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2022 - Final Revised - Butte Reduction Works (BRW) Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site Phase II Quality Assurance Project Plan (QAPP)

Pioneer Technical Services, Inc.

SILVER BOW CREEK/BUTTE AREA NPL SITE
BUTTE PRIORITY SOILS OPERABLE UNIT

2022

Final Revised

Butte Reduction Works (BRW) Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site Phase II Quality Assurance Project Plan (QAPP)

Atlantic Richfield Company
317 Anaconda Road
Butte, Montana 59701

June 24, 2022

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Phase II Quality Assurance Project Plan (QAPP)

Prepared for:

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June 24, 2022

APPROVAL PAGE

Silver Bow Creek/Butte Area NPL Site
Butte Reduction Works Phase II
Quality Assurance Project Plan (QAPP)

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Plan is effective on date of approval.
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Silver Bow Creek/Butte Area NPL Site
Butte Reduction Works Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site
Phase II Quality Assurance Project Plan

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*The Draft Final was called Butte Reduction Works (BRW) Phase I Quality Assurance Project Plan (QAPP) Request for Change BRW-2019-02: **Phase II Hydrocarbon and Pumping Test Investigations.** In 2019 the hydrocarbon investigation information was pulled out and issued under a separate RFC (RFC03).
The Final was called BRW Phase I QAPP RFC BRW-2019-02: Phase II Site Investigation.**
*****Per Agencies request, the Final RFC BRW-2019-02 was modified and reissued as a standalone QAPP (this document) for the proposed Phase II Site Investigation. Additionally, the procedures and protocols from the BRW Phase I QAPP RFC BRW-2019-04: Investigation of Slag Physical Properties and Demolition Methods were incorporated into this Phase II QAPP.

ACRONYMS

Acronym	Definition	Acronym	Definition
%D	Percent Difference	**MBMG**	Montana Bureau of Mines and Geology
%R	Percent Recovery	**MPTP**	Montana Pole Treatment Plant
kN	kilonewton	**MS**	Matrix Spike
mg/kg	milligrams per kilogram	**MSD**	Matrix Spike Duplicate
Mm	millimeter	**NRDP**	Natural Resource Damage Program
MPa	megapascal	**NTU**	Nephelometric Turbidity Units
pCi/L	picocurie per liter	**O'Keefe**	O'Keefe Drilling Company
psi	pounds per square inch	**ORP**	Oxidation Reduction Potential
ARAR	Applicable or Relevant and Appropriate Requirement	**OHSA**	Occupational Health and Safety Administration
Atlantic Richfield	Atlantic Richfield Company	**PARCCS**	Precision, Accuracy, Representativeness, Comparability, Completeness, and Sensitivity
bgs	Below ground surface	**Parsons**	Parsons Drilling
BH	Borehole (for sample identification)	**PAH**	Polycyclic Aromatic Hydrocarbons
BMP	Best Management Practices	**PCB**	Polychlorinated biphenyl
BNSF	Burlington Northern Santa Fe Railway	**PCP**	Pentachlorophenol
Boland	Boland Construction & Drillings	**PDI**	Pre-Design Investigation
BPSOU	Butte Priority Soils Operable Unit	**PDS**	Post Digestion Spike
BRW	Butte Reduction Works	**PID**	Photoionization Detector
BSB	Butte-Silver Bow	**Pioneer**	Pioneer Technical Services, Inc.
BTL	Butte Treatment Lagoons	**PM**	Project Manager
°C	Degree Celsius	**PPE**	Personal Protective Equipment
CAR	Corrective Action Report	**PVC**	Polyvinyl Chloride
CD	Consent Decree	**PZ**	Piezometer (for sample identification)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act	**QA**	Quality Assurance
CFRSSI	Clark Fork River Superfund Site Investigation	**QAM**	Quality Assurance Manager
cfs	cubic feet per second	**QAO**	Quality Assurance Officer
CLP	Contract Laboratory Program	**QAPP**	Quality Assurance Project Plan
COC	Contaminant of Concern	**QC**	Quality Control
CPM	Contractor Project Manager	**RA**	Remedial Action
CRQL	Contract Required Quantitation Limit	**RCRA**	Resource Conservation and Recovery Act
DEQ	Montana Department of Environmental Quality	**RD**	Remedial Design
DI	Deionized	**RDWP**	Remedial Design Work Plan
DO	Dissolved Oxygen	**REW**	Right Edge of Water
Domestic Manganese	Domestic Manganese and Development Company	**RFC**	Request for Change
DQA	Data Quality Assessment	**RPD**	Relative Percent Difference
DQO	Data Quality Objective	**RQD**	Rock Quality Designation
EDD	Electronic Data Deliverable	**S2BVM**	Stage 2B Validation Manual
EPA	Environmental Protection Agency	**S4VEM**	Stage 4 Validation Electronic and Manual
EPH	Extractable Petroleum Hydrocarbon	**SC**	Specific Conductance
EWI	Equal Width Increment	**SDR**	Standard Dimension Ratio
GAC	Granulated Activated Carbon	**SIO2**	Silicon Dioxide

Acronym	Definition	Acronym	Definition
gpm	gallons per minutes	**SOP**	Standard Operating Procedure
GPS	Global Positioning System	**SOW**	Statement of Work
HDPE	High-Density Polyethylene	**SPLP**	Synthetic Precipitation Leaching Procedure
Hunter	Hunter Brothers Construction	**SRM**	Standard Reference Material
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry	**SSHASP**	Site-Specific Health and Safety Plan
JCI	Jordan Contracting Inc.	**TP**	Test Pit (for sample identification)
LAO	Lower Area One	**TPH**	Total Petroleum Hydrocarbon
LCS	Laboratory Control Sample	**USCS**	Unified Soil Classification System
LCSD	Laboratory Control Sample Duplicate	**USGS**	US Geological Survey
LDS	Laboratory Duplicate Sample	**VFD**	Variable Frequency Drive
LEW	Left Edge of Water	**VOC**	Volatile Organic Compound
LMS	Laboratory Matrix Spike	**VPH**	Volatile Petroleum Hydrocarbon
LNAPL	Light Non-Aqueous Phase Liquid	**XRF**	X-Ray Fluorescence
MB	Method Blank		

1.0 INTRODUCTION

This site-specific Butte Reduction Works (BRW) Phase II Quality Assurance Project Plan (QAPP) (BRW Phase II QAPP) provides the procedures and protocols necessary to conduct a Phase II Site Investigation as a part of the overall remedial design (RD) effort for the BRW Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site (Site).

The Site is within the Butte Priority Soils Operable Unit (BPSOU) located within the city of Butte, Montana (0). The Site is located within Lower Area One (LAO), which has a history of multiple industrial uses (0). As a result, there are accumulations of slag, tailings, demolition debris, and other impacted materials that may be a source of contaminants of concern (COCs) (i.e., arsenic, cadmium, copper, mercury, lead, and zinc) and additional constituents of concern (e.g., manganese, trace elements, hydrocarbons, etc.) to the underlying groundwater. The Phase I Site Investigation occurred during August 2018 through February 2020, except for groundwater level measurements which continued through June 2021 (Atlantic Richfield Company, 2019a). Based on results of the Phase I Site Investigation, an additional Site investigation is needed to collect additional information and refine the characterization of groundwater and solid materials within the Site to guide remedy design and implementation.

The Phase II Site Investigation will include a pumping test(s), pre- and post-pumping test groundwater analysis, Silver Bow Creek (SBC) metals loading analysis, additional opportunistic solid material characterization, investigation of slag physical properties and demolition methods (slag investigation), and groundwater characterization. This QAPP provides a new Data Quality Objectives (DQOs) section specific to this Phase II Site Investigation. The DQOs were identified according to the U.S. Environmental Protection Agency (EPA) *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006).

This BRW Phase II QAPP has been updated to reflect changes in the content and technical approach, as requested by Agencies, and to incorporate Requests for Change (RFC) BRW-2021-01 and BRW-2021-02. The procedures and protocols in this BRW Phase II QAPP have been updated to reflect any changes determined necessary to meet the DQOs (e.g., change in sampling technique). The BRW Phase II QAPP has not been updated to reflect any changes in the locations or number of samples collected. Details regarding the actual number of samples collected and analyses completed are included in the BRW Pre-Design Investigation Evaluation Report.

1.1 Purpose of the Phase II Site Investigation

The Phase I Site Investigation included an initial data collection effort to help refine the characterization of solid materials and groundwater within the Site. The Phase I Site Investigation took place from August 2018 through February 2020, except for groundwater level measurements which continued through June 2021 and included the investigation activities detailed in the BRW Phase I QAPP (Atlantic Richfield Company, 2019a).

The Phase II Site Investigation is necessary to address additional design-related data gaps related to future hydraulic control and construction dewatering as well as to collect additional data related to the characterization of solid materials, particularly slag, and groundwater within the Site (Table 1-1). Results from the pumping tests and the loading analysis will be used to better understand the groundwater aquifer within the Site and connection between the aquifer and SBC. This information will be used to aid in the BRW hydraulic control design for groundwater impacted with COCs and in future dewatering design efforts for the remedial action (RA).

The Phase II Site Investigation includes multiple stages to further delineate the extents (horizontal and vertical) of the slag within the Site and to collect appropriate information to inform the potential effectiveness of methods that may be employed to remove the slag. The slag investigation will focus on areas within the Site where slag is anticipated to be removed during remedial activities to achieve final grading for end land use and realignment of SBC.

Additional soil and groundwater data will be collected to further define the nature and extents of the COC presence within the Site, which will aid in the design of the BRW hydraulic control and assist in determining the appropriate waste removal depth for the RA. It is anticipated that a subsequent investigation (i.e., Phase III) will be required to further characterize the solid materials within the Site, seasonal groundwater and surface water conditions, and define the appropriate waste removal depth for the RA.

To support the Phase II Site Investigation, this document includes the following discussions:

1. Site Background (Section 2.0);
2. DQOs (Section 3.0);
3. Sampling Process and Design (Section 4.0);
4. Assessment and Oversight (Section 5.0);
5. Health and Safety (Section 6.0);
6. Project Organization and Responsibilities (Section 7.0); and
7. Data Validation and Usability (Section 8.0).

This document references Pioneer Technical Services, Inc. (Pioneer) Standard Operating Procedures (SOPs) for specific activities that outline specific procedures to safely complete tasks included in the Phase II Site Investigation. Table 1-2 lists the applicable SOPs for the Phase II Site Investigation.

1.2 Objectives of the Phase II Site Investigation

The main purpose of the Phase II Site Investigation is to collect additional data to support the RD for the Site, including the BRW hydraulic control. The specific objectives of the Phase II Site Investigation include the following:

- **Pumping Test(s):** To further define the aquifer parameters, boundary conditions, anisotropy, etc., as well as the quality of pumped groundwater within the Site to adequately design the dewatering system, BRW hydraulic control, and provide needed information on additional flows to the Butte Treatment Lagoons (BTL).

- **Pre- and Post-Pumping Test Groundwater Analysis:** To provide finer detail on the nature and extent of COC- and hydrocarbon-impacted groundwater within the Site and upgradient of the Site to guide the design and implementation for the realigned SBC and the BRW hydraulic control.
- **Silver Bow Creek Loading Analysis:** Collect additional information needed to determine the nature, extent, and source of the chemical loading to SBC from the area between SS05B and SS06A.
- **Additional Solid Material Characterization:** Collect additional information needed to refine the volume and location of waste materials and additional information needed on the chemical stability/leachability of solid materials that may remain after the remedial action is complete.

To meet the objectives above, the following activities will be completed as part of the Phase II Site Investigation:

- Conduct an initial pumping test and an optional, second pumping test to determine groundwater characteristics to design a plan for construction dewatering and to aid in the design of the BRW hydraulic control for COC-impacted groundwater.
  - Collect groundwater field parameters during pumping, including:
    - Aquifer parameters (i.e., hydraulic conductivity, transmissivity, boundary conditions, etc.);
    - Effective pumping rates; and
    - Groundwater quality.
  - Collect relevant information to determine effects of the pumping test(s) on SBC and to the existing groundwater remedy, including:
    - Collecting staff gage data on SBC to determine the effects of creek fluctuations on the pumping test(s).
    - Collecting staff gage and flow data from the nearby BRW-00 Pond to determine the effect of the pumping test(s) on capture rate to the existing groundwater remedy.

- Collect additional groundwater samples before and after the pumping test(s) to further define the characterization of groundwater within the Site and aid in the design of the BRW hydraulic control.
  - Collect groundwater samples from the proposed and existing wells and piezometers and analyze for specified analytes to further define the nature and extent of the areas within the groundwater aquifer that have been impacted with dissolved COCs,

hydrocarbons, polychlorinated biphenyls (PCBs), pentachlorophenol (PCP), dioxins, and lead scavengers (1.2 dichloroethane and 1,2 dibromoethane).

- Complete a loading analysis for SBC from the area between SS05B and SS06A to aid in the design of the BRW hydraulic control.
  - Collect groundwater and surface water samples from monitoring wells and staff gages, respectively, and analyze for specified analytes before, during, and after the pumping test(s) to help determine the changes in chemical concentration and load to SBC during an aquifer test.

- Conduct a slag investigation to further delineate the extents (horizontal and vertical) of the slag within the Site and to collect appropriate information to inform the potential effectiveness of methods that may be employed to remove the slag.
  - Excavate test pits at locations within the Site where slag is anticipated to be removed during remedial activities and investigate the remaining smelter stack foundation which is constructed of slag. Document physical features of the slag. This will help refine the extent and physical characteristics of the slag within the Site.
  - Drill boreholes and collect core samples of slag for laboratory tests. Boreholes will be drilled at areas within the Site at locations where slag caused refusal during the excavation of test pits. The data will aid removal efforts and methods that may be employed.
  - Conduct field tests at select locations within the Site and record production data to help determine the effectiveness of heavy equipment and expandable grout for slag removal. The data may also be used to potentially establish indicators of what portions of slag can be removed by equipment and what portions of slag may require an alternative means for removal.

- Continue to collect opportunistic solid material data to further define the nature and extent of the COCs and organic contamination presence within the Site, which will aid in the design of the BRW hydraulic control and assist in determining the appropriate waste removal depth for the RA, including:
  - Collect soil samples from lithological layers within the removal corridor that are not located near a previous investigation point and analyze for metals and hydrocarbons.
  - Collect soil samples from lithological layers within select boreholes and analyze for specified analytes to determine the chemical stability/leachability of the soils. The Synthetic Precipitation Leaching Procedure (SPLP) samples from Phase I identified that the alluvium at BRW may be a source of copper to SBC. Based on this finding, this QAPP modifies the Phase I SPLP selection criteria (discussed in Section 3.0) to further define this secondary source.

- Collect additional groundwater samples to provide remaining RD data gaps for the Site. Additional groundwater and surface water sampling is needed during a representative range of seasonal groundwater and surface water conditions (such as high- and low -groundwater and surface water conditions).

2.0 BACKGROUND

A detailed discussion of the Site description, history, and previous investigations was included in the BRW Remedial Design Work Plan (RDWP) (Atlantic Richfield Company, 2019b) and the BRW Pre-Design Investigation (PDI) Work Plan (PDI Work Plan) (included as an attachment to the RDWP). Summaries relevant to the Phase II Site Investigation are included in the sections below.

2.1 Site Description

The Site is located in Butte, Montana, covers approximately 23.3 acres, and is located immediately west of Montana Street between SBC and the Burlington Northern Santa Fe Railway (BNSF) line (Figure 1-1 and Figure 1-2). Currently, Butte-Silver Bow (BSB) uses the Site for materials storage and has a crusher and asphalt plant on the Site.

2.2 Site History

Beginning in 1885 to present day, the Site has been the location of multiple industrial operations including a copper smelter and a zinc concentrator, and was also used by the Domestic Manganese and Development Company (Domestic Manganese) (Sanborn, 1943) and Rocky Mountain Phosphates, Inc. (GCM Services, Inc., 1991). This complex history of activities has resulted in a complex distribution of materials within the Site (including slag, tailings, manganese waste, demolition debris, foundations, and other historic structures) as well as impacted soils and groundwater (Atlantic Richfield Company, 2019b).

2.3 Relevant Previous Investigations

2.3.1 2016 BRW Smelter Site Test Pit Report

In 2016 for the Natural Resource Damage Program (NRDP) conducted a test pit investigation and subsurface material sampling within the Site to characterize subsurface mine waste deposits, slag, impacted soil, and miscellaneous fill materials placed within the area (NRDP, 2016). As part of the test pit investigation, 30 test pits were excavated, which assisted in mapping the extents of slag within the Site. Results indicated that the thickest areas of slag were along the west, north, and northeast portions of the Site (Table 2-1 and Figure 2-1). Although some test pits in these areas met refusal when slag was encountered giving little or no indication of thickness, the thickness of the slag wall along the northern and western side of the Site indicates the slag is thickest in these areas. In 14 of the 30 test pits, the field team encountered hard slag that could not be penetrated by the Caterpillar 336L Excavator (Figure 2-1). Refusal depths ranged from 1.8 feet below ground surface (bgs) to greater than 16 feet bgs (Table 2-1). The results also indicated that in some locations, the underlying slag was weaker or more fractured than the overlying slag, which created unstable and dangerous surface conditions. Figures, logs, and field notes included in the appendices of the BRW Smelter Site Draft Test Pit Report (NRDP, 2016) do not list or describe these undermining locations.

Ultimately, the investigation concluded that additional field work was necessary to further define the extent and competency of the slag. Table 2-1 and Figure 2-1 summarize results from the investigation (NRDP, 2016). Test pit identification along with overburden depths and slag thickness are also provided in Table 2-1, and test pit locations along with slag thickness are shown on Figure 2-1. Additional information from the investigation including figures and tables with results, photographic logs, field sampling notes, and laboratory reports are included in the appendices of the NRDP report (2016).

2.3.2 Preliminary Results from Phase I Site Investigation

The Phase I Site Investigation took place in 2018 through 2020. Preliminary results from the work completed in 2018 and early 2019 are summarized in the BRW Phase I QAPP (Atlantic Richfield Company, 2019a) and additional details are provided in the various tables and figures mentioned in this report.

Results Relevant to Impacted Groundwater within the Site

In the fall of 2018, Pioneer constructed new piezometers within the Site. The piezometers were installed using either a Geoprobe® or sonic drill rig. Groundwater samples were collected from the new piezometers and submitted to the laboratory for specified analyses detailed in the BRW Phase I QAPP (Atlantic Richfield Company, 2019a). Since January 2019, monthly groundwater levels have been collected. Additionally, transducers were installed in select piezometers identified in the BRW Phase I QAPP, and data from these transducers is downloaded as a part of the monthly groundwater level efforts. The preliminary results of the Phase I Site Investigation identified areas within the groundwater aquifer that are impacted with COCs. Figure 2-2 shows the piezometers where COC concentrations exceeded the Montana Department of Environmental Quality (DEQ) Circular DEQ-7 standards (http://deq.mt.gov/Portals/112/Water/WQPB/Standards/PDF/DEQ7/DEQ-7.pdf) (based on 2018 sampling analytical results) and the approximate groundwater contours (based on water level data from May 2019).

Results Relevant to Slag Distribution within the Site

An evaluation of historic infrastructure was also performed during the Phase I Site Investigation, which included the slag and concrete steel reinforced foundation of the BRW smelter stack. Part of the Phase I Site Investigation included construction of test pits and boreholes to document the lithology and determine the distribution of materials, including slag, within the Site (Figure 2-1).

Results of the Phase I Site Investigation indicate that the thickest areas of slag are along the northern part of the Site, particularly the northeastern corner. Slag was encountered in 3 test pits and 19 boreholes. Water was required for drilling in 10 boreholes based on field notes, which may indicate harder-to-demolish slag in these areas. Additionally, the results indicate that the smelter stack stood on a slag base 12.5-feet thick and the reinforced concrete base was 42.5 feet by 42.5 feet and 8-feet thick.

While the Phase I Site Investigation provided additional detail to define the lateral limits and thickness of slag within the Site, it did not include collecting data relevant to the demolition of the slag. A summary of the results from the investigation is included in Table 2-1 and Figure 2-1. Test pit and borehole identification, overburden depths (i.e., depth to slag), and slag thickness are included in Table 2-1, and test pit and borehole locations along with slag thickness are shown on Figure 2-1.

Please note that all of the BRW Phase I Site Investigation analytical data presented in this report were preliminary when the BRW Phase II QAPP was originally drafted. The data were subsequently reviewed using the appropriate quality assurance/quality control (QA/QC) procedures and data validation procedures. Atlantic Richfield Company (Atlantic Richfield) has included a complete summary of the validated results, including an interpretation, in the PDI Evaluation Report.

2.3.3 Additional Investigations

The following two additional investigations have occurred since the initial Phase I Site Investigation in 2018:

- Second Groundwater Sampling, BRW Phase I QAPP Request for Change (RFC) BRW-2019-01 (RFC01)
- Hydrocarbon Investigation, BRW Phase I QAPP Request for Change (RFC) BRW-2019-03 (RFC03)

The procedures and protocols for both investigations are incorporated in the BRW Phase I QAPP (Atlantic Richfield Company, 2019a). Atlantic Richfield will include a complete summary of the results from these investigations, including an interpretation, in the PDI Evaluation Report (Section 5.4).

2.4 Site Geology and Hydrogeology

The Butte area lies within the Summit Valley of southwest Montana and is characterized by Quaternary alluvium surrounded by the Butte Granite of the Cretaceous Boulder Batholith (*Geologic Map of the Upper Clark Fork Valley, Southwestern Montana, Open File Report 506,* [MBMG, 2004]). Groundwater at the Site travels through an aquifer comprised of alternating layers ranging from fine silts and clays to medium gravel (alluvial aquifer). The aquifer also has intermittent layers of black organic silt and has weathered and/or competent bedrock underneath. Groundwater primarily travels through the more conductive alluvial aquifer via the small, interconnected spaces between the alluvial material and weathered bedrock, but also travels more slowly through the relatively nonconductive competent bedrock (Canonie, 1994).

Alluvium

The primary source of the alluvial material existing at the Site is the granitic bedrock (i.e., Butte Granite) surrounding most of the Summit Valley. The alluvial material at the Site consists of clays, silts, sands, and gravels. Generally, the upper portion of the alluvium is finer grained with clay with silt being more dominant. With depth, the alluvium gets coarser with sand, however gravel is more predominant. Using available well/piezometer logs and averaged groundwater elevations for the Site, an isopach map was created (Figure 2-3) showing the saturated alluvial thicknesses to facilitate selection of the pumping test(s) well location.

Black Organic Silt
In certain locations (e.g., BPS07-13B and Atlantic Richfield Company, 2013), a black organic silt is encountered on top of the coarser alluvium, and is generally near the top of the undisturbed material in the area throughout the BPSOU aquifer. When this silt is directly in contact with impacted materials and/or groundwater, the organic component has the capacity to adsorb elements with a positive charge (e.g., cadmium, copper, lead, and zinc), and therefore can serve as a secondary source of COCs. The extent of this organic silt is intermittent throughout the Site, and in many areas appears to be unimpacted with COCs.

Bedrock
Underneath the alluvium is granitic bedrock. A layer of this bedrock (closest to the overlying alluvium) has been weathered, and the bedrock has the consistency of crumbly sand. Deeper within the bedrock, the granitic bedrock has not been as heavily weathered, and has the consistency of hard rock. There are notable differences between weathered and competent bedrock and the overlying alluvium. First, competent bedrock is typically identified with drilling refusal using light direct push equipment and a general lack of weathering, whereas weathered bedrock is typically identified with relatively easy drilling and can be differentiated from the overlying alluvium by the lack of rounded grains. Second, the more weathered material can conduct groundwater at a similar rate to the overlying alluvial material, while the unweathered bedrock is much less conductive unless fractures are present (Canonie, 1994).

Depths to the weathered bedrock and unweathered bedrock were measured during the BRW Phase I Site Investigation completed in fall 2018. Piezometers and some test holes were installed down to bedrock to provide local control in the study area. The depth to the weathered bedrock ranged from 22.2 feet below ground surface (bgs) in the lower western vegetated area of the Site to 44.2 feet bgs in upper central portion of the Site. The weathered bedrock contour surface is presented on Figure 2-4 that shows a low spot in the location of piezometer BRW18-PZ02. The thickness of the weathered bedrock layer ranged from 0.8 to 15.7 feet with an average thickness of 4.4 feet.

2.4.1 Surface Water

The SBC travels through the Site (Figure 1-2). The current path of SBC is not the historical one, as the creek channel was moved to the north through the operations of the BRW Smelter. Between SBC stations SS-05.7 to SS-05A (Figure 1-2), SBC is generally considered a losing stream. It should be noted, that depending on the stage at BRW-00 (i.e., when the stage at BRW-00 is at the middle or highest stage), the reach from SS-05.9(R) to SS-05A can be gaining. Between SBC stations SS-05A to SS-06A (Figure 1-2), SBC is generally considered a gaining stream (Atlantic Richfield Company, 2016a).

2.4.2 Groundwater

As groundwater enters the Site, groundwater flow within the alluvial system is generally from southeast to northwest. The flow direction to the east of the Site generally mimics the lay of the land (i.e., topographic slope), and due to the shallowing bedrock depth, historically flowed toward and into SBC, even as it was shifted to the north by the BRW Smelter operations. The reason that groundwater flows into SBC is that water flows from areas of high potential to areas of low potential; just as surface water flows from areas of high elevation (i.e., mountains) to areas of lower elevation (i.e., valleys), groundwater follows the path of least resistance. In the case of the Site, the path of least resistance was historically SBC.

Currently, the groundwater remedy maintains hydraulic control to the north of the Site (i.e., the BRW-00 Pond and the hydraulic control channel, [Figure 1-2]). These features hydraulically control groundwater to the north of SBC, causing groundwater to flow toward the BRW-00 Pond. Between SBC stations SS-05.7 and SS-05B (Figure 1-2), this hydraulic control extends underneath SBC and into the Site when the stage at the BRW-00 Pond is at the lowest stage elevation. This configuration prevents groundwater flow into this reach of SBC; as a result, SBC is generally a losing reach between these stations when the stage at the BRW-00 Pond is at the lowest stage elevation (Atlantic Richfield Company, 2016a). The groundwater contour map for the May 29, 2019, monitoring event is shown on Figure 2-5.

2.5 BRW Remedial Action

The BRW RA includes removing tailings, waste, contaminated soils, including hydrocarbon-impacted material, and slag within the SBC 100-year floodplain reconstruction area to a depth to be determined following the PDI activities. The conceptual RD is shown on Figure 2-6 and will include the following:

- Removing waste (as defined by the Waste Identification Screening Criteria [EPA, 2020]) from the Site in a corridor that will contain a new channel for SBC to a depth determined during the RD.
- Managing soils and groundwater impacted by hydrocarbons, as appropriate.
- Realigning SBC and constructing the bank-full channel and 100-year floodplain.
- Regrading and constructing caps over the tailings, waste, contaminated soils, and slag left in place.
- Hydraulically control and treat COC-impacted groundwater from the Site.

All contaminated soils and slag will be removed within a corridor with an average width of 275 feet from the south toe of the BNSF Railway embankment extending north (Figure 2-6). The removal corridor will include the conceptual alignment of SBC and the 100-year floodplain. Some slag and contaminated soils may be removed outside of the removal corridor to regrade the area for erosion control and end land use features such as walking trails. Areas where slag and contaminated soils are left in place will have an appropriate cap constructed over the areas to ensure protectiveness of human health and surface water.

To remove tailings, waste, COC-impacted soils, and slag from the Site, heavy construction equipment will need to safely and effectively travel on the material at the bottom of the excavation. Initial reconnaissance of this area suggests that most of the Site construction area may require at least nominal construction dewatering while deeper portions of the construction area may require that the water table be lowered 19 feet below the current water table elevation (16 feet to bottom of waste [Figure 2-70], plus additional 3 feet for safe equipment access).

As part of the RD, COC-impacted groundwater from the Site must be hydraulically controlled to prevent COC-impacted groundwater discharge to the newly constructed and existing portions of SBC that would lead to violations of surface water Applicable or Relevant and Appropriate Requirements (ARARs) for the BPSOU, to prevent degradation of groundwater that exceeds current standards, and to comply with the forthcoming Surface Water Management Plan. To adequately design the BRW hydraulic control, additional information is needed on the aquifer characteristics and the properties of solid materials (e.g., the chemical stability/leachability) that may remain after the RA is complete.

3.0 DATA QUALITY OBJECTIVES

The DQOs are statements that define the type, quality, quantity, purpose, and use of data to be collected. The EPA developed a seven-step process for establishing DQOs to help ensure that data collected during a field sampling program will be adequate to support reliable site-specific decision making or estimation, whichever is appropriate (EPA, 2006). The following DQOs were developed for the Phase II Site Investigation according to the EPA process and are detailed in the referenced tables:

- Pumping Test(s) (Table 3-1).
- Pre- and Post-Pumping Test Groundwater Analysis (Table 3-1).
- SBC Loading Analysis (Table 3-1).
- Slag Physical Properties and Demolition Methods Investigation (Table 3-2).
- Additional Solid Material Characterization (Table 3-1).

The project schedule, which is discussed in the DQOs, is included as Table 3-3.

3.1 Measurement Performance Criteria for Data

Specific data validation processes ensure that analytical results are within acceptable limits. All of the information and data gathered during the QAPP will be checked to ensure they are usable for their intended purposes. An evaluation of analytical control limits and of the precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS) parameters will be performed. If significant issues with the data are found, data results will be discussed with the EPA and Montana DEQ project managers. The EPA, in consultation with Montana DEQ, will then decide if the total study error could cause them to make an incorrect decision. Using this approach, the probability of making an incorrect decision (i.e., either a false negative or positive) based on the information collected is considered small.

The definitions of precision, accuracy, representativeness, comparability, and completeness are provided below along with the acceptance criteria for data collected. Equations for calculating precision, accuracy, and completeness are provided in Table 3-4.

Precision

Precision is the amount of scatter or variance that occurs in repeated measurements of a particular analyte. Acceptance or rejection of precision measurements is based on the relative percent difference (RPD) of the laboratory and field duplicates. For example, perfect precision would be a 0% RPD between duplicate samples (both samples have the same analytical result). For groundwater samples, the control limit of an RPD less than 20 percent will be used when sample results are greater than 5 times the Contract Required Quantitation Limit (CRQL). If either of the sample results are less than 5 times the CRQL, the control limit used will be a difference between sample results less than the CRQL. For soil samples, the control limit of an RPD less than 35 percent will be used when sample results are greater than 5 times the CRQL. If either of the sample results are less than 5 times the CRQL, the control limit used will be a difference between sample results less than 2 times the CRQL. This precision requirement is derived from the *Clark Fork River Superfund Site Investigation (CFRSSI) Laboratory Analytical Procedure* (ARCO, 1992a), the National Functional Guidelines for Inorganic Superfund Methods Data Review (EPA, 2017a), and the CFRSSI QAPP (ARCO, 1992b).

Accuracy

Accuracy is the ability of the analytical procedure to determine the actual or known quantity of a particular substance in a sample. Accuracy is assessed based on the percent recovery (%R) and percent difference (%D) of various laboratory QC samples. Perfect %R is 100% and perfect %D is 0% (the analysis result is exactly the known concentration of the QC sample). The laboratory control sample (LCS) and laboratory matrix spike (LMS) are used to measure accuracy, based on the percent recovery (% R) of the LMS and LCS. An acceptable accuracy range for the %R of LMS and LCS is 80.0% to 120% in groundwater samples and 75.0% to 125% for soil samples. Additional laboratory QC samples may be used to assess accuracy as appropriate to the analytical method. Accuracy requirements for this project are derived from the EPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Inorganic Superfund Methods (EPA, 2016), the National Functional Guidelines for Inorganic Superfund Methods Data Review (EPA, 2017a), and the CFRSSI QAPP (ARCO, 1992b).

Representativeness

Representativeness is a qualitative parameter that is addressed through proper design of the sampling program. The sampling program described in the QAPP will be designed to obtain a sufficient number of samples that adequately represent the range of conditions present in the medium being sampled and will specify suitable sampling methods and procedures.

The Contractor Project Manager (CPM) will review each QAPP to ensure that it is designed to collect the data and information necessary to meet the purpose of the investigation. The review will consider the volume, variability, and intended use of the data to ensure proper sampling methods and adequate spatial distribution of samples.

After the data have been collected and analyzed, the Field Team Leader (FTL) or CPM will review the data and qualitatively assess if the data adequately represent the Site conditions and intended purpose of the investigation. Sample representativeness may also be evaluated using the RPDs for field duplicate sample results, if applicable. The representativeness will be addressed in the PARCCS.

Comparability

Comparability determines if one set of data can be compared to another set of data. Comparability is assessed by determining if an EPA-approved analysis method was used, if values and units are sufficient for the database, if specific sampling points can be established and documented, and if field collection methods are similar. All SOPs for these investigations are included in Appendix A. All analysis methods are listed in Table 3-5.

Completeness

Completeness determines if enough valid data have been collected to meet the investigation needs. Completeness is assessed by comparing the number of valid sample results to the number of sample results planned for the investigation. Although not all the analytes measured in this sampling effort have completeness objectives outlined in the CFRSSI QAPP (ARCO, 1992b), the completeness target for this investigation is 95.0% or greater as designated in the CFRSSI QAPP.

Method Sensitivity

Method sensitivity is related to the method detection limits. The method sensitivity or lower limit of detection depends on several factors, including the analyte of interest, the method used, the type of detector used, matrix effects, etc. Appropriate methods must be selected with sufficient method sensitivity to accomplish the project's goals.

X-Ray Fluorescence (XRF) Analysis: The method sensitivity or lower limit of detection for XRF analysis depends on several factors, including the analyte of interest, the type of detector used, the type of excitation source, the strength of the excitation source, count times used to irradiate the sample, physical matrix effects, chemical matrix effects, and interelement spectral interferences. Example lower limits of detection for analytes of interest in environmental applications are shown in Table 3-6. These limits apply to a clean, spiked matrix of quartz sand (silicon dioxide) free of interelement-spectral interferences using long (100 - 600 second) count times. These sensitivity values are given for guidance only and may not always be achievable, because they will vary depending on the sample matrix, which instrument is used, and operating conditions.

Laboratory Analysis: The method sensitivity for laboratory analyses is determined as part of the laboratory's SOPs. The CRQL for each analyte is listed in Table 3-5. A review of these detection limits will be conducted as part of the data validation process (Section 8.0).

4.0 SAMPLING PROCESS AND DESIGN

The Phase II Site Investigation is necessary to address additional design-related data gaps relevant to future hydraulic control and construction dewatering as well as to collect additional data related to the characterization of solid materials, particularly slag, and groundwater within the Site. The Phase II Site Investigation will include a pumping test(s), pre- and post-pumping test groundwater analysis, chemical loading analysis, a slag investigation, and additional opportunistic solid material characterization. Supplemental groundwater and surface sampling during low-groundwater and surface water conditions also occurred, per Agency request, as part of the Phase II investigation. The following subsections provide the procedures and protocols necessary to complete these tasks.

4.1 Preparation for Field Work

The following tasks will be completed prior to conducting field activities.

4.1.1 Training

All field personnel will have current certification for both the 40-hour Occupational Safety and Health Administration Hazardous Waste Site and Emergency Response Training and the 24-hour Mine Safety and Health Administration Training. Current certification records are maintained at Pioneer's headquarters at 1101 S. Montana Street in Butte, Montana.

In a project meeting held prior to fieldwork, all field personnel will review the BRW Phase II QAPP and receive training per the BRW Phase II QAPP. Field personnel will review sampling and monitoring procedures and requirements prior to field activities to ensure collecting and handling methods are completed according to the BRW Phase II QAPP requirements. Field personnel will be trained in how to properly use field equipment and complete activities according to field data collection SOPs (Appendix A).

The FTL will conduct a review of the BRW Site-Specific Health and Safety Plan (SSHASP) with all field personnel prior to fieldwork to assess the Site's specific hazards and the control measurements put in place to mitigate these hazards. The BRW SSHASP review will cover all other safety aspects of the Site including personnel responsibilities and contact information, additional safety requirements and procedures, and the emergency response plan.

The FTL will be responsible for training field personnel on how to calibrate field measurement instruments. The FTL will be experienced in the use and calibration of the equipment that will be used and responsible for training and overseeing the support staff. One hard copy of the current approved version of the BRW Phase II QAPP will be maintained for reference purposes in the field vehicle and/or field office. All field team personnel will have access to electronic PDF format files of all documents pertaining to sampling. All field team personnel will sign the BRW Phase II QAPP after receiving training.

4.1.2 Property Access

Atlantic Richfield, BNSF Railway Line, Montana DEQ, and NorthWestern Energy own the property where the field activities will be performed. Atlantic Richfield currently has an access agreement with NorthWestern Energy to sample monitoring well MW-03-MPC and an access agreement with Montana DEQ to sample monitoring wells MW-O-01 and MW-I-96 on the

Montana Pole Treatment Plant (MPTP) Site. Atlantic Richfield is in the process of obtaining a property access agreement with BNSF Railway Line to sample monitoring wells GW-13 and GW-17. Copies of the access agreements will be placed in the field binder to have on hand during the field activities.

Atlantic Richfield is currently completing the process to gain access to the BNSF property; however, it is anticipated that this process may take months based on communication with BNSF and may not be timely for the groundwater sampling event. Montana DEQ has offered to sample the wells on behalf of Atlantic Richfield. As part of the 1996 consent decree (CD) for the MPTP Site (information available on the Montana DEQ Superfund site at https://deq.mt.gov/cleanupandrec/Programs/superfundfed), EPA and DEQ (and EPA and DEQ contractors) have access at all reasonable times to the MPTP Site and any other property to which access is required for implementing the MPTP CD, which includes monitoring wells GW-13 and GW-17 (EPA, 1996). The DEQ views the data collected from GW-13 and GW-17 as mutually beneficial to both DEQ and Atlantic Richfield. Particularly, DEQ agrees with Atlantic Richfield that data are needed to establish a baseline of groundwater conditions between the BRW Site and the MPTP Site to avoid any potential impacts to the MPTP Site groundwater remedy by future remedial activities at the BRW Site, such as construction dewatering and hydraulic control.

In the event that Atlantic Richfield is unable to obtain access to the BNSF property in a timely manner, Tetra Tech (Tom Bowler), contractor and representative to DEQ, will collect the groundwater samples from monitoring wells GW-17 and GW-13 following the protocols and procedures identified in this QAPP. Mr. Bowler will collect the samples and then hand them over to Atlantic Richfield to submit to the laboratory for analyses.

4.1.3 Utility Locates

There is a possibility that investigation points could shift once underground utilities are located throughout the Site. Utility locates will be performed prior to any field work and will follow BP Remediation Management Defined Procedures for ground disturbance in addition to applicable control measures addressed in the internal BRW SSHASP. Final utility locates for the work area will be completed by the performing authority prior to any ground disturbance activities.

4.1.4 Best Management Practices

Although a Joint Application for Proposed Work in Montana’s Streams, Wetlands, Floodplains, and other Water Bodies (Joint Application) is not required for Superfund related activities, Atlantic Richfield Company has identified measures that will be taken to ensure that the substantive requirements of the Joint Application and applicable requirements are met during the field activities. Protection of the environment during field activities will be addressed through implementation of short-term construction Best Management Practices (BMPs). General descriptions of the BMPs to be implemented to minimize the project impacts to the vegetated area/wetland area within the Site are provided below.

4.1.4.1 Minimize Project Impacts to Floodplain/Wetland

During the Phase II Site Investigation, work must be performed within the vegetated/wetland area on the west side of the Site. Specifics of the work activities are detailed in the sections below. To minimize project impacts to the vegetated/wetland area, the following measures will be taken:

- The access road and drill pad have been designed to limit the amount of disturbance in the vegetated/wetland area (i.e., it will not be oversized).
- Equipment will be required to use the access road and drill pad while working in the vegetated/wetland area, with the exception of the Geoprobe which will be installing piezometers in the vegetated/wetland area and equipment needed to install the water conveyance line over SBC.
- Material and supplies will be stored on the drill pad in appropriate containers.

4.1.4.2 In-Stream Turbidity Control

During the Phase II Site Investigation, some work must be performed within close proximity to the stream channel under flowing conditions with the potential to release sediments into the active watercourse. This work includes installation of the water conveyance line for the pumping test(s) and installation of additional piezometers.

The following construction BMPs will be implemented for work along SBC to reduce sediment loading and excessive turbidity:

- A vegetative buffer strip of native soil/vegetation will be left along the channel.
- Any equipment that must work in close proximity to the stream channel will be required to track perpendicularly to the streambank to prevent bank collapse or equipment falling into the stream.
- No heavy equipment will be allowed to enter the active stream channel.
- A temporary channel crossing will be constructed for the water conveyance line to cross the stream.

4.1.4.3 Stormwater Management

During Site work activities, standard BMPs will be followed/installed, as appropriate, to minimize off-Site sediment tracking and to prevent stormwater runoff from transporting sediments and/or pollutants (e.g., construction related oils, fuels, and other materials) downgradient into SBC. These BMPs may include, but are not limited to:

- Maintaining a vegetative buffer strip of native soil/vegetation between the access road and drill pad and SBC.
- Drill mud will be contained within an appropriately designed mud pan.
- Spillguard® secondary containment systems (or equivalent) will be used, as necessary, to contain any inadvertent spills or leaks.
- A dual containment pipe will be used to convey water generated during the pumping well development and pumping test(s) across SBC.
- General good housekeeping practices.

The FTL will be responsible for ensuring BMPs are installed properly at appropriate locations. Additionally, the FTL will be responsible for initiating corrective actions, as necessary.

4.2 Pumping Test(s)

The pumping test portion of the Phase II Site Investigation consists of an initial pumping test with plans for an optional, second pumping test to refine our knowledge about the aquifer characteristics at the Site. Table 4-1 lists the data to be collected and the proposed monitoring for the pumping test(s).

The initial pumping test site (BRW-PW-01A, Figure 4-1 and Figure 4-2) was selected for several reasons, including aquifer thickness, relatively higher hydraulic conductivity of the alluvial aquifer, apparent location of secondary source, and proximity to SBC, and will likely be a principal focus area for the future BRW hydraulic control as well as dewatering efforts during the construction phase of the RA. If the initial pumping test does not provide an appropriate area of influence that extends into a sufficient portion of the east and central areas of the removal corridor, a second pumping test may be completed to gather additional data for these areas. The optional, second pumping test site (BRW-PW-01B, Figure 4-3 and Figure 4-4) was selected because it is still located within an area where the alluvial aquifer is relatively thicker than other parts of the site (Figure 2-3), and data collected from this area could provide necessary information related to the central part of the removal area and central part of the upgradient impacted boundary area, based on initial modeling using AQTESOLV (Table 4-2).

Regardless of whether one or two pumping tests are completed, each pumping test will be completed by installing and developing a pumping test well, installing additional piezometers for water level monitoring, setting up a water treatment system and discharge line for water disposal, completing baseline water level monitoring, conducting a step-drawdown test, conducting a long-term pumping test, and conducting a recovery test. The pumping well will be used to pump groundwater from the aquifer at a constant rate and record the local responses in water levels and flows in the pumping well and nearby observation locations. Pumped groundwater will be treated to remove hydrocarbons and then conveyed to either the BRW-00 Pond or the BTL drying beds and ultimately to BTL for metals treatment. This section details the fieldwork to be completed. Table 4-1 lists the data to be collected and the proposed monitoring for the pumping test(s).

4.2.1 Pumping Test Location

The initial pumping test well BRW-PW-01A will be drilled and installed approximately 3 feet southwest of existing piezometer BRW18-PZ02 as shown on Figure 4-1. The optional, second pumping test well BRW-PW-01B will be drilled and installed approximately 5 feet south of piezometer BRW18-PZ21 (Figure 4-3).

Additionally, 26 new piezometers will be installed prior to conducting the pumping test(s) to provide additional observation points during the pumping test(s) (Figure 4-5). The entire pumping test observation well network(s) is shown on Figure 4-2(pumping test well BRW-PW-01A) and Figure 4-4 (pumping test well BRW-PW-01B). The spacing of the piezometers located near the pumping well(s) was estimated using AQTESOLV, with the assumptions listed in Table 4-2.

4.2.2 Pumping Test Process

There are a lot of tasks associated with the pumping test(s) and to be successful, the project will require coordination between all parties (refer to Section 7.0). The following work tasks will be required to complete each pumping test:

- Install and develop the pumping well (Sections 4.2.3 and 4.2.4).
- Install additional piezometers (Section 4.2.5).
- Install pumping test systems (Section 4.2.6).
- Groundwater level trend monitoring (Section 4.2.7).
- Step drawdown test (Section 4.2.8).
- Long-term pumping test and associated monitoring (Section 4.2.9).
- Recovery test (Section 4.2.10).

The FTL will be responsible for coordination, safety, and quality of the fieldwork during the pumping test(s) (Section 7.0). The logistics during the long-term pumping test(s) include a sufficiently sized field team to manually measure drawdown in a subset of observation wells. The recovery test will require the same field team.

The layout of the observation locations at the pumping test site(s) is based on the anticipated footprint of the future construction dewatering needs and the direction of groundwater flow (Figure 2-70 and Figure 2-5). The piezometer layout has new piezometers placed in line with and perpendicular to the groundwater flow direction at various distances from the pumping well along with additional piezometers installed along the southern boundary of the Site (Figure 4-5). The new piezometers, along with selected existing piezometers and monitoring wells, will provide a robust observation well network to help determine aquifer anisotropy.

Prior to the pumping test(s), a water treatment system and water conveyance line will be installed to treat the production water for hydrocarbons prior to eventual dissolved metals treatment at the BTL. Additionally, groundwater levels across the pumping test area will be monitored prior to and after the pumping test(s) to determine trends that can be applied to pumping test water level information when it is evaluated.

4.2.2.1 Pre-Installation Sampling for PCBs, PCP and Dioxins

Before installing the staff gages and piezometers, but after the installation and development of the pumping well(s), groundwater samples from BRW18-PZ01, the pumping well(s) (BRW-PW-01A and BRW-PW-01B), and surface water samples from B-5 and B-6 will be collected and analyzed for PCBs, PCP, and dioxins (Table 3-5). The surface water samples will be collected before the staff gages are installed. The field team will use a hand-held Global Positioning System (GPS) unit to determine the locations of B-5 and B-6. If analytical results indicate that concentrations of PCBs, PCP, and/or dioxins are above applicable standards, Atlantic Richfield will communicate these results to Agencies and discuss a path forward with Agencies prior to completing the pumping test(s).

The pumping test groundwater analysis, discussed in Section 4.3 and the SBC loading analysis discussed in Section 4.4 will be conducted after the staff gages have been installed and are separate sampling events than the one discussed here.

4.2.3 Pumping Well Installation

An 8-inch diameter pumping well will be installed at the selected pumping test location(s) and will be drilled using the mud rotary method. The polymer mud rotary drilling method was selected over cable tool, sonic, or air rotary due to the following advantages:

- Drilling creates an open hole that facilitates construction of the well.
- The fluid-filled hole stabilizes the borehole and controls formation heave by maintaining a positive borehole pressure.
- Drilling proceeds quickly with no steel casing to weld or handle.
- Drilling does not introduce air into the formation, which can cause oxidation and precipitation of dissolved contaminants.
- The polymer mud will break down over time or can be accelerated with the use of additives during well development.

To streamline the Site investigation and meet the RA schedule, both pumping test well locations will be drilled initially (Table 3-3). However, the second, optional pumping test will only be conducted if determined necessary by the CPM in consultation with the Contractor Quality Assurance Officer (QAO) (Section 7.0) based on results from the initial pumping test.

Equipment, materials, and supplies; drilling mud information; and well development is discussed below. The configuration and location may be modified by the FTL in consultation with the CPM and/or Contractor QAO (Section 7.0) based on field observations.

4.2.3.1 Equipment, Materials, and Supplies

Equipment, materials, and supplies used to install the pumping well(s) will include, but not be limited to, the following:

- Mud rotary rig, drill rods, and nominal 12-inch drill bit.
- A 12-inch steel surface casing.
- Mud pan to mix, store, and receive drilling mud.
- Potable water for mud mixing.
- Polymer mud additives.
- Twenty-foot Stainless steel continuous wrap Vee-wire 8-inch well screen (slot size to be determined), with a 5-foot, 0-wrap screen sump.
- Polyvinyl chloride (PVC) solid 8-inch well casing with threaded adapter or similar for attaching well screen.
- Bentonite: 3/8-inch chips for annular well seal.
- Surge block/water jetting tool for developing well.
- Additive to break down the polymer drilling mud viscosity, if necessary.
- Trash pump.
- Waste-water haul truck and/or vacuum trucks.

4.2.3.2 Drilling Mud

The drilling mud will be mixed using potable water and a polymer (organic or synthetic, e.g., Matex Hole Control or equivalent). The polymer drilling mud was selected because it will break down and not plug the aquifer material like a bentonite-based drilling mud. The polymer-based drilling mud will provide the viscosity and gel strength to effectively remove cuttings and create a filter cake on the borehole wall for stabilization.

To facilitate drilling mud returns at the surface, a steel surface casing will likely be installed to a depth of approximately 5 feet, depending on the drill rig used. The driller will install a mud pan around the surface casing to hold and receive the return mud. Cuttings will drop out in the pan as the mud flows back toward the far end of the pan where the pump intake is located.

Once drilling is complete and the well is constructed, additives will be pumped into the column of drilling mud in the well, if necessary, to break down the polymer-based drilling mud before development begins. The mud will then be pumped from the well and mud pan into a vacuum or water truck for disposal. The drilling mud from BRW-PW-01A will be disposed of at the BTL drying beds. As an alternative to hauling, the spent drilling mud might be pumped through additional piping directly to the drying beds. The drilling mud from BRW-PW-01B will be contained on the Site and sampled for hydrocarbons prior to disposal. The need for treatment/disposal options, if necessary, will be determined based on the laboratory results.

4.2.3.3 Screen and Casing

The production rate is anticipated to be between 50 to 250 gallons per minute (gpm), which will be produced from an 8-inch diameter well. The pumping well(s) will be constructed using a 20-foot stainless Vee-wire wrapped 8-inch diameter screen and solid 8-inch PVC well riser pipe (Figure 4-6, Figure 4-7, and Figure 4-8). The slot size selected for the screen at BRW-PW-01A will be determined based on the lithology of piezometer BRW18-PZ02, and the slot size selected for the screen at BRW-PW-01B will be determined based on the lithology of piezometer BRW18-PZ21. A 5-foot piece of "0-wrap screen" will be installed on the bottom of the well string to create a sump for fines to accumulate for removal during development and to house the submersible pump during the pumping test(s). A formation packer will be installed approximately 3 feet above the well screen to isolate the screen from the well seal above. Bentonite will be added above the formation packer to provide a well seal. The 8-inch PVC well riser pipe will be set to project out of the ground with a stick-up of approximately 2.0 feet. A 12-inch diameter locking steel protective casing will be installed around the 8-inch PVC well casing to safeguard the well.

4.2.4 Pumping Well Development

Pumping well development is necessary to ensure good hydraulic connection between the well and aquifer. The development process removes the finer-grained material in the screen zone, increasing the hydraulic conductivity in the aquifer material around the screen. Development of the pumping well will include mechanical surging and pumping. No air development will occur to minimize the addition of oxygen into the aquifer.

