DOE/RL-2015-28
Draft A

2015 Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

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Executive Summary

This document presents a revision to the 1997 183-H Solar Evaporation Basins groundwater monitoring plan.[1] This revised monitoring plan is based on the requirements for final status facilities, as identified in the Hanford Facility Resource Conservation and the *Recovery Conservation and Recovery Act of 1976*[2] (RCRA) Permit (WA7890008967), Part II, Condition II.F, which specifies that final status groundwater monitoring programs are subject to the requirements in WAC 173-303-645.[3] Due to the age of the plan, the U.S. Department of Energy (DOE), Richland Operations Office (RL) has undertaken revision of this RCRA groundwater monitoring plan to ensure that the plan contains the most current Hanford groundwater monitoring information for the treatment, storage, and disposal (TSD) unit. This document will supersede the previous groundwater monitoring plan (PNNL-11573) upon modification of the RCRA Permit (WA7890008967). This corrective action groundwater monitoring plan is the principal controlling document for conducting groundwater monitoring at 183-H Solar Evaporation Basins.

The 183-H Solar Evaporation Basins are a final status TSD unit (TSD number T-1-4) in the 100-HR-1 Source Operable Unit (OU). The 183-H Solar Evaporation Basins are located north of the 105-H Reactor. The 183-H Solar Evaporation Basins are in modified closure with corrective action. The four basins were originally part of the 183-H water treatment facility but were used for evaporation of 300 Area fuel fabrication wastes from 1973 to 1985. In 1996, the basins were demolished and the soil was removed to a depth of 0.6 m (2 ft) below the basin floor, with excavation to 4.6 m (15 ft) below Basin 1. The basin floor depth ranged from 4.7 to 5.0 m (15.5 to 16.5 ft). Groundwater protection was demonstrated through modeling and a modified RCRA closure (soil column) was approved in 1997. Clean closure was not approved due to high levels of fluoride and

[1] PNNL-11573, 1997, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D1659822.

[2] *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: http://www.epa.gov/epawaste/inforesources/online/index.htm.

[3] WAC 173-303-645, "Releases from Regulated Units," *Washington Administrative Code*, Olympia, Washington. Available at: http://app.leg.wa.gov/WAC/default.aspx?cite=173-303-645.

nitrate remaining in the soil 4.6 m (15 ft) below the Basin 1 floor. Groundwater at the site is approximately 13 m (42 ft) below ground surface.

A final status groundwater compliance monitoring program in accordance with WAC 173-303-645 was implemented in 1995 (WHC-SD-EN-AP-180[4]). The plan identified chromium (collected as a filtered sample) and nitrate as dangerous waste constituents and technetium-99 and uranium as waste indicators. Fluoride was monitored as an indicator of 183-H contamination in groundwater. Additional constituents to aid data interpretation, (alkalinity, anions, and selected metals) and field parameters (pH, specific conductance, temperature, and turbidity) were also included.

The first samples collected under the compliance monitoring plan exceeded concentration limits for nitrate, chromium, uranium, and technetium-99. As a result, corrective action was required. Groundwater remediation (pump and treat) was undertaken as part of the interim remedial measure (IRM) and, therefore, the corrective action for the 183-H Solar Evaporation Basins was deferred to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[5] program. The IRM commenced in 1997 and is ongoing at the 100-HR-3 groundwater OU. In accordance with WAC 173-303-645(11), a final status, corrective action groundwater monitoring plan (PNNL-11573) replaced the compliance monitoring plan (WHC-SD-EN-AP-180) in 1997.

This revised plan retains total chromium, collected as a filtered sample, as the dangerous waste constituent identified for corrective action monitoring. Other constituents identified for monitoring in the previous plan (PNNL-11573) (nitrate, uranium, technetium-99, and fluoride), are not dangerous waste constituents as defined in 40 CFR 261[6] and are not included in this plan. Alkalinity, anions, and metals are also not included in this plan since these analytes are collected at multiple nearby wells supporting the IRM.

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[4] WHC-SD-EN-AP-180, 1995, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196050052.

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

[6] 40 CFR 261, "Identification and Listing of Hazardous Waste," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr261_main_02.tpl.

This revised RCRA groundwater monitoring plan presents an updated corrective action monitoring plan of the uppermost aquifer beneath the 183-H Solar Evaporation Basins. This plan addresses the following:

- Number, locations, and depths of wells in the 183-H Solar Evaporation Basins groundwater monitoring network
- Sampling and analytical methods of parameters required for groundwater contamination detection monitoring
- Methods for evaluating groundwater quality information
- Schedule for groundwater monitoring at the 183-H Solar Evaporation Basins

This revised plan modifies the existing groundwater monitoring well network as identified in the previous groundwater monitoring plan (PNNL-11573). Previous monitoring network changes occurred in 2005 and 2013 and were incorporated into the RCRA Permit (WA7890008967). In 2005, Well 199-H4-7 was removed from the monitoring network and replaced with Well 199-H4-8. In 2013, Well 199-H4-84 replaced 199-H4-3 when it was decommissioned.

This plan removes Well 199-H4-12C, which is completed in the confined aquifer, from the monitoring network. Monitoring Well 199-H4-12A is replaced with Well 199-H4-85, which is located closer to the waste site, is completed in the unconfined aquifer, and better represents the groundwater conditions at the 183-H Solar Evaporation Basins. Planned Wells 199-H4-89 and 199-H4-88 are added to the RCRA monitoring network. Drilling for Wells 199-H4-88 and 199-H4-89 is planned for fiscal year (FY) 2016. Until the new wells are drilled and accepted, Well 199-H4-12A will remain in the monitoring network. In summary, upon Permit modification, the well network will include existing wells 199-H4-8, 199-H4-84, and 199-H4-85 and new wells 199-H4-88 and 199-H4-89 (or existing Well 199-H4-12A until the two new wells are accepted). The monitoring network wells represent the point of compliance.

Groundwater flows generally toward the east-northeast beneath the 183-H Solar Evaporation Basins and is influenced by the ongoing IRM as well as changes in river stage. Active extraction wells east and northeast of the site enhance the flow in that direction.

The concentration limit for total chromium (filtered) in this plan is 100 µg/L. This concentration represents the current background concentration for total chromium (filtered). This concentration is also the maximum contaminant level for chromium.[7,8]

Under this plan, groundwater in the 183-H Solar Evaporation Basins monitoring wells will be sampled and analyzed semiannually for the dangerous waste constituent total chromium and for field parameters (pH, specific conductance, temperature, dissolved oxygen, and turbidity). Water level measurements will be taken each time a sample is collected to satisfy WAC 173-303-645(8)(f).

[7] 40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr141_main_02.tpl.

[8] WAC 246-290-310, "Group A Public Water Supplies," "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=246-290-310.

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Terms

AEA	*Atomic Energy Act of 1954*
amsl	above mean sea level
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CSM	conceptual site model
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
FY	fiscal year
IRM	interim remedial measure
MCL	maximum contaminant level
MTCA	"Model Toxics Control Act—Cleanup" (WAC 173-340)
NA	not applicable
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
OU	operable unit
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	Richland Operations Office
RUM	Ringold Formation upper mud
TBD	to be determined
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
UCL	upper confidence limit
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System

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1 Introduction

This document presents the revised corrective action groundwater monitoring plan for the 183-H Solar Evaporation Basins and supersedes the previous plan (PNNL-11573, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*). The 183-H Solar Evaporation Basins are a post-closure treatment, storage, and disposal (TSD) unit (TSD number T-1-4) in Part VI, Chapter 2, of the Hanford Facility *Resource Conservation and Recovery Act of 1976* (RCRA) Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit*). The basins and underlying soil were remediated in 1996, and the unit was closed in 1997 under modified RCRA closure provisions with specified remedial measures under post-closure care (Soper, 1997, "Re: Acceptance of "Closure Certification for the 183-H Solar Evaporation Basins (T-1-4)," 96-EAP-246"). The Hanford Facility RCRA Permit (WA7890008967), Part II, Condition II.F specifies final status groundwater monitoring program requirements will comply with WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units." Groundwater is monitored in accordance with WAC 173-303-645 and Part VI, Chapter 2, of the Hanford Facility RCRA Permit (WA7890008967).

This plan monitors dangerous waste and field parameters in groundwater samples that are used to demonstrate the effectiveness of the associated corrective action. For regulatory purposes, the TSD unit boundary of the 183-H Solar Evaporation Basins is identified on the current Hanford Facility Dangerous Waste Permit (WA7890008967) Part A Form.

The 183-H Solar Evaporation Basins (waste sites 116-H-6 and 100-H-33) are located within the 100-H Area, in the 100-HR-1 Source OU (Figure 1-1). The basins (Figure 1-2) were originally part of the 183-H water treatment facility. Operating records indicate that four of the basins were used from 1973 to 1985 to evaporate various liquid waste streams, including neutralized, spent acid etch solutions from the 300 Area Fuel Fabrication Facility containing technetium-99 and uranium, as well as miscellaneous used and unused chemicals (DOE/RL-97-48, *183-H Solar Evaporation Basins Postclosure Plan*). All operations ceased in 1985 and Basin 1 solids and sludge material was removed in 1985. In 1990, Basins 1 and 4 were cleaned by wet sandblasting. Waste generated during sandblasting was packaged and disposed.

In 1989 and 1990, the basin concrete and soil were sampled. Analytical results indicated the presence of contamination within 0.6 m (2 ft) below the bottom of the basin structure. Decontamination and demolition of the basins started in September 1995, and the demolition waste was removed and disposed. As a result of the 1991 borehole data showing contamination, the soil underlying the basins was removed starting in 1996 with excavation to a depth of 0.9 m (3 ft) below the structure. Nitrate and fluoride soil contamination in the vadose zone at a depth greater than 4.6 m (15 ft) below the basin floor was identified at Basin 1, resulting in a total excavation depth of approximately 9 m (30 ft) below grade. A test pit below Basin 1 was dug to 7.6 m (25 ft) below the former structure for a total depth of about 12 m (40 ft) below grade, which was the depth of groundwater at the time of excavation. Both nitrate and fluoride contamination were identified at that depth. No additional soil removal was performed.

Due to presence of contamination extending from 4.6 m to 7.6 m (15 to 25 ft) below the Basin 1 structure, waste site 116-H-6 underwent a modified RCRA closure in 1997, which included groundwater monitoring. Protection of groundwater was demonstrated through modeling. The 116-H-6 waste site pertains to the chemical contamination beneath the site, which has been "closed-out" under RCRA (Soper, 1997). The radiological component of the basins was later addressed under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as the 100-H-33 waste site and reclassified to (interim) No Action.

RCRA compliance groundwater monitoring began at the 183-H Solar Evaporation Basins in 1985, based on the groundwater monitoring requirements for interim status facilities (those facilities still engaged in the permitting process). In 1994, the Washington State Department of Ecology (Ecology) issued RCRA Permit (WA7890008967) for the Hanford Site, which included the Part II, Condition II.F requirement that final status TSD units comply with WAC 173-303-645. A final status compliance monitoring plan under WAC 173-303-645 (WHC-SD-EN-AP-180, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*) was initiated in 1995.

Results from the first final status compliance monitoring samples collected in 1995 (Furman, 1996, "Exceedance of Concentration Limits in Groundwater at 183-H Solar Evaporation Basins") showed exceedances of the concentration limits for nitrate, chromium, uranium, and technetium-99 that were established per WAC 173-303-645(5). The regulations in WAC 173-303-645(11), "Corrective Action Program," require implementation of a corrective action program to reduce contaminant concentrations in groundwater. Groundwater corrective action for the 183-H Solar Evaporation Basins was deferred to the CERCLA interim action for the 100-HR-3 Groundwater OU, which includes groundwater affected by the basins. The CERCLA interim remedial measure (IRM) at the 100-HR-3 OU consists of two pump-and-treat systems.

A corrective action groundwater monitoring plan (PNNL-11573) was developed in accordance with WAC 173-303-645(11) and implemented in 1997. The post-closure plan (DOE/RL-97-48) was incorporated into the RCRA Permit (WA7890008967) in February 1998 and includes the corrective action groundwater monitoring described in PNNL-11573.

The purpose of this RCRA plan is to present an updated groundwater monitoring program for dangerous waste from the 183-H Solar Evaporation Basins. Specifically, this plan is intended to satisfy monitoring requirements for final status TSD units undergoing corrective action, as prescribed in Part VI of the RCRA Permit (WA7890008967) and required by WAC 173-303-645(11). This monitoring plan is the principal controlling document for conducting groundwater monitoring at the 183-H Solar Evaporation Basins and is used to modify the permit. Once the permit is modified, this document will supersede PNNL-11573.

This revised plan monitors only dangerous waste (total chromium) and includes field parameters (pH, specific conductance, temperature, dissolved oxygen, and turbidity). Other constituents monitored in PNNL-11573 (nitrate, uranium, technetium-99, and fluoride) are not dangerous wastes and are not included for monitoring in this RCRA plan. The corrective action monitoring program detailed in this plan requires semiannual sampling of total chromium (collected as a filtered sample) and field parameters at five wells. Additionally, water level measurements are required each time a sample is collected to satisfy WAC 173-303-645(8)(f).

This groundwater monitoring plan addresses the operational history, current hydrogeology, and conceptual site model (CSM) for the site and incorporates knowledge regarding contamination originating from the 183-H Solar Evaporation Basins. Chapter 2 of this plan summarizes background information and references other documents that contain more detailed or additional information. Additionally, Chapter 2 describes the 183-H Solar Evaporation Basins and the regulatory basis, types of waste present, and the pertinent geology and hydrogeology beneath the 183-H Solar Evaporation Basins as well as providing a brief history of groundwater monitoring. All of this information is summarized as a CSM to aid in development of the groundwater monitoring program. Chapter 3 describes the RCRA groundwater monitoring program, including the wells in the monitoring network, constituents analyzed, sampling frequency, and sampling protocols. Chapter 4 describes the data evaluation and reporting, and Chapter 5 contains the references cited in this plan. Appendix A provides the quality assurance project plan (QAPjP), Appendix B contains sampling protocols, and Appendix C provides information for the wells within the groundwater monitoring. Appendix D presents monitoring data of the dangerous waste (including both total chromium and hexavalent chromium results) that have been collected from the network wells during corrective action monitoring.

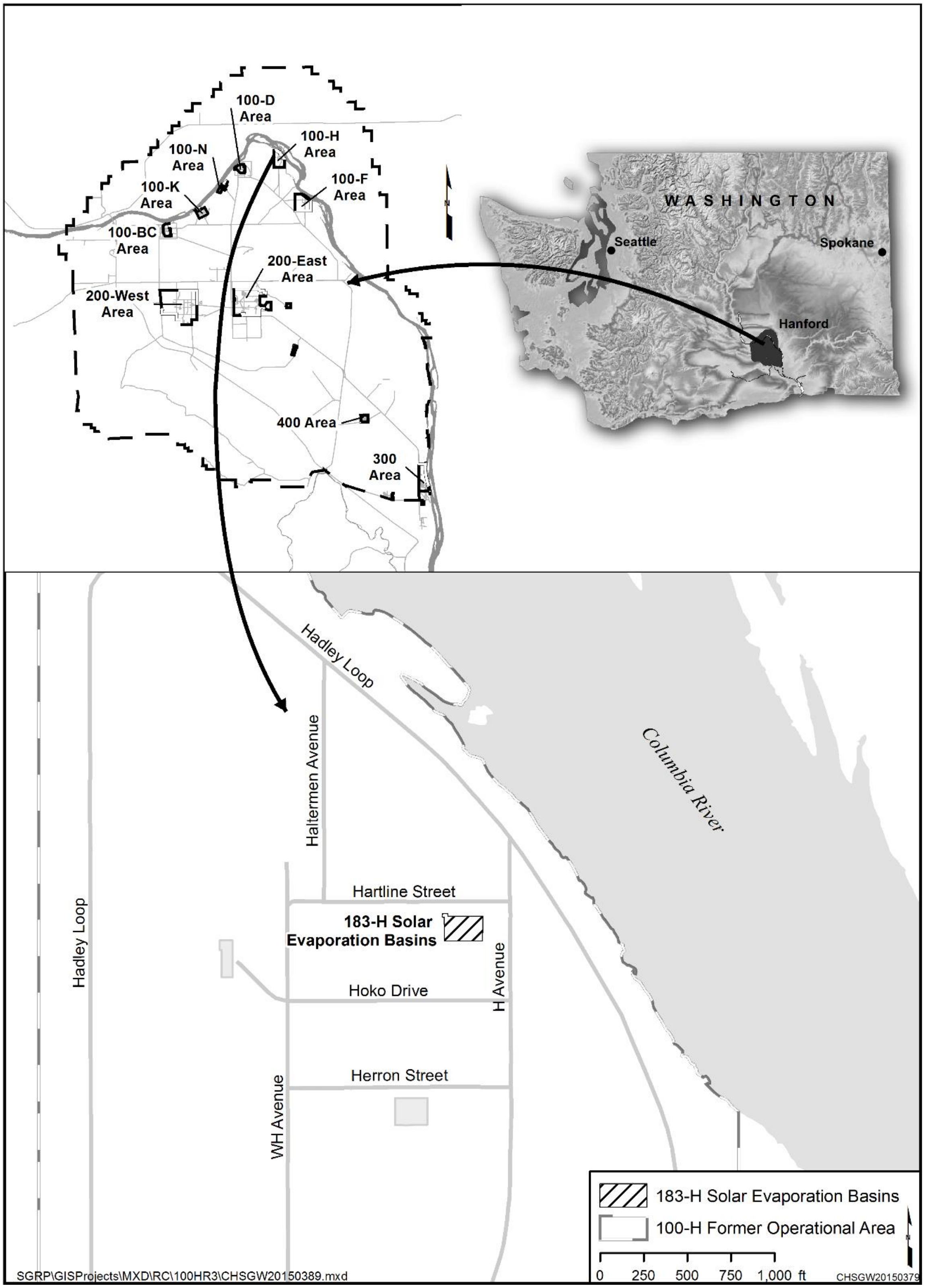

Figure 1-1. Location Map for the 183-H Solar Evaporation Basins

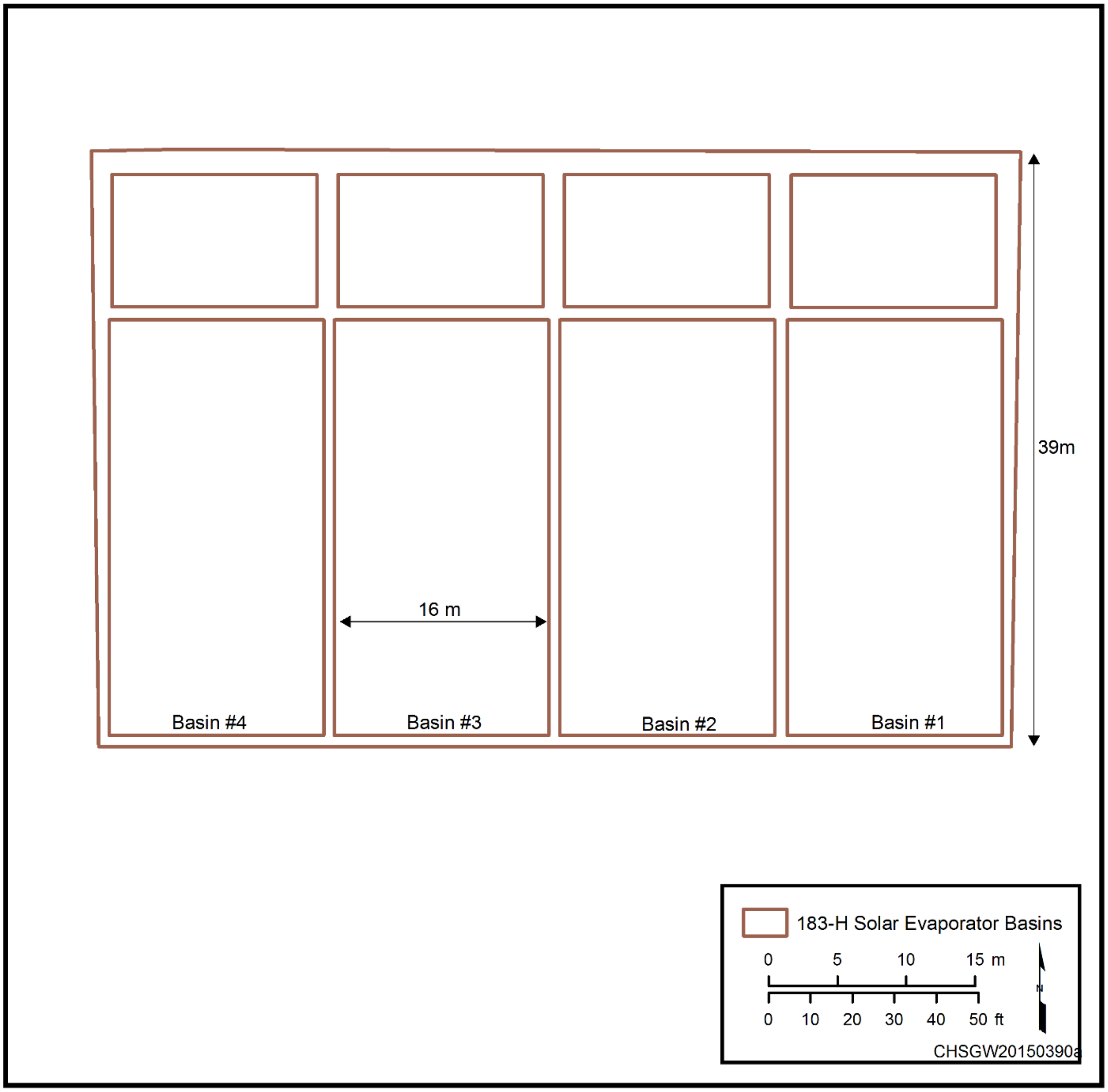

Figure 1-2. Schematic of the Former 183-H Solar Evaporation Basins

2 Background

This chapter describes the 183-H Solar Evaporation Basins and their operating history, regulatory basis, wastes and waste characteristics associated with the 183-H Solar Evaporation Basins, local subsurface geology and hydrogeology, a summary of previous groundwater monitoring, and the CSM for the 183-H Solar Evaporation Basins.

The information contained in this chapter was obtained from several sources, including the Waste Information Data System (WIDS) general summary reports, previous groundwater monitoring plans listed in Table 2-1, and the following documents:

- DOE/RL-88-04, *Interim Status Closure/Post-Closure Plan 183-H Solar Evaporation Basins*
- DOE/RL-97-48, *183-H Solar Evaporation Basins Postclosure Plan*
- 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*
- DOE/RL-2011-111, *Proposed Plan for Remediation of the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*

2.1 Facility Description and Operational History

The 183-H Basins were located beside the Columbia River in the northern portion of the Hanford Site (Figure 2-1). Each basin was 16 m (52 ft) wide and 39 m (128 ft) long and contained a 5 m (16 ft) deep sedimentation basin and a smaller, 3 m (10 ft) deep flocculation basin. The basins were surrounded by earthen berms.

