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

Pioneer Technical Services, Inc.

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Draft Final

Preliminary 30% Remedial Design Report for the Butte Reduction Works (BRW) Smelter Area

Atlantic Richfield Company

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May 13, 2021

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ACRONYMS

Term	Definition
µg/L	microgram per Liter
µg/m³	micrograms per cubic meter
ADA	Americans with Disabilities Act
amsl	above mean sea level
ARAR	Applicable or Relevant and Appropriate Requirement
ARM	Administrative Rules of Montana
Atlantic Richfield	Atlantic Richfield Company
ATO	Alluvium, Tailings, and Organics
AWWA	American Water Works Association
bcy	bank cubic yards
bgs	below ground surface
BMFOU	Butte Mine Flooding Operable Unit
BMP	Best Management Practice
BNSF	Burlington Northern Santa Fe
BPSOU	Butte Priority Soils Operable Unit
BSB	Butte-Silver Bow
BRW	Butte Reduction Works
BTL	Butte Treatment Lagoon
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
COC	Contaminant of Concern
CSM	Conceptual Site Model
cy	cubic yards
DEQ	Montana Department of Environmental Quality
Domestic Manganese	Domestic Manganese and Development Company
DNRC	Department of Natural Resources and Conservation
EPA	U.S. Environmental Protection Agency
EPH	Extractable Petroleum Hydrocarbon
ET	Evapotranspiration
FEMA	Federal Emergency Management Agency
FEWA	Functional Evaluation Wetlands Area
FIRM	Flood Insurance Rate Map
ft/s	Feet per second
H:V	Horizontal:Vertical
HCC	Hydraulic Control Channel
HEC-RAS	Hydrologic Engineering Center River Analysis System
lb/sq ft	pounds per square foot
LDI	Land Design, Inc.
LiDAR	Light Detection and Ranging
MBMG	Montana Bureau of Mining and Geology
MCA	Montana Code Annotated
MCL	Maximum Contaminant Levels
MCLG	Maximum Contaminant Level Goals
mg/kg	milligrams per kilograms
MPTP	Montana Pole and Treating Plant
MPDES	Montana Pollutant Discharge Elimination System
MPWSS	Montana Public Works Standard Specification
MSD	Metro Storm Drain

NCP	National Contingency Plan
NFIP	National Flood Insurance Program
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NWI	National Wetland Inventory
O&M	Operation and Maintenance
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyls
PCP	Pentachlorophenol
PDI	Pre-Design Investigation
PDI ER	Pre-Design Investigation Evaluation Report
PDI WP	Pre-Design Investigation Work Plan
pH	Potential Hydrogen
PM-10	Particulate matter that is 10 microns in diameter or smaller
PM-2.5	Particulate matter that is 2.5 microns in diameter or smaller
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RBCA	Risk-Based Corrective Action
RBSL	Risk-Based Screening Level
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDWP	Remedial Design Work Plan
RG	Remedial Goal
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SBC	Silver Bow Creek
SFHA	Special Flood Plain Hazard
SIP	State Implementation Plan
SOW	Statement of Work
SST	Streamside Tailings (OU)
SWMP	Surface Water Management Plan
SWPPP	Stormwater Pollution Prevention Plan
TI	Technical Impracticability
TIN	Triangular Irregular Network
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VPH	Volatile Petroleum Hydrocarbons
WP	Work Plan

1.0 INTRODUCTION

This report provides a Preliminary 30% Remedial Design (RD) for the Butte Reduction Works (BRW) Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site (Site) within the Butte Priority Soils Operable Unit (BPSOU) of the Silver Bow Creek/Butte Area National Priorities List (NPL) Site. The remedial action (RA) at the Site involves removal of tailings, waste, soil, and slag within the stream reconstruction corridor (referred to herein as the waste removal corridor) that fail the Waste Identification Screening Criteria (Table 1) to a depth determined during the RD; construction of a hydraulic control system to capture groundwater impacted with contaminants of concern (COCs) (i.e., arsenic, cadmium, copper, mercury, lead, and zinc); and reconstruction of Silver Bow Creek (SBC) and the riparian floodplain. The Preliminary 30% RD is conceptual and presents the design approach for the remedial elements outlined in the U.S. Environmental Protection Agency (EPA) *Further Remedial Elements Scope of Work,* which is Attachment C to Appendix D to the C*onsent Decree for The Butte Priority Soils Operable Unit Partial Remedial Design/Remedial Action and Operation and Maintenance* (EPA, 2020; referred to herein as BPSOU CD).