Following well installation, the well will be developed using a surge block within the solid casing portion of the well above the screen. After a period of gentle surging, the surge block will be removed from the well and a drop pipe installed to the bottom of the well. The fine material on the bottom of the well sump will be vacuumed or pumped out using a vacuum truck or trash pump. Development water will be transported to a holding tank and sampled for hydrocarbons prior to treatment/disposal. The need for treatment/disposal options, if necessary, will be determined based on the laboratory results. If necessary, the water will be routed through the hydrocarbon removal system (Section 4.2.6.2) before it is pumped to the BRW-00 Pond or BTL drying beds for metals treatment at BTL.

The process will be repeated as necessary with increasing surge block intensity until the well is properly developed. The well is considered developed when 3 consecutive readings for turbidity are below 5 Nephelometric Turbidity Units (NTUs) or are within 10% of each other and the water quality parameters are stable, or the well has been developed for 4 hours. The water quality parameters are considered stable when three consecutive readings are as follows:

- Temperature range is no more than +/- 1 degree Celsius (°C).
- pH varies by no more than 0.1 pH unit.
- Specific conductance (SC) readings are within 3% of the average.

Additionally, the specific capacity (which includes the estimate of the pumping rate) will be estimated, if feasible. If a good hydraulic connection is not established with surging and pumping, other methods may be considered by the FTL and CPM in consultation with the Contractor QAO. This may include, but is not limited to, the following methods:

1. Over-pumping. This activity will use a trash pump, the pump for pumping test, or other appropriate means, as deemed appropriate by the FTL and CPM in consultation with the Contractor QAO.
2. Water jetting. Any water jetting will use groundwater extracted from the pumping well to minimize any changes in pH or dissolved oxygen (DO). This may require storage and/or filtering of this water. Tap water will not be used.

During well development, the water level in the pumping test well will be measured during pumping episodes to qualitatively determine the approximate amount of drawdown for an estimated pumping rate. This information will be used to approximate the initial pumping rate for the step-drawdown test. All development water will be contained within a holding tank, treated for hydrocarbons, and pumped to the BTL drying beds or BRW-00 pond through water conveyance piping for metals treatment at BTL.

The well development approach may be modified, or additional steps added by the FTL and CPM in consultation with the Contractor QAO as conditions change in the field.

4.2.5 Installation of Additional Piezometers

The field team will install 26 additional piezometers to provide additional water level/drawdown data at strategic locations around the pumping test well(s) and along the southern boundary of the Site (Figure 4-5 and Table 4-3). Actual placement of the piezometers in the field will be subject to change based on existing infrastructure and land use in the area due to ongoing BSB operations, saturated conditions in the western portion of BRW, and field team judgment. The actual location and number of piezometers may be modified as determined by the FTL and CPM in consultation with the Contractor QAO. Field personnel will record all GPS location coordinates for all piezometer locations.

4.2.5.1 Drilling Procedures

Piezometers are anticipated to be drilled and constructed using either a sonic drilling rig or Geoprobe unit, which provides high-quality core samples. These samples will be examined to produce a detailed lithologic characterization log of the subsurface materials at each borehole location.

The following general procedures will be performed at each borehole or piezometer location (at the depth intervals). Note that this list is not intended to be a complete list.

- Prepare drill rig/Geoprobe unit for operation. This includes, but is not limited to, decontaminating drilling tools and sampling equipment, leveling the rig, preparing the down-hole tool, and establishing the drill location.

- Begin advancing the core barrel. Advance the core barrel (anticipated to be 5 feet for the sonic rig and Geoprobe unit) to collect the core sample, then retrieve the inner core barrel to recover the core sample. Continue adding core barrel segments and collecting core samples until desired depth has been reached.
- Decontaminate the drill rig core barrel(s) between samples by rinsing with tap water and/or using a high-pressure washer.

Sonic Drilling Rig

- The sonic drilling rig will provide continuous core samples, which are anticipated to be 5 feet in length by 4 inches in diameter. To temporarily store the sediment core, 600 polyethylene sleeves designed to fit over the core barrels will be used. Each 5-foot length will be properly labeled to split the core into manageable units for storage.

Geoprobe

- The Geoprobe unit will provide continuous core samples using the dual tube soil sampling system. These core samples are anticipated to be 5 feet in length by 2 inches in diameter. To temporarily store the sediment core from the Geoprobe, plastic liners will be used within the inner core barrel to collect the core samples. Each 5-foot length will be properly labeled for storage.

Depth and Location

The general depth of each borehole and piezometer is specified in Table 4-3 and may be limited or increased based on field personnel observations. If the depth of a piezometer borehole will be notably deeper than the screen depth of the piezometer, a second borehole may be drilled for purposes of installing the piezometer.

4.2.5.2 Installing Piezometers

Piezometers will be installed as best suits the field conditions. While there may be organic COCs, the primary COCs of interest will be groundwater metals; therefore, PVC material will be appropriate to use with the piezometers.

All piezometers will be installed in general accordance with the SOP-GW-11 included in Appendix A. Specific details for the piezometer construction are provided on Figure 4-90. The procedures below assume that either a vibratory roto-sonic drilling rig or Geoprobe unit will be used to install the piezometers. These procedures may change based on field conditions and equipment availability.

The general target depth for the piezometer screen is specified in Table 4-3 and may be limited or increased based on field personnel observations as determined by the FTL and CPM in consultation with the Contractor QAO. Equipment, materials, and supplies used to install the piezometer will include, but is not limited to, the following:

- 1.5 inch by 5- or 10-foot Schedule 40 PVC (flush-threaded) casing (number to vary per piezometer) (0).
- One 1.5-inch by 5-foot Schedule 40 PVC pre-packed screen 0.010 slot (flush-threaded) per piezometer.
- One 1.5-inch PVC bottom cap.
- One 1.5-inch slip cap.
- Field logbook and pens.
- Measuring tape.
- Sharpie marker.
- Water level probe.
- Metal tag with the identification
- Camera and film, digital camera, or digital video camera.
- Appropriate safety personal protective equipment (PPE).

The following procedures will be performed at each new piezometer location. Construction details are provided on 0.

- Once the target depth is reached (0), select the well screen interval according to the objectives for the piezometer location.

- Backfill any over-drilled boring with hydrated bentonite chips or bentonite pellets to a depth of at least 2 feet below the expected total depth of the well, and transition to building filter pack (10-20 Mesh Colorado Silica Sand). This will help ensure that bentonite does not swell into the screened zone.

    - Alternatively, field personnel may elect to backfill the original borehole with bentonite, drill an adjacent borehole to the desired bottom depth of the piezometer, and install the piezometer in this second borehole.

- For the Screen and Riser:

    - Each piezometer will consist of 5 feet of 1.5-inch nominal diameter schedule 40 flush-threaded PVC well screen with a slot size of 0.010-inches, with 1.5-inch nominal diameter schedule 40 flush-threaded PVC blank casing extending to approximately 2 feet above the ground surface or finished as a flush-mount at locations where an aboveground surface finish is not possible (e.g., access roads, etc.).
    - Install an appropriately sized schedule 40 slip-fit cap on top of the PVC blank casing before installing the filter pack and other components described below.

- For the Filter Pack:
  - Install the filter pack to at least 3 feet above the top of the screen.
  - Install the annular seal of hydrated bentonite chips from the top of the filter pack to 3 feet bgs. For shallower completions of piezometers, the thickness of the seal may be reduced by field personnel as necessary.
  - Install bentonite grout from 3 feet bgs to 6 inches bgs (may be altered for shallower completions).

- For the Casing:
  - Install a 6-inch by 5-foot steel surface casing from approximately 2.5 feet bgs to approximately 2.5 feet above ground surface.
  - If the location is anticipated to be subject to frost-heave, such as in the western portion of the Site, install a longer steel surface casing that extends below the frost line.
  - In areas susceptible to flooding, the protective casing should extend high enough to be above flood level (OhioEPA, 2008).
  - In high traffic areas, 3 bollards should be installed around the piezometer.
  - Install 10-20 mesh Colorado Silica Sand from 6 inches bgs to approximately 2 inches below the top of the 1.5-inch diameter PVC.
  - Mark a measuring point on the north side of the inner casing using permanent marker.
  - Install a concrete pad around the surface casing.
  - Provide a locking steel cap for each piezometer.
  - Write the piezometer name, depth, and installation data on the underside of the locking steel cap.

Pioneer will prepare a piezometer completion log for the location and, at a minimum, it will contain the following.

- Time and date installed.
- Borehole, casing, and screen diameters.
- Bottom cap length.
- Boring depth (plus or minus 0.1 foot) in relation to the ground surface.
- Well depth (plus or minus 0.1 foot) in relation to the ground and final measuring point.
- Lithology logs.
- Casing materials.
- Screen size, length, and depth to top and bottom of screen from ground surface.

- Filter pack material, size, and thickness in relation to the ground surface.
- Seal thickness and depth below ground in relation to the ground surface.
- Depth to groundwater at time of completion, in relation to the ground and final measuring point.
- Survey-grade X and Y coordinates and elevations for the measuring point (marked on the north side of the well), top of protective casing, and ground surface.

All drilling equipment and accessories will be decontaminated at the completion of the piezometer installation.

4.2.5.3 Site-Specific Installation Concerns

Past drilling and probing at the Site found heaving sands to be a concern. Therefore, potable water may be added to the drill and/or probe strings as they are advanced to prevent formation heave inside the drill and/or probe rod. The added water provides a positive pressure inside the sample string, minimizing the amount of water and soil invading the drill and/or probe rod as the core sample is retrieved or the well screen is set. Water will be added only when needed and not on a routine basis. Any recovered water will be contained and sampled for hydrocarbons prior to treatment/disposal. The need for treatment/disposal options, if necessary, will be determined based on the laboratory results.

4.2.5.4 Logging and Sampling

Classification and lithology of the core from each borehole will be logged and sampled following the general procedures listed below. Equipment used to collect core samples will include, but not be limited to, the following:

- Field logbook and pens.
- Measuring tape.
- Unified Soil Classification System (USCS) chart (ASTM D-2488) (Appendix B).
- Munsell color chart (Munsell, 2009).
- Field XRF unit.
- Sieve.
- Portable heater or oven.
- Two photoionization detectors (PIDs) (9.8 eV and 10.6 eV lamps) with humidity filter.
- Sample containers and labels.
- Chain of custody forms.
- Coolers.
- Decontamination equipment (pressure washer, tap water, dilute nitric acid, liquinox soap, decontamination containers, paper towels, scrub brushes, and spray bottles) (refer to SOP-DE-02 in Appendix A).
- Camera and film, digital camera, or digital video camera.

- GPS unit.
- CHEMetrics V-2000 photometer and ampules.
- Appropriate safety PPE.

Logging

The classification and lithology of the core will be logged and photographed. This will include a soil log of the borehole that lists USCS classification (Appendix B); visual estimate of rock content (2-inch plus fraction); angularity of the grains (when feasible); color (as per Munsell color chart [Munsell, 2009]); depth to top and bottom of each stratigraphic unit; presence or absence of soil staining, odors, nodules, organic matter, and/or groundwater; percent recovery; type of drilling equipment; and bedrock depth (if encountered). All relevant observations will be recorded in a bound field logbook.

PID Screening Analysis

Prior to drilling each borehole, visual observations (sight and/or smell) and a PID will be used to identify sources of hydrocarbons on the surface. Any findings will be recorded in the field logbook. The procedures for using the PID are detailed in Section 4.10.2. If the presence of hydrocarbons is detected (via sight and/or smell or detection with a PID) on the surface, a surface sample may be collected for hydrocarbon analyses as determined by the FTL.

Groundwater Sampling (Proposed Southern Boundary Piezometers Only)

During drilling of the proposed southern boundary piezometers (0), groundwater samples will be collected approximately every 5 feet and analyzed for total recoverable copper via field analysis with the CHEMetrics V-2000 photometer. Samples will be collected with a bailer and analyzed following the general procedures in Section 4.10.4. Samples will target groundwater located below the level of known waste based on field metals analysis via the XRF unit, but other groundwater intervals may be collected for reference. Sample results will be considered during the selection of screened intervals for each southern boundary piezometer. This selection will consider other relevant factors, including the relative hydraulic conductivity and thickness of lithologic layers encountered during core collection, field metals analysis, etc.

Field conditions may not allow for groundwater samples to be collected approximately every 5 feet (i.e., unable to remove drilling rods to collect groundwater samples due to the pressure of heaving sands), however, additional boreholes may need to be drilled to collect groundwater samples. This may include additional potholing for utilities.

Soil Sampling

Additional opportunistic soil samples may be collected for metals analysis via the XRF field unit and/or laboratory methods. At each piezometer location (0), soil samples will be collected from the soil boring per the general procedures specified in Section 4.6 with the following exceptions:

- For unpaired piezometers, the following samples will be collected at the discretion of the field personnel.
    - Field metals analysis will be conducted for each material horizon via the XRF unit, unless determined otherwise by field personnel. The field analysis results will be used

to estimate the first lithological layer in each boring which passes the Waste Identification Screening Criteria (EPA, 2020).

  - Based on the XRF analyses, a sample will be collected for each lithological layer with a field XRF concentration of greater than 367 milligrams per kilogram (mg/kg) copper that is outside the conceptual removal area (i.e., is located below the first lithological layer that passes Waste Identification Screening Criteria (EPA, 2020) or outside the removal corridor [0]) and submitted for SPLP analysis, unless determined otherwise by field personnel. Please reference Step 5 of DQO Process for explanation on the derivation of the 367 mg/kg threshold (Table 3-1). At the discretion of the CPM and Contractor QAO, the analytical approach may be altered based on field observations or analytical results (e.g., no samples having concentrations greater than the thresholds listed above). Agency personnel will be notified prior to implementing a new analytical approach.
  - A sample will be collected from each lithological layer in each boring and submitted for metals analysis via Inductively coupled plasma optical emission spectrometry (ICP-OES) (0), unless the lithological layer is too thin and there is not enough soil to fulfill the required sample volume. In this instance, a sample will be collected and prepped (Section 4.10.1) for XRF analysis.
- Samples will not be collected at locations within approximately 5 feet of a deeper, previously completed investigation point from the Phase I Site Investigation unless the lithology encountered in the new location significantly varies from the lithology in the deeper paired location.

4.2.5.5 Development

The piezometers will be developed following the general procedures detailed in SOP-GW-14 (Appendix A). The piezometer will be considered developed when 3 consecutive readings for turbidity are below 5 NTUs or are within 10% of each other and the water quality parameters are stable, or the well has been developed for 4 hours. The water quality parameters are considered stable when three consecutive readings are as follows:

- Temperature range is no more than +/- 1 °C.
- pH varies by no more than 0.1 pH units.
- SC readings are within 3% of the average.

If a light non-aqueous phase liquid (LNAPL) layer is detected on the groundwater table using an interface probe, the well will not be developed.

Development water from locations of observed hydrocarbon presence (i.e., visual indications or detections with PID during drilling and/or sheen on development water) will be transported to a holding tank and sampled for hydrocarbons prior to treatment/disposal. The need for treatment/disposal options, if necessary, will be determined based on the laboratory results.

Development water that has no observed hydrocarbon presence, will be taken directly to the drying beds at BTL for disposal.

4.2.5.6 Groundwater Sampling

Once the piezometers have been installed, field personnel will collect samples from the new piezometers and BRW18-PZ01 (0). Sampling will be conducted following the procedures detailed in Section 4.3.

4.2.6 Pumping Test Systems

This section describes the details of the various pumping test systems that will be installed at the pumping well location(s).

4.2.6.1 Submersible Pumps and Controls

The selection of a suitable submersible pump and flow controls will be critical to the success of each pumping test. A single submersible pump is being considered for the test(s) that has a pumping range of 25 to over 200 gpm in which flow will be controlled using a variable frequency drive (VFD). Final selection of a single pump will be based on technical input from the pump manufacturer, results of the pumping well(s) development, and final well construction details.

The proposed pump configuration is shown on 0. The submersible pump will be placed down the well 1 to 2 feet into the 5-foot “0-wrap” well sump to provide the maximum drawdown during the pumping test(s), if needed. The driller will install a pump shroud to direct the flow of water around the pump motor before it enters the intake area for pump motor cooling requirements. The pump and independent check valve will be attached to an appropriate size drop pipe. The drop pipe will be secured at the surface with a pipe hanger resting on the steel surface casing. The discharge pipe will then be routed horizontally off the ground (control section) with a slight upward incline (e.g., 3 inches in a 10-foot run) to help maintain full pipe flow. The discharge pipe will then be run vertically to the ground and horizontally to a holding tank where the water will discharge into the holding tank.

The submersible pump control section will consist of a primary and secondary flow meter, pressure gauge, sample port for collecting water quality samples, and a throttling control valve. The pumping rate will be controlled during the step-drawdown test(s) and pumping test(s) by varying the AC motor speed with a variable frequency drive.

The primary and secondary flow meters will be ultrasonic flow meters (or equivalent). The meters will have a flow range of 25 gpm to 250 gpm to cover the anticipated pumping rates at the pumping test site(s). A clamp-on ultrasonic flow meter is preferred because it can be adapted to different materials and pipe diameters. This type of flow meter requires the production water to be relatively clean (0 to 10% particles, or 0 to 100,000 parts per million). The flow meters will have a constant read screen showing instantaneous flow rates in gpm and totalizers to record the volume pumped. To ensure proper flow meter accuracy, the setup requires full pipe flow, a straight length of upstream piping that is 10 times the pipe diameter in length, and a straight length of downstream piping that is 5 times the pipe diameter in length.

A sampling port will be installed in the control piping to measure water quality. The sampling port will be installed in the control piping and located downstream of the flow meter to avoid interference with flow measurements. The sample port will have a ¼-inch pipe fitting with a gate valve to control flow. Tubing will be connected from the sampling port to a flow cell to facilitate measuring field parameters and collecting groundwater samples.

A throttling control valve will be installed at the downstream end of the flow meter piping. This valve may be used to put backpressure on the pump and/or flow meter or provide additional flow control.

Installation of submersible pumps and controls may be modified as necessary by the FTL and CPM in consultation with the Contractor QAO.

4.2.6.2 Hydrocarbon Removal System

Based on groundwater sampling results from existing wells and piezometers, a water treatment system will be necessary to remove petroleum hydrocarbons from the production water before it is discharged to the BTL metals treatment system. The following section describes the water treatment system and the various components that will be used to remove the petroleum hydrocarbons before the water is conveyed to either the BRW-00 Pond or the BTL drying beds.

The water treatment system is designed as an independent system to treat potential petroleum hydrocarbon contaminated groundwater that may be produced during the development, the step-drawdown tests, and the long-term pumping test(s). The preliminary water treatment system design is shown in (Figure 4-110) and described below. The water treatment system design will be finalized after the step-drawdown tests are completed at each well, and the system will be installed prior to conducting the long-term pumping test(s).

Initially, the production water from the pumping test well(s) will be directed into a holding tank to isolate the pumping test equipment from the treatment system. Water will be drawn from the bottom of the holding tank with a properly sized transfer pump that will push the water through the treatment system (particulate filter and carbon vessels) and the conveyance piping to the discharge point in either the BRW-00 Pond or the BTL drying beds. A redundant transfer pump will be installed parallel to the system in the event of a primary pump failure, allowing the pumping test and water treatment to continue. The water from the transfer pump will then pass through a flow indicator, flow control valve, and pressure regulator. Flow will be adjusted to match the current flow rate of the pumping test and the pressure regulator will sustain a constant feed pressure of 50 pounds per square inch (psi) to the particulate filters and carbon vessels. Fifty (50) psi is the recommended operating pressure for the particulate filter and is below the maximum working pressure of 150 psi of the particulate filters and 75 psi for the carbon vessels.

Water entering the filter system will be controlled with a flow meter and butterfly valve and monitored with a pressure gauge. The water will then pass through a sediment filtration unit using 5-micron bag filters to remove suspended solids. Removal of suspended solids is needed to prevent clogging and fouling of the carbon vessels. The filtration unit has a pressure gauge on the inlet and outlet, allowing operators to monitor pressure differentials. A high differential reading will signify that the particulate filter is plugging, and flow should be redirected to the next bag filter to continue water filtration. Each filter can be isolated from the system thereby allowing removal of a plugged filter and replacement with a new filter.

After sediment filtration, the contaminated water will pass through a series of 3 (primary, secondary, and tertiary) liquid-phase carbon vessels to remove petroleum hydrocarbons. Each of the carbon vessels will be filled with granulated activated carbon (GAC). The 3 carbon vessels will be connected in series to effectively remove the petroleum hydrocarbons from the water. The primary carbon vessel will remove the hydrocarbons from the water, with the secondary carbon vessel acting as a backup in case breakthrough occurs with the primary filter. The tertiary carbon vessel will act as a backup to the secondary filter in case breakthrough occurs in the secondary filter. As the pumping test proceeds, there is a chance that petroleum hydrocarbon concentrations in the groundwater could increase if more hydrocarbons are captured and/or drawn into the test well. If breakthrough were to occur in the primary carbon vessel due to higher petroleum hydrocarbon contaminant concentrations in the groundwater, the secondary vessel will become the primary filter and the tertiary filter would become the secondary filter.

During the pumping test, field personnel will periodically monitor the water within the holding tank. If free product is observed floating on the surface of the water within the holding tank, the pumping test will be stopped because the hydrocarbon removal system has not been designed to treat free product. To monitor the production water and presence of hydrocarbon, a Hanby Total Petroleum Hydrocarbon (TPH) Field Test Kit will sample the production water prior to discharging into the holding tank and sample the effluent from the hydrocarbon treatment system. The frequency of monitoring will be determined based on the final design of the hydrocarbon removal system and field conditions, and it will be frequent enough to prevent free product discharging from the hydrocarbon removal system. If the pumping test is stopped due to free product, Atlantic Richfield will develop a plan to complete the pumping test and properly manage the free product. This change will be communicated to Agencies in a RFC.

Water samples will be collected periodically for petroleum hydrocarbon analysis to determine the effectiveness of the carbon treatment operations and disposal requirements for the GAC. Production water from the pumping test well and effluent from the hydrocarbon removal system will be sampled every 24 hours to document production water hydrocarbon concentrations going into and exiting the carbon treatment system beginning at startup. Up to 3 additional opportunity water sample pairs may be collected if the discharge into the holding tank has visible indications of hydrocarbons (i.e., sheen observed on water surface). The entire treatment system, including the holding tank, will be placed in one or more Spillguard® secondary containment systems to contain any inadvertent spills or leaks in the treatment system. The Spillguard® system is a portable berm system constructed with a polyurethane coated fabric with collapsible 12-inch walls.

4.2.6.3 Water Conveyance Line

A water conveyance line(s) from the pumping test location(s) will be used to convey pumping test water from the pumping test well, to the holding tank, through the hydrocarbon removal system, and ultimately to either the BRW-00 Pond or the BTL drying beds (Figure 4-120). Depending on the Site conditions, the holding tank and hydrocarbon removal system may be located at the pumping well location or near the BTL drying beds.

The water conveyance line will consist of 4-inch diameter, standard dimension ratio (SDR), high-density polyethylene (HDPE) pipe and fittings. The pipe lengths and fittings will be fused together. A crossing will be installed over SBC that will be used to hold the water conveyance line above the creek. To provide additional protection while crossing SBC, an 8-inch SDR HDPE pipe will be installed across SBC and approximately 100 feet on either side, and the 4-inch SDR HDPE pipe will be inserted into the 8-inch SDR HDPE pipe. The water conveyance lines may be modified by the FTL and CPM in consultation with the Contractor QAO as field conditions change.

4.2.6.4 Electrical Power and Controls

Electrical power for the pumping test will likely be supplied by 2 diesel-powered generators to allow up to 72 hours of continuous running without refueling. The generators will be placed on a Spillguard® (or equivalent) to contain any fuel spills and engine leaks. The generators will be used to supply power to the pumping test well pump, the water treatment system transfer pumps, area lighting, and pump control panels. All electrical wiring associated with the pumping test(s) will be performed by a licensed electrician.

Protective system devices will be installed to safeguard the submersible pump, prevent overfilling of the holding tank, and to safeguard the transfer pump. A layout of the water treatment system is included as Figure 4-11. A VFD will be installed to control the submersible pump in terms of flow rate while providing underload/dry-well protection. High-and low-level switches will be placed inside the holding tank. The high-level switch will be used to control the submersible pump (P-PW01) in the well. If the water level in the tank rises to a high set level, the submersible pump will shut down, avoiding an overfill of the holding tank. The low-level switch will be used to control the holding tank transfer pumps (shown as P-100 or P-110 respectively on Figure 4-11). If the water level in the holding tank falls to a low set level, the transfer pumps will shut down, avoiding pump damage due to running dry.

4.2.7 Water Level Monitoring

Water level monitoring will be conducted during the 4 phases of the pumping test (baseline water level trend monitoring, step-drawdown test, pumping test, and recovery test). Water levels will be monitored using both manual measurements and automatic water level recording using transducers. Water levels at the Site will be measured at a selection of the observation wells from the available locations identified on 0, Figure 4-4 and in Table 4-4. The rationale for selecting monitoring locations is provided in Table 4-3. The selection of monitoring wells may change between the phases of the pumping test depending on the results of the step-drawdown test, selected long-term pumping rate, and field conditions.

If equipment malfunctions during field activities, monitoring may be adjusted to collect sufficient data for the DQOs during the four phases of the pumping test (baseline water level trend monitoring, step-drawdown test, pumping test and/or recovery test).