The concrete basins were originally part of the 183-H water treatment plant for treating cooling water and operated concurrently with the 100-H Reactor from October 1949 to April 1965. At that time, there were 16 basins. Following shutdown of the reactor in the mid-1960s, most of the facility was demolished. Four basins were retained for use as solar evaporation basins for chemical waste from the 300 Area (PNL-6470, *Revised Ground-Water Monitoring Compliance Plan for the 183-H Solar Evaporation Basins*), as well as for miscellaneous used and unused chemicals. These remaining basins were modified to seal openings and to install a pipeline before being used to evaporate various liquid waste streams, including neutralized, spent acid etch solutions containing technetium-99 and uranium from the 300 Area Fuel Fabrication Facility.

Use of the 183-H Basins for liquid disposal began in June 1973, when liquid was first pumped into Basin 1, but discharges ceased after two months due to operational problems at the 300 Area. Discharge to the basins resumed in 1975 and continued until 1978, when nitrate contamination in a downgradient well (199-H4-3) was attributed to wastes from the unlined Basin 1. Basins 2 and 3, with sprayed-on liners of a polyurethane material, were used beginning in 1977 and 1978, and Basin 1 was permanently retired. Basin 4, with a sprayed-on butyl and Hypalon® liner, also was used beginning in October 1982. Basins 2, 3, and 4 were used until 1985. The total volume of routine wastes from the fuel fabrication process discharged to the 183-H Basins from 1973 to 1985 was 9.573 million L (2.529 million gal) (PNL-6470).

Basin 1 solids and sludge were removed in 1985. Basins 2, 3, and 4 held waste consisting of three distinct layers: a basal crystalline layer, a sludge layer, and a liquid layer on top. In 1986, the liquid waste was

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solidified inside lined drums. The sludge and crystalline layers were removed from the basins by manually shoveling and/or scooping the material into the drums. Basins 1 and 4 were subsequently cleaned by wet sandblasting. By the end of 1990, all waste had been removed.

The basins were decontaminated and demolished in 1996 and soil was removed to at least 1 m (3 ft) beneath each of the former basins. Below Basin 1, additional soil was removed up to a depth of 4.6 m (15 ft) below the former structure (DOE/RL-97-48), with the floor of the former structure at 4.7 to 5.0 m (15.5 to 16.5 ft) below grade. In Basin 1, a test pit was excavated to a depth of 7.6 m (25 ft) below the structure for a total depth of about 12 m (40 ft) below grade (the depth of groundwater at the time of excavation). Soil from the test pit was sampled and both nitrate and fluoride contamination above 1996 WAC 173-340, "Model Toxics Control Act—Cleanup" (MTCA) Method B cleanup levels were detected at this depth. No further source remediation was done and the excavation was filled with clean soil to meet the surrounding grade. All decontamination and demolition waste and contaminated soil was transported from the site and disposed.

2.2 Regulatory Basis

In 1986, the U.S. Department of Energy (DOE) entered into a regulatory order (EPA and Ecology, 1986, EPA Regulatory Order No. 1085-10-07-3008 and Ecology No. DE 86-133). The compliance order mandated interim status groundwater quality assessment monitoring according to 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," and WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," at the 183-H Solar Evaporation Basins. This initiated the RCRA monitoring program at the 183-H Solar Evaporation Basins.

In May 1987, DOE issued a final rule (10 CFR 962, "Byproduct Material"), stating that the hazardous waste components of mixed waste are subject to RCRA regulations. In November 1987, the U.S. Environmental Protection Agency (EPA) authorized Ecology to regulate these hazardous waste components within the State of Washington (51 FR 24504, "EPA Clarification of Regulatory Authority Over Radioactive Mixed Waste"). In 1996, the Washington State Attorney General determined that the effective date for regulation of mixed waste in Washington State was August 19, 1987.

In May 1989, DOE, EPA, and Ecology signed the Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes the 183-H Solar Evaporation Basins.

Dangerous waste is regulated under RCRA, as modified in 40 CFR 265 and RCW 70.105, "Hazardous Waste Management," and its implementing requirements in the Washington State dangerous waste regulations (WAC 173-303-400). Radionuclides in mixed waste may include source, special nuclear, and byproduct materials as defined in the *Atomic Energy Act of 1954* (AEA). Both RCRA and AEA state that these radionuclide materials are regulated at DOE facilities, exclusively by DOE, acting pursuant to its AEA authority. Radionuclide materials are not hazardous/dangerous wastes and, therefore, are not subject to regulation by the State of Washington under RCRA or RCW 70.105.

In 1994, Ecology issued a RCRA Permit (WA7890008967) for the Hanford Site. The 183-H Solar Evaporation Basins were included as a closure unit in Part V of the permit, which contains requirements specifically applicable to TSD units that are undergoing closure. Part II, Condition II.F of the permit specified that a groundwater monitoring program under final status was subject to the requirements of WAC 173-303-645.

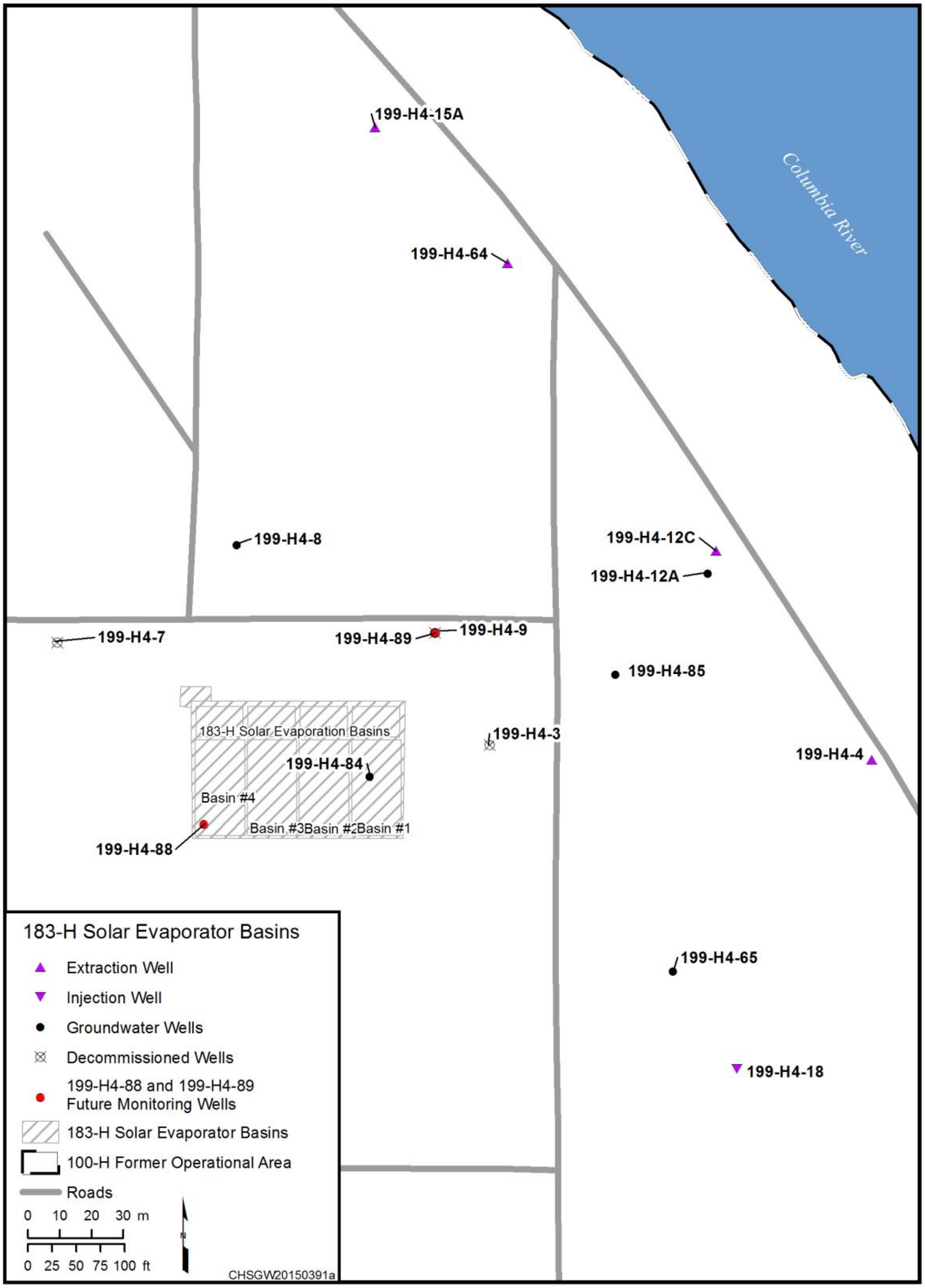


Figure 2-1. Map of the 183-H Solar Evaporation Basins

Although the permit specified final status requirements for groundwater monitoring, it also stated that monitoring should continue under the then-current (interim status) program as described in DOE/RL-88-04. This was an apparent contradiction in the permit. A final status compliance monitoring program was prepared in 1995 (WHC-SD-EN-AP-180) to comply with the groundwater monitoring requirements specified in Part II, Condition II.F., of the permit.

The first sample set collected under the final status plan showed that downgradient concentrations of the four identified analytes (nitrate, chromium, uranium, and technetium-99) exceeded the concentration limits established in the compliance monitoring plan (WHC-SD-EN-AP-180). WAC 173-303-645(11) requires corrective action activities to reduce contaminant concentrations in groundwater. Remediation of the groundwater was deferred to the CERCLA program, with the RCRA corrective action to be integrated with the remediation of the 100-HR-3 OU. The RCRA monitoring continued under the compliance program (WHC-SD-EN-AP-180).

Corrective action to address groundwater contamination in the 100-H Area, including chromium that resulted from the 183-H Solar Evaporation Basin, was initiated as part of CERCLA remediation activities. An IRM to remove hexavalent chromium began operation in 1997 as specified in DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*. The CERCLA IRM is ongoing and is not subject to the conditions of the RCRA Permit (WA7890008967).

Corrective action groundwater monitoring at the 183-H Solar Evaporation Basins was initiated in accordance with WAC 173-303-645(11). In 1997, the corrective action groundwater monitoring plan (PNNL-11573) replaced the compliance monitoring plan (WHC-SD-EN-AP-180) and was incorporated in the post-closure plan (DOE/RL-97-48) and the RCRA Permit (WA7890008967). Groundwater protection at the site was demonstrated through modeling and a modified RCRA closure (soil) was approved by Ecology on May 13, 1997 (Soper, 1997). The site was not clean-closed under RCRA because fluoride and nitrate concentrations were identified above the 1996 MTCA (WAC 173-340) Method B cleanup levels, even though these are not dangerous wastes. Therefore, the unit was closed in place under the modified closure provisions of the RCRA Hanford permit with post-closure care. Corrective action groundwater monitoring under PNNL-11573 continues to this day. RCRA closures do not have authority to address the cleanup of radiological contamination, which is performed under CERCLA. Waste site 116-H-6 pertains to the chemical contamination beneath the site, which has been "closed-out" under RCRA (Soper, 1997). Accordingly, the 116-H-6 waste site was reclassified to Closed Out in 1997 in WIDS. A second waste site for the 183-H Solar Evaporation Basins, 100-H-33, was created to address the radiological contamination that is within the same footprint as 116-H-6. Waste site 100-H-33 (radiological component) was evaluated and reclassified in 2012 to No Action in WIDS.

2.3 Waste Characteristics

The waste discharged to the 183-H Solar Evaporation Basins from 1973 to 1985 was received from the 300 Area Fuel Fabrication Facility, along with miscellaneous used and unused chemicals. The four basins received routine waste consisting of spent acid etch solutions (i.e., chromic, hydrofluoric, nitric, and sulfuric acids), typically neutralized with sodium hydroxide (PNNL-11573). Metal constituents included aluminum, chromium, copper, manganese, nickel, silicon, uranium, and zirconium (primarily in the form of precipitates after neutralization. The resultant slurry of liquid and metal precipitates was discharged into the basins.

Chemical analyses were not performed routinely on the waste discharged during the operating life of the basins; however, chemical waste disposal permits indicate that some the waste was corrosive (high and low pH). PNNL-11573 reported up to 700 µg/L of chromium were found in a monthly composite sample.

The neutralized waste contained high concentrations of nitrate and copper from the nitric acid used in the copper-stripping procedures. Chromium waste included hexavalent chromium, mostly from the chromic acid used in fuel fabrication. After 1983, hexavalent chromium was reduced to its trivalent state before disposal. Two other minor sources of chromium were the etching of stainless steel (mostly trivalent chromium) and the disposal of various industrial solutions.

The routine waste included uranium and technetium-99, causing the material to be categorized as nontransuranic, low-level, radioactive waste. Nonroutine waste discharged to the basins periodically included unused chemicals and spent solutions from miscellaneous processes, development tests, and laboratories. These discharges included the following components: cadmium and cadmium compounds; copper and copper compounds; oxalic acid; cyanide, mercury, and lead compounds; barium perchlorate; hydrazine; chromium and chromium compounds; vanadium pentoxide; and nickel and nickel compounds.

2.4 Geology and Hydrogeology

The following documents describe the geology and hydrogeology of the 100-H Area and 100-HR-3 groundwater OU, including the region of the 183-H Solar Evaporation Basins, in detail:

- 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*
- PNL-6728, *Geohydrologic Characterization of the Area Surrounding the 183-H Solar Evaporation Basins*
- BHI-00917, *Conceptual Site Models for Groundwater Contamination at 100-BC-5, 100-KR-4, 100-HR-3, and 100-FR-3 Operable Units*
- WHC-SD-EN-TI-011, *Geology of the Northern Part of the Hanford Site: An Outline of Data Sources and the Geologic Setting of the 100 Areas*
- WHC-SD-EN-TI-132, *Geologic Setting of the 100-HR-3 Operable Unit, Hanford Site, South-Central Washington*

2.4.1 Stratigraphy

The 100-H Area is underlain by unconsolidated sediments and the Columbia River Basalt Group. Unconsolidated sediments in this area include the Hanford formation (informal name) and the Ringold Formation. The stratigraphy of the 100-H Area has been described in WHC-SD-EN-TI-132 and DOE/RL-2010-95. Stratigraphic units at 100-HR-3 are listed in the following text and shown on the left side of Figure 2-2.

Surface sediments at the 100-H Area include Holocene deposits and backfill, generally less than 0.3 m (1 ft) thick. Recent deposits include eolian sands and river alluvium, which were placed over the past 10,000 years, and backfill materials deposited by humans. Construction backfill varies in depth, depending on the excavated depth of waste sites and building foundations, and backfill material may cover larger graded areas to depths of 0.3 m (1 ft) or more. Backfill deposits may be up to 8 m (26 ft) thick near the 100-H reactor and 183-H Clearwells, but are generally less than 5 m (16 ft) thick in other areas.

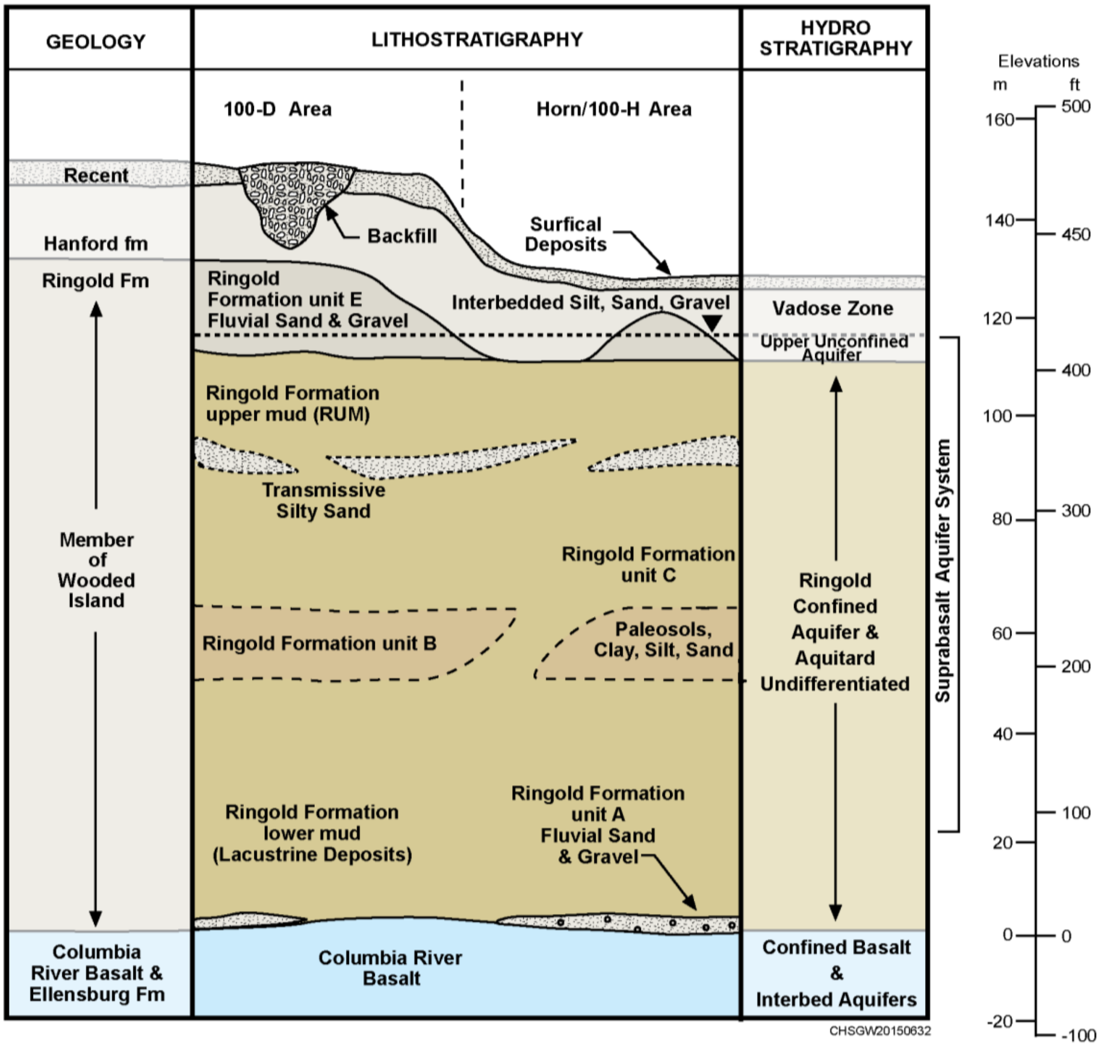


Figure 2-2. Stratigraphy and Hydrogeologic Units of 100-HR-3

The Hanford formation consists predominantly of unconsolidated sediments that cover a wide range of grain sizes, from boulder-sized gravel to sand, silty sand, and silt. 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. The Hanford formation has traditionally been classified into three separate lithofacies: gravel-dominated, sand-dominated, and interbedded sand and silt-dominated (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*). The gravel-dominated Hanford formation is highly basaltic, ranging from approximately 50 to 80 percent basalt (WHC-SD-EN-TI-011). The sand fractions are also high in basalt content, with the remaining portion composed of feldspar, quartz, and traces of mica. The grains typically are subround to round gravel and subangular to subround in the sand grain fraction. The gravel-dominated facies typically are well stratified and contain little to no cementation (WHC-SD-EN-TI-132). Discrete sand lenses are present in 100-D/H, which may serve as preferential flow paths or collection zones for vadose zone contaminants. Caliche (calcium carbonate crust) is occasionally observed on Hanford formation gravels.

The thickness of the Hanford formation ranges from 10 to 19 m (33 to 62 ft) across the 100-H Area and makes up most of the unconfined aquifer material.

Ringold Formation underlies the Hanford formation and is a combination of alluvial and lacustrine deposits produced by the ancestral Columbia River and other regional river systems. The formation is approximately 41 m (134 ft) thick beneath the 100-H Area, and consists of nonindurated and semi-indurated clay, silt, fine- to coarse-grained sand, and variably cemented, multilithic, granule to cobble gravel. The Ringold Formation under the 100-H Area includes the following three main depositional facies: overbank/paleosol deposits, sand and interbedded overbank paleosol deposits, and the lacustrine-dominated lower mud unit. Ringold Formation unit E is the uppermost Ringold unit, but is found in small areas at 100-H.

The Ringold Formation upper mud (RUM) unit 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. The RUM is considered an aquitard and forms the base of the unconfined aquifer. Within the RUM, thin sand-to-gravel layers form zones with variable hydraulic conductivity (K). Horizontal K ranges from 1.2×10^{-4} to 1.9×10^{-3} cm/sec (3.4×10^{-1} to 5.4 ft/day) and vertical K ranges from 1.4×10^{-8} to 5.0×10^{-3} cm/sec (4.0×10^{-5} to $1.4 \times 10^{+1}$ ft/day). These sand and gravel layers form confined or semiconfined aquifers within the RUM. The connectivity of the first water bearing unit of the RUM across the site and the extent of connection to the unconfined aquifer has not been determined. The top surface of the RUM is found between 11 and 40 m (37 and 66 ft) below ground surface (bgs) at 100-H.

The Ringold unit B separates and differentiates the fine-grained sediment of the RUM from the underlying fine-grained sediment of the Ringold lower mud unit. Fine sand to silty sand deposits of the Ringold unit B overlie the lower mud unit and are approximately 15 to 24.5 m (50 to 80 ft) thick beneath 100-D/H. The Ringold unit B sands are inferred to be equivalent to fluvial gravel deposits of unit B (and possibly unit D) to the south in the Cold Creek Syncline. Ringold units A and C, which are present in other parts of the Cold Creek Syncline to the south of Gable Mountain, have not been found beneath 100-H. The lower mud consists of fine-grained (silt- and clay-dominated) deposits that are approximately 23.0 to 30.5 m (75 to 100 ft) thick beneath 100-H (WHC-SD-EN-TI-132).

Approximately 300 basalt flows of the Columbia River Basalt Group have been identified, with a maximum total thickness of approximately 4,600 m (15,000 ft) in the Pasco Basin. The basalt has been divided into four formations from youngest to oldest: Saddle Mountains Basalt, Wanapum Basalt, Grand Ronde Basalt, and Imnaha Basalt. The Elephant Mountains Member of the Saddle Mountains Basalt Formation is the upper basalt unit beneath 100-H. The Saddle Mountains Basalt Formation was encountered in Well 199-H4-15C at a depth of 95 m (314 ft). Sedimentary units of the Ellensburg Formation are interbedded with the basalt flows. The shallowest of these beneath 100-H is the Rattlesnake Ridge interbed.

Geologic cross-sections, which include selected wells in the 183-H Solar Evaporation Basins monitoring network and surrounding area, present the approximate stratigraphy underlying and adjacent to the site (Figures 2-3 and 2-4).

2.4.2 Hydrogeology

The principal hydrostratigraphic units encountered beneath the 100-H Area include the following, in descending order:

- The unsaturated sediments of the Hanford formation (vadose zone)

- An unconfined aquifer in the saturated sediments of the Hanford formation, and in some areas, within remnants of the Ringold Formation unit E
- A series of confined (or semiconfined) aquifers within the Ringold Formation
- A confined aquifer (within the Saddle Mountain Basalt Formation and the Rattlesnake Ridge interbed)

Figure 2-2 shows, on the right side, a generalized hydrostratigraphic column for the 100-H Area.

The vadose zone (unsaturated zone) extends from ground surface to the water table of the uppermost aquifer. Also called the zone of aeration, it includes the soil at the surface, the capillary fringe zone above the principal water bearing zone, the periodically rewetted zone, and the combined rock, soil, air, and moisture interface linking the water table to the vadose zone. As the water table fluctuates in response to river stage and changes in recharge rates, the periodically rewetted zone experiences either saturated or unsaturated conditions. The capillary fringe is the edge of that wetted surface where water seeps into the vadose zone material because of tension saturation. The thickness of the capillary fringe is typically small in sand and gravel formations (e.g., a centimeter or two), whereas the periodically rewetted zone in areas near the river may be as much as 2 m (6 ft) thick. The dominant stratigraphic unit in the vadose zone underlying 100-H is the Hanford formation.

