRM compliance well	572389.064	151202.144
199-D4-87	Unconfined Aquifer Well	ISRM Barrier	572757.049	151550.035
199-D4-88	Unconfined Aquifer Well	ISRM Barrier	572758.674	151553.219
199-D4-89	Unconfined Aquifer Well	ISRM Barrier	572759.624	151547.119
199-D4-9	Unconfined Aquifer Well	ISRM Barrier	572758.204	151543.316
199-D4-90	Unconfined Aquifer Well		572823.2	151616.13
199-D4-91	Unconfined Aquifer Well		572817.65	151621.08

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D4-92	Unconfined Aquifer Well	ZVI treatability test monitoring well	572714.05	151486.31
199-D4-93	Unconfined Aquifer Well	ZVI treatability test monitoring well	572710.39	151491.2
199-D4-94	Unconfined Aquifer Well		572712.89	151496.05
199-D4-95	Unconfined Aquifer Well	Extraction	572612.82	151226.7
199-D4-96	Unconfined Aquifer Well	Extraction	572777.03	151519.78
199-D4-97	Unconfined Aquifer Well	Extraction	572906.23	151625.33
199-D4-98	Unconfined Aquifer Well	Extraction	572574.52	151481.65
199-D4-99	Unconfined Aquifer Well	Extraction	572527.36	151377.08
199-D5-101	Unconfined Aquifer Well	Extraction	572943.04	151521.52
199-D5-103	Unconfined Aquifer Well		573505.87	151460.87
199-D5-104	Unconfined Aquifer Well	Extraction	573265.48	151422.43
199-D5-106	Unconfined Aquifer Well		573503.74	151597.97
199-D5-107	Unconfined Aquifer Well	Biostimulation - Miscible substrate treatability test injection well[d]	572932.37	151283.14
199-D5-108	Unconfined Aquifer Well	Biostimulation - Immiscible substrate treatability test injection well[e]	572923.34	151222.9
199-D5-109	Unconfined Aquifer Well	Biostimulation - Miscible substrate treatability test monitoring well[d]	572917.37	151285.57
199-D5-110	Unconfined Aquifer Well	Biostimulation - Miscible substrate treatability test monitoring well[d]	572931.57	151277.61
199-D5-111	Unconfined Aquifer Well	Biostimulation - Miscible substrate treatability test monitoring well[d]	572943.24	151281.47

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D5-112	Unconfined Aquifer Well	Biostimulation - Miscible substrate treatability test monitoring well[d]	572929.08	151289.87
199-D5-113	Unconfined Aquifer Well	Biostimulation - Miscible substrate treatability test monitoring well[d]	572927.02	151288.45
199-D5-114	Unconfined Aquifer Well	Biostimulation - Immiscible substrate treatability test monitoring well[e]	572918.04	151223.75
199-D5-115	Unconfined Aquifer Well	Biostimulation - Immiscible substrate treatability test monitoring well[e]	572923.15	151221.12
199-D5-116	Unconfined Aquifer Well	Biostimulation - Immiscible substrate treatability test monitoring well[e]	572926.93	151222.35
199-D5-117	Unconfined Aquifer Well	Biostimulation - Immiscible substrate treatability test monitoring well[e]	572922.94	151225.43
199-D5-118	Unconfined Aquifer Well	Biostimulation - Immiscible substrate treatability test monitoring well[e]	572921.03	151224.45
199-D5-123	Unconfined Aquifer Well		573824.21	151639.41
199-D5-125	Unconfined Aquifer Well		573667.39	151746.18
199-D5-126	Unconfined Aquifer Well		573705.71	151843.28
199-D5-127	Unconfined Aquifer Well	Extraction	572992.26	151428.31
199-D5-128	Unconfined Aquifer Well	Injection	573622.4	151237.35
199-D5-129	Unconfined Aquifer Well	Injection	573735.5	151465.13
199-D5-13	Unconfined Aquifer Well		573535.527	151955.183
199-D5-130	Unconfined Aquifer Well	Extraction	574039.2	151928.51
199-D5-131	Unconfined Aquifer Well	Extraction	573684.39	152006.75

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D5-132	Unconfined Aquifer Well		573875.35	151586.87
199-D5-133	Unconfined Aquifer Well		573731.55	151497.37
199-D5-134	RUM First Water Bearing Unit		573675.32	151862.46
199-D5-14	Unconfined Aquifer Well		573789.632	151787.99
199-D5-141	RUM First Water Bearing Unit		573243.43	151424.51
199-D5-142	Unconfined Aquifer Well		573791.87	151563.26
199-D5-143	Unconfined Aquifer Well		573701.53	151784.26
199-D5-145	Unconfined Aquifer Well		573215.62	151396.28
199-D5-146	Unconfined Aquifer Well	Extraction	573219.79	151345.59
199-D5-147	Unconfined Aquifer Well		572993.13	151380.78
199-D5-148	Unconfined Aquifer Well	Injection	573361.48	151083.48
199-D5-15	Unconfined Aquifer Well		573738.61	151673.75
199-D5-153	Unconfined Aquifer Well	Extraction		
199-D5-16	Unconfined Aquifer Well		573917.45	151652.51
199-D5-17	Unconfined Aquifer Well		573730.52	151322.83
199-D5-18	Unconfined Aquifer Well		573861.7	151325.18
199-D5-19	Unconfined Aquifer Well		573849.12	151243.19
199-D5-20	Unconfined Aquifer Well	Extraction	573239.97	152030.15
199-D5-32	Unconfined Aquifer Well	Extraction	573372.04	151903.39

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D5-33	Unconfined Aquifer Well		573095.03	151714.54
199-D5-34	Unconfined Aquifer Well		573240.42	151554.12
199-D5-36	Unconfined Aquifer Well		572909.823	151746.32
199-D5-37	Unconfined Aquifer Well		573092.236	151916.365
199-D5-38	Unconfined Aquifer Well		572996.824	151545.593
199-D5-39	Unconfined Aquifer Well	Extraction	573142.858	151428.428
199-D5-40	Unconfined Aquifer Well		573003.258	151272.017
199-D5-41	Unconfined Aquifer Well		573358.16	151792.191
199-D5-42	Unconfined Aquifer Well	Injection	573479.771	151622.674
199-D5-43	Unconfined Aquifer Well		573179.976	151269.43
199-D5-44	Unconfined Aquifer Well	Injection	572993.581	151835.736
199-D5-92	Unconfined Aquifer Well	Extraction	573131.93	152009.82
199-D5-97	Unconfined Aquifer Well		573250.11	151302.47
199-D6-1	Unconfined Aquifer Well	Injection	574129.87	151691.71
199-D6-2	Unconfined Aquifer Well	Injection	574544.61	151970.2
199-D6-3	Unconfined Aquifer Well		574159.09	151643.85
199-D7-3	Unconfined Aquifer Well	Extraction	574151.38	152363.41
199-D7-4	Unconfined Aquifer Well	Injection	574377.07	152369.64
199-D7-5	Unconfined Aquifer Well	Injection	574434.31	152678.72
199-D7-6	Unconfined Aquifer Well	Extraction	574429.2	152980.43

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D8-101	Unconfined Aquifer Well		574069.46	152262.43
199-D8-4	Unconfined Aquifer Well		573447.185	152090.212
199-D8-5	Unconfined Aquifer Well		573537.146	152243.497
199-D8-53	Unconfined Aquifer Well	Extraction	573889.86	152452.26
199-D8-54A	Unconfined Aquifer Well		573781.17	152408.03
199-D8-54B	RUM First Water Bearing Unit		573768.24	152398.65
199-D8-55	Unconfined Aquifer Well	Extraction	573620.954	152364.345
199-D8-6	Unconfined Aquifer Well	Extraction	573434.693	152060.822
199-D8-68	Unconfined Aquifer Well		573711.67	152427.1
199-D8-69	Unconfined Aquifer Well	Extraction	573843.61	152552.201
199-D8-70	Unconfined Aquifer Well		573942.097	152508.741
199-D8-71	Unconfined Aquifer Well		573837.097	152429.388
199-D8-72	Unconfined Aquifer Well		573570.481	152211.774
199-D8-73	Unconfined Aquifer Well	Extraction	573388.7	152167.38
199-D8-88	Unconfined Aquifer Well	Extraction	573292.33	152141.26
199-D8-89	Unconfined Aquifer Well	Extraction	573478.64	152249.65
199-D8-90	Unconfined Aquifer Well	Extraction	573948.64	152646.23
199-D8-91	Unconfined Aquifer Well	Extraction	574036.89	152741.44
199-D8-93	Unconfined Aquifer Well	Injection	574148.7	153085.8

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-D8-94	Unconfined Aquifer Well	Injection	574047.82	152949.53
199-D8-95	Unconfined Aquifer Well	Extraction	573611.96	152160.61
199-D8-96	Unconfined Aquifer Well	Extraction	573706	152152.24
199-D8-97	Unconfined Aquifer Well	Extraction	573859.56	152087.42
199-D8-98	Unconfined Aquifer Well	Extraction	574013.12	152123.02
199-D8-99	Unconfined Aquifer Well	Injection	574006.77	152364.37
199-H1-1	Unconfined Aquifer Well	Extraction	576702.31	153384.49
199-H1-2	Unconfined Aquifer Well	Extraction	576451.07	153378.26
199-H1-20	Unconfined Aquifer Well	Injection	575706.04	154183.61
199-H1-21	Unconfined Aquifer Well	Injection	575896.84	154163.8
199-H1-25	Unconfined Aquifer Well	Extraction	576279.64	154069.97
199-H1-27	Unconfined Aquifer Well	Extraction	576403.86	154024.21
199-H1-3	Unconfined Aquifer Well	Extraction	576163.04	153372.22
199-H1-32	Unconfined Aquifer Well	Extraction	576767.07	153766
199-H1-33	Unconfined Aquifer Well	Extraction	576833.29	153716.23
199-H1-34	Unconfined Aquifer Well	Extraction	576883.13	153667.06
199-H1-35	Unconfined Aquifer Well	Extraction	576958.26	153628.14
199-H1-36	Unconfined Aquifer Well	Extraction	576885.62	153486.51
199-H1-37	Unconfined Aquifer Well	Extraction	577106.92	153641.63
199-H1-38	Unconfined Aquifer Well	Extraction	577161	153555.01

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-H1-39	Unconfined Aquifer Well	Extraction	577223.54	153533.4
199-H1-4	Unconfined Aquifer Well	Extraction	575826.78	153366.87
199-H1-40	Unconfined Aquifer Well	Extraction	577279.34	153500.19
199-H1-42	Unconfined Aquifer Well	Extraction	577127.18	153391.65
199-H1-43	Unconfined Aquifer Well	Extraction	577213.74	153384.28
199-H1-45	Unconfined Aquifer Well	Extraction	577240.96	153062.41
199-H1-5	Unconfined Aquifer Well	Extraction	574850.72	153090.3
199-H1-6	Unconfined Aquifer Well	Extraction	576037.81	153745.74
199-H1-7	Unconfined Aquifer Well		577629.6	153172.1
199-H2-1	RUM First Water Bearing Unit		577752.31	153239.89
199-H3-10	RUM First Water Bearing Unit		577545.14	152723.52
199-H3-11	Unconfined Aquifer Well		577786.74	152490.41
199-H3-25	Unconfined Aquifer Well	Injection	577410.36	152978.49
199-H3-26	Unconfined Aquifer Well	Injection	577440.83	152846.5
199-H3-27	Unconfined Aquifer Well	Injection	577567.05	152811.14
199-H3-2A	Unconfined Aquifer Well		577624.608	152750.068
199-H3-2B	Unconfined Aquifer Well		577628.271	152757.164
199-H3-2C	RUM First Water Bearing Unit	Extraction	577632.065	152750.302

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-H3-3	Unconfined Aquifer Well		577562.091	152363.166
199-H3-4	Unconfined Aquifer Well	Extraction	577544.287	152293.21
199-H3-5	Unconfined Aquifer Well		577454.697	152287.496
199-H3-6	Unconfined Aquifer Well		578266.47	152425.33
199-H3-7	Unconfined Aquifer Well		577931.74	152279.97
199-H3-9	RUM First Water Bearing Unit		578039.12	152913.6
199-H4-10	Unconfined Aquifer Well		577827.209	153155.813
199-H4-11	Unconfined Aquifer Well		578141.906	152728.433
199-H4-12A	Unconfined Aquifer Well		578009.151	152912.729
199-H4-12B	Unconfined Aquifer Well		578004.385	152918.467
199-H4-12C	RUM First Water Bearing Unit	Extraction	578011.772	152919.812
199-H4-13	Unconfined Aquifer Well		578219.304	152595.273
199-H4-15A	Unconfined Aquifer Well	Extraction	577904.313	153053.42
199-H4-15B	Unconfined Aquifer Well		577899.598	153059.548
199-H4-15C	Unconfined Aquifer Piezometer		577907.681	153059.983
199-H4-15CP	Basalt Piezometer		577907.681	153059.983
199-H4-15CQ	Ringold Unit A Piezometer		577907.681	153059.983
199-H4-15CR	Ringold Unit B Piezometer		577907.681	153059.983

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-H4-15CS	RUM First Water Bearing Unit Piezometer		577907.681	153059.983
199-H4-16	Unconfined Aquifer Well		577981.91	152591.573
199-H4-17	Unconfined Aquifer Well	Injection	577779.175	153037.635
199-H4-18	Unconfined Aquifer Well	Injection	578018.292	152756.478
199-H4-2	Basalt Well		578093.552	152501.475
199-H4-4	Unconfined Aquifer Well	Extraction	578060.859	152853.956
199-H4-45	Unconfined Aquifer Well		578156.386	152433.394
199-H4-46	Unconfined Aquifer Well		577883.861	152439.868
199-H4-47	Unconfined Aquifer Well		577891.179	152553.297
199-H4-49	Unconfined Aquifer Well		577713.83	152445.154
199-H4-5	Unconfined Aquifer Well		577944.937	152939.783
199-H4-6	Unconfined Aquifer Well		577585.316	152888.391
199-H4-63	Unconfined Aquifer Well	Extraction	578185.825	152665.531
199-H4-64	Unconfined Aquifer Well	Extraction	577946.11	153010.582
199-H4-65	Unconfined Aquifer Well		577998.259	152787.285
199-H4-69	Unconfined Aquifer Well	Extraction	578014.05	152686.66
199-H4-7	Unconfined Aquifer Well		577804.134	152890.845
199-H4-70	Unconfined Aquifer Well	Extraction	578003.82	152646.45
199-H4-71	Unconfined Aquifer Well	Injection	578010.64	152581.53

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-H4-72	Unconfined Aquifer Well	Injection	578036.28	152500.14
199-H4-73	Unconfined Aquifer Well	Injection	577940.58	152369.98
199-H4-74	Unconfined Aquifer Well	Injection	577239.07	152268.83
199-H4-75	Unconfined Aquifer Well	Extraction	577212.36	152704.64
199-H4-76	Unconfined Aquifer Well	Extraction	576787.32	152976.85
199-H4-77	Unconfined Aquifer Well	Extraction	576487.79	152975.43
199-H4-78	Unconfined Aquifer Well	Injection	576168.23	152166.12
199-H4-79	Unconfined Aquifer Well	Injection	575659.13	151989.31
199-H4-8	Unconfined Aquifer Well		577860.691	152921.704
199-H4-80	Unconfined Aquifer Well	Extraction	575238.97	152568.16
199-H4-81	Unconfined Aquifer Well	Extraction	575236.93	153035.36
199-H4-82	Unconfined Aquifer Well	Extraction	574906.99	152677.72
199-H4-83	Unconfined Aquifer Well		578135.04	152634.01
199-H4-84	Unconfined Aquifer Well		577902.58	152848.73
199-H4-85	Unconfined Aquifer Well		577980.02	152880.81
199-H4-86	Unconfined Aquifer Well		577704.55	152745.65
199-H4-90	RUM First Water Bearing Unit		577922.8	152592.37
199-H4-91	RUM First Water Bearing Unit		578126.4	152524.6
199-H5-10	Unconfined Aquifer Well	ISRM field injection test monitoring well	577644	152266

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-H5-11	Unconfined Aquifer Well	ISRM field injection test monitoring well	577646	152268
199-H5-12	Unconfined Aquifer Well	ISRM field injection test monitoring well	577650	152279
199-H5-13	Unconfined Aquifer Well	ISRM field injection test monitoring well	577650	152288
199-H5-14	Unconfined Aquifer Well	ISRM field injection test monitoring well	577656	152286
199-H5-15	Unconfined Aquifer Well	ISRM field injection test monitoring well	577657	152288
199-H5-1A	Unconfined Aquifer Well	ISRM field injection test monitoring well	577650.08	152257.724
199-H5-2	Unconfined Aquifer Well	ISRM field injection test injection well	577631	152262
199-H5-3O	Unconfined Aquifer Piezometer	ISRM field injection test monitoring well	577634	152261
199-H5-3P	Unconfined Aquifer Piezometer	ISRM field injection test monitoring well	577634	152263
199-H5-4O	Unconfined Aquifer Piezometer	ISRM field injection test monitoring well	577637	152261
199-H5-4P	Unconfined Aquifer Piezometer	ISRM field injection test monitoring well	577637	152263
199-H5-5O	Unconfined Aquifer Piezometer	ISRM field injection test monitoring well	577640	152261
199-H5-5P	Unconfined Aquifer Piezometer	ISRM field injection test monitoring well	577640	152263
199-H5-6	Unconfined Aquifer Well	ISRM field injection test monitoring well	577643	152260
199-H5-7	Unconfined Aquifer Well	ISRM field injection test monitoring well	577645	152259
199-H5-8	Unconfined Aquifer Well	ISRM field injection test monitoring well	577647	152258
199-H5-9	Unconfined Aquifer Well	ISRM field injection test monitoring well	577643	152264

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
199-H6-1	Unconfined Aquifer Well		578236.557	152247.63
199-H6-2	Unconfined Aquifer Well	Injection	577886.5	152194.11
199-H6-3	Unconfined Aquifer Well		578340.4	151929.35
199-H6-4	Unconfined Aquifer Well		577771.59	151737.1
35-S	Aquifer Tube – 100-D Area		572918.04	151930.04
36-D	Aquifer Tube – 100-D Area		573120.65	152146.43
36-M	Aquifer Tube – 100-D Area		573120.65	152146.43
36-S	Aquifer Tube – 100-D Area		573120.65	152146.43
37-D	Aquifer Tube – 100-D Area		573335.96	152287.34
37-M	Aquifer Tube – 100-D Area		573335.96	152287.34
37-S	Aquifer Tube – 100-D Area		573335.96	152287.34
38-D	Aquifer Tube – 100-D Area		573471.85	152368.72
38-M	Aquifer Tube – 100-D Area		573471.85	152368.72
43-M	Aquifer Tube – 100-H Area		576782.564	153963.57
44-M	Aquifer Tube – 100-H Area		577033.113	153810.532
45-D	Aquifer Tube – 100-H Area		577597.84	153493.801
45-M	Aquifer Tube – 100-H Area		577597.84	153493.801
45-S	Aquifer Tube – 100-H Area		577597.84	153493.801
47-D	Aquifer Tube – 100-H Area		578193.394	152744.421
47-M	Aquifer Tube – 100-H Area		578193.919	152743.533

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
48-M	Aquifer Tube – 100-H Area		578465.52	152420.795
48-S	Aquifer Tube – 100-H Area		578465.52	152420.795
49-D	Aquifer Tube – 100-H Area		578699.755	152232.861
49-M	Aquifer Tube – 100-H Area		578699.741	152232.831
49-S	Aquifer Tube – 100-H Area		578699.741	152232.831
50-D	Aquifer Tube – 100-H Area		578611.816	152118.084
50-M	Aquifer Tube – 100-H Area		578611.816	152118.084
50-S	Aquifer Tube – 100-H Area		578611.792	152118.154
51-D	Aquifer Tube – 100-H Area		578779.254	151843.755
51-M	Aquifer Tube – 100-H Area		578779.254	151843.755
51-S	Aquifer Tube – 100-H Area		578779.254	151843.755
52-D	Aquifer Tube – 100-H Area		578919.484	151586.176
52-M	Aquifer Tube – 100-H Area		578919.484	151586.176
52-S	Aquifer Tube – 100-H Area		578919.484	151586.176
53-D	Aquifer Tube – 100-H Area		579510.188	151531.413
53-M	Aquifer Tube – 100-H Area		579510.574	151531.727
53-S	Aquifer Tube – 100-H Area		579510.574	151531.727
54-D	Aquifer Tube – 100-H Area		579033.518	151231.944
54-M	Aquifer Tube – 100-H Area		579033.518	151231.944
54-S	Aquifer Tube – 100-H Area		579033.518	151231.944

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
55-D	Aquifer Tube – 100-H Area		579135.286	150891.368
55-M	Aquifer Tube – 100-H Area		579134.582	150891.146
55-S	Aquifer Tube – 100-H Area		579134.582	150891.146
58-D	Aquifer Tube – 100-H Area		579310.118	150233.17
58-M	Aquifer Tube – 100-H Area		579311.429	150232.317
58-S	Aquifer Tube – 100-H Area		579310.627	150232.255
699-100-43B	Unconfined Aquifer Well		576675.9	154008.65
699-101-45	Unconfined Aquifer Well		576032.4	154124.17
699-101-48B	Unconfined Aquifer Well		575283.678	154404.019
699-88-41	Unconfined Aquifer Well		577221.545	150333.764
699-89-35	Unconfined Aquifer Well		579121.737	150543.514
699-90-34	Unconfined Aquifer Well		579410.129	150782.646
699-90-37B	Unconfined Aquifer Well		578474.693	151031.322
699-90-45	Unconfined Aquifer Well		576169.25	151024.529
699-91-46A	Unconfined Aquifer Well		575910.95	151156.642
699-92-49	Unconfined Aquifer Well		575063.136	151647.471
699-93-48A	Unconfined Aquifer Well		575094.127	151795.301
699-94-41	Unconfined Aquifer Well		577223.05	152111.68
699-94-43	Unconfined Aquifer Well		576625.6	152087.9
699-95-45	Unconfined Aquifer Well		576257	152556.28

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
699-95-48	Unconfined Aquifer Well		575253.42	152323.05
699-95-51	Unconfined Aquifer Well		574439.5	152528.59
699-96-41	Unconfined Aquifer Well		576770.62	152607.64
699-96-42	Unconfined Aquifer Well		576773.16	152612.6
699-96-43	Unconfined Aquifer Well		576761.453	152605.307
699-96-44	Unconfined Aquifer Well		576773.1	152608.21
699-96-45	Unconfined Aquifer Well		576768.17	152607.03
699-96-52B	Unconfined Aquifer Well		573910.16	152656.22
699-97-41	Unconfined Aquifer Well		577217.5	153090.38
699-97-43B	Unconfined Aquifer Well		576859.84	152981.3
699-97-43C	RUM First Water Bearing Unit		576857.31	152980.67
699-97-45	Unconfined Aquifer Well		576051.7	152978.95
699-97-45B	RUM First Water Bearing Unit		576049.34	152979.41
699-97-48B	Unconfined Aquifer Well		575247.59	152909.76
699-97-48C	RUM First Water Bearing Unit		575245.39	152909.66
699-97-51A	Unconfined Aquifer Well		574468.122	153122.092
699-98-43	Unconfined Aquifer Well		576863.24	153371.37
699-98-46	Unconfined Aquifer Well		575726.86	153365.63

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
699-98-49A	Unconfined Aquifer Well		574823.368	153310.153
699-98-51	Unconfined Aquifer Well		574339.32	153302.71
699-99-41	Unconfined Aquifer Well		577283.99	153590.74
699-99-42B	Unconfined Aquifer Well		577010.23	153761.02
699-99-44	Unconfined Aquifer Well		576458.77	153592.4
AT-D-1-D	Aquifer Tube – 100-D Area		572860.651	151852.065
AT-D-1-M	Aquifer Tube – 100-D Area		572861.512	151850.404
AT-D-1-S	Aquifer Tube – 100-D Area		572861.059	151850.983
AT-D-2-M	Aquifer Tube – 100-D Area		573105.776	152130.318
AT-D-2-S	Aquifer Tube – 100-D Area		573108.251	152129.777
AT-D-3-D	Aquifer Tube – 100-D Area		573233.231	152224.319
AT-D-3-M	Aquifer Tube – 100-D Area		573234.706	152224.974
AT-D-3-S	Aquifer Tube – 100-D Area		573233.717	152224.602
AT-D-4-D	Aquifer Tube – 100-D Area		572992.239	152039.564
AT-D-4-M	Aquifer Tube – 100-D Area		572993.148	152040.484
AT-D-4-S	Aquifer Tube – 100-D Area		572993.254	152039.864
AT-D-5-D	Aquifer Tube – 100-D Area		573934.803	152850.597
AT-D-5-M	Aquifer Tube – 100-D Area		573934.672	152848.206
AT-H-1-D	Aquifer Tube – 100-H Area		578068.733	152955.059
AT-H-1-M	Aquifer Tube – 100-H Area		578069.144	152954.335

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
AT-H-1-S	Aquifer Tube – 100-H Area		578070.238	152957.484
AT-H-2-D	Aquifer Tube – 100-H Area		578109.838	152896.44
AT-H-2-M	Aquifer Tube – 100-H Area		578110.719	152895.191
AT-H-2-S	Aquifer Tube – 100-H Area		578111.797	152893.943
AT-H-3-D	Aquifer Tube – 100-H Area		578142.216	152853.072
AT-H-3-S	Aquifer Tube – 100-H Area		578141.784	152848.945
C5632	Aquifer Tube – 100-H Area		576389.25	154227.69
C5633	Aquifer Tube – 100-H Area		576390.6	154227.98
C5634	Aquifer Tube – 100-H Area		576391.43	154228.9
C5635	Aquifer Tube – 100-H Area		576478.81	154181.12
C5636	Aquifer Tube – 100-H Area		576481.4	154179.43
C5637	Aquifer Tube – 100-H Area		576483.67	154178.3
C5638	Aquifer Tube – 100-H Area		576634.08	154070.38
C5641	Aquifer Tube – 100-H Area		576871.56	153916.62
C5644	Aquifer Tube – 100-H Area		576960.87	153869.32
C5673	Aquifer Tube – 100-H Area		577157.45	153736.67
C5674	Aquifer Tube – 100-H Area		577157.45	153736.67
C5676	Aquifer Tube – 100-H Area		577276.26	153656.07
C5677	Aquifer Tube – 100-H Area		577277.33	153657.18
C5678	Aquifer Tube – 100-H Area		577278.65	153653.5

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
C5679	Aquifer Tube – 100-H Area		577409.7	153593.4
C5680	Aquifer Tube – 100-H Area		577409.4	153593.79
C5681	Aquifer Tube – 100-H Area		577407.43	153594.58
C5682	Aquifer Tube – 100-H Area		577699.79	153338.71
C6266	Aquifer Tube – 100-D Area		572269.9	151241.63
C6267	Aquifer Tube – 100-D Area		572270.42	151242.23
C6268	Aquifer Tube – 100-D Area		572274.21	151246.19
C6269	Aquifer Tube – 100-D Area		572335.82	151323.2
C6270	Aquifer Tube – 100-D Area		572337.13	151324.52
C6271	Aquifer Tube – 100-D Area		572332.3	151317.57
C6272	Aquifer Tube – 100-D Area		572920.42	151926.86
C6275	Aquifer Tube – 100-D Area		573337.49	152284.93
C6278	Aquifer Tube – 100-D Area		573533.98	152428.19
C6281	Aquifer Tube – 100-D Area		574056.82	153353.31
C6282	Aquifer Tube – 100-D Area		574057.53	153353.6
C6284	Aquifer Tube – 100-H Area		576042.29	154363.63
C6285	Aquifer Tube – 100-H Area		576039.24	154364.31
C6286	Aquifer Tube – 100-H Area		576037.53	154364.5
C6287	Aquifer Tube – 100-H Area		576781.62	153965.55
C6288	Aquifer Tube – 100-H Area		576783.38	153964.05