4.2.7.1 Baseline Water Level Trends

Once the pumping well has been developed, baseline monitoring will start at least 7 days before the step-drawdown test(s). Depending on the amount of time between the step-drawdown test(s) and long-term pumping test(s) and the amount of time between each long-term pumping test, baseline monitoring will also be performed for at least 7 days prior to each long-term pumping test (Table 3-3).

New or existing transducers will either be deployed or reprogrammed in approximately 30 wells as determined by the FTL and CPM in consultation with the Contractor QAO (Table 4-4). The data from the transducers will be used to quantify the natural variability and water level trends. Water levels will be measured manually during transducer deployment and recorded to verify transducer depths and to correlate with transducer data. The monitoring results will be used to establish overall water level trends that can be used to correct pumping test data once the pumping test begins. Existing equipment consists of Solinst brand transducers that are programmed to collect water level readings every 15 minutes (SOP-GW-15 in Appendix A) as well as record temperatures (LT model) or temperature and conductivities (LTC model). The data will be downloaded after the baseline monitoring period as a means of safeguarding the water level trend data.

Of the potential observation wells for the pumping test (Table 4-4), 15 currently have transducers installed and can be used to identify groundwater level trends and used during the pumping test data analysis. Additional transducers will be installed to monitor water levels in additional wells, as determined by the FTL and CPM in consultation with the Contractor QAO, including the pumping test well(s). Manual water level readings will be recorded at all the observation wells immediately before removing an existing transducer or adding a new transducer and immediately after the transducer is in place. Corresponding readings from the transducer will be collected to correlate to the manual water level and also to verify transducer placement.

The location and number of transducers used for baseline water level trends may be modified or additional steps may be added by the FTL and CPM in consultation with the Contractor QAO.

4.2.7.2 Manual Water Level Measurements

Initially, manual water level measurements will be used to tie the transducer water level data to known elevations using surveyed measuring points. Manual water levels will be recorded before and after each phase to allow for correcting transducer data for any long-term drift. Manual water level measurements will also be collected in critical well locations during the pumping and recovery tests as per Table 4-5.

During the pumping and recovery tests, monitoring wells/piezometers will be divided into manageable groups. Sufficient numbers of field team members will be used to measure water levels during the long-term pumping test and recovery test. These measurements will be conducted at appropriate intervals as shown in Table 4-5 and as directed by the FTL. These intervals are approximate and will decrease throughout the pumping test because the drawdown at each location will decrease.

The manual measurement team members will each have synchronized watches or cell phones and will collect water levels in their assigned wells to ensure water levels are recorded as a function of the actual time of measurement. As errors could be caused by measuring water levels with different meters, team members will minimize the number of water level meters used at any given location and will record any change in water level meter equipment at a location.

4.2.7.3 Automated Measurement of Pumping Test Water Levels

The variability of water levels during the pumping test will initially be high and decrease over time. Because automatic water level recording is easily collected and easily filtered, water level measurements will be collected every 15 seconds. A logarithmic recording cycle will not be used because of the unknown start time for the recovery portion of the pumping test and the fact that the transducers will have ample data storage space.

4.2.7.4 Measurement of Recovery Test Water Levels

The variability of water levels during the recovery test will be similar to the variability during the pumping test and decrease over time. During the recovery portion of the test, manual measurements will be collected using the measurement schedule shown in Table 4-5 until water levels have recovered to within approximately 10% of original static water levels observed before the pumping test. At that time, manual water level monitoring will be discontinued, and transducers will be retrieved from the wells/piezometers.

4.2.8 Step-Drawdown Test

A one-day, step-drawdown test will be conducted to determine an effective pumping rate for the long-term pumping test. The long-term pumping test rate must draw the water table down at the observation locations as much as possible while not decreasing the water level in the pumping well below the intake of the pump. The latter will disrupt the flow and impact test results. Data collected during each step-drawdown test will be evaluated with the Walton (1987) methodology (or equivalent Kruseman and de Ridder [1994] used in the AQTESOLV software or the Hantush and Jacob [1955] or the Bierschenk [1964] method) to determine an effective pumping rate.

A step-drawdown test consists of 3 different pumping rates for a duration of approximately 1 hour each. It is not required that the steps be conducted sequentially (i.e., a pause to change pumps or equipment is acceptable) nor that each step be conducted on the same day or for exactly the same duration. However, for the step-drawdown test, the intent is to conduct the test sequentially starting at the lowest pumping rate and increasing the rate with each 1-hour step followed by the recovery. The first “step” of the step-drawdown test will be determined from the drawdown and pumping rates measured during well development (Section 4.2.4), and additional pumping steps may be necessary.

After each 1-hour step of the step-drawdown test, if the drawdown in the pumping test well is at or near the level of the submersible pump, the pumping rate will either be decreased or held at the same rate for the remainder of the step-drawdown test. If after pumping for 1 hour, the drawdown in the well has stabilized above the pump, the pumping rate will be increased.

The pumping rates for the step-drawdown test are anticipated to be:

- First step pumping rate: 50 gpm.
- Second step pumping rate: 100 gpm.
- Third step pumping rate: 200 gpm.

Water produced during the step-drawdown test will be pumped into a holding tank and sampled for hydrocarbons prior to treatment/disposal. The need for treatment/disposal options, if necessary, will be determined based on the laboratory results. If necessary, the water will be routed through the hydrocarbon removal system (Section 4.2.6.2) before it is pumped to the BRW-00 Pond or BTL drying beds for metals treatment at BTL.

The step-drawdown test pumping rates and duration will be limited due to the storage limitations of the holding tank. The number of steps, the pumping rates, and other aspects of the step-drawdown test may be modified by the FTL and CPM in consultation with the Contractor QAO, as necessary.

After completing the step-drawdown test, the FTL and CPM in consultation with the Contractor QAO may revise the selected monitoring wells depending on the results of the step-drawdown test, selected long-term pumping rate, and field conditions.

4.2.9 Long-Term Pumping Test

Before conducting the long-term pumping test, the well will be allowed to recover to at least 95% of the original water level, or 24 hours, whichever occurs first. The pumping test will require the groundwater to be pumped continuously at the selected rate for 24 to 72 hours, followed by a “recovery” test of equal duration. The pumping test will be scheduled during fair weather, if possible, to avoid the problems that precipitation and resulting recharge to the aquifers create during tests. The length of the pumping test will depend on the stabilization of groundwater levels in nearby piezometers and observation wells.

The tasks listed in this section are necessary to conduct the pumping test. Each task is broken into greater detail to list the steps necessary to complete a comprehensive, defensible pumping test. The configuration, duration, and other details regarding each long-term pumping test may be modified by the FTL and CPM in consultation with the Contractor QAO, depending on the field conditions and final setup of the pumping test.

4.2.9.1 Pumping Rate Monitoring

Flow during the pumping test will be monitored and recorded at 15-second intervals using the ultrasonic flow meters and manual readings will be periodically recorded on field data sheets.

4.2.9.2 Groundwater Quality Monitoring

General water quality will be assessed in the pumping well during the pumping test by monitoring field parameters and collecting groundwater samples. As the cone of depression from the pumping well moves outward, away from the pumping test well, the cone of depression will encounter new sources of water. These new sources of water will be drawn towards the pumping well and, if pumping continues, will enter the pumping well and be pushed upward through the pump. The groundwater quality monitoring data along with other pumping test data (i.e., drawdown in other wells, pumping rate, etc.) will assist in determining the location of the source or sources of water. For example, if specific conductance readings remain steady through the initial part of the pumping test, but readings begin to decrease as the pumping test proceeds, this would suggest that water from a nearby, less-impacted, source has traveled through the BRW aquifer and is now being pushed through the pump.

Additionally, a single piezometer location will be outfitted with an *in-situ* DO sensor to document DO concentrations during the long-term pumping test. The DO sensor will be installed in BRW19-HCW37 for pumping test well BRW-PW-01A, and the DO sensor will be installed in BRW19-HCW38 for pumping test well BRW-PW-01B. If necessary, a 2-inch diameter piezometer may be installed to accommodate the DO sensor. Monitoring for changes in DO will help assess if hydrocarbon-impacted groundwater is migrating. If the DO sensor malfunctions at either BRW19-HCW37 or BRW19-HCW38 during the pumping tests, DO measurements at each pumping well (manual and flow cell) will serve as a backup indicator for migrating hydrocarbon-impacted groundwater.

4.2.9.2.1 Field Parameters

Field parameters (pH, SC, temperature, DO, oxidation reduction potential [ORP]) will be measured and recorded using a flow cell (SOP-GW-14 in Appendix A). The flow cell will be connected to the sampling port located on the pumping test control manifold. A continuous flow of water will pass through the flow cell, allowing water quality measurements to be made as the pumping test progresses. Field parameters will be recorded every 15 minutes with the data logger system and manual readings will be periodically recorded on field data sheets. The water passing through the flow cell will be directed into the holding tank, through the hydrocarbon removal system, and eventual metals treatment at the BTL.

4.2.9.2.2 Water Quality Samples

The pumping test water will be sampled immediately after the long-term pumping test is started and immediately before the test is concluded. These samples will document initial water quality and water quality after pumping has occurred. All water samples collected will be analyzed for total and dissolved metals, volatile petroleum hydrocarbons (VPH), extractable petroleum hydrocarbons (EPH) with polycyclic aromatic hydrocarbons (PAHs), major ions and trace elements, PCBs, PCP, and dioxins.

Sample collection will follow the SOPs included in Appendix A for collecting water samples: SOP-SA-01, SOP-SA-02, and SOP-SA-03A. Additional production water opportunity samples may be collected based on field observations such as changing field parameters or significant changes in water levels in the pumping or observation wells during the long-term pumping test. The samples will be collected in the appropriate sample containers, labeled, preserved, and sent to an analytical laboratory for analyses.

4.2.9.3 Pumping Test Duration

The duration of the pumping tests will be from at least 24 hours up to 72 hours. The duration will be determined based on the data collected during the pumping test. Conditions for shortening the length of the pumping test include the sufficient stabilization of water levels (in the pumping well and select observation wells) and field chemistry (i.e., SC, pH, etc.) in the pumped water. Drawdown data will be plotted as they are collected from a select few wells completed in the appropriate aquifers to determine if delayed yield effects have passed and water levels have stabilized in terms of delayed yield and cone-of-depression expansion. The duration may also be changed based on other unforeseen changes in local conditions (e.g., precipitation event of 0.25 inches or more or continued drawdown in observation wells). If after 72 hours of pumping, drawdown continues in wells across each site or the effects of delayed yield are still being observed, the duration of the pumping test may be modified by the FTL and CPM in consultation with the Contractor QAO and extended up to an additional 24 hours.

4.2.9.4 Monitoring Silver Bow Creek

During the pumping and recovery tests at pumping well location BRW-PW-01A, the water levels in SBC will be recorded to determine if the stream is affecting the pumping test or the pumping test is affecting the stream. Stream water levels will be monitored and recorded at existing monitoring station B-6 and the existing groundwater remedy system BRW-00 (Figure 4-1) as per the 2018 Surface Water QAPP (Atlantic Richfield Company, 2018). Changes in stream levels could affect the pumping test by adding additional recharge to the groundwater system. The pumping test will not likely affect the stream levels. Generally, SBC in the BRW stretch flows at approximately 15 cubic feet per second (cfs) or 6,732 gpm. If the pumping test were pumped at 200 gpm that would amount to approximately 3% of the total stream flow. Assuming the well would draw from the aquifer and only half of the production flow was from SBC recharge, the loss from the creek would be 100 gpm or 1.5% of total stream flow. Therefore, it is unlikely to see stream water level changes caused by the pumping test.

The water levels in the stream will be recorded every hour for the first 8 hours of the pumping test and then every 8 hours after. If no changes in stream flow are observed during the pumping test, the monitoring will be discontinued after 24 hours.

4.2.10 Recovery Test

Once the decision is made to conclude the active pumping of the test well, preparations for conducting the recovery test will begin. To avoid disturbing the transducers during the pumping test, transducer data is not required to be downloaded prior to starting the recovery test. There are select wells that will be downloaded prior to starting the recovery test due to insufficient data storage. No adjustments will be necessary for the transducers and they will continue recording water levels at 15-second intervals during the recovery test. The duration and/or number of locations selected for the recovery test may be modified by the FTL and CPM in consultation with the Contractor QAO, depending on the radius of influence during the pumping tests.

4.2.11 Weather Monitoring

Weather will be monitored through all phases of the long-term pumping test including daily high and low temperatures, barometric pressure, and precipitation amounts. The temperatures monitored at the BTL/LAO weather station (KMTBUTTE5) will be used for the high and low temperatures. The barometric pressures will be monitored and recorded using a Solinst Barologger set to record barometric pressure every 15 minutes. The Barologger will be kept at the Pioneer office in Butte to safeguard the monitoring tool. Precipitation measurements from the BTL weather station will be used to document precipitation amounts.

4.2.12 Pumping Test Data Analysis

Data from all piezometers and wells where drawdown/recovery occurs will be analyzed using the AQTESOLV software package. During the data analyses activity, drawdown data will be corrected for groundwater trends and barometric changes. It is anticipated that a subset of piezometers/wells will not have drawdown demonstrating that the pumping test had no effect on the aquifer at those locations.

4.3 Pre- and Post-Pumping Test Groundwater Analyses

As stated in Section 4.2.5.6, groundwater samples from the locations shown on Figure 4-10 will be collected before the pumping test. After the conclusion of the pumping test, additional groundwater samples will be collected at the locations shown on Figure 4-13. The sampling locations may be modified at the discretion of field personnel. The samples will be analyzed for the analytes listed in Table 3-5 as specified in Table 4-3. As noted in Table 4-3, hydrocarbon samples will only be collected from those proposed pumping test piezometers that contained soils with positive PID readings.

4.3.1 General Sampling Procedures

Field personnel will collect a water sample using the appropriate sampling equipment (e.g., peristaltic pump, submersible pump, or bladder pump) in conjunction with a low-flow sampling methodology approved by the FTL and CPM in consultation with the Contractor QAO. All water sampling results will be recorded in a bound field logbook.

Prior to groundwater sampling, depth to groundwater will be measured at each piezometer location in accordance with SOP-GW-03 (Appendix A). After water levels have been collected, the piezometers will be purged with the appropriate sampling equipment (e.g., peristaltic pump, submersible pump, or bladder pump) (SOPs in Appendix A) until the water quality parameters (turbidity, temperature, SC, and pH) and water level have stabilized. Water quality measurements will be collected at 3- to 5-minute intervals to monitor stabilized water quality parameters. Water quality parameters will be collected in accordance with the applicable and relevant SOPs (Appendix A). The piezometer will be considered stable when 3 consecutive readings for turbidity are below 5 NTUs or are within 10% of each other and the water quality parameters are stable. The water quality parameters are considered stable when three consecutive readings are as follows:

- Temperature range is no more than +/- 1 °C.
- pH varies by no more than 0.1 pH units.
- SC readings are within 3% of the average.

Once the water quality parameters stabilize, samplers will collect the groundwater sample directly from the sampling equipment and place it into appropriate sample containers. The sampling procedures follow the applicable SOPs developed by Pioneer (Appendix A), which adhere to or expand upon the CFRSSI SOPs (ARCO, 1992c). Table 4-3 lists the detailed procedures for sample collection and handling.

4.3.2 LNAPL Considerations

If sufficient LNAPL thickness is observed (at least 0.2 feet) in the piezometer, baildown tests will be performed where the rapid removal of floating hydrocarbons is performed followed by the monitoring of the hydrocarbon recovery. The tests will be conducted following the baildown test procedures described in the *American Petroleum Institute LNAPL Transmissivity Workbook: A Tool for Baildown Test Analysis User Guide* for conducting baildown tests (API, 2016; included in Appendix A). These tests, if performed, will provide a useful measure of potential hydrocarbon lateral mobility (transmissivity) within the groundwater environment. By conducting baildown tests, LNAPL transmissivity can be calculated to help determine if active LNAPL recovery is a viable remedial alternative.

During the baildown test, a sample of LNAPL will be collected for laboratory analysis (Table 4-3 and Table 3-5). Once the LNAPL layer has been sampled, field personnel will bail out any remaining LNAPL and use low flow sampling to collect groundwater samples for dissolved metals analysis. If the interface probe shows no presence of LNAPL, field personnel will develop the well and take samples as indicated in Section 4.3.1.

If LNAPL is detected, field personnel with attempt to make sure the pump's inlet is a minimum of 1 foot below the top of the groundwater interface to avoid interference of hydrocarbons with the probe and will use low flow sampling to avoid drawdown in the well. Additionally, the ORP probe will be cleaned between wells, following the manufacturer’s instructions, to remove any hydrocarbons that may interfere with the readings.

4.4 Silver Bow Creek Loading Analysis

The purpose of the SBC loading analysis is to determine the changes in chemical concentrations and load in SBC from the area between SS05B and SS06A during the aquifer test to guide the remedy design and implementation. The loading analysis will use a combination of manual flow measurements and radon tracing methodology to locate sub-reaches along SBC where impacted groundwater is upwelling and quantify the load to SBC.

4.4.1 Sampling Process and Design

Staff gages will be installed at B-5, BRW-SS-01, and at B-6 in SBC (Figure 4-14). Field personnel will make adjustments to the locations as necessary to accommodate field conditions. The staff gages will be installed in a location that minimizes the potential for clogging from floating debris and secured to prevent movement during higher flows. The staff gage must be mounted vertically and plumb to the water surface. After installation, the location and "zero elevation" of each staff gage will be surveyed.

4.4.1.1 Flow Measurements and Surface Water Sampling

Flow measurements and samples will be completed during low-flow and/or stable surface water flow conditions before, during, and after the initial pumping test and before, during, and after the optional, second pumping test if it is conducted. When taking flow measurements and samples, the field teams will start at the downstream-most-sampling location and move upstream. Flow data and samples will be collected from the existing and proposed staff gages (Figure 4-14).

It is anticipated that the field technician will be able to collect flow measurements and samples by wading. Stream flow measurements will be conducted utilizing a cross-section of the stream channel. Field personnel will use a FlowTracker2 following the SOPs in Appendix A. Staff gages will be read to an accuracy of 0.01 feet before and after flow measurements are taken. The FTL will identify any change in flow over the duration of each sampling event using the nearby U.S. Geological Survey (USGS) station 12323250 or other appropriate location.

Samples will be collected per SOP-SW-01 (Appendix A). Samples will be collected using equal width increment (EWI) sampling technique (Atlantic Richfield Company, 2018). The process to sample by the EWI sampling technique is to start at the right edge of water (REW), collect a small portion of water into the sample container, avoid touching the bottom of the streambed so that sediment is not stirred up during sample collection, step towards the left side of the stream, and collect a second portion of water into the sample container. Continue in this manner until the sample container is filled and the left edge of water (LEW) is reached. The field team will use common sense dividing the stream reach into equal increments.

4.4.1.2 Groundwater Sampling

Groundwater samples will be collected from five groundwater monitoring wells (shown on Figure 4-14) before and after the pumping test, samples will not be taken during the pumping test. The staff gages and BRW19-PZ46 will be installed before the pumping test. The samples will be collected and analyzed as indicated in Table 4-3 and Table 3-5. The samples will be taken following the general procedures below and SOPs in Appendix A. The selected groundwater sampling locations may be changed, increased, or decreased as determined by the FTL and CPM in consultation with the Contractor QAO.

Field personnel will collect a water sample using the appropriate sampling equipment (e.g., peristaltic pump, submersible pump, or bladder pump) in conjunction with a low-flow sampling methodology approved by the FTL and CPM in consultation with the Contractor QAO. All water sampling results will be recorded in a bound field logbook.

Prior to groundwater sampling, depth to groundwater will be measured at each piezometer location in accordance with SOP-GW-03 (Appendix A). After water levels have been collected, the piezometers will be purged with the appropriate sampling equipment (e.g., peristaltic pump, submersible pump, or bladder pump) (SOPs in Appendix A) until the water quality parameters (turbidity, temperature, SC, and pH) and water level have stabilized. Water quality measurements will be collected at 3- to 5-minute intervals to monitor stabilized water quality parameters. Water quality parameters will be collected in accordance with the applicable and relevant SOPs. The piezometer will be considered stable when 3 consecutive readings for turbidity are below 5 NTUs or are within 10% of each other and the water quality parameters are stable. The water quality parameters are considered stable when three consecutive readings are as follows:

- Temperature range is no more than +/- 1 °C.
- pH varies by no more than 0.1 pH units.
- SC readings are within 3% of the average.

Once the water quality parameters stabilize, samplers will collect the groundwater sample directly from the sampling equipment and place it into appropriate sample containers. The sampling procedures will follow the applicable SOPs (Appendix A), which adhere to or expand upon the CFRSSI SOPs (ARCO, 1992c). Table 3-5 lists the detailed procedures for sample collection and handling.

4.4.2 Data Analysis

The analysis of the data collected from the field actives will be similar to the radon tracing methodology described in the *Final Revised 2011 Blacktail Creek and Silver Bow Creek Radon Tracing and Thermal Imaging Survey Technical Memorandum* (Radon Tracing Memo) (Atlantic Richfield Company, 2016b). That methodology is described below.

Estimation of Surface Water Gain using Radon Concentrations

Results from the radon analysis combined with surface water flow monitoring help define locations where groundwater is upwelling into surface water. The relationship between surface water and groundwater is defined by the mass balance equation:

$$(Q_{us} * C_{us}) + \left(Q_{gw} * C_{gw}\right) = (Q_s * C_s) \qquad \text{(Equation 1)}$$

Where:

- Q_{us} = Flow rate of stream at upstream sample location (cfs)
- C_{us} = Concentration of radon at upstream sample location (picocurie per liter [pCi/L])
- Q_{gw} = Groundwater inflow or gain (cfs)
- C_{gw} = Concentration of radon in groundwater (pCi/L)
- Q_s = Flow rate of stream at sample location (cfs)
- C_s = Concentration of radon at sample location (pCi/L)

With stream flow and radon measurements known, the groundwater discharge between two locations in the stream is determined by rewriting Equation 1:

$$Q_{gw} = \frac{(Q_s * C_s) - (Q_{us} * C_{us})}{C_{gw}} \qquad \text{(Equation 2)}$$

It is necessary to use only the upstream discharge measurement of flow (Q_{us}) in the calculation to determine the total flow downstream rather than the measured flow downstream in case there is both a loss and a gain in the stream reach. This is accomplished by substituting for Q_s in Equation 2 using the following:

$$Q_s = Q_{us} + Q_{gw} \qquad \text{(Equation 3)}$$

Using the product from Equation 3 and substituting it back into Equation 2, the resulting equation through algebraic manipulation becomes:

$$Q_{gw} = Q_{us} * \frac{(C_s - C_{us})}{(C_{gw} - C_s)} \qquad \text{(Equation 4)}$$

Equation 4 allows calculation of the total groundwater discharged into a specific surface water reach. To account for the natural off-gassing of radon, each downgradient station will be adjusted individually using the procedures and results presented in the Radon Tracing Memo (Atlantic Richfield Company, 2016b).

This methodology will be adjusted as needed to meet the requirements of the Site.

4.5 Investigation of Slag Physical Properties and Demolition Methods

The specific objectives of the slag investigation include excavating test pits and drilling boreholes to help refine the extent and physical characteristics of the slag within the Site. Test pits will be excavated at locations within the Site where slag is anticipated to be removed during remedial activities to investigate the remaining smelter stack foundation, which is constructed of slag. The boreholes will be drilled at areas within the Site at locations where slag caused refusal during the excavation of test pits.

4.5.1 Stage 1 – Test Pits

The main objective of Stage 1 is to excavate multiple test pits and document physical features of the slag. The data will help inform the removal methods for the slag. This section details the procedures and protocols for Stage 1. Additional procedures are specified in corresponding SOPs. Table 3-3 lists the work schedule.

4.5.1.1 Test Pit Excavation

Test pits will be excavated within the area shown on Figure 4-15 where slag is planned to be removed during construction activities. The final number and locations of test pits will be determined by the FTL and CPM in consultation with the Contractor QAO. Considerations that will impact the decision on sampling locations include the results from surrounding test pits, location of utilities, infrastructure and land use in the area due to ongoing BSB operations, safety concerns, and equipment access.

Excavation of test pits will follow the general procedures presented in SOP-S-06 (Appendix A). Additionally, the following steps will be conducted when slag is encountered while excavating the test pit:

- A digital video camera (or equivalent) will be used to record the excavation of the test pit as directed by the FTL.
- Time will be recorded when the excavator begins to excavate slag from the test pit and when the excavator stops excavating slag from the test pit (or hits refusal).
- The length, width, and depth of slag removed (or refusal depth) will be measured with a measuring tape and/or wheel and recorded to determine the total volume of slag removed.

During excavation of the test pits, the following limits will be observed:

- Test pits will be excavated using a track-mounted or rubber-tired excavator capable of excavating to a maximum depth of 15 feet. The type of excavation equipment used (e.g., excavator model number, bucket type, teeth type, etc.) as well as any modifications to the equipment (e.g., hydraulic modifications, counterweights, boom extensions, bucket thumbs, attachments, etc.) will be documented.
- Test pits will be excavated until the target depth is reached, until the equipment hits refusal (i.e., cannot excavate through material), to the limits of the equipment (i.e., 15 feet), or other site-specific limitations are encountered (e.g., groundwater is encountered, sidewall stability becomes insufficient, etc.). The general target depth of each test pit is as follows:

- For locations outside the removal corridor (Figure 4-16), the test pit will extend until the vertical extent of slag can be determined.
- For locations within the removal corridor and not located within approximately 5 feet of a deeper, previously completed investigation point (Figure 4-16), the test pit will extend until the bottom of waste is determined (i.e., field screening indicates that the solid material passes the passes the Waste Identification Screening Criteria [EPA, 2020]).
- The final depth of the test pit will ultimately be determined by the FTL and CPM in consultation with the Contractor QAO based on field conditions and results from previous investigations.

- Excavated materials will be stockpiled a minimum of 3 feet from the edge of the excavation.
- From the ground surface to a depth of 4 feet, 1 wall of the test pit will be prepared for evaluation. The test pit should have 1 vertical smooth wall for evaluation and 1 sloping or stepped wall for egress into and out of the test pit. Field personnel may only enter the test pit if a competent person (as identified in the corresponding Task Risk Assessment, Section 6.0) has examined the test pit and determined it is safe to enter.
- No personnel will be permitted access to test pits deeper than 4 feet during performance of this work.
- If the depth of the test pit is greater than 6 feet, field personnel must maintain a 6-foot horizontal distance from the edge of the test pit unless they are wearing a safety harness anchored to the excavator bucket.
- Indicators of test pit stability will be documented in the corresponding Task Risk Assessment (Section 6.0) to establish protocols to cease excavation and safely backfill if a test becomes or appears to become unstable.
- Dewatering of test pits will not be conducted due to the considerations of impacted groundwater. No further excavation will occur in a test pit if groundwater is encountered.

During excavation of the test pit, visual observations (sight and/or smell), and two PIDs will be used to identify sources of hydrocarbons. Any findings will be evaluated with a combustible gas meter, appropriate actions taken if necessary, and the results recorded in the field logbook. The procedures for using the PIDs and combustible gas meter are detailed in Section 4.10.2. At the discretion of field personnel, a soil sample may be collected for hydrocarbon analysis. The sample will be collected and analyzed for VPH and EPH fractionation with PAH in accordance with the sampling procedures detailed in Section 4.11.3.

4.5.1.2 BRW Smelter Stack Foundation Test Pit Excavation

During Stage 1 activities, an excavator will be used to expose the east side of the stack foundation and a test pit will be excavated, following the methods mentioned in Section 4.5.1.1, to confirm the construction of the stack foundation and document machine performance to fracture the foundation material. The stack foundation consists of a pyramid-shaped, 18-foot-thick slag foundation reinforced with T-rails, steel wire rope, and chain and scrap metal. A 5- to 8-foot-thick concrete slag was cast on top of the slag pyramid and was reinforced with T-bars (JAES, 1906). Previous field investigations have not attempted to fracture the reinforced foundation slag nor have they encountered slag with similar steel reinforcement.

4.5.1.3 Equipment

Equipment used to record observations during Stage 1 will include, but is not limited to, the following:

- Field logbook and pens.
- Field forms and references (Appendix B).
- Measuring tape/wheel.
- Digital stopwatch.
- Penknife.
- Mylar Soil Sample Cups.
- Disposable sampling scoops.
- XRF field unit – Niton™ XL# Analyzer (XL3).
- Sieve.
- Portable heater or oven.
- Two PIDs (9.8 electron volt [eV] and 10.6 eV lamps) with humidity filter.
- Camera and film, digital camera, and/or digital video camera.
- Sharpshooter shovels and spoons or disposable sampling spoons.
- Sample containers and labels.
- Chain of custody forms.
- Coolers.
- Decontamination equipment (pressure washer, tap water, dilute nitric acid, liquinox soap, decontamination containers, paper towels, scrub brushes, and spray bottles) (refer to SOP-DE-02 in Appendix A).
- PPE.
- Survey-grade GPS unit.

4.5.1.4 Logging and Sampling

The classification and lithology of the test pit sidewalls will be logged and the areas photographed and/or videoed. This will include a soil log of the test pit sidewall that lists a general description of soil classification (e.g., silty sand, clay, gravel, etc.); visual estimate of rock content (2-inch plus fraction); depth to top and bottom of each stratigraphic unit; presence or absence of soil staining, odors, nodules, organic matter, and/or groundwater; and bedrock depth (if encountered). All relevant observations will be recorded in a bound field logbook and on the forms included in Appendix B.

In addition to the classification and lithology, the following observations will be recorded for slag encountered while excavating the test pit:

- Descriptive data of the slag (e.g., visual description, bedding, discontinuities, weathering, hardness, color, noticeable changes at depth, etc.).
  - Weathering, hardness, joint and fracture spacing, and bedding thickness will be recorded according to the rock descriptive terms and defining characteristics from Ecology and Environment, Inc.'s Geologic Logging SOP, Figure 3 (E&E, 1998), which is included in Appendix B.
- Size of fractured slag produced by excavator.

Additionally, opportunistic soil samples may be collected for metals analysis via the XRF field unit and/or laboratory methods. The field team will collect samples following the general procedures in Section 4.6 with the following exceptions:

- For locations within the removal corridor and not located within approximately 5 feet of a deeper, previously completed investigation point (Figure 4-16), a sample will be collected from each lithological layer and submitted for metals analysis via ICP-OES (Table 3-5), unless the lithological layer is too thin and there is not enough soil to fulfill the required sample volume. In this instance, a sample will be collected and prepped (Section 4.10.1) for XRF analysis.
- For locations outside the removal corridor (Figure 4-16), no samples will be collected.

The field team will record the information in the Test Pit Excavation log provided in Appendix B. The field team will also record the survey-grade GPS coordinates of all test pits.

4.5.2 Stage 2 – Slag Core Sample Collection

The main objective of slag core collection and laboratory tests is to establish the tensile strength, compressive strength, and the fracture toughness of the slag. Previous investigations showed that the physical properties of the slag vary across the Site (NRDP, 2016). The data will help inform the selection of locations for Stage 3 and Stage 4 and also assist in specifying the correct expansive grout. Additionally, this information may be shared with future contractors to inform the contractors of the physical properties of the slag so they can determine the appropriate methodology and potential equipment that may be practical for use during the remedial action. The following sections detail the sampling process, procedures, and protocols for slag core collection. Additional procedures are specified in the corresponding SOPs. Table 3-3 lists the work schedule.

4.5.2.1 Drilling Locations

The location of slag core samples will be determined based on the results of Stage 1 (see Step 5 of DQOs detailed in Table 3-2). Up to 20 locations will be selected based on slag properties, and the selection will focus on areas where the excavator was unable to remove the slag in Stage 1. Field personnel will record all GPS location coordinates for all borehole locations.

The FTL, CPM, Contractor QAO, and Safety and Health Manager will identify potential slag core sample locations that are appropriate in meeting the objectives of this investigation. These locations will be reviewed with the Atlantic Richfield Company Project Manager (PM) and Quality Assurance Manager (QAM) for final approval. Additional considerations that will impact the decision on sampling locations include location of utilities, infrastructure and land use in the area due to ongoing BSB operations, safety concerns, and equipment access.

4.5.2.2 Drilling Procedures

Boreholes are anticipated to be drilled and constructed using a Geoprobe rig (e.g., O'Keefe Drilling Company's Geoprobe 8150 LS) capable of drilling both by traditional (i.e., rotating drill bit) and sonic methods. The traditional method will produce a 2.5-inch core, and the sonic method will produce a 4-inch core. Both methods may be attempted to produce a solid core sample of slag that is needed for the laboratory tests. The following general procedures will be performed at each borehole location (at the depth intervals). Note that this list is not intended to be a complete list.

- Complete utility locates and drill rig inspection prior to drilling boreholes.
- Complete any Site preparation necessary to ensure safe and effective entry and egress for the drill rig.
- Prepare drill rig for operation. This includes, but is not limited to, decontaminating drilling tools and sampling equipment, leveling the rig, preparing the down-hole tool, and establishing the drill location.
- Arrange service water to be supplied from a fire hydrant on Montana Street. Water usage will be metered using a rented meter from BSB.
- Contain drilling return water to the extent practical at the borehole location and convey it into an approved container supplied by the driller.
- Use a TPH field test kit to determine if TPHs are present in the drilling return water (Section 4.10.3).
    - At the discretion of field personnel, one test will be administered per borehole.
    - If TPHs are detected, the water will be containerized in storage tanks. At the end of the slag investigation, water samples will be collected and submitted for laboratory analysis (Table 3-5). The need for treatment/disposal options, if necessary, will be determined based on the laboratory results.

    - If TPHs are not detected, containerized water will be transported and disposed of at the drying beds in LAO (Figure 1-2).
- Begin advancing the core barrel. Advance the core rod/barrel (anticipated to be 5 feet) to collect the core, then retrieve the inner core barrel to recover the core. Continue adding core rod segments and collecting core until desired depth has been reached.
- Place recovered core in boxes, log the core, and collect samples (Section 4.5.2.4).

The general depth of each borehole will be determined as follows:

- For locations outside the removal corridor (Figure 4-16), the borehole will extend until the vertical extent of slag can be determined.
- For locations within the removal corridor and not located in close proximity to a previous investigation point (Figure 4-16), the borehole will extend until the bottom of waste is determined (i.e., field screening indicates that the solid material passes the Waste Identification Screening Criteria [EPA, 2020]).

The final depth of the borehole will ultimately be determined by the FTL and CPM in consultation with the Contractor QAO based on field conditions and results from previous investigations.

4.5.2.3 Equipment

Equipment, materials, and supplies used to collect core samples will include, but not be limited to, the following:

- Field logbook and pens.
- Field forms and references (Appendix B).
- Digital stopwatch.
- Measuring tape/wheel.
- Penknife.
- Mylar Soil Sample Cups.
- Disposable sampling scoops.
- XRF field unit.
- Sieve.
- Portable heater or oven.
- TPH field test kit.
- Two PIDs (9.8 eV and 10.6 eV lamps) with humidity filter.
- Chain of custody forms.
- Sample containers and labels.
- Core boxes.
- Coolers.

- Camera and film, digital camera, or digital video camera.
- Decontamination equipment (pressure washer, tap water, dilute nitric acid, liquinox soap, decontamination containers, paper towels, scrub brushes, and spray bottles) (refer to SOP-DE-02 in Appendix A).
- Appropriate safety PPE.
- Survey-grade GPS unit.

4.5.2.4 Logging and Sampling

The general depth of each borehole is anticipated to extend through the entire thickness of slag (range from 1 to 30 feet), and the core is anticipated to be either 2.5 inches or 4 inches in diameter depending on the drilling method used. The general lithology of the core will be logged and photographed, and samples will be collected from the boreholes for tensile strength, compressive strength, and fracture toughness tests.

- Complete borehole log (Appendix B).
  - Log should include general description of soil classification (e.g., silty sand, clay, gravel, etc.); visual estimate of rock content (2-inch plus fraction); depth to top and bottom of each stratigraphic unit; bedrock depth (if encountered); presence or absence of soil staining, odors, nodules, organic matter, and/or groundwater; core recovery; type of drilling equipment; rock-quality designation (RQD); drilling rates; and down pressure.
  - For each lithological layer of slag, additional descriptive data of the slag should be recorded (e.g., visual description, bedding, discontinuities, weathering, hardness, color, noticeable changes at depth, etc.).
    - Weathering, hardness, joint and fracture spacing, and bedding thickness will be recorded according to the rock descriptive terms and defining characteristics from the Geologic Logging SOP, Figure 3 (E&E, 1998), included in Appendix B.
- Collect slag core samples from borehole: 1 sample for compressive strength test, 1 sample for tensile strength test, and 1 sample for fracture toughness test.
  - The compressive strength test requires a length-to-diameter ratio ranging from 2.0 to 2.5. For a 2.5-inch diameter core, the length would be between 5 and 6.25 inches. For a 4-inch diameter core, the length would be between 8 and 10 inches.
  - The tensile strength test requires a length-to-diameter ratio ranging from 0.5 to 0.75. For a 2.5-inch diameter core, the length would be between 1.25 and 1.875 inches. For a 4-inch diameter core, the length would be between 2 and 3 inches.
  - The fracture toughness test requires a length-to-diameter ratio ranging from 3.5 to 4. For a 2.5-inch diameter core, the length would be 8.75 and 10 inches. For a 4-inch diameter core, the length would be between 14 and 16 inches.

- The cores may be transported to the Pioneer Bozeman Materials Testing Laboratory where they will be cut to the required length prior to shipping for analytical testing.

- Additionally, opportunistic soil samples may be collected for metals analysis via the XRF field unit and/or laboratory methods. The field team will collect samples following the general procedures in Section 4.6 with the following exceptions:
  - For locations within the removal corridor and not located in close proximity to a previous investigation point (Figure 4-16), a sample will be collected from each lithological layer and submitted for metals analysis via ICP-OES (Table 3-5), unless the lithological layer is too thin and there is not enough soil to fulfill the required sample volume. In this instance, a sample will be collected and prepped (Section 4.10.1) for XRF analysis.
  - For locations outside the removal corridor (Figure 4-16), no samples will be collected.

4.5.3 Stage 3 – Heavy Equipment Removal

The main objective of the slag removal with heavy equipment is to determine if slag can be removed with heavy equipment and which piece and/or combination of equipment is most effective. Heavy equipment used during this stage will include an excavator with bucket, dozer with ripper attachment, and/or an excavator with a breaker attachment. The following sections detail the sampling process, procedures, and protocols for Stage 3. Additional procedures are in corresponding SOPs. Table 3-3 lists the work schedule.

4.5.3.1 Locations

The location of field tests for slag removal using heavy equipment will be determined based on the results of Stage 1 and Stage 2. The locations will be selected to focus on different areas with varying slag properties to help determine the removal efficiency of each piece of equipment. Additional considerations that will impact the decision on field test locations include equipment access, amount of known overburden over slag, infrastructure and land use in the area due to ongoing BSB operations, location of utilities, and other safety concerns. The FTL, CPM, Contractor QAO, and Safety and Health Manager will identify potential field test locations that are appropriate in meeting the objectives of this investigation. These locations will be reviewed with the Atlantic Richfield Company PM and QAM for final approval.

4.5.3.2 Equipment

The equipment selected includes an excavator with bucket attachment, dozer with a ripper attachment, and an excavator with a hydraulic breaker and/or ripper attachment. Actual sizes, model numbers, and attachments will be documented and will depend on the contractor's fleet, but the anticipation is that the equipment will be similar in size and power to a Caterpillar 365 excavator and Caterpillar D8 Dozer. Additional equipment, materials, and supplies used to complete Stage 3 will include, but are not limited to, the following:

- Field logbook and pens.
- Field forms and references (Appendix B).
- Digital stopwatch.
- Measuring tape/wheel.
- Penknife.
- Two PIDs (9.8 eV and 10.6 eV lamps) with humidity filter.
- Camera and film, digital camera, or digital video camera.
- Sharpshooter shovels and spoons or disposable sampling spoons.
- Sample containers and labels.
- Chain of custody forms.
- Coolers.
- Decontamination equipment (pressure washer, tap water, dilute nitric acid, liquinox soap, decontamination containers, paper towels, scrub brushes, and spray bottles) (refer to SOP-DE-02 in Appendix A).
- Appropriate safety PPE.
- Survey-grade GPS unit.
- Trimble S7 Direct Reflector Robotic Total Station (Trimble S7 Total Station) or equivalent.

4.5.3.3 Field Test Procedures

The general procedures that will be followed during the field tests include, but are not limited to, the following:

- A dozer or excavator will be used to clear overburden from the test locations. If conditions allow, the equipment will be used to expose enough slag for equipment tracks to contact slag during the field tests.
- The area of exposed slag will be surveyed with a Trimble S7 Total Station or equivalent.
- A digital video camera (or equivalent) will be used to record the fracture and removal of slag, as directed by the FTL.
- A dozer with a ripper attachment will initiate the removal effort.
    - Start and stop time of the dozer’s operation will be recorded.
    - An excavator with bucket attachment will remove the fractured slag produced by the dozer to measure the depth of excavation. Start and stop time of the excavator’s operation will be recorded.

- The excavation area/void will be surveyed to determine the volume of slag. Both equipment's (dozer and excavator) time of operation will be used to determine the production rate.
    - Additional observations of the equipment's performance will be recorded during the test.
- An excavator with bucket attachment will attempt to fracture and remove the slag following the dozer.
    - Start and stop time of the excavator's operation will be recorded.
    - The excavation area/void will be surveyed to determine the volume of slag removed and production rate.
    - Additional observations of the equipment's performance will be recorded during the test.
- An excavator with breaker attachment will attempt to fracture the slag.
    - Start and stop time of the excavator's operation will be recorded.
    - An excavator with bucket attachment will remove the fractured slag to measure the depth of excavation. Start and stop time of the excavator's operation will be recorded.
    - The excavation area/void will be surveyed to determine the volume of slag. Both equipment's time of operation will be used to determine the production rate.
    - Additional observations of the equipment's performance will be recorded during the test.
- Field tests will continue until the total depth of slag can be determined, the equipment hits refusal (i.e., cannot excavate through material), the limits of the equipment are reached, or other Site-specific limitations are encountered (e.g., groundwater is encountered, sidewall stability becomes insufficient, etc.). Areas where refusal is met will be identified for potential use in Stage 4.
- Post-test activities will include backfilling excavations with excavated soil and slag and grading the excavation to the original topography or to the extent practical in the field.

All relevant observations will be recorded in a bound field logbook. The field team will record the survey-grade GPS coordinates of all field test locations. Several factors including, but not limited to, overburden depth, surface obstructions (e.g., dirt piles, structures), slag hardness, equipment success, and equipment limits (e.g., excavation depth) may alter the selection of equipment and/or the procedures used for each piece of equipment during the field tests.

During the field tests, visual observations (sight and/or smell) and two PIDs will be used to identify sources of hydrocarbons. Any findings will be evaluated with a combustible gas meter, appropriate actions taken if necessary, and the results recorded in the field logbook. The procedures for using the PIDs and combustible gas meter are detailed in Section 4.10.2. At the discretion of field personnel, a soil sample may be collected for hydrocarbon analysis. The sample will be collected and analyzed for VPH and EPH fractionation with PAH in accordance with the sampling procedures detailed in Section 4.11.3.

4.5.3.4 Logging

The classification and lithology of the excavated area will be logged (including overburden), and the areas photographed and/or videoed. This will include a soil log of the excavation sidewall that lists general description of soil classification (e.g., silty sand, clay, gravel, etc.); visual estimate of rock content (2-inch plus fraction); depth to top and bottom of each stratigraphic unit; presence or absence of soil staining, odors, nodules, organic matter, and/or groundwater; and bedrock depth (if encountered).

In addition to the classification and lithology, the following observations will be recorded for slag:

- Descriptive data of the slag (e.g., visual description, bedding, discontinuities, weathering, hardness, color, noticeable changes at depth, etc.).
  - Weathering, hardness, joint and fracture spacing, and bedding thickness will be recorded according to the rock descriptive terms and defining characteristics from the Geologic Logging SOP, Figure 3 (E&E, 1998), included in Appendix B.
  - Any vertical and/or horizontal travel patterns of observed hydrocarbons.
- Size of fractured slag produced by equipment.

All relevant observations will be recorded in a bound field logbook.

4.5.4 Stage 4 – Expandable Grout Field Test

The main objective of the expandable grout field test is to determine if slag can be fractured with expandable grout. The expandable grout field test will only be conducted if there are areas within the Site where heavy equipment could not remove the slag during Stage 3 and if determined necessary by the Atlantic Richfield Company PM, QAM, CPM, and Contractor QAO based on the results of Stage 1, Stage 2, and Stage 3. This section details the sampling process, procedures, and protocols for Stage 4. Additional procedures are specified in corresponding SOPs (Appendix A). 0 lists the work schedule.

4.5.4.1 Field Test Locations

The location of field tests for the expandable grout will be determined based on the results of Stage 1, Stage 2, and Stage 3 and will focus on areas within the Site where heavy equipment could not remove the slag during Stage 3. Up to 4 separate locations will be tested based on slag properties, including tensile strength and compressive strength. Each location will be approximately 45 square feet, and test depths will be determined based on results of Stages 1 and 2 and previous investigations.

The FTL, CPM, Contractor QAO, and Safety and Health Manager will identify potential field test locations that are appropriate in meeting the objectives of this investigation. These locations will be reviewed with the Atlantic Richfield Company PM and QAM for final approval. Additional considerations that will impact the decision on locations include location of utilities, infrastructure and land use in the area due to ongoing BSB operations, safety concerns, and equipment access. Expandable grout requires that a vertical face of the material receiving the grout be exposed to allow room for expansion and fracture (Appendix C). As a result, the location of the field tests is dependent on having a vertical face exposed, adequate access for drill rig, and adequate access to remove fractured slag. Lastly, there is potential that tensile strength results and/or hole temperatures may not allow for the use of expandable grout due to the risk of blowout (Appendix C).

4.5.4.2 Equipment

A standard drill rig capable of drilling 1.5-inch diameter holes and/or a handheld cordless drill will be used to drill the holes. A septic removal truck capable of removing material from a 1-inch diameter drill hole will be used to free the holes of water and debris. An excavator will be used to remove the fractured grout and backfill test locations, and a dozer will be used to achieve final grading.

Additional equipment, materials, and supplies used to complete the field test will include, but are not limited to, the following:

- Field logbook and pens.
- Field forms and references (Appendix B).
- Digital stopwatch.
- Digital thermometer with probe.
- Measuring tape/wheel.
- Penknife.
- TPH field test kit.
- Decontamination equipment (pressure washer, tap water, dilute nitric acid, liquinox soap, decontamination containers, paper towels, scrub brushes, and spray bottles) (refer to SOP-DE-02 in Appendix A).
- Camera and film, digital camera, or digital video camera.
- Appropriate safety PPE.
- Survey-grade GPS unit.
- Trimble S7 Total Station or equivalent.

4.5.4.3 Field Test Procedures

The main steps of the field test include drilling holes for the grout application, determining the core temperature of the slag and selecting the correct grout, applying the expandable grout, and removing fractured slag with heavy equipment. The following subsections details these processes.

4.5.4.3.1 Drilling Procedures

Grout holes are anticipated to be drilled using a standard drill rig capable of drilling 1.5-inch diameter holes or other suitable equipment identified by FTL, CPM, Contractor QAO, and Safety and Health Manager. Equipment from Stage 3 may be used to prepare an appropriate area for this drilling rig and/or excavate a nearby vertical face. Each area is anticipated to be approximately 45 square feet, and approximately 56 expandable grout test holes will be drilled on 1-foot centers. If 4 areas are selected, this will result in up to 224 expandable grout test holes. Expandable grout manufactures specify that holes are to be drilled at 1.5 inches in diameter, be drilled to a minimum depth of 8 inches, and be drilled to a total depth that is approximately 80% to 90% of the desired depth of removal (Appendix C). The desired depth of removal will be determined based on the depth of the slag observed during Stage 2 (Section 4.5.2).

At each selected area, up to 10 holes will be pre-drilled prior to the field test to monitor the core temperature of the slag. The main objective of pre-drilling grout holes is to establish the core temperature of the slag. The secondary objective is to observe and record drilling performance through the slag. The data will help inform the selection for correct expansive grout. Once a product has been selected, the remaining holes will be drilled.

Several manufactures recommend that holes be spaced on 1-foot centers, but there is potential that hole spacing may be further or closer depending on drill hole temperature measurements and tensile strength results. The number of holes detailed above are estimates, and the expandable grout manufacturers will be consulted for a final drill pattern prior to drilling the grout holes.

The following general procedures will be performed at each hole location. Note that this list is not intended to be a complete list.

- Complete utility locates prior to drilling holes.
- Prepare an appropriate and safe area for each test. This may include using equipment from Stage 3.
- Measure and mark the hole grid with environment-safe paint prior to drilling.
- Prepare drill rig or handheld cordless drill for operation.
    - For the drill rig this includes, but is not limited to, leveling the rig, preparing the down-hole tool, and establishing the drill location.
    - For the handheld cordless drill this includes inspecting and cleaning the equipment, if necessary.
- Coordinate service water to be supplied from a fire hydrant on Montana Street. Water usage will be metered using a rented meter from BSB.

- Contain drilling return water to the extent practical at the drilling location and convey it into an approved container supplied by the driller.
- Use a TPH field test kit to determine if TPHs are present in the drilling return water (Section 4.10.3).
    - At the discretion of field personnel, one test will be administered per borehole.
    - If TPHs are detected the water will be containerized in storage tanks. At the end of the slag investigation, water samples will be collected and submitted for laboratory analysis (Table 4-3). The need for treatment/disposal options, if necessary, will be determined based on the laboratory results.
    - If TPHs are not detected containerized water will be transported and disposed of at the drying beds in LAO (Figure 1-2).
- Begin advancing the drill rod. Advance the rod to drill the hole until desired depth has been reached. Holes will be drilled to between 80% and 90% of the desired depth of removal, as recommended by expandable grout manufacturers. The desired depth of removal will be determined based on the depth of the slag observed during Stage 2 (Section 4.5.2).
- Use a septic truck with a 1-inch diameter hose to remove water from the holes with suction.
    - If hydrocarbons were detected in the drilling water with the TPH field test kit, the water will be containerized in storage tanks. At the end of the slag investigation, water samples will be collected and submitted for laboratory analysis (Table 4-3). The need for treatment/disposal options, if necessary, will be determined based on the laboratory results.
    - If hydrocarbons were not detected in the drilling water with the TPH field test kit, the water will be disposed of at the drying beds in LAO (Figure 1-2).

The following observations will be recorded during drilling:

- Survey-grade GPS boundary for each test location.
- Drilling start and stop time for each hole along with the amount of drilling time.
- Drill bit changes and the total footage drilled prior to the change.
- Changes in drill rods.
- Drilling performance (e.g., ability drilling through slag).
- Dill hole stability (e.g., hole collapse).
- Total depth of each hole.
- Estimated thickness of slag.

All relevant observations will be recorded in a bound field logbook.

4.5.4.3.2 Temperature Measurements and Grout Selection

Temperature measurements will be conducted with a digital thermometer with a probe and cable capable of being placed into a drill hole. After the hole has been cleaned, tap water will be placed into the bottom of the hole. The water will equilibrate to the temperature of surrounding slag in the hole and allow for accurate temperature measurements of the slag. Temperature measurements will be taken periodically, for a minimum of 3 days, until drill hole temperatures stabilize (i.e., temperature readings during a 24-hour period are all within a temperature range for the expandable grout) (Table 4-6).

The core temperature of the slag will be used to select the type of expandable grout. Once the drill hole temperatures stabilize within a temperature range for the expandable grout, a product will be selected and ordered from the manufacturer. Both expandable grout products are sold based on the core temperature of the material needing fracture (Table 4-6). The proper type must be selected to prevent defective results (e.g., slag not fracturing) or a blowout (Appendix C).

Once the temperature readings are complete, the tap water will be removed from the drill holes with a septic truck and 1-inch diameter hose following the same procedures as in Section 4.5.4.3.1 previously.

4.5.4.3.3 Expandable Grout Application and Slag Removal

The pre-drilled holes will be filled with expansive grout and the grout will expand to fracture the slag. Expansive grout is a powdered substance that is mixed with water and poured into the drill holes. Grout will be on stored on the Site according to the manufacturer's specifications. After the slag is fractured, heavy equipment will be used to verify the slag has fractured enough for removal.

The following are the general procedures that will be followed for the application of the expandable grout:

- The area of the field test will be surveyed.
- Grout will be mixed by the drilling contractor according to the manufacturer's recommendations. Example procedures are included in Appendix C.
- Holes closest to the exposed slag face will be filled first. Most grout manufactures offer drill hole patterns and spacing designs after core temperature is known. Some holes may be left open, if specified by the manufacturer.
- Inspection of slag will occur 24 hours after the last hole is poured and recorded observations will include, but not be limited to:
    - Fracture progress and particle size.
    - Grout escape through drill holes slag seams, cracks, fissures, etc.
- Additional inspections will occur at 48 hours and 72 hours. Grout will be left at least 72 hours before slag removal.

- An excavator or other appropriate equipment will remove fractured slag after 72 hours. The start and stop time of the equipment operation will be recorded.
- The field test area/void will be surveyed to determine the volume of slag. The amount of time it takes to complete the field test (including clearing the fractured slag with equipment) and the volume of slag removed will be recorded to estimate the production rate using expandable grout.
- The slag will either be stored at a location within the Site or backfilled within the test location depending on where the field test is conducted.

During and after the field test, the following observations will be recorded for slag:

- Descriptive data of the slag (e.g., visual description, bedding, discontinuities, weathering, hardness, color, noticeable changes at depth, etc.).
  - Weathering, hardness, joint and fracture spacing, and bedding thickness will be recorded according to the rock descriptive terms and defining characteristics from the Geologic Logging SOP, Figure 3 (E&E, 1998), included in Appendix B.
- Success or failure of fracture, fracture piece size, and if additional fracturing is needed by heavy equipment for transportation off the Site during remedial activities.
- Potential factors that may have contributed to failure to fracture, including overall slag thickness, inconsistency in the slag material, etc.
- Estimates of the quantity of slag removed at each test area.

All relevant observations will be recorded in a bound field logbook.

4.6 Additional Solid Material Characterization

Opportunistic soil samples may be collected for metals analysis via the XRF field unit and/or laboratory methods. For each of the following field activities, the field team will collect samples following the general procedures in this section:

- Installation of Additional Piezometers (Section 4.2.5)
- Stage 1 Test Pits, Excavation of Test Pits (Section 4.5.1)
- Stage 2 Slag Core Sample Collection (Section 4.5.2)

Specific details on the sampling unique to each of the field activities are detailed in the referenced sections.

4.6.1 Core Sampling and Analysis Procedures

Core samples will be collected from boreholes using a sonic drilling rig or Geoprobe unit. Core samples will be collected in accordance with all applicable SOPs (Appendix A). The list of specific analytes and analyses are provided in Table 3-5 and Table 4-3. The following general procedures will be performed at each borehole location (at the depth intervals). Note that this is not intended to be a complete list.

- Prior to use, and between samples, wash all utensils with a detergent solution, followed by a tap water rinse, a diluted acid rinse, and a final rinse with distilled/deionized (DI) water.
- Open the core sleeve and lay out the core samples in order on strips of visqueen or other appropriate material where the boring depth footage has been pre-labeled.
- Split any non-slag material within the core lengthwise using a plastic spatula and/or stainless-steel blades.
- Use two PIDs to immediately to screen for any hydrocarbons (Section 4.10.2). If the presence of hydrocarbons is detected (via sight, smell, and/or detection with a PID), complete the following:
  - All visual and olfactory observations of suspected hydrocarbons will be confirmed with a PID prior to collecting a sample.
  - Immediately collect samples for headspace detection method (Section 4.10.2) and laboratory hydrocarbon analyses (Table 3-5).
  - In all boreholes, a soil sample will be collected near the top of the saturated layer (in the capillary fringe) for hydrocarbon analyses (Table 3-5 and Table 4-3) even if there is no evidence of hydrocarbons, if feasible.
  - Hydrocarbon analyses will not be conducted at locations that are paired with deeper previous investigation points if that location was previously sampled for hydrocarbons.
- Photograph the complete length of the core in 2-foot segments from directly overhead using parallel camera movement and a high-resolution setting.
  - The photographs can be stitched together later to provide a continuous photographic record of the core.
  - Take additional photographs of subsamples for documentation as necessary.
- Complete the borehole log with required information detailed in Section 4.2.5 (Installation of Additional Piezometers) and Section 4.5.2 (Stag 2 - Slag Core Sample Collection).
- Collect specific samples from each lithological layer as described in Section 4.2.5 (Installation of Additional Piezometers, Pumping Test) and Section 4.5.2 (Slag Core Sample Collection, Stage 2 of Slag Investigation).

- Place the core samples in properly labeled sample core boxes for transport (the labels will include location, depth interval, and core orientation). It is imperative that the core sample is marked clearly and is carefully transported horizontally, as it will be used for further observation, sample selection, and analysis.
- If the borehole is to be advanced deeper, and after recovery of the sample, add a drill rod to the drill string to advance core barrel beyond sonic casing.
- Repeat these steps to advance the drill to the desired depth.

Sediment cores from every borehole drilled during this project will be stored in their entirety (in increments) at the Pioneer field office at 244 Anaconda Road in Butte, Montana, or an alternate suitable location. When it has been determined that enough sample is present for design-related purposes, additional samples will be shared with other parties, transferred off the Site, or disposed of appropriately.

Samples will be collected as per SOP-S-06 (Appendix A). The general procedures for the field analyses methods for the XRF and PID units are included in Section 4.10.

4.6.2 Test Pit Sampling and Analysis Procedures

Soil samples will be collected from test pits following the general procedures in SOP-S-06 (Appendix A). The list of specific analytes and analyses is provided in Table 3-5 and Table 4-3. Samples will be collected from specific lithological layers as described in Section 4.5.2. The general procedures for the field analyses methods for the XRF and PID units are included in Section 4.10.

Samples will be collected using a disposable hand scoop or decontaminated shovel by scraping soil from the sidewall or collecting it from the appropriate excavated piles or from the excavator bucket. An appropriate sample volume will be collected to provide enough material for each required analysis (Table 3-5).No water samples will be collected for laboratory analysis; however, the pH, SC, and redox potential (Eh) of groundwater that enters the pit will be tested, if feasible. All field water sampling results will be recorded in the field logbook.

If the presence of hydrocarbons is detected (via sight and/or smell or detection with a PID), a soil sample will be immediately collected for headspace detection method (Section 4.10.2) and laboratory hydrocarbon analyses (Table 3-5). All visual and olfactory observations of suspected hydrocarbons will be confirmed with a PID prior to collecting a sample. If the presence of hydrocarbons is detected (via sight and/or smell or detection with a PID) and groundwater is present, an additional soil sample may be collected near the top of the saturated layer (in the capillary fringe) for hydrocarbon analyses (Table 3-5), if feasible. Hydrocarbon analyses will not be conducted at locations near previous investigation points if that location was previously sampled for hydrocarbons.

4.7 Groundwater Characterization

Prior to the approval of the BRW Phase III QAPP, Agencies approved a supplemental groundwater and surface water sampling event to occur during low-groundwater conditions as part of the Phase II QAPP. This allowed the sampling event to occur within the allotted timeframe of the Site Investigation schedule. The DQOs detailed in the BRW Phase III QAPP will cover the supplemental sampling event; however, the protocols and procedures for the supplemental groundwater sampling event are contained in this BRW Phase II QAPP.

1. The following actions will be completed as part of the supplemental groundwater and surface water sampling: Use USGS streamflow data from USGS station 12323250, and/or other appropriate location, as an analog for low-groundwater conditions. The SBC flow generally corresponds to seasonal groundwater levels at the Site and will provide an appropriate estimation to target the seasonally lower groundwater conditions. Based on the streamflow data, the FTL and CPM in consultation with the Contractor QAO will determine when sampling takes place.

2. Complete a synoptic water level measurement at all the locations to be sampled the day prior to the day of sampling as deemed appropriate by the FTL and CPM in consultation with the Contractor QAO (Table 5-2 and Figure 4-14). A synoptic event consists of measuring groundwater elevations from piezometers and monitoring wells along with surface water staff gage levels the day prior to the sampling event. Water levels will be recorded as a parameter during the sampling event. The field team will record field parameters, collect groundwater and surface water samples, and analyze for specified analytes.

    - Field personnel will collect a water sample and record field parameters from each piezometer and monitoring well identified in Table 5-2 following the procedures identified in Section 4.3 of this Phase II QAPP and associated SOP. In the "Samples to be Collected" column in Table 5-2, the required samples for each location are identified and correspond to the "Analytical Group" identified in Table 5-1.

    - At each surface water location identified in Table 5-2**Error! Reference source not found.**, field personnel will collect a water sample, record field parameters, and collect flow measurements following the procedures identified in Section 4.4 of this Phase II QAPP and associated Standard Operating Procedures. In the "Samples to be Collected" column in Table 5-2, the required samples for each location are identified and correspond to the "Analytical Group" identified in Table 5-1. To provide data for a future chemical loading analysis detailed in the yet-to-be-approved Phase III QAPP, select piezometers/wells will be sampled on the same day as surface water samples are collected. These locations are shown on Figure 4-14.

    - The field parameters identified in Table 5-1 will be recorded at each location, with the exception of concentrations using the *Modern Water RaPID Assay PCP Field Kit*

(PCP Field Kit). The PCP Field Kit will be used to identify any pre-existing concentrations of pentachlorophenol in select wells. In the “Samples to be Collected” column in Table 5-2, the required samples for each location are identified and correspond to the “Analytical Group” identified in Table 5-1. The samples will be analyzed in the field following the procedures in the user manual.

- The samples will be submitted to the laboratory for the specified analyses identified in Table 5-1. Eurofins TestAmerica (Eurofins) will be responsible for analyzing samples collected during the low groundwater sampling event (Table 5-1).
- The selected groundwater and surface water sampling and/or flow measurement locations may be changed, increased, or decreased as determined by the FTL and CPM in consultation with the Contractor QAO.

Prior to the sampling event, additional staff gages will be installed in the Hydraulic Control Channel as shown on Figure 4-14. The number and location of the staff gages may be modified as determined by the FTL and/or CPM in consultation with the Contractor QAO. The staff gages will be installed in a location that minimizes the potential for clogging from floating debris, are representative of the water level within the Hydraulic Control Channel, and secured to prevent movement during higher flows. Each staff gage must be mounted vertically and plumb to the water surface. After installation, the location and “zero elevation” of each staff gage will be surveyed.

4.7.1 Water Level Measurements

Continuous Groundwater Level Measurements

Transducers will be installed at the piezometer locations listed in Table 5-2 and set to collect a data point every 15 minutes, in a linear mode. Transducers will be installed and monitored in accordance with SOP-GW-15 included in Appendix A. The proposed locations may be modified based on field observations and as approved by the FTL and CPM in consultation with the Contractor QAO.

Data from transducers will be downloaded monthly (unless needed for more frequent analysis during sampling events) and concurrently with synoptic monthly water level measurements. At the time the data from the transducers are downloaded, the transducers will be checked for proper functionality and visually inspected for fouling. If the transducer is becoming fouled, it will be rinsed with tap water. When removing transducers from piezometers, care will be taken to avoid contacting the transducer and any suspension cables with the ground surface. Should contact with the ground surface occur, the transducer and suspension cable will be rinsed with tap water to remove all foreign material.

Manual Groundwater Level Measurements
Manual water levels will be collected monthly (unless needed for more frequent analysis during sampling events) until the conclusion of Phase II groundwater sampling events from the identified locations in Table 5-2 using a dedicated electronic depth to water indicator tape (E-tape), unless the location must be removed or an alternate location is designated. The proposed locations may be modified based on field observations and as approved by the FTL and CPM in consultation with the Contractor QAO.

Manual water levels will be measured from the measuring point as indicated on the inner PVC well or piezometer casing, typically located on the north side of the inner PVC casing. Measuring point locations and elevations of all monitoring wells and piezometers identified in Table 5-2 have been or will be surveyed using a survey-grade GPS unit.

4.7.2 Groundwater Sampling

Groundwater samples will be collected from groundwater monitoring wells and piezometers (shown on Table 5-2 and Figure 4-17) during a representative range of seasonal groundwater and surface water conditions, such as high- and low-groundwater conditions; the FTL and CPM, in consultation with the Contractor QAO, will assess if additional sampling is needed. Groundwater samples will be collected from the groundwater monitoring wells and piezometers and will be submitted and analyzed for varying analytical groups, as appropriate, to support the Phase II DQOs (Table 3-1). Groundwater samples will be collected from the locations listed in Table 5-2 and analyzed for analytes specified in Table 5-1.

The samples will be collected following the general procedures below and SOPs in Appendix A. The selected groundwater sampling locations may be changed, increased, or decreased as determined by the FTL and CPM in consultation with the Contractor QAO. Field personnel will collect a water sample using the appropriate sampling equipment (e.g., peristaltic pump, submersible pump, or bladder pump) in conjunction with a low-flow sampling methodology approved by the FTL and CPM in consultation with the Contractor QAO. All field parameters will be recorded in a bound field logbook.

Prior to groundwater sampling, depth-to-groundwater will be measured at each piezometer/ monitoring well location in accordance with SOP-GW-03 in Appendix A. After water levels have been collected, the piezometers will be purged with the appropriate sampling equipment (e.g., peristaltic pump, submersible pump, or bladder pump; corresponding SOPs are in Appendix A) until the water quality parameters (turbidity, temperature, SC, and pH) and water level have stabilized. Water quality measurements will be collected at 3- to 5-minute intervals to monitor stabilized water quality parameters. Water quality parameters will be collected in accordance with the applicable and relevant SOPs. The piezometer will be considered stable when 3 consecutive readings for turbidity are below 5 NTUs or are within 10% of each other and the water quality parameters are stable. The water quality parameters are considered stable when 3 consecutive readings are as follows:

- Temperature range is no more than plus or minus (+/-) 1 degree Celsius (°C).
- pH varies by no more than 0.1 pH units.

- SC readings are within 3% of the average.

Once the water quality parameters stabilize, samplers will collect the groundwater sample directly from the sampling equipment and place it into appropriate sample containers. The sampling procedures will follow the applicable SOPs in Appendix A, which adhere to or expand upon the CFRSSI SOPs (ARCO, 1992c).

4.8 Standard Operating Procedures

This QAPP includes SOPs that apply to particular field activities (Appendix A), and the SOPs are referenced in the appropriate sections throughout this report. Depending on circumstances and needs, it may not be possible or appropriate to follow the SOPs exactly in all situations due to Site conditions, equipment limitations, and limitations of the standard procedures. When necessary to perform an activity that does not have a specific SOP, or when the SOP cannot be followed, existing SOPs may be used as a general guidance or similar SOPs (not listed in this report) may be adopted if they meet the project DQOs. All modifications or adoptions will be approved by the FTL, CPM, and Contractor QAO and documented in the field logbook and/or the final project report, as appropriate.

4.9 Documents and Records

4.9.1 Sample Labeling and Identification

Soil Samples

A sample number system will be used to uniquely identify the project site, the sample medium, and the specific sample location and depth interval. The sample identification number will be derived from the test pit, borehole, or piezometer number with the Site Name followed by the sample interval enclosed in parentheses. For example, a sample designated BRW19-TP02(1.6-3.1) describes a sample from test pit BRW19-TP02 taken from a depth of 1.6-3.1 feet below existing grade. All measurements will be decimal feet. There will be no blank spaces permitted in the identification. The following is an example of the sample numbering system:

Sample Number: **BRW19-TP02(1.6-3.1)-07192020**

Location/Year:	*"BRW19"* - BRW project area, installed in 2020.
Media:	*"TP"* – Test Pit, *"BH"* – Borehole, *"PZ"* – Piezometer
Number:	*"02"* - Sample Location (corresponds with Test Pit, Borehole, or Piezometer ID No.). All sample locations will be plotted on the sampling maps.
Depth Interval:	*"(1.6-3.1)"* (upper limit-lower limit). If sample is a duplicate, label the interval "T." Do not use specific intervals. Intervals and duplicates will be recorded in the field log or logbook.
Date:	*"07192020"* - sample collected on July 19, 2020.

For field duplicates, the depth interval will be replaced by "(T)." For example, a duplicate of BRW19-TP02(1.6-3.1)-07192020 would be BRW19-TP02(T)-07192020. Field duplicate samples will be recorded in the log or logbook, and the primary sample will be clearly indicated.

All subsample locations and depths will be described in the data log. The field logbook will include the subsample locations plotted on the site sketch. All samples will be labeled in the field with documentation of the date and time of sample collection, the sample number, sample container type, analyses requested, and the sampler's initials. A permanent marker will be used for labeling.

All soil samples will be collected in the proper sample container. The sample ID, date, and depth interval of the sample will be written on the sample container with an indelible marker. Samples will be stored, handled, and packaged as described in Section 4.9.3 and Table 3-5. A copy of the chain of custody record will accompany the samples during shipment and will serve as the laboratory request form. The chain of custody form will specify the type of analysis requested for each individual sample. The original form will be maintained with the field notes and in the project records.

Groundwater Samples

As with soil sampling, a sample number system will be used to uniquely identify the project site, the sample type, and the specific sample location. The following is an example of the sample numbering system:

Sample Number: **BRW19-PZ02T-07192020**

Location/Year:	*"BRW19"* - BRW project area, installed in 2020.
Media:	"*PZ*" – Sampled from a piezometer in BRW.
Location:	"*02*" – Piezometer location.
Duplicates:	"T" – Duplicates or "Twin" samples will be recorded on the field log or logbook.
Date:	*"07192020"* - sample collected on July 19, 2020.

All samples will be labeled in the field with documentation of the date and time of sample collection, the sample number, sample container type, analyses requested, and the sampler's initials. The sample number is specific to this project; however, some naming conventions could be confusing with respect to data validation. To clarify, some location IDs have an "S", "D", and/or "R", which correspond to shallow, deep, and redrill, respectively. A permanent marker will be used for labeling. All groundwater samples will be collected in the appropriate groundwater sample container, with preservative in place from the laboratory (if necessary). Samples will be taken or shipped to the identified laboratory for analyses. Samples will be stored, handled, and packaged as described in Section 4.9.3 and Table 3-5. A copy of the chain of custody record will accompany the samples during shipment and will serve as the laboratory request form. A chain of custody form will be completed that specifies the type of analysis requested for each individual sample. The original form will be maintained with the field notes and in the project records.

4.9.2 Field Documentation

4.9.2.1 Field Logbook

To provide a permanent record of all field activities, field personnel will document all activities in a bound field logbook (refer to field SOPs in Appendix A). This will include a description of site conditions during sampling activities. When field logbooks are used, each logbook will have a unique document control number, be bound, and have consecutively numbered pages. All entries will be in waterproof ink, and any mistakes will be lined out with a single line and initialed by the person making the correction. Whenever a sample is collected or a measurement is made, a detailed description of the sample location and any additional observations will be recorded. The GPS coordinates will be recorded when appropriate. Individual field team members may be responsible for required documentation based on specific tasks assigned by the FTL or CPM.

All significant observations, measurements, relevant data, and results will be clearly documented in the data log or the field logbook. At a minimum, the following will be recorded:

- A description of the field task.
- Time and date fieldwork started.
- Location and description of the work area including sketches if possible, map references, and references to photographs collected.
- Names and titles of field personnel.
- Name, address, and phone number of any field contacts or Site visitors (e.g., Agency representatives, auditors, etc.).
- Meteorological conditions at the beginning of fieldwork and any ensuing changes in the weather conditions.
- Details of the fieldwork performed and the field data sheets used.
- All field measurements made.
- Any field analysis results.
- Personnel and equipment decontamination procedures.
- Deviations from the BRW Phase II QAPP or applicable field SOPs (Appendix A).

For test pits, boreholes, and piezometers the following entries will be made:

- Lithologic log of the test pit/boring indicating material types, from and to depths, rock content, color, presence of water, etc.
- Depth intervals from the ground surface for each soil horizon and total depth of the test pit/test boring.
- Depth to groundwater from the ground surface, identifying the depth at which water is seen initially flowing into the test pit (if applicable).

- Water pH, SC, and redox potential (Eh) when it begins flowing into pit and after the water level in the test pit stabilizes (if applicable).
- After a piezometer is installed (if applicable), record the height of stickup from the ground surface and the distance from the measuring point at the top of the piezometer to the water table.
- Photograph or video of each test pit/boring or trench with a staff gage or tape measure for scale to document existing conditions. Include Site name ID in photograph using a white board or note pad.
- Abnormal occurrences, deviations from the BRW Phase II QAPP, or other relevant observations.

For any field sampling work the following entries will be made:

- Sample location and ID number.
- Sample type collected.
- Date and time of sample collection.
- Sample location descriptions and designations, soil type and texture (e.g., sand, silt, etc.), grain-size, and color (in the field). Further sample information will be included with the laboratory results.
- Split samples taken by other parties (note the type of sample, sample location, time/date, name of individual, individual's company, and any other pertinent information).
- Sampling method, particularly any deviations from the field SOPs (Appendix A).
- Documentation or reference of preparation procedures for reagents or supplies that will become an integral part of the sample (if any used in the field).
- Sample preservation (if used).
- Decontamination procedure (if used)
- Sample custody.

For boreholes and piezometers, the lithologic and completion information will be transcribed into a spreadsheet or database that can be used with Strater® or other appropriate lithologic log software.

4.9.2.2 Field Photographs

Photographs will be taken of sampling locations and field activities using a digital camera. When practical, photographs should include a scale in the picture as well as a white board with relevant information (e.g., time, date, location, sample number, etc.). Additional photographs documenting Site conditions will be taken, as necessary. Documentation of all photographs taken during sampling activities will be recorded in the bound field logbook or appropriate field data sheets (refer to field SOPs in Appendix A), and will specifically include the following for each photograph taken:

- Time, date, and location.
- Photograph or video number from the camera or video recorder.
- The identity of the person taking the photograph/video.
- Direction that the photograph was taken and description of the subject photographed.

The digital files will be placed with the electronic project files with copies of supporting documentation from the bound field logbooks.

4.9.3 Sample Handling, Documentation, and Shipping

As applicable, samples will be either hand delivered or shipped via Federal Express to the appropriate laboratory under strict EPA chain of custody procedures. Samples will be shipped in appropriate containers that will prevent detrimental effects to the sample.

Sample containers and holding times are listed in Table 3-5. All procedures will strictly follow appropriate protocols and field SOPs in Appendix A. Chain of custody records will be kept with the samples and custody seals will be placed on the sample storage containers (coolers).

All samples not submitted to the laboratory will be archived. When it is determined that the samples are no longer needed, they will be disposed at the Mine Waste Repository.

4.9.4 Chain of Custody

The SOP for chain of custody (SOP-SA-04) is in Appendix A. Maintaining the integrity of the sample from collection through data reporting is critical to the sampling and analytical program. This process includes the ability to trace the possession and handling of samples from the time of collection through analysis and final disposition. This documentation of the sample's history is referred to as chain of custody. A sample is considered to be under an individual's custody if it is in that individual's physical possession, in view of the individual after taking possession, or secured by that individual so that no one can tamper with the sample.

The components of the field chain of custody (chain of custody form, labels, and custody seals) and laboratory chain of custody (chain of custody form, custody seals, and laboratory custody) are described in this section.

4.9.4.1 Chain of Custody Form

A chain of custody form will be completed and will accompany every sample. A standard form will be provided from each laboratory. The form will include the following information:

- Project code.
- Project name.
- Sampler’s signature.
- Sample identification.
- Date sampled.

- Time sampled.
- Analysis requested.
- Remarks.
- Relinquishing signature, data, and time.
- Receiving signature, date, and time.

4.9.4.2 Custody Seals

Custody seals are used to detect unauthorized tampering with samples following sample collection up to the time of analysis. Custody seals will be applied to the shipping containers when the samples are not in the sampler's custody.

4.9.4.3 Laboratory Custody

Laboratory custody procedures will conform to procedures established for the EPA CLP (EPA, 2016). These procedures include the following:

- Designation of sample custodian.
- Correct completion of the chain of custody form, recording of sample identification numbers, and documentation of sample condition upon receipt.
- Laboratory sample tracking and documentation procedures.
- Secure sample storage.

The samples will be delivered to the laboratory for analysis in a timely manner to ensure the requested analyses can be performed within the specified allowable holding times. The sample will be hand delivered or addressed to a person in the laboratory who is authorized to receive samples (laboratory sample custodian).

4.10 Field Analysis Methods

This section describes field analysis methods, including XRF analysis and field soil nitrate testing.

4.10.1 XRF Analysis

Field XRF Analysis
Field XRF analysis will be used mainly as a guide to estimate the first lithological layer in each test pit/boring which passes the Waste Identification Screening Criteria (EPA, 2020) and to identify materials from borings that are to be submitted to the laboratory for SPLP (Section 4.2.5.4), and as deemed necessary based on field observations.

The XRF analysis will be conducted using a Niton™ XL3 XRF Analyzer (XL3) and following the procedures outlined in SOP-SFM-02 (Appendix A) as well as the XL3 user manual to ensure that the techniques employed are appropriate for the analytes of interest. Samples will be collected in a Ziplock ® bag and mixed. Samples will be dried if conditions require and are deemed necessary by field personnel. If a portable heater or oven is used to dry samples, the sample will be dried while maintaining a temperature that does not exceed the boiling point of water (100 °C).

Official XRF Analysis

Limited XRF analysis will be conducted in the event a lithological layer is too thin and there is not enough soil to fulfill the required sample volume required for laboratory metals analysis. In this instance, a sample will be collected and prepped for XRF analysis at Pioneer's field office at 244 Anaconda Road in Butte, Montana, after sampling activities have finished.

The XRF analysis will be conducted using a Niton™ XL3 XRF Analyzer (XL3) and following the procedures outlined in SOP-SFM-02 (Appendix A) as well as the XL3 user manual to ensure that the techniques employed are appropriate for the analytes of interest. Prior to completing analysis with the XRF, any large aggregate will be removed from the sample. For gravel or rocky soils, a sieve may be used to remove the large aggregates. Samples will be dried prior to analysis. Samples will be collected in a Ziplock® bag and mixed. The samples will then be placed in a small plastic cup with a mylar film cover for analysis.

4.10.2 PID Screening Analysis

The hydrocarbon screening will be conducted using two PIDs, one with a 9.8 eV lamp and another with a 10.6 eV lamp. The procedures for using the PID unit are summarized below and additional detail is included applicable user's manuals It is anticipated that a MiniRae 3000 unit and a UltraRAE 3000+ unit will be used, or equivalent.

Initially, the PIDs will be used to detect hydrocarbons from soils with visual evidence of soil staining or if an odor is detected. A slow sweeping motion will be used to detect hydrocarbons with the PID for soils from test pits and borehole cores. For soils from test pits, the PIDs will be used to screen the soils within the test pit immediately after excavation (if it is safe to enter the pit) or the PIDs will be used to screen the soils immediately after they are excavated. For boreholes, the PIDs will be used to screen the cores immediately after they are split.

Once it has been determined that volatile organic compound (VOCs) might be present, a combustible gas meter will be used to monitor the atmosphere for hazardous conditions. The combustible gas meter will be mounted on or near the drill rig or excavator to monitor conditions near the test pit or drill hole. If hazardous conditions are present, appropriate action will be taken by safety personnel.

If hazardous conditions are not present, a portion of the sample will immediately be collected in the appropriate sample container (Table 3-5) and the remainder placed in a Ziplock® bag with air space at the top above the sample (headspace) to allow testing using the headspace screening method. For the headspace screening method, the sample is brought to room temperature, the sample is mixed or shaken depending on soil type to allow the contaminants to volatilize, and then the PID probe is inserted into the bag and the headspace concentration is measured and recorded.

4.10.3 Total Petroleum Hydrocarbon Field Test Kit

Since hydrocarbons are present at the Site, the field team will be taking precautions and screening the drilling water during the slag investigation (Section 4.5) for hydrocarbons prior to disposal. The hydrocarbon screening will be conducted using a Hanby TPH Water Field Test Kit (or similar test kit as determined by field personnel). The general procedures for using the field test kit are summarized below and additional detail is included in the user manual accompanying the test kit:

- Collect a 500-milliliter sample of containerized water.
- Pour sample into separatory funnel.
- Add solvent to the sample.
- Shake sample and solvent for 2 minutes to form an extract.
- Place funnel in stand and wait 1 minute for extract to settle.
- Drain extract into test tube and add catalyst to test tube.
- Shake test tube for 1 minute.
- Compare resultant color to color identification chart to determine presence of TPHs.

If it appears that turbidity is going to interfere with the hydrocarbon screening, the sample may be filtered prior to completing the field test. If another field test kit is used, the user manual for that unit will be followed.

During fieldwork, changing from laboratory analysis to field test kits (described in Section 4.2.6.2) may be necessary to limit discharging hydrocarbon-impacted water to the BTL.

4.10.4 CHEMetrics Field Kit

Samples will be collected in the field sample cups provided in the CHEMetrics field kits. Using the glass vacuum ampules, pre-filled with the appropriate colorimetric reagents, field personnel will snap open the ampule at the base of the sample cup and pull in a water sample. After the prescribed color development time, field personnel will place the ampule in a colorimeter that has been previously calibrated at the correct analytical wavelength, as provided in the manual. A CHEMetrics V-2000 multi-analyte photometer (or equivalent) will be used along with CHEMetrics V-2000 ampules and field sample cups (or equivalent). Detailed procedures can be downloaded from CHEMetrics website (www.chemetrics.com). Dilution of some samples may be necessary prior to analysis. Each CHEMetrics kit includes a zero solution that will be used to zero the CHEMetrics V-2000 multi-analyte photometer (or equivalent) before the analysis of each sample. Sample cups will be rinsed and decontaminated following SOP-DE-02 (Appendix A) between each sample.

4.11 Laboratory Analysis Methods

The anticipated laboratory analytical methods to be used are detailed below. Laboratory analysis of samples collected during the course of this study will be performed by laboratories with established protocols and QA procedures that meet or exceed EPA guidelines. The EPA-approved methods will be used for all applicable equipment (refer to Table 3-5). Standard laboratory turnaround times will be requested.

4.11.1 Total Metals

Samples collected from test pits and boreholes will be sent for laboratory metals analysis analyzed by ICP-OES. Table 3-5 includes the analyte list and a description of the analytical technique. The ICP-OES laboratory sample results will be used to better determine the total mass of COCs and other constituents currently present within waste materials and the alluvial aquifer system at the Site.

4.11.2 SPLP Method

A select group of soil samples will be selected by field personnel to be analyzed for SPLP for the groundwater analytes detailed in Table 3-5. Sufficient material will be provided to the selected laboratory for the additional SPLP analysis and those samples selected for blind duplicate analysis. Note that SPLP samples will be analyzed "as received" by the laboratory as per the SPLP extraction method, and that the equilibrium pH of the SPLP extraction fluid will be recorded. All splitting of samples for duplicate and SPLP analysis will be completed prior to submittal. Extraction fluid #2 will be used for all SPLP, and 2 liquid-to-solid ratios will be analyzed (20:1 and 4:1, Table 3-5).

4.11.3 Hydrocarbons

Soils that appear to contain hydrocarbons (via sight and/or smell or detection with a PID) will be analyzed for VPH, EPH fractionation with PAH, and lead scavengers (Table 3-5). All visual and olfactory observations of suspected hydrocarbons will be confirmed with a PID prior to collecting a sample.

4.11.4 LNAPL Samples

If the interface probe indicates there is an LNAPL layer on the surface of the groundwater, a sample will be collected. If an LNAPL layer is present, a pure LNAPL sample will be collected, if possible. If a pure sample is not possible, a mixed sample of LNAPL and groundwater will be collected. The analytical procedures and proper preservation methods are detailed in Table 3-5.

4.11.5 Groundwater Analysis

Groundwater samples will be analyzed for analytes specified in Table 4-3 and Table 3-5. The analytical procedures for these analytes are identified in Table 3-5. Low-flow sampling parameters will be used to estimate the hydraulic conductivity of the screened aquifer interval (Robbins et al., 2009).

4.12 Lab Test Methods

As part of the slag investigation (Section 4.5), select slag core samples will be sent to the Department of Civil, Environmental, and Geo-Engineering materials testing laboratory of the University of Minnesota in Minneapolis for tensile strength, compressive strength, and fracture toughness tests. The results will be shared with grout manufactures to help determine the optimal hole spacing and pattern design to best fracture the slag. Tensile strength will be used to estimate the capacity of the slag to withstand expanding loads and assess if the expandable grout has the ability to fracture the slag (Appendix C).

4.12.1 Tensile Strength Test

The laboratory test used to determine the tensile strength of the slag cores is the Standard Test Method for Splitting Tensile Strength of Intact Rock Core Specimens, ASTM D3967-16 (ASTM, 2016). The method requires a length-to-diameter ratio ranging from 0.5:1 to 0.75:1 and that the diameter be at least 10 times greater than the largest mineral grain constituent. At least 10 samples will be tested to obtain a meaningful average.

The test determines the splitting tensile strength (an indirect measurement of tensile strength) by diametral line compression of a disk of rock (i.e., sample). The ASTM Standard D3967-16 (ASTM, 2016) specifies that compressive load is continuously increased at a constant rate until failure of the sample occurs. Indirect tensile strength is typically calculated based on the assumption that failure occurs at the point of maximum tensile stress (i.e., at the center of the disk). The formula for calculating the splitting tensile strength is:

$$\sigma_t = \frac{2P}{\pi D t}$$

Where:

σ_t – splitting tensile strength, Megapascal (MPa)
P – maximum applied load indicated by the testing machine, Newton (N)
D – diameter of sample, millimeter (mm)
t – thickness of sample, mm

4.12.2 Compressive Strength Test

The laboratory test used to determine compressive strength of slag is Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures, ASTM D7012-14e1, Method C (ASTM, 2014). The method requires a length-to-diameter ratio ranging from 2.0:1 to 2.5:1. The diameter of rock test specimens must be at least 10 times the diameter of the largest mineral grain and the minimum diameter accepted by the method is $1^7/_8$ inches.

The test is used to establish the compressive force or crush resistance of a material and behavior under load. A rock core specimen is cut to length and the ends are machined flat. The specimen is placed in a loading frame where the axial load on the specimen is then increased and measured continuously until failure. Compressive strength is calculated from the failure load divided by the cross-sectional area resisting the load:

$$\sigma_u = \frac{P}{\pi r^2}$$

Where:

σ_t – uniaxial compressive strength, MPa
P – failure load, kilonewton (kN)
r – radius of sample, mm

4.12.3 Fracture Toughness Test

The laboratory test used to determine the fracture toughness of the slag is the Suggested Method for Determining the Fracture Toughness of Rock Using Chevron Bend Specimens, ISRM, Vol. 25, No. 2, pp. 71-96, Method 1 (ISRM, 1988). The method requires a length-to-diameter ratio ranging from 3.5:1 to 4:1. The diameter of rock test specimens must be at least 10 times the diameter of the largest mineral grain. At present there are not sufficient data from chevron bend testing of rocks to establish a validity criterion for minimum specimen size for Method 1, not even in qualitative terms (ISRM, 1988).

This test is intended to measure the fracture toughness of rock material. The main use of this property is for the classification and characterization of intact rock with respect to its resistance to crack propagation. Other important uses are either as an index of fragmentation processes such as crushing and tunnel boring, or in the analysis of hydraulic or explosive fracturing and stability. A diamond wheel saw is used to cut either a chevron or a V-shaped notch perpendicular to the core axis. Two cuts are made perpendicular to the core axis. The chevron or V-notch is positioned equal distance from the ends of the core with a depth-of-cut-to-diameter ration of 0.25:1 or 1 inch for a 4-inch diameter core. The width of the notch is a width-to-diameter ratio and must be less than or equal to 0.03:1 or 0.12 inches for a 4-inch diameter core. The core is then rotated 90 degrees and the same notch is cut into the core. The rock core specimen is attached to a saddle, placed on 2 support rollers centered to a ram head. The ram head applies pressure to the specimen until failure occurs.

The test is used to measure the resistance of a material to the presence of a flaw in terms of the load required to cause brittle or ductile crack extension or to reach a maximum load condition in a specimen containing a pre-crack. Fracture toughness is calculated from the failure load divided by the diameter resisting the load:

$$K_{CB} = \frac{A_{min}\, F_{max}}{D^{1.5}}$$

Where:

K_{CB} – fracture toughness, MPa
F_{max} – failure load, kN
D – diameter, centimeter
A_{min} – Is a dimensionless unit (Equation 4; ISRM, 1988)

4.13 Quality Assurance/Quality Control Samples

4.13.1 Field Quality Control Samples

Field QC samples are used to identify any biases from transportation, storage, and field handling processes during sample collection, and to determine sampling precision. All field QC samples will be shipped with field samples to the laboratory per SOP-SA-01 (Appendix A). Brief descriptions of the field QC samples are below along with when and how many are to be collected.

Within the BPSOU area, it is a requirement that all soil and groundwater generated must be collected and contained within a containment area prior to disposal. Additional samples will be collected to determine proper disposal. Samples collected solely for determining the proper treatment and/or disposal requirements (i.e., not for design purposes) will not require enforcement quality data, therefore; field QC samples will not be collected. These samples were validated in accordance with Stage 2A criteria.

Field Duplicate
Field duplicates will be collected for the soil and groundwater sampling. A field duplicate is an identical/twin ("T") sample collected from the same location, in immediate succession of the primary sample, using identical techniques. This applies to all groundwater and soil sampling procedures including instream grab samples, pumps, and other water sampling devices. The duplicate sample will have its own sample number. Duplicate samples will be sealed, handled, stored, shipped, and analyzed in the same manner as the primary sample. Both the primary sample and duplicate sample will be analyzed for identical chemical parameters by the laboratory. The analytical results of the primary and duplicate sample will be compared to determine sampling precision. Field duplicate samples will be collected at a frequency of at least 1 per 20 samples (5%) (for all soil and groundwater samples) or once per sampling event, whichever is more frequent.

Equipment, Cross Contamination, or Rinsate Blank
Equipment contamination blanks will be collected for the groundwater sampling effort. No equipment contamination blanks will be collected for the test pit and core collection sampling effort. All soil sampling equipment is anticipated to be *one time use*; the drilling augers, casing, drill rods, and samplers will be properly decontaminated between boreholes; and the excavator bucket will have gross contamination removed with a shovel between test pits. Therefore, no equipment, cross contamination, or rinsate blank samples will be submitted for soil sampling unless the equipment must be decontaminated and used between samples.

If equipment, cross contamination, or rinsate blank samples are necessary, they will be collected after sampling equipment is decontaminated or prior to sampling activities. An equipment blank is prepared by running distilled, DI, or analyte-free water through or over the cleaned, decontaminated sampling equipment; gathering the water in a sample collection bottle; and adding the appropriate chemical preservatives. Analysis on the equipment blanks will assess the adequacy of the decontamination process as well as the potential contamination of samples by the containers, preservatives, and filters. The appropriate sample number will be placed on the collection bottle and recorded in the project logbook as an equipment blank. The equipment blank will be analyzed for identical chemical parameters by the laboratory as a natural sample collected from the equipment. A minimum of 1 equipment blank is required for every 20 natural samples collected.

Field Blank

Field blanks will be collected for the groundwater sampling effort. A field blank is a sample bottle containing DI or analyte-free water and appropriate preservatives and is prepared in the field. A sample bottle is randomly chosen from bottles received by the contract laboratory or supplier, and DI or analyte-free water is poured directly into the sample bottle while in the field and the bottle is preserved and shipped to the laboratory with the field samples. Field blanks must be prepared in the field and help evaluate the potential for possible contamination from the sampling environment. The field blank will have its own unique sample number and will be recorded in the project logbook as a field blank or bottle blank. Field blanks will be prepared at a frequency of at least 1 field blank per 20 natural samples collected.

Temperature Blank

A temperature blank is a vial of water that accompanies the samples that will be opened and tested upon arrival at the laboratory to ensure that the temperature of the shipping container was within the required 4 °C plus or minus 2 °C. One temperature blank is required for each cooler shipped to the laboratory.

Trip Blank

One trip blank is required per sampling event when VOC samples are collected. Trip blanks are used to determine if samples were contaminated during storage and/or transportation back to the laboratory. A trip blank is only required for VOC sampling. A trip blank is prepared for field personnel by the contract laboratory staff prior to the sampling event and is shipped and stored in the same cooler with the investigative VOC samples throughout the sampling event. At no time after their preparation are trip blanks to be opened before they reach the laboratory. Trip blanks should be kept on ice in the cooler, along with the VOC samples during the entire sampling run. They must be stored in an iced cooler from the time of collection, while they are in the sampling vehicle, until they arrive at the laboratory.

4.13.2 XRF Quality Control Samples

The XRF QC samples will be collected and used to assess the accuracy and precision of the XRF data. The XRF QC samples required are described below.

Energy Calibration Check

Field personnel will run a preprogrammed energy calibration check on the equipment at the beginning of each working day. If the individual believes that drift is occurring during analysis, that individual will run the energy calibration check. The energy calibration check determines whether the characteristic X-ray lines are shifting, which would indicate drift within the instrument.

Silicon Dioxide Standard

The silicon dioxide (SiO_2) sample, as provided by Niton, is a "clean" quartz or silicon dioxide matrix that contains concentrations of selected analytes near or below the machine's lower limit of detection. These samples are used to monitor for cross contamination. Field personnel will analyze this sample at the beginning of each day, once per every 20 samples, and at the end of each day's analysis. The sample information will be recorded as "SIO2" on XRF field data sheets. This sample will also be analyzed whenever field personnel suspect contamination of the XRF aperture. Any elements with concentrations above the established lower limit of detection will be evaluated for potential contamination. If it is determined that the concentration is higher than that recorded at the start of the day, the probe window and the silicon dioxide sample will be checked for contamination. If it is determined that contamination is not a problem, and the concentration is significantly above the limit of detection, the sample result will be qualified by the XRF operator as 'J' estimated, and the problem recorded on the XRF field data sheet and in the logbook. If the problem persists, the XRF will be returned to Niton for calibration.

Calibration Verification Check Samples (Standards)

Calibration verification check samples help check the accuracy of the XL3 and assess the stability and consistency of the analysis for the analytes of interest. One to 3 (preferably) of the check samples will be analyzed at the start of each day, once per every 20 samples, and as the last analysis. Results for the check sample (standard reference material [SRM]) will be recorded on the individual site XRF field data sheets and identified as a check sample. There are 3 Niton-provided SRM check samples: NIST 2709a- Joaquin Soil (2709), USGS SdAR-M2 (SRM created by the USGS), and a Resource Conservation and Recovery Act (RCRA) sample. There are also Niton-provided, machine-specific expected results for several elements for the check samples. Pioneer has refined the range of expected results for each SRM standard for each of the field XRF units in use. The measured values of a standard will be compared to the expected results. If a measured value falls outside this range, then the check sample will be reanalyzed. If the value continues to fall outside the acceptance range, this information will be noted on the XRF log. If any of the check sample results indicate that the XRF is not analyzing accurately, the XRF will be cleaned, turned off, and the energy calibration rerun. This information will be noted in the logbook and on the XRF field data sheet. The batch of samples analyzed prior to the unacceptable calibration verification check samples will be reanalyzed. If 1 standard continues to be outside of the expected range, it may indicate that the standard has been contaminated and needs replacing. If more than 1 standard is falling outside of the expected range, Niton will be contacted and the machine may be returned for calibration.

Duplicate Samples

The XRF duplicate samples will be analyzed to assess reproducibility of field procedures and soil heterogeneity. To run a duplicate sample on the Niton XL3, field personnel will remove the sample cup/Ziplock® from the analytical stand, knead the Ziplock® bag once or twice/rotate the sample cup, and replace it in the stand to be analyzed a second time. Duplicate samples will be recorded on the XRF field data form with a D designator in the sample identification number. One duplicate sample will be analyzed per site or at the rate of at least 1 per 20 samples.

Replicate Samples
Field personnel will analyze a replicate sample at the rate of at least 1 per 20 XRF samples. To run a replicate sample on the Niton XL3, once the primary sample analysis has been completed, the XRF is restarted to analyze the same sample a second time with the same soil in the XRF aperture. Replicate samples help in assessing the stability and consistency of the XRF analysis. Replicate sample results will be recorded on the XRF field data form and designated with an R in the sample identification number.

4.13.3 Laboratory Quality Control Samples

Laboratory QC samples are introduced into the measurement process to evaluate laboratory performance and sample measurement bias. Laboratory QC samples can be prepared from environmental samples or generated from standard materials in the laboratory per the internal laboratory SOPs. Standard laboratory QC sample information is listed below.

Method Blank
The method blank (MB) samples will be prepared and analyzed for every 20 samples analyzed. The MB is laboratory DI water that has gone through the applicable sample preparation and analysis procedure. Control limits vary based on the laboratory method performed (Table 3-5) and are contained in the applicable laboratory method and SOP. Failure will trigger corrective action and the blanks will be reanalyzed. All samples affected will be footnoted with the appropriate flag to document contamination in the blank.

Laboratory Control Sample
The LCSs will be prepared and analyzed for every 20 samples analyzed. Control limits vary based on the laboratory method performed (Table 3-5) and are contained in the applicable laboratory method and SOP. Failure will trigger corrective action and the analysis will be terminated, the problem corrected, and the samples associated with that LCS reanalyzed. If reanalysis of the samples fails, the samples affected by the failing LCS elements need to be re-digested and reanalyzed.

Matrix Spike/Matrix Spike Duplicate
The matrix spike (MS) and matrix spike duplicate (MSD) samples will be prepared and analyzed at different frequencies based on the laboratory method performed. The control limits also depend on the method used (Table 3-5) and are contained in the applicable laboratory method and SOP. If the percent recovery for the MS and MSD falls outside the control limits, the results are flagged as outside acceptance criteria along with the parent sample. If the RPD exceeds the acceptance criteria, the MSD sample and associated parent sample will be flagged.

Post Digestion Spike
Post digestion spikes (PDS) will be prepared and analyzed at different frequencies based on the laboratory method performed. The control limits also depend on the method used (Table 3-5) and are contained in the applicable laboratory method and SOP.

Laboratory Duplicate Sample
The laboratory duplicate samples (LDSs) will be prepared and analyzed for every 20 samples analyzed. An LCS and laboratory control sample duplicate (LCSD) pair or an MS and MSD sample pair may be used as the LDS. Control limits will vary based on the QC sample used. Failure will trigger corrective action and a single reanalysis of the respective failing QC sample is allowed. If the reanalysis is outside the acceptance criteria, the analysis must be terminated, the problem corrected, the instrument recalibrated, and the calibration re-verified.

4.14 Instrument/Equipment Testing, Inspection, Maintenance and Calibration

To ensure continual quality performance of all instruments and equipment, testing, inspection, and maintenance will be performed and recorded as described in this section. All field and laboratory equipment will be operated, maintained, calibrated, and standardized in accordance with all EPA and manufacturer's recommended procedures.

4.14.1 Field Equipment

Field equipment will be examined to verify that it is in proper operating order prior to its first use. Equipment, instruments, tools, gauges, and other items requiring preventative maintenance will be serviced and/or calibrated in accordance with the manufacturer’s specified recommendations, as necessary. Field equipment will be cleaned (decontaminated) and safely stored between each use. Any routine maintenance recommended by the equipment manufacturer will also be performed and documented in field logbooks. Calibration of field equipment will be completed in the field at the beginning of each day and recorded in the field logbooks. Any equipment deficiencies or malfunctions during fieldwork will be recorded as appropriate in the field logbooks. The SOPs for the field equipment are in Appendix A.

Groundwater Meter - Multi-Parameter Probe
The multi-parameter probe will be used to record parameters during purging to ensure field measurements have stabilized as defined in previous sections and in the field equipment SOPs (Appendix A). To accommodate field meters, discharge from the sampling pump will be directed through a flow-through cell for the multi-parameter probe so that parameters can be measured until stabilized. Once parameters have stabilized, the flow-through cell will be disconnected and samples for field and laboratory analysis will be collected directly from the tubing. This will ensure that the tubing has acclimated to the water chemistry and the water being sampled is represented by the stabilized field parameters.

XRF Unit
The XRF analysis will be conducted using a Niton™ XL3 XRF Analyzer (XL3) and following the procedures outlined in SOP-SFM-02 (Appendix A) as well as the XL3 user manual to ensure that the techniques employed are appropriate for the analytes of interest. Additional details on the operation of the XRF are included in Section 4.10.1.

PID Unit
The hydrocarbon screening will be conducted using two PIDs, one with a 9.8 eV lamp and another with a 10.6 eV lamp. The procedures for using the PID unit are included in Section

4.10.2 as well as in the applicable user's manual. It is anticipated that a MiniRae 3000 unit and a UltraRAE 3000+ unit will be used, or equivalent.

Transducers
Transducers will be installed and programmed in accordance with SOP-GW-15 (Appendix A). Transducers will be maintained per manufacture specifications. Table 4-3 provides the specific details including the locations where transducers will be installed and type of transducers to be used.

The following data screening steps will be taken to ensure the water level measuring device data accurately represents field conditions.

> **Compensation:** Raw water level data will be barometrically compensated and manually adjusted in a Microsoft Excel spreadsheet to match acceptable manual water level measurements recorded in the field notes. The compensated data will then be downloaded into the project database and plotted and analyzed for abnormalities (e.g., spikes, drops, inconsistencies, fluctuations, etc.).

> **Comparison:**

a. To justify atypical water level fluctuations, water level data will be compared to precipitation events at Bert Mooney Airport in Butte, Montana.
b. Trends in water levels will also be compared between nearby wells.
c. Any discrepancies will be flagged in the data.

4.14.2 Lab Equipment

Instruments used by the laboratory will be maintained in accordance with the laboratory QA plan requirements and analytical method requirements. All analytical measurement instruments and equipment used by the laboratory will be controlled by a formal calibration and preventive maintenance program. The laboratory will keep maintenance records and make them available for review, if requested. Laboratory preventive maintenance will include routine equipment inspection and calibration at the beginning of each day or each analytical batch, per the laboratory internal SOPs and method requirements.