The unconfined aquifer is the zone between the water table and the surface of the RUM. At 100-H, the unconfined aquifer is primarily present in the Hanford formation, since the Ringold Formation unit E is absent in most locations. The unconfined aquifer thickness at 100-HR-3 generally thins from west to east from 100-D toward 100-H. Thickness of the unconfined aquifer ranges from near 0 to 12 m (39 ft) across the area. At the 183-H Solar Evaporation Basins, the aquifer is approximately 1.5 m (5.0 ft) thick, with some seasonal variation. Aquifer thickness is greater beneath 100-D, where the unconfined aquifer matrix consists solely of Ringold Formation unit E sediments. The unconfined aquifer matrix in the 100-H Area consists of Hanford formation sediments where Ringold Formation unit E sediments are typically absent because of erosion. However, some remnants of unit E are present locally. The aquifer is also influenced by the river stage, which causes fluctuations in the water table. Areas closest to the river are most affected by these fluctuations, with the effect muted farther inland (DOE/RL-2010-95).

The upper confined aquifer occurs within the silty clayey sand to sandy silty clay unit of the Ringold Formation. As presented in Section 2.4.1, the stratigraphic units identified within the Ringold Formation in the 100-H Area include the RUM, the Ringold unit B, the lower mud, and Ringold unit A. Aquifers found below the upper surface of the RUM are typically confined or semiconfined, but leakage between the units may also occur. A basalt-confined aquifer occurs within the uppermost basalt flow of the Saddle Mountains Basalt Formation and the Rattlesnake Ridge interbed.

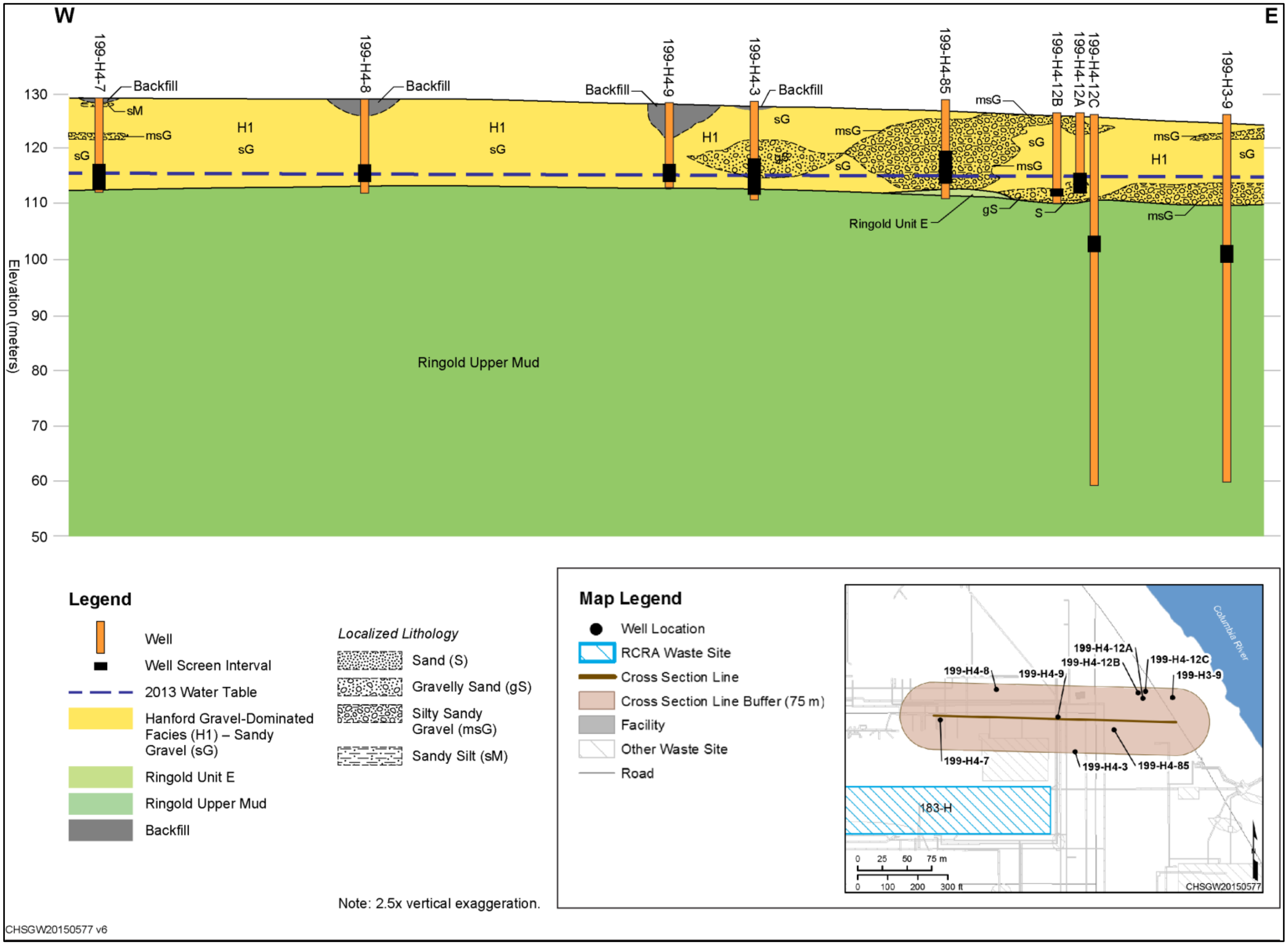


Figure 2-3. West-East Geologic Cross Section Showing the Stratigraphy Underlying the 183-H Solar Evaporation Basins

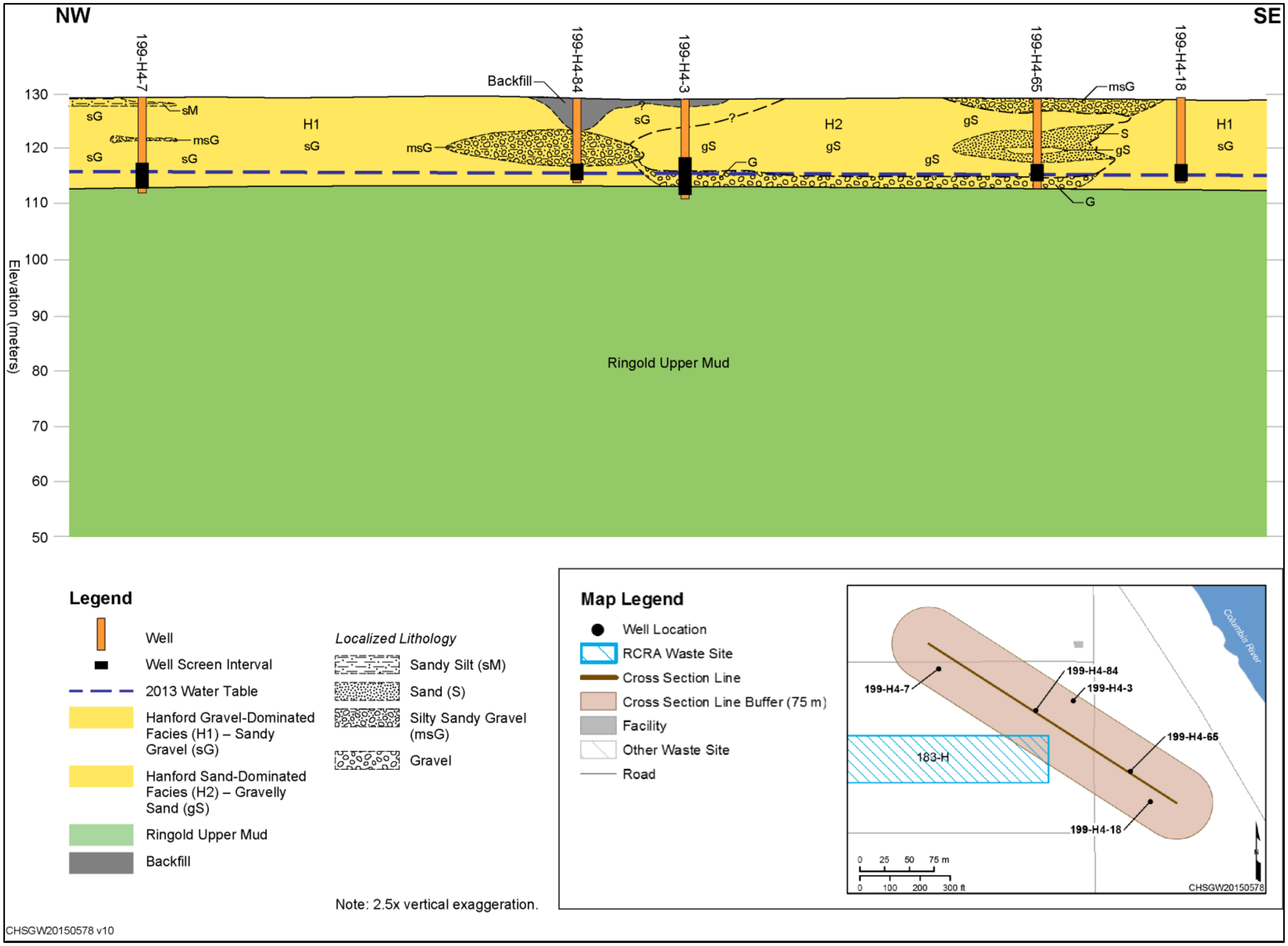


Figure 2-4. Northwest-Southeast Geologic Cross Section Showing the Stratigraphy Underlying the 183-H Solar Evaporation Basins

2.4.3 Groundwater Flow Interpretation

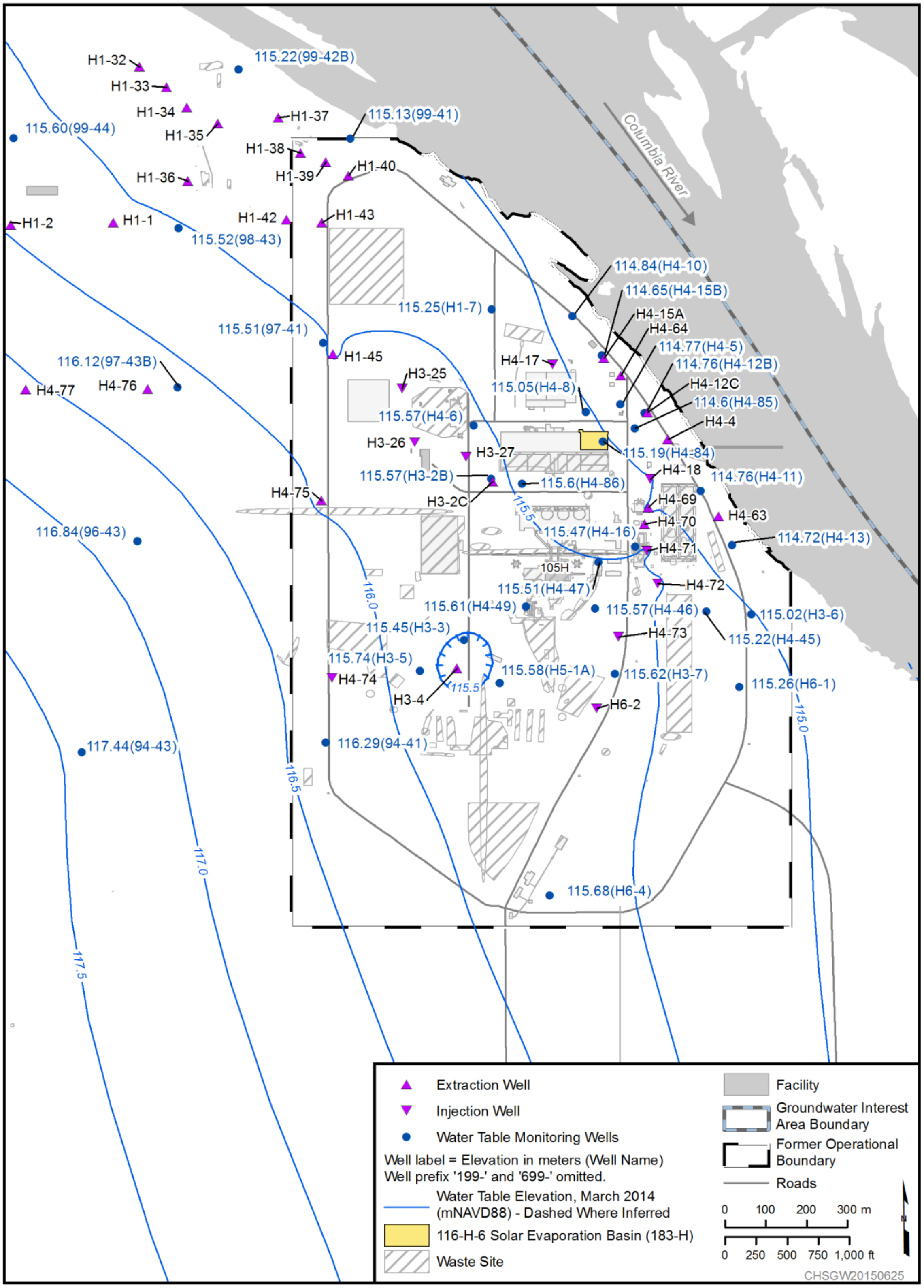
Groundwater generally flows from west to east in the uppermost aquifer beneath the 100-H Area and discharges to the Columbia River. The direction of groundwater flow is interpreted from water table elevations (Figure 2-5).

The water table is affected by daily and seasonal fluctuations in river stage, depending on dam operation upstream. Fluctuations in river stage cause hydraulic gradients in the aquifer immediately adjacent to the shoreline to be highly variable. When the river stage is high for weeks or months, the hydraulic gradient in the aquifer reverses near the river, and river water can flow into the aquifer. When the river level drops, this water flows from the bank back into the river.

Operation of the HX pump and treat system has created changes in groundwater flow direction and velocity. These changes are expressed as local depressions and mounds in the water table, affecting the local flow direction and gradient, primarily in the unconfined aquifer. However, the flow directions and gradients experienced during low and high river stage have a greater effect in wells adjacent to the river.

The groundwater flow at the 183-H Solar Evaporation Basins is primarily toward the river (east-northeast) during most of the year. Figures 2-6 and 2-7 present the water table maps for low and high river stage, respectively. The low river stage illustrates groundwater flow heading toward the river with isolated areas of effect from the pump and treat extraction well cones of depression or injection well mounding.

Water levels in the RUM are currently under the effects of the remediation system, which is extracting water from two locations (Well 199-H3-2C and 199-H4-12C). In areas where extraction is not taking place, the head value for the RUM well is generally slightly lower than the overlying unconfined aquifer, indicating a downward gradient. However, this is not consistent across 100-H Area, and not all RUM wells have a nearby well in the unconfined aquifer to use for comparison.



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

Figure 2-5. Water Table Map for 100-H Area (March 2014)

2.5 Summary of Previous Groundwater Monitoring

Table 2-1 lists the previous groundwater monitoring plans implemented at the 183-H Solar Evaporation Basins.

Table 2-1. Previous Monitoring Plans

Document	Date Issued	Monitoring Program
Revised Ground-Water Monitoring Compliance Plan for the 183-H Solar Evaporation Basins (PNL-6470)	1986	Interim Status Compliance[a]
Interim Status Closure/Post-Closure Plan 183-H Solar Evaporation Basins (DOE/RL-88-04)	1988	Interim Status Compliance[a]
Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins (WHC-SD-EN-AP-180)	1995	Final Status Compliance[b]
Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins (PNNL-11573)[c]	1997	Final Status Corrective Action[d]

a. The compliance monitoring programs in PNL-6470 and DOE/RL-88-04 were developed to satisfy the requirements in 40 CFR 265.90, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” “Applicability,” and WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards.”

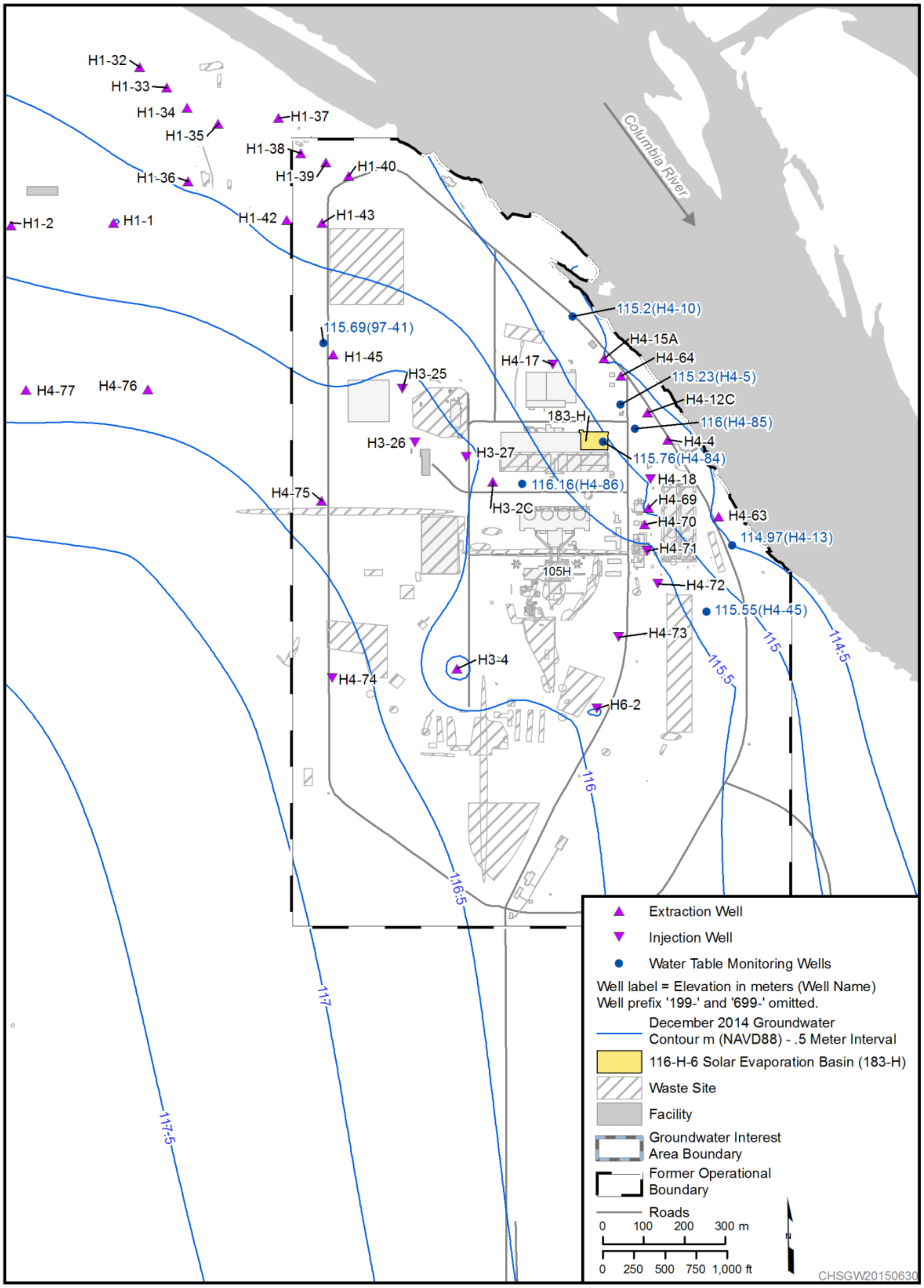
b. The compliance monitoring program satisfied the requirements of WAC 173-303-645(10), “Dangerous Waste Regulations,” “Releases from Regulated Units,” “Compliance Monitoring Program.”

c. The requirements identified in PNNL-11573 were incorporated in the Hanford Facility RCRA Permit (WA7890008967).

d. The corrective action monitoring program satisfies the requirements of WAC 173-303-645(11), “Dangerous Waste Regulations,” “Releases from Regulated Units,” “Corrective Action Program.”

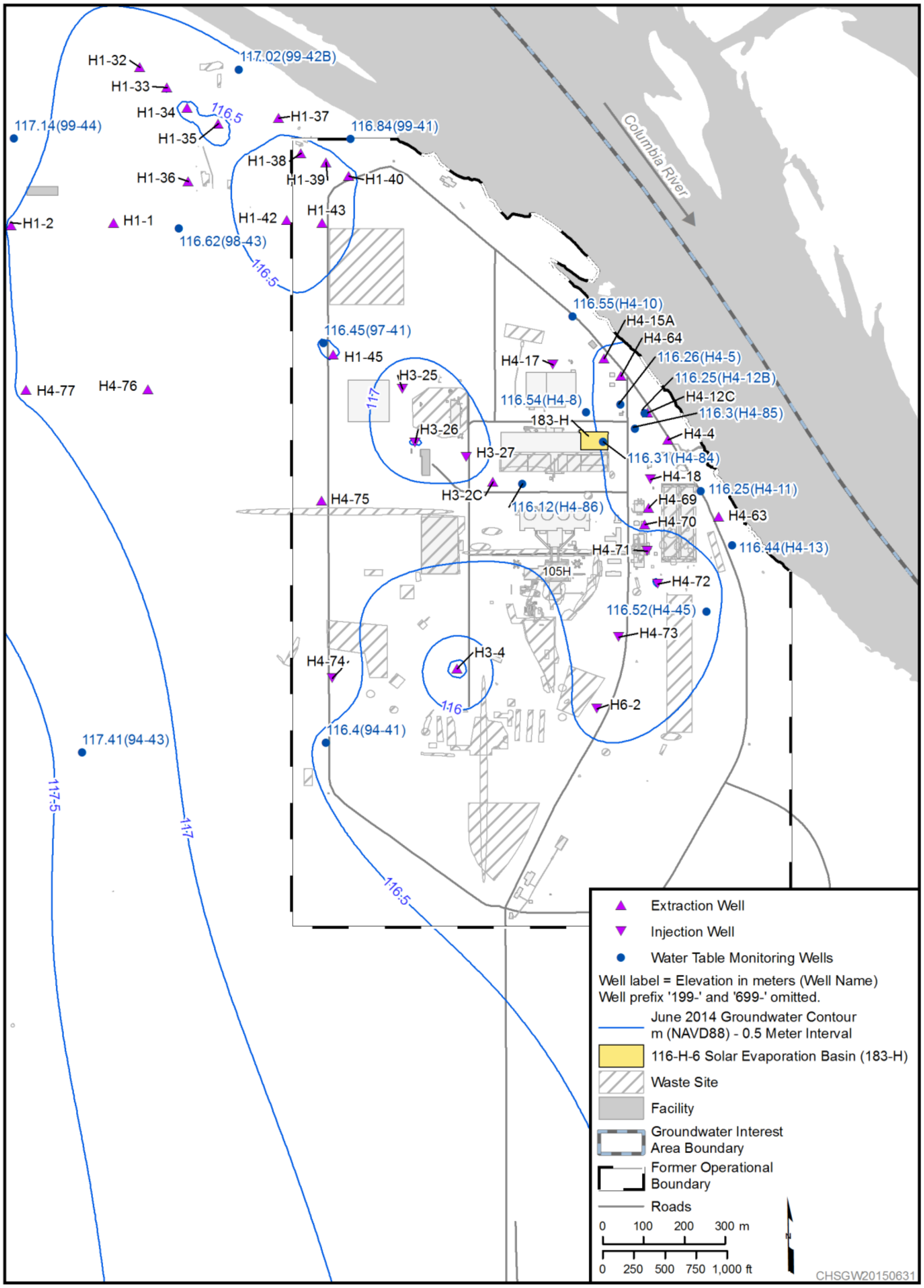
Limited groundwater monitoring was conducted during the operational life of the 183-H Solar Evaporation Basins (1973 to 1985). Four wells were installed: one in 1974 and three in 1983. These wells were sampled for a limited suite of analytes as part of a routine monitoring program. Analytical sampling results from the early 1970s indicated the presence of groundwater contamination associated with Basin 1. Due to known groundwater contamination, a facility-specific, RCRA compliance groundwater monitoring program for the 183-H Solar Evaporation Basins started in June 1985, as described in PNL-6470.

The compliance monitoring program presented in PNL-6470 was intended to meet 40 CFR 265.90(d), “Applicability,” and WAC 173-303-400 but was determined to have an inadequate well network by Ecology. This determination resulted in a regulatory order (EPA and Ecology, 1986). In 1986 and 1987, 18 monitoring wells were installed, and a compliance plan was developed in response to the regulatory order (EPA and Ecology, 1986). The suite of analytes for monitoring was expanded to include temperature, pH, specific conductance, coliform bacteria, metals, anions, volatile and semi-volatile organic compounds, selected organic constituents, pesticides, herbicides, total organic halogens, total organic carbon, ammonium ion, total alpha-emitters, total beta-emitters, gamma emitters, radium, uranium, and strontium-90.



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

Figure 2-6. Water Table Contours (December 2014; Low River Stage)



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

Figure 2-7. Water Table Contours (June 2014; High River Stage)

Initial monitoring data indicated that most of the analytes were below regulatory standards and continued monitoring was no longer needed. The monitoring program was subsequently modified. The updated program was described in DOE/RL-88-04. Like the 1986 monitoring program (PNL-6470), DOE/RL-88-04 addressed the interim status requirements then in effect. Under the 1988 plan (DOE/RL-88-04), 23 wells surrounding the basins were to be sampled on a quarterly and annual basis until closure activities were concluded and during the post-closure period.

The 1994 RCRA Permit (WA7890008967) for the Hanford Site (Ecology, 1994) required groundwater monitoring programs under final status to comply with requirements of WAC 173-303-645. Accordingly, a final status compliance monitoring program for the 183-H Solar Evaporation Basins (WHC-SD-EN-AP-180) began in 1995. Previous monitoring had included up to 23 wells, many of which were outside the area influenced by the basins. Information from these wells defined the contaminant plume boundaries and provided groundwater chemistry data for the larger 100-H Area. The wells identified in WHC-SD-EN-AP-180 were intended to meet the requirements of compliance monitoring of the identified constituents of concern (nitrate, chromium, uranium, and technetium-99) and represented conditions upgradient of the basins as well as in the most contaminated zone downgradient of the basins. The network consisted of eight wells: 199-H4-6 and 199-H3-2A (upgradient) and 199-H4-3, 199-H4-4, 199-H4-9, 199-H4-12A, 199-H4-18, and 199-H4-12C (downgradient). Groundwater samples were collected semiannually and analyzed for nitrate, chromium, uranium, and technetium-99.

The first sample set collected under the 1995 compliance monitoring plan showed that downgradient concentrations of nitrate, chromium, uranium, and technetium-99 exceeded concentration limits identified in the monitoring plan (WHC-SD-EN-AP-180). The exceedance was reported to Ecology through a letter in 1996 (Furman, 1996). Corrective action groundwater monitoring at the 183-H Solar Evaporation Basins, as required in WAC 173-303-645(11), was then initiated in 1997 under PNL-11573. The corrective action groundwater monitoring plan (PNNL-11573) was incorporated into the post-closure plan (DOE/RL-97-48) in 1997 and the RCRA Permit (WA7890008967). The correction action was deferred to the interim remedial action under CERCLA for the 100-HR-3 Groundwater OU.

Groundwater monitoring under PNNL-11573 included sampling from a network of four wells (199-H4-3, 199-H4-7, 199-H4-12A, and 199-H4-12C). These wells were identified based on their location within the chromium plume and met the monitoring objective of tracking concentration trends in the chromium plume during the IRM. Samples were collected annually and analyzed for dangerous waste constituents (chromium and nitrate), waste indicators (technetium-99 and uranium), additional constituents to aid data interpretation (alkalinity, anions, and selected metals), and field parameters (pH, specific conductance, temperature, and turbidity). Fluoride was also monitored as an indicator of 183-H contamination in groundwater. Water level measurements were collected each time a sample was obtained from a network well. Hexavalent chromium samples were often collected as well, as part of the CERCLA monitoring program. The hexavalent chromium plume for high and low river stage of 2014 are presented in Figures 2-8 and 2-9. The hexavalent chromium plume near Well 199-H4-86, shown on Figure 2-8, is likely associated with waste site 100-H-46, while the plume near the river appears to be associated with the 183-H Solar Evaporation Basins (Figure 2-8 and 2-9).

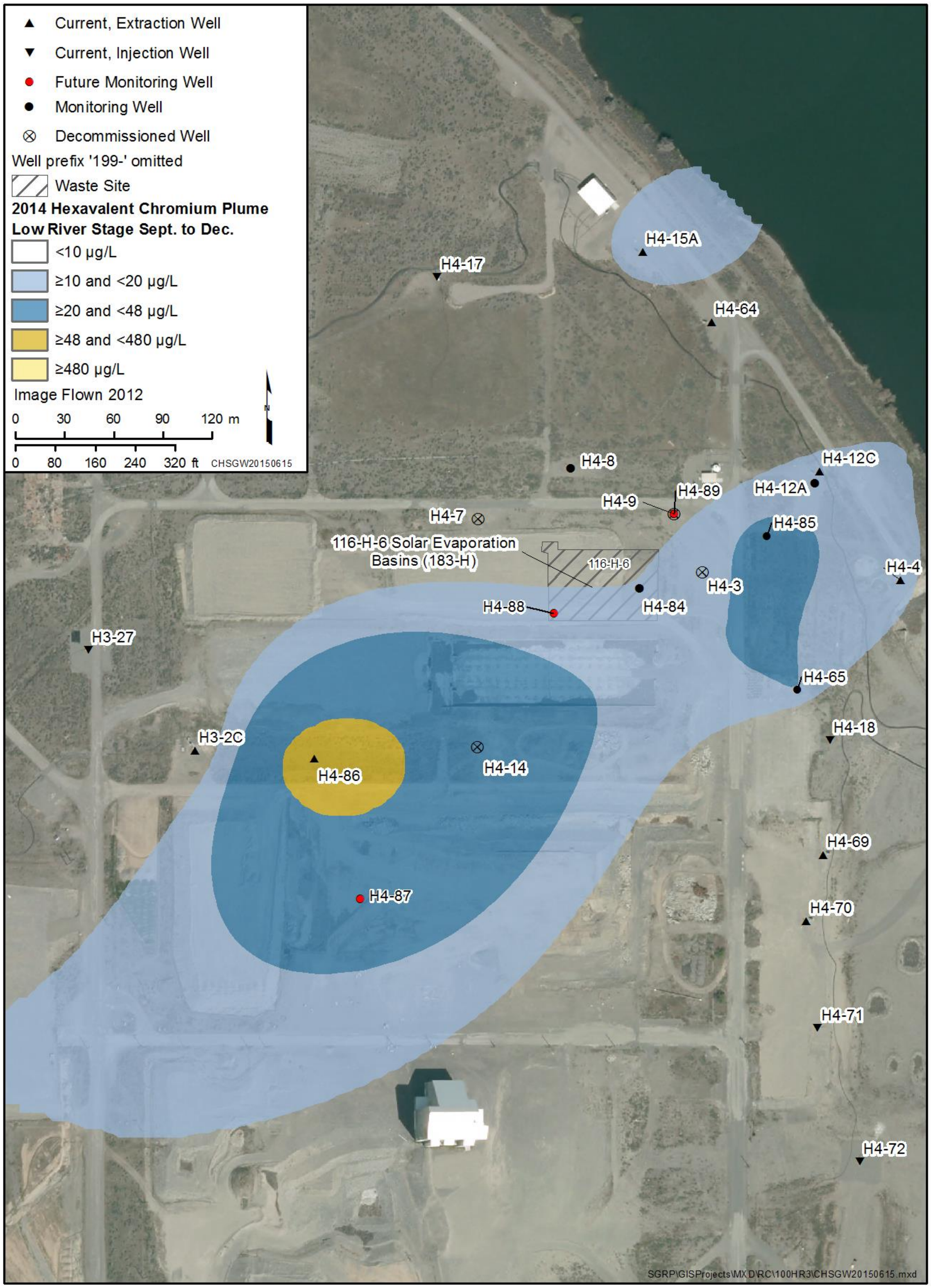


Figure 2-8. 2014 Hexavalent Chromium Plume during Low River Stage

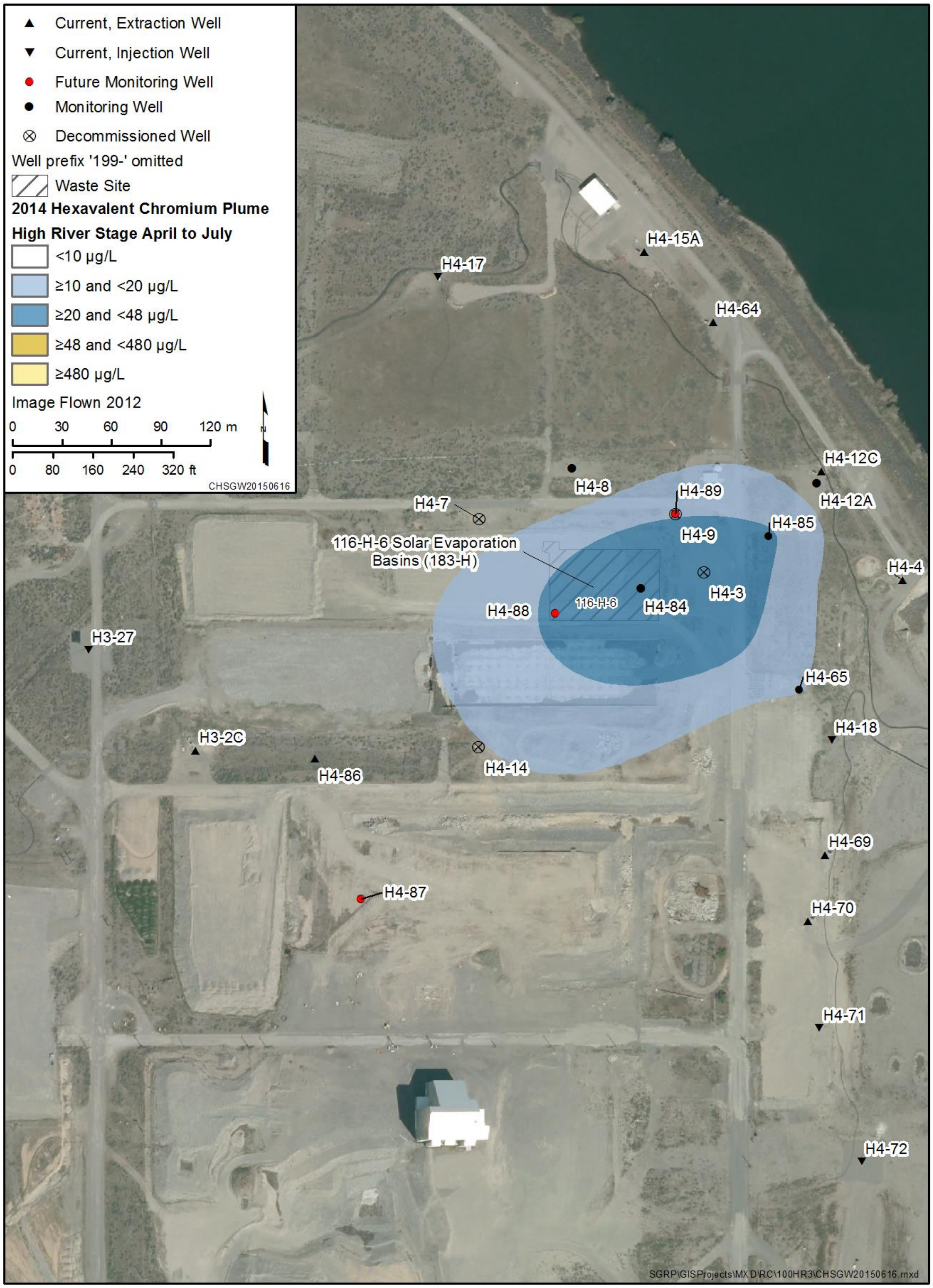


Figure 2-9. 2014 Hexavalent Chromium Plume during High River Stage

Since its issuance in 1997, two changes to the well network identified in PNNL-11573 were made to accommodate waste site remediation. In 2005, Well 199-H4-7 was removed from the monitoring network and replaced with Well 199-H4-8. The RCRA Permit (WA7890008967) was modified to incorporate this change. In 2013, the permit was again modified to change the monitoring network because Well 199-H4-3 required decommissioning due to its proximity to an active soil remediation site. Well 199-H4-84 was added to the network in May 2013 to replace 199-H4-3. Ecology approved this revision by letter (13-NWP-051, “Approval of 13-EMD-0019, Class 2 Modification to the Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste, Part VI, Post-Closure Unit 2, 183-H Solar Evaporation Unit (T-1-4) WA7890008967”).

Chromium at the 183-H Solar Evaporation Basins is attributed to both the waste disposal activities at the basins and from other sources. The 1996 chromium plume clearly demonstrates the upgradient contribution (Figure 2-10). Chromium continues to be present at the basins and monitoring under RCRA will continue.

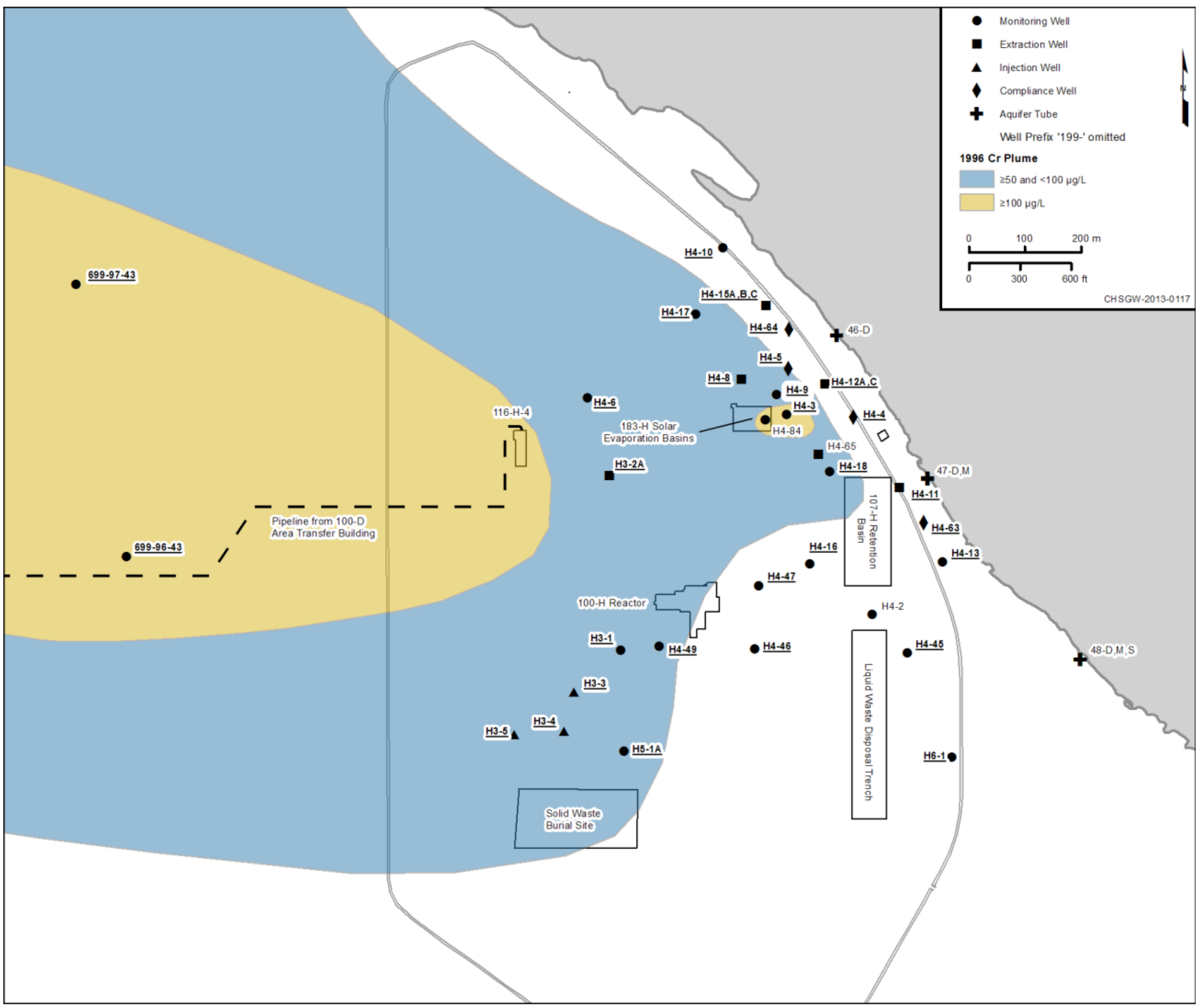


Figure 2-10. 100-H Area Chromium Plume in 1996

Other contaminants that are not dangerous wastes (nitrate, uranium, technetium-99 and fluoride) are removed from the 183-H Solar Evaporation Basins RCRA monitoring under this plan. As with chromium, nitrate contamination was the result of multiple sources. Historically, the highest concentrations of nitrate were found in Well 199-H4-18 and Well 199-H4-69, located to the south of the basins. Monitoring for nitrate will continue under the CERCLA program. Uranium is attributed to the basins and monitoring of uranium will continue under CERCLA. Technetium-99 concentrations have been below the maximum contaminant level (MCL) since 2005, and fluoride has not been detected above the MCL. Monitoring of technetium-99 and fluoride will be discontinued.

Under this monitoring plan, the network is modified to include the three existing monitoring wells and two additional monitoring wells scheduled for installation in fiscal year (FY) 2016, and the sampling frequency is modified from annual to semiannual. However, until the two planned wells are installed and accepted, Well 199-H4-12A will remain in the monitoring network. Samples are analyzed semiannually for total chromium (filtered) and field parameters under this plan. Water level measurements are collected each time a sample is obtained from a network well. Most of the network wells also are included in the annual comprehensive March water level measurement campaign (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). Groundwater monitoring results for the 183-H Solar Evaporation Basins are reported on a semiannual basis per WAC 173-303-645(11)(g) and are summarized annually in the annual groundwater monitoring report.

2.6 Conceptual Site Model

This section describes the 183-H Solar Evaporation Basins CSM for potential contaminant transport to guide future groundwater monitoring. The CSM (Figure 2-11) describes the current understanding of the contaminant release and transport.

The most likely sources of chromium contamination from the 183-H Solar Evaporation Basins included sodium dichromate dihydrate used for corrosion control in reactor cooling water when the basins were used as a water treatment facility and the liquid waste discharged into the basins when they were used as evaporation basins.

Source remediation removed the engineered structure and soil contaminants underneath the 183-H Solar Evaporation Basin as necessary to reduce or eliminate the potential for direct exposure migration through the vadose zone to the groundwater, and wind-blown suspended particles. Remediation extended to 0.6 m (2 ft) beneath each basin (2.7 m [9 ft] bgs total depth). Below Basin 1, additional soil was removed to depths of up to 4.6 m (15 ft) below the former structure (DOE/RL-97-48). Since removal of the source of contamination (the basin liquids) in the late 1980s, contaminant concentrations in the groundwater have declined. However, at the time of closure, the extent of remaining contamination extended from a depth of 4.6 m (15 ft) below the bottom of the basin structure to groundwater, and appeared to include chromium, nitrate, and uranium.

An evaluation of the borehole and test pit sample results for the 183-H Solar Evaporation Basins was performed as part of the CERCLA remedial investigation/feasibility study conducted in 2009 through 2010 (DOE/RL-2010-95, Section 4.3.17). Contaminant distribution in individual boreholes indicated that technetium-99, strontium-90, and tritium concentrations increased with depth, but their levels were typically <2 to 7 pCi/g. Nitrate reached a maximum of 304 mg/kg at 10.2 m (33.4 ft) bgs, while hexavalent chromium concentrations were <2 mg/kg beneath the site. Only eight contaminants (cobalt-60, technetium-99, antimony, cadmium, lead, selenium, nitrate, and fluoride) either were detected in the vadose zone (those with no background concentration established) or were present above background levels from boreholes adjacent to the site. Detecting fewer contaminants adjacent to the site suggests that transport was mainly vertical beneath the site with little lateral spreading in the vadose zone.

Hexavalent chromium and nitrate were the only contaminants detected above the MCLs in groundwater (48 µg/L and 45 mg/L, respectively) beneath this site in 2009, and only chromium is considered a dangerous waste.

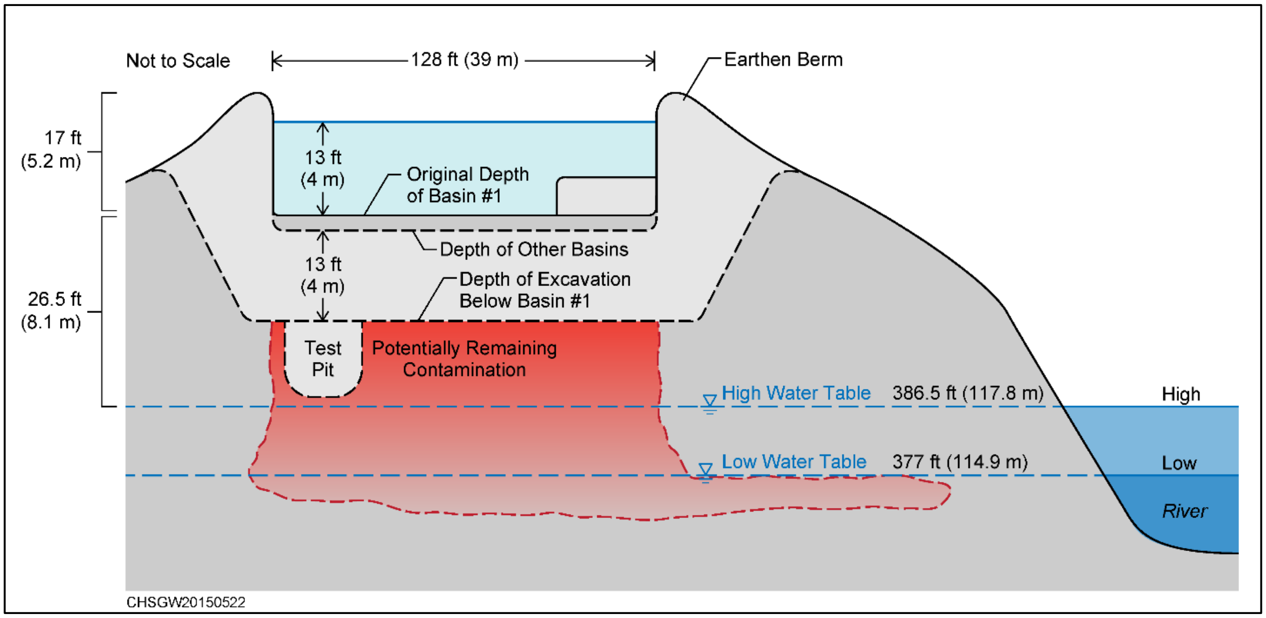


Figure 2-11. Conceptual Site Model for the 183-H Solar Evaporation Basins

The hydraulic and geochemical properties of this region control the downward movement of liquids and contaminants released near ground surface. Any residual contaminants that remain in the vadose zone after the cessation of waste discharges can migrate downward by any of four mechanisms:

- Contaminants may continue to move by gravity drainage of residual wastewater within the vadose zone (this process is not believed to be continuing at this time).
- Contaminants may be mobilized in the fraction of annual precipitation that actually percolates deep into the vadose zone to recharge into the aquifer.
- Contaminants may be mobilized into groundwater from the vadose zone during seasonal increases in groundwater table elevation resulting from high river stages.
- Contaminants may be mobilized in water added for dust control during remedial actions (for example, excavation) and migrate deeper into the vadose zone.

At 183-H, chromium continues to be detected in the groundwater at the site. This indicates the chromium is present in the vadose zone soil. During periods of high river stage, some of this chromium is released into the groundwater. Chromium concentrations appear to fluctuate seasonally in response to changing river stage at the 183-H Solar Evaporation Basins. The chromium concentrations typically rise when groundwater elevations are low in the wells located downgradient from the basins. This correlation is also seen in specific conductance, indicating that there is less river water in the aquifer during low water periods. This further suggests there is remaining contamination in the vadose zone that is mobilized to groundwater during elevated water table periods. The chromium concentrations in the vicinity of the 183-H Solar Evaporation Basins have been below 100 µg/L in the unconfined aquifer since 2001 (as shown in Appendix D). Chromium concentrations within the first water bearing unit of the RUM continue to have chromium concentrations near 120 µg/L, however the contamination in that aquifer have been determined to not originate from the basins and monitoring of that aquifer is not included in this plan.

2.7 Monitoring Objectives

The groundwater monitoring program at the 183-H Solar Evaporation Basins is conducted with the objectives identified in WAC 173-303-645, as required by the RCRA Permit (WA7890008967), Part II, Condition II.F. Corrective action groundwater monitoring is implemented in accordance with WAC 173-303-645(11), which requires the establishment and implementation of a groundwater monitoring program that is capable of demonstrating the effectiveness of the corrective action, currently pump and treat. This requirement states two general objectives:

- The corrective action groundwater monitoring program may be based on the requirements for a compliance monitoring program under WAC 173-303-645(10) and must be as effective as that program in determining compliance with the groundwater protection standard under WAC 173-303-45(3).
- Monitoring during corrective actions must be capable of determining the effectiveness of the corrective action program.

Table 2-2 identifies where each groundwater monitoring element of the pertinent applicable regulations is addressed within this plan.

Table 2-2. Pertinent WAC 173-303-645 Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
Corrective Action Program	WAC 173-303-645(11) “Corrective Action Program”: (a) Corrective action to ensure that regulated units are in compliance with WAC 173-303-645(3). The groundwater protection standard will be specified in the facility permit, including: (i) A list of the dangerous constituents and parameters identified under WAC 173-303-64(4); (ii) Concentration limits under WAC 173-303-645(5), for each of those dangerous constituents and parameters; (iii)The compliance point under WAC 173-303-645(6); and (iv) The compliance period under WAC 173-303-645(7).	Section 3.1 Section 3.2 Section 3.3 Section 3.4
Groundwater Protection Standard	WAC 173-303-645(3) “Groundwater Protection Standard”: Conditions specified in the facility permit are designed to ensure that dangerous constituents under WAC 173-303-645(4), detected in the groundwater from a regulated unit do not exceed the concentration limits under WAC 173-303-645(5), in the uppermost aquifer underlying the waste management area beyond the point of compliance under WAC 173-303-645(6), during the compliance period under WAC 173-303-645(7).	Section 3.2

Table 2-2. Pertinent WAC 173-303-645 Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
Dangerous Constituents	WAC 173-303-645(4) "Dangerous Constituents": (a) The facility permit will specify the dangerous constituents to which the groundwater protection standard of WAC 173-303-645(3) applies.	Section 3.1
Concentration Limits	WAC 173-303-645(5) "Concentration Limits": (a) The facility permit will specify concentration limits in the groundwater for the dangerous constituents established under WAC 173-303-645(4) of this section. (ii) For constituents listed in Table 1, the concentration limit must not exceed the value given in that table if the background level of the constituent is below the value given in Table 1.	Section 3.2
Point of Compliance	WAC 173-303-645(6) "Point of Compliance": The facility permit will specify the point of compliance at which the groundwater protection standard WAC 173-303-645(3) applies and at which monitoring must be conducted. The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.	Section 3.3
Compliance Period	WAC 173-303-645(7) "Compliance Period": (a) The facility permit will specify the compliance period during which the groundwater protection standard of WAC 173-303-645(3) applies. The compliance period is the number of years equal to the active life of the waste management area (including any waste management activity prior to permitting, and the closure period). (c) If the owner or operator is engaged in a corrective action program at the end of the compliance period specified in (a), the compliance period is extended until the owner or operator can demonstrate that the groundwater protection standard of WAC 173-303-645(3) has not been exceeded for a period of three consecutive years.	Section 3.4 Section 4.2 Appendix D
Number and Location of Wells	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (a) The groundwater monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that: (i) Represent the quality of background groundwater that has not been affected by leakage from a regulated unit; (ii) Represent the quality of groundwater passing the point of compliance. (iii) Allow for the detection of contamination when dangerous waste or dangerous constituents have migrated from the waste management area to the uppermost aquifer.	Section 3.5

Table 2-2. Pertinent WAC 173-303-645 Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
Well Configuration	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must allow collection of representative groundwater samples. Wells must be constructed in such a manner as to prevent contamination of the samples, the sampled strata, and between aquifers and water bearing strata. Wells must meet the requirements applicable to resource protection wells, which are set forth in Chapter 173-160 WAC, "Minimum standards for construction and maintenance of wells."	Section 3.5 Appendix C
Parameters to be Sampled Frequency of Sampling Water Level Measurements	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (e) The groundwater monitoring program must include consistent sampling and analytical methods that ensure reliable groundwater sampling, accurately measure dangerous constituents and indicator parameters in groundwater samples, and provide a reliable indication of groundwater quality below the waste management area. (f) The groundwater monitoring program must include a determination of the groundwater surface elevation each time groundwater is sampled. (g) The owner or operator will determine an appropriate sampling procedure and interval for each hazardous constituent listed in the facility permit.	Section 3.1 Appendix B, Section B1-2
Statistical Evaluation Statistical Methods	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (h) Groundwater monitoring data will be evaluated using a specified statistical method. The statistical test will be conducted separately for each dangerous constituent in each well. A statistical method not specified in the subsection may be submitted for approval. (i) The statistical method must be appropriate for the distribution of the dangerous constituent. The practical quantification limit used in the statistical method must be the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.	Section 4.2 Appendix A, Section A3-1
Recordkeeping and Reporting	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (j) Groundwater monitoring data collected in accordance with WAC 173-303-645(8)(g) including actual levels of constituents must be maintained in the facility operating record. The permit specifies when the data must be submitted for review. WAC 173-303-645(11) "Corrective Action Program": (g) Reports on the effectiveness of the corrective action program must be submitted semiannually.	Section 4.4 Appendix A, Sections A1.6 and A2.9

Note: Complete citations for references listed in this table are provided in Chapter 5 of this plan.

* Part II, Condition II.F of the Hanford Facility RCRA Permit (WA7890008967) specifies that a groundwater monitoring program under final status is subject to the requirements of WAC 173-303-645. Because of previous exceedances of the

Table 2-2. Pertinent WAC 173-303-645 Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
prescribed concentration limits identified in the previous monitoring plan (PNNL-11573), the 183-H Solar Evaporation Basins are subject to corrective action monitoring under WAC 173-303-645(11).		
WAC = *Washington Administrative Code*		

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3 Groundwater Monitoring Program

This chapter describes the corrective action groundwater monitoring program for the 183-H Solar Evaporation Basins consisting of a monitoring well network, dangerous waste constituent, field parameters, concentration limit, point of compliance, compliance period, and sampling and analysis protocols. The monitoring program presented herein has been revised from that presented in the previous plan (PNNL-11573).

3.1 Constituents List and Sampling Frequency

Table 3-1 presents the wells in the groundwater monitoring network, constituents analyzed as required for RCRA monitoring, and sampling frequency for monitoring of the 183-H Solar Evaporation Basins. The dangerous waste constituent identified for the 183-H Solar Evaporation Basins is total chromium, collected as a filtered sample. The sampling frequency in this revised plan is changed from annual to semiannual to align with semiannual reporting requirements under WAC 173-303-645(11)(g). Total chromium (filtered) will be sampled semiannually with collection scheduled during low river stage (typically September through December) and high river stage (typically April through August). Field parameters (pH, specific conductance, temperature, dissolved oxygen, and turbidity) will also be sampled semiannually. New wells (199-H4-88 and 199-H4-89) will be sampled quarterly for the first 2 years to collect sufficient samples to support statistical evaluation (Section 4.2). Water level measurements at each monitoring well will be determined each time a sample is obtained (WAC 173-303-645(8)(f)).

Maintenance problems and sampling logistics sometime delay scheduled sampling events. Sampling events are scheduled by month. The Field Work Supervisor (FWS) determines the specific times within a given month that a well is sampled. If a well cannot be sampled at the times determined by the FWS, then the FWS and Sampling Management and Reporting group, along with the project scientist, consult on how best to recover or reschedule the sampling event as close to the original sampling date as possible. Missed sampling events that are not rescheduled within the same month are given top priority when rescheduling in the following month. In the case of sampling at the 183-H Solar Evaporation Basins, ongoing CERCLA sampling is also being conducted, and the missed sample can typically be collected within the same quarter as scheduled. Missed or cancelled sampling events are reported to DOE-RL, at the appropriate Unit Managers Meeting, in the semiannual monitoring reports required by WAC 173-303-645(11)(g), and the annual groundwater monitoring report.

3.2 Concentration Limit

Dangerous waste constituents from the regulated waste unit may not exceed concentration limits established by the RCRA Permit (WA7890008967) (WAC 173-303-645[5]). The concentration limit for total chromium (collected as a filtered sample) in the previous plan (PNNL-11573) was 122 µg/L. This value was determined in WHC-SD-EN-AP-180, based on background concentrations of upgradient wells 199-H3-2A and 199-H4-6. The concentration limit was applied during compliance monitoring to determine whether corrective action was necessary as required by WAC 173-303-645.

Concentration limits of dangerous waste constituents during corrective action are required in WAC 173-303-645(11). The concentration limit for total chromium (collected as a filtered sample) in this plan is 100 µg/L. This concentration represents the current background value and is also the MCL for chromium in 40 CFR 141, “National Primary Drinking Water Regulations,” and WAC 246-290-310, “Group A Public Water Supplies,” “Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs).” Because of the previous exceedances of the concentration limit for chromium and the ongoing remedial action, any concentration limit exceedances at the point of compliance during the remediation period do not require additional action.

3.3 Point of Compliance

The point of compliance is defined in WAC 173-303-645(6) as "...a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units." This is the location in the uppermost aquifer where groundwater monitoring occurs and the groundwater protection standard applies. Three existing wells (199-H4-8, 199-H4-84, and 199-H4-85) and two new wells (199-H4-88 and 199-H4-89) are located either at or near the 183-H Solar Evaporation Basins. Wells in the monitoring network (Section 3.5 and Figure 2-1) represent the point of compliance. The wells were identified based on their location in the contaminant plume, extending from the 183-H Solar Evaporation Basins to the Columbia River, and within the general groundwater flow direction toward the river (downgradient). The network wells are or will be screened in the unconfined aquifer.

The point of compliance wells will be monitored to assess the progress of the corrective action (CERCLA remedial action). Concentrations of total chromium (filtered) in these wells will be evaluated in accordance with Section 3.4 to determine if the compliance period can be ended.

3.4 Compliance Period

The compliance period (WAC 173-303-645(7)) for the 183-H Solar Evaporation Basins will end when the sample results for total chromium (filtered) in point of compliance wells (Section 3.3) have been below 48 µg/L for three years. The sampling results will be evaluated as described in Section 4.2. When the compliance period has ended, then corrective action monitoring will be discontinued, and the site will be closed and removed from the RCRA Permit (WA7890008967).

3.5 Monitoring Well Network

The current 183-H Solar Evaporation Basins monitoring network consists of five wells. Wells are not specified as upgradient or downgradient since the area is influenced by an active pump and treat system, however the groundwater flow is generally towards the river. Figure 2-1 shows the groundwater monitoring network, and information on the wells is summarized in Table 3-2. Wells 199-H4-3 and 199-H4-9 were decommissioned in 2013 in support of waste site remediation. Monitoring Well 199-H4-85 was installed to replace Well 199-H4-3, and Well 199-H4-89 will replace Well 199-H4-9 as described in DOE/RL-2012-45, *Sampling and Analysis Plan for Installation of 100-HR-3 Groundwater Operable Unit Replacement Wells* and TPA-CN-659.

As of the last network well change in 2013, the 183-H Solar Evaporation Basins monitoring network included four wells (199-H4-8, 199-H4-12A, 199-H4-12C, and 199-H4-84). This plan updates the monitoring network to remove Well 199-H4-12C, an extraction well that is completed in the first water bearing unit of the RUM unit, a confined aquifer. Chromium concentrations from Well 199-H4-12C are from historical releases at other sources and not attributable to the 183-H Solar Evaporation Basins. Also, Well 199-H4-12A is replaced with Well 199-H4-85, which is located closer to the waste site, is completed in the unconfined aquifer, and better represents the groundwater conditions at the 183-H Solar Evaporation Basins.

Table 3-1. Monitoring Well Network for the 183-H Solar Evaporation Basins

Well Name	Purpose	WAC Compliant	Dangerous Waste Constituents and Other Parameters*						
				Dangerous Waste Constituent	Field Parameters				
			Water Level	Total Chromium (Filtered)	pH	Specific Conductance	Temperature	Dissolved Oxygen	Turbidity
199-H4-8	Corrective Action Monitoring	Y	S	S	S	S	S	S	S
199-H4-12A[a]	Corrective Action Monitoring	Y	S	S	S	S	S	S	S
199-H4-84	Corrective Action Monitoring	Y	S	S	S	S	S	S	S
199-H4-85	Corrective Action Monitoring	Y	S	S	S	S	S	S	S
199-H4-88[b,c]	Corrective Action Monitoring	Y	Q	Q	Q	Q	Q	Q	Q
199-H4-88[b,d]	Corrective Action Monitoring	Y	S	S	S	S	S	S	S
199-H4-89 [b,c]	Corrective Action Monitoring	Y	Q	Q	Q	Q	Q	Q	Q
199-H4-89[b,d]	Corrective Action Monitoring	Y	S	S	S	S	S	S	S

* Monitoring as required under WAC 173-303-645(11), “Dangerous Waste Regulations,” “Releases from Regulated Units,” “Corrective Action Program.”

a. Until new Wells 199-H4-88 and 199-H4-89 are drilled and accepted, Well 199-H4-12A will remain in the monitoring network. After Wells 199-H4-88 and 199-H4-89 are accepted, Well 199-H4-12A will no longer be sampled.

b. Well to be drilled in fiscal year 2016.

c. Sampling frequency for the first 2 years of monitoring.

d. Sampling frequency following the first 2 years of monitoring.

Q = to be sampled quarterly
S = to be sampled semiannually
WAC = *Washington Administrative Code*
Y = well is, or will be, constructed as a resource protection well (WAC 173-160, “Minimum Standard for Construction and Maintenance of Wells”)

Table 3-2. Attributes for Wells in the 183-H Solar Evaporation Basins Groundwater Monitoring Network

Well Name	Completion Date	Easting[a] (m)	Northing[a] (m)	Top of Casing Elevation (m [ft]) NAVD88	Total Well Depth[b] (m [ft] bgs)	Water Table Elevation m (ft) amsl	Water Depth (m [ft] bgs)	Bottom of Screen Depth (m [ft] bgs)	Water Remaining (m [ft])	Water Table Measurement Date
199-H4-8	1986	577860.70	152921.70	129.2 (423.9)[c]	11.6 (38.1)	116.0 (380.6)	12.6 (41.3)	14.6 (47.9)	2.0 (6.6)	3/4/2015
199-H4-12A[d]	1986	578009.15	152912.73	127.2 (417.3)[c]	14.6 (47.9)	115.7 (379.6)	10.8 (35.4)	14.6 (47.9)	3.8 (12.5)	5/04/2015
199-H4-84	2011	577902.58	152848.73	128.7 (422.2)[e]	14.6 (47.9)	115.9 (380.6)	12.7 (41.7)	14.5 (47.6)	1.8 (5.9)	4/10/2015
199-H4-85	2013	577980.02	152880.81	128.8 (422.6)[f]	16.0 (52.5)	116.0 (380.6)	12.0 (39.4)	14.4 (47.2)	2.4 (7.9)	2/26/2015
199-H4-88 (FY 2016)	TBD	577850.40 (est)	152833.60(est)	TBD	TBD	TBD	TBD	TBD	TBD	NA
199-H4-89 (FY 2016)	TBD	577923.20 (est)	152893.90 (est)	TBD	TBD	TBD	TBD	TBD	TBD	NA

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

a. Coordinates are in NAD83, *North American Vertical Datum of 1988*.

b. Total depth of cased well, not drilled depth.

c. Elevation at top of casing.

d. Until new Wells 199-H4-88 and 199-H4-89 are drilled and accepted, Well 199-H4-12A will remain in the monitoring network. After Wells 199-H4-88 and 199-H4-89 are accepted, Well 199-H4-12A will no longer be sampled.

e. Elevation at top of outer casing.

f. Elevation at top of pump plate.

amsl	=	above mean sea level
bgs	=	below ground surface
est	=	estimated
FY	=	fiscal year
NA	=	not applicable
TBD	=	to be determined

Planned Wells 199-H4-89 (located downgradient) and 199-H4-88 (located in the southwest corner of the former 183-H Solar Evaporation Basins location) are added to the RCRA monitoring network and are planned for drilling in FY 2016. Until new Wells 199-H4-88 and 199-H4-89 are drilled and accepted, 199-H4-12A will remain in the monitoring network. Well 199-H4-12A will no longer be sampled after 199-H4-88 and 199-H4-89 are accepted.

In summary, upon Permit modification, the monitoring network will include existing wells 199-H4-8, 199-H4-84, and 199-H4-85 and new wells 199-H4-88 and 199-H4-89 (or 199-H4-12A until 199-H4-88 and 199-H4-89 are accepted).

If a well is within approximately 2 years of going dry, a replacement well will be proposed. All new RCRA wells proposed for installation at the Hanford Site are negotiated annually by Ecology, DOE, and EPA under Tri-Party Agreement Milestone (Ecology et al., 1989) M-24-00. At 100-H Area, the water table is not declining and is directly affected by the Columbia River, so that replacement for dry well conditions is highly unlikely.

Construction details and pertinent information for the wells are provided in Appendix C and include wells in the current network and those proposed. Some wells are co-sampled with other monitoring programs (e.g., monitored to meet CERCLA requirements). Monitoring requirements for those other monitoring programs are described in separate plans. The reported data from those other monitoring programs are supplementary to information gathered under this plan.

3.6 Differences between This Plan and Previous Plan

Table 3-3 identifies the main differences between this plan and the previous groundwater monitoring plan.

Table 3-3. Main Differences between This Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
Constituents	Dangerous Wastes: Chromium (collected as a filtered sample), Nitrate	Dangerous Waste: Total chromium (collected as a filtered sample)	Only dangerous waste is monitored in this revised plan. Nitrate, uranium, technetium-99, and fluoride are not dangerous wastes and are not monitored.
	Waste Indicators: Uranium, Technetium-99, Fluoride	None	
	Additional constituents to aid data interpretation: alkalinity, anions, and metals	None	Alkalinity, anions, and metals will be collected under CERCLA monitoring if needed.
	Field parameters: pH, specific conductance, temperature, turbidity	Field parameters: pH, specific conductance, temperature, turbidity, dissolved oxygen	Dissolved oxygen added as a field parameter to supplement dissolved chromium results.

Table 3-3. Main Differences between This Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
Concentration Limit	Total chromium at 122 µg/L: based on background determination from two upgradient wells	Total chromium (filtered) at 100 µg/L will be used as background. The 100 µg/L concentration is also the MCL for chromium (40 CFR 141 and WAC 246-290-310).	Updated to current background value and MCL
Point of Compliance	Not identified at the onset of corrective action (pump and treat)	Wells in the RCRA monitoring network	Allows for comparison to the concentration limit and the compliance period standard during the CERCLA remedial action
Sampling Frequency	Annual	Semiannual	Alignment with semiannual reporting.
Well Network	3 wells in unconfined aquifer and 1 well in confined aquifer: 199-H4-3 (199-H4-8) 199-H4-7 (199-H4-84) 199-H4-12A 199-H4-12C	5 wells in unconfined aquifer: 199-H4-8 199-H4-84 199-H4-85 199-H4-88 (FY 2016) 199-H4-89 (FY 2016) 199-H4-12A[b]	Well 199-H4-12C is removed from the network because it is below the unconfined aquifer and monitors contamination from other sources. Well 199-H4-12A is replaced with 199-H4-85, which is closer to the site, and better represents the groundwater conditions. Wells 199-H4-3 and 199-H4-7 were previously replaced with Wells 199-H4-8 and 199-H4-84, respectively. Planned Wells 199-H4-88 and 199-H4-89 added to define the point of compliance.
Groundwater Flow Direction	Generally toward the river (east-northeast), and affected by the pump and treat system	Same	No change
Type of Groundwater Monitoring Program	Corrective Action	Same	No change
Compliance Period	As defined in WAC 173-303-645(7): Number of years equal to the active life of the waste management area (including any waste management activity prior to permitting and the closure period).	The compliance period will end when the sample results for total chromium (filtered) in the point of compliance wells have been below 48 µg/L for three years.	Identifies requirement to demonstrate that further RCRA monitoring is not required.

Table 3-3. Main Differences between This Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
	If corrective action is engaged at the end of the compliance period, then the compliance period is extended until it can be demonstrated that the concentration limit has not been exceeded for a period of three consecutive years.		
Statistical Evaluation	Not identified at the onset of corrective action (pump and treat)	95 percent UCL on the mean, targeting 8 to 10 samples. Calculation of the 95 percent UCL is not performed for data sets that are less than the concentration limit. Also, the practical quantitation limit must be less than the concentration limit.	Evaluation methods will be used to determine if the corrective action (CERCLA remedial action) is progressing as expected and demonstrate that the concentration limit has been achieved.

a. Previous plan is PNNL-11573, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*.

b. Until new Wells 199-H4-88 and 199-H4-89 are drilled and accepted, 199-H4-12A will remain in the monitoring network. After Wells 199-H4-88 and 199-H4-89 are accepted, 199-H4-12A will no longer be sampled.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR = *Code of Federal Regulations*
MCL = maximum contaminant level
RCRA = *Resource Conservation and Recovery Act of 1976*
UCL = upper confidence interval
WAC = *Washington Administrative Code*

The previous monitoring plan (PNNL-11573) included chromium and nitrate as dangerous waste constituents and technetium-99 and uranium as waste indicators. Fluoride was monitored as an indicator of 183-H Solar Evaporation Basins contamination in groundwater. Additional constituents to aid data interpretation, alkalinity, anions, and metals were analyzed. Field parameters pH, specific conductance, temperature, and turbidity were also included.

This revised plan monitors only dangerous waste and, therefore, includes monitoring only for total chromium (collected as a filtered sample). Field parameters routinely collected at the wellhead are retained and measurement of dissolved oxygen is added to monitor the potential for reduction. Nitrate, uranium, technetium-99, and fluoride are not dangerous waste in 40 CFR 261, “Identification and Listing of Hazardous Waste,” and are not included in this monitoring plan. Collection of alkalinity, anions, and metals is not included; however, these analyses are routinely performed for multiple nearby wells as part of the IRM monitoring.

The sampling frequency in this revised plan is changed from annual to semiannual to align with semiannual reporting requirements under WAC 173-303-645(11)(g).

The concentration limit in the previous plan for chromium (122 µg/L) was determined in 1995 using two upgradient wells to represent the background concentration. The concentration limit for total chromium (filtered) in this plan is 100 µg/L, the current background concentration. This value is also the MCL for chromium (40 CFR 141 and WAC 246-290-310).

The previous plan from 1997 included Wells 199-H4-3, 199-H4-7, 199-H4-12A, and 199-H4-12C. In 2005, Well 199-H4-7 was removed from the monitoring network and replaced with 199-H4-8. Well 199-H4-3 required decommissioning in 2013 and was replaced with 199-H4-84. Well 199-H4-12C is removed from the monitoring network because it is completed in the confined aquifer and contaminants detected in this well are not associated the 183-H Solar Evaporation Basins. Monitoring Well 199-H4-12A is replaced with Well 199-H4-85, which is located closer to the waste site, is completed in the unconfined aquifer, and better represents the groundwater conditions at the 183-H Solar Evaporation Basins. Planned Wells 199-H4-89 and 199-H4-88 are added to the RCRA monitoring network. Wells 199-H4-88 and 199-H4-89 are planned for drilling in FY 2016 and Well 199-H4-12A will continue in the monitoring network until the new wells are accepted.

The previous plan was issued in 1997 at the onset of the corrective action (pump and treat remedial action under CERCLA) and did not identify point of compliance wells. The current plan identifies the monitoring network wells as representing the point of compliance. Because of the previous exceedances of the concentration limit for chromium and the ongoing remedial action, any concentration limit exceedances at the point of compliance during the remedial action period do not require additional action.

The previous plan did not define the compliance period. In the current plan, the compliance period will end when the sample results for total chromium (filtered) in the 183-H Solar Evaporation Basins point of compliance wells have been below 48 µg/L for three years. When the compliance period has ended, then corrective action monitoring will be discontinued, and the site will be closed and removed from the RCRA Permit (WA7890008967).

The previous plan did not include a method for statistical evaluation of the monitoring data. The current plan is updated with a statistical method that will be used to determine if the corrective action (CERCLA remedial action) is progressing as expected and demonstrate that the concentration limit has been achieved. Non-statistical evaluation of the results will be used for data sets that are below the concentration limit and have a practical quantitation limit less than the concentration limit.

3.7 Sampling and Analysis Protocol

In accordance with the RCRA Permit (WA7890008967), the groundwater protection regulations of WAC 173-303-645 dictate the groundwater sampling and analysis requirements applicable to final status TSD units. The QAPjP outlining the project management structure, data generation and acquisition, analytical procedures, and quality control is provided in Appendix A. Appendix B provides the sampling protocols (e.g., sampling methods, sample handling and custody, management of waste, and health and safety considerations).

4 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data.

4.1 Data Review

The data review and verification are discussed in the QAPjP (Appendix A).

4.2 Statistical Evaluation

The objective of the corrective action monitoring program is to monitor the concentration trends to demonstrate the effectiveness of the corrective action. Accordingly, the objective of the statistical evaluation during the corrective action is to monitor the trend of the dangerous waste to confirm that the corrective action (CERCLA remedial action) is progressing as expected.

In corrective action monitoring, an upper confidence limit (UCL) of the mean can be compared to a fixed regulatory limit to determine with prescribed confidence whether the mean concentration of the target population (population of interest) significantly exceeds the fixed limit (EPA, 1989, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Interim Final Guidance*; EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*). Calculation of UCLs of the mean are routinely calculated using EPA, 2013, ProUCL (Version 5.0.00), a software package developed for EPA that has undergone expansions and upgrades, including the most recent in 2013.

The 95 percent UCL of the mean, hereafter referred to as a 95 percent UCL, calculated with ProUCL (EPA, 2013), is the statistic used to evaluate groundwater data collected under this monitoring plan. Revised versions of ProUCL will be used as they become available. ProUCL calculates an appropriate 95 percent UCL considering data distribution, data set size, skewness of the data, and percentage of nondetects. The ProUCL technical guide recommends data sets include a minimum of eight to ten independent results, with at least four detections within the data set. Replicate samples are not considered independent.

The most recent eight to ten independent monitoring results of total chromium (filtered) from the 183-H Solar Evaporation Basins monitoring wells are the data set used to compute a 95 percent UCL on an intra-well basis. When available, results from the last nine or ten independent sampling events (whichever is the maximum number of results) from a given well are used for the calculation.

Statistical evaluation of results from wells will begin when eight independent samples are available for the 95 percent UCL calculation. Wells 199-H4-84 and 199-H4-85 have been sampled for total chromium (filtered) under CERCLA (and RCRA for Well 199-H4-84) since 2013 (Appendix D) and therefore have additional results available. Results for total chromium (filtered) collected for CERCLA monitoring may be included in the data sets used for 95 percent UCL calculation until a sufficient number of samples (eight) is collected under this RCRA plan. Wells 199-H4-88 and 199-H4-89 are planned for installation in FY 2016 and will be sampled quarterly for the first 2 years. Until eight sample results are available to calculate the 95 percent UCL, non-statistical evaluation of monitoring results to the concentration limit will be performed.

Not all data sets require computation of a 95 percent UCL. When the sample results in the data set comprising eight to ten samples are less than the concentration limit, a nonstatistical or visual analysis of the data (such as presented in Appendix D) is appropriate. In these cases, each result in the data set (eight to ten samples) must be less than the concentration limit. In addition, the practical quantitation limit for each sample in the data set must not exceed the concentration limit.

The 95 percent UCL calculations are performed as necessary for the 183-H Solar Evaporation Basins point of compliance well results to support preparation of the semiannual reports required by WAC 173-303-645(11)(g). Any calculated 95 percent UCL values will be compared to the concentration limit in the reports After data sets comprising eight to ten independent samples demonstrate that concentrations of total chromium (filtered) in the network wells (representing the point of compliance) are less than the concentration limit of 100 µg/L, then non-statistical evaluations of monitoring results are performed until the end of the compliance period (Section 3.4). The compliance period will end when the concentration of total chromium (filtered) in the point of compliance wells have been less than 48 µg/L for a three-year period (Section 3.4).

4.3 Interpretation

Data are used to interpret groundwater conditions at the 183-H Solar Evaporation Basins. Interpretive techniques may include the following:

- **Hydrographs:** Graph water levels versus time to determine decreases and increases and seasonal or manmade fluctuations in groundwater levels.
- **Water table maps:** Use water table elevations from multiple wells to construct contour maps and estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential on the maps.
- **Trend plots:** Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water table maps to determine if concentrations relate to changes in water level or groundwater flow directions.
- **Plume maps:** Map distributions of chemical constituent concentrations in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and direction of groundwater flow.

4.4 Reporting

The effectiveness of the corrective action program is reported twice each year as required by WAC 173-303-645(11)(g). Results from this monitoring plan are reported in both the semiannual corrective action groundwater report and the annual Hanford Site groundwater monitoring report (e.g., DOE/RL-2014-32).

5 References

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Appendix A

Quality Assurance Project Plan

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Contents

Tables

Figure

Terms

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQA	data quality assessment
DQI	data quality indicator
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FTB	full trip blank
FWS	Field Work Supervisor
GC/MS	gas chromatography/mass spectrometry
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
HEIS	Hanford Environmental Information System
LCS	laboratory control sample
MB	method blank
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
PS	post digestion spike
PQL	practical quantitation limit
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RDL	required detection limit
RDR	request for data review
RPD	relative percent difference

S&GRP	Soil and Groundwater Remediation Project
SAF	Sampling Authorization Form
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
WAC	*Washington Administrative Code*

A1 Introduction

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the quality assurance (QA) elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). Sections 6.5 and 7.8 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*) require the QA/quality control (QC) and sampling and analysis activities to specify QA requirements for treatment, storage, and disposal (TSD) units, as well as for past-practice processes. This QAPjP also describes the applicable requirements and controls based on guidance found in Washington State Department of Ecology (Ecology) Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to the 183-H Solar Evaporation Basins groundwater monitoring activities: Project Management, Data Generation and Acquisition, Assessment and Oversight, and Data Review and Usability.

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A2 Project Management

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

A2.1 Project/Task Organization

The contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, and shipping samples to the laboratory. The contractor is also responsible for preparing and maintaining configuration control of the groundwater monitoring plan and assisting the U.S. Department of Energy (DOE)-Richland Operations Office (RL) project manager in obtaining approval of the groundwater monitoring plan and future proposed revisions. Project organization (regarding routine groundwater monitoring) is described in the following sections and illustrated in Figure A-1.

A2.1.1 DOE-RL Project Manager

Hanford Site cleanup is the responsibility of DOE-RL. The DOE-RL project manager is responsible for authorizing the contractor to perform activities under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, *Resource Conservation and Recovery Act of 1976* (RCRA), *Atomic Energy Act of 1954*, and Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*) for the Hanford Site.

A2.1.2 DOE-RL Technical Lead

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

A2.1.3 Soil and Groundwater Remediation Project Manager

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

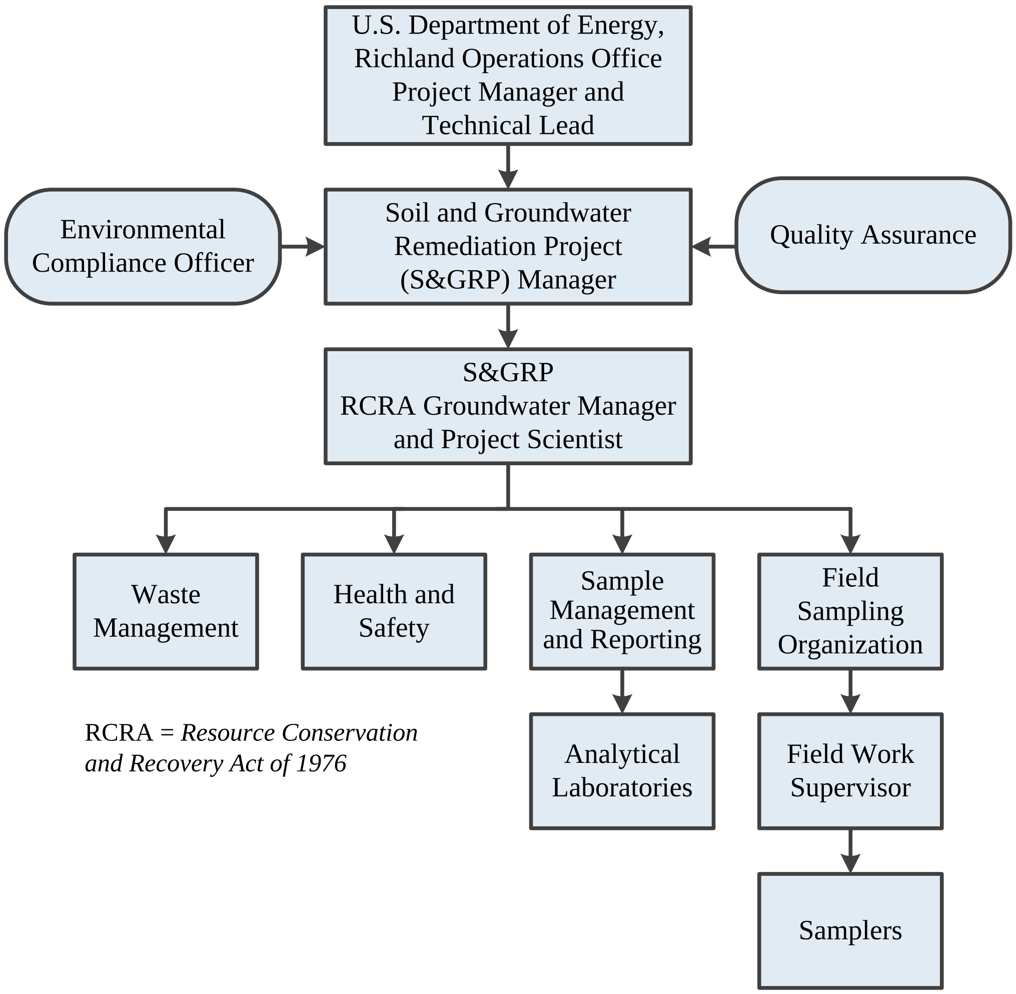

Figure A-1. Project Organization

A2.1.4 S&GRP RCRA Groundwater Manager

The S&GRP RCRA groundwater manager is responsible for direct management of activities performed to meet RCRA TSD monitoring requirements. The S&GRP RCRA groundwater manager coordinates with and reports to DOE-RL and primary contractor management regarding RCRA TSD monitoring requirements. The S&GRP RCRA groundwater manager (or delegate) works closely with the Environmental Compliance Officer (ECO), QA, Health and Safety, and Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope. The S&GRP RCRA groundwater manager assigns scientists to provide technical expertise.

A2.1.5 Sample Management and Reporting Group

The SMR group coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan. The SMR group generates field sampling documents, labels, and instructions for field sampling personnel and develops the Sampling Authorization Form (SAF), which provides information and instruction to the analytical laboratories. The SMR group receives analytical data from the laboratories, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with the Field Sampling Organization, laboratories, or other entities. The SMR group is responsible for informing the S&GRP RCRA groundwater manager of any issues reported by the analytical laboratories.

A2.1.6 Field Sampling Organization

The Field Sampling Organization is responsible for planning and coordinating field sampling resources and provides the Field Work Supervisor (FWS) for routine groundwater sampling operations. The FWS directs the nuclear chemical operators (samplers), who collect groundwater samples in accordance with this groundwater monitoring plan and in accordance with corresponding standard procedures and work packages. The FWS ensures that samplers are appropriately trained and available. The samplers collect all salient samples in accordance with sampling documentation. The samplers also complete field logbooks and chain-of-custody forms, including any shipping paperwork, and ensure delivery of the samples to the analytical laboratory.

In addition, pre-job briefings are conducted by the Field Sampling Organization, in accordance with work management and work release requirements, to evaluate activities and associated hazards by considering various factors, including 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 which the job will be performed
- Facility where the job will be performed
- Equipment and material required

A2.1.7 Quality Assurance

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

A2.1.8 Environmental Compliance Officer

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

A2.1.9 Health and Safety

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

A2.1.10 Waste Management

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

A2.1.11 Analytical Laboratories

The analytical laboratories analyze samples, in accordance with established procedures and the requirements of this plan, and provide necessary data packages containing analytical and QC results. The laboratories provide explanations of results to support data review and in response to resolution of analytical issues. The laboratories are evaluated under the DOE Consolidated Audit Program and must be accredited by Ecology for the analyses performed for S&GRP.

A2.2 Problem Definition/Background

The purpose of this groundwater monitoring plan is to satisfy the requirements of *Washington Administrative Code* (WAC) 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units." Specifics on the activities to satisfy the requirements are provided in the main body of the monitoring plan, such as in Chapter 1.0 and Sections 2.7, 3.1, 3.2, 3.3, 3.4, 3.5, and 4.2. Background information on monitoring is also provided in the main body of this plan, such as in Sections 2.2, 2.5, and 3.6.

A2.3 Project/Task Description

The project description is provided in Chapters 2, 3, and 4 of this monitoring plan and includes the dangerous waste as required by WAC 173-303-645(5) for a corrective action monitoring plan. The dangerous waste and field parameters to be monitored, along with the monitoring wells and frequency of sampling, are provided in Chapter 3. Information on the collection and analyses of groundwater from the monitoring network is provided in this appendix and in Appendix B.

A2.4 Quality Assurance Objectives and Criteria

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

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. DQIs are evaluated during the data quality assessment (DQA) process (Section A5.3).

Table A-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	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or re-measurement. • Qualify the data before use.

Table A-1. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
	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.	same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	
Accuracy	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. Quality control analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use. • Request reanalysis or re-measurement.
Representativeness	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring 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.
Comparability	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that	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.

Table A-1. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
	proper sampling and analysis techniques are applied.		• Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.
Completeness	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives 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.
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 (MS).	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.

Table A-1. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Sensitivity	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation* is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

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

* For purposes of this groundwater monitoring plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

DQI = data quality indicator

MS = matrix spike

QA = quality assurance

A2.5 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting groundwater samples according to the dangerous waste training plan maintained for the TSD unit to meet the requirements of WAC 173-303-330, "Dangerous Waste Regulations," "Personnel Training." The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Training has been instituted by the contractor management team to meet training and qualification programs to satisfy multiple training drivers imposed by the applicable *Code of Federal Regulations* (CFR) and WAC requirements. For example, the environmental, safety, and health training program provides workers with the knowledge and skills necessary to execute assigned duties safely.

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

A2.6 Documents and Records

The S&GRP RCRA groundwater manager (or designee) is responsible for ensuring that the current version of the groundwater monitoring plan is used and providing any updates to field personnel. Version control is maintained by the administrative document control process. Table A-2 defines the types of changes that may affect the groundwater monitoring plan and the associated approvals, notifications, and documentation requirements.

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

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

Table A-2. Change Control for Monitoring Plans

Type of Change	Action	Documentation
Temporary addition of wells or site-specific constituents, or increased sampling frequency that do not affect the requirements of WAC 173-303-645.	S&GRP RCRA groundwater manager approves temporary change; provides informal notice to Ecology.	SMR group's integrated groundwater monitoring schedule
Unintentional impact to groundwater monitoring plan including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of indicator parameters, and loss of samples in transit.	S&GRP RCRA groundwater manager provides electronic notification to DOE-RL.	Annual groundwater monitoring report
Planned change to groundwater monitoring activities, including addition or deletion of site-specific constituents, change of sampling frequency for site-specific constituents, or changes to well network.	S&GRP RCRA groundwater manager obtains DOE-RL approval; revise monitoring plan.	Revised RCRA groundwater monitoring plan and modification to RCRA Permit [a]
Anticipated unavoidable changes (e.g., dry wells).	S&GRP RCRA groundwater manager provides electronic notification to DOE-RL; revise monitoring plan.	Annual groundwater monitoring report. Permanent changes require revised RCRA groundwater monitoring plan and modification to RCRA Permit [a]

a. Hanford Facility RCRA Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*)

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

Ecology = Washington State Department of Ecology

RCRA = *Resource Conservation and Recovery Act of 1976*

S&GRP = Soil and Groundwater Remediation Project

SMR = Sample Management and Reporting

The S&GRP RCRA groundwater manager, FWS, or designee is responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities. The S&GRP RCRA groundwater manager is also responsible for ensuring that project files are setup, as appropriate, and/or maintained. The project files will contain project records or references to their storage locations. Project files generally include, as appropriate, the following information:

- Operational records and logbooks
- Data forms
- Global positioning system data (a copy will be provided to the SMR group)
- Inspection or assessment reports and corrective action reports
- Field summary reports
- Interim progress reports
- Final reports
- Forms required by WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells,” and the master drilling contract

The following records are managed and maintained by SMR personnel:

- 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

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

The results of corrective action groundwater monitoring are reported twice each year as required by WAC 173-303-645(11). Groundwater monitoring results are also presented in the annual groundwater monitoring reports.

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A3 Data Generation and Acquisition

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

A3.1 Analytical Method Requirements

Analytical method requirements for samples collected are presented in Table A-3. Updated U.S. Environmental Protection Agency (EPA) methods may be substituted for analytical methods identified in Table A-3.

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
Dangerous Waste Constituent (µg/L)		
Total Chromium (filtered)	EPA 200.8 or SW-846 6020 – ICP/MS	10
Field Parameters		
Dissolved Oxygen	Field measurement Instrument/meter	N/A
pH		N/A
Specific Conductance		N/A
Temperature		N/A
Turbidity		N/A

Note: The information in this table does not represent EPA requirements but is intended solely as guidance.

a. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.* Equivalent methods may be substituted.

b. Highest allowable practical quantitation limits are specified in contracts with analytical laboratories. Actual quantitation limits vary by laboratory and may be lower than required contractually. Method detection limits are three to five times lower than quantitation limits.

EPA = U.S. Environmental Protection Agency

N/A = not applicable

PQL = practical quantitation limit

A3.2 Field Analytical Methods

Field screening and survey data used will be measured in accordance with HASQARD (DOE/RL-96-68) requirements (as applicable). Field analytical methods may also be performed in accordance with manufacturer manuals. Appendix B provides the parameters identified for field measurements.

A3.3 Quality Control

QC requirements specified in the plan 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. Field and laboratory QC sample requirements are summarized in Table A-4. Acceptance criteria for field and laboratory QC are shown in Table A-5. Data will be qualified and flagged in HEIS, as appropriate.

Table A-4. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
Field Quality Control		
Field Duplicates	One 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 (Table A-3).	Precision, including sampling, analytical, and interlaboratory
Full Trip Blanks	One in 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 EB is not required; otherwise, one for every 20 samples.[a]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical Quality Control[b]		
Matrix Spikes	1 per analytical batch[c]	Matrix effect/laboratory accuracy
Laboratory Control Samples	1 per analytical batch[c]	Laboratory accuracy
Method Blanks	1 per analytical batch[c]	Laboratory contamination

Note: The information in this table does not represent EPA requirements but is intended solely as guidance.

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

c. Unless not required by, or different frequency is called out in, laboratory analysis methods.

EPA = U.S. Environmental Protection Agency

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analysis	Quality Control	Acceptance Criteria	Corrective Action
Dangerous Waste Constituent			
Total Chromium (filtered)	MB	< RDL < 5% Sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	MS or PS, and MSD	75–125% recovery	Flagged with "N"
	MS/MSD	≤ 20% RPD	Data reviewed[a]
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"

Notes: The information in this table does not represent EPA requirements but is intended solely as guidance.

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

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

b. Applies only in cases where both results are greater than 5 times the method detection limit.

EB = equipment blank
EPA = U.S. Environmental Protection Agency
FTB = full trip blank
GC/MS = gas chromatography/mass spectrometry
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PS = post digestion spike
QC = quality control
RDL = required detection limit
RPD = relative percent difference

Data Flags:

C (inorganics/wetchem) = The analyte was detected in both the sample and the associated QC blank and the blank value exceeds 5% of the measured concentration present in the associated sample.

N = all except GC/MS – matrix spike outlier

Q = associated QC sample is out of limits

A3.3.1 Field Quality Control Samples

Field QC samples are collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability and laboratory performance to help ensure that reliable data are obtained. Field QC samples include field duplicates, field split (SPLIT) samples, and two types of field blanks (full trip blanks [FTBs] and equipment blanks [EBs]). 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: independent samples collected as close as possible to the same time and same location as the scheduled sample, and are intended to be identical. Field duplicates are placed in separate sample containers and analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.

Field Splits: two samples collected as close as possible to the same time and same location and are 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: 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, 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: 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 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.

A3.3.2 Laboratory Quality Control 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), matrix duplicates, matrix spike duplicates (MSDs), laboratory control samples (LCSs), surrogates (SURs), post-digestion spikes (PSs), and method blanks (MBs). These QC analyses are required by EPA methods (e.g., those in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended), and will be run at the frequency specified in the respective references unless superseded by agreement. QC checks outside of control limits are documented in analytical laboratory reports during DQAs, if performed. Laboratory QC and their typical frequencies are listed in Table A-4. Acceptance criteria are shown in Table A-5. The following text describes the various laboratory QC samples:

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

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

Method Blank: 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 preparations and analytical procedure and is used to quantify contamination resulting from the analytical process.

Post-Digestion Spike: the same as MS; however, the spiking occurs after sample preparation and before analysis.

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

Table A-6. Preservation, Container, and Holding Time Guidelines for Laboratory Analyses

Constituent/Parameter	Minimum Volume	Container Type[a]	Preservation[b]	Holding Time
Total Chromium (filtered)	250 mL	Narrow-mouth poly or glass	Adjust pH to < 2 with nitric acid	6 months

Notes: The information in this table does not represent EPA requirements but is intended solely as guidance.

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

a. Under the Container heading, the term poly stands for EPA clean polyethylene bottles.

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

EPA = U.S. Environmental Protection Agency

A3.4 Measurement Equipment

Each user of the measuring equipment is responsible to ensure 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.

A3.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or should 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 applicable Hanford Site requirements.

A3.6 Instrument/Equipment Calibration and Frequency

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

A3.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with test methods in SW-846 and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

A3.8 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.

A3.9 Data Management

The SMR group, in coordination with the S&GRP RCRA groundwater manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with the applicable programmatic requirements governing data management methods.

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

Laboratory errors are reported to the SMR group on a routine basis. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with applicable methods. This process is used to document analytical errors and establish their resolution with the S&GRP RCRA groundwater manager. The sample issue resolution forms become a permanent part of the analytical data package for future reference and records management.

A4 Assessment and Oversight

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

A4.1 Assessments and Response Actions

Random surveillances and assessments verify compliance with the requirements outlined in this plan, project field instructions, the QAPjP, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates the corrective actions/deficiencies resolutions in accordance with the QA program, corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the S&GRP RCRA groundwater manager.

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 laboratories are qualified for performing Hanford Site analytical work.

A4.2 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 reported by the laboratories are communicated to the SMR group, which then initiates a sample issue resolution form. This process is used to document analytical or sample issues and establish resolution with the S&GRP RCRA groundwater manager.

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A5 Data Review 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.

A5.1 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, if any, have been met, and reviewing QC data to determine whether analyses have met the data quality requirements specified in this plan.

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

The project scientist, assigned by the S&GRP RCRA groundwater manager, will perform a data review to help determine if observed changes reflect improved/degraded groundwater quality or potential data errors and may result in submittal of a request for data review (RDR) on questionable data. The laboratory may be asked to check calculations or re-analyze 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.

A5.2 Data Validation

Data validation activities may be performed at the discretion of the S&GRP RCRA groundwater manager and under the direction of the SMR group. If performed, data validation activities will be based on EPA functional guidelines.

A5.3 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 data quality needs. For routine groundwater monitoring undertaken through this groundwater monitoring plan, the DQA is captured in QC associated with the annual Hanford Site groundwater report, which evaluates field and laboratory QC and the usability of data. Further DQAs will be performed at the discretion of the S&GRP RCRA groundwater manager and documented in a report overseen by the SMR group.

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Appendix B

Sampling Protocol

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Contents

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Terms

APHA	American Public Health Association
AWWA	American Water Works Association
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
FWS	Field Work Supervisor
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
IATA	International Air Transport Association
NTU	nephelometric turbidity unit
RCRA	*Resource Conservation and Recovery Act of 1976*
S&GRP	Soil and Groundwater Remediation Project
SMR	Sampling Management and Reporting
WAC	*Washington Administrative Code*

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B1 Introduction

Resource Conservation and Recovery Act of 1976 (RCRA) groundwater monitoring at the Hanford Site has been conducted since the mid 1980's. Hanford Site groundwater sampling methods contain extensive requirements for sampling precautions to be taken, equipment and its use, cleaning and decontamination, records and documentation, and sample collection, management, and control activities. Appendices A and B, together, provide the sampling and analysis essentials (sample collection, sample preservation, chain of custody control, analytical procedures, and field and laboratory quality assurance/quality control) necessary for the groundwater monitoring plan.

This appendix provides more specific elements of the sampling protocols and techniques used for the RCRA groundwater monitoring plan. Chapter 3 of the groundwater monitoring plan identifies the monitoring wells that will be sampled, the constituents to be analyzed for, and the sampling frequency for the groundwater monitoring at the 183-H Solar Evaporation Basins.

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B2 Sampling Methods

Sampling methods may include, but are not limited to, the following:

- Field screening measurements
- Groundwater sampling
- Water level measurements

Groundwater samples will be collected according to the current revision of applicable operating methods. Groundwater samples are collected after field measurements of purged groundwater have stabilized:

- pH – two consecutive measurements agree within 0.2 pH units
- Temperature – two consecutive measurements agree within 0.2°C
- 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)

Dissolved oxygen will also be measured in the field in this plan, but it is not required to demonstrate concentration stability before field measurement.

Absent any special requirements from project scientists, wells are purged utilizing the three borehole volume method. Stable field readings are also required as specified above. The default pumping rate is 7.6 to 45.4 L/min (2 to 12 gal/min), depending on the pump, although this is not practical at every well. On occasions when the purge volume is extraordinarily large, wells are purged a minimum of 1 hour and then sampled once stable field readings are obtained.

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

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

Typically, three types (i.e., Grundfos, Hydrostar, and submersible electrical pumps) of environmental grade sampling pumps are used for groundwater sampling at Hanford Site monitoring wells. Individual pumps are selected based on the unique characteristics of the well and the sampling requirements. A small number of wells will not support a pumped sample because of yield or the physical characteristics of the well. In these cases, a grab sample may be obtained.

For certain types of samples, preservatives are required. While the preservative may be added to the 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 form.

To ensure sample and data usability, the sampling associated with this plan will be performed according to DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD), pertaining to sample collection, collection equipment, and sample handling.

Suggested sample container, preservation, and holding time requirements are specified in Appendix A (Table A-6) for groundwater samples. These requirements are in accordance with the analytical method specified in Appendix A (Table A-3). The final container type and volumes will be identified on the chain-of-custody form. This groundwater monitoring plan defines a “sample” as a filled sample bottle for starting the clock for holding time restrictions.

Holding time is the maximum allowable time 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 depend on the constituent and are listed in analytical method compilations such as APHA et al., 2012, *Standard Methods for the Examination of Water and Wastewater*, and SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition; Final Update IV-B*. Recommended holding times are also provided in HASQARD (DOE/RL-96-68).

B2.1 Decontamination of Sampling Equipment

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

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

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)

- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

B2.2 Water Levels

Each time a sample is obtained, measurement of the groundwater surface elevation at each monitoring well is required by *Washington Administrative Code* (WAC) 173-303-645(8)(f), "Dangerous Waste Regulations," "Releases from Regulated Units." A measurement of depth to water 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 information. 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.

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B3 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 sampling Field Work Supervisor (FWS), cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

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

A summary of information to be recorded in logbooks is as follows:

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

B3.1 Corrective Actions and Deviations for Sampling Activities

The Soil and Groundwater Remediation Project (S&GRP) RCRA groundwater manager, FWS, appropriate field crew supervisors, and Sampling Management and Reporting (SMR) personnel must document deviations from protocols, problems pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected because of field conditions.

As appropriate, such deviations or problems will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The S&GRP RCRA groundwater manager, FWS, field crew supervisors, or SMR personnel will be responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities.

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

B4 Calibration of Field Equipment

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

- Prior to initial use of a field analytical measurement system.
- At the frequency recommended by the manufacturer or methods, or as required by regulations.
- Upon failure to meet specified quality control criteria.
- Daily calibration checks will be performed and documented for each instrument used. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.
- Standards used for calibration will be traceable to a nationally recognized standard agency source or measurement system.

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B5 Sample Handling

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

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

B5.1 Containers

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

Containers shall be capped and stored in an environment which minimizes the possibility of contamination of the sample containers. If contamination of the stored sample containers occurs, corrective actions shall be implemented to prevent reoccurrences. Contaminated sample containers cannot be used for a sampling event. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. Container types and sample amounts/volumes are identified in Appendix A (Table A-6).

B5.2 Container Labeling

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

B5.3 Sample Custody

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

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 custody of the sample 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 group within 48 hours of shipping.

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

- Project name
- Collectors' names
- Unique sample number

- Date and time of collection
- Matrix
- Preservatives
- Chain of possession information (i.e., signatures and printed names of all individuals involved in the transfer of sample custody and storage locations, and dates of receipt and relinquishment)
- Requested analyses (or reference thereto)
- Shipped-to information (i.e., analytical laboratory performing the analysis)

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

B5.4 Sample Transportation

All packaging and transportation instructions shall be in compliance with applicable transportation regulations and U.S. Department of Energy (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, “General Information, Regulations, and Definitions,” through 49 CFR 177, “Carriage by Public Highway.” Carrier specific requirements defined in the International Air Transport Association (IATA) *Dangerous Goods Regulations* (IATA, current edition) shall also be used when preparing sample shipments conveyed by air freight providers.

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

B6 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with DOE/RL-97-01, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units*. For waste designation purposes, the wells listed in Table 3-1 will be surveyed in the Hanford Environmental Information System and the maximum concentration for each analyte within the most recent 5 years evaluated for use in creating a waste profile, if required. 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 Richland Operations Office is required before returning unused samples or waste from offsite laboratories.

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B7 Health and Safety

The safety and health program is designed to ensure the safety and health of workers including those involved in dangerous 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” (Chapter III, “Energy”). The health and safety program defines the chemical, radiological, and physical hazards and specifies the controls and requirements for daily work activities on the overall Hanford Site. Personnel training, control of industrial safety and radiological hazards, personal protective equipment, site control, and general emergency response to spills, fire, accidents, injury, site visitors, and incident reporting are governed by the health and safety program.

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B8 References

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49 CFR 171, "General Information, Regulations, and Definitions."

49 CFR 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements, and Security Plans."

49 CFR 173, "Shippers-General Requirements for Shipments and Packagings."

49 CFR 174, "Carriage by Rail."

49 CFR 175, "Carriage by Aircraft."

49 CFR 176, "Carriage by Vessel."

49 CFR 177, "Carriage by Public Highway."

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http://www.hanford.gov/files.cfm/DOE-RL-96-68-VOL4-04.pdf.

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SW-846, 2007, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington D.C. Available at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-645.

Appendix C

Well Construction

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Contents

Figures

Tables

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C1 Introduction

This appendix provides the following information for the 183-H Solar Evaporation Basins groundwater monitoring wells:

- Well name
- Hydrogeologic unit to be monitored – the portion of the aquifer that is located at the well screen or perforated casing (Table C-1)

The following sampling interval information, as shown in Table C-2:

- Elevation at top of the screen or perforated interval
- Elevation at the bottom of the screen or perforated interval
- Open interval length (i.e., difference between elevations of top and bottom of the screen or perforated interval)

Figures C-1 through C-4 provide the well construction and completion summary for Wells 199-H4-8, 199-H4-12A, 199-H4-84, and 199-H4-85.

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
TU	**Top of Unconfined.** Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.

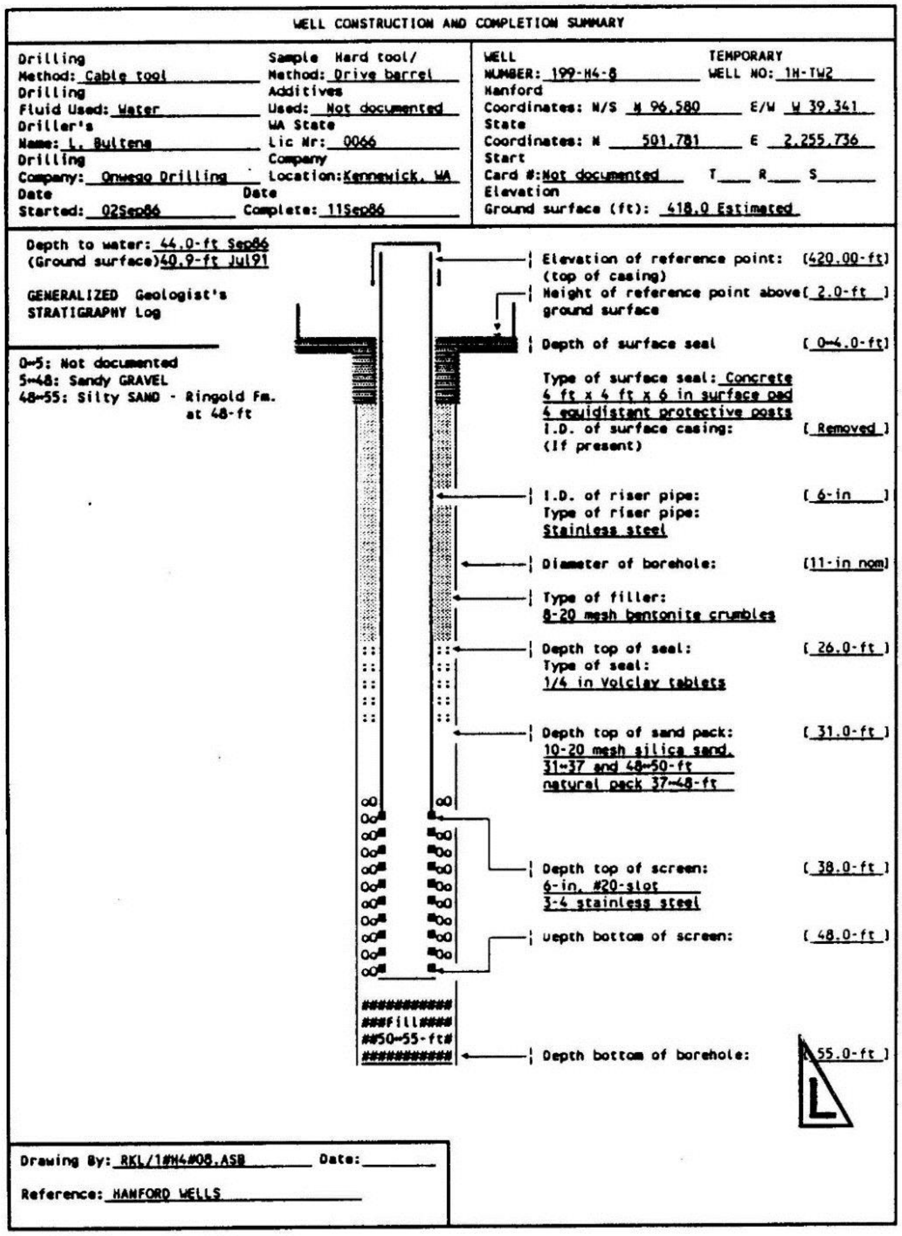
Table C-2. Sampling Interval Information for Wells within the 183-H Solar Evaporation Basins Network

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft]) NAVD88	Elevation Bottom of Open Interval (m [ft]) NAVD88	Open Interval Length (m [ft])
199-H4-8	TU	117.0 (383.9)	114.0 (374.0)	3.1 (10.2)
199-H4-12A	TU	116.4 (381.9)	111.8 (366.8)	4.6 (15.1)
199-H4-84	TU	117.9 (386.8)	114.1 (374.3)	3.1 (10.2)
199-H4-85	TU	119.7 (392.7)	113.6 (272.7)	6.1 (20.0)
199-H4-88[a]	TU	TBD	TBD	TBD
199-H4-89[a]	TU	TBD	TBD	TBD

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

a. Well to be drilled in fiscal year 2016.

NA = not applicable
TBD = to be determined
TU = Top of Unconfined, as described in Table C-1



WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool/ Drive barrel	WELL NUMBER: 199-H4-8 TEMPORARY WELL NO: 1H-TW2
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 96,580 E/W W 39,341
Driller's Name: L. Bultena	WA State Lic Nr: 0066	State Coordinates: N 501,781 E 2,255,736
Drilling Company: Onwego Drilling	Company Location: Kennewick, WA	Start Card #: Not documented T___ R___ S___
Date Started: 02Sep86	Date Complete: 11Sep86	Elevation Ground surface (ft): 418.0 Estimated

Depth to water: 44.0-ft Sep86
(Ground surface) 40.9-ft Jul91

GENERALIZED STRATIGRAPHY
Geologist's Log

0-5: Not documented
5-48: Sandy GRAVEL
48-55: Silty SAND - Ringold Fm. at 48-ft

Elevation of reference point: (top of casing)	[420.00-ft]
Height of reference point above ground surface	[2.0-ft]
Depth of surface seal	[0-4.0-ft]
Type of surface seal: Concrete 4 ft x 4 ft x 6 in surface pad 4 equidistant protective posts	
I.D. of surface casing: (If present)	[Removed]
I.D. of riser pipe:	[6-in]
Type of riser pipe: Stainless steel	
Diameter of borehole:	[11-in nom]
Type of filler: 8-20 mesh bentonite crumbles	
Depth top of seal:	[26.0-ft]
Type of seal: 1/4 in Volclay tablets	
Depth top of sand pack: 10-20 mesh silica sand, 31-37 and 48-50-ft natural pack 37-48-ft	[31.0-ft]
Depth top of screen: 6-in, #20-slot 3-4 stainless steel	[38.0-ft]
Depth bottom of screen:	[48.0-ft]
Depth bottom of borehole:	[55.0-ft]

Drawing By: RKL/1#H4#08.ASB Date:________

Reference: HANFORD WELLS

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Figure C-1. Well 199-H4-8 Construction and Completion Summary

WHC-SD-ER-TI-006, Rev. 0

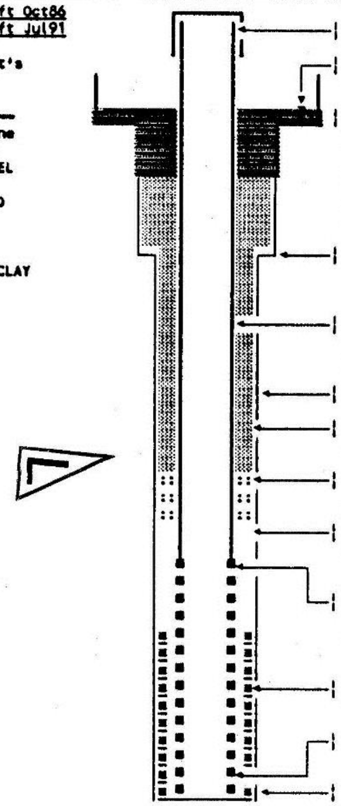
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool Drive barrel	WELL NUMBER: 199-H4-12A
Drilling Fluid Used: Water	Additives Used: Not documented	TEMPORARY WELL NO: 1H-TC1A
Driller's Name: D. Ludtke	WA State Lic Nr: 1333	Hanford Coordinates: N/S N 96,549 E/W W 38,854
Drilling Company: Onwego Drilling	Company Location: Kennewick, WA	State Coordinates: N 501,751 E 2,256,223
Date Started: 27Oct86	Date Complete: 04Nov86	Start Card #: Not documented T___ R___ S___
		Elevation Ground surface (ft): 411.0 Estimated

Depth to water: 38.5-ft Oct86
(Ground surface) 35.2-ft Jul91

GENERALIZED STRATIGRAPHY — Geologist's Log

0–5: Gravelly silty fine to very fine SAND
5–11: Silty sandy GRAVEL
11–34: Sandy GRAVEL
34–35: GRAVEL with SAND
35–40: Sandy GRAVEL
40–45: Gravelly SAND
45–51: Sandy GRAVEL
51–52: Ringold, brown CLAY and CALICHE



Elevation of reference point: (top of casing) [413.50-ft]
Height of reference point above ground surface [2.5-ft]
Depth of surface seal [0–4.5-ft]
Type of surface seal: Concrete 4 ft x 4 ft x 6 in surface pad 4 equidistant protective posts
I.D. of surface casing: (If present) [Removed]
Surface hole to 10 ft
I.D. of riser pipe: [6-in]
Type of riser pipe: Stainless steel
Diameter of borehole: [11-in nom]
Diameter of surface hole: [15-in nom]
Type of filler: 8–20 mesh granular bentonite
Depth top of seal: [26.0-ft]
Type of seal: 1/4-in Volclay tablets
Depth top of sand pack: 10–20 mesh silica sand [28.0-ft]
Depth top of screen: 6-in, 20-slot 304 stainless steel [33.0-ft]
10-in telescoping screen 37.5–47.5-ft, #40-slot
Depth bottom of screen: [48.0-ft]
Depth bottom of borehole: [48.0-ft]

Drawing By: RKL/1#H4#12A.ASB Date:______
Reference: HANFORD WELLS

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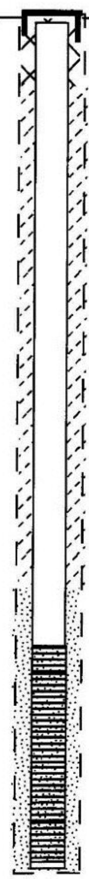
Figure C-2. Well 199-H4-12A Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 2-4-11	Page 1 of 1
		Finish Date: 2-16-11	
Well ID: C7860		Well Name 199-H4-84	
Location: N of D Reactor		Project: WCH Characterization Borehole	
Prepared by: C. Burnette	Date: 2-22-11	Reviewed by: L. D. Walker	Date: 3-2-11
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA

Description	Diagram
Ground surface circular concrete seal with brass well marker: 0-2.5 ft bgs Well monument 0.0-1.0 ft bgs	
4-in dia (cw 3/2/11) SCH 40 PVC blank 0.42-37.65 ft bgs	
#8 bentonite crumbles: 2.5-33.5 ft bgs	
Temporary Casing: 10 5/8-in Carbon Steel: 0-46.2 ft bgs	
4-in dia. (cw 3/2/11) 20 slot PVC Screen 37.65-47.65 ft bgs	
10-20 ~~slot~~ mesh silica sand (cw 3-2-11) 33.5-48.6 ft bgs bgs	
PVC cap 47.65-48.0 ft bgs	
Note: All temporay casing was removed during well construction. Centralizers were place just above and below the screen.	

GEOLOGIC/HYDROLOGIC DATA

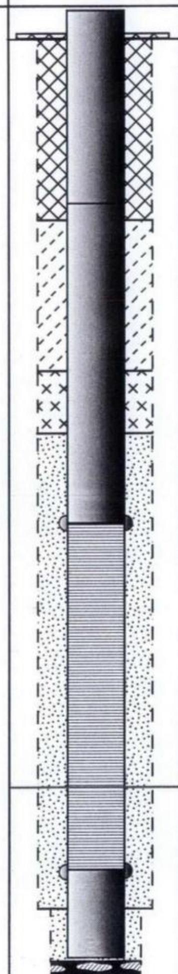
Depth in Feet	Graphic Log	Lithologic Description
0		0-19' Sandy Gravel (sG)
		0-19 ft bgs was backfill from previous remediation.
10		
20		19-41 ft. bgs Sitly Sandy Gravel (msG)
30		
40		41-48.6 ft bgs Sandy Gravel (sG)
		Static water at 41.5 ft bgs. Tagged on 2-9-11
		T.D 48.6 ft bgs Tagged on 2-9-11
50		

Figure C-3. Well 199-H4-84 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 3/05/2013 Finish Date: 3/14/2013	Page 1 of 1
Well ID: C8723		Well Name: 199-H4-85	
Location: 100-H, North of Reactor on H Ave.		Project: WCH Replacement Wells at 100-D/H	
Prepared by: Tessa Clark	Date: 3/18/2013	Reviewed by: L. Craig Swanson	Date: 5/29/13
Signature:		Signature:	

CONSTRUCTION DATA

Description	Diagram
Surface Completion: 4'x4'x6" Concrete Pad w/brass survey marker and 8 5/8" protective monument (3 ft ags).	
Concrete Surface Seal: Type I/II Portland Cement 0.0' bgs - 10.2' bgs.	
Permanent Well: 6 5/8" OD Stainless Steel Blank 2.0' ags - 27.39' bgs	
6 5/8" OD Stainless Steel 0.040 slot Screen 27.39' bgs - 47.29 ' bgs	
6 5/8" Stainless Steel Sump w/end cap 47.29' bgs - 52.40' bgs	
#8 Granular Bentonite Crumbles: 10.2' bgs - 18.9' bgs	
1/4" Uncoated Bentonite Pellets: 18.9' bgs - 22.5' bgs	
10-20 Colorado Silica Sand Pack: 22.5' bgs - 52.5' bgs	
Natural Backfill: 52.5' bgs - 53.5' bgs	
All temporary 10 3/4" OD casing completely removed from ground (3/13/2013).	
bgs = below ground surface ags = above ground surface	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0 - 2: Silty Sandy Gravel, msG
		2 - 5: Sandy Gravel, sG
		5 - 35: Silty Sandy Gravel, msG
10		
20		
30		
		35 - 47.5: Silty Sandy Gravel, msG
40		
		DTW = 42.6'bgs (3/11/2013)
		47.5 - 53.5: Silt, M
50		
		TD = 53.5' bgs (3/7/2013)

Figure C-4. Well 199-H4-85 Construction and Completion Summary

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C2 Reference

NAVD88, 1988, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

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Appendix D

Dangerous Waste Corrective Action Monitoring Results

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Contents

Figures

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D1 Introduction

This appendix presents the corrective action monitoring results of the 183-H Solar Evaporation Basins dangerous waste total chromium (collected as a filtered sample) in the groundwater monitoring well network. Results for hexavalent chromium (filtered) are also presented.

Corrective action monitoring of 183-H Solar Evaporation Basins commenced in 1997. The 183-H Solar Evaporation Basins' specific concentration limit identified in Part VI, Chapter 1, of the Hanford Facility *Resource Conservation and Recovery Act of 1976* (RCRA) Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit*) for total chromium (filtered) is 100 µg/L.

The 183-H Solar Evaporation Basins monitoring network included a total of four wells since the corrective action monitoring period began in 1997. However, wells within the network have changed since 1997. Wells were within the 183-H Solar Evaporation Basins network for the following durations:

- 199-H4-3 – 1997 to 2013
- 199-H4-7 – 1997 to 2005
- 199-H4-8 – 2005 to present
- 199-H4-12A – 1997 to present
- 199-H4-12C – 1997 to present
- 199-H4-84 – 2013 to present

Figures D-1 through D-6 present the results of total chromium (filtered) monitoring at 183-H Solar Evaporation Basin monitoring network wells during corrective action monitoring. The available hexavalent chromium (filtered) results during these periods are also included. Well 199-H4-85 was drilled in 2013 and is added to the monitoring network in this updated plan. Available sampling results for Well 199-H4-85 are presented in Figure D-7.

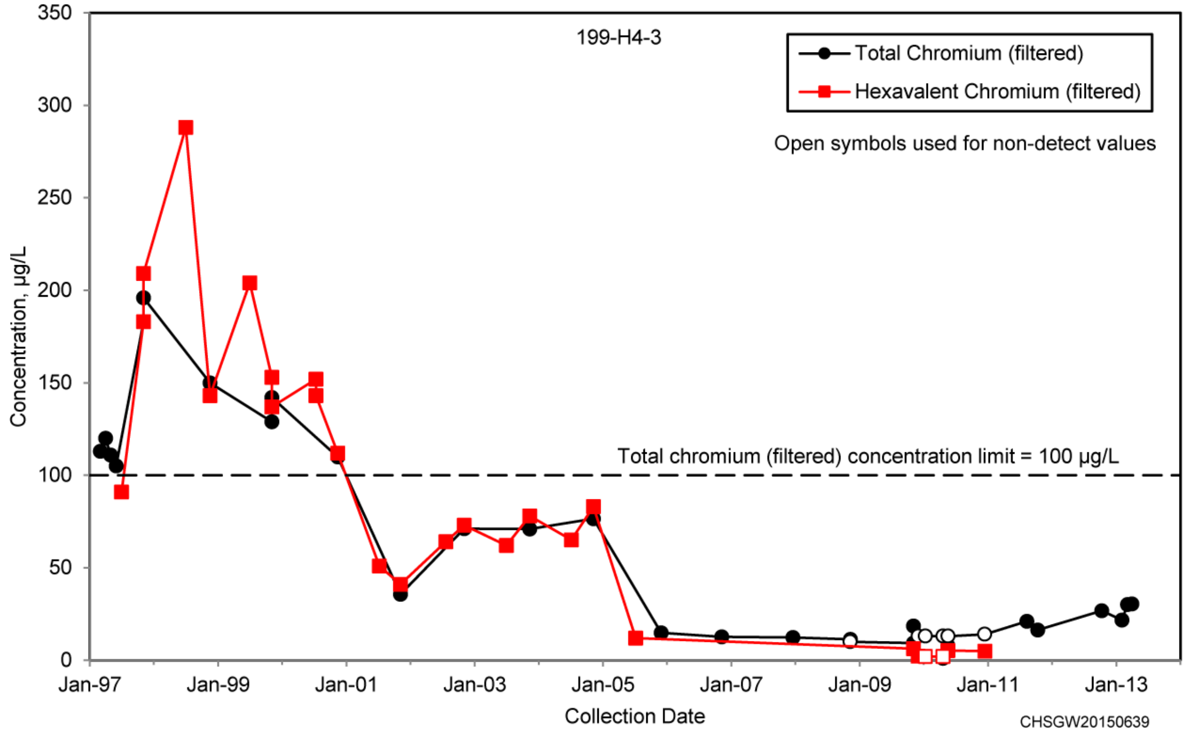

Figure D-1. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-3

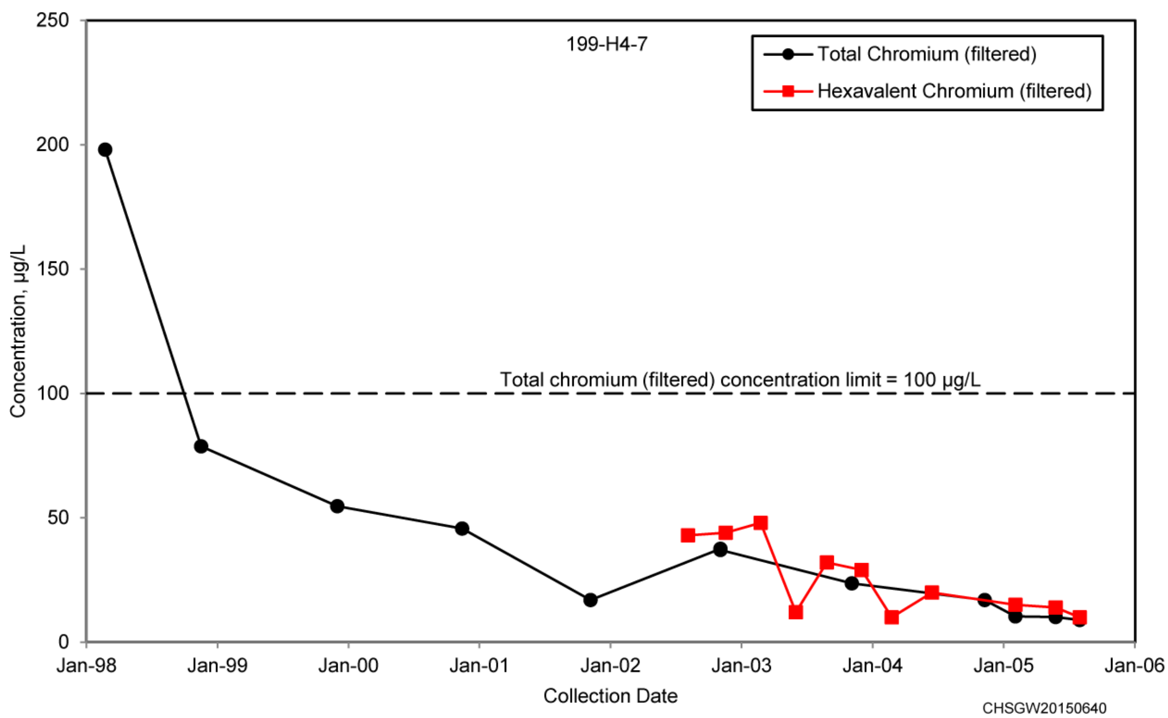

Figure D-2. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-7

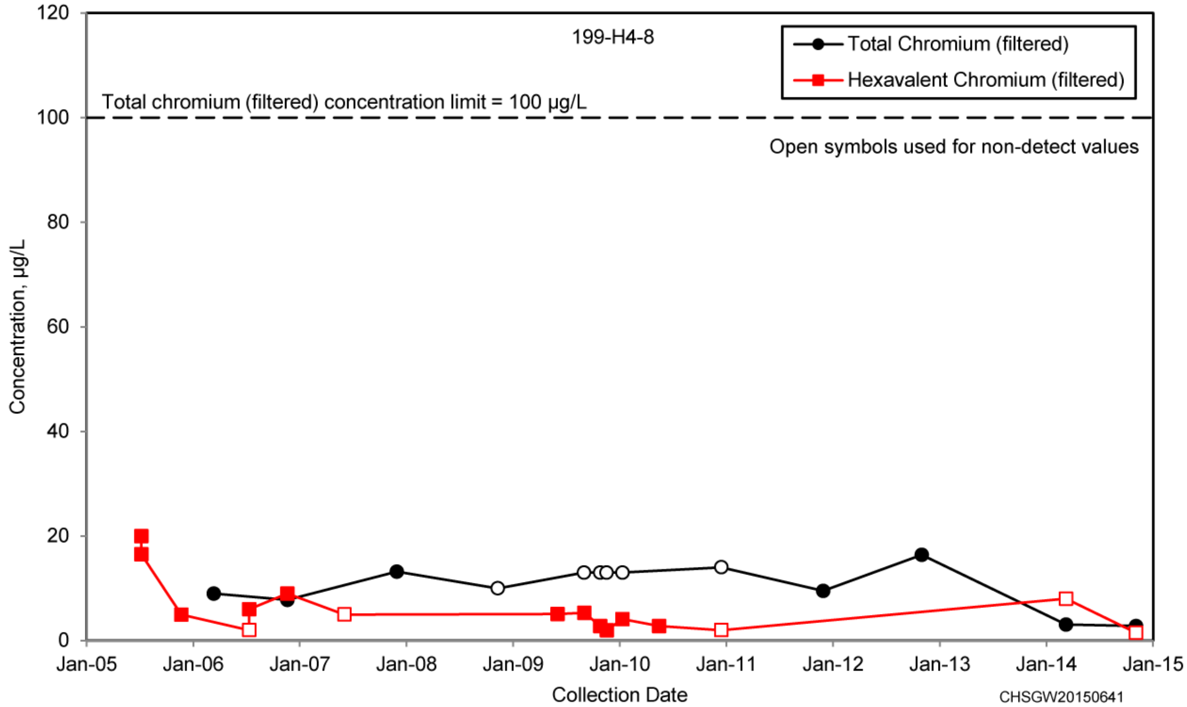

Figure D-3. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-8

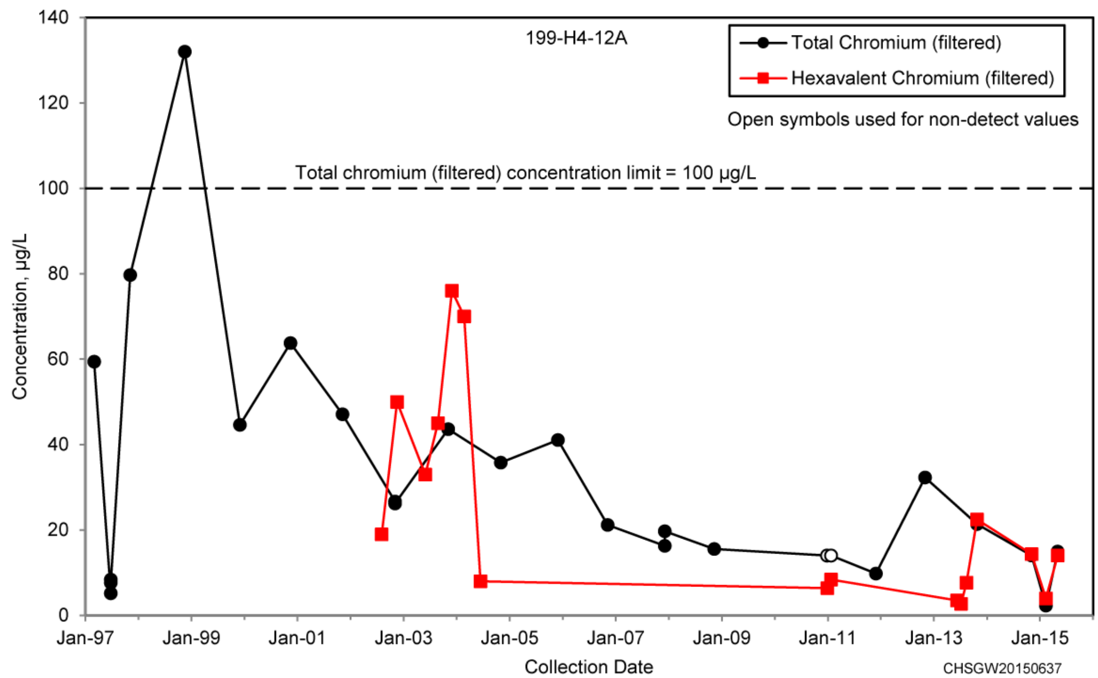

Figure D-4. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-12A

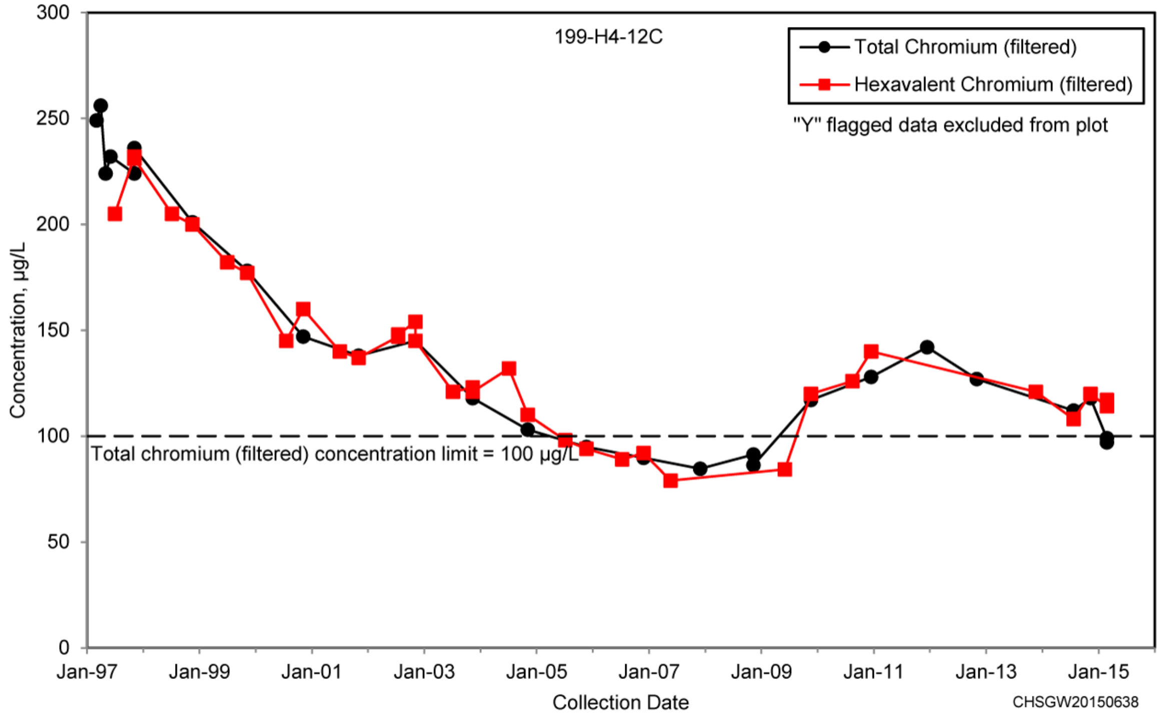

Figure D-5. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-12C

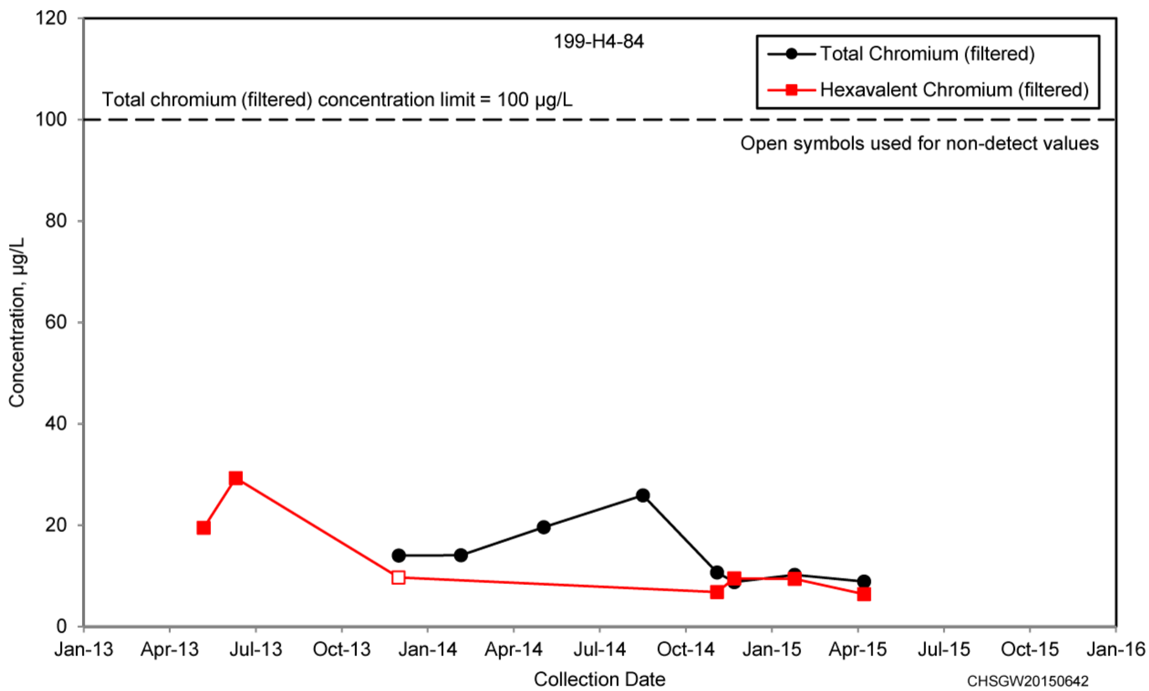

Figure D-6. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-84

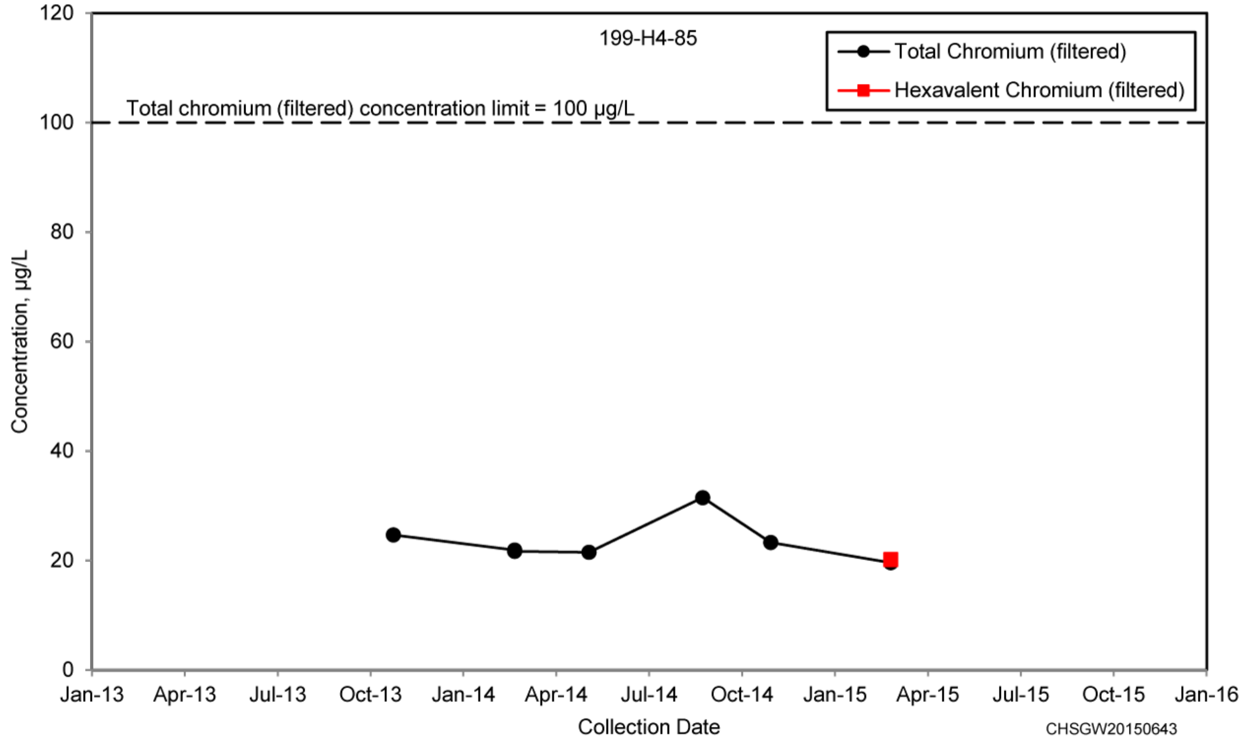

Figure D-7. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-85

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D2 References

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://www.epa.gov/epawaste/inforesources/online/index.htm.

WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit*, as amended, Washington State Department of Ecology, Richland, Washington. Available at: http://www.ecy.wa.gov/programs/nwp/permitting/hdwp/rev/8c/.

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