This preliminary design report follows the *BPSOU Statement of Work* (BPSOU SOW [Appendix D to the BPSOU CD]) and contains the components listed in the *Remedial Design/Remedial Action Handbook*, EPA 540/R-95/059 (EPA, 1995), which include the following elements:

- Introduction, including Site description (Section 1.0).
- Existing data summary (Section 2.0).
- Applicable or relevant and appropriate requirements (ARARs), including permitting requirements (Section 3.0).
- Conceptual Site Model (CSM) (Section 4.0).
- Design criteria (Section 5.0).
- Design approach, including summary of calculations and/or modeling results (Section 6.0).
- Discussion of data gaps (Section 7.0).
- Description of Site access and easements (Section 8.0).
- Summary (Section 9.0).

Calculations referenced throughout this report are provided in Appendix A. Figure 1 through Figure 6 provide graphical views of the Site and Table 1 through Table 5 provide data related to the work required. Additionally, the report references the Construction Drawings, which are provided as a separate document.

1.1 Purpose and Objectives

This RD report outlines all design criteria and documents the basis on which the design meets the criteria. The design criteria address how the proposed RA will be designed and managed according to ARARs, including the remedial action objectives (RAOs) and RA levels, the BPSOU SOW (Appendix D to the BPSOU CD) requirements, and applicable engineering standards and codes for Site-specific engineering parameters. The basis of design is a description of the design approach necessary to meet the design criteria, including a detailed summary of the assumptions and the analyses and calculations completed, which are guided by the design criteria requirements.

1.2 Site Description

The SBC/Butte Area NPL Site is located in the upper Clark Fork River watershed and includes portions of Butte and Walkerville, Montana. EPA designated the original SBC site as a Superfund site in September 1983, under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). EPA expanded the SBC site to include the Butte area in 1987.

The Site is located within the BPSOU, one of seven active operable units that make up the NPL Site. The BPSOU (Figure 1) is situated in an urban setting and includes residential neighborhoods, schools, and parks as well as commercial and industrial areas. The Site is located within Lower Area One (LAO), an area approximately 80 acres in size. The Butte-Silver Bow (BSB) municipal wastewater treatment plant bisects the LAO area, separating the Butte Treatment Lagoons (BTL) on the western half of LAO from the Site on the eastern half of LAO (Figure 2). The Site covers approximately 24 acres and is located to the immediate west of Montana Street between SBC and the Burlington Northern Santa Fe (BNSF) Railway railroad line (Figure 3).

Historically, the Site included several different smelting configurations and was also used by the Domestic Manganese and Development Company (Domestic Manganese) (Sanborn, 1943). The operations left behind a complex distribution of materials (including slag, tailings, manganese waste, demolition debris, foundations, and other historic structures) as well as COC-impacted soil and groundwater. Currently, the Site is occupied by BSB for construction-related materials mixing and storage and as an asphalt plant.

Note: The section of SBC "east of its confluence with Blacktail Creek" was previously referred to as the Metro Storm Drain (MSD); consequently, the subdrain beneath the channel was renamed as the BPSOU subdrain by EPA in 2019. Many of the previous documents referenced in this report use the original MSD naming convention[1].

[1] A State of Montana District Court decision known as Silver Bow Creek Headwaters Coalition v. State of Montana, DV-10-431 (August 17, 2015) declared that the surface area between Texas Avenue in Butte and the confluence of Blacktail and Silver Bow Creek was named "Silver Bow Creek." In prior Superfund removal and remedial documents and publications, including the 2006 Butte Priority Soils Operable Unit (BPSOU) Record of Decision and 2011 BPSOU Explanation of Significant Differences (ESD) (EPA, 2020), EPA has called this surface area the "Metro Storm Drain." Due to the Montana Department of Environmental Quality (DEQ) involvement in this document's issuance, and where reference to this specific section of Silver Bow Creek is necessary, further geographic descriptions such as Silver Bow Creek "east" or "above" its confluence with Blacktail Creek are used in order for DEQ to comply with the Court's order. Reference to the area as "Silver Bow Creek" or "Silver Bow Creek east of its confluence with Blacktail Creek" should not be construed as an admission or determination by any Consent Decree party on any procedural or substantive issue. The United States retains and reserves all its rights and authorities.

1.3 Site Setting

1.3.1 Climate

The Butte area climate is characterized by short, cool, dry summers and long, cold winters. The annual precipitation in Butte generally varies from 6 to 20 inches per year, with an average of 13 inches. The greatest amount of precipitation, approximately one third, occurs during the months of May and June. The estimated annual evaporation in the Butte area is 30 inches (NOAA, 2019), which exceeds the annual precipitation.