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
C6290	Aquifer Tube – 100-H Area		577793.47	153266.01
C6291	Aquifer Tube – 100-H Area		577792.39	153267
C6293	Aquifer Tube – 100-H Area		578035.06	152996.7
C6296	Aquifer Tube – 100-H Area		578314.84	152574.8
C6297	Aquifer Tube – 100-H Area		578313.22	152575.13
C6299	Aquifer Tube – 100-H Area		578585.36	152323.62
C6300	Aquifer Tube – 100-H Area		578585.17	152324.65
C6301	Aquifer Tube – 100-H Area		578583.54	152323.27
C6329	Aquifer Tube – 100-D Area		571871.47	150718.71
C6330	Aquifer Tube – 100-D Area		571872	150718.88
C6331	Aquifer Tube – 100-D Area		571872.77	150720.49
C6332	Aquifer Tube – 100-D Area		572045.85	150949.08
C6333	Aquifer Tube – 100-D Area		572045.34	150948.24
C6334	Aquifer Tube – 100-D Area		572046.29	150949.98
C7645	Aquifer Tube – 100-D Area		572077.01	151003.06
C7646	Aquifer Tube – 100-D Area		572077.51	151003.82
C7647	Aquifer Tube – 100-D Area		572076.62	151002.47
C7648	Aquifer Tube – 100-D Area		572077.26	151003.55
C7649	Aquifer Tube – 100-H Area		578271.2	152659.93
C7650	Aquifer Tube – 100-H Area		578271.58	152659.02

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
DD-06-2	Aquifer Tube – 100-D Area		573964.576	153015.374
DD-06-3	Aquifer Tube – 100-D Area		573964.576	153015.374
DD-08-2	Aquifer Tube – 100-D Area		573940.057	152903.527
DD-08-3	Aquifer Tube – 100-D Area		573940.057	152903.527
DD-08-4	Aquifer Tube – 100-D Area		573940.057	152903.527
DD-10-2	Aquifer Tube – 100-D Area		573899.056	152788.072
DD-10-3	Aquifer Tube – 100-D Area		573899.056	152788.072
DD-10-4	Aquifer Tube – 100-D Area		573899.056	152788.072
DD-12-2	Aquifer Tube – 100-D Area		573818.681	152683.696
DD-12-3	Aquifer Tube – 100-D Area		573820.559	152683.591
DD-12-4	Aquifer Tube – 100-D Area		573819.657	152683.584
DD-15-2	Aquifer Tube – 100-D Area		573700.609	152547.828
DD-15-3	Aquifer Tube – 100-D Area		573700.597	152547.317
DD-15-4	Aquifer Tube – 100-D Area		573701.271	152548.199
DD-16-3	Aquifer Tube – 100-D Area		573650.431	152516.128
DD-16-4	Aquifer Tube – 100-D Area		573651.165	152516.993
DD-17-2	Aquifer Tube – 100-D Area		573597.984	152482.772
DD-17-3	Aquifer Tube – 100-D Area		573597.162	152483.304
DD-39-1	Aquifer Tube – 100-D Area		572606.547	151625.856
DD-39-2	Aquifer Tube – 100-D Area		572606.894	151626.189

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
DD-41-1	Aquifer Tube – 100-D Area		572532.894	151530.892
DD-41-2	Aquifer Tube – 100-D Area		572532.209	151530.033
DD-41-3	Aquifer Tube – 100-D Area		572532.688	151530.738
DD-42-2	Aquifer Tube – 100-D Area		572485.319	151492.503
DD-42-3	Aquifer Tube – 100-D Area		572485.766	151492.564
DD-42-4	Aquifer Tube – 100-D Area		572486.189	151492.48
DD-43-2	Aquifer Tube – 100-D Area		572450.504	151443.236
DD-43-3	Aquifer Tube – 100-D Area		572450.906	151443.222
DD-44-3	Aquifer Tube – 100-D Area		572412.676	151394.279
DD-44-4	Aquifer Tube – 100-D Area		572411.362	151396.947
DD-49-1	Aquifer Tube – 100-D Area		572213.696	151161.553
DD-49-2	Aquifer Tube – 100-D Area		572213.968	151162.781
DD-49-2.5	Aquifer Tube – 100-D Area		572213	151162
DD-49-3	Aquifer Tube – 100-D Area		572210.802	151163.304
DD-49-4	Aquifer Tube – 100-D Area		572211.15	151163.981
DD-50-1	Aquifer Tube – 100-D Area		572172.189	151121.164
DD-50-2	Aquifer Tube – 100-D Area		572172.633	151121.569
DD-50-3	Aquifer Tube – 100-D Area		572172.166	151120.007
DD-50-4	Aquifer Tube – 100-D Area		572173.03	151121.18
DH-14-1	Aquifer Tube – 100-H Area		577787.186	153374.82

Table A-2. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a]

Monitoring Location	Type[b]	Treatment System[c]	Northing	Easting
DH-14-11	Aquifer Tube – 100-H Area		577788.415	153377.955
DH-1451-1	Aquifer Tube – 100-H Area		577182.865	153704.528
DH-1452-1	Aquifer Tube – 100-H Area		577255.023	153661.681
DH-22-1	Aquifer Tube – 100-H Area		578460.331	152468.304
DH-22-2	Aquifer Tube – 100-H Area		578460.331	152468.304
DH-22-3	Aquifer Tube – 100-H Area		578460.331	152468.304
Redox-1-3.3	Aquifer Tube – 100-D Area		572716.336	151730.81
Redox-1-6.0	Aquifer Tube – 100-D Area		572716.336	151730.81
Redox-2-6.0	Aquifer Tube – 100-D Area		572636.662	151687.803
Redox-3-3.3	Aquifer Tube – 100-D Area		572583.206	151603.027
Redox-3-4.6	Aquifer Tube – 100-D Area		572583.206	151603.027
Redox-4-3.0	Aquifer Tube – 100-D Area		572529.706	151540.006
Redox-4-6.0	Aquifer Tube – 100-D Area		572529.706	151540.006
100-D	River Gage			
100-H	River Gage			

a. Information is from Well Information and Document Lookup (March 13, 2013). For additional details, see Appendix B.

b. Type = WELL_TYPE_D from database or other identifier.

c. Based on status in DOE/RL-2014-25, *Calendar Year 2013 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation*.

d. Molasses was selected as the soluble (miscible) substrate.

e. Emulsified vegetable oil was selected as the insoluble (immiscible) substrate.

ISRM = in situ redox manipulation

RUM = Ringold Formation upper mud

ZVI = zero valent iron

A5.2 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.

The Columbia River functions as a discharge boundary for the shallow unconfined aquifer beneath the 100-HR-3 Groundwater OU. While not yet definitively determined, it is possible that portions of the confined or semiconfined aquifer within the RUM are also hydraulically connected to the river. During periods of low river stage, groundwater flows toward the river and discharges into the river along the shore. During periods of rising level and high river stage, the magnitude of the groundwater gradient is reduced, and in portions of the shallow aquifer near the river, gradient may actually reverse and river water may enter the aquifer. As the river stage remains elevated, groundwater from inland continues to flow toward the river and backs up against the boundary head provided by the elevated river stage; groundwater elevation inland of the river shore rises accordingly. As the river stage declines after the freshet, groundwater again flows toward the river, typically under 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.

Response of the Cr(VI) plume in the 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-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). The dimensions and changes in plume geometry with changes in river stage are well understood. The plume boundaries are generally further inland from the river during high river stage in comparison to low river stage. The greatest flux of contaminants to the river occurs as the river transitions from seasonal high to seasonal low.

The Cr(VI) plume boundaries also have been tracked as a component of groundwater monitoring since implementation of the interim remedial action ROD (EPA/ROD/R10-96/134). The expansion of the groundwater pump-and-treat system through the addition of the DX and HX extraction and injection networks, as described in DOE/RL-2013-13, *Calendar Year 2012 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation*, 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 if 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 PSQs 1 and 2. The areal extent requiring monitoring will shrink over time, commensurate with groundwater cleanup. As RAOs are achieved and verified, monitoring needs will change. This completion process is described in DOE/RL-2013-31.

A5.3 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

A6 Step 5: Develop the Analytic Approach

Step 5 of the DQO process involves developing an analytic approach that will guide analysis of the study results. This is accomplished by developing a decision rule for each PSQ. Decision rules can be formed as If-Then statements. Table A-3 presents decision rules for each of the PSQs.

Table A-3. Decision Rules

Principal Study Question	Decision Rules
PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?	If monitoring indicates exceedance of contaminant concentrations greater than 10 µg/L, then evaluate pump-and-treat optimization and maintain monitoring at established frequency. If monitoring indicates a plume discharge location change, then re-evaluate pump-and-treat system configuration and monitoring configuration.
PSQ 2: Is the remedy effectively reducing the groundwater Cr(VI) plume?	If monitoring indicates increasing or stable Cr(VI)/Cr (total) concentrations within the plume, then evaluate remedy modifications and potential changes to monitoring frequencies in specific wells. If monitoring indicates a change in plume configuration, then evaluate pump-and-treat optimization. If monitoring indicates decreasing Cr(VI)/Cr (total) concentrations within the plume, then evaluate if monitoring should continue at established or decreasing frequencies for specific locations.
PSQ 3: Are other contaminant plumes that exceed risk based/ARAR levels decreasing as predicted?	If there are plume changes, then identify monitoring configuration changes until there is a final decision for nitrate and strontium-90.
PSQ 4a: What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?	If water level analysis indicates inadequate capture (as described in ECF-Hanford-15-0001), then evaluate optimization of the pump-and-treat system configuration. If the pump-and-treat system configuration changes, then evaluate changes to the automated water level network.
PSQ 4b: What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?	If water level analysis indicates inadequate capture (as described in ECF-Hanford-15-0001), then evaluate optimization of the pump-and-treat system configuration. If the pump-and-treat system configuration changes, then evaluate changes to the automated water level network.

Table A-3. Decision Rules

Principal Study Question	Decision Rules
PSQ 5a: Are infrequently detected analytes confirmed not to be COPCs?	If monitoring indicates that infrequently detected analytes are not present at concentrations greater than action levels, discontinue monitoring. If monitoring indicates that concentrations are greater than action levels, then evaluate path forward in the remedial design/remedial action work plan.
PSQ 5b: Are analytes with detection limits above action levels confirmed not to be COPCs?	If monitoring indicates that analytes are not present at concentrations greater than action levels, discontinue monitoring.
PSQ 5c: Are potential source areas confirmed not to be continuing sources of COPCs in groundwater?	If monitoring indicates that contaminant concentrations are decreasing, determine that there is not a continuing source and cease monitoring.

Reference: ECF-Hanford-15-0001, *Description of Groundwater Modeling Calculations and Assessments for the Calendar Year 2014 (CY2014) 100 Areas Pump and Treat Report.*

COPC = contaminant of potential concern

Cr(VI) = hexavalent chromium

PSQ = principal study question

A7 Step 6: Specify Performance or Acceptance Criteria

This step 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 DQO Step 6 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.

A7.1 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.

Traditional statistical sampling designs were not identified for the groundwater monitoring for PSQs 1, 2, 3, 4, and 5c. PSQs 5a and 5b will use a statistical approach to evaluate whether analyte concentrations are less than action levels. OSWER 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 nondetect, or data are a combination of nondetect, and all detected contaminant of concern (COC) 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 analyte as a 95 percent 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 action level will be performed using UCL_{95} for each analyte. The UCL_{95} calculation will be completed using the recommended methodologies found in U.S. Environmental Protection Agency (EPA) 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-4 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 time frame over which each of the PSQs applies, qualitative consequences of an inadequate sampling design, and accessibility of the site if resampling is required.

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

Table A-4. 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
5a	Annual	Low	Accessible	Statistical
5b	Annual	Low	Accessible	Statistical
5c	Annual	Low	Accessible	Nonstatistical

A8 Step 7: Develop the Detailed Plan for Obtaining Data

The goal of Step 7 is to develop a resource effective design for collecting data to address the identified problems. Monitoring locations and frequencies were selected to address the problem statements. The following sections provide the methodology used to select the final list of groundwater monitoring locations and sampling frequencies that adequately meet the data needs associated with the PSQs.

A8.1 Identify Available Monitoring Locations

All available monitoring locations (wells, aquifer tubes, and treatment process streams) were identified within the groundwater OU and surrounding area of interest (Table A-2). Available locations included wells planned for construction in the future based on SGW-54542, *Recommendations and Technical Justifications for New and Replacement Wells and Re-alignment of Existing Wells Associated with Interim Remedial Actions at 100-D/H Area*. Table A-2 identifies the wells, aquifer tubes, and water level gages that can be used to collect measurements and observations. Available locations are shown on Figure A-2 for the 100-D Area and Figure A-3 for the 100-H Area and Horn Area.

A8.2 Evaluate Available Locations Against the Data Needs

Each existing and potential location was 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, first water bearing unit of the RUM
- Historical sample results –contaminant detections at existing monitoring locations

Well locations and construction information were extracted from the Well Information Document Lookup (WIDL), available at the Hanford Virtual Library. 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 (HEIS) were used to identify historical sample results, including detection of contaminants of interest, contaminant concentration time series, and water level measurements. Contaminant plumes were generated based on DOE/RL-2014-32. The list of available monitoring locations to collect measurements and observations for each data need is included in Table A-2.

A Hanford base map was generated that showed the following:

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

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.

A8.3 Monitoring Location Evaluations

Each available monitoring location was systematically evaluated to determine the suitability in fulfilling the data need.

A8.3.1 Monitoring Locations Retained/Excluded

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 both retaining and excluding specific monitoring locations. Table A-5 identifies the qualitative evaluation criteria for each PSQ and data need. The following general criteria were considered in the evaluation:

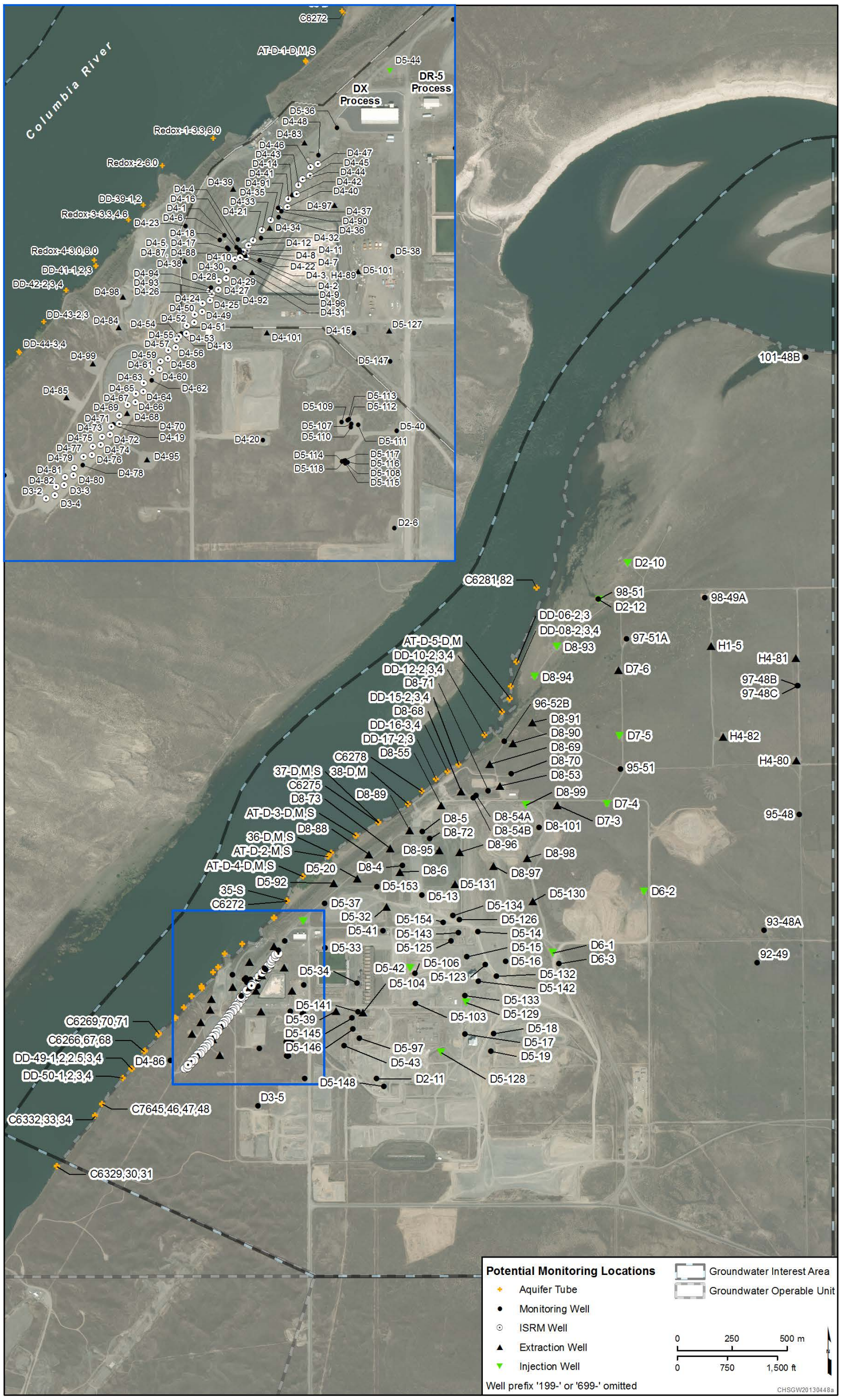

Figure A-2. Available Monitoring Locations for 100-D Area

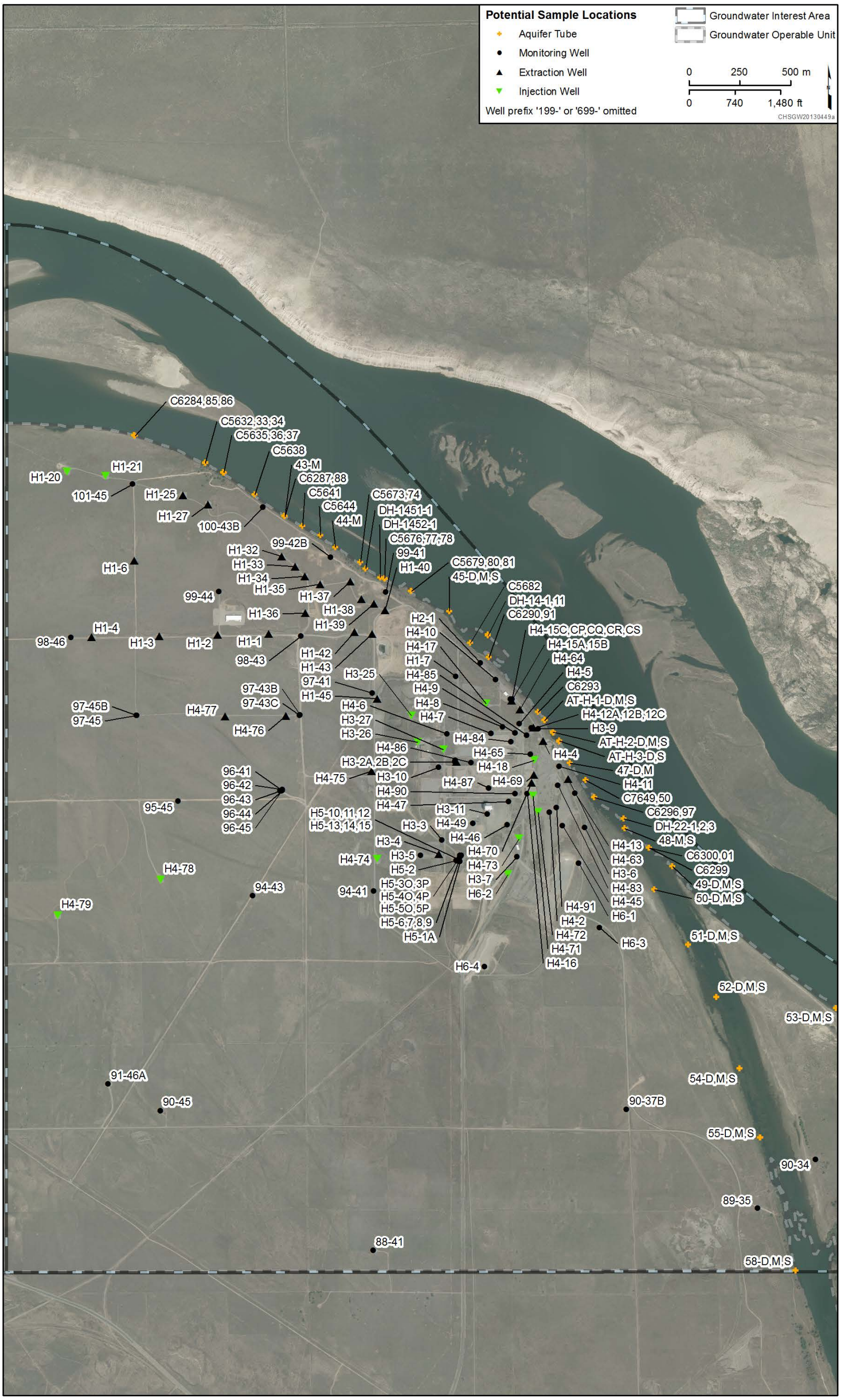

Figure A-3. Available Monitoring Locations for 100-H Area

Table A-5. 100-HR-3 Groundwater Operable Unit Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
Problem Statement 1: The interim action ROD identifies protection of aquatic receptors as an RAO. **PSQ 1: Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?**				
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 or extraction well proximal to river a. Select if within 100 m (328 ft) of the river 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	1. Distance from river indicates 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) **Frequency:** Annual (low/declining river stage, as appropriate) **Basis:** Historical trends of contaminants are well documented and recorded for 100-HR-3; this sampling frequency and timing best represents groundwater 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	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	**Analyte:** Cr(VI) **Frequency:** Annual (low/declining river stage) **Basis:** Historical trends of contaminants are well documented and recorded for 100-HR-3; aquifer tubes are generally only available during low river stage

Table A-5. 100-HR-3 Groundwater Operable Unit Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
		4. Aquifer tubes exhibiting specific conductance consistent with groundwater[a]	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)	
Aquifer tubes: locations that provide qualitative information	Provide information to support 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 is 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) **Frequency:** Annual (low/declining river stage) **Basis:** Historical trends of contaminants are documented for 100-HR-3; aquifer tubes are generally only available during low river stage and need to sample concurrent with upgradient well(s)
Problem Statement 2: The interim action ROD identifies pump-and-treat as the remedy for treating Cr(VI). **PSQ 2: Is the remedy effectively reducing the groundwater Cr(VI) plume?**				
Wells: Wells located within, and adjacent to, current and historically defined contaminant plume segments	Provide information that supports definition of plume geometry and estimation of residual mass	1. Wells that define the boundaries of plume segments a. Concentrations below RAGs located along the periphery of the plume segment	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	**Analyte:** Cr(VI) **Frequency:** Annual **Basis:** This sampling frequency supports definition of plume boundaries that, when combined with the operations data, will provide mass removal in order to

Table A-5. 100-HR-3 Groundwater Operable Unit Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
		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 4. Well screened in the first water bearing unit of the Ringold Formation upper mud	pathways, measurement of conditions in a discrete aquifer unit)	determine whether the remedy 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) **Frequency:** Annual **Basis:** This sampling frequency supports definition of plume boundaries
Problem Statement 3: The interim action ROD identifies an RAO to provide information that will lead to a final remedy. **PSQ 3: Are other contaminants that exceed risk based/ARAR levels decreasing as predicted?**				
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 strontium-90 concentrations that are greater than the action level	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	**Analytes:** Nitrate and strontium-90 **Frequency:** Annual for nitrate, triennial for strontium-90 **Basis:** This sampling frequency supports definition of plume boundaries and identification of natural attenuation of contaminants when combined with operations data

Table A-5. 100-HR-3 Groundwater Operable Unit Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
		2. Wells located downgradient to wells exhibiting contamination that may exhibit migrating contamination in the future	pathways, measurement of conditions in a discrete aquifer unit)	
Problem Statement 4: Water level data are needed to optimize the pump-and-treat system and verify hydraulic containment of contaminant plumes. **PSQ 4a: What are the direction and magnitude of groundwater hydraulic gradients in the unconfined aquifer?** **PSQ 4b: What are the direction and magnitude of groundwater hydraulic gradients in the confined aquifer?**				
Wells: Operating extraction and injection wells equipped with continuous water level measurement equipment and monitoring wells equipped with AWLN systems; also includes groundwater elevation measurements collected during routine groundwater monitoring activities	Provide quantitative measurements to support determination of direction and magnitude of groundwater flow, hydraulic gradients, and verify plume hydraulic capture	1. Extraction and injection wells that are part of the remedial systems operating within the OU 2. Monitoring wells selected based on professional judgment for placement of AWLN system units, based on examination of historical water level data 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 examination of data 2. Wells completed in discrete, hydraulically separated aquifer units will not be combined for gradient analysis, but evaluated separately	**Analyte:** water level **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

Table A-5. 100-HR-3 Groundwater Operable Unit Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
Problem Statement 5 – Through comment resolution with Ecology during the RI/FS process DOE agreed to collect data to address specific uncertainties. PSQ 5a: Are infrequently detected analytes confirmed not to be contaminants of potential concern?				
Spatially representative locations that have previously shown detected concentrations of uncertain analytes	Spatially representative locations that have previously shown detected concentrations of uncertain analytes	Wells that have previous analyte detections within an exposure area: **100-D Area** –199-D4-15, 199-D5-142, and 199-D5-14 **100-H Area** – 199-H3-2A, 199-H4-13, and 199-H4-84 **Horn Area** – 699-97-43B, 699-98-46, 699-99-42B	1. Remedial system injection wells	**Analytes: 100-D Area** – antimony, cadmium, cobalt, copper, lead, and silver **100-H Area** – antimony, cadmium, cobalt, copper, lead, and silver **Horn Area** – antimony, cadmium, cobalt, copper, and silver **Frequency:** Triannual until 9 samples are collected **Basis:** This sampling frequency supports definition of analyte concentrations based on river stage
Problem Statement 5 – Through comment resolution with Ecology during the RI/FS process DOE agreed to collect data to address specific uncertainties. PSQ 5b: Are analytes with detection limits above action levels confirmed not to be contaminants of potential concern?				
Spatially representative locations that were previously analyzed for uncertain analytes	Spatially representative locations that have previously shown detected concentrations of uncertain analytes	Wells that have previous analyte detections within an exposure area **100-D Area** – 199-D4-15, 199-D5-142, and 199-D5-14 **100-H Area** – 199-H3-2A, 199-H4-13, and 199-H4-84 **Horn Area** – 699-97-43B, 699-98-46, 699-99-42B	1. Remedial system injection wells	**Analytes: 100-D Area** – antimony, cadmium, cobalt, copper, lead, and silver **100-H Area** – antimony, cadmium, cobalt, copper, lead, and silver **Horn Area** – antimony, cadmium, cobalt, copper, and silver **Frequency:** Triannual until 9 samples are collected **Basis:** This sampling frequency supports comparison of analyte detection limits and concentrations to action levels based on river stage
Problem Statement 5 – Through comment resolution with Ecology during the RI/FS process DOE agreed to collect data to address specific uncertainties. PSQ 5c: Are potential source areas confirmed not to be continuing sources of COPC in groundwater?				
Wells downgradient of a continuing source	Provide information to confirm there is	Wells based on downgradient locations	1. Remedial system injection wells	**Analytes:** 100-D-100 – Cr(VI), 183-H - uranium

Table A-5. 100-HR-3 Groundwater Operable Unit Monitoring Location Evaluation

Monitoring Location	Basis	Criteria for Selection	Criteria for Exclusion	Analyte/Frequency/Basis
	not a continuing source	**100-D-100:** 199-D5-103, 199-D5-104, 199-D5-127, 199-D5-133, 199-D5-145, 199-D5-146, 199-D5-34, 199-D5-39, 199-D5-97 **183-H:** 199-H4-12A, 199-H4-12C, 199-H4-8, 199-H4-84, 199-H4-85		**Frequency:** Triannual until 9 samples are collected **Basis:** This sampling frequency supports comparison of analyte detection limits and concentrations to action levels based on river stage

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 2013 contaminant distributions.

PSQ 3: The identification and selection of wells for Cr(VI) assume that total chromium is within the same area, and no separate selection process was used for total chromium.

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 measured 2013 contaminant distribution.

PSQ 4a: Selection of monitoring locations for the unconfined aquifer automated water level monitoring will use locations selected using professional judgment, based on experience at the Hanford Site. Extraction and injection wells are identified based on pump-and-treat 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*. Groundwater elevation data are also collected during sample collection.

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

Cr(VI) = hexavalent chromium

OU = operable unit

RI/FS = remedial investigation/feasibility study

ROD = record of decision

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 of, and aquifer effects of, ongoing operation of remedial action systems (e.g., pump-and-treat extraction wells and specifically identified performance monitoring wells).

Criteria for Exclusion included locations that meet the following requirements:

- Redundant (i.e., are located within 100 m [328 ft] of another monitoring location) and do not provide supplemental or definitive input to a data need
- Pump-and-treat 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.

A8.3.2 Monitoring Locations for Analytes with Uncertainty

The locations for PSQs 5a, 5b, and 5c were identified using the process described in the following paragraphs. Locations for PSQs 5a and 5b were based on exposure areas and analytes identified in the risk assessment of the 100-D/H RI/FS report (DOE/RL-2010-95). The locations for PSQs 5a and 5b are combined, as it is anticipated that analytical methods with detection limits low enough for comparison to action levels will be used. The risk assessment summarized the analytes and exposure areas as follows:

> *The COPC identification process identified six analytes for the 100-D source exposure area that are retained as COPCs for further monitoring. The occurrence of antimony, cadmium, cobalt, copper, lead, and silver, and their nature and extent evaluation, indicates these analytes historically have been detected in groundwater at concentrations above their respective action level, but their presence was not associated with a specific location or a trend. Therefore, these analytes warrant further monitoring.*
>
> *The COPC identification process identified 12 analytes for the 100-D ISRM that are retained as COPCs for further monitoring. Seven of the 12 analytes (fluoride, iron, lead, manganese, nitrite,*

sulfate, and zinc) occur in a limited number of wells within the ISRM and their presence is associated with the reducing conditions created by the presence of zero valence iron. The remaining five analytes (antimony, cadmium, cobalt, copper, and silver) historically have been detected in groundwater at concentrations above their respective action level, but their presence was not associated with a specific location or a trend. Therefore, these analytes warrant further monitoring.

The COPC identification process identified six analytes for the 100-H source exposure area that are retained as COPCs for further monitoring. The analytes in the 100-H source exposure area include antimony, cadmium, cobalt, copper, lead, and silver. The nature and extent evaluation indicates these analytes historically have been detected in groundwater at concentrations above their respective action level, but their presence was not associated with a specific location or a trend. Therefore, these analytes warrant further monitoring.

The COPC identification process identified five analytes for the Horn exposure area that are retained as COPCs for further monitoring. The analytes in the Horn exposure area include antimony, cadmium, cobalt, copper, and silver. The nature and extent evaluation indicates these analytes historically have been detected in groundwater at concentrations above their respective action level, but their presence was not associated with a specific location or a trend. Therefore, these analytes warrant further monitoring.

The data and results discussed in the following section are summarized in Table A-6. Three locations were selected to provide a representative evaluation for each exposure area, with the objective of selecting locations where a detection of the analyte is most likely. Three monitoring locations within each exposure area were identified as follows:

1. Groundwater data (20,035 results) for the listed analytes from the 100-D/H RI/FS report (Appendix D of DOE/RL-2010-95), and a query of HEIS groundwater data for the 100-HR-3 OU (6,441 results) from 2013 through June 23, 2014 were copied to a spreadsheet (Table A-6, Number of Results).

2. Results were compared to action levels for each analyte to identify all results greater than an action level (Table A-6; Number of Results ≥ Action Level).

3. Laboratory qualifiers were filtered to remove all nondetect results and identify results with detected concentrations greater than an action level (Table A-6; Number of Results ≥ Action Level and no U LAB_Qual).

4. RI and HEIS detected analyte results were combined (1,021 results), and unique locations were identified (114 wells).

5. The number of different analytes detected at each of the unique locations was identified (varied from 1 to 9).

6. Unique locations were examined by exposure area:

    a. 100-D Area – 39 wells
    b. 100-H Area – 17 wells
    c. Horn – 18 wells

The ISRM Area was eliminated from consideration due to the high potential of analytical interference from anions and nutrients. Trace metals and anions, such as iron and sulfate, were included in the injections into the barrier. Therefore, this area is not appropriate for evaluation of low level

concentrations of antimony, cadmium, cobalt, copper, fluoride, iron, lead, manganese, nitrite, silver, sulfate, and zinc.

Locations were selected in the following order:

a. Highest number of detected analytes were selected, with the intention of increasing the likelihood of detection during sampling.

b. If an analyte was not detected in a well with a higher number of analytes detected, a different location (where the analytes had been previously detected) was selected.

c. Locations with equal numbers of detected analytes were examined to identify spatially representative wells.

Results were as follows:

100-D Area – 199-D4-15, 199-D5-142, and 199-D5-14

100-H Area – 199-H3-2A, 199-H4-13, and 199-H4-84

Horn Area – 699-97-43B, 699-98-46, and 699-99-42B

Analytes for wells within each of the exposure areas are as follows:

100-D Area – antimony, cadmium, cobalt, copper, lead, and silver

100-H Area – antimony, cadmium, cobalt, copper, lead, and silver

Horn Area – antimony, cadmium, cobalt, copper, and silver

Wells for PSQ 5c were selected from available wells (as described in A8.3.1) that are located downgradient from areas with detections, based on professional judgment.

The purpose of sampling for PSQs 5a and 5b is to collect statistically valid data sets that can be used to evaluate locations and compare analyte concentrations to the respective action levels using the procedures identified in Section A7.1. Analyte action levels are in Table A-6.

A8.4 Data Collection Frequency

Historical groundwater monitoring and pump-and-treat system performance monitoring provide a well understood CSM of contaminant distribution and groundwater movement. The monitoring frequencies and criteria for selection of the frequency for the PSQs are as follows:

- PSQ 1 – Is Cr(VI) discharging to the river at concentrations greater than 10 µg/L?
  - Criteria: Cr(VI) concentrations are highest in near-shore locations.
  - Frequency Selected and Rationale: The flux of Cr(VI) to the river is greatest during the transition from high to low river stage and during low river stage. An annual sampling frequency targeting the November to December period is adequate to identify the maximum Cr(VI) discharge concentrations for exposure of aquatic receptors. This period generally provides groundwater samples that will have the lowest effects from dilution by river water and typically the highest concentrations.
- PSQ 2 – Is the remedy effectively reducing the groundwater Cr(VI) plume?

- Criteria: Monitor at frequency to identify changes in overall Cr(VI) plume geometry over time and track reduction in high concentration areas. Sampling frequency should target time frames when concentrations are highest based on historical data.
- Frequency Selected and Rationale: The Cr(VI) plume behavior and effects from the pump-and-treat system are well understood. Annual sampling from pump-and-treat system monitoring is the primary data to support definition of the plume geometry and identify contaminant mass removal. Data from selected monitoring wells are used to supplement plume definition. Additional monthly Cr(VI) concentration data collected for operations and maintenance (O&M) will supplement the understanding of plume behavior. Total chromium measurements from extraction wells and the pump-and-treat system influent and effluent collected for O&M will be used to evaluate plume behavior.

- PSQ 3 – Are the other contaminant plumes that exceed risk based/ARAR levels decreasing as predicted?
  - Criteria: Monitor at frequency to identify changes in overall nitrate plume geometry over time, and track reduction in high concentration areas. Monitor at frequency to identify changes in overall strontium-90 plume geometry (a less mobile constituent) over time, and track reduction in high concentration areas.
  - Frequency Selected and Rationale: Nitrate and strontium-90 contamination are identified in the 100-D/H RI/FS report (DOE/RL-2010-95) and have been tracked and reported annually and triennially, respectively. (e.g., DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*). Annual monitoring for nitrate, until a well has three consecutive sampling events with concentrations below the action level, and triennial monitoring for strontium-90 are adequate to track the plume geometry and concentration trends.

- PSQ 4 – What are the direction and magnitude of groundwater hydraulic gradients in the confined and unconfined aquifers?
  - Criteria: Monitor at frequency sufficient to track seasonal changes in water levels, and evaluate capture (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*).

Table A-6. Summary of Data Evaluation for PSQ 5a and PSQ 5b

Analyte	Action Level (µg/L)[a]	Basis	Data from Remedial Investigation[b]				Data from Hanford Environmental Information System[c,d]			
			Number of Results	Number of Results ≥ Action Level	Number of Results ≥ Action Level and U or DU LAB_QUAL (Nondetect)	Number of Results ≥ Action Level and No U LAB_QUAL	Number of Results	Number of Results ≥ Action Level	Number of Results ≥ Action Level and U or DU LAB_QUAL (Nondetect)	Number of Results ≥ Action Level and No U LAB_QUAL
Antimony	6.0	40 CFR 141- Primary Federal MCL	1,880	1,397	1,344	53	596	191	191	0
Cadmium	0.25	Clean Water Act Freshwater CCC	1,918	1,508	1,492	16	596	191	189	2
Cobalt	4.8	WAC 173-340-720(4)(b)(iii)(A) and (B)	1,881	301	164	137	596	11	0	11
Copper	9	Clean Water Act Freshwater CCC	1,918	134	27	107	596	56	0	56
Fluoride	960	WAC 173-340-720(4)(b)(iii)(A) and (B)	1,412	53	48	5	499	1	1	0
Iron	1,000	Clean Water Act Freshwater CCC	1,873	134	0	134	529	26	0	26
Lead	2.1	WAC 173-201A	423	33	3	30	405	2	0	2
Manganese	384	WAC 173-340-720(4)(b)(iii)(A) and (B)	1,918	85	0	85	534	30	0	30
Nitrite	3,300	40 CFR 141 - Primary Federal MCL	1,398	6	3	3	499	0	0	0
Silver	2.6	WAC 173-201A	1,880	1,498	1,384	114	552	191	191	0
Sulfate	250,000	40 CFR 141 – Secondary Federal MCL	1,616	69	0	69	505	5	0	5
Zinc	91	WAC 173-201A	1,918	132	0	132	534	4	0	4
		Totals:	20,035			885	6,441			136

Sources: 40 CFR 141, "National Primary Drinking Water Regulations."

Ecology Publication No. 94-06, *Model Toxics Control Act Cleanup Regulation and Statute*.

EPA, 2009, *National Recommended Water Quality Criteria*.

WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington."

WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards."

CCC = criteria continuous concentration

D = analyte identified in an analysis at a secondary dilution factor (i.e., dilution factor different than 1.0)

MCL = maximum contaminant level

U = not detected above the practical quantitation limit

a. Action levels are from Table 6-31 in 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*.

b. Appendix D groundwater data are from 2007 to December 2012.

c. Groundwater data are from Hanford Environmental Information System database (June 23, 2014). Data are from January 2013 through June 23, 2014 for 100-HR-3 OU.

d. Historical supporting data are summarized in Section 6.3 of DOE/RL-2010-95.

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- Frequency Selected and Rationale: The pump-and-treat system and automated water level network (AWLN) wells provide high frequency measurements of water levels for select wells. These measurements are recorded on an hourly basis. A round of synoptic water level measurements will be collected two times per year, once each during low and high river stage. The measurements will be collected to represent the overall groundwater system within the 100-HR-3 OU through collection of measurements at individual wells within 1 to 3 days. Low river conditions will be represented by a round of measurements collected during September through December, and high river conditions will be represented by a round of measurements collected between mid-June and mid-August.

- PSQ 5a – Are the infrequently detected analytes confirmed not to be COPCs?

  - Criteria: Monitor at frequency sufficient to demonstrate that infrequently detected analytes are not COPCs during low, high, or transitional river stage.

  - Frequency Selected and Rationale: Triannual monitoring is identified for collection of samples to provide representative samples based on river stage. The target sample periods are during the high to low river transition and during low river stage (late August to December), high river stage (mid-May to end of July), and transitional. This monitoring frequency is selected to achieve the desired data set to meet these needs more quickly and to demonstrate that there are not impacts of river stage on the concentrations of these constituents. Nine samples will be collected.

- PSQ 5b – Are the analytes with detection limits above action levels confirmed not to be COPCs?

  - Criteria: Monitor at frequency sufficient to demonstrate that analytes with detection limits above action levels are not COPCs during low, high, or transitional river stage.

  - Frequency Selected and Rationale: Triannual monitoring is identified for collection of samples to provide representative samples based on river stage. The target sample periods are during the high to low river transition and during low river stage (late August to December), high river stage (mid-May to end of July), and transitional. This monitoring frequency is selected to achieve the desired data set to meet these needs more quickly and to demonstrate that there are not impacts of river stage on the concentrations of these constituents. Nine samples will be collected.

- PSQ 5c – Are potential source areas confirmed not to be continuing sources of COPCs in groundwater?

  - Criteria: Monitor at frequency sufficient to demonstrate that there are or are not continuing sources present near selected waste sites.

Frequency Selected and Rationale: Triannual monitoring is identified for collection of samples to provide representative samples based on river stage. The target sample periods are during the low to high river stage transition period (January through mid-April), during low river stage (typically September to December), and during high river stage (typically mid-April through August). This monitoring frequency is selected to achieve the desired data set to meet these needs more quickly and to demonstrate that there are not impacts of river stage on the concentrations of these constituents. Up to nine samples will be collected at the 100-D-100 and 100-D-30/100-D-104 waste sites. Monitoring for uranium at 183-H will continue until compliance with the maximum contaminant level (MCL) can be demonstrated.

A9 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 3-3, presented in the main document, presents a summary of monitoring locations, frequencies, and constituents. The PSQ addressed at each location also is included.

Figures A-4 and A-5 show the chromium monitoring locations for PSQ 1 and PSQ 2, respectively, relative to defined groundwater chromium plumes. Figures A-6 and A-7 show nitrate and strontium-90 monitoring locations, respectively, relative to defined groundwater contaminant plumes. Figure A-8 shows monitoring locations for water levels, and Figures A-9 and A-10 show monitoring locations for additional analytes and source locations.

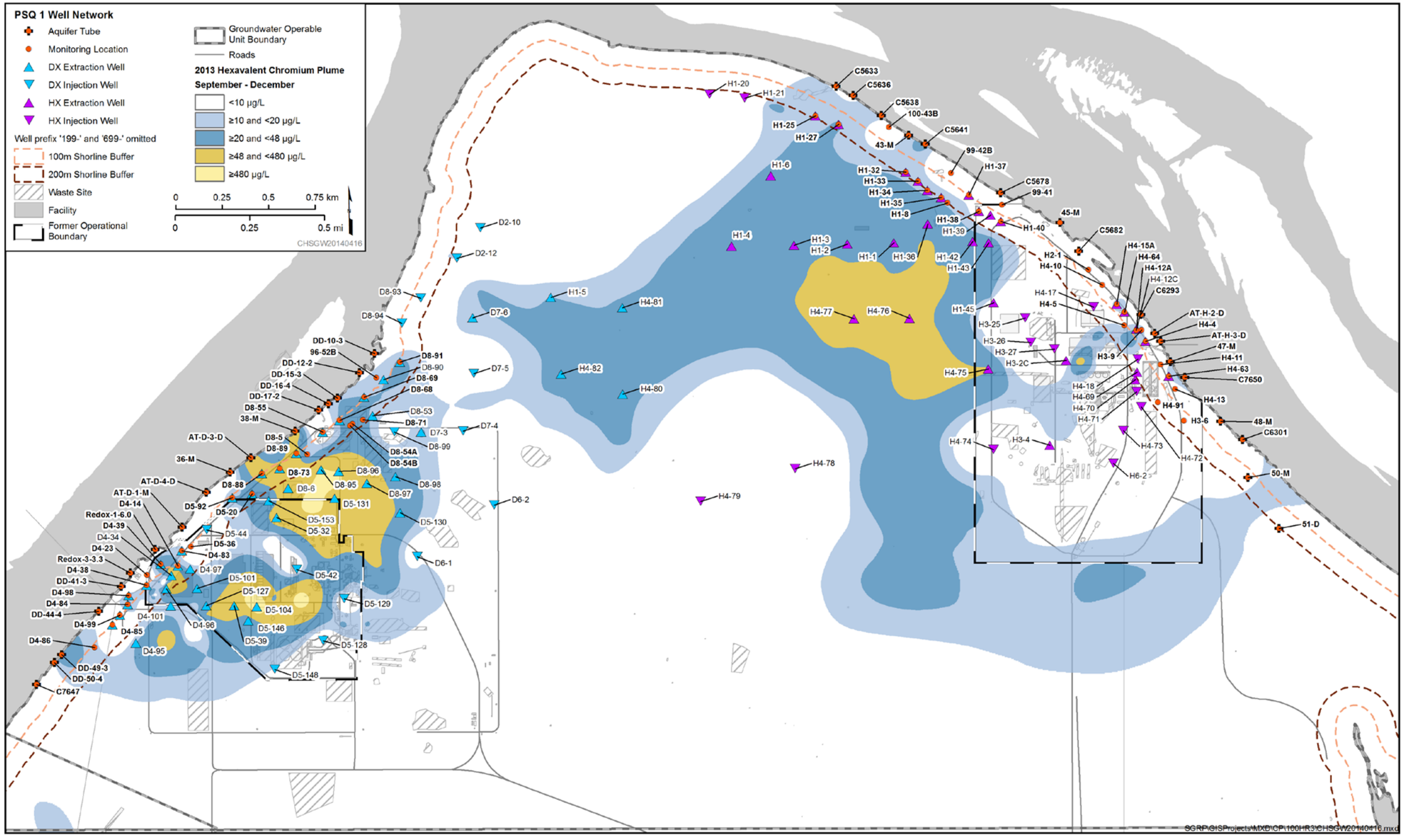

Figure A-4. Monitoring Locations for PSQ 1: Is Cr(VI) Discharging to the River at Concentrations Greater than 10 µg/L?

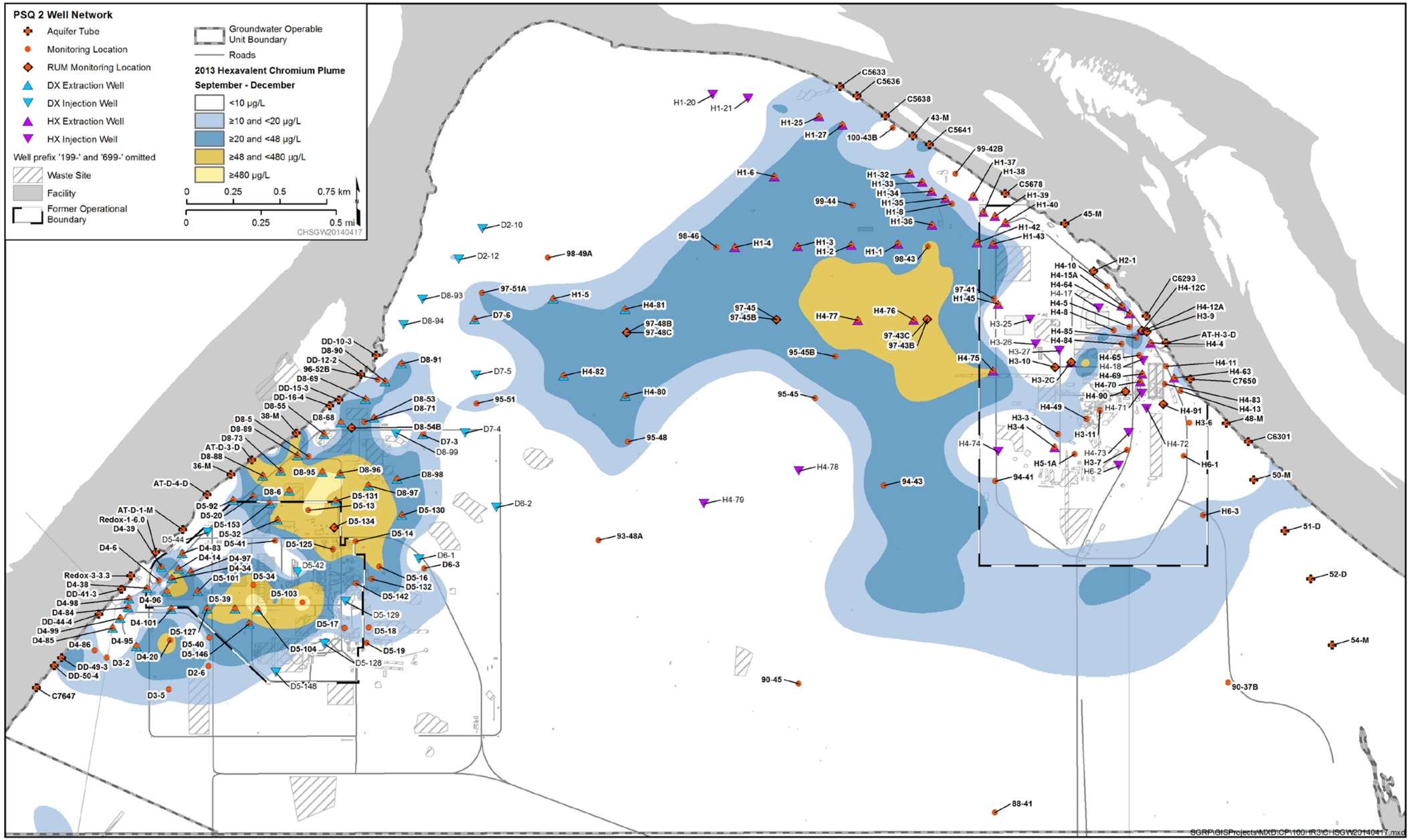

Figure A-5. Monitoring Locations for PSQ 2: Is the Remedy Effectively Reducing the Groundwater Cr(VI) Plume?

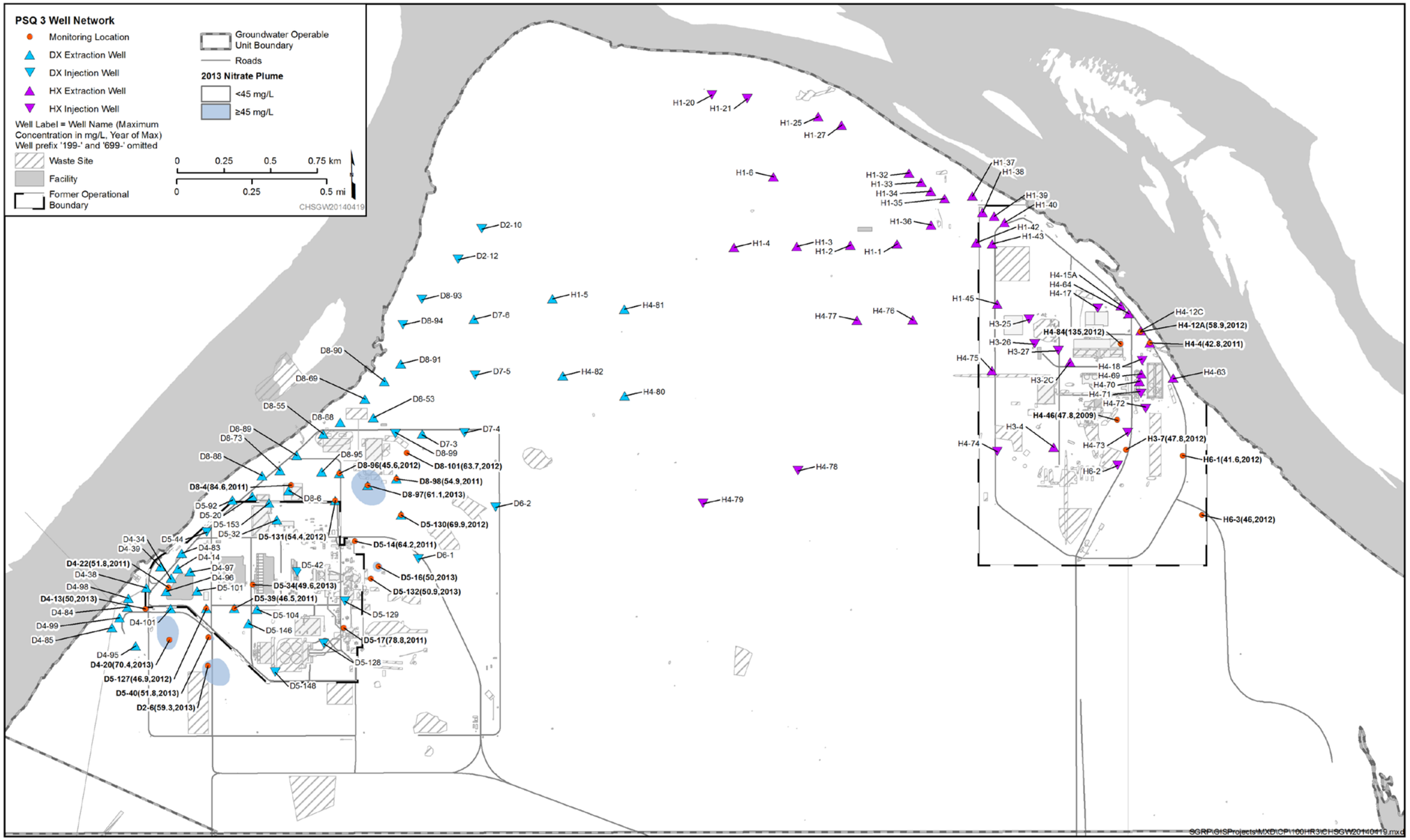

Figure A-6. Nitrate Monitoring Locations for PSQ 3: Are Other Contaminant Plumes that Exceed Risk Based/Applicable or Relevant and Appropriate Requirements (ARAR) Levels Decreasing as Predicted?

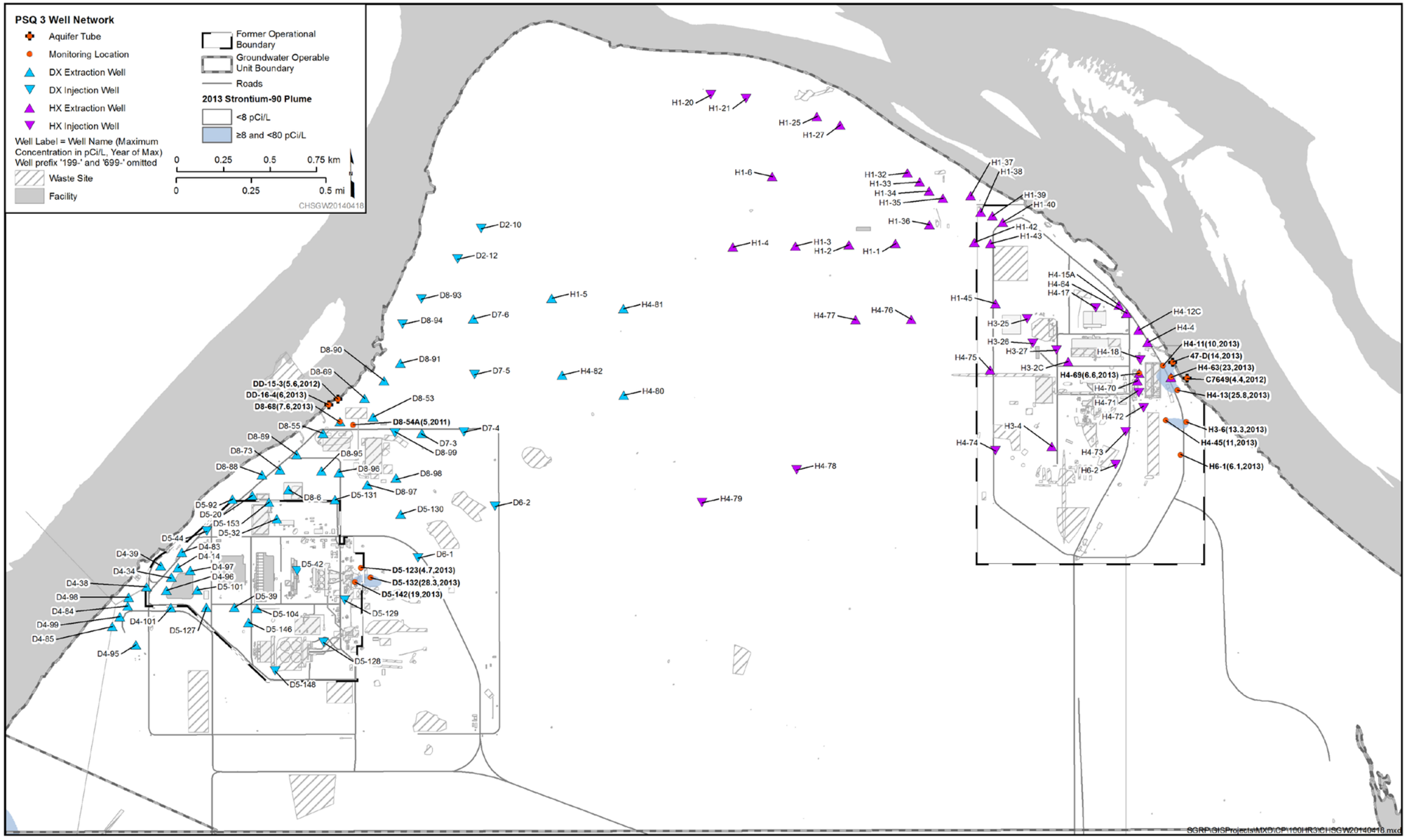

Figure A-7. Strontium-90 Monitoring Locations for PSQ 3: Are Other Contaminant Plumes that Exceed Risk Based/Applicable or Relevant and Appropriate Requirement Levels Decreasing as Predicted?

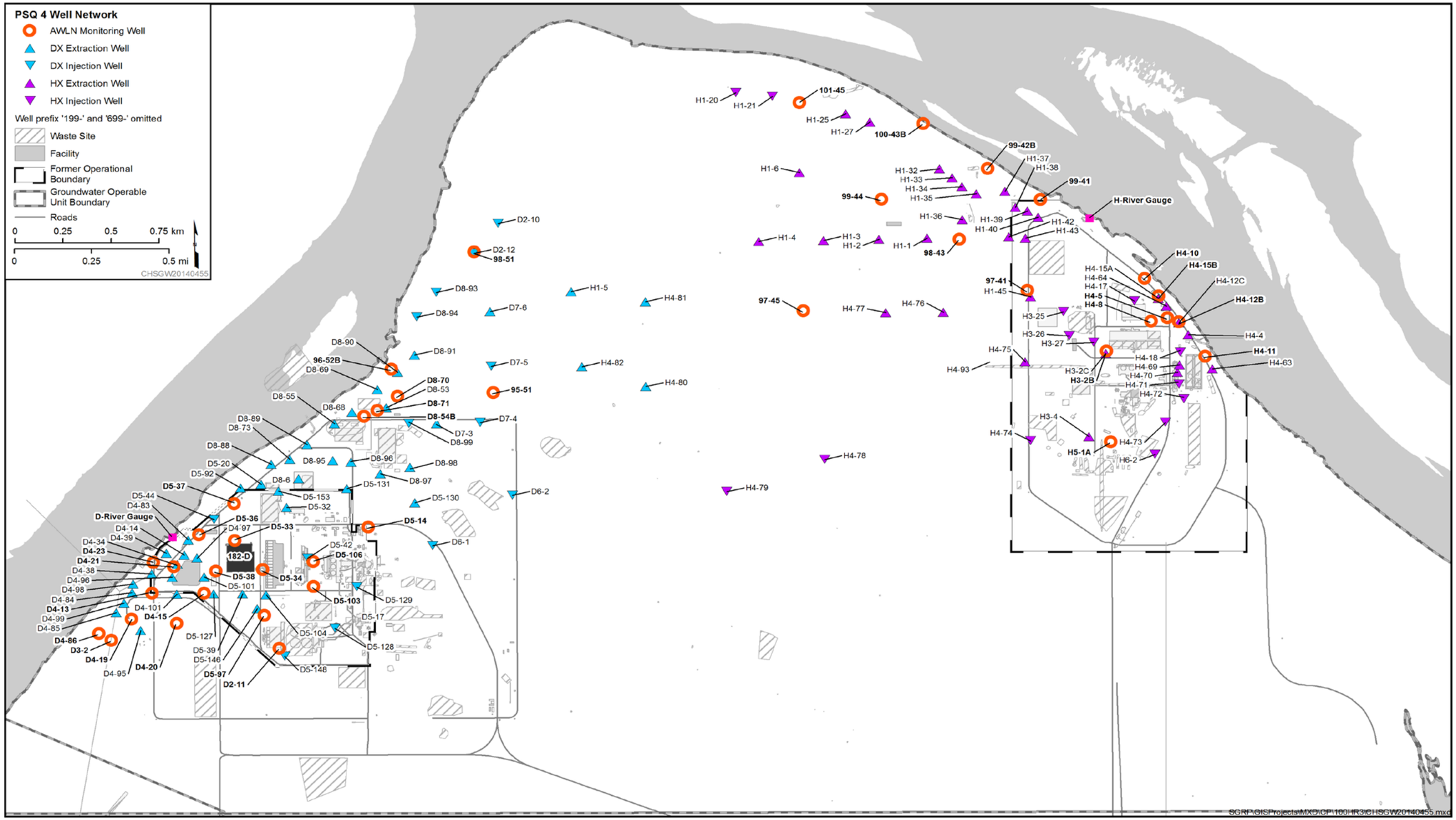

Figure A-8. Automated Water Level Network Monitoring Locations for PSQ 4a: What Are the Direction and Magnitude of Groundwater Hydraulic Gradients in the Confined and Unconfined Aquifers?

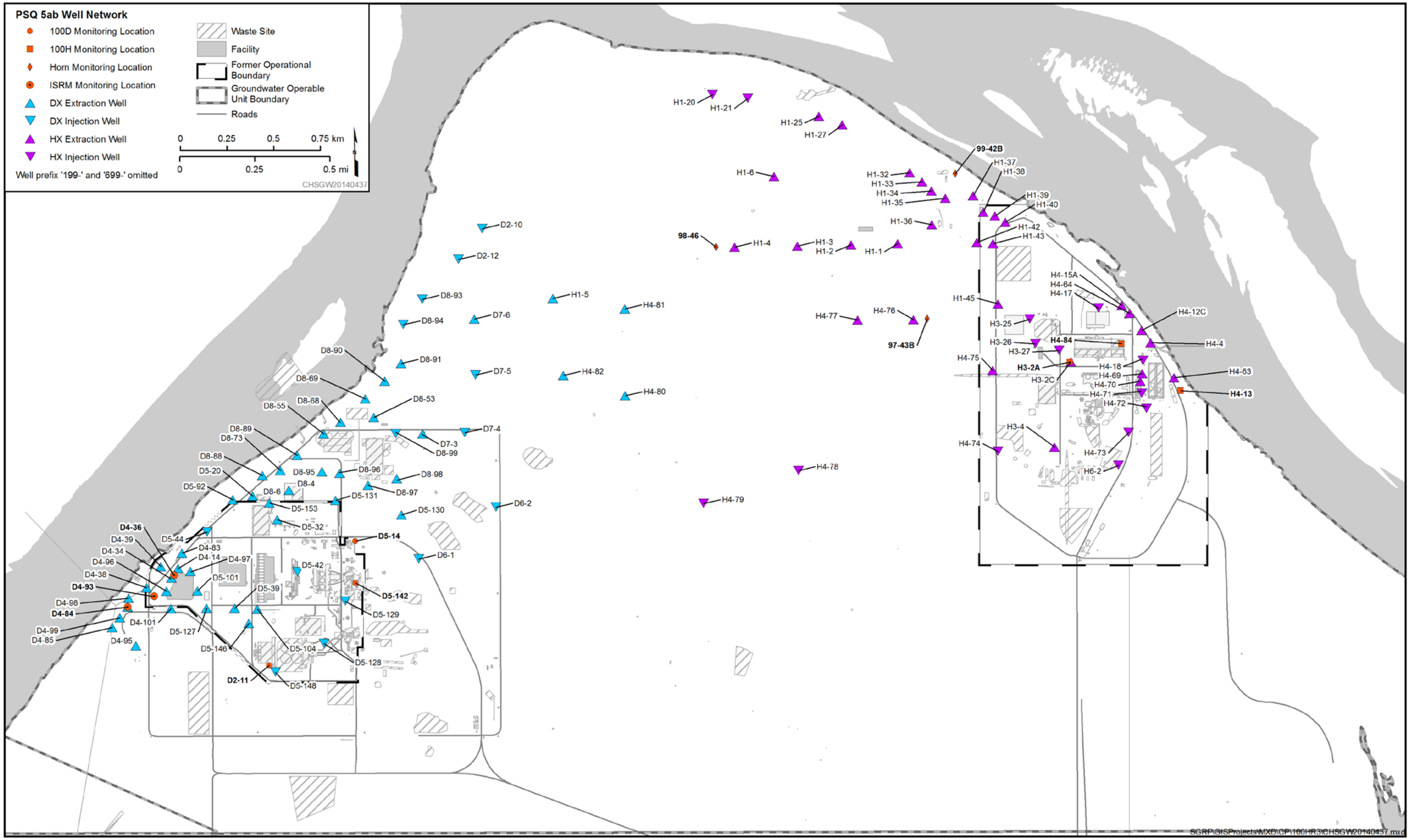

Figure A-9. Monitoring Locations for PSQ 5a: Are Infrequently Detected Analytes Confirmed Not to Be Contaminants of Potential Concern? and PSQ 5b: Are Analytes with Detection Limits above Action Levels Confirmed Not to Be Contaminants of Potential Concern?

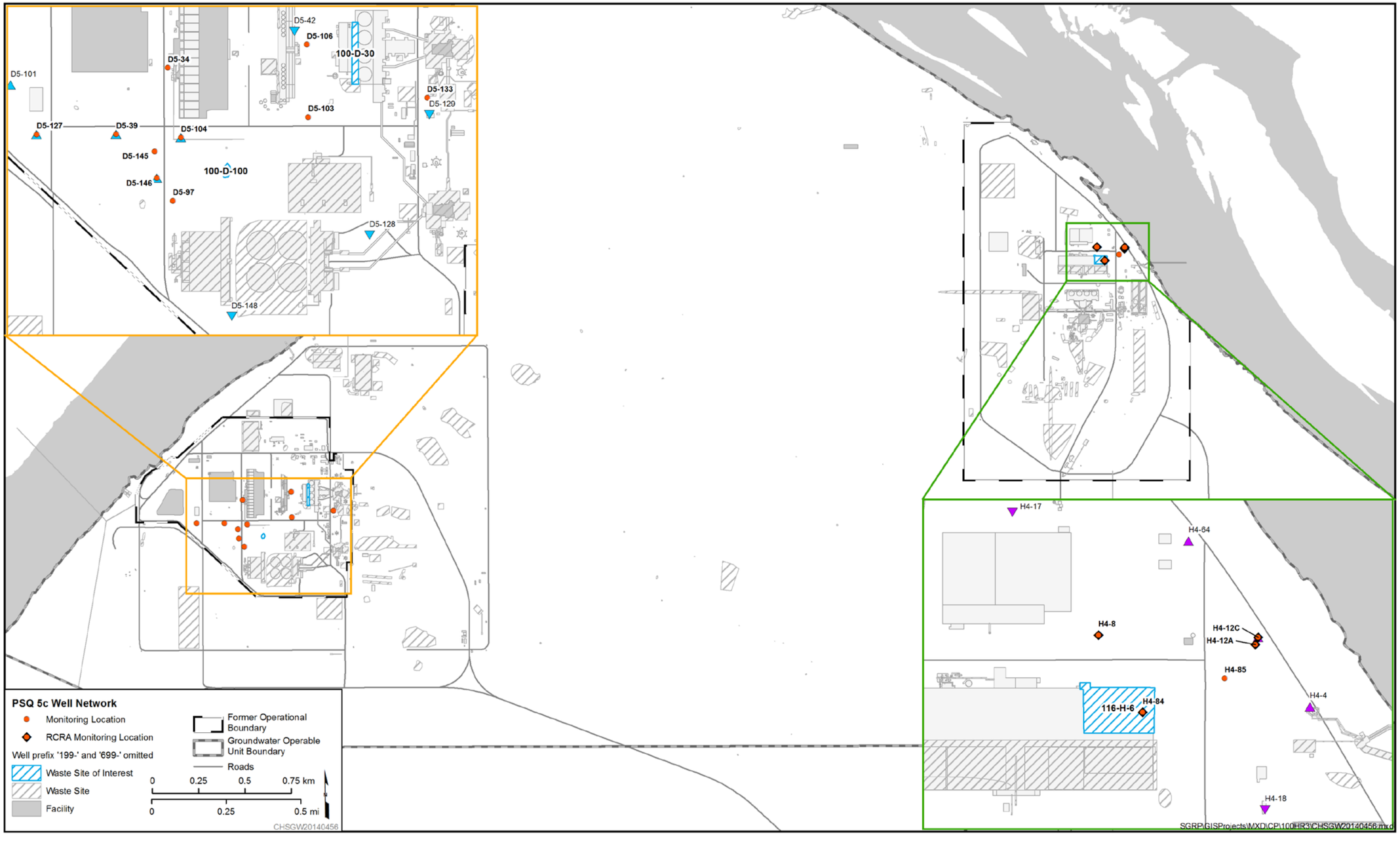

Figure A-10. Monitoring Locations for PSQ 5c: Are Potential Source Areas Confirmed Not to Be Continuing Sources of Contaminants of Potential Concern in Groundwater?

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Supporting Information for Appendix A

Recommendations and Technical Justifications for New and Replacement Wells and Realignment of Existing Wells Associated with Interim Remedial Actions at 100-D/H Area, Technical Memorandum (SGW-54542)

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CH2MHILL Plateau Remediation Company

TECHNICAL MEMORANDUM

Recommendations and Technical Justification for New and Replacement Wells and Re-alignment of Existing Wells Associated with Interim Remedial Actions at 100-D/H Area

APPROVED
By Julia R. Raymer at 3:12 pm, Apr 09, 2013

Approved for Public Release; Further Dissemination Unlimited

Prepared for: 100-HR-3 Groundwater Operable Unit Project File (030.13)

Prepared by: KA Ivarson/North Wind for PRC

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Correspondence Control – MSIN – A3-01

Date: 22 February 2013

Doc ID: SGW-54542, REV. 0

1. Introduction

CH2MHILL Plateau Remediation Company has evaluated groundwater contamination conditions and the existing monitoring and remediation systems at 100-HR-3 Groundwater Operable Unit (OU) to identify additional groundwater wells that are needed to support the continued system operation and monitoring. The existing interim remedy consists of two operating pump-and-treat systems that capture contaminated groundwater, treat it to remove hexavalent chromium, and inject the treated water back into the aquifer. The interim remedy is currently successfully capturing the hexavalent chromium plume, however, some additional wells have been identified that will enhance the operation. These wells are identified as either new wells to be installed for extraction, injection, and/or groundwater monitoring, or existing wells that can be re-aligned to provide additional groundwater extraction capability. The need for additional wells in the remedial system is based on assessment of a three-level priority as follows:

1. River Protection. To maintain protection of the Columbia River from discharges of groundwater exceeding the hexavalent chromium remedial action objective of 20 µg/L.
2. Mass Removal. To effectively remove mass from the areas of highest concentration of hexavalent chromium in groundwater.
3. Plume Delineation. To clearly delineate the extent of groundwater plumes of hexavalent chromium and other identified co-contaminants. The specific co-contaminants in groundwater that were evaluated in this assessment are strontium-90, nitrate, and tritium. Both uranium and technetium-99 are monitored in association with the 183-H solar evaporation basins, however the contaminants are localized to that area.

This technical memorandum is organized to present the 100-HR-3 well recommendations using the following topics of discussion:

- Introduction
- Overview of Groundwater Contamination at 100-HR-3 OU

- Proposed Well Locations
  - Existing Wells to Be Re-aligned for Extraction/ Injection
  - New Wells to be Drilled and Constructed for Extraction, Injection, and Monitoring
  - Wells to be Evaluated for Future Use

2. Overview of Groundwater Contamination at 100-HR-3 OU

Groundwater contamination at 100-HR-3 OU originated from discharges of contaminated waste water and chemical solutions during the period of operation of the 105-D, 105-DR, and 105-H plutonium production reactors. The 105-D reactor started operation in 1945. The 105-DR started operation in early 1949 as a replacement for D Reactor. However, the D Reactor graphite distortion was controlled, and both reactors operated until 1964 when the DR Reactor was shut down. The D Reactor was shut down in 1967. Construction of H Reactor began in 1948, and the reactor operated from 1949 until 1965.

Hexavalent Chromium. Groundwater contamination by hexavalent chromium, which is the basis for the current interim remedial action, originated from planned discharges of chromium-treated cooling water, to the retention basins and to the 116-DR-1&2 Trench during the 1967 infiltration test. Other sources of contamination were from planned and unplanned releases of concentrated sodium dichromate solution, which was used to treat the reactor cooling water along with other chemicals. Waste sites associated with hexavalent chromium use, and the 2010 plume configurations are presented in Figures 1 and 2. Decontamination solutions, burial grounds and other waste disposal sites also contributed to the groundwater contamination. The hexavalent chromium plume essentially encompasses the areas with co-contaminants and is the focus of the well priorities. Sampling of co-contaminants would be needed during any extraction operation, however no additional locations were identified solely for those contaminants.

Strontium-90. Strontium-90 was produced as a fission product in reactor fuel during the plutonium production operations. Contamination of water by fission products occurred commonly in the reactor fuel storage basins; water was released from the fuel storage basins by unplanned releases (i.e., leaks and spills), as well as during planned releases (e.g., basin water overflow during reactor defueling operations). In addition, reactor cooling water became contaminated with fuel and fission product residues during reactor fuel failure incidents.

Nitrate. The primary source of nitrate in 100 D/H is nitric acid used during reactor operations as a decontamination solution. Nitric acid and other decontamination solutions were disposed in cribs, trenches, and French drains near the building where they were used. These solutions were also occasionally combined with reactor cooling water and discharged to the river (100 D Area Technical Baseline Report [WHC SD-EN-TI-181]). Another reactor operation related source is from oxidation of ammonia discharged in the condensate solution. Secondary contributors include septic systems, sewer lines, and former agricultural practices.

Tritium. Tritium is also present in groundwater at levels slightly below MCLs at 100-D, as a result of reactor operations in that area.

3. Proposed Well Locations

Several wells are required within 100-D/H to support ongoing groundwater remediation actions, support effective groundwater contaminant plume monitoring, and confirm remedial system performance. The requirements include a combination of monitoring wells and dual purpose wells that can also be used for groundwater extraction. The following general areas are identified as currently having inadequate well coverage:

a) River shoreline areas with potential for contamination to reach the river. These areas have been identified at 100-D south, 100-D north, 100-H north, and within the 100-H reactor area.

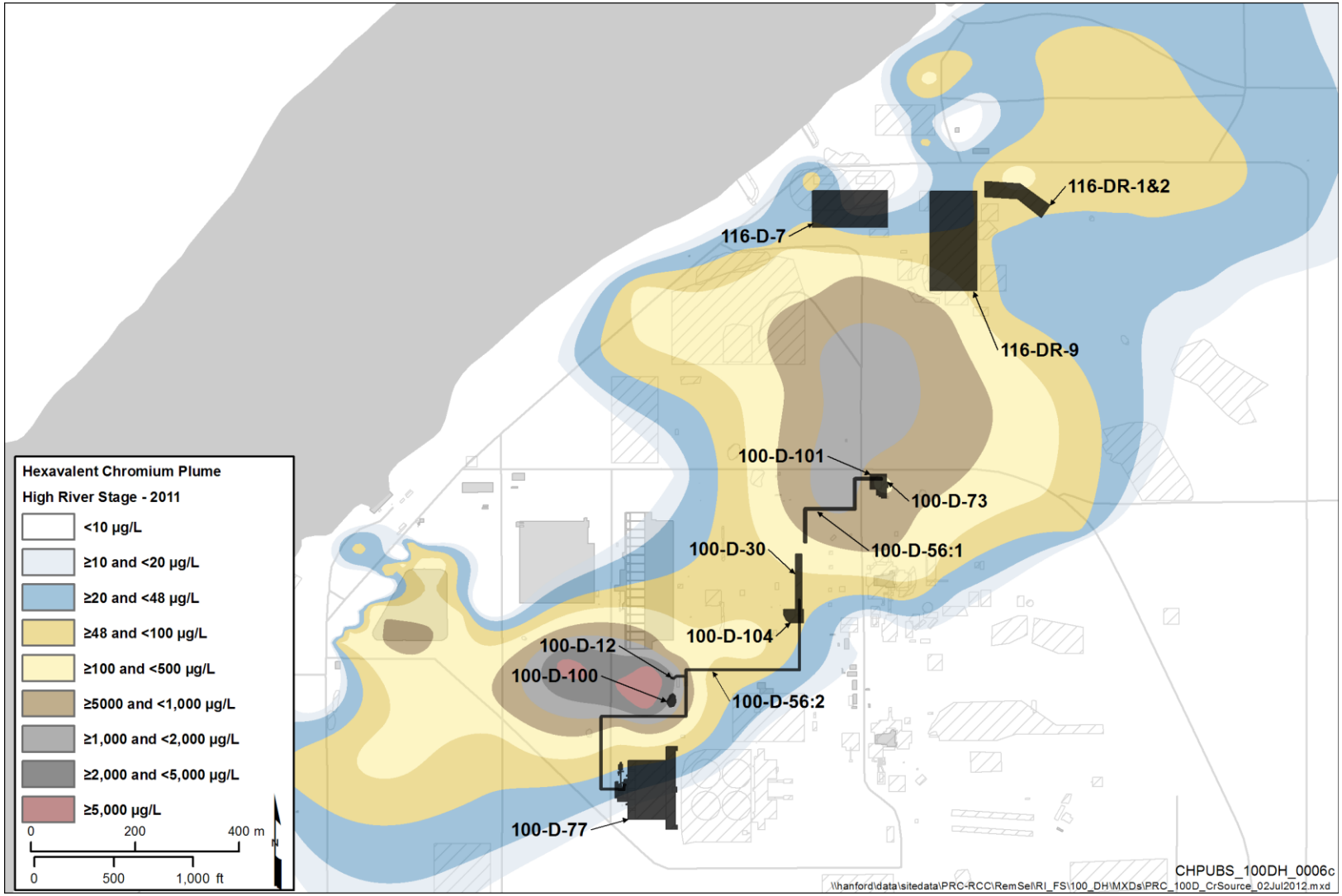

Figure 1. 100-D Spring 2011 Cr(VI) Plume and Waste Sites Associated with Sodium Dichromate Use

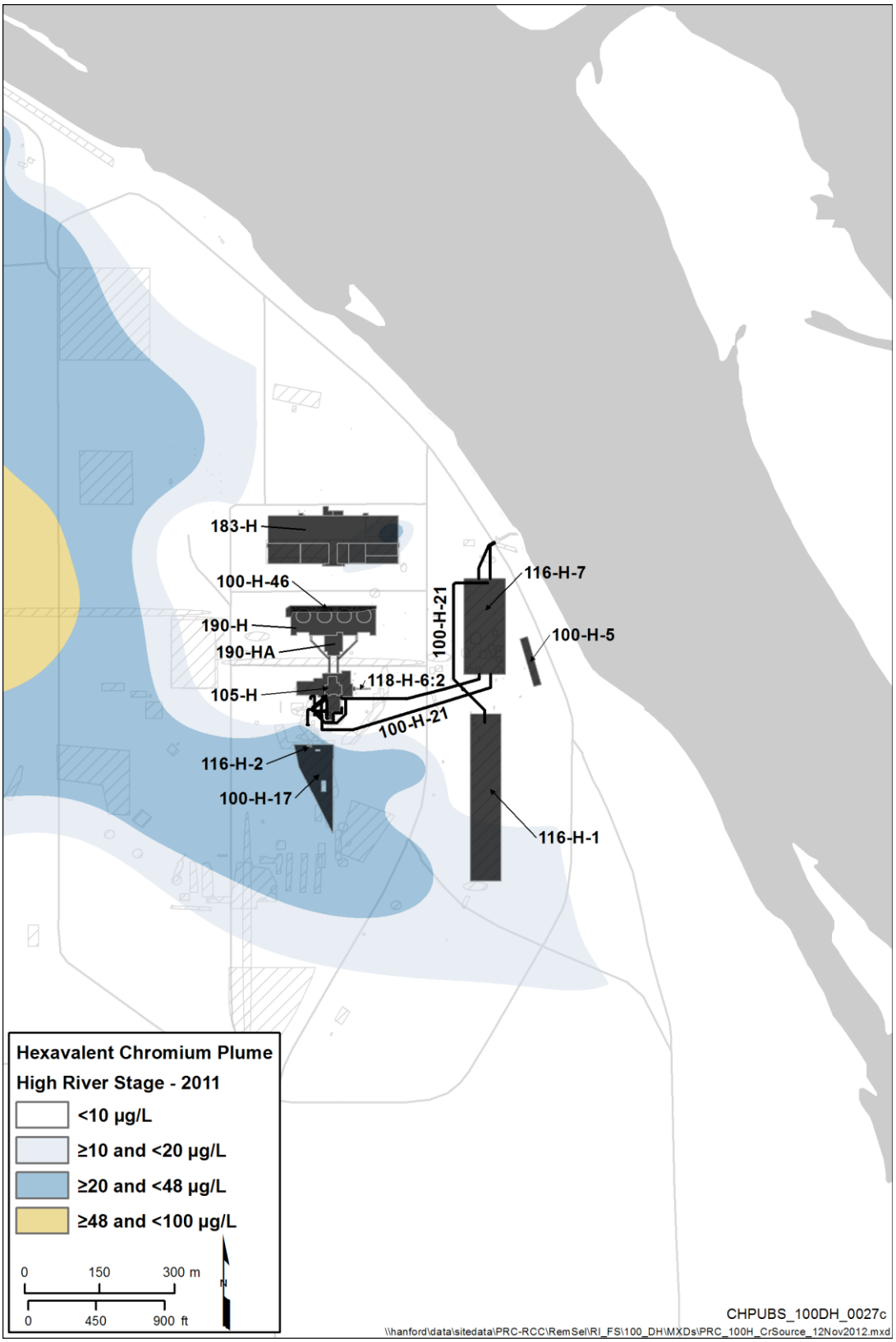

Figure 2. 100-H: Cr(VI) Spring 2010 Plume and Waste Sites Associated with Sodium Dichromate Use

b) The first water bearing unit within the Ringold Upper Mud unit (RUM) where contamination has been identified has potential for impacting the river. The RUM wells at 100-H have Cr(VI) concentrations above 100 µg/L.

The well locations identified for either re-alignment of existing wells or drilling and construction of new wells at 100-HR-3 groundwater OU are shown in plan view in Figures 3 and 4, and described in Table 1. The table headings in Table 1 are defined below:

Well Use/Function: This column contains a description of the intended purpose of the well. This may include groundwater monitoring, groundwater extraction, or injection of treatment system effluent water. Some wells that are identified primarily for monitoring purposes will be constructed for potential use as groundwater extraction wells in the event conditions require expanded groundwater extraction capacity.

Proposed Location: This column describes the general well location (more exact locations are indicated in Figure 3 and 4) relative to existing features, other wells, or specific waste sites.

Technical Justification: This column briefly describes the reason for re-aligning or constructing the well at the specific location. Typical reasons are to enhance hexavalent chromium capture at specific plume segments, to enhance the description, or boundary of, known contaminant plumes, to provide for increased contaminant mass removal from high-concentration plume segments, or to provide additional treatment system effluent injection capacity.

Well Name: The well name column indicates the well name assigned to the specific well if, in fact, the well has already been assigned a name. Only existing wells have a name assigned. The remaining wells have not yet been surveyed, and the well name column has “TBD”. In addition, the column has the well identifier used on Figures 3 and 4 which shows the well rank, such as 100-DH-005, which has a rank of “5”.

Well Priority: This column identifies the well priority characteristic for the specific well. The three evaluation priorities used for this evaluation are presented in the introduction. Assignment of these priorities to a well indicates the following:

1. River Protection. This indicates a well that is considered to be an essential part of the interim remedial action system that will enhance the degree to which the system intercepts and captures the hexavalent chromium plume before it approaches the Columbia River hyporheic zone.

2. Mass Removal. This indicates a well that has been identified for a location where additional groundwater extraction efforts will provide expanded removal of contaminant mass from the aquifer. Enhanced mass removal is expected to shorten the overall remedial action life cycle.

3. Plume Delineation. This indicates that the well has been located to provide important information regarding the magnitude and extent of groundwater contamination. This may be by providing information on the maximum concentration present, or to provide information on the apparent boundaries of contaminant plumes.

Some wells may be assigned more than one priority; in that instance, the first priority listed is the primary one, additional priorities are considered subsidiary. This may indicate, for instance, a well location where information is needed to define a plume segment, but, depending on conditions observed after well completion, it may be appropriate to integrate the well as an extraction well.

Well Rank: The well rank columns are used to identify the recommended sequencing, or relative importance, of a specific well within each of the three priority categories. Well(s) with the lowest numerical value in this column are considered to be the most important wells to complete within each of the priority categories. Existing wells are identified and ranked separately from wells needing to be installed.

TABLE 1: 100-D/H Area New and Replacement Wells to Install and Existing Wells to Realign

Priority 1 – Wells Identified for Rive r Protection Enhancement

Well Use/Function	Proposed Location	Technical Justification	Well Name	Well Priority	New Well Rank	Existing Well Rank
Monitoring and Extraction well (HX)	New RUM Well at 100-H plume to the southwest, located to the south of H3-10 and Solar Evap. Basin, keep within the RUM low associated with that area. Approximate Coordinates: N 152549.0; E 577915.8	Delineation of Cr(VI) plume within the RUM. Hot spot of contamination at 100-H is located within the RUM. We have inadequate delineation of the plume in that zone, and therefore an unknown risk of near river contamination contributing to the River.	C8787, 199-H4-90; Pre plan id: DH-01	1- River Protection	1	--
Monitoring and Extraction well (HX)	New RUM Well 100-H Plume to the south, located south of H3-9, near the River, and within the RUM low in that area. Approximate Coordinates: N 152524.6; E 578126.4	Delineation of Cr(VI) plume within the RUM. Hot spot of contamination at 100-H is located within the RUM. We have inadequate delineation of the plume in that zone, and therefore an unknown risk of near river contamination contributing to the River.	C8788, 199-H4-91; Pre plan id: DH-02	1- River Protection	1	--
Extraction well for hydraulic control (DX)	199-D8-68	Realign existing well to extraction to increase hydraulic control and capture adjacent to river along north end of 100-D plume	199-D8-68	1 - River Protection	--	1
Extraction well for hydraulic control (DX)	199-D8-53	Realign existing well to extraction to increase hydraulic control and capture adjacent to river along north end of 100-D plume	199-D8-53	1- River Protection	--	2
Extraction well for hydraulic control and mass removal (DX)	199-D8-55	Realign existing well to extraction to increase hydraulic control and capture adjacent to river in area along north end of 100-D plume. Well is currently used for injection, however pumping rates are minimal. Well construction appears to be adequate for extraction purposes.	199-D8-55	1- River Protection 2 – Mass removal	--	3
Extraction well for hydraulic control (DX)	New Well near well 199-D5-20 Downgradient of 100-D north plume, along the river. Approximate Coordinates: N 152013; E 573335	Increase hydraulic control and capture adjacent to river in area along the north end of the 100-D plume.	C8789, 199-D5-153; Pre plan id: DH-03	1- River Protection	3	--
Extraction well for hydraulic control and mass removal (DX)	New Well near well 199-D5-126 and waste site 100-D-73; Located around the 199-D5-126 area, N plume Approximate Coordinates: N 151813; E 573694	Remove mass at higher concentration area of plume.	C8790, 199-D5-154; Pre plan id: DH-04	1 - River Protection; 2- mass removal	4	--
Extraction well for hydraulic control (HX)	New Well near well 199-H1-35; North of 100-H, along the river. Approximate Coordinates: N 153612; E 576987	Based on capture maps, there is a need for increased hydraulic control and capture of the plume in this area.	C8791, 199-H1-8 Pre plan id: DH-05	1- River Protection	5	--
Monitoring and hydraulic control extraction well (DX)	New Well 100-D South Plume, South Flank. Extraction of Cr(VI) in the area around well D3-5. Approximate Coordinates: N 150797.1, E 572466.7	Install monitoring well for delineation of Cr(VI) plume along southern edge of plume at 100-D. Plume needs delineation to determine risk to river.	C8736, 199-D3-6; Pre plan id: DH-06	1- River Protection; 3-delineation	6	--
Extraction well (DX)	Convert ISRM well 199-D4-32, located between 199-D4-96 and 199-D4-39	Well construction was evaluated for suitability as an extraction well. The well has 20 ft of screen in a 6 in dia well, gravel formation and appears to be adequate placement and construction.	199-D4-32	1 - River Protection; 2- mass removal	--	4
Extraction well (DX)	Convert ISRM well 199-D4-14, located between 199-D4-97 and 199-D4-39	Well construction was evaluated for suitability as an extraction well. The well has 20 ft of screen in a 6 in dia well, gravel formation and appears to be adequate placement and construction.	199-D4-14	1 - River Protection; 2- mass removal	--	5

Priority 2 – Wells Identified for Enhanced Hexavalent Chromium Mass Removal						
Extraction well (HX)	New Well 100-H Plume, southeast flank. Approximate Coordinates: N 152234.0; E 576723.4	Extract mass from the eastward encroachment of the Horn Plume into 100-H, particularly along the south edge. Well is northwest of proposed location for new extraction well.	C8792, 199-H4-92; Pre plan id: DH-07	2 - Mass Removal	7	--
Extraction well (HX)	Realign existing well to extraction; 199-H3-5	Extract mass from the eastward encroachment of the Horn Plume into 100-H, particularly along the south edge.	199-H3-5	2 - Mass Removal	--	6
Monitoring and Potential Extraction well (DX or HX)	New Well in Horn completed in the RUM, located downgradient of RUM Well 699-97-48C for mass removal and plume delineation. Potential for future extraction location. Approximate Coordinates: N 152847.7; E 575455.4	Delineation of Cr(VI) plume within the RUM - in the HORN. The area of contamination in the RUM is defined by a single point and concentrations have recently risen to 62 ppb. The concern is Cr(VI) migration across the Horn. We need to understand the extent before we can understand the potential risk.	C8793, 699-97-60; Pre plan id: DH-08	2 - Mass Removal; 3-delineation	8	--
Monitoring and Potential Extraction well (DX or HX)	New Well in Horn completed in the RUM, located upgradient of RUM Well 699-97-48C for mass removal and plume delineation. Potential for future extraction location. Approximate Coordinates: N 152913.3; E 574890.3	Delineation of Cr(VI) plume within the RUM - in the HORN. The area of contamination in the RUM is defined by a single point and concentrations have recently risen to 62 ppb. The concern is Cr(VI) migration across the Horn. We need to understand the extent before we can understand the potential risk.	C8794, 699-97-61; Pre plan id: DH-09	2 - Mass Removal; 3- delineation	9	--
Possible Wells to Realign in Out Years - Pending Evaluation						
Injection (DX)	Convert wells at 100-D-100	Evaluate well construction for suitability; Evaluate Cr(VI) concentrations; Consider injection following field remediation to support injection limitations of the DX system.	199-D5-148	2 - Mass Removal	FY13 replacement.	1
Monitoring and Potential Extraction (DX)	Convert wells at 100-D-100	Evaluate well construction for suitability; Evaluate Cr(VI) concentrations	199-D5-146	2 - Mass Removal	FY13 replacement.	7
Monitoring and Potential Extraction (DX)	Convert wells at 100-D-100	Evaluate well construction for suitability; Evaluate Cr(VI) concentrations	199-D5-145	2 - Mass Removal	FY13 replacement.	8
Monitoring and Potential Extraction (DX)	Convert wells at 100-D-100	Evaluate well construction for suitability; Evaluate Cr(VI) concentrations	199-D5-147	2 - Mass Removal	FY13 replacement.	9
Evaluate for Extraction (DX)	Convert well 199-D3-5 to extraction well	Evaluate Cr(VI) concentrations. Well may be fitted with a packer and the change in construction may render well unsuitable for extraction.	199-D3-5	2 - Mass Removal	--	--
Evaluate for Installation	New Well downgradient of 199-D3-5, closer to River from Well Priority DH-06.	Evaluate near river data; Evaluate data from new well DH-06	TBD	1- River Protection; 3-delineation	--	--
Evaluate for Installation	New Well north of 199-H1-35 along the river, near Well Priority DH-05	A second well may be needed after the installation of DH-05 to ensure plume capture and control. Evaluate well construction for suitability; Evaluate Cr(VI) concentrations.	TBD	1- River Protection; 3-delineation	--	--
Wells currently assigned for connection to DX system						
Monitoring Well	Ext well (existing Well D8-54A)	RUM well adjacent - do not connect			--	--
Monitoring Well	Ext well (existing Well D8-72)	Redundant location - do not connect			--	--

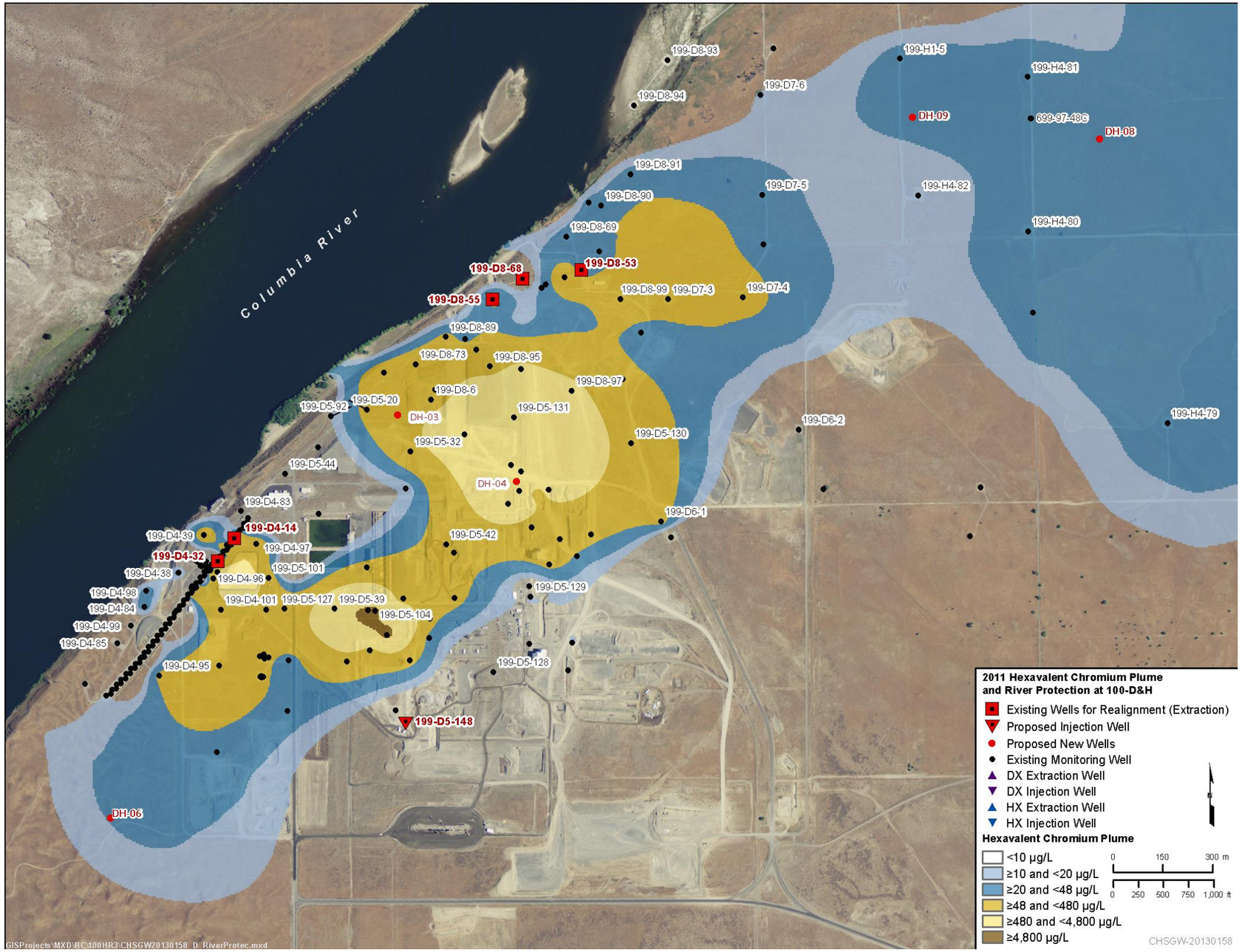

Figure 3. Proposed Well Realignment and Installation at 100-D and Horn

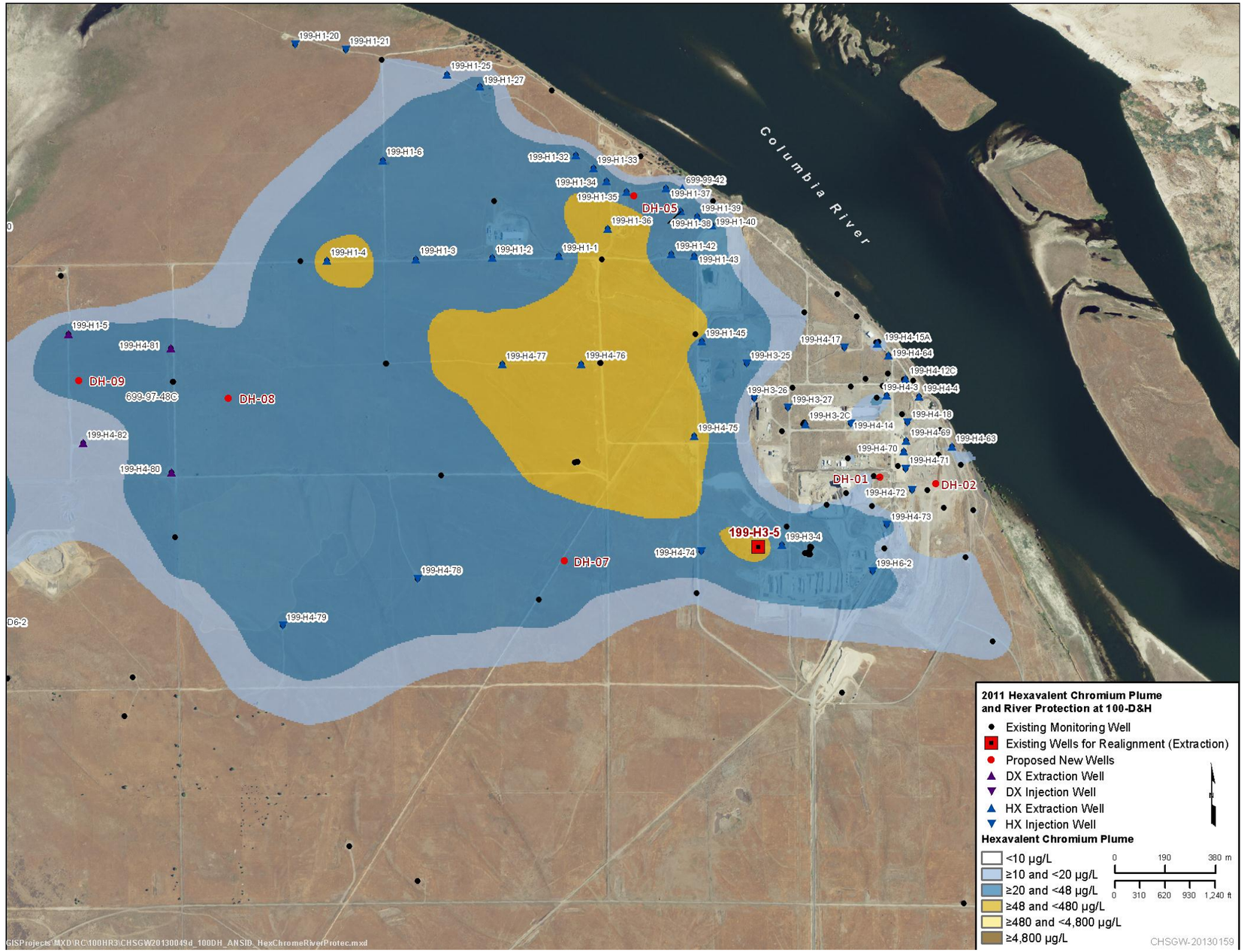

Figure 4. Proposed Well Realignment and Installation at 100-H

Appendix B

Sampling Location Information for 100-HR-3 Groundwater Operable Unit

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Contents

B1 Introduction B-1

B2 References B-1

Table

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations[a] B-3

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B1 Introduction

This appendix provides the following information for the 100-HR-3 Groundwater Operable Unit wells:

- Sampling location name (well identification, aquifer tube identification, or river gage identification)
- Hydrogeologic unit monitored
- Sampling interval information for wells within the 100-HR-3 Groundwater Operable Unit
- Elevation at top of the screen or perforated interval
- Elevation at the bottom of the screen or perforated interval
- Open interval = Length of the open interval, difference between elevations of top and bottom of the screen or perforated interval
- Water Level Elevation = Most recent water level elevation in the well
- Water Level Date = Date of most recent water level elevation measured in the well

B2 References

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Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-D2-10	Unconfined Aquifer Well	Injection	117.29	112.72	117.40		4.57	*15*	574470.87	153465.19
199-D2-11	Unconfined Aquifer Well		119.04	109.89	118.73	2/28/2013	9.15	*30*	573328.16	151120.73
199-D2-12	Unconfined Aquifer Well	Injection	116.96	112.39	117.45		4.57	*15*	574343.45	153300.01
199-D2-6	Unconfined Aquifer Well								573000.21	151119.86
199-D3-2	Unconfined Aquifer Well	TZMW	117.83	111.73	118.26	2/28/2013	6.10	*20*	572453.95	151165.65
199-D3-3	Unconfined Aquifer Well	ISRM Barrier	118.19	109.13	118.02		9.06	*30*	572482.54	151186.95
199-D3-4	Unconfined Aquifer Well	ISRM Barrier	118.16	109.03	118.20		9.13	*30*	572468.15	151170.97
199-D3-5	Unconfined Aquifer Well		121.56	112.41	118.15	2/28/2013	9.15	*30*	572787.66	150994.54
199-D4-1	Unconfined Aquifer Well	TTMW	120.50	114.39	117.50		6.11	*20*	572752.84	151558.89
199-D4-10	Unconfined Aquifer Well	ISRM Barrier	118.72	114.16	117.50		4.56	*15*	572750.24	151540.44
199-D4-101	Unconfined Aquifer Well	Extraction	118.86	112.76	117.72		6.10	*20*	572800.10	151425.94
199-D4-11	Unconfined Aquifer Well	ISRM Barrier	118.93	114.36	117.50		4.57	*15*	572768.94	151554.13
199-D4-12	Unconfined Aquifer Well	ISRM Barrier	118.67	114.10	117.50		4.57	*15*	572771.58	151562.08
199-D4-13	Unconfined Aquifer Well	TZMW	121.06	114.96	117.75	2/28/2013	6.10	*20*	572665.85	151424.47
199-D4-14	Unconfined Aquifer Well	Extraction	120.28	114.17	117.62	2/28/2013	6.11	*20*	572839.81	151641.64
199-D4-15	Unconfined Aquifer Well		120.00	113.90	117.83	2/28/2013	6.10	*20*	572936.63	151424.86
199-D4-16	Unconfined Aquifer Well	TTMW	119.00	114.30	117.50		4.70	*15*	572756.74	151555.32
199-D4-17	Unconfined Aquifer Well	TTMW	118.80	114.07	117.50		4.73	*15*	572738.08	151558.43
199-D4-18	Unconfined Aquifer Well	TTMW	118.78	114.02	117.50		4.76	*15*	572726.33	151570.93
199-D4-19	Unconfined Aquifer Well	TZMW	119.67	110.53	117.89	2/28/2013	9.14	*30*	572559.34	151282.03
199-D4-2	Unconfined Aquifer Well	TTMW	118.25	113.69	117.50		4.56	*15*	572768.37	151543.96
199-D4-20	Unconfined Aquifer Well		118.93	112.83	118.09	2/28/2013	6.10	*20*	572794.04	151257.47
199-D4-21	Unconfined Aquifer Well	ISRM Barrier	118.62	114.06	117.50		4.56	*15*	572778.84	151569.80
199-D4-22	Unconfined Aquifer Well	TTMW	119.95	113.85	117.33	2/28/2013	6.10	*20*	572788.45	151539.29
199-D4-23	Unconfined Aquifer Well		120.79	114.70	117.36	2/28/2013	6.09	*20*	572672.45	151592.87
199-D4-24	Unconfined Aquifer Well	ISRM Barrier	118.80	114.23	117.68		4.57	*15*	572699.89	151471.43
199-D4-25	Unconfined Aquifer Well	ISRM Barrier	117.93	113.35	117.68		4.58	*15*	572711.44	151476.23
199-D4-26	Unconfined Aquifer Well	ISRM Barrier/ZVI Injection	117.53	112.95	117.50		4.58	*15*	572712.32	151488.87

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-D4-27	Unconfined Aquifer Well	ISRM Barrier	117.89	113.31	117.50		4.58	*15*	572724.22	151493.48
199-D4-28	Unconfined Aquifer Well	ISRM Barrier	118.41	113.84	117.50		4.57	*15*	572725.08	151506.07
199-D4-29	Unconfined Aquifer Well	ISRM Barrier	118.65	114.08	117.50		4.57	*15*	572736.85	151510.68
199-D4-3	Unconfined Aquifer Well	TTMW	118.22	113.65	117.50		4.57	*15*	572766.07	151546.12
199-D4-30	Unconfined Aquifer Well	ISRM Barrier	119.18	114.60	117.50		4.58	*15*	572737.44	151523.21
199-D4-31	Unconfined Aquifer Well	ISRM Barrier	119.14	114.57	117.50		4.57	*15*	572749.46	151527.99
199-D4-32	Unconfined Aquifer Well	ISRM Barrier	118.69	114.11	117.53		4.58	*15*	572790.87	151573.74
199-D4-33	Unconfined Aquifer Well	ISRM Barrier	118.17	113.60	117.52		4.57	*15*	572792.62	151585.93
199-D4-34	Unconfined Aquifer Well	Extraction	118.22	113.65	117.52		4.57	*15*	572804.60	151590.02
199-D4-35	Unconfined Aquifer Well	ISRM Barrier	118.73	114.15	117.52		4.58	*15*	572806.30	151602.27
199-D4-36	Unconfined Aquifer Well	TZMW	118.73	114.16	117.52		4.57	*15*	572818.19	151606.21
199-D4-37	Unconfined Aquifer Well	ISRM Barrier	118.49	113.91	117.52		4.58	*15*	572820.29	151618.58
199-D4-38	Unconfined Aquifer Well	Extraction	119.86	113.77	117.50		6.09	*20*	572671.31	151537.85
199-D4-39	Unconfined Aquifer Well	Extraction	120.57	114.47	117.43		6.10	*20*	572747.45	151650.84
199-D4-4	Unconfined Aquifer Well	TTMW	119.75	113.66	117.50		6.09	*20*	572754.61	151571.60
199-D4-40	Unconfined Aquifer Well	ISRM Barrier	118.67	114.00	117.52		4.67	*15*	572832.34	151622.63
199-D4-41	Unconfined Aquifer Well	ISRM Barrier	118.43	113.85	117.52		4.58	*15*	572834.10	151634.65
199-D4-42	Unconfined Aquifer Well	ISRM Barrier	119.84	113.75	117.52		6.09	*20*	572847.12	151642.44
199-D4-43	Unconfined Aquifer Well	ISRM Barrier	118.24	113.74	117.52		4.50	*15*	572849.64	151656.21
199-D4-44	Unconfined Aquifer Well	ISRM Barrier	117.57	113.00	117.52		4.57	*15*	572856.11	151665.63
199-D4-45	Unconfined Aquifer Well	ISRM Barrier	119.30	113.30	117.52		6.00	*20*	572868.00	151671.79
199-D4-46	Unconfined Aquifer Well	ISRM Barrier	117.50	112.93	117.50		4.57	*15*	572868.85	151684.93
199-D4-47	Unconfined Aquifer Well	ISRM Barrier	117.86	113.29	117.50		4.57	*15*	572880.48	151690.13
199-D4-48	Unconfined Aquifer Well	ISRM Barrier	119.07	112.98	117.50		6.09	*20*	572881.30	151703.45
199-D4-49	Unconfined Aquifer Well	ISRM Barrier	118.25	113.67	117.68		4.58	*15*	572699.11	151458.69
199-D4-5	Unconfined Aquifer Well	TTMW	118.97	112.89	117.50		6.08	*20*	572740.54	151556.50
199-D4-50	Unconfined Aquifer Well	ISRM Barrier	117.93	113.46	117.68		4.47	*15*	572687.30	151454.00
199-D4-51	Unconfined Aquifer Well	ISRM Barrier	118.23	113.65	117.68		4.58	*15*	572686.61	151441.40

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-D4-52	Unconfined Aquifer Well	ISRM Barrier	118.29	113.76	117.69		4.53	*15*	572674.91	151436.73
199-D4-53	Unconfined Aquifer Well	ISRM Barrier	118.14	113.63	117.69		4.51	*15*	572674.09	151424.62
199-D4-54	Unconfined Aquifer Well	ISRM Barrier	118.12	113.60	117.69		4.52	*15*	572662.42	151419.72
199-D4-55	Unconfined Aquifer Well	ISRM Barrier	117.86	113.29	117.69		4.57	*15*	572659.02	151414.63
199-D4-56	Unconfined Aquifer Well	ISRM Barrier	118.22	113.63	117.69		4.59	*15*	572657.65	151402.28
199-D4-57	Unconfined Aquifer Well	ISRM Barrier	118.12	113.59	117.69		4.53	*15*	572645.94	151397.86
199-D4-58	Unconfined Aquifer Well	ISRM Barrier	118.05	113.54	117.69		4.51	*15*	572644.81	151385.35
199-D4-59	Unconfined Aquifer Well	ISRM Barrier	117.49	112.92	117.69		4.57	*15*	572633.32	151380.82
199-D4-6	Unconfined Aquifer Well	TTMW	120.18	114.09	117.43		6.09	*20*	572733.34	151577.91
199-D4-60	Unconfined Aquifer Well	ISRM Barrier	117.21	112.70	117.87		4.51	*15*	572632.36	151368.25
199-D4-61	Unconfined Aquifer Well	ISRM Barrier	116.84	112.31	117.87		4.53	*15*	572620.65	151363.70
199-D4-62	Unconfined Aquifer Well	ISRM Barrier	117.71	110.14	117.87		7.57	*25*	572619.52	151351.06
199-D4-63	Unconfined Aquifer Well	ISRM Barrier	117.38	109.86	117.87		7.52	*25*	572607.63	151346.84
199-D4-64	Unconfined Aquifer Well	ISRM Barrier	117.55	109.95	117.87		7.60	*25*	572606.94	151333.91
199-D4-65	Unconfined Aquifer Well	ISRM Barrier	117.43	109.87	117.87		7.56	*25*	572594.76	151329.73
199-D4-66	Unconfined Aquifer Well	ISRM Barrier	117.70	110.13	117.87		7.57	*25*	572594.28	151316.86
199-D4-67	Unconfined Aquifer Well	ISRM Barrier	117.46	109.93	117.87		7.53	*25*	572581.85	151312.77
199-D4-68	Unconfined Aquifer Well	ISRM Barrier	118.53	109.40	117.87		9.13	*30*	572581.32	151299.83
199-D4-69	Unconfined Aquifer Well	ISRM Barrier	117.73	110.13	117.87		7.60	*25*	572568.99	151295.69
199-D4-7	Unconfined Aquifer Well	TTMW	118.98	114.42	117.47	2/28/2013	4.56	*15*	572760.86	151551.25
199-D4-70	Unconfined Aquifer Well	ISRM Barrier	118.18	110.56	117.87		7.62	*25*	572568.78	151282.67
199-D4-71	Unconfined Aquifer Well	ISRM Barrier	118.92	109.86	117.87		9.06	*30*	572556.28	151278.50
199-D4-72	Unconfined Aquifer Well	ISRM Barrier	118.64	109.58	118.02		9.06	*30*	572554.43	151265.77
199-D4-73	Unconfined Aquifer Well	ISRM Barrier	118.61	109.56	118.02		9.05	*30*	572542.16	151262.72
199-D4-74	Unconfined Aquifer Well	ISRM Barrier	118.23	109.18	118.02		9.05	*30*	572539.80	151249.79
199-D4-75	Unconfined Aquifer Well	ISRM Barrier	118.14	109.12	118.02		9.02	*30*	572527.75	151246.94
199-D4-76	Unconfined Aquifer Well	ISRM Barrier	118.24	109.18	118.02		9.06	*30*	572526.06	151234.23
199-D4-77	Unconfined Aquifer Well	ISRM Barrier	118.58	109.49	118.02		9.09	*30*	572513.33	151231.00

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-D4-78	Unconfined Aquifer Well	ISRM Barrier	118.31	109.25	118.02		9.06	*30*	572511.28	151218.26
199-D4-79	Unconfined Aquifer Well	ISRM Barrier	118.84	109.78	118.02		9.06	*30*	572498.23	151214.02
199-D4-8	Unconfined Aquifer Well	TTMW	120.18	114.20	117.50		5.98	*20*	572763.29	151552.64
199-D4-80	Unconfined Aquifer Well	ISRM Barrier	118.73	109.67	118.02		9.06	*30*	572496.86	151202.59
199-D4-81	Unconfined Aquifer Well	ISRM Barrier	118.56	109.50	118.02		9.06	*30*	572484.36	151199.64
199-D4-82	Unconfined Aquifer Well	ISRM Barrier	118.24	109.18	118.03		9.06	*30*	572470.26	151183.89
199-D4-83	Unconfined Aquifer Well	Extraction	119.42	114.85	117.50		4.57	*15*	572859.43	151723.41
199-D4-84	Unconfined Aquifer Well	Extraction	120.48	112.87	117.70		7.61	*25*	572568.04	151433.52
199-D4-85	Unconfined Aquifer Well	Extraction	119.54	110.39	117.87		9.15	*30*	572486.16	151324.20
199-D4-86	Unconfined Aquifer Well	ISRM Compliance Well	119.20	110.07	118.03		9.13	*30*	572389.06	151202.14
199-D4-87	Unconfined Aquifer Well	ISRM Barrier	116.82	116.24	117.50		0.58	*2*	572757.04	151550.03
199-D4-88	Unconfined Aquifer Well	ISRM Barrier	118.47	117.89	117.50		0.58	*2*	572758.67	151553.21
199-D4-89	Unconfined Aquifer Well	ISRM Barrier	115.12	114.54	117.50		0.58	*2*	572759.62	151547.11
199-D4-9	Unconfined Aquifer Well	ISRM Barrier	119.12	114.26	117.50		4.86	*15*	572758.20	151543.31
199-D4-90	Unconfined Aquifer Well		118.44	113.88	117.52		4.56	*15*	572823.20	151616.13
199-D4-91	Unconfined Aquifer Well		119.97	113.88	117.52		6.09	*20*	572817.65	151621.08
199-D4-92	Unconfined Aquifer Well	ZVI TT Monitoring Well (DOE/RL-2008-49)	118.22	112.13	117.50		6.09	*20*	572714.05	151486.31
199-D4-93	Unconfined Aquifer Well	ZVI TT Monitoring Well (DOE/RL-2008-49)	118.28	112.18	117.50		6.10	*20*	572710.39	151491.20
199-D4-94	Unconfined Aquifer Well		121.05	113.44	117.50		7.61	*15*	572712.89	151496.05
199-D4-95	Unconfined Aquifer Well	Extraction	119.24	108.56	118.01		10.68	*35*	572612.82	151226.70
199-D4-96	Unconfined Aquifer Well	Extraction	117.38	114.33	117.50		3.05	*10*	572777.03	151519.78
199-D4-97	Unconfined Aquifer Well	Extraction	117.02	112.45	117.66		4.57	*15*	572906.23	151625.33
199-D4-98	Unconfined Aquifer Well	Extraction	118.66	112.56	117.52		6.10	*20*	572574.52	151481.65
199-D4-99	Unconfined Aquifer Well	Extraction	119.47	110.32	117.70		9.15	*30*	572527.36	151377.08
199-D5-101	Unconfined Aquifer Well	Extraction	120.60	111.45	117.69		9.15	*30*	572943.04	151521.52
199-D5-103	Unconfined Aquifer Well		119.13	110.05	119.23	2/28/2013	9.08	*30*	573505.87	151460.87
199-D5-104	Unconfined Aquifer Well	Extraction	119.67	110.52	118.47		9.15	*30*	573265.48	151422.43

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-D5-106	Unconfined Aquifer Well		122.89	112.23	119.31	2/28/2013	10.66	*35*	573503.74	151597.97
199-D5-107	Unconfined Aquifer Well	MSTT Injection Well (PNNL-18784)	119.00	112.91	117.98		6.09	*20*	572932.37	151283.14
199-D5-108	Unconfined Aquifer Well	ISTT Injection Well (PNNL-18784)	118.84	112.74	118.10		6.10	*20*	572923.34	151222.90
199-D5-109	Unconfined Aquifer Well	MSTT Monitoring Well (PNNL-18784)	118.75	112.66	117.98		6.09	*20*	572917.37	151285.57
199-D5-110	Unconfined Aquifer Well	MSTT Monitoring Well (PNNL-18784)	119.58	113.49	117.98		6.09	*20*	572931.57	151277.61
199-D5-111	Unconfined Aquifer Well	MSTT Monitoring Well (PNNL-18784)	119.68	113.58	117.98		6.10	*20*	572943.24	151281.47
199-D5-112	Unconfined Aquifer Well	MSTT Monitoring Well (PNNL-18784)	118.74	117.22	117.98		1.52	*5*	572929.08	151289.87
199-D5-113	Unconfined Aquifer Well	MSTT Monitoring Well (PNNL-18784)	114.97	113.45	117.98		1.52	*5*	572927.02	151288.45
199-D5-114	Unconfined Aquifer Well	ISTT Monitoring Well (PNNL-18784)	119.00	112.81	118.10		6.19	*20*	572918.04	151223.75
199-D5-115	Unconfined Aquifer Well	ISTT Monitoring Well (PNNL-18784)	119.00	112.90	118.10		6.10	*20*	572923.15	151221.12
199-D5-116	Unconfined Aquifer Well	ISTT Monitoring Well (PNNL-18784)	119.02	112.93	118.10		6.09	*20*	572926.93	151222.35
199-D5-117	Unconfined Aquifer Well	ISTT Monitoring Well (PNNL-18784)	118.73	117.20	118.10		1.53	*5*	572922.94	151225.43
199-D5-118	Unconfined Aquifer Well	ISTT Monitoring Well (PNNL-18784)	114.44	112.95	118.10		1.49	*5*	572921.03	151224.45
199-D5-123	Unconfined Aquifer Well		120.16	107.89	119.05		12.27	*40*	573824.21	151639.41
199-D5-125	Unconfined Aquifer Well		119.90	111.32	118.91		8.58	*28*	573667.39	151746.18
199-D5-126	Unconfined Aquifer Well		119.25	110.10	118.54		9.15	*30*	573705.71	151843.28
199-D5-127	Unconfined Aquifer Well	Extraction	119.63	113.54	117.98		6.09	*20*	572992.26	151428.31
199-D5-128	Unconfined Aquifer Well	Injection	119.40	113.30	119.31		6.10	*20*	573622.40	151237.35
199-D5-129	Unconfined Aquifer Well	Injection	119.56	111.94	119.48		7.62	*25*	573735.50	151465.13
199-D5-13	Unconfined Aquifer Well		120.39	114.08	117.89	2/28/2013	6.31	*20*	573535.52	151955.18
199-D5-130	Unconfined Aquifer Well	Extraction	118.31	113.73	118.24		4.58	*15*	574039.20	151928.51

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-D5-131	Unconfined Aquifer Well	Extraction	119.01	111.39	117.82		7.62	*25*	573684.39	152006.75
199-D5-132	Unconfined Aquifer Well		119.72	112.10	119.05		7.62	*25*	573875.35	151586.87
199-D5-133	Unconfined Aquifer Well		120.58	111.45	119.58	2/28/2013	9.13	*30*	573731.55	151497.37
199-D5-134	RUM First Water Bearing Unit		103.48	100.40	118.52		3.08	*10*	573675.32	151862.46
199-D5-14	Unconfined Aquifer Well		120.35	114.01	118.72	2/28/2013	6.34	*20*	573789.63	151787.99
199-D5-141	RUM First Water Bearing Unit		95.13	92.09	118.47		3.04	*10*	573243.43	151424.51
199-D5-142	Unconfined Aquifer Well		119.70	116.64	119.14	2/28/2013	3.06	*10*	573791.87	151563.26
199-D5-143	Unconfined Aquifer Well		119.36	111.74	118.54		7.62	*25*	573701.53	151784.26
199-D5-145	Unconfined Aquifer Well								573215.62	151396.28
199-D5-146	Unconfined Aquifer Well	Extraction							573219.79	151345.59
199-D5-147	Unconfined Aquifer Well								572993.13	151380.78
199-D5-148	Unconfined Aquifer Well	Injection							573361.48	151083.48
199-D5-15	Unconfined Aquifer Well								573738.61	151673.75
199-D5-153	Unconfined Aquifer Well	Extraction							573329.77	151992.82
199-D5-16	Unconfined Aquifer Well								573917.45	151652.51
199-D5-17	Unconfined Aquifer Well								573730.52	151322.83
199-D5-18	Unconfined Aquifer Well								573861.70	151325.18
199-D5-19	Unconfined Aquifer Well								573849.12	151243.19
199-D5-20	Unconfined Aquifer Well	Extraction							573239.97	152030.15
199-D5-32	Unconfined Aquifer Well	Extraction							573372.04	151903.39
199-D5-33	Unconfined Aquifer Well								573095.03	151714.54
199-D5-34	Unconfined Aquifer Well								573095.03	151714.54
199-D5-36	Unconfined Aquifer Well		120.30	114.20	117.64	2/28/2013	6.10	*20*	572909.82	151746.32
199-D5-37	Unconfined Aquifer Well		119.36	114.79	117.80	2/28/2013	4.57	*15*	573092.23	151916.36
199-D5-38	Unconfined Aquifer Well		119.01	112.91	117.75	2/28/2013	6.10	*20*	572996.82	151545.59
199-D5-39	Unconfined Aquifer Well	Extraction	119.59	113.48	118.20		6.11	*20*	573142.85	151428.42
199-D5-40	Unconfined Aquifer Well		118.82	112.73	118.15	2/28/2013	6.09	*20*	573003.25	151272.01
199-D5-41	Unconfined Aquifer Well		118.59	112.49	118.21		6.10	*20*	573358.16	151792.19

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-D5-42	Unconfined Aquifer Well	Injection	118.56	112.46	118.89		6.10	*20*	573479.77	151622.67
199-D5-43	Unconfined Aquifer Well		119.85	112.22	118.42	2/28/2013	7.63	*25*	573179.97	151269.43
199-D5-44	Unconfined Aquifer Well	Injection	119.10	114.53	117.75		4.57	*15*	572993.58	151835.73
199-D5-92	Unconfined Aquifer Well	Extraction	119.44	113.04	117.62		6.40	*21*	573131.93	152009.82
199-D5-97	Unconfined Aquifer Well		119.34	110.19	118.51		9.15	*30*	573250.11	151302.47
199-D6-1	Unconfined Aquifer Well	Injection	119.84	113.74	118.60		6.10	*20*	574129.87	151691.71
199-D6-2	Unconfined Aquifer Well	Injection	119.39	111.77	118.35		7.62	*25*	574544.61	151970.20
199-D6-3	Unconfined Aquifer Well		120.73	113.11	118.75	2/28/2013	7.62	*25*	574159.09	151643.85
199-D7-3	Unconfined Aquifer Well	Extraction	120.97	110.30	117.84		10.67	*35*	574151.38	152363.41
199-D7-4	Unconfined Aquifer Well	Injection	118.52	112.42	118.37		6.10	*20*	574377.07	152369.64
199-D7-5	Unconfined Aquifer Well	Injection	121.32	115.22	117.99		6.10	*20*	574434.31	152678.72
199-D7-6	Unconfined Aquifer Well	Extraction	120.31	114.19	117.66		6.12	*20*	574429.20	152980.43
199-D8-101	Unconfined Aquifer Well		118.17	115.13	117.62	2/28/2013	3.04	*10*	574069.46	152262.43
199-D8-4	Unconfined Aquifer Well		120.66	114.57	117.52	2/28/2013	6.09	*20*	573447.18	152090.21
199-D8-5	Unconfined Aquifer Well		118.97	112.87	117.05	2/28/2013	6.10	*20*	573537.14	152243.49
199-D8-53	Unconfined Aquifer Well	Extraction							573889.86	152452.26
199-D8-54A	Unconfined Aquifer Well								573781.17	152408.03
199-D8-54B	RUM First Water Bearing Unit								573768.24	152398.65
199-D8-55	Unconfined Aquifer Well	Extraction							573620.95	152364.34
199-D8-6	Unconfined Aquifer Well	Extraction	118.75	112.56	117.73		6.19	*20*	573434.69	152060.82
199-D8-68	Unconfined Aquifer Well		120.19	112.57	117.17		7.62	*25*	573711.67	152427.10
199-D8-69	Unconfined Aquifer Well	Extraction	119.22	113.13	117.24		6.09	*20*	573843.61	152552.20
199-D8-70	Unconfined Aquifer Well		119.45	110.31	117.36	2/28/2013	9.14	*30*	573942.09	152508.74
199-D8-71	Unconfined Aquifer Well		119.70	110.56	117.31	2/28/2013	9.14	*30*	573837.09	152429.38
199-D8-72	Unconfined Aquifer Well		118.66	112.72	117.19		5.94	*20*	573570.48	152211.77
199-D8-73	Unconfined Aquifer Well	Extraction	120.06	114.87	117.47		5.19	*17*	573388.70	152167.38
199-D8-88	Unconfined Aquifer Well	Extraction	118.41	112.00	117.49		6.41	*21*	573292.33	152141.26
199-D8-89	Unconfined Aquifer Well	Extraction	117.65	114.60	117.23		3.05	*10*	573478.64	152249.65

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-D8-90	Unconfined Aquifer Well	Extraction	118.52	110.90	117.31		7.62	*25*	573948.64	152646.23
199-D8-91	Unconfined Aquifer Well	Extraction	117.52	111.43	117.41		6.09	*20*	574036.89	152741.44
199-D8-93	Unconfined Aquifer Well	Injection	117.34	115.81	117.42		1.53	*5*	574148.70	153085.80
199-D8-94	Unconfined Aquifer Well	Injection	117.25	112.67	117.38		4.58	*15*	574047.82	152949.53
199-D8-95	Unconfined Aquifer Well	Extraction	118.96	112.87	117.48		6.09	*20*	573611.96	152160.61
199-D8-96	Unconfined Aquifer Well	Extraction	119.12	113.03	117.54		6.09	*20*	573706.00	152152.24
199-D8-97	Unconfined Aquifer Well	Extraction	120.77	111.62	117.62		9.15	*30*	573859.56	152087.42
199-D8-98	Unconfined Aquifer Well	Extraction	120.38	112.75	117.80		7.63	*25*	574013.12	152123.02
199-D8-99	Unconfined Aquifer Well	Injection	119.79	112.17	117.64		7.62	*25*	574006.77	152364.37
199-H1-1	Unconfined Aquifer Well	Extraction	118.03	113.46	115.84		4.57	*15*	576702.31	153384.49
199-H1-2	Unconfined Aquifer Well	Extraction	117.34	114.29	116.17		3.05	*10*	576451.07	153378.26
199-H1-20	Unconfined Aquifer Well	Injection	117.63	111.53	116.11		6.10	*20*	575706.04	154183.61
199-H1-21	Unconfined Aquifer Well	Injection	116.17	111.59	115.98		4.58	*15*	575896.84	154163.80
199-H1-25	Unconfined Aquifer Well	Extraction	119.44	113.34	115.55		6.10	*20*	576279.64	154069.97
199-H1-27	Unconfined Aquifer Well	Extraction	119.24	113.15	115.44		6.09	*20*	576403.86	154024.21
199-H1-3	Unconfined Aquifer Well	Extraction	118.81	115.76	116.69		3.05	*10*	576163.04	153372.22
199-H1-32	Unconfined Aquifer Well	Extraction	120.60	114.51	115.52		6.09	*20*	576767.07	153766.00
199-H1-33	Unconfined Aquifer Well	Extraction	119.08	114.51	115.45		4.57	*15*	576833.29	153716.23
199-H1-34	Unconfined Aquifer Well	Extraction	118.47	113.90	115.47		4.57	*15*	576883.13	153667.06
199-H1-35	Unconfined Aquifer Well	Extraction	117.80	113.23	115.47		4.57	*15*	576958.26	153628.14
199-H1-36	Unconfined Aquifer Well	Extraction	118.45	113.88	115.53		4.57	*15*	576885.62	153486.51
199-H1-37	Unconfined Aquifer Well	Extraction	118.28	113.70	115.35		4.58	*15*	577106.92	153641.63
199-H1-38	Unconfined Aquifer Well	Extraction	118.16	113.58	115.42		4.58	*15*	577161.00	153555.01
199-H1-39	Unconfined Aquifer Well	Extraction	118.56	113.99	115.35		4.57	*15*	577223.54	153533.40
199-H1-4	Unconfined Aquifer Well	Extraction	118.36	115.32	117.00		3.04	*10*	575826.78	153366.87
199-H1-40	Unconfined Aquifer Well	Extraction	118.94	114.37	115.35		4.57	*15*	577279.34	153500.19
199-H1-42	Unconfined Aquifer Well	Extraction	116.05	112.99	115.48		3.06	*10*	577127.18	153391.65
199-H1-43	Unconfined Aquifer Well	Extraction	115.60	112.55	115.42		3.05	*10*	577213.74	153384.28

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-H1-45	Unconfined Aquifer Well	Extraction	116.06	111.48	115.87		4.58	*15*	577240.96	153062.41
199-H1-5	Unconfined Aquifer Well	Extraction	119.09	111.46	117.67		7.63	*25*	574850.72	153090.30
199-H1-6	Unconfined Aquifer Well	Extraction	117.56	114.51	116.22		3.05	*10*	576037.81	153745.74
199-H1-7	Unconfined Aquifer Well		118.25	115.20	115.63	2/28/2013	3.05	*10*	577629.60	153172.10
199-H2-1	RUM First Water Bearing Unit		103.85	100.81	115.18		3.04	*10*	577752.31	153239.89
199-H3-10	RUM First Water Bearing Unit		96.90	93.85	116.35		3.05	*10*	577545.14	152723.52
199-H3-11	Unconfined Aquifer Well		117.39	114.33	116.12		3.06	*10*	577786.74	152490.41
199-H3-25	Unconfined Aquifer Well	Injection	117.52	111.42	116.22		6.10	*20*	577410.36	152978.49
199-H3-26	Unconfined Aquifer Well	Injection	116.64	112.07	116.41		4.57	*15*	577440.83	152846.50
199-H3-27	Unconfined Aquifer Well	Injection	117.45	111.36	116.46		6.09	*20*	577567.05	152811.14
199-H3-2A	Unconfined Aquifer Well		117.08	112.51	116.22		4.57	*15*	577624.60	152750.06
199-H3-2B	Unconfined Aquifer Well		112.78	111.26	116.14	2/28/2013	1.52	*5*	577628.27	152757.16
199-H3-2C	RUM First Water Bearing Unit	Extraction	97.37	94.32	116.22		3.05	*10*	577632.06	152750.30
199-H3-3	Unconfined Aquifer Well		119.21	113.11	115.76	2/28/2013	6.10	*20*	577562.09	152363.16
199-H3-4	Unconfined Aquifer Well	Extraction	120.06	112.44	115.92		7.62	*25*	577544.28	152293.21
199-H3-5	Unconfined Aquifer Well		118.37	112.27	116.22	2/28/2013	6.10	*20*	577454.69	152287.49
199-H3-6	Unconfined Aquifer Well		118.01	111.92	115.45	2/28/2013	6.09	*20*	578266.47	152425.33
199-H3-7	Unconfined Aquifer Well		117.71	113.14	116.24	2/28/2013	4.57	*15*	577931.74	152279.97
199-H3-9	RUM First Water Bearing Unit		102.54	99.49	114.88		3.05	*10*	578039.12	152913.60
199-H4-10	Unconfined Aquifer Well		116.67	112.10	114.93	2/28/2013	4.57	*15*	577827.20	153155.81
199-H4-11	Unconfined Aquifer Well		116.10	111.53	114.67	2/28/2013	4.57	*15*	578141.90	152728.43
199-H4-12A	Unconfined Aquifer Well		116.41	111.84	114.88		4.57	*15*	578009.15	152912.72
199-H4-12B	Unconfined Aquifer Well		112.75	111.23	114.83	2/28/2013	1.52	*5*	578004.38	152918.46
199-H4-12C	RUM First Water Bearing Unit	Extraction	104.24	101.20	114.88		3.04	*10*	578011.77	152919.81
199-H4-13	Unconfined Aquifer Well		116.70	112.13	114.67	2/28/2013	4.57	*15*	578219.30	152595.27
199-H4-15A	Unconfined Aquifer Well	Extraction	116.61	112.04	114.99		4.57	*15*	577904.31	153053.42
199-H4-15B	Unconfined Aquifer Well		113.58	112.06	114.74	2/28/2013	1.52	*5*	577899.59	153059.54
199-H4-15C	Unconfined Aquifer Piezometer								577907.68	153059.98

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-H4-15CP	Basalt Piezometer – Upper SM								577907.68	153059.98
199-H4-15CQ	Ringold Unit A Piezometer								577907.68	153059.98
199-H4-15CR	Ringold Unit B Piezometer								577907.68	153059.98
199-H4-15CS	RUM First Water Bearing Unit Piezometer								577907.68	153059.98
199-H4-16	Unconfined Aquifer Well		116.87	111.99	116.04	2/28/2013	4.88	*16*	577981.91	152591.57
199-H4-17	Unconfined Aquifer Well	Injection	117.69	114.64	115.60		3.05	*10*	577779.17	153037.63
199-H4-18	Unconfined Aquifer Well	Injection	116.91	113.86	115.25		3.05	*10*	578018.29	152756.47
199-H4-2	Basalt Well		16.15	11.58	115.46		4.57	*15*	578093.55	152501.47
199-H4-4	Unconfined Aquifer Well	Extraction							578060.85	152853.95
199-H4-45	Unconfined Aquifer Well								578156.38	152433.39
199-H4-46	Unconfined Aquifer Well								577883.86	152439.86
199-H4-47	Unconfined Aquifer Well								577891.17	152553.29
199-H4-49	Unconfined Aquifer Well								577713.83	152445.15
199-H4-5	Unconfined Aquifer Well								577944.93	152939.78
199-H4-6	Unconfined Aquifer Well		116.78	113.73	116.14	2/28/2013	3.05	*10*	577585.31	152888.39
199-H4-63	Unconfined Aquifer Well	Extraction	116.53	110.44	114.88		6.09	*20*	578185.82	152665.53
199-H4-64	Unconfined Aquifer Well	Extraction	118.65	112.55	114.99		6.10	*20*	577946.11	153010.58
199-H4-65	Unconfined Aquifer Well		116.94	113.89	115.05		3.05	*10*	577998.25	152787.28
199-H4-69	Unconfined Aquifer Well	Extraction	115.45	112.39	115.25		3.06	*10*	578014.05	152686.66
199-H4-7	Unconfined Aquifer Well		117.18	112.61	115.50		4.57	*15*	577804.13	152890.84
199-H4-70	Unconfined Aquifer Well	Extraction	115.88	112.84	115.53		3.04	*10*	578003.82	152646.45
199-H4-71	Unconfined Aquifer Well	Injection	116.05	111.47	115.53		4.58	*15*	578010.64	152581.53
199-H4-72	Unconfined Aquifer Well	Injection	116.20	111.63	115.77		4.57	*15*	578036.28	152500.14
199-H4-73	Unconfined Aquifer Well	Injection	116.13	110.03	116.22		6.10	*20*	577940.58	152369.98
199-H4-74	Unconfined Aquifer Well	Injection	118.35	113.78	116.89		4.57	*15*	577239.07	152268.83
199-H4-75	Unconfined Aquifer Well	Extraction	118.02	113.45	115.79		4.57	*15*	577212.36	152704.64
199-H4-76	Unconfined Aquifer Well	Extraction	118.38	115.33	116.34		3.05	*10*	576787.32	152976.85

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-H4-77	Unconfined Aquifer Well	Extraction	117.95	114.90	116.85		3.05	*10*	576487.79	152975.43
199-H4-78	Unconfined Aquifer Well	Injection	117.96	111.86	118.08		6.10	*20*	576168.23	152166.12
199-H4-79	Unconfined Aquifer Well	Injection	119.39	113.29	118.10		6.10	*20*	575659.13	151989.31
199-H4-8	Unconfined Aquifer Well		117.03	113.98	115.56	2/28/2013	3.05	*10*	577860.69	152921.70
199-H4-80	Unconfined Aquifer Well	Extraction	119.83	109.16	117.94		10.67	*35*	575238.97	152568.16
199-H4-81	Unconfined Aquifer Well	Extraction	119.15	113.06	117.67		6.09	*20*	575236.93	153035.36
199-H4-82	Unconfined Aquifer Well	Extraction	119.65	113.57	117.88		6.08	*20*	574906.99	152677.72
199-H4-83	Unconfined Aquifer Well		116.77	113.72	115.18		3.05	*10*	578135.04	152634.01
199-H4-84	Unconfined Aquifer Well		117.18	114.14	115.38		3.04	*10*	577902.58	152848.73
199-H4-85	Unconfined Aquifer Well								577980.02	152880.81
199-H4-86	Unconfined Aquifer Well								577704.55	152745.65
199-H4-90	RUM First Water Bearing Unit								577922.94	152592.59
199-H4-91	RUM First Water Bearing Unit								577922.94	152592.59
199-H5-10	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	14.24 bgs	15.00 bgs			0.76	*2.5*	577644.00	152266.00
199-H5-11	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	14.12 bgs	14.9 bgs			0.78	*2.5*	577646.00	152268.00
199-H5-12	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	12.82 bgs	15.8 bgs			2.98	*10*	577650.00	152279.00
199-H5-13	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	12.81 bgs	15.84 bgs			3.03	*10*	577650.00	152288.00
199-H5-14	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	12.88 bgs	15.91 bgs			3.03	*10*	577656.00	152286.00
199-H5-15	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	12.56 bgs	16.48 bgs			3.94	*13*	577657.00	152288.00
199-H5-1A	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	12.64 bgs	16.62 bgs			3.98	*13*	577650.08	152257.72
199-H5-2	Unconfined Aquifer Well	FIT Injection Well (PNNL-11372)	13.87 bgs	15.37 bgs			1.50	*5*	577631.00	152262.00
199-H5-3O	Unconfined Aquifer Piezometer	FIT Monitoring Well (PNNL-11372)	12.52 bgs	13.27 bgs			0.75	*2.5*	577634.00	152261.00

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
199-H5-3P	Unconfined Aquifer Piezometer	FIT Monitoring Well (PNNL-11372)	14.11 bgs	14.87 bgs			0.76	*2.5*	577634.00	152263.00
199-H5-4O	Unconfined Aquifer Piezometer	FIT Monitoring Well (PNNL-11372)	12.70 bgs	13.46 bgs			0.76	*2.5*	577637.00	152261.00
199-H5-4P	Unconfined Aquifer Piezometer	FIT Monitoring Well (PNNL-11372)	14.55 bgs	15.29 bgs			0.76	*2.5*	577637.00	152263.00
199-H5-5O	Unconfined Aquifer Piezometer	FIT Monitoring Well (PNNL-11372)	12.69 bgs	13.45 bgs			0.78	*2.5*	577640.00	152261.00
199-H5-5P	Unconfined Aquifer Piezometer	FIT Monitoring Well (PNNL-11372)	14.76 bgs	15.51 bgs			0.75	*2.5*	577640.00	152263.00
199-H5-6	Unconfined Aquifer Piezometer	FIT Monitoring Well (PNNL-11372)	13.99 bgs	14.75 bgs			0.76	*2.5*	577643.00	152260.00
199-H5-7	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	14.23 bgs	14.98 bgs			0.75	*2.5*	577645.00	152259.00
199-H5-8	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	14.26 bgs	15.01 bgs			0.75	*2.5*	577647.00	152258.00
199-H5-9	Unconfined Aquifer Well	FIT Monitoring Well (PNNL-11372)	14.39 bgs	15.14 bgs			0.75	*2.5*	577643.00	152264.00
199-H6-1	Unconfined Aquifer Well									
199-H6-2	Unconfined Aquifer Well	Injection	116.89	113.84	116.21		3.05	*10*	577886.50	152194.11
199-H6-3	Unconfined Aquifer Well		117.12	109.50	115.66		7.62	*25*	578340.40	151929.35
199-H6-4	Unconfined Aquifer Well		117.74	110.12	116.16	2/28/2013	7.62	*25*	577771.59	151737.10
35-S	Aquifer Tube – 100-D Area								572918.06	151930.05
36-D	Aquifer Tube – 100-D Area								573120.63	152146.44
36-M	Aquifer Tube – 100-D Area								573120.63	152146.44
36-S	Aquifer Tube – 100-D Area								573120.63	152146.44
37-D	Aquifer Tube – 100-D Area								573335.94	152287.34
37-M	Aquifer Tube – 100-D Area								573335.94	152287.34
37-S	Aquifer Tube – 100-D Area								573335.94	152287.34
38-D	Aquifer Tube – 100-D Area								573471.88	152368.72
38-M	Aquifer Tube – 100-D Area								572918.06	151930.05
43-M	Aquifer Tube – 100-H Area		113.80	113.76	115.33		0.04	*0.13*	576782.56	153963.57

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
44-M	Aquifer Tube – 100-H Area		113.52	113.47	115.26		0.05	*0.16*	577033.11	153810.53
45-D	Aquifer Tube – 100-H Area								577597.81	153493.80
45-M	Aquifer Tube – 100-H Area								577597.81	153493.80
45-S	Aquifer Tube – 100-H Area								577597.81	153493.80
47-D	Aquifer Tube – 100-H Area		113.42	113.37	114.69		0.05	*0.16*	578193.39	152744.42
47-M	Aquifer Tube – 100-H Area		113.33	113.29	114.69		0.04	*0.13*	578193.91	152743.53
48-M	Aquifer Tube – 100-H Area		111.17	111.12	114.85		0.05	*0.16*	578465.52	152420.79
48-S	Aquifer Tube – 100-H Area		113.61	113.56	114.85		0.05	*0.16*	578465.52	152420.79
49-D	Aquifer Tube – 100-H Area		108.04	107.99	114.48		0.05	*0.16*	578699.75	152232.86
49-M	Aquifer Tube – 100-H Area		110.66	110.61	114.48		0.05	*0.16*	578699.74	152232.83
49-S	Aquifer Tube – 100-H Area		113.40	113.35	114.48		0.05	*0.16*	578699.74	152232.83
50-D	Aquifer Tube – 100-H Area		109.00	108.96	114.86		0.04	*0.13*	578611.81	152118.08
50-M	Aquifer Tube – 100-H Area		111.75	111.70	114.86		0.05	*0.16*	578611.81	152118.08
50-S	Aquifer Tube – 100-H Area		114.49	114.44	114.86		0.05	*0.16*	578611.79	152118.15
51-D	Aquifer Tube – 100-H Area		108.99	108.94	114.96		0.05	*0.16*	578779.25	151843.75
51-M	Aquifer Tube – 100-H Area		111.43	111.38	114.96		0.05	*0.16*	578779.25	151843.75
51-S	Aquifer Tube – 100-H Area		113.86	113.82	114.96		0.04	*0.13*	578779.25	151843.75
52-D	Aquifer Tube – 100-H Area		108.68	108.64	114.62		0.04	*0.13*	578919.48	151586.17
52-M	Aquifer Tube – 100-H Area		111.43	111.38	114.62		0.05	*0.16*	578919.48	151586.17
52-S	Aquifer Tube – 100-H Area		113.87	113.82	114.62		0.05	*0.16*	578919.48	151586.17
53-D	Aquifer Tube – 100-H Area		107.44	107.39	113.93		0.05	*0.16*	579510.18	151531.41
53-M	Aquifer Tube – 100-H Area		110.16	110.11	113.93		0.05	*0.16*	579510.57	151531.72
53-S	Aquifer Tube – 100-H Area		112.90	112.86	113.93		0.04	*0.13*	579510.57	151531.72
54-D	Aquifer Tube – 100-H Area		108.08	108.03	114.48		0.05	*0.16*	579033.51	151231.94
54-M	Aquifer Tube – 100-H Area		110.82	110.77	114.48		0.05	*0.16*	579033.51	151231.94
54-S	Aquifer Tube – 100-H Area		113.71	113.67	114.48		0.04	*0.13*	579033.51	151231.94
55-D	Aquifer Tube – 100-H Area		107.33	107.28	114.26		0.05	*0.16*	579135.28	150891.36
55-M	Aquifer Tube – 100-H Area		109.81	109.77	114.26		0.04	*0.13*	579134.58	150891.14

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
55-S	Aquifer Tube – 100-H Area		112.25	112.21	114.26		0.04	*0.13*	579134.58	150891.14
58-D	Aquifer Tube – 100-H Area		106.78	106.74	114.17		0.04	*0.13*	579310.11	150233.17
58-M	Aquifer Tube – 100-H Area		108.94	108.89	114.17		0.05	*0.16*	579311.42	150232.31
58-S	Aquifer Tube – 100-H Area								579310.63	150232.25
699-100-43B	Unconfined Aquifer Well		116.33	113.27	115.37	2/28/2013	3.06	*10*	576675.90	154008.65
699-101-45	Unconfined Aquifer Well		116.74	113.69	115.78	2/28/2013	3.05	*10*	576032.40	154124.17
699-101-48B	Unconfined Aquifer Well		106.80	105.27	116.19	2/28/2013	1.53	*5*	575283.67	154404.01
699-88-41	Unconfined Aquifer Well								577221.56	150333.77
699-89-35	Unconfined Aquifer Well								579121.75	150543.52
699-90-34	Unconfined Aquifer Well								579410.13	150782.64
699-90-37B	Unconfined Aquifer Well								578474.69	151031.33
699-90-45	Unconfined Aquifer Well								576169.25	151024.53
699-91-46A	Unconfined Aquifer Well								575910.94	151156.64
699-92-49	Unconfined Aquifer Well								575063.13	151647.47
699-93-48A	Unconfined Aquifer Well								575094.13	151795.30
699-94-41	Unconfined Aquifer Well		117.07	114.02	116.94	2/28/2013	3.05	*10*	577223.05	152111.68
699-94-43	Unconfined Aquifer Well		117.59	113.02	117.57	2/28/2013	4.57	*15*	576625.60	152087.90
699-95-45	Unconfined Aquifer Well		117.54	114.49	117.65	2/28/2013	3.05	*10*	576257.00	152556.28
699-95-48	Unconfined Aquifer Well		118.57	112.48	117.99	2/28/2013	6.09	*20*	575253.42	152323.05
699-95-51	Unconfined Aquifer Well		118.27	112.17	118.08	2/28/2013	6.10	*20*	574439.50	152528.59
699-96-41	Unconfined Aquifer Well		118.28	115.22	117.04		3.06	*10*	576770.62	152607.64
699-96-42	Unconfined Aquifer Well		117.69	114.64	117.04		3.05	*10*	576773.16	152612.60
699-96-43	Unconfined Aquifer Well								576761.44	152605.31
699-96-44	Unconfined Aquifer Well		118.32	112.20	117.04		6.12	*20*	576773.10	152608.21
699-96-45	Unconfined Aquifer Well		118.22	112.10	117.04		6.12	*20*	576768.17	152607.03
699-96-52B	Unconfined Aquifer Well		117.47	111.34	117.28	2/28/2013	6.13	*20*	573910.16	152656.22
699-97-41	Unconfined Aquifer Well		117.29	111.19	116.02	2/28/2013	6.10	*20*	577217.50	153090.38
699-97-43B	Unconfined Aquifer Well		117.76	114.71	116.36	2/28/2013	3.05	*10*	576859.84	152981.30

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
699-97-43C	RUM First Water Bearing Unit		104.57	103.04	116.34		1.53	*5*	576857.31	152980.67
699-97-45	Unconfined Aquifer Well		118.20	113.63	117.28	2/28/2013	4.57	*15*	576051.70	152978.95
699-97-45B	RUM First Water Bearing Unit		109.07	107.40	117.26		1.67	*5*	576049.34	152979.41
699-97-48B	Unconfined Aquifer Well		118.67	112.56	117.77	2/28/2013	6.11	*20*	575247.59	152909.76
699-97-48C	RUM First Water Bearing Unit		106.21	104.69	117.76		1.52	*5*	575245.39	152909.66
699-97-51A	Unconfined Aquifer Well								574468.13	153122.09
699-98-43	Unconfined Aquifer Well		116.51	111.92	115.89	2/28/2013	4.59	*15*	576863.24	153371.37
699-98-46	Unconfined Aquifer Well		118.38	115.32	117.06	2/28/2013	3.06	*10*	575726.86	153365.63
699-98-49A	Unconfined Aquifer Well								574823.38	153310.16
699-98-51	Unconfined Aquifer Well		117.07	112.50	117.47	2/28/2013	4.57	*15*	574339.32	153302.71
699-99-41	Unconfined Aquifer Well		116.02	112.98	115.27	2/28/2013	3.04	*10*	577283.99	153590.74
699-99-42B	Unconfined Aquifer Well		116.21	113.14	115.32	2/28/2013	3.07	*10*	577010.23	153761.02
699-99-44	Unconfined Aquifer Well		117.17	114.13	115.89	2/28/2013	3.04	*10*	576458.77	153592.40
AT-D-1-D	Aquifer Tube – 100-D Area		114.23	114.18	117.48		0.05	*0.16*	572860.65	151852.06
AT-D-1-M	Aquifer Tube – 100-D Area		115.36	115.31	117.48		0.05	*0.16*	572861.51	151850.40
AT-D-1-S	Aquifer Tube – 100-D Area		116.41	116.36	117.48		0.05	*0.16*	572861.05	151850.98
AT-D-2-M	Aquifer Tube – 100-D Area								573105.75	152130.31
AT-D-2-S	Aquifer Tube – 100-D Area								573108.25	152129.78
AT-D-3-D	Aquifer Tube – 100-D Area								573233.25	152224.31
AT-D-3-M	Aquifer Tube – 100-D Area								573234.69	152224.97
AT-D-3-S	Aquifer Tube – 100-D Area								573233.69	152224.61
AT-D-4-D	Aquifer Tube – 100-D Area								572992.25	152039.56
AT-D-4-M	Aquifer Tube – 100-D Area								572993.13	152040.48
AT-D-4-S	Aquifer Tube – 100-D Area								572993.25	152039.86
AT-D-5-D	Aquifer Tube – 100-D Area		115.69	115.65	117.27		0.04	*0.13*	573934.80	152850.59
AT-D-5-M	Aquifer Tube – 100-D Area		116.28	116.23	117.27		0.05	*0.16*	573934.67	152848.20
AT-H-1-D	Aquifer Tube – 100-H Area		111.64	111.59	114.88		0.05	*0.16*	578068.73	152955.05
AT-H-1-M	Aquifer Tube – 100-H Area		112.16	112.12	114.88		0.04	*0.13*	578069.14	152954.33

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
AT-H-1-S	Aquifer Tube – 100-H Area		113.34	113.29	114.88		0.05	*0.16*	578070.23	152957.48
AT-H-2-D	Aquifer Tube – 100-H Area		111.77	111.72	114.66		0.05	*0.16*	578109.83	152896.44
AT-H-2-M	Aquifer Tube – 100-H Area		112.68	112.63	114.66		0.05	*0.16*	578110.71	152895.19
AT-H-2-S	Aquifer Tube – 100-H Area		113.82	113.78	114.66		0.04	*0.13*	578111.79	152893.94
AT-H-3-D	Aquifer Tube – 100-H Area		113.07	113.03	114.78		0.04	*0.13*	578142.21	152853.07
AT-H-3-S	Aquifer Tube – 100-H Area		113.80	113.76	114.78		0.04	*0.13*	578141.78	152848.94
C5632	Aquifer Tube – 100-H Area		113.41	113.25	115.33		0.16	*0.52*	576389.25	154227.69
C5633	Aquifer Tube – 100-H Area		110.19	110.04	115.33		0.15	*0.49*	576390.60	154227.98
C5634	Aquifer Tube – 100-H Area		105.87	105.72	115.33		0.15	*0.49*	576391.43	154228.90
C5635	Aquifer Tube – 100-H Area		113.29	113.13	115.33		0.16	*0.52*	576478.81	154181.12
C5636	Aquifer Tube – 100-H Area		110.63	110.17	115.33		0.46	*1.5*	576481.40	154179.43
C5637	Aquifer Tube – 100-H Area		111.61	111.45	115.28		0.16	*0.52*	576483.67	154178.30
C5638	Aquifer Tube – 100-H Area		113.44	113.29	115.37		0.15	*0.49*	576634.08	154070.38
C5641	Aquifer Tube – 100-H Area		113.67	113.52	115.33		0.15	*0.49*	576871.56	153916.62
C5644	Aquifer Tube – 100-H Area		112.86	112.71	115.33		0.15	*0.49*	576960.87	153869.32
C5673	Aquifer Tube – 100-H Area		113.18	113.02	115.28		0.16	*0.52*	577157.45	153736.67
C5674	Aquifer Tube – 100-H Area		112.29	112.14	115.28		0.15	*0.49*	577157.45	153736.67
C5676	Aquifer Tube – 100-H Area		113.66	113.51	115.30		0.15	*0.49*	577276.26	153656.07
C5677	Aquifer Tube – 100-H Area		112.44	112.29	115.30		0.15	*0.49*	577277.33	153657.18
C5678	Aquifer Tube – 100-H Area		112.94	112.79	115.30		0.15	*0.49*	577278.65	153653.50
C5679	Aquifer Tube – 100-H Area		113.76	113.61	115.15		0.15	*0.49*	577409.70	153593.40
C5680	Aquifer Tube – 100-H Area		111.46	111.31	115.15		0.15	*0.49*	577409.40	153593.79
C5681	Aquifer Tube – 100-H Area		110.87	110.72	115.15		0.15	*0.49*	577407.43	153594.58
C5682	Aquifer Tube – 100-H Area								577699.81	153338.70
C6266	Aquifer Tube – 100-D Area		114.76	114.61	117.93		0.15	*0.49*	572269.90	151241.63
C6267	Aquifer Tube – 100-D Area		113.77	113.61	117.93		0.16	*0.52*	572270.42	151242.23
C6268	Aquifer Tube – 100-D Area		111.01	110.85	117.93		0.16	*0.52*	572274.21	151246.19
C6269	Aquifer Tube – 100-D Area		114.98	114.83	117.86		0.15	*0.49*	572335.82	151323.20

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
C6270	Aquifer Tube – 100-D Area		113.72	113.57	117.86		0.15	*0.49*	572337.13	151324.52
C6271	Aquifer Tube – 100-D Area		111.89	111.74	117.86		0.15	*0.49*	572332.30	151317.57
C6272	Aquifer Tube – 100-D Area		115.76	115.61	117.52		0.15	*0.49*	572920.42	151926.86
C6275	Aquifer Tube – 100-D Area		114.77	114.61	117.14		0.16	*0.52*	573337.49	152284.93
C6278	Aquifer Tube – 100-D Area		114.54	114.39	117.02		0.15	*0.49*	573533.98	152428.19
C6281	Aquifer Tube – 100-D Area		114.28	114.13	117.24		0.15	*0.49*	574056.82	153353.31
C6282	Aquifer Tube – 100-D Area		112.02	111.87	117.24		0.15	*0.49*	574057.53	153353.60
C6284	Aquifer Tube – 100-H Area		113.08	112.93	115.70		0.15	*0.49*	576042.29	154363.63
C6285	Aquifer Tube – 100-H Area		111.67	111.52	115.70		0.15	*0.49*	576039.24	154364.31
C6286	Aquifer Tube – 100-H Area		105.77	105.62	115.70		0.15	*0.49*	576037.53	154364.50
C6287	Aquifer Tube – 100-H Area		113.90	113.75	115.40		0.15	*0.49*	576781.62	153965.55
C6288	Aquifer Tube – 100-H Area		113.62	113.47	115.33		0.15	*0.49*	576783.38	153964.05
C6290	Aquifer Tube – 100-H Area		112.41	112.26	114.96		0.15	*0.49*	577793.47	153266.01
C6291	Aquifer Tube – 100-H Area		111.08	110.93	114.96		0.15	*0.49*	577792.39	153267.00
C6293	Aquifer Tube – 100-H Area		112.66	112.51	114.76		0.15	*0.49*	578035.06	152996.70
C6296	Aquifer Tube – 100-H Area		112.70	112.55	114.88		0.15	*0.49*	578314.84	152574.80
C6297	Aquifer Tube – 100-H Area		111.16	111.01	114.88		0.15	*0.49*	578313.22	152575.13
C6299	Aquifer Tube – 100-H Area		112.69	112.53	114.54		0.16	*0.52*	578585.36	152323.62
C6300	Aquifer Tube – 100-H Area		111.18	111.03	114.54		0.15	*0.49*	578585.17	152324.65
C6301	Aquifer Tube – 100-H Area		110.07	109.92	114.54		0.15	*0.49*	578583.54	152323.27
C6329	Aquifer Tube – 100-D Area		112.82	112.66	117.94		0.16	*0.52*	571871.47	150718.71
C6330	Aquifer Tube – 100-D Area		110.82	110.67	117.94		0.15	*0.49*	571872.00	150718.88
C6331	Aquifer Tube – 100-D Area		108.75	108.60	117.94		0.15	*0.49*	571872.77	150720.49
C6332	Aquifer Tube – 100-D Area		114.43	114.28	117.96		0.15	*0.49*	572045.85	150949.08
C6333	Aquifer Tube – 100-D Area		112.10	111.95	117.96		0.15	*0.49*	572045.34	150948.24
C6334	Aquifer Tube – 100-D Area		109.76	109.61	117.96		0.15	*0.49*	572046.29	150949.98
C7645	Aquifer Tube – 100-D Area								572077.00	151003.06
C7646	Aquifer Tube – 100-D Area								572077.50	151003.81

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
C7647	Aquifer Tube – 100-D Area								572076.63	151002.47
C7648	Aquifer Tube – 100-D Area								572077.25	151003.55
C7649	Aquifer Tube – 100-H Area								578271.19	152659.94
C7650	Aquifer Tube – 100-H Area								578271.56	152659.02
DD-06-2	Aquifer Tube – 100-D Area		113.92	113.88	117.26		0.04	*0.13*	573964.57	153015.37
DD-06-3	Aquifer Tube – 100-D Area		112.70	112.66	117.26		0.04	*0.13*	573964.57	153015.37
DD-08-2	Aquifer Tube – 100-D Area								573940.06	152903.53
DD-08-3	Aquifer Tube – 100-D Area								573940.06	152903.53
DD-08-4	Aquifer Tube – 100-D Area								573940.06	152903.53
DD-10-2	Aquifer Tube – 100-D Area		113.63	113.59	117.27		0.04	*0.13*	573899.05	152788.07
DD-10-3	Aquifer Tube – 100-D Area		112.11	112.06	117.27		0.05	*0.16*	573899.05	152788.07
DD-10-4	Aquifer Tube – 100-D Area		110.58	110.54	117.27		0.04	*0.13*	573899.05	152788.07
DD-12-2	Aquifer Tube – 100-D Area		113.98	113.94	117.17		0.04	*0.13*	573818.68	152683.69
DD-12-3	Aquifer Tube – 100-D Area		112.36	112.31	117.17		0.05	*0.16*	573820.55	152683.59
DD-12-4	Aquifer Tube – 100-D Area		110.75	110.70	117.17		0.05	*0.16*	573819.65	152683.58
DD-15-2	Aquifer Tube – 100-D Area		114.75	114.70	117.12		0.05	*0.16*	573700.60	152547.82
DD-15-3	Aquifer Tube – 100-D Area		110.53	110.48	117.12		0.05	*0.16*	573700.59	152547.31
DD-15-4	Aquifer Tube – 100-D Area		111.52	111.47	117.12		0.05	*0.16*	573701.27	152548.19
DD-16-3	Aquifer Tube – 100-D Area		114.68	114.63	117.04		0.05	*0.16*	573650.43	152516.12
DD-16-4	Aquifer Tube – 100-D Area		112.20	112.15	117.04		0.05	*0.16*	573651.16	152516.99
DD-17-2	Aquifer Tube – 100-D Area		114.19	114.14	117.04		0.05	*0.16*	573597.98	152482.77
DD-17-3	Aquifer Tube – 100-D Area		112.74	112.69	117.04		0.05	*0.16*	573597.16	152483.30
DD-39-1	Aquifer Tube – 100-D Area		116.23	116.19	117.38		0.04	*0.13*	572606.54	151625.85
DD-39-2	Aquifer Tube – 100-D Area		114.74	114.69	117.38		0.05	*0.16*	572606.89	151626.18
DD-41-1	Aquifer Tube – 100-D Area		113.31	113.26	117.38		0.05	*0.16*	572606.54	151626.19
DD-41-2	Aquifer Tube – 100-D Area		113.53	113.49	117.52		0.04	*0.13*	572532.20	151530.03
DD-41-3	Aquifer Tube – 100-D Area		112.08	112.03	117.52		0.05	*0.16*	572532.68	151530.73
DD-42-2	Aquifer Tube – 100-D Area		114.76	114.71	117.52		0.05	*0.16*	572485.31	151492.50

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
DD-42-3	Aquifer Tube – 100-D Area		113.40	113.35	117.52		0.05	*0.16*	572485.76	151492.56
DD-42-4	Aquifer Tube – 100-D Area		112.48	112.44	117.52		0.04	*0.13*	572486.18	151492.48
DD-43-2	Aquifer Tube – 100-D Area		114.89	114.85	117.71		0.04	*0.13*	572450.50	151443.23
DD-43-3	Aquifer Tube – 100-D Area		113.33	113.28	117.71		0.05	*0.16*	572450.90	151443.22
DD-44-3	Aquifer Tube – 100-D Area		113.84	113.80	117.71		0.04	*0.13*	572412.67	151394.27
DD-44-4	Aquifer Tube – 100-D Area		112.35	112.31	117.71		0.04	*0.13*	572411.36	151396.94
DD-49-1	Aquifer Tube – 100-D Area		116.11	116.07	118.01		0.04	*0.13*	572213.69	151161.55
DD-49-2	Aquifer Tube – 100-D Area		114.87	114.82	118.01		0.05	*0.16*	572213.96	151162.78
DD-49-2.5	Aquifer Tube – 100-D Area								572213.94	151162.78
DD-49-3	Aquifer Tube – 100-D Area		111.36	111.31	118.01		0.05	*0.16*	572210.80	151163.30
DD-49-4	Aquifer Tube – 100-D Area		109.42	109.37	118.01		0.05	*0.16*	572211.15	151163.98
DD-50-1	Aquifer Tube – 100-D Area		115.51	115.47	117.94		0.04	*0.13*	572172.18	151121.16
DD-50-2	Aquifer Tube – 100-D Area		113.59	113.54	117.94		0.05	*0.16*	572172.63	151121.56
DD-50-3	Aquifer Tube – 100-D Area		112.10	112.05	117.94		0.05	*0.16*	572172.16	151120.00
DD-50-4	Aquifer Tube – 100-D Area		110.38	110.33	117.94		0.05	*0.16*	572173.03	151121.18
DH-14-1	Aquifer Tube – 100-H Area		106.01	105.96	114.88		0.05	*0.16*	577787.18	153374.82
DH-14-11	Aquifer Tube – 100-H Area		105.28	105.23	114.82		0.05	*0.16*	577788.41	153377.95
DH-1451-1	Aquifer Tube – 100-H Area		106.48	106.43	115.23		0.05	*0.16*	577182.86	153704.52
DH-1452-1	Aquifer Tube – 100-H Area		106.23	106.18	115.30		0.05	*0.16*	577255.02	153661.68
DH-22-1	Aquifer Tube – 100-H Area		113.00	112.95	114.85		0.05	*0.16*	578460.33	152468.30
DH-22-2	Aquifer Tube – 100-H Area		111.78	111.74	114.85		0.04	*0.13*	578460.33	152468.30
DH-22-3	Aquifer Tube – 100-H Area		110.11	110.06	114.85		0.05	*0.16*	578460.33	152468.30
Redox-1-3.3	Aquifer Tube – 100-D Area								572716.33	151730.81
Redox-1-6.0	Aquifer Tube – 100-D Area								572716.33	151730.81
Redox-2-6.0	Aquifer Tube – 100-D Area								572636.66	151687.80
Redox-3-3.3	Aquifer Tube – 100-D Area								572583.20	151603.02
Redox-3-4.6	Aquifer Tube – 100-D Area								572583.20	151603.02
Redox-4-3.0	Aquifer Tube – 100-D Area								572529.70	151540.00

Table B-1. 100-HR-3 Groundwater Operable Unit Available Monitoring Locations

Monitoring Location Name	Hydrogeologic Unit or Discharge Location Monitored	Treatment System Wells[a]	Elevation (m NAVD88)[b]			Water Level Date[c]	Open Interval[e] Length (m/ft[d])		Northing	Easting
			Top of Open Interval	Bottom of Open Interval	Water Level					
Redox-4-6.0	Aquifer Tube – 100-D Area								572529.70	151540.00
100-D	River Gage									
100-H	River Gage									

Note: Information is from Well Information and Document Lookup (March 13, 2013). Blank areas indicate data not yet compiled or not available.

a. Pump and treat system well status was updated on July 24, 2014. Other treatment system wells were identified through other reports: ISRM barrier, TTMW, TZMW in DOE/RL-2009-01; ZVI in DOE/RL-2008-49; FIT in PNNL-11372; ISTT and MSTT in PNNL-18784.

b. Elevation is in meters (NAVD88, *North American Vertical Datum of 1988*) unless otherwise noted (for example meters below ground surface [bgs]).

c. Where water level is provided and date is not entered, level is interpreted based on measured values.

d. Length in feet is provided in italics as an approximate value.

e. Open interval length is the distance between the top and bottom of the screen, perforated pipe, or length of open hole.

FIT = field injection test
ISRM = in situ redox manipulation
ISTT = insoluble substrate treatability test
MSTT = miscible substrate treatability test
SM = Saddle Mountain basalt
TTMW = treatability test monitoring well
TZMW = treatability zone monitoring well
USGS = United States Geological Survey
ZVI TT = zero valent iron treatability test

Appendix C
Example Forms

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CH2MHill Plateau Remediation Company
SAMPLING AUTHORIZATION FORM

SAF NUM S15-010 **SAF TITLE** SURV, OCT 2014 **REV** 1

EXAMPLE FORM
NOT FOR USE

PROJECT	SURV15	
PROGRAM / PROJECT TYPE	SURV	Sitewide Surveillance
OPERABLE UNIT	NONE	

REQUESTER	WATERS-HUSTED, K	**CHARGE CODES**	
TASK MANAGER	TRENT, SJ	Analytical Services	300071ES20
PROJECT COORDINATOR	WATERS-HUSTED, K	Sample Management	300071ES30
		CHPRC Field Samplers	300072ES10
		Shipping to Off-Site Lab	300072JDBA
		Analytical Services	303309ES20

ESTIMATED START DATE	10/1/2014	**SAMPLE AREA**	Hanford Site
ESTIMATED COMPLETION DATE	10/31/2014	**MATRIX**	WATER
ESTIMATED NUMBER OF SAMPLES	148		

SAMPLING ORGANIZATIONS

CHPRC Samplers

LABORATORY / PRICE_CODE / PRIORITY TURNAROUND / REQUIRED TURNAROUND / DATA DELIVERABLE

Primary / Field Analysis Activities / 7H / 30 Days / 30 Days / Summary
Primary / GEL Laboratories, LLC / 7H / 30 Days / 30 Days / Summary
Primary / TestAmerica Incorporated, Richland / 7H / 30 Days / 30 Days / Summary
Primary / TestAmerica St. Louis / 7H / 30 Days / 30 Days / Summary

SAF COMMENT

Do not exceed SDG closure of 14 days.
Submit deliverables & invoices to Scott Fitzgerald, CHPRC
Do not batch FY14 and FY15 samples into the same SDG.

EXAMPLE FORM
NOT FOR USE

SAF REVISION COMMENT

*Rev. 1 Anions added for TARL analysis.
Updated to add bromide and phosphate for TARL. 12/8/14

COC COMMENT

Do not exceed SDG closure of 14 days.
Submit deliverables & invoices to Scott Fitzgerald, CHPRC
Do not batch FY14 and FY15 samples into the same SDG.

CH2MHill Plateau Remediation Company
SAMPLING AUTHORIZATION FORM

SAF NUM S15-010 **SAF TITLE** SURV, OCT 2014 **REV** 1

EXAMPLE FORM
NOT FOR USE

Field Sampling Requirements

Laboratory: Field Analysis Activities **Matrix: WATER**

Parameter / Analysis	Reference Method	Container / Volume	VolReq	Preservation	Holding Times
360.1_OXYGEN_FLD: Dissolved Oxygen (1) Dissolved oxygen	360.1_OXYGEN_FLD		None	None	ASAP
CONDUCTIVITY Specific Conductance	CONDUCT_FLD		None	None	None
OXIDATION-REDUCTION POTENTIAL Oxidation Reduction Potential	REDOX_PROBE_FLD		None	None	None
pH ANALYSIS pH Measurement	PH_ELECT_FLD		None	None	None
TEMPERATURE Temperature	TEMP_FLD		None	None	None
TURBIDITY Turbidity	TURBIDITY_FLD		None	None	None

EXAMPLE FORM
NOT FOR USE

CH2MHill Plateau Remediation Company
SAMPLING AUTHORIZATION FORM

SAF NUM S15-010 **SAF TITLE** SURV, OCT 2014 **REV** 1

EXAMPLE FORM
NOT FOR USE

Field Sampling Requirements

Laboratory: GEL Laboratories, LLC **Matrix: WATER**

Parameter / Analysis	Reference Method	Container / Volume	VolReq	Preservation	Holding Times
2320_ALKALINITY: COMMON Alkalinity	2320_ALKALINITY	G/P 250 mL	Full QC	Cool <=6C	14 Days
2320_ALKALINITY: GW 01 Alkalinity, Bicarbonate, Carbonate alkalinity, Hydroxylion	2320_ALKALINITY	G/P 250 mL	Full QC	Cool <=6C	14 Days
350.1_AMMONIA: COMMON Ammonia	350.1_AMMONIA	G/P 500 mL	Full QC	H2SO4 to pH <2/Cool <=6C	28 Days
6010_METALS_ICP: COMMON Antimony, Arsenic, Barium, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Magnesium, Manganese, Nickel, Potassium, Silver, Sodium, Vanadium, Zinc	6010_METALS_ICP	G/P 500 mL	Full QC	HNO3 to pH <2	6 Months
6010_METALS_ICP: GW 03 Beryllium, Strontium	6010_METALS_ICP		Full QC		6 Months
6020_METALS_ICPMS: GW 01 Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Molybdenum, Nickel, Selenium, Silver, Strontium, Thallium, Thorium, Tin, Uranium, Zinc	6020_METALS_ICPMS	G/P 500 mL	Full QC	HNO3 to pH <2	6 Months
6010_METALS_ICP: GW 04 Calcium, Iron, Magnesium, Potassium, Sodium, Vanadium	6010_METALS_ICP		Full QC		6 Months
7470_MERCURY_CV: COMMON (AQUEOUS) Mercury	7470_HG_CVAA	G/P 500 mL	Full QC	HNO3 to pH <2	28 Days
8260_VOA_GCMS: COMMON 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2-Dichloroethane, 2-Butanone, 4-Methyl-2-pentanone, Acetone, Benzene, Carbon disulfide, Carbon tetrachloride, Chlorobenzene, Chloroform, Ethylbenzene, Methylene chloride, Tetrachloroethene, Toluene, Trichloroethene, Vinyl chloride, Xylenes (total)	8260_VOA_GCMS	aGs* 4X40 mL	Full QC	HCl or H2SO4 to pH <2/Cool <=6C	14 Days
8260_VOA_GCMS: GW 01 1,4-Dichlorobenzene, 1-Butanol, cis-1,2-Dichloroethylene, Ethyl cyanide, Tetrahydrofuran, trans-1,2-Dichloroethylene	8260_VOA_GCMS		Full QC		14 Days
8260_VOA_GCMS_IX: COMMON 1,1,1,2-Tetrachloroethane, 1,1,1-Trichloroethane, 1,1,2,2-Tetrachloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2,3-Trichloropropane, 1,2-Dibromo-3-chloropropane, 1,2-Dibromoethane, 1,2-Dichloroethane, 1,2-Dichloropropane, 2-Butanone, 2-Hexanone, 4-Methyl-2-pentanone, Acetone, Acetonitrile, Acrolein, Acrylonitrile, Allyl chloride, Benzene, Bromoform, Carbon disulfide, Carbon tetrachloride, Chlorobenzene, Chloroethane, Chloroform, Chloromethane, Chloroprene, cis-1,3-Dichloropropene, Dibromochloromethane, Dibromomethane, Dichlorodifluoromethane, Ethyl methacrylate, Ethylbenzene, Iodomethane, Isobutyl alcohol, Methacrylonitrile, Methylene chloride, Styrene, Tetrachloroethene, Toluene, trans-1,2-Dichloroethylene, trans-1,3-Dichloropropene, trans-1,4-Dichloro-2-butene, Trichloroethene, Vinyl acetate, Vinyl chloride, Xylenes (total)	8260_VOA_GCMS	aGs* 4X40 mL	Full QC	HCl or H2SO4 to pH <2/Cool <=6C	14 Days
8270_SVOA_GCMS: COMMON 2,4-Dichlorophenol, 2-Methylphenol (cresol, o-), 2-Nitrophenol, Bis(2-ethylhexyl) phthalate, Naphthalene, Pentachlorophenol, Phenol	8270_SVOA_GCMS	aG 4X1 L	Full QC	Cool <=6C	7/40 Days
9012_CYANIDE: COMMON	9012_CYANIDE	G/P 250 mL	Full QC	NaOH to pH >=12/Cool <=6C	14 Days

EXAMPLE FORM
NOT FOR USE

CH2MHill Plateau Remediation Company
SAMPLING AUTHORIZATION FORM

Cyanide					
9060_TOC: COMMON	9060_TOC	aG 250 mL	Full QC	HCl or H2SO4 to pH <2/Cool <=6C	28 Days
Total organic carbon					
9310_ALPHABETA_GPC: COMMON	9310_ALPHABETA_GPC	P 2 L	Full QC	HNO3 to pH <2	6 Months
Gross alpha, Gross beta					

EXAMPLE FORM
NOT FOR USE

CH2MHill Plateau Remediation Company
SAMPLING AUTHORIZATION FORM

SAF NUM S15-010 **SAF TITLE** SURV, OCT 2014 **REV** 1

EXAMPLE FORM
NOT FOR USE

Field Sampling Requirements

Laboratory: GEL Laboratories, LLC **Matrix: WATER**

Parameter / Analysis	Reference Method	Container / Volume	VolReq	Preservation	Holding Times
9310_ALPHABETA_GPC: Gross Beta (1) Gross beta	9310_ALPHABETA_GPC	P 2 L	Full QC	HNO3 to pH <2	6 Months
AMCMISO_EIE_PRECIP_AEA: COMMON Americium-241	AMCMISO_EIE_PREC_AEA	G/P 1 L	Full QC	HNO3 to pH <2	180 Days
C14_LSC: COMMON Carbon-14	C14_LSC	G/P 500 mL	Full QC	None	6 Months
GAMMA_GS: COMMON Cesium-137, Cobalt-60, Europium-152, Europium-154, Europium-155	GAMMA_GS	G/P 4 L	Full QC	HNO3 to pH <2	6 Months
GAMMA_GS: GW 01 Antimony-125, Cesium-134, Potassium-40	GAMMA_GS		Full QC		6 Months
I129LL_SEP_LEPS_GS_LL: COMMON Iodine-129	I129LL_SEP_LEPS_GS	G/P 2X4 L	Full QC	None	6 Months
KPA_UTOT: COMMON Uranium	UTOT_KPA	G/P 500 mL	Full QC	HNO3 to pH <2	6 Months
NP237_IE_PRECIP_AEA: COMMON Neptunium-237	NP237_IE_PRECIP_AEA	G/P 1 L	Full QC	HNO3 to pH <2	180 Days
PUISO_PLATE_AEA: COMMON Plutonium-238, Plutonium-239/240	PUISO_PLATE_AEA	G/P 1 L	Full QC	HNO3 to pH <2	6 Months
SRISO_SEP_PRECIP_GPC: COMMON Strontium-90	SRISO_SEP_PRECIP_GPC	G/P 3X1 L	Full QC	HNO3 to pH <2	6 Months
TC99_EIE_LSC: COMMON Technetium-99	TC99_EIE_LSC	G/P 500 mL	Full QC	HNO3 to pH <2	6 Months
THISO_IE_PLATE_AEA: COMMON Thorium-228, Thorium-230, Thorium-232	THISO_IE_PLATE_AEA	G/P 1 L	Full QC	HNO3 to pH <2	6 Months
TRITIUM_DIST_LSC: COMMON Tritium	TRITIUM_DIST_LSC	P 500 mL	Full QC	None	6 Months
TRITIUM_ELECT_LSC_ML: COMMON Tritium	TRITIUM_ELECT_LSC	P 2 L	Full QC	None	6 Months
9056_ANIONS_IC: COMMON Chloride, Fluoride, Nitrogen in Nitrate, Nitrogen in Nitrite, Sulfate	9056_ANIONS_IC	G/P 250 mL	Full QC	Cool <=6C	28 Days/48 Hours
9056_ANIONS_IC: GW 02 Bromide, Phosphate	9056_ANIONS_IC		Full QC		28 Days/48 Hours
6020_METALS_ICPMS: Arsenic (1) Arsenic	6020_METALS_ICPMS	G/P 500 mL	Full QC	HNO3 to pH <2	6 Months

EXAMPLE FORM
NOT FOR USE

CH2MHill Plateau Remediation Company
SAMPLING AUTHORIZATION FORM

SAF NUM S15-010 **SAF TITLE** SURV, OCT 2014 **REV** 1

EXAMPLE FORM
NOT FOR USE

Field Sampling Requirements

Laboratory: TestAmerica Incorporated, Richland **Matrix: WATER**

Parameter / Analysis	Reference Method	Container / Volume	VolReq	Preservation	Holding Times
906.0 TRITIUM LSC: COMMON Tritium	906.0 H3 LSC	P 1 L	Full QC	None	6 Months
9310_ALPHABETA_GPC: COMMON Gross alpha, Gross beta	9310_ALPHABETA_GPC	P 1 L	Full QC	HNO3 to pH <2	6 Months
AMCMISO_EIE_PLATE_AEA: COMMON Americium-241	AMCMISO_EIE_PLT_AEA	G/P 1 L	Full QC	HNO3 to pH <2	6 Months
C14_LSC: COMMON Carbon-14	C14_LSC	G/P 2X1 L	Full QC	None	6 Months
GAMMA_GS: COMMON Cesium-137, Cobalt-60, Europium-152, Europium-154, Europium-155	GAMMA_GS	G/P 3X1 L	Full QC	HNO3 to pH <2	6 Months
GAMMA_GS: GW 01 Antimony-125, Cesium-134, Potassium-40	GAMMA_GS		Full QC		6 Months
I129LL_SEP_LEPS_GS_LL: COMMON Iodine-129	I129LL_SEP_LEPS_GS	G/P 2X4 L	Full QC	None	6 Months
KPA_UTOT: COMMON Uranium	UTOT_KPA	G/P 500 mL	Full QC	HNO3 to pH <2	6 Months
NP237_LLE_PLATE_AEA: COMMON Neptunium-237	NP237_LLE_PLATE_AEA	G/P 1 L	Full QC	HNO3 to pH <2	6 Months
PUISO_PLATE_AEA: COMMON Plutonium-238, Plutonium-239/240	PUISO_PLATE_AEA	G/P 1 L	Full QC	HNO3 to pH <2	6 Months
SRISO_SEP_PRECIP_GPC: COMMON Strontium-90	SRISO_SEP_PRECIP_GPC	G/P 3X1 L	Full QC	HNO3 to pH <2	6 Months
TC99_ETVDSK_LSC: COMMON Technetium-99	TC99_ETVDSK_LSC	P 500 mL	Full QC	HCl to pH <2	6 Months
THISO_IE_PLATE_AEA: COMMON Thorium-228, Thorium-230, Thorium-232	THISO_IE_PLATE_AEA	G/P 1 L	Full QC	HNO3 to pH <2	6 Months
7196_CR6: COMMON Hexavalent Chromium	7196_CR6	aG 500 mL	Full QC	Cool <=6C	24 Hours
300.0_ANIONS_IC: COMMON Chloride, Fluoride, Nitrogen in Nitrate, Nitrogen in Nitrite, Sulfate	300.0_ANIONS_IC	P 500 mL	Full QC	Cool <=6C	48 Hours
300.0_ANIONS_IC: GW 02 Bromide, Phosphorus in phosphate	300.0_ANIONS_IC		Full QC		48 Hours

EXAMPLE FORM
NOT FOR USE

CH2MHill Plateau Remediation Company
SAMPLING AUTHORIZATION FORM

SAF NUM S15-010 **SAF TITLE** SURV, OCT 2014 **REV** 1

EXAMPLE FORM
NOT FOR USE

Field Sampling Requirements

Laboratory: TestAmerica St. Louis **Matrix: WATER**

Parameter / Analysis	Reference Method	Container / Volume	VolReq	Preservation	Holding Times
310.1_ALKALINITY: COMMON Alkalinity	310.1_ALKALINITY	G/P 500 mL	Full QC	Cool <=6C	14 Days
310.1_ALKALINITY: GW 01 Alkalinity, Bi-carbonate alkalinity, Carbonate alkalinity, Hydroxylion	310.1_ALKALINITY	G/P 500 mL	Full QC	Cool <=6C	14 Days
350.1_AMMONIA: COMMON Ammonia	350.1_AMMONIA	G/P 500 mL	Full QC	H2SO4 to pH <2/Cool <=6C	28 Days
6010_METALS_ICP: COMMON Antimony, Arsenic, Barium, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Magnesium, Manganese, Nickel, Potassium, Silver, Sodium, Vanadium, Zinc	6010_METALS_ICP	G/P 500 mL	Full QC	HNO3 to pH <2	6 Months
6010_METALS_ICP: GW 03 Beryllium, Strontium	6010_METALS_ICP		Full QC		6 Months
6020_METALS_ICPMS: GW 01 Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Molybdenum, Nickel, Selenium, Silver, Strontium, Thallium, Thorium, Tin, Uranium, Zinc	6020_METALS_ICPMS	G/P 500 mL	Full QC	HNO3 to pH <2	6 Months
6010_METALS_ICP: GW 04 Calcium, Iron, Magnesium, Potassium, Sodium, Vanadium	6010_METALS_ICP		Full QC		6 Months
6020_METALS_ICPMS: Arsenic (1) Arsenic	6020_METALS_ICPMS	G/P 500 mL	Full QC	HNO3 to pH <2	6 Months
7470_MERCURY_CV: COMMON (AQUEOUS) Mercury	7470_HG_CVAA	G/P 500 mL	Full QC	HNO3 to pH <2	28 Days
8260_VOA_GCMS: COMMON 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2-Dichloroethane, 2-Butanone, 4-Methyl-2-pentanone, Acetone, Benzene, Carbon disulfide, Carbon tetrachloride, Chlorobenzene, Chloroform, Ethylbenzene, Methylene chloride, Tetrachloroethene, Toluene, Trichloroethene, Vinyl chloride, Xylenes (total)	8260_VOA_GCMS	aGs* 4X40 mL	Full QC	HCl or H2SO4 to pH <2/Cool <=6C	14 Days
8260_VOA_GCMS_IX: COMMON 1,1,1,2-Tetrachloroethane, 1,1,1-Trichloroethane, 1,1,2,2-Tetrachloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2,3-Trichloropropane, 1,2-Dibromo-3-chloropropane, 1,2-Dibromoethane, 1,2-Dichloroethane, 1,2-Dichloroethene (Total), 1,2-Dichloropropane, 1,4-Dichlorobenzene, 1-Butanol, 2-Butanone, 2-Hexanone, 4-Methyl-2-pentanone, Acetone, Acetonitrile, Acrolein, Acrylonitrile, Allyl chloride, Benzene, Bromodichloromethane, Bromoform, Bromomethane, Carbon disulfide, Carbon tetrachloride, Chlorobenzene, Chloroethane, Chloroform, Chloromethane, Chloroprene, cis-1,2-Dichloroethylene, cis-1,3-Dichloropropene, Dibromochloromethane, Dibromomethane, Dichlorodifluoromethane, Ethyl cyanide, Ethyl methacrylate, Ethylbenzene, Iodomethane, Isobutyl alcohol, Methacrylonitrile, Methyl methacrylate, Methylene chloride, Styrene, Tetrachloroethene, Tetrahydrofuran, Toluene, trans-1,2-Dichloroethylene, trans-1,3-Dichloropropene, trans-1,4-Dichloro-2-butene, Trichloroethene, Trichloromonofluoromethane, Vinyl acetate, Vinyl chloride, Xylenes (total)	8260_VOA_GCMS	aGs* 4X40 mL	Full QC	HCl or H2SO4 to pH <2/Cool <=6C	14 Days
8270_SVOA_GCMS: COMMON 1,4-Dichlorobenzene, 2,4-Dichlorophenol, 2-Methylphenol (cresol, o-), 2-Nitrophenol, Bis(2-ethylhexyl) phthalate, Naphthalene, Pentachlorophenol, Phenol	8270_SVOA_GCMS	aG 3X1 L	Full QC	Cool <=6C	7/40 Days

EXAMPLE FORM
NOT FOR USE

CH2MHill Plateau Remediation Company
SAMPLING AUTHORIZATION FORM

9012_CYANIDE: COMMON Cyanide	9012_CYANIDE	G/P 250 mL	Full QC	NaOH to pH >=12/Cool <=6C	14 Days
9060_TOC: COMMON Total organic carbon	9060_TOC	aG 250 mL	Full QC	HCl or H2SO4 to pH <2/Cool <=6C	28 Days

EXAMPLE FORM
NOT FOR USE

CH2MHill Plateau Remediation Company
SAMPLING AUTHORIZATION FORM

SAF NUM S15-010 **SAF TITLE** SURV, OCT 2014 **REV** 1

EXAMPLE FORM
NOT FOR USE

Field Sampling Requirements

Laboratory: TestAmerica St. Louis **Matrix: WATER**

Parameter / Analysis	Reference Method	Container / Volume	VolReq	Preservation	Holding Times
300.0 ANIONS IC: COMMON Chloride, Fluoride, Nitrogen in Nitrate, Nitrogen in Nitrite, Sulfate	300.0 ANIONS IC	P 500 mL	Full QC	Cool <=6C	48 Hours
300.0_ANIONS_IC: GW 02 Bromide, Phosphate	300.0_ANIONS_IC		Full QC		48 Hours
RSK175_VOA: Methane (1) Methane	RSK175_VOA_HDSPC_GC	aGs* 4X40 mL	Full QC	HCl or H2SO4 to pH <2/Cool <=6C	14 Days

Key to Container Types

G = Glass
Gs = Glass w/ septum cap
Gs* = Glass w/ septum cap- no head space in container
P = Plastic (Polyethylene)

aG = Amber Glass
aGs = Amber Glass w/ septum cap
aGs* = Amber Glass w/ septum cap- no head space in container
aG/T = Amber Glass w/ Teflon Lined Lid

EXAMPLE FORM
NOT FOR USE

CH2MHill Plateau Remediation Company

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. # **P15-005-002**

Page 1 of 1

Collector		Contact/Requester	WATERS-HUSTED, K	Telephone No.	376-4650
SAF No.	P15-005	Sampling Origin	Hanford Site	Purchase Order/Charge Code	300071
Project Title	SALDS, JULY 2015	Logbook No.	HNF-N-506 /	Ice Chest No.	N/A
Shipped To (Lab)	222-S Lab Operations	Method of Shipment	GOVERNMENT VEHICLE	Bill of Lading/Air Bill No.	N/A
Protocol	Permit Monitoring	Priority:	30 Days **PRIORITY**	Offsite Property No.	N/A

POSSIBLE SAMPLE HAZARDS/REMARKS

*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.

SPECIAL INSTRUCTIONS Hold Time

N/A

Total Activity Exemption: Yes ☑ No ☐

Sample No.	Filter	*	Date	Time	No/Type Container	Sample Analysis	Holding Time	Preservative
B31RC8	Y	W			1x500-mL G/P	6020_METALS_ICPMS: SALDS; 6010_METALS_ICP: SALDS; 7470_MERCURY_CV: COMMON (AQUEOUS)	6 Months	HNO3 to pH <2
B31RC7	N	W			1x1-L P	906.0_TRITIUM_LSC: COMMON	6 Months	None
B31RC7	N	W			1x1-L P	9310_ALPHABETA_GPC: COMMON	6 Months	HNO3 to pH <2
B31RC7	N	W			2x1-L G/P	SRISO_SEP_PRECIP_GPC: COMMON	6 Months	HNO3 to pH <2
B31RC9	N	W			1x500-mL G/P	160.1_TDS: TDS (1)	7 Days	Cool <=6C
B31RC9	N	W			1x500-mL G/P	310.1_ALKALINITY: GW 01	14 Days	Cool <=6C
B31RC9	N	W			1x500-mL G/P	6020_METALS_ICPMS: SALDS; 6010_METALS_ICP: SALDS; 7470_MERCURY_CV: COMMON (AQUEOUS)	6 Months	HNO3 to pH <2
B31RC9	N	W			3x40-mL aGs*	8260_VOA_GCMS: SALDS	14 Days	HCl or H2SO4 to pH <2/Cool <=6C
B31RC6	N	W			1x100-mL P	300.0_ANIONS_IC: COMMON; 300.0_ANIONS_IC: GW 02	48 Hours	Cool <=6C

EXAMPLE FORM
NOT FOR USE

Relinquished By	Print	Sign	Date/Time	Received By	Print	Sign	Date/Time
Relinquished By			Date/Time	Received By			Date/Time
Relinquished By			Date/Time	Received By			Date/Time
Relinquished By			Date/Time	Received By			Date/Time

Matrix *

S	= Soil	DS	= Drum Solids
SE	= Sediment	DL	= Drum Liquids
SO	= Solid	T	= Tissue
SL	= Sludge	WI	= Wipe
W	= Water	L	= Liquid
O	= Oil	V	= Vegetation
A	= Air	X	= Other

FINAL SAMPLE DISPOSITION	Disposal Method (e.g., Return to customer, per lab procedure, used in process)	Disposed By	Date/Time

PRINTED ON 7/23/2015 FSR ID = FSR2221 A-6004-842 (REV 2)

CH2MHill Plateau Remediation Company

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. # **P15-005-006**

Page 1 of 1

Collector		Contact/Requester	WATERS-HUSTED, K	Telephone No.	376-4650
SAF No.	P15-005	Sampling Origin	Hanford Site	Purchase Order/Charge Code	300071
Project Title	SALDS, JULY 2015	Logbook No.	HNF-N-506 /	Ice Chest No.	N/A
Shipped To (Lab)	222-S Lab Operations	Method of Shipment	GOVERNMENT VEHICLE	Bill of Lading/Air Bill No.	N/A
Protocol	Permit Monitoring	Priority:	30 Days **PRIORITY**	Offsite Property No.	N/A

POSSIBLE SAMPLE HAZARDS/REMARKS

*Contains Radioactive Material at concentrations that are not be regulated for transportation per 49 CFR/IATA Dangerous Goods Regulations but are not releasable per DOE Order 458.1.

SPECIAL INSTRUCTIONS N/A

Hold Time

Total Activity Exemption: Yes ☑ No ☐

Sample No.	Filter	*	Date	Time	No/Type Container	Sample Analysis	Holding Time	Preservative
B31RD4	N	W			1x100-mL P	300.0_ANIONS_IC: COMMON; 300.0_ANIONS_IC: GW 02	48 Hours	Cool <=6C
B31RD7	N	W			1x500-mL G/P	160.1_TDS: TDS (1)	7 Days	Cool <=6C
B31RD7	N	W			1x500-mL G/P	310.1_ALKALINITY: GW 01	14 Days	Cool <=6C
B31RD7	N	W			1x500-mL G/P	6020_METALS_ICPMS: SALDS; 6010_METALS_ICP: SALDS; 7470_MERCURY_CV: COMMON (AQUEOUS)	6 Months	HNO3 to pH <2
B31RD7	N	W			3x40-mL aGs*	8260_VOA_GCMS: SALDS	14 Days	HCl or H2SO4 to pH <2/Cool <=6C
B31RD5	N	W			1x1-L P	906.0_TRITIUM_LSC: COMMON	6 Months	None
B31RD5	N	W			1x1-L P	9310_ALPHABETA_GPC:.COMMON	6 Months	HNO3 to pH <2
B31RD5	N	W			2x1-L G/P	SRISO_SEP_PRECIP_GPC: COMMON	6 Months	HNO3 to pH <2
B31RD6	Y	W			1x500-mL G/P	6020_METALS_ICPMS: SALDS; 6010_METALS_ICP: SALDS; 7470_MERCURY_CV: COMMON (AQUEOUS)	6 Months	HNO3 to pH <2

EXAMPLE FORM
NOT FOR USE

Relinquished By	Print	Sign	Date/Time	Received By	Print	Sign	Date/Time
Relinquished By			Date/Time	Received By			Date/Time
Relinquished By			Date/Time	Received By			Date/Time
Relinquished By			Date/Time	Received By			Date/Time

Matrix *

S	= Soil	DS	= Drum Solids
SE	= Sediment	DL	= Drum Liquids
SO	= Solid	T	= Tissue
SL	= Sludge	WI	= Wipe
W	= Water	L	= Liquid
O	= Oil	V	= Vegetation
A	= Air	X	= Other

FINAL SAMPLE DISPOSITION	Disposal Method (e.g., Return to customer, per lab procedure, used in process)	Disposed By	Date/Time

PRINTED ON 7/23/2015 FSR ID = FSR2222 A-6004-842 (REV 2)

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