4.15 Inspection/Acceptance of Supplies and Consumables

All supplies and consumables received for the project (e.g., sampling equipment, calibration standards, etc.) will be checked to ensure their condition is satisfactory, such as free of defects that would affect performance. The types of equipment needed to complete sampling activities are described in the relevant field SOPs (Appendix A). Inspections of field supplies will be performed by the FTL or field team members. The personnel at each laboratory will be responsible for inspecting laboratory supplies in accordance with the laboratory QA program.

4.16 Data Management Procedures

This section describes how the data for the project will be managed, including field and laboratory data. Data will generally be managed in accordance with the BPSOU Final Draft Data Management Plan (Atlantic Richfield Company, 2017).

The BRW Phase II QAPP quality records will be maintained by Atlantic Richfield Company. These records, in either electronic or hard copy form, may include the following:

- Project work plans with any approved modifications, updates, and addenda.
- Project QAPP with any approved modifications, updates, addenda, and any approved corrective or preventative actions.
- Field documentation (including logbooks, data sheets, and photographs) in accordance with SOP-SA-05 (Appendix A).
- Chain of custody records in accordance with SOP-SA-04 (Appendix A).
- Field forms, which are provided in Appendix B.
- Laboratory documentation (results received from the laboratory will be documented in hard copy and in an electronic format).
- PDI Evaluation Report.

Hard copy field and laboratory records will be maintained in the project's central data file, where original field and laboratory documents are filed chronologically for future reference. These records will also be scanned to produce electronic copies. The electronic versions of these records will be maintained on a central Microsoft SQL server system that is backed up regularly. The data will be stored on the SQL server and a Microsoft Access database will be set up to access the data, which can then be exported to Excel, if necessary, for further graphing and interpretive analysis. Using a Microsoft-based software configuration is widely accepted with support from Microsoft and allows for easy data sharing with most hardware configurations.

All field and laboratory data and supporting documentation will be subject to appropriate review to ensure the accuracy and completeness of original data records prior to uploading into the project database. Field data that have been reviewed and approved in a hard copy format will be entered into an electronic system to be uploaded to the project database. Laboratory electronic data deliverables (EDDs) provided in Microsoft Excel format and correlating PDF Stage 4 data packages (simplified format) will be reviewed as part of the internal data review process. Following these review steps, field and laboratory electronic data files will be imported to the project database.

Standardized data import formats and procedures will be used to upload both field and laboratory data into the electronic database. Standardized parameter names, numerical formats, and units of measure will be applied to the original information to facilitate comparability across all data sets and within the database. Using these standardized formats will allow for quick and easy querying to retrieve data. Data can be retrieved by exporting into an Excel file and, because the data will be formatted with parameter names, easily made into a pivot table for data processing.

All data will be maintained by Pioneer until finalized, and then the data will be transferred and maintained in the BPSOU databases described in the BPSOU Final Draft Data Management Plan (Atlantic Richfield Company, 2017) for long-term storage and data retrieval.

5.0 ASSESSMENT AND OVERSIGHT

Assessment and oversight of data collection and reporting activities are designed to verify that sampling and analyses are performed in accordance with the procedures established in this BRW Phase II QAPP. The audits of field and laboratory activities include two independent parts: internal and external audits. Internal audits will be performed by Atlantic Richfield Company, their contractor, or a contracted laboratory consultant as necessary. External audits will be performed by the EPA as necessary. Performance and systems audits of field and laboratory data collection and reporting procedures are described in this section.

5.1 Field Activities Oversight

Oversight personnel will have the ability to inspect each test pit, soil boring, and piezometer completion interval and determine the appropriateness of the recorded data and ensure that the appropriate samples are collected. Copies of field logbook pages will be provided to oversight personnel as part of the PDI Evaluation Report.

Any deviations from this BRW Phase II QAPP will be brought to the attention of oversight personnel. If the deviation is first determined by oversight personnel, Atlantic Richfield Company and/or field representatives will be immediately notified. Reasons for such deviations will be recorded in the field logbook along with corrective actions to be implemented, if required. If oversight personnel request a deviation from the BRW Phase II QAPP, the deviation and the reasons for the deviation will be noted and then signed by the agency personnel.

5.2 Corrective Action Procedures

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out-of-QC performance, which can affect data quality. Corrective action can occur during field activities, laboratory analyses, and data assessment.

Non-conforming equipment, items, activities, conditions, and unusual incidents that could affect data quality and attainment of the project’s quality objectives will be identified, controlled, and reported in a timely manner. For the BRW Phase II QAPP, a non-conformance is defined as a malfunction, failure, deficiency, or deviation that renders the quality of an item unacceptable or indeterminate in meeting the project’s quality objectives. Corrective actions implemented by field personnel will follow appropriate field SOPs (Appendix A), as necessary.

Corrective action in the laboratory may occur prior to, during, and after initial analyses. A number of conditions such as broken sample containers, preservation or holding-time issues, and potentially high-concentration samples may be identified during sample log in or just prior to analyses. Corrective actions to address these conditions will be taken in consultation with the

CPM and reported on a Corrective Action Report (CAR) form included in Appendix D. In the event that corrective action requests are not in complete accordance with approved project planning documents, the EPA will be consulted and concurrence will be obtained before the change is implemented.

If during sample analyses, the associated laboratory QC results fall outside of the project's performance criteria, the laboratory should initiate corrective actions immediately. If laboratory QC results are outside of the project specifications, the laboratory should take the appropriate corrective actions for the specific analytical method. Following consultation with laboratory analysts and section leaders, it may be necessary for the CPM to approve implementing a corrective action. These conditions may include dilution of samples, additional sample extract cleanup, or automatic reanalysis when certain QC criteria are not met. If the laboratory cannot correct the situation that caused the non-conformance and an out-of-control situation continues to occur or is expected to occur, then the laboratory will immediately contact the CPM and request instructions regarding how to proceed with sample analyses.

Completion of any corrective action should be evidenced by data once again falling within the project's performance criteria. If this is not the case, and an error in laboratory procedures or sample collection and handling procedures cannot be found, the results will be reviewed by the CPM and FTL in consultation with the Contractor QAO to assess whether reanalysis or re-sampling is required.

All corrective actions taken by the laboratory will be documented in writing by the Laboratory Project Manager and reported to the FTL and CPM. In the event that corrective action requests are not in complete accordance with approved project planning documents, the EPA will be consulted and concurrence will be obtained before the change is implemented. All corrective action records will be included with the QAPP records.

5.3 Corrective Action During Data Assessment

During data assessment, the Contractor QAO could identify the need for corrective action. Potential types of corrective action include re-sampling by the field team, reanalyzing samples by the laboratory, or re-submitting Stage 4 data packages with corrected clerical errors. The appropriate and feasible corrective actions will depend on the ability to mobilize the field team and whether the data to be collected are necessary to meet the required QA objectives (e.g., the holding time for samples is not exceeded, etc.). If corrective action requests are not in complete accordance with approved project planning documents, the EPA will be consulted and concurrence will be obtained before the change is implemented. Corrective actions of this type will be documented by the Contractor QAO on a CAR and will be included in any subsequent reports.

5.4 Quality Assurance Reports to Management

After the investigation is complete, the Atlantic Richfield Company contractor will incorporate the results into the BRW PDI Evaluation Report summarizing and interpreting the sampling activities. The report will include the following:

- Summary of the investigations performed.
- Summary of investigation results.
- Summary of validated data (i.e., tables and graphics).
- Data validation reports and laboratory data reports.
- Narrative interpretation of data and results.
- Results of statistical and modeling analyses.
- Photographs documenting the work conducted.
- Conclusions and recommendations for RD, including design parameters and criteria.
- Recommendations for an additional phase(s) (if necessary).

The CPM and Contractor QAO are responsible for preparing the PDI Evaluation Report. The report will be submitted in draft final form to the EPA and Montana DEQ for review 90 days after the filed investigation or approximately 30 days prior to the Intermediate 60% RD Report for the Site RD. Upon receipt of comments, the draft final report will be revised to address the comments and re-submitted to the EPA and Montana DEQ for final approval.

6.0 HEALTH AND SAFETY

All work completed by Pioneer and its subcontractor during execution of the Phase II Site Investigation will be performed in accordance with all procedures outlined in the BRW Site-SSHASP. The BRW SSHASP will be updated to include the additional field investigation activities for the Phase II Site Investigation. Potential unique hazards associated with the pumping test include the drilling, installation, development, and sampling of the pumping test well, and working at night during the pumping test. Potential unique hazards associated with the slag investigation include excavating test pits (or larger areas) in potentially unstable soil conditions (i.e., slag and demolition debris) and handling, mixing, and pouring expandable grout which is considered hazardous by the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard.

7.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The roles, duties, and responsibilities of personnel assigned to the Phase II Site Investigation are provided below. An organizational chart showing the overall organization of the project team for the Phase II Site Investigation is detailed on 0.

Atlantic Richfield Company Operations Project Manager – Josh Bryson

The Atlantic Richfield Operations Project Manager (PM) communicates directly to the Agencies on project matters, monitors the performance of the contractor(s), consults with the CPM and Contractor QAO on deficiencies and helps finalize resolution actions.

Atlantic Richfield Company Quality Assurance Manager (QAM) – David Gratson

The Atlantic Richfield Company QAM interfaces with the Atlantic Richfield Company Operations PM on company policies regarding quality and has the authority and responsibility to approve specific QA documents including this QAPP.

Contractor

Pioneer Technical Services Inc. (Pioneer) is the Contractor responsible for conducting the elements of the Phase II Site Investigation under the direction of Atlantic Richfield Company (0).

Pioneer Contractor Project Manager (CPM) – Karen Helfrich

The CPM is responsible for scheduling all testing and sampling work to be completed and ensuring that the work is performed in accordance with the requirements contained herein. The CPM, or designated alternate, is also responsible for consulting with the specific project QA personnel regarding any deficiencies and finalizing resolution actions, maintaining the BRW Phase II QAPP, and verifying effective implementation of BRW Phase II QAPP requirements and procedures, including RFCs. This includes reviewing field and laboratory data and evaluating data quality.

Contractor Quality Assurance Officer (QAO) – Mike Borduin/Thomas Brown

The Contractor QAO is responsible for verifying effective implementation of BRW Phase II QAPP requirements and procedures, including reviewing field and laboratory data, and evaluating data quality. The Contractor QAO may conduct Site reviews and prepare Site review reports for the QAM. The Contractor QAO will have a direct line of communication to the QAM to ensure issues related to project QA are resolved.

The Contractor QAO is also authorized to stop work if, in the judgment of that individual, the work is performed contrary to or in the absence of prescribed QCs or approved methods and further work would make it difficult or impossible to obtain acceptable results.

Pioneer Field Team Leader – Kendra Jackson

The FTL ensures that the BRW Phase II QAPP and associated RFCs have been reviewed by all members of the field team and the BRW Phase II QAPP procedures are properly followed during field activities. The FTL will conduct daily safety meetings, assist in field activities, and document activities in the field logbook. The FTL is responsible for facilitating field activities and managing equipment and is responsible for coordinating with the CPM and Contractor QAO regarding problem solving and decision making in the field. The FTL is responsible for technical aspects of the project and providing “on-the-ground” overviews of project implementation by observing Site activities to ensure compliance with technical project requirements and the BRW SSHASP. The FTL is responsible for identifying potential Integrity Management issues during field activities and reporting any issues to the Contractor QAO.

Safety and Health Manager – Tara Schleeman

The Safety and Health Manager is responsible for reviewing the BRW SSHASP with all members of the field team and updating it if necessary. The Safety and Health Manager will lead applicable Task Risk Assessments and conduct the initial safety meeting prior to starting fieldwork. The Safety and Health Manager will monitor work crews' compliance with all Site safety and health requirements.

Contractor and Representative of Department of Environmental Quality (DEQ)

Tetra Tech (Tom Bowler), contractor and representative to DEQ, will collect the groundwater samples from monitoring wells GW-17 and GW-13 following the protocols and procedures identified in the BRW Phase II QAPP and RFC-BRW-2021-01. Mr. Bowler will collect the samples and then hand them over to Atlantic Richfield to submit to the laboratory for analyses.

7.1.1 Subcontractors

Multiple contractors will assist with the BRW Phase II Site Investigation activities. These companies will subcontract to Pioneer and follow all health and safety protocols established by Pioneer to work on the Site. These subcontractors have been selected due to their unique skillset and specialized equipment.

7.1.1.1 Pumping Test(s)

O'Keefe Drilling (O'Keefe) or an equivalent contractor. O'Keefe, or an equivalent contractor approved by Atlantic Richfield Company, will supply the rotary sonic drill rig and personnel to drill and install the pumping test piezometers in the upper reaches of the Site, if necessary.

Boland Construction & Drillings (Boland) or an equivalent contractor. This driller has experience using mud rotary drilling techniques. Installation and development of the pumping test well will be performed by Boland, or an equivalent contractor approved by Atlantic Richfield Company.

Parsons Drilling (Parsons) or an equivalent contractor. Parsons, or an equivalent contractor approved by Atlantic Richfield Company, will set pumps and controls for conducting the pumping test. Once the testing is complete, Parsons will remove the pumping equipment from the Site.

Jordan Contracting Inc. (JCI) or an equivalent contractor. JCI, or an equivalent contractor approved by Atlantic Richfield Company, will be responsible for installing the water conveyance line(s). One stream crossing will be necessary to get the conveyance line across SBC. To remove petroleum hydrocarbons, JCI will also assist with installation of the water treatment system

Hunter Brothers Construction (Hunter) or an equivalent contractor. Hunter, or an equivalent contractor approved by Atlantic Richfield Company, will be responsible for constructing an access road into the vegetated area allowing access for drill rigs, water trucks, equipment deliveries, and personnel. Any necessary permits for constructing an access road will be identified and secured by Pioneer and/or Hunter personnel.

During the pumping test well development, Hunter will also assist by using a water truck or vacuum truck. First, the drilling mud will be pumped or vacuumed as the well is being installed, displacing the drilling mud as the screen and casing are lowered into the borehole. Once the drilling mud is removed, the well will be developed by surging and pumping.

Additionally, Hunter will install the pumping test flow control system that directs the pumping test water into the holding tank.

7.1.1.2 Slag Investigation

Hunter or an equivalent contractor. Hunter, or an equivalent contractor approved by Atlantic Richfield Company, will supply the equipment and personnel to excavate test pits and backfill (Stage 1) and complete the slag removal with heavy equipment (Stage 3). Hunter will also provide a septic truck and personnel to remove water and debris from slag drill holes (Stage 4).

O'Keefe or an equivalent contractor. O'Keefe, or an equivalent contractor approved by Atlantic Richfield Company, will supply the drill rig and personnel to perform core drilling (Stage 2).

An Atlantic Richfield Company-approved contractor will supply the equipment and personnel to drill the holes for the expandable grout tests as well as mix and pour expandable grout (Stage 4).

7.1.2 Laboratory

The laboratory(s) selected to analyze the soil and groundwater samples will be an Atlantic Richfield Company-approved laboratory in general accordance with EPA's CLP SOW (EPA, 2016). Three laboratories have been selected to provide analytical services: Pace Analytical Laboratory, Energy Laboratories, MBMG, and Eurofins TestAmerica. These laboratories are required to generate and report high quality data that identify and define the physical and chemical characteristics of soil and groundwater for environmental investigations, remediation activities, long-term monitoring programs, discharge compliance monitoring, and waste characterization under the purview of RCRA and Comprehensive Environmental Response, Compensation & Liability Act (CERCLA), referred to as Superfund. As such, analytical data must be accurately and precisely generated and reported in conformance with the applicable method "best industry standards." The selected laboratories will have QA personnel familiar with the approved QAPP and be responsible for reviewing final analytical reports, scheduling analyses, and supervising in-house custody procedures.

The laboratory selected to provide compressive strength, tensile strength, and fracture toughness testing is the Department of Civil, Environmental, and Geo-Engineering materials testing laboratory of the University of Minnesota in Minneapolis. The laboratory is required to generate high quality data that identify and define the compressive strength, tensile strength, and fracture toughness of the slag. Results must be accurately and precisely generated and reported in conformance with the applicable “best industry standards” method.

8.0 DATA VALIDATION AND USABILITY

This section addresses the final project checks conducted after the data collection phase of the project is completed to confirm that the data obtained meet the project objectives and to estimate the effect of any deviations on data usability for the express purposes of achieving the stated DQOs (Section 3.0). Based on a review of EPA guidance, the analytical data collected under the BRW Phase II QAPP will undergo Stage 4 Validation Electronic and Manual (S4VEM) as defined in the EPA *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (EPA, 2009) (Stage 4 data validation). Official XRF analysis data as described in Section 4.10.1 will undergo Stage 2B Validation Manual (S2BVM) (EPA, 2009).

8.1 Data Review, Verification, and Validation

This section describes the review, verification, and validation process for field data and laboratory data. The section also details laboratory data reporting requirements, which describe how results are conveyed to data users.

8.1.1 Data Review Requirements

Data review is performed by the data producer to ensure that the data have been recorded, transmitted, and processed correctly.

8.1.1.1 Field Data Review

Raw field data will be entered in field logbooks and/or field data sheets per appropriate field SOPs (Appendix A), and the data will be reviewed for accuracy and completeness by the FTL before the records are considered final. The overall quality of the field data from any given sampling round will be further evaluated during the process of data reduction and reporting.

Field data reduction procedures will be minimal in scope compared to those implemented in the laboratory setting. Field data review will include verification that any QC checks and calibrations, if necessary, are recorded properly in the field logbooks and/or data sheets and that any necessary and appropriate corrective actions were implemented and recorded. Such data will be written into the field logbook and/or data sheets immediately after measurements are taken. If errors are made, results will be legibly crossed out, initialed and dated by the field member, and corrected in a space adjacent to the original (erroneous) entry. Later, the FTL will proof the field logbooks and/or data sheets to determine whether any transcription errors have been made by the field crew. If transcription errors have been made, the FTL and field crew will address the errors to provide resolution.

If appropriate, field measurement data will be entered into electronic files for import to the project database. Data entries will be made from the reviewed field data sheets or logbooks, and all data entries will be reviewed for accuracy and completeness before the electronic file is provided to the database manager. Electronic files of field measurement data will be maintained as part of the project's quality records.

8.1.1.2 Laboratory Data Review

Internal laboratory data reduction procedures will be according to each laboratory's quality management plan. At a minimum, paper records will be maintained by the analysts to document sample identification number and the sample tag number with sample results and other details, such as the analytical method used (e.g., method SOP Number), name of analyst, the date of analysis, matrix sampled, reagent concentrations, instrument settings, and the raw data. These records will be signed and dated by the analyst. Secondary review of these records by laboratory personnel will take place prior to final data reporting to Atlantic Richfield Company. The laboratory will appropriately flag unacceptable data in the data package.

8.1.2 Data Verification Requirements

Data verification is the process for evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual specifications.

8.1.2.1 Field Data Verification

The Level A/B review, as described in the CFRSSI Data Management/Data Validation (DV/DM) Plan (ARCO, 1992d) and the CFRSSI DM/DV Plan Addendum (AERL, 2000), will be used in the verification process for field documentation related to samples collected for laboratory analysis.

The Level A criteria are:

- Sampling date.
- Sample team and/or leader.
- Physical description of sample location.
- Sample depth (soils).
- Sample collection technique.
- Field preservation technique.
- Sample shipping records.

The Level B criteria are:

- Field instrumentation methods and standardization complete.
- Sample containers preparations.
- Collection of field duplicates.
- Proper and decontaminated sampling equipment.

- Field custody documentation.
- Shipping custody documentation.
- Traceable sample designation number.
- Field notebook(s), custody records in secure repository.
- Complete field forms.

8.1.2.2 Laboratory Data Verification

The laboratory will prepare Stage 4 data packages for transmittal of results and associated QC information to Atlantic Richfield Company or its designee within a standard turnaround time, unless otherwise required.

The laboratory will prepare Stage 4 data packages in general accordance with the EPA CLP SOW (Multi-Media, Multi-Concentration) (EPA, 2016). Deviations from these specifications should be acceptable provided the report presents all the requested types of information in an organized, consistent, and readily reviewable format.

Each data package, as described above, will be accompanied by an EDD prepared by the laboratory. Additional laboratory QC data can be included in the EDD. The EDDs will be cross checked against corresponding data reports to confirm consistency in results reported in these two separate formats. This cross check will take place as part of the data verification process.

The data packages from the laboratory will contain the following minimum information:

- A narrative addressing any anomalies encountered during sample analysis, and a discussion of any exceedances in the laboratory QC sample results.
- Analytical method references.
- Definition of any data flags or qualifiers used.
- Chain of custody documentation signed and dated by the laboratory to indicate sample receipt.
- Method detection limits and reporting limits.
- Analytical results for each field sample.
- QC sample results (as applicable).

Stage 4 data packages will also include raw data as well as results for all QC samples and calibration data.

8.1.2.3 Resolution of Deficiencies

Any deficiencies found during the verification process will be discussed with the data producer and may be resolved with a revised data package.

8.1.3 Data Validation Requirements

Data validation is the process of ensuring data are correct and useful. Data validation will be performed by qualified, independent data validation personnel, who are not associated with data collection or sampling responsibilities, and that have applicable training. The QC criteria used during the data validation process will follow the National Functional Guidelines for Inorganic Superfund Methods Data Review (EPA, 2017a), the National Functional Guidelines for Organic Superfund Methods Data Review (EPA, 2017b), the CFRSSI QAPP (ARCO, 1992b), the CFRSSI DM/DV Plan (ARCO, 1992d), the CFRSSI DM/DV Plan Addendum (AERL, 2000), laboratory-specific QC criteria, and/or method-specific criteria where applicable.

8.2 Verification and Validation Methods

The Level A/B Assessment checklists included in Appendix E are based on the CFRSSI DM/DV Plan Addendum (AERL, 2000) guidance.

Stage 4 Verification and Validation checks include an evaluation of the following, as applicable for each analytical method:

- Completeness of laboratory data package
- Requested analytical methods performed
- Holding times
- Reported detection limits
- Dilution factors
- Method blanks
- Laboratory control samples (LCS) and LCS duplicates
- Matrix spike samples and matrix spike duplicates
- Laboratory duplicate samples
- Field blanks
- Field duplicates
- Raw data included
- Tuning
- Instrument Calibration
- Internal Standards
- Initial and Continuing Calibration Verification Standards
- Initial and Continuing Calibration Blank Standards
- Reporting Limit Check Standards
- Interference Check Samples
- Serial Dilution

Data qualifiers will follow those used in the National Functional Guidelines for Inorganic Superfund Methods Data Review (EPA, 2017a) and the National Functional Guidelines for

Organic Superfund Methods Data Review (EPA, 2017b). Data validation for each laboratory data package will be documented on the data validation checklists in Appendix E.

The Data Validator will be responsible for reviewing field documentation associated with sample collection, conducting the verification and validation of laboratory-produced data, and completing a data validation report, which will be reviewed by the CPM.

8.3 Reconciliation and User Requirements

The Data Quality Assessment (DQA) process described in the CFRSSI DM/DV Plan Addendum (AERL, 2000) and the Guidance for Data Quality Assessment EPA QA/G-9 (EPA, 2000) will be performed to determine whether project-specific DQOs have been satisfied. The DQA process consists of five steps that relate the quality of the results to the intended use of the data:

Step 1: Review DQOs and sampling design.
Step 2: Conduct preliminary data review.
Step 3: Select statistical test(s), as appropriate, to evaluate data quality.
Step 4: Verify assumptions.
Step 5: Draw conclusions about the quality of the data (data report will not include interpterion of results but will state conclusions regarding the quality of the results).

If, as a result of the DQA process, it is determined that data do not satisfy all DQOs, then corrective action(s) should be recommended. Corrective actions include, but are not limited to, revision of the DQOs based on the results of the investigation, or collection of more information or data. It may be determined that corrective actions are not required, or the decision process may continue with the existing data, with recognition of the limitations of the data.

The PARCCS data quality indicators (Section 3.1) will be used when conducting the DQA. If the PARCCS assessment satisfies the project DQOs, then usability of the data will follow the enforcement/screening/unusable data categories as described in the CFRSSI DV/DM (ARCO, 1992d):

1. Enforcement Quality (Unrestricted Use) Data

   Enforcement quality data may be used for all purposes under the Superfund program including the following: site characterization, health and safety, Environmental Evaluation/Cost Analysis, remedial investigation/feasibility study, alternatives evaluation, conformational purpose, risk assessment, and engineering design.

2. Screening Quality (Restricted Use) Data

   Potential uses of screening quality data, depending upon their quality, include site characterization, determining the presence or absence of contaminants, developing or refining sampling and analysis techniques, determining relative concentrations, scoping and planning for future studies, engineering studies and engineering design, and monitoring during implementation of the response action.

3. Unusable Data

   These data are not useable for Superfund-related activities.

Data that meet the Level A and Level B criteria and are not qualified as estimated or rejected during the data validation process are assessed as enforcement quality data and can be used for all Superfund purposes and activities. Data that meet only the Level A criteria and are not rejected during the data validation process can be assessed as screening quality data. Screening quality data can be used only for certain activities, which include engineering studies and design. Data that do not meet the Level A and/or B criteria and/or are rejected during the data validation process are designated as unusable. The data are assigned one of the following qualifiers:

E = Enforcement quality. No qualifiers or U qualifier and meets Level A and B criteria.
S = Screening quality. J or UJ qualifier and/or meets only Level A criteria.
R = Unusable. R qualifier and/or does not meet Level A or B requirements.

Enforcement/Screening Designation

	Meets Level A and B	Meets Level A	Does not meet Level A or B
No qualifier, A, or U	E	S	R
J, J+, J-, or UJ	S	S	R
R	R	R	R

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FIGURES

TABLES

Appendix A
Standard Operating Procedures

Appendix B
Field Forms and Tables

Appendix C
Expandable Grout Manufacture Information

Appendix D
Corrective Action Report

Appendix E
Data Validation Checklists