1.3.2 Topography

The Site is located in the west-central portion of the BPSOU at elevations ranging from approximately 5,469 to 5,436 feet above mean sea level. The general slope of the terrain is relatively flat with a general slope towards the south; however, there are multiple piles of various materials from historic and recent industrial activities at the Site as well as historic features throughout the Site (Figure 4). The north boundary of the Site is SBC, the south boundary is the BNSF Railway railroad line, the east boundary is Montana Street, and the west boundary is SBC.

1.3.3 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]). The alluvial aquifer in the vicinity of the Site is comprised of a relatively uniform depth of alluvium consisting of alternating layers ranging from fine sand to medium gravel, which may have a layer of black organic silt on top, and has weathered and/or competent bedrock underneath.

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 older alluvium consists of light orange to tan coarse clay, sand, silt, and gravel, with interbedded light brown clay layers and infrequent occurrence of cobbles and boulders (*Geologic Map and Geohazard Assessment of Silver Bow County, Montana, Open-File Report 58* [MBMG, 2009]). 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. Based on well/piezometer logs and averaged groundwater elevations for the Site, the saturated alluvial thicknesses across the Site ranges from approximately 20 to 30 feet.

Black Organic Silt

In certain locations (e.g., BPS07-13B) (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 COC-impacted materials and/or groundwater, the organic soil 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). Based on well/piezometer logs, the depth to the weathered bedrock ranges from approximately 22 feet below ground surface (bgs) in the lower western floodplain area of the Site to approximately 44 feet bgs in the upper central portion of the Site. The thickness of the weathered bedrock layer ranges from approximately 0.8 feet to 15.7 feet with an average thickness of 4.4 feet across the Site.

1.3.4 Groundwater

As groundwater enters the Site, groundwater flow within the alluvial system is generally from southeast to northwest. Groundwater at the Site travels primarily through the more hydraulically conductive alluvial aquifer via the small, interconnected spaces between the alluvial material and weathered bedrock, but also travels more slowly through the competent bedrock, which has much lower hydraulic conductivity (Canonie, 1994).

The depth to groundwater within the Site ranges from approximately 3 feet bgs on the western portion of the Site to approximately 24 feet bgs on the eastern portion of the Site; however, a majority of the change in depth to groundwater can be attributed to the topographic change in the existing ground surface. The groundwater table within the Site varies seasonally but typically ranges from approximately 5,442 feet in elevation above mean sea level (amsl) within the eastern portion of the Site to approximately 5,436 feet in elevation amsl within the western portion of the Site (Figure 6). The flow direction east of the Site generally mimics the lay of the original land surface (i.e., topographic slope) and, due to the shallowing bedrock depth, historically flowed toward and upwelled into SBC, even as it was shifted to the north by the BRW Smelter operations. Groundwater generally flows along the path of least resistance from areas of high potential to areas of low potential. In the case of this Site, the path of least resistance was historically SBC.

Currently, the area of lowest potential is the BRW-00 Pond and the Hydraulic Control Channel (HCC) adjacent to the Site (Figure 2), which function as a combined groundwater capture system within LAO. The HCC was designed and constructed during Phase I of the LAO Expedited Response Action specifically to maintain a gradient away from SBC at the west end of BPSOU and, therefore, reduce the amount of groundwater discharging to SBC (Atlantic Richfield

Company, 2002). The BRW-00 Pond has been graded such that groundwater gradient flows from SBC towards the BRW-00 Pond (Atlantic Richfield Company, 2012). These features hydraulically control groundwater to the north of SBC, causing groundwater to flow toward the BRW-00 Pond.

The groundwater beneath the Site is located within the Groundwater Technical Impracticability (TI) waiver area adopted by EPA in the 2006 BPSOU Record of Decision (ROD) (2006 BPSOU ROD) (provided in Appendix A of the BPSOU CD) where restoration of groundwater has been determined by EPA to be technically impracticable. The TI waiver of ARARs for the alluvial groundwater aquifer includes arsenic, cadmium, copper, lead, mercury, and zinc (Figure 1). Groundwater quality standards apply to groundwater at, and beyond the edge of, this boundary.

1.3.5 Hydrology

Blacktail Creek converges with SBC approximately 450 feet upgradient (east) of the Site and Buffalo Gulch drains into SBC approximately 200 feet upgradient of the Site; SBC travels along the northