SGW-64372
Revision 0

100-D/H Continuing Hexavalent Chromium Source Evaluation

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
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1 Introduction

As remediation efforts progress along the Hanford Site River Corridor, many sources of hexavalent chromium (Cr(VI)) contamination have been removed through excavation activities. To continue the effective remediation of groundwater, any sources of Cr(VI) contamination remaining in the soil that may potentially impact groundwater must be discerned. This document identifies and evaluates known and suspected secondary sources of Cr(VI) contamination in the 100-D Area, 100-H Area, and the Horn that are affecting groundwater conditions. This document also presents data needed to provide recommendations for remedial action, including an evaluation of soil flushing to address residual Cr(VI) in the vadose zone.

1.1 Background

Historical operations at plutonium-production reactors along the Columbia River resulted in the contamination of soil and groundwater with various metals, radioactive materials, and other constituents. The most widespread contaminant along the River Corridor is Cr(VI), which is the focus of this discussion. Sodium dichromate dihydrate was added to the cooling water to inhibit corrosion within the reactors. After passing through the reactors, the majority of the Cr(VI)-contaminated cooling water was discharged to retention basins and trenches and subsequently released to the Columbia River. Large volumes of cooling water were also discharged to the earthen trenches. Leakage of cooling water from the retention basins and trenches was common. As a result, the groundwater was contaminated with low-concentration Cr(VI) over a large area. In addition, the high-concentration sodium dichromate dihydrate solution entered the environment through spills and leaks from storage facilities and during transfers, causing further soil and groundwater contamination.

In response to the Cr(VI) contamination, groundwater remediation activities were initiated in 1997. The interim remedial action at the 100-HR-3 Groundwater Operable Unit (OU) consisted of two pump and treat (P&T) systems, which treat contaminated groundwater with an ion-exchange resin. The P&T systems have been expanded over the years and have been effective in reducing Cr(VI) concentrations in groundwater and improving hydraulic containment to protect the Columbia River from continuing releases of Cr(VI). The potential for continuing contributions of Cr(VI) to groundwater from secondary sources can negatively affect remedy completion timeframes.

1.2 Purpose and Scope

The purpose of this evaluation is to assess the Cr(VI) groundwater plumes in order to identify secondary sources and to provide recommendations for remedial action implementation.

2 Identification of Secondary Source Areas

This chapter discusses the methodology and lines of evidence used in secondary source identification. A summary for each secondary source is also provided.

2.1 Methodology and Lines of Evidence

Identifying a secondary source in the vadose zone relies on the following lines of evidence:

- Known contamination remaining in an excavation footprint or sidewall (based on visual observation or sampling)
- Slow reductions in Cr(VI) concentrations or persistent contamination in the groundwater
- Increasing Cr(VI) concentrations in groundwater during or following periods of high water table

In areas where contamination remains in the lower vadose zone, the source material can leach slowly into the groundwater. The leaching of source material results in persistent contamination concentrations in the groundwater. In areas of active remediation (e.g., P&T systems), the presence of a remaining source can express itself as slow reductions in the Cr(VI) contamination levels with the rate of concentration decrease slowing over time.

For Cr(VI), there is a typical pattern observed in the groundwater monitoring wells near a contributing source. For a well located within the source area, the contaminant concentrations in groundwater will tend to rise with an increase in groundwater head and will drop as groundwater levels decrease. Contaminant concentrations in wells downgradient of a vadose zone source will often increase as groundwater levels decrease. A delay in increased concentrations is a result of the travel time of the contaminant from the source area to the well. However, the effects of P&T activities can mask the effect of the source area because the water extraction can artificially lower the water table. Because of the lowered water table, a rise in groundwater elevation may not be sufficient to intersect the zone of contamination, effectively keeping the source material above the groundwater interface zone. Rebound tests, where the P&T system is offline and the groundwater levels are allowed to recover to natural conditions, can be helpful in targeting the source areas. P&T rebound tests have not yet been conducted in the 100-HR-3 OU, although some aquifer tests in the Ringold Formation upper mud unit have previously been conducted. However, the effectiveness of a rebound test is evident in SGW-62061, *KW Rebound Study Summary Report and Assessment*, where the rebound test results were able to bound the magnitude and extent of potential sources.

The following approach was used to determine whether potential secondary sources of Cr(VI) exist in the 100-HR-3 OU:

- Reviewing existing plume maps to determine the approximate location of origin for each plume.
- Using Hanford Geographic Information System resources to identify waste sites and facilities near the suspected source of each plume.
- Reviewing the history of nearby waste sites to determine if those waste sites could contribute to the known plumes. Site remediation documentation was reviewed to understand the magnitude of residual contamination that may remain in place in the vadose zone.
- Reviewing concentration time series at monitoring wells to evaluate contaminant concentration reductions over time.

Sections 2.2 and 2.3 identify areas and lines of evidence where secondary sources are known or suspected.

2.2 100-D Operational Area

The 100-D operational area includes two major Cr(VI) plume areas: one in the south and one in the north. Figure 1 shows the potential source area locations and the 2018 Cr(VI) plumes.

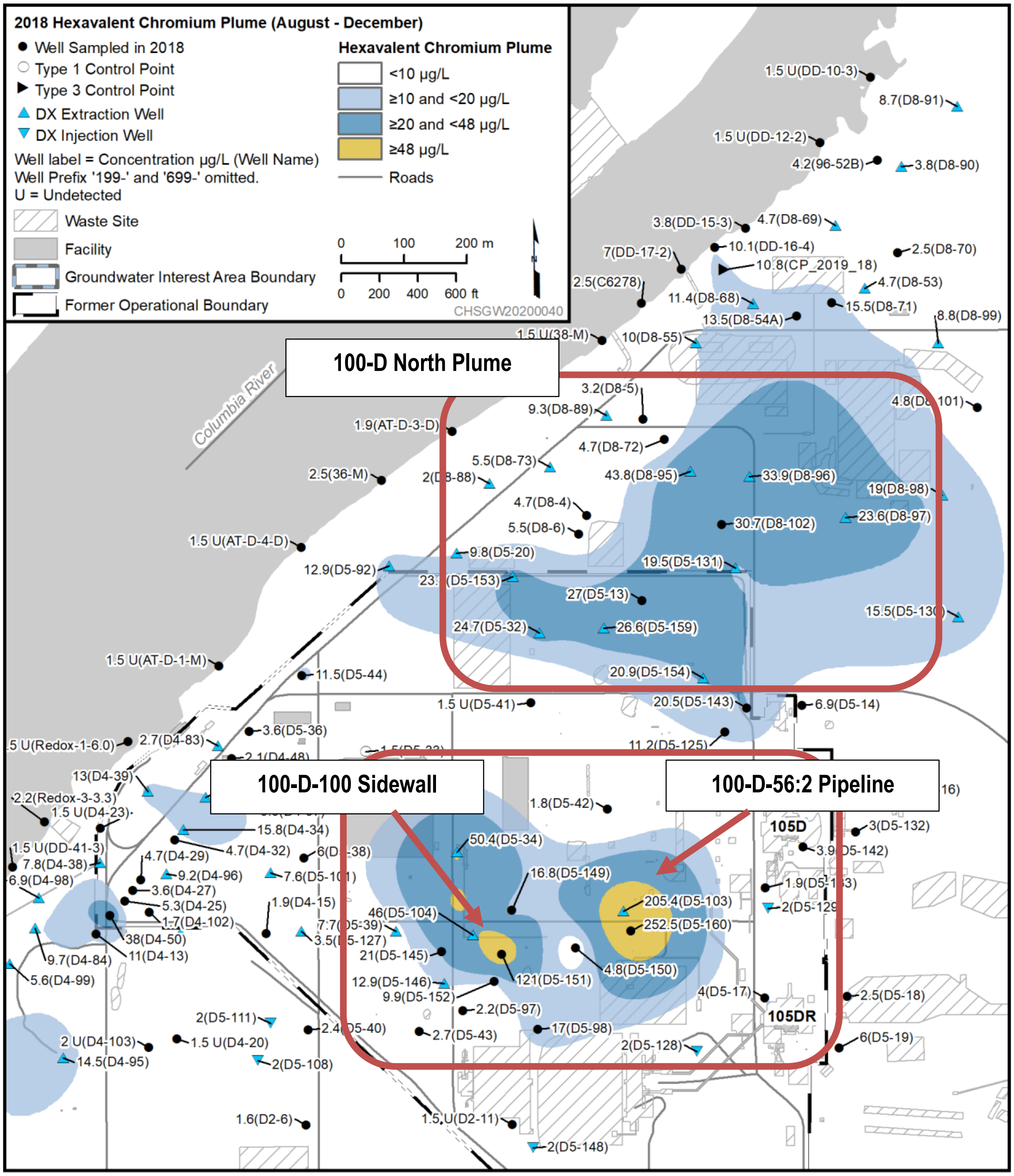

Figure 1. 100-D Area Cr(VI) Plumes and Areas with Potential Sources, 2018

2.2.1 100-D-100 Sidewall

An area of suspect Cr(VI) soil staining near a former sodium dichromate railcar unloading station was first identified in 2008 and classified as the 100-D-100 waste site. The waste site was excavated in 2014 and backfilled with clean material and debris. Excavation of the 100-D-100 waste site extended into the groundwater, which was encountered at a depth of 26 m (85 ft) below ground surface (bgs). As a result of the excavation activities, groundwater contamination in that area decreased rapidly. However, two areas of elevated Cr(VI) remain in the groundwater near the 100-D-100 excavation footprint.

A secondary source is known to be present based on the following lines of evidence:

- Elevated Cr(VI) in groundwater at well 199-D5-151 responds to groundwater fluctuations. Increased concentrations have been noted when the water table is high. Concentrations have remained >40 µg/L in well 199-D5-151 (Figure 2) since June 2016. Figure 3 shows the Cr(VI) plume, the location of well 199-D5-151 and other wells in the area, and the extent of the excavation footprint.

- Soil samples at locations SW-1 and SW-2 collected during the excavation of 100-D-100 had elevated Cr(VI), as shown in Figure 4 (SGW-58416, *Persistent Source Investigation at 100-D Area*). The sidewall area was not excavated due to the depth and size of the excavation and the proximity of nearby structures. The extent of the contamination is not known but is assumed to be limited based on the small area of elevated groundwater contamination in the area.

- Soil samples at location SW-3 were collected during the excavation of 100-D-100 near the former 100-D-56:2 pipeline (Figure 4). Analytical results at SW-3 had detected levels of Cr(VI), with concentrations in the SW-3 samples collected above the capillary fringe having a maximum value of 6.47 mg/kg Cr(VI) (SGW-58416). Visually stained soil was noted in that area, indicating the concentration may have been higher than indicated by the SW-3 results. The sidewall area was not excavated. The area of contamination at SW-3, while not well defined, is likely to be contributing to the western portion of the Cr(VI) plume (and concentrations at well 199-D5-104) based on the groundwater flow direction in that area.

- Surface staining in the southern portion of the 100-D-56 pipeline was noted in 2008 and was designated as the 100-D-100 waste site. The maximum Cr(VI) concentrations in the surface soil was 2,110 mg/kg (15-AMRP-0285, "Transmittal of Approved Waste Site Reclassification Form and Supporting Documentation for the 100-D-100, Stained Soil Near the 183-DR Railroad Track Waste Site, Revision 0") and indicates that there was leakage along the line.

2.2.2 100-D-56:2 Pipeline

A continuing Cr(VI) source is known to be present along the former 100-D-56 sodium dichromate supply pipeline that was remediated in 2006, of which 100-D-56:2 is the southern segment. As shown in Figures 3 and 4, later remediation of the 100-D-100 waste site extended over a portion of the 100-D-56:2 remediation footprint. The secondary source is likely located east of the 100-D-100 excavation footprint, based on the following lines of evidence. It should be noted, however, that the exact location of source material is not well defined, and there may be more than one area contributing to the elevated Cr(VI) at well 199-D5-103.

- During remediation activities in 2006, the pipeline was breached twice and Cr(VI)-contaminated liquid was spilled on the ground. Based on the documentation (WCH, 2011, *Remaining Sites Verification Package for the 100-D-56:2, South Portion of the 100-D-56 Sodium Dichromate Underground Supply Lines Waste Site*), at least one breach of the pipeline during remediation appears to have been located approximately 80 m (262 ft) east of where well 199-D5-160 now exists.

- Persistent Cr(VI) concentrations are noted in groundwater near the former pipeline at wells 199-D5-103 and 199-D5-160 (Figures 3 and 5). Previous contaminant concentrations in well 199-D5-103 also show the influences from changes of the P&T system configuration and river-stage fluctuations.
- The pipeline is a likely candidate for the Cr(VI) at well 199-D5-103; however, it should be noted that the 100-D-104 excavation may have also left residual material.

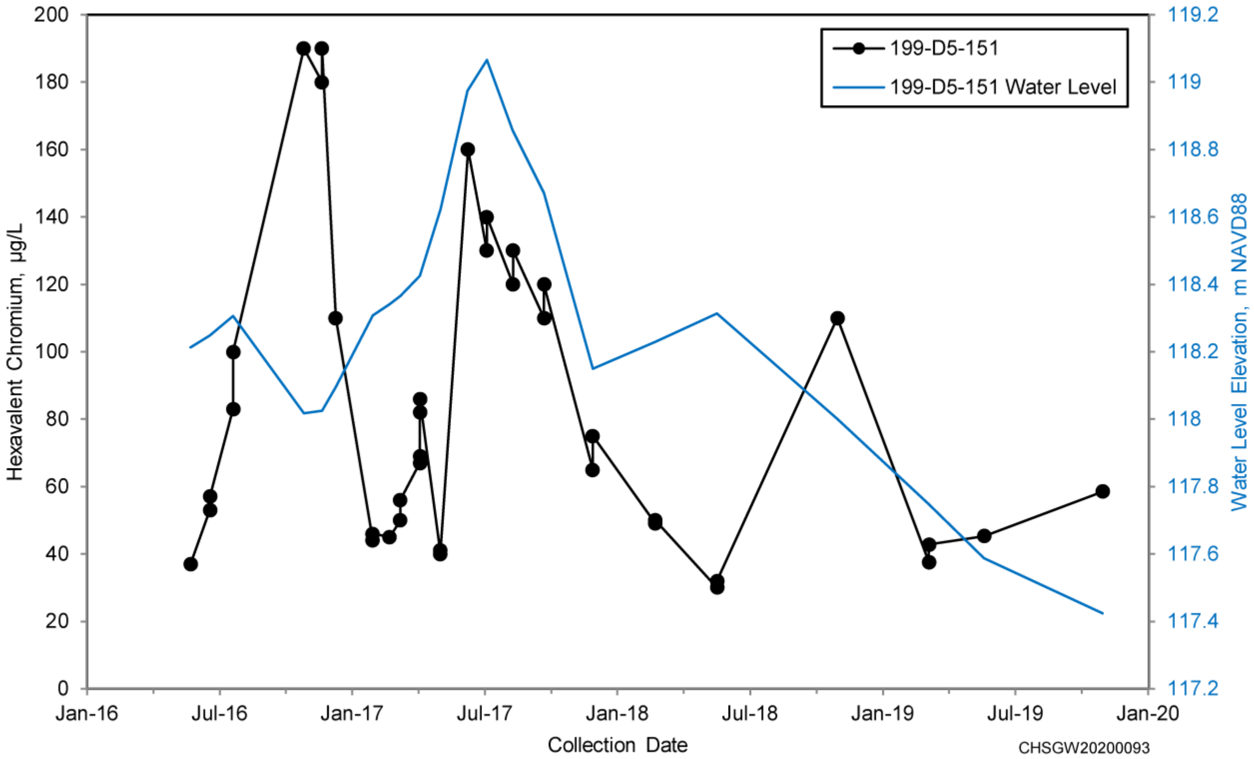

Figure 2. Cr(VI) Concentrations Response to Groundwater Fluctuation at Well 199-D5-151

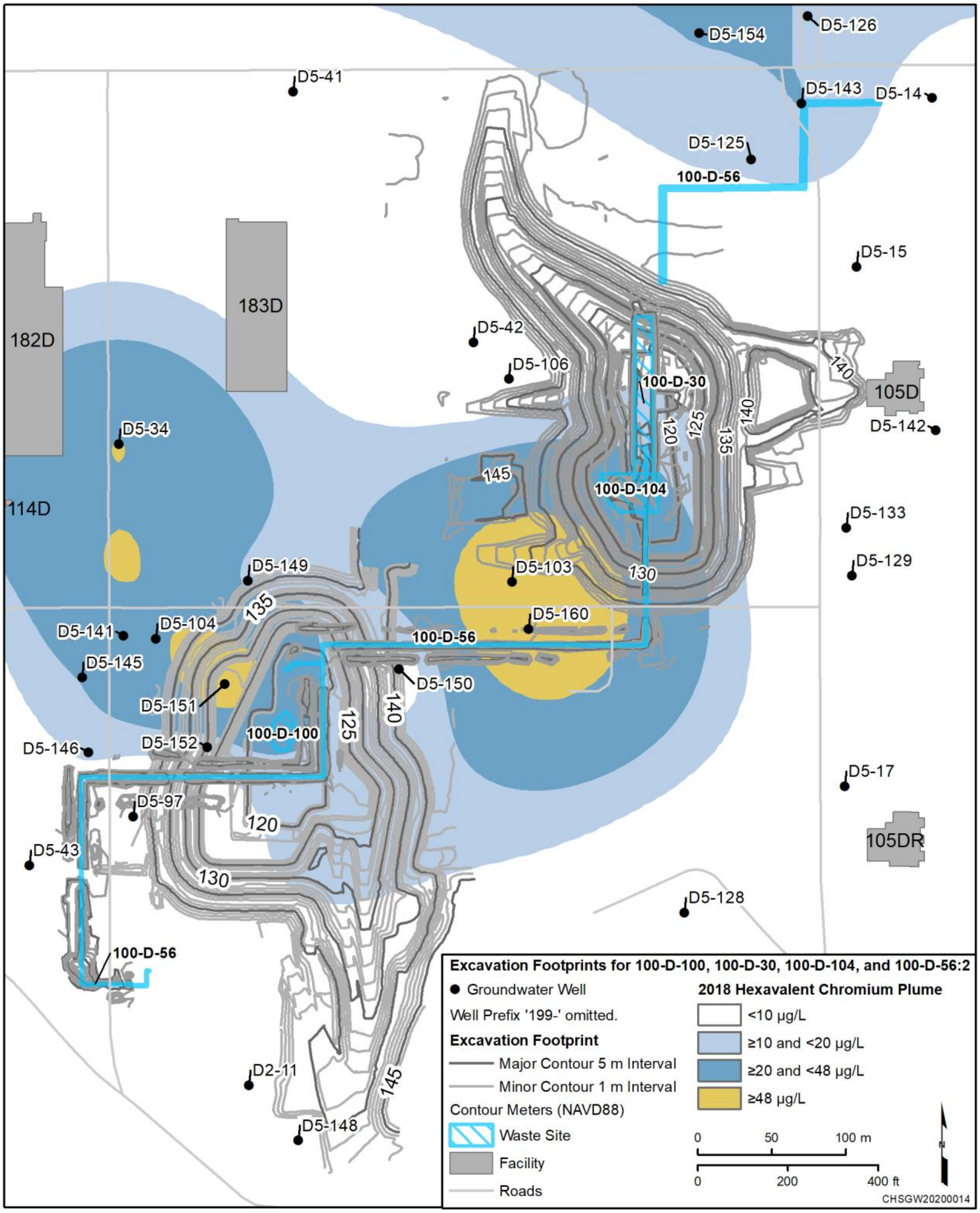

Figure 3. Cr(VI) Plume and Previous Excavation Extent Details

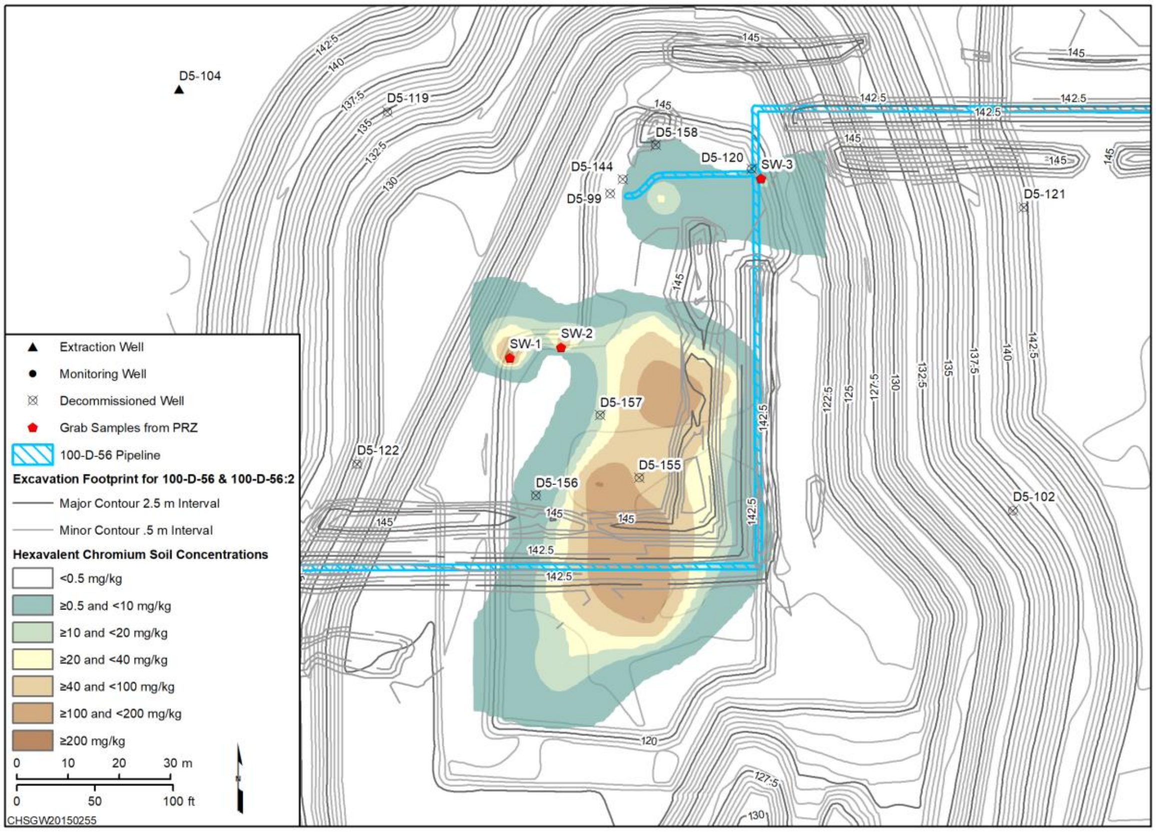

Figure 4. Cr(VI) Soil Sample Results at 100-D-100 Waste Site Excavation

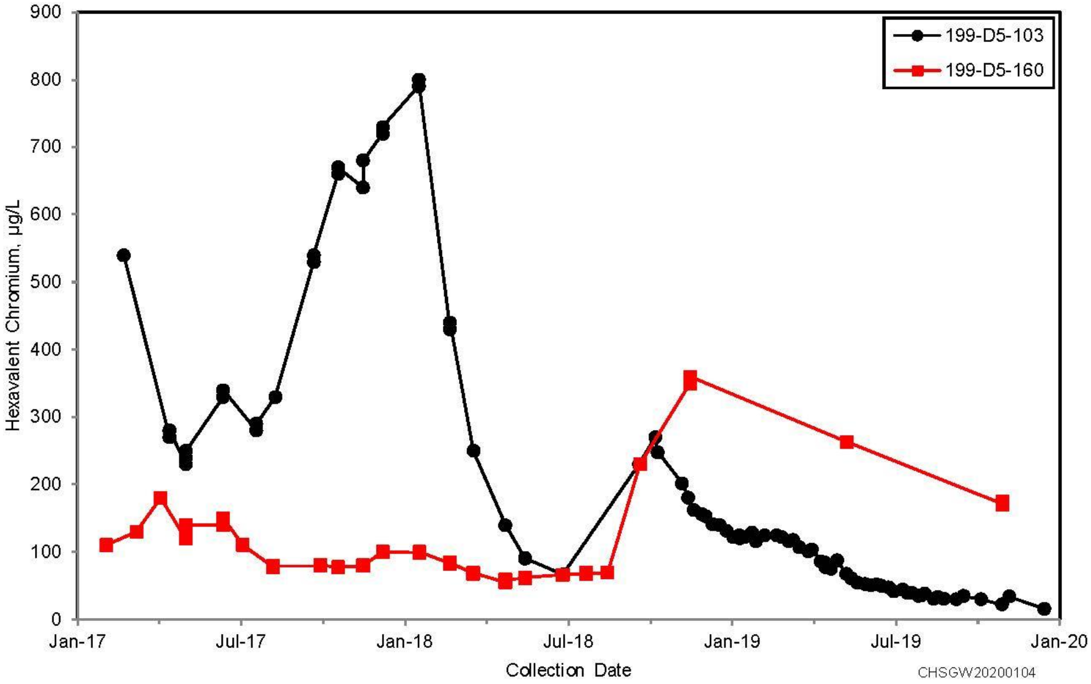

Figure 5. Cr(VI) Concentrations at Wells 199-D5-103 and 199-D5-160

2.2.3 100-D North Area

Waste sites in the northern portion of 100-D have been remediated. However, even though source area removals have been completed, Cr(VI) levels remain >20 µg/L in multiple wells (Figure 6). The persistent contamination in groundwater indicates the potential for a secondary source. The location of a secondary source has not been determined; however, several possible source areas are discussed in the following sections. Other potential causes for the slow reduction in Cr(VI) concentrations include the presence of mass in a lower transmissivity zone and/or hydraulic effects of stagnation due to the alignment of extraction wells in the area.

Discharges of reactor coolant effluent to the 116-DR-1 Trench started in 1950, with the 116-DR-2 Trench coming online a few years later. In 1967, an infiltration test was conducted, and effluent (a low-concentration Cr(VI) solution) from the D and DR Reactors was discharged to the 116-DR-1&2 Trench at a rate of 102,206 L/min (27,000 gal/min) during the study period. The releases to the trench resulted in a large groundwater mound consisting of contaminated cooling water with elevated Cr(VI) levels. As operations ceased, the mound quickly collapsed to levels below pre-test conditions in about 3 months (BNWL-CC-1352, *Ground Disposal of Reactor Coolant Effluent*) (Figures 4 through 7). Given the rate at which the groundwater mound collapsed, it is likely that some residual Cr(VI) was entrapped in the soil matrix, resulting in a potential secondary source area. Leakage from the retention basins and cooling water effluent piping systems may have also contributed to a secondary source of groundwater contamination in the vicinity.

Evidence for a secondary source in the 100-D North Area is as follows:

- Cr(VI) groundwater concentrations in wells in the 100-D North Plume have been slowly decreasing but remain >10 µg/L. As shown in Figure 7, the concentration decrease in wells 199-D8-96, 199-D8-97, and 199-D8-102 is becoming asymptotic, indicating that source material may be leaching from the vadose zone into the groundwater.

2.3 100-H Operational Area

Two Cr(VI) plumes remain in the 100-H operational area: a plume near the 183-H Solar Evaporation Basins and a plume near the 107H Retention Basin (Figure 8). The plume near the 183-H Solar Evaporation Basins extends upgradient to extraction well 199-H4-86, which is located on the edge of the excavation area for the 100-H-46 contaminated soil waste site. The 100-H-46 waste site is discussed separately as a potential secondary source area. The areas where a secondary source is known or suspected are discussed in the following sections. Figure 8 presents the site locations and the 2018 Cr(VI) plumes.

2.3.1 183-H Solar Evaporation Basins

The 183-H Solar Evaporation Basins consisted of four repurposed concrete flocculation/sedimentation basins that were constructed in 1949 and used for water treatment until the mid-1960s. When water treatment ceased, the basins became inactive. From 1973 to 1985, the basins accepted radioactive and mixed waste from the 300 Area fuel fabrication facilities. Routine waste included spent acid etch solutions (primarily nitric, sulfuric, hydrofluoric, and chromic acids). Metal constituents, including chromium, manganese, and uranium (among others), were in the form of precipitates (Section 4.6 in BHI-00127, *100-H Area Technical Baseline Report*).

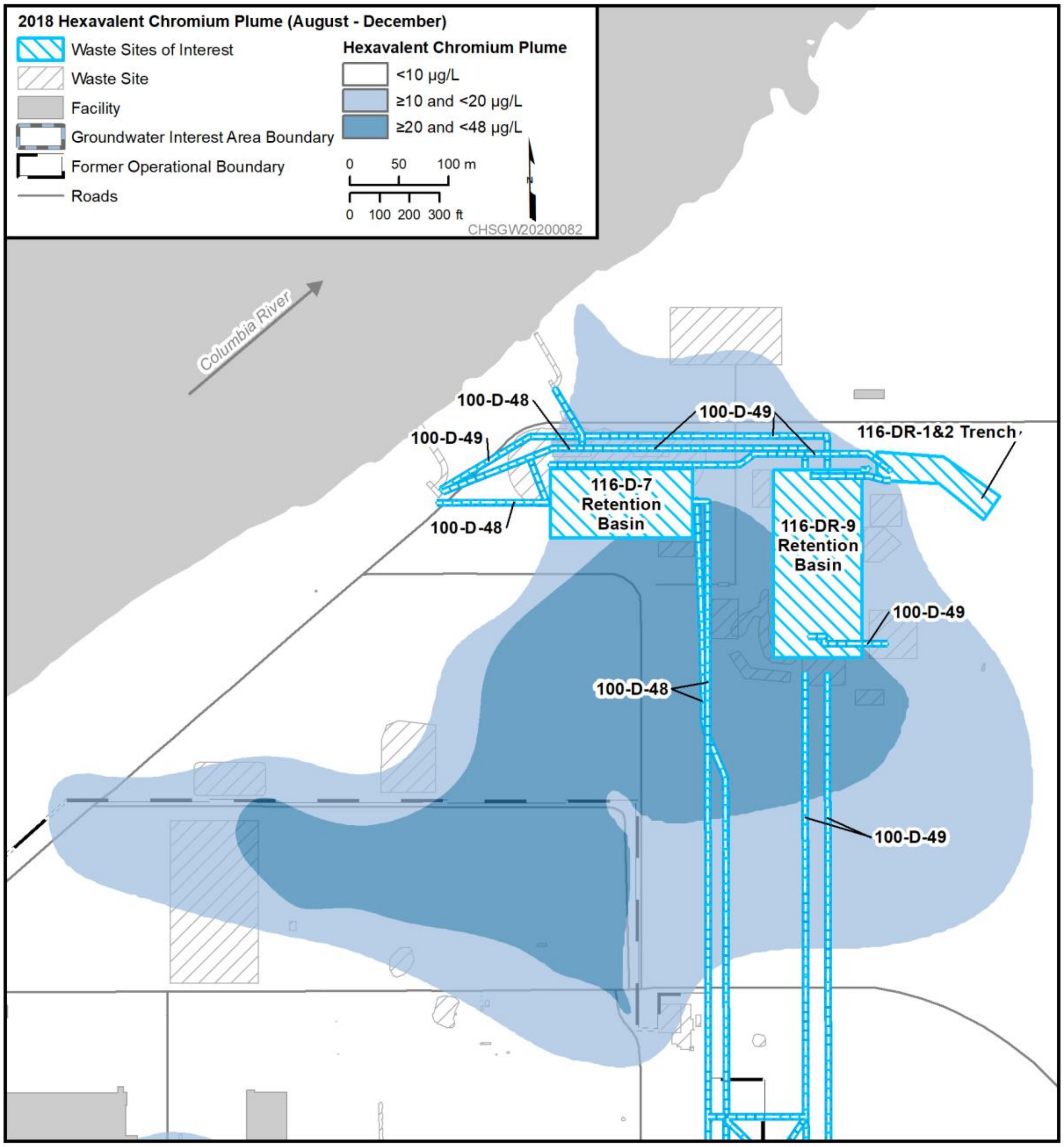

Figure 6. Cr(VI) Plume in the 100-D North Area

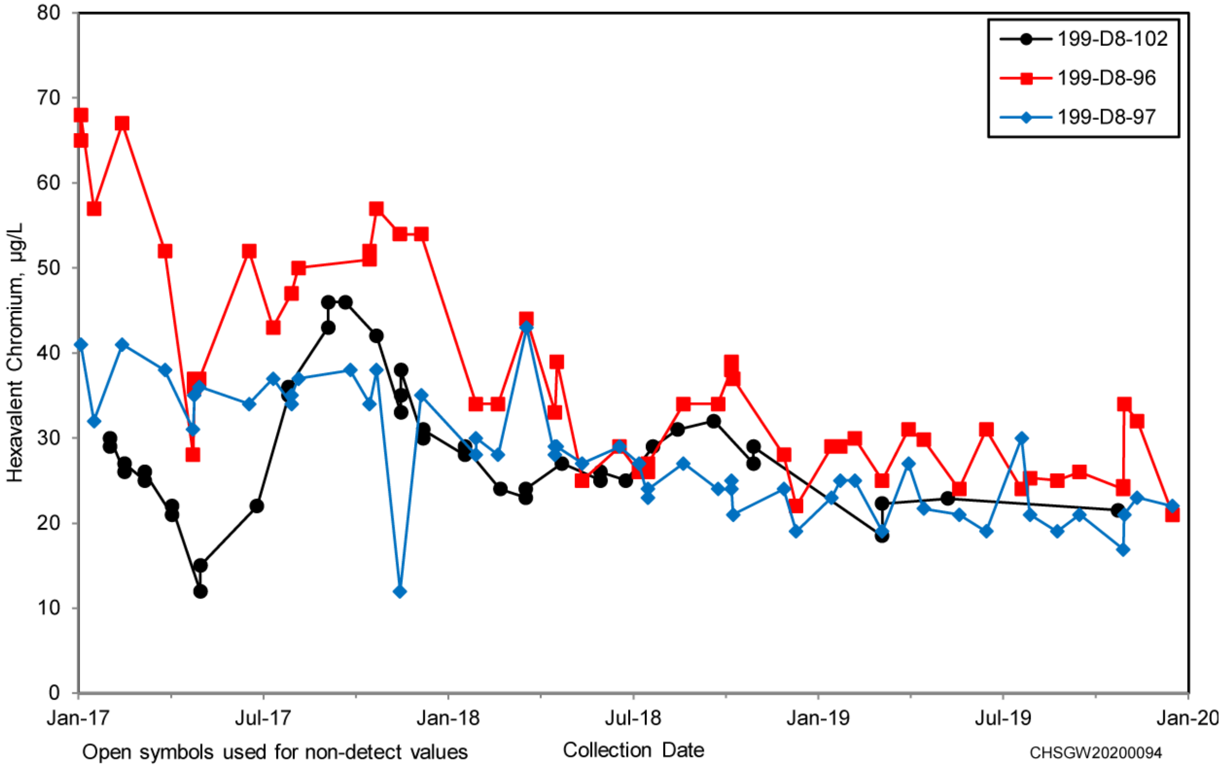

Figure 7. Cr(VI) Concentrations in 100-D North Area Wells

Based on DOE/RL-97-48, *183-H Solar Evaporation Basins Postclosure Plan*, the concrete floor of the basins was removed; however, a portion of the footings likely remain. In addition, the concrete floor of the clearwells to the south and the piping gallery likely remain in place.

Lines of evidence for a source area are as follows:

- Eleven soil samples were analyzed from the basin area following excavation, which extended up to 3.5 m (11.5 ft) beneath the base of the former facility. The samples were collected from within the Basin #1 footprint as deep vadose zone samples. The Cr(VI) results ranged from nondetected to 1.07 mg/kg. Nitrate results (also found in this waste site area) ranged from 26.9 to 1,930 mg/kg (Table 4-3 in BHI-00932, *1996 Phase II Soil Sampling at the 183-H Solar Evaporation Basin Site*).
- Concentrations of Cr(VI), nitrate, and uranium in groundwater at well 199-H4-88 responded to groundwater fluctuations. Increased concentrations are noted when the water table is high (Figure 9). Well 199-H4-84 has a similar pattern of responses to water level.

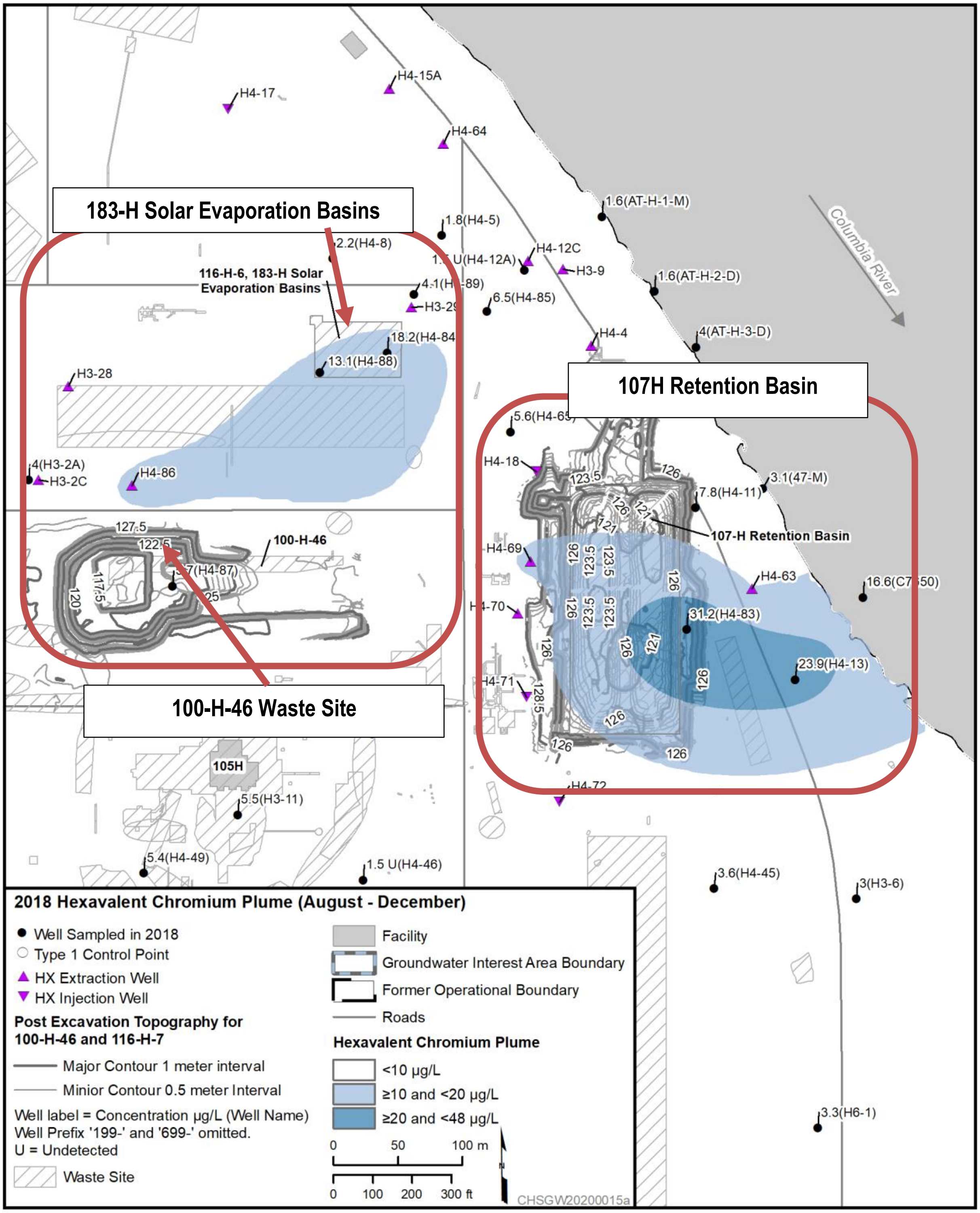

Figure 8. 100-H Area Cr(VI) Plumes with Excavation Footprints, 2018

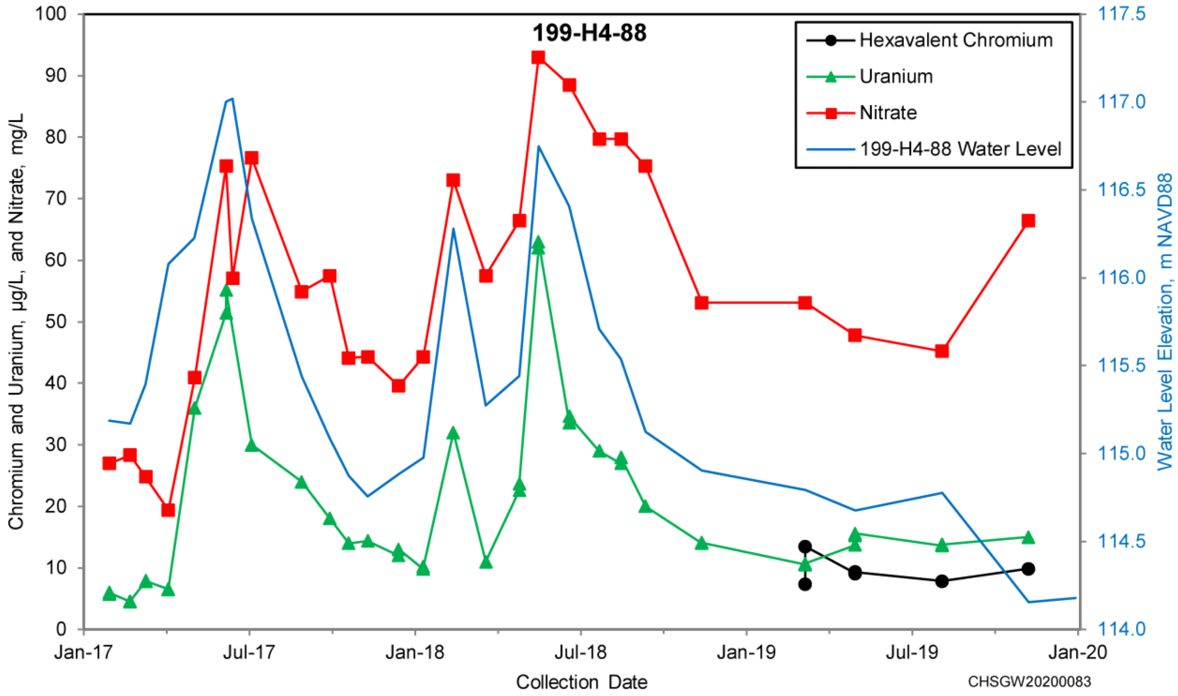

Figure 9. Contaminant Response to Groundwater Fluctuation at Well 199-H4-88

2.3.2 100-H-46 Waste Site

The 100-H-46 waste site includes a portion of the former 190H Pump House footprint associated with concentrated sodium dichromate handling (Figures 10 and 11). Dry and concentrated bulk sodium dichromate was received via railcar on the northwestern side of the pump house and was mixed and stored within the facility. The concentrated solution was injected into treated water supplied by the 183H Facility, which was then held in the four large water tanks within the 190H Pump House for supply to H Reactor. The mixing and feed tanks, injection pumps, and associated distribution piping for concentrated sodium chromate were all located within the 190H Pump House on the northern side of the facility. Above-grade portions of the 190H Pump House were demolished in 1977, leaving the slab in place.

The 100-H-46 waste site was identified for remedial action after confirmatory sampling identified 66.6 mg/kg Cr(VI) in stained concrete at the former unloading dock area. The site was excavated between February and July 2013, removing structural debris and soil up to 12.5 m (41 ft) bgs. The water table was measured in adjacent monitoring well 199-H4-86 on May 22, 2013, at 13.45 m (44.12 ft) below the top of the casing. Figures 11, 12, and 13 show the extent of the excavation. Green-stained concrete was observed in areas of the remediation. Systematic in-process sampling during remediation detected Cr(VI) in deeper soil at concentrations up to 4.53 mg/kg; however, indications of a large, concentrated release to soil were not identified. The site was reclassified as “interim closed out” based on verification sampling results and was then backfilled.

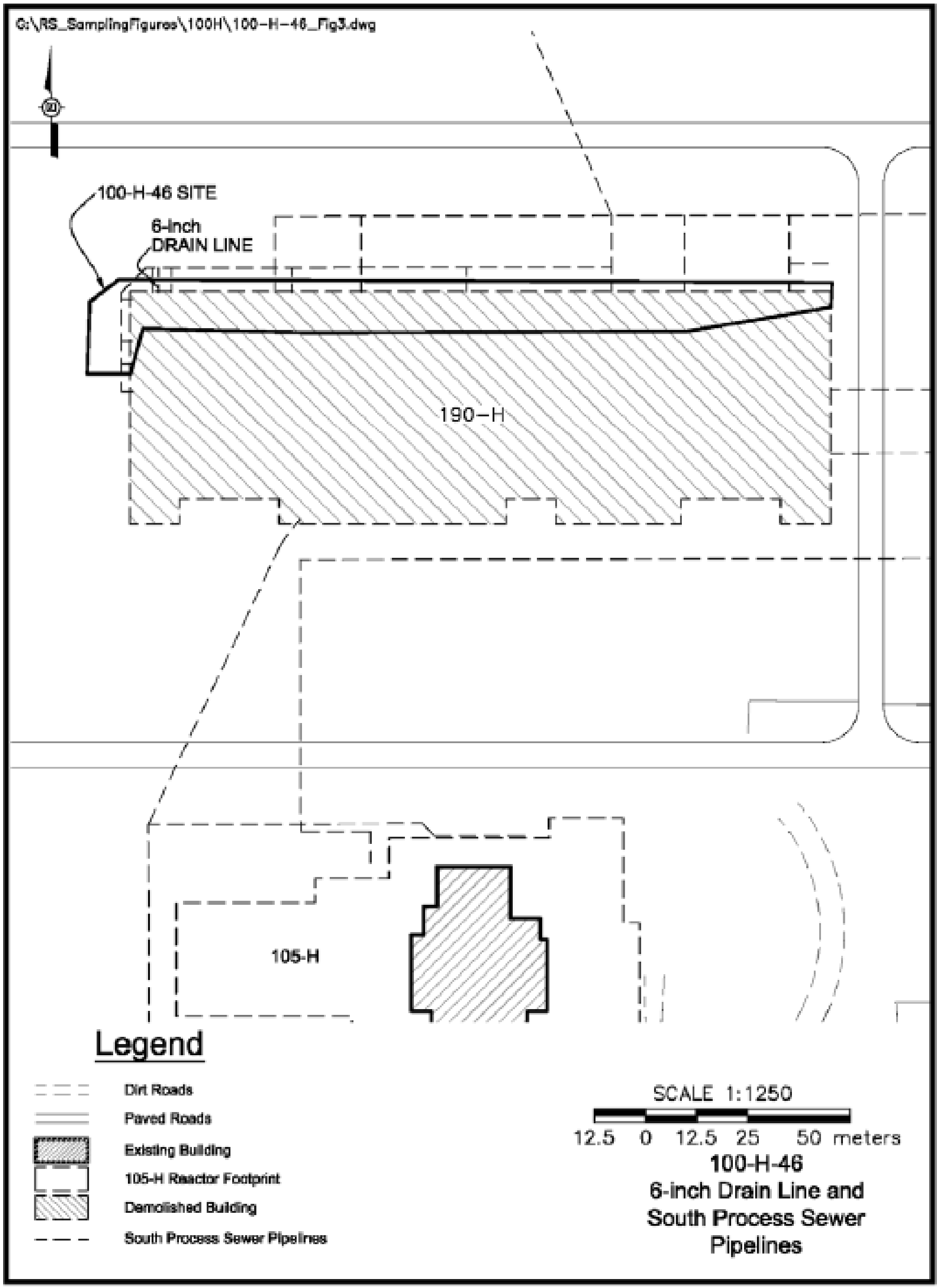

Figure 10. Location of the 100-H-46 Waste Site and 190H Pump House

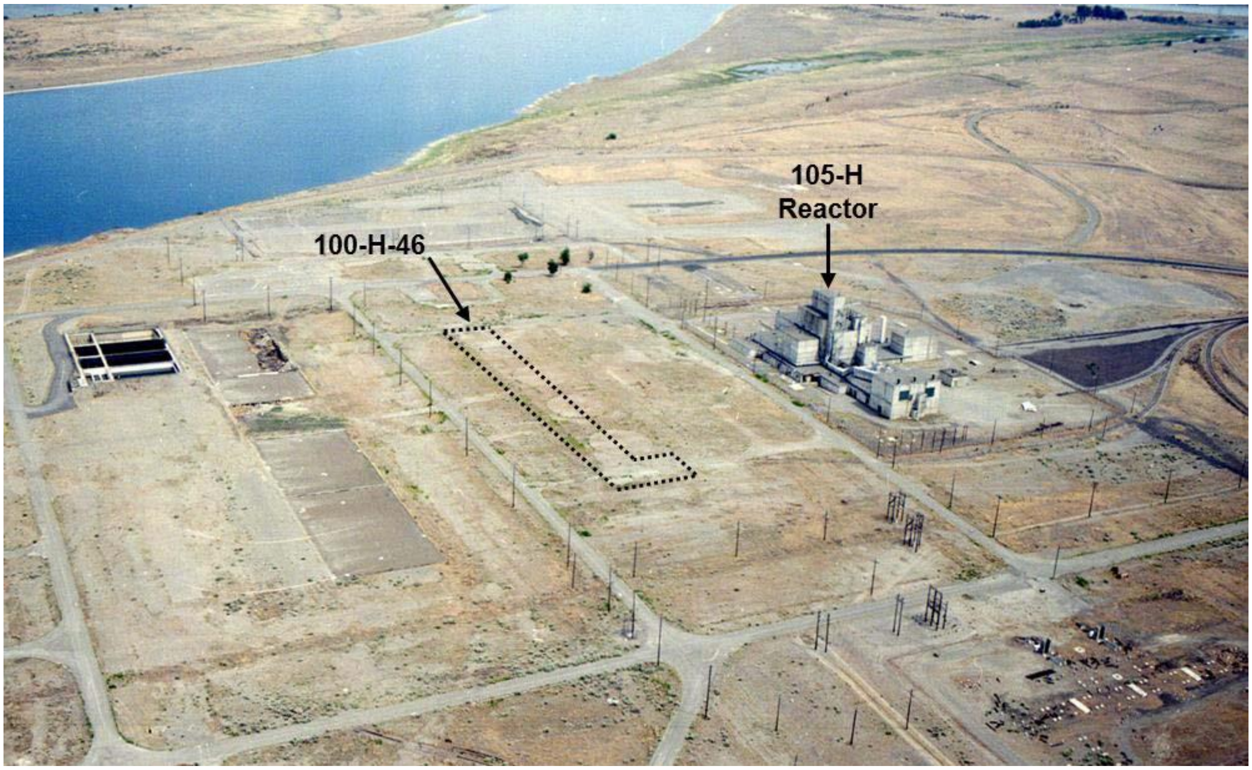

Figure 11. 100-H-46 Waste Site Location (1985 Aerial Imagery, View to Southeast)

Figure 12. Aerial Photograph of the 100-H-46 Waste Site Excavation at Final Depth (August 2013)

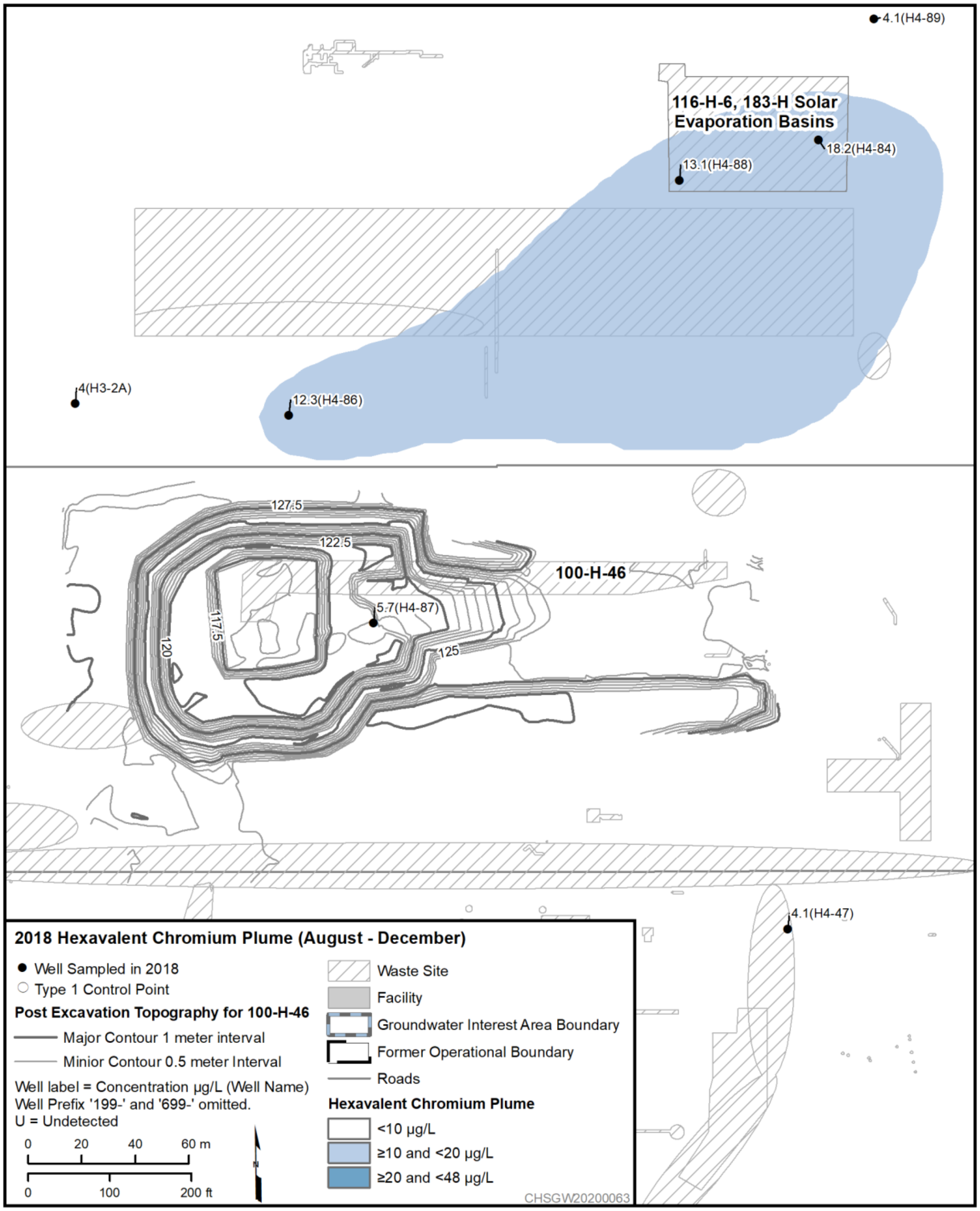

Figure 13. 100-H-46 Waste Site Excavation Footprint and Cr(VI) Plume

Lines of evidence for a potential source area are as follows:

- Green-stained concrete was observed in areas of the remediation, and systematic in-process sampling during remediation detected Cr(VI) in deeper soil at concentrations up to 4.53 mg/kg. During remediation activities, the site was excavated to a depth of 12.5 m (41 ft) bgs, which was just above the water table during high river stage when the excavation took place (May 2013). Monitoring at nearby well 199-H3-2B indicates that the water level decreased about 1 m (3.3 ft) following the completion of excavation at the site.

- Cr(VI) contamination remains elevated in well 199-H4-86, located on the edge of the former excavation. This side of the excavation was observed to have soil staining during remediation activities. Because the well is operating as an extraction well, it is unclear if the contamination is originating in that area or is migrating from a separate upgradient source.

- Cr(VI) concentrations in well 199-H4-87 (installed in the footprint of the excavation) have also periodically shown elevated Cr(VI) concentrations, up to 30 µg/L during high river stage in May 2017. This was the highest water period since the well was installed, which raised the water level to an elevation of 116.07 m (380 ft) (NAVD88, *North American Vertical Datum of 1988*). The water level was also high in August 2018; however, the water rose to only to 115.74 m (379 ft). The response in well 199-H4-87 along with the limited area of contaminated groundwater further indicates a small zone of contamination remaining in the lower vadose zone.

2.3.3 107H Retention Basin

The 107H Retention Basin received cooling water from H Reactor from 1949 to 1965. After radioactive decay and thermal cooling, the effluent was discharged from this concrete basin to the Columbia River. The 107H Basin was known to leak large volumes of contaminated water, which affected groundwater beneath the site. The basin leaked at rates as high as 38,000 L/min (10,000 gal/min). Contamination extended deeper than the interim remedial action excavation depth (4.6 m [15 ft] bgs) to groundwater (Sections 4.3.13 and 4.5.1.3 in DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*), although the lateral extent is not determined.

Lines of evidence for a potential source area are as follows:

- A Cr(VI) plume remains persistent in the area of the former retention basin, regardless of ongoing groundwater extraction in the area (Figure 8).

- Monitoring well 199-H3-21, which was drilled on the edge of the 107H Retention Basin (116-H-7 waste site), had Cr(VI) concentrations at 25 µg/L in July 11, 2019. Upgradient wells 199-H4-69, 199-H4-70, and 199-H4-71 have Cr(VI) concentrations <10 µg/L in most samples. Downgradient concentrations are slowly declining.

3 Data Needs

In order to determine whether soil flushing is an appropriate remedial technology to address secondary sources of Cr(VI) contamination in the vadose zone, the following factors must be understood:

- Approximate lateral footprint of residual contamination in the vadose zone

- Depth to water

- Ability of the current extraction well network to successfully capture water downgradient for treatment
- Estimated mass of Cr(VI) in the vadose zone
- Presence of construction materials or utilities that could impact remedial activities
- An understanding of other planned remediation or removal activities in the vicinity of secondary sources
- Proximity to the shoreline, areas of sensitive habitat, and culturally sensitive areas

For the Cr(VI) plumes in the 100-HR-3 OU, the data needs are addressed on a site-by-site basis. Design-specific considerations include the following:

- Presence of chromate-substituted calcium carbonate, which would require low pH flushing water
- Application of lessons learned from the KW soil flushing treatability test (DOE/RL-2017-30, *KW Soil Flushing/Infiltration Treatability Test Plan*), as appropriate, to determine the most appropriate infiltration design based on the site-specific infiltration rate and P&T system capacity to provide infiltration water, slopes, and soil compositions
- Geology of the vadose zone

3.1 100-D Operational Area

Table 1 summarizes the data needs and design considerations for the areas with potential or known secondary sources.

Table 1. 100-D Operational Area – Data Needs and Design Consideration Summary

Data Needs		100-D-100 Sidewall	100-D-56:2 Pipeline	100-D North
Secondary source status		Yes	Yes	Possible
Well defined footprint		Yes	Needs additional delineation	No
Depth to water		Approximately 26 m (85 ft) below ground surface		
Geology	Vadose zone	Hanford formation sand and gravel (favorable conditions)		
	Aquifer	Ringold Formation member of Wooded Island – unit E contact at water table, with some variation (favorable conditions)		
Good extraction network downgradient		Yes	May need additional downgradient extraction	Unknown
Good understanding of remaining mass		High level of understanding	Moderate level of understanding	No
Location and thickness of backfill		High level of understanding	Unknown	Unknown
Presence of concrete, rebar, or utilities		Area of rubble in backfill is mapped	None	Unknown
Known chromate-substituted calcium carbonate		Yes	Yes	Unknown

Table 1. 100-D Operational Area – Data Needs and Design Consideration Summary

Data Needs	100-D-100 Sidewall	100-D-56:2 Pipeline	100-D North
Other concerns (i.e., culturally sensitive area or nearshore location)	None	None	Unknown until source area is confirmed and defined

3.2 100-H Operational Area

Table 2 summarizes the data needs and design considerations for the areas with potential or known secondary sources.

Table 2. 100-H Operational Area – Data Needs and Design Consideration Summary

Data Needs		183-H Solar Evaporation Basins	100-H-46 Waste Site	107H Retention Basin
Secondary source status		Yes	Possible	Likely
Well defined footprint		Yes	No	No
Depth to water		Approximately 14 m (45 ft) below ground surface		
Geology	Vadose zone	Hanford formation sand and gravel (favorable conditions)		
	Aquifer	Hanford formation, with potential for small areas of Ringold Formation member of Wooded Island – unit E (Hanford formation areas are favorable)		
Good extraction network downgradient		May need additional downgradient extraction	May need additional downgradient extraction	No
Good understanding of remaining mass		Moderate understanding	No	No
Location and thickness of backfill		High level of understanding	High level of understanding	Moderate level of understanding
Presence of concrete, rebar, or utilities		Electrical resistance tomography results to confirm	None within the 100-H-46 remediation footprint	None
Known chromate-substituted calcium carbonate		No	No	No
Other concerns (i.e., culturally sensitive area, nearshore location, or other contaminants)		Nearshore; nitrate and uranium present	None	Nearshore; Sr-90 present

4 Soil Flushing Favorability Assessment

Soil flushing is a potentially effective tool to mobilize pockets of Cr(VI) in the vadose zone to groundwater, where the Cr(VI) can then be extracted and treated. If secondary sources can be reduced or eliminated, the time to achieve remedial goals using the existing P&T systems will likely be decreased. This chapter discusses the applicability of soil flushing at the 100-HR-3 OU based on the data needs identified in Chapter 3. Soil flushing is currently being implemented for the K West Cr(VI) plume, and initial tests indicate that it is an effective method for removing Cr(VI) from the vadose zone

(SGW-63885, *KW Soil Flushing Treatability Test Effectiveness Assessment and Recommendation*). It should be noted, however, that each site has its own complications, and remedial actions may not perform the same at all locations. As discussed below, various remedial options should be considered in areas with a secondary source.

4.1 100-D Operational Area

As shown in Table 1, the 100-D-100 sidewall near well 199-D5-151 is a good candidate for further consideration of either soil flushing or excavation. Excavation in this area would be an effective remediation method, but the depth to groundwater is approximately 26 m (85 ft) bgs, which would increase the cost due to the need for ramping. Due to the well delineated and likely small size of the secondary source, as well as the permeable Hanford formation sand and gravel in the vadose zone, soil flushing is likely to be cost effective. Considerations for the presence of chromate-substituted calcium should be made during design.

The 100-D-56:2 pipeline area may also be a good candidate for soil flushing, as conditions are similar to those at the 100-D-100 sidewall. The primary data gap is the size of the area needing remediation, which may be as large as 182 m by 182 m (600 m by 600 ft). Excavation in this area would be an effective remediation method, but the depth to groundwater is approximately 26 m (85 ft) bgs, which would increase the cost.

As shown in Table 1, the pipeline area will need additional investigation to delineate the extent of the secondary source footprint prior to soil flushing. Delineation of the source zone would reduce the cost and amount of water needed to remediate the material. Considerations for chromate-substituted calcium should be made during design. A cost-benefit analysis is recommended to determine whether soil flushing or excavation is the better option.

The area at 100-D North is not considered a candidate for soil flushing or excavation at this time due to the undefined area that may need remediation. After the Cr(VI) plume has been further remediated and the plume footprint is smaller, a rebound test is recommended to identify a potential treatment area.

4.2 100-H Operational Area

Both soil flushing and excavation should be considered further at the 183-H Solar Evaporation Basins. Soil flushing is likely to be effective, as indicated by the data presented in Table 2. However, the presence of other contaminants and the proximity to the river should be considered in addition to the costs. Also, the downgradient extraction network for the unconfined aquifer may not be adequate for the volume of water needed to conduct effective soil flushing.

Excavation of the 183-H Solar Evaporation Basins is likely a better alternative than soil flushing for the following reasons:

- Both uranium and nitrate sources are indicated in the lower vadose zone at the site, with groundwater concentrations increasing during periods of high water table.
- Contaminants associated with the site have a lower mobility than Cr(VI).
- Concrete or other rubble may be present within the Basin #1 footprint, which has the potential to interfere with the effectiveness of the flushing activities.
- The depth to groundwater is about 14 m (45 ft) bgs, therefore excavation should be evaluated for cost effectiveness.

- Proximity to the river would require a highly reliable extraction well network during a soil flushing remedy to ensure capture.

The presence of the clearwell concrete slab to the south may complicate the excavation design, further reinforcing the need for a cost evaluation. A potential unrelated benefit to excavation that should be considered is because the 183-H Solar Evaporation Basins are in the *Resource Conservation and Recovery Act of 1976* permit, and removal of the source material should result in a clean closure of the site and removal from the permit.

The 100-H-46 waste site has several data needs to be addressed prior to evaluating whether soil flushing is the best treatment option (Table 2). The primary data need is the location of the source material. A rebound test is recommended to confirm the presence of a secondary source and to identify a treatment area.

As with the 100-H-46 waste site, the 107H Retention Basin area has several data needs (Table 2), which include better identification of the potential source footprint and whether the backfill material incorporates debris or rubble. Until these data needs are addressed, soil flushing is not considered as an option. In addition, because the depth to groundwater is limited to about 14 m (45 ft) bgs, excavation should be evaluated for cost effectiveness.

5 Recommendations

Based on the data presented in this document, recommendations are provided in Table 3.

Table 3. Recommendations by Site

Site	Further Evaluations/Considerations for Preferred Option
100-D-100 sidewall	• Recommend soil flushing. • Evaluate excavation costs versus soil flushing.
100-D-56:2	• Recommend soil flushing. • Delineate the treatment zone with additional investigation or plan for larger treatment area. • Evaluate excavation costs versus soil flushing.
100-D North	• Recommend allowing the pump and treat system to continue to operate until a defined remediation target area can be identified.
183-H Solar Evaporation Basins	• Evaluate excavation costs versus soil flushing. • Perform a rebound study. • Consider risks associated with other contaminants and proximity to the river in design. • Evaluate the need for additional extraction downgradient from the basins. • Consider impacts to the *Resource Conservation and Recovery Act of 1976* site. • Conduct cost-benefit analysis for clean closure of site.
100-H-46 waste site	• Perform a rebound study.
107H Retention Basin	• Evaluate excavation costs versus soil flushing. • Perform a rebound study. • Consider risks associated with other contaminants and proximity to the river in design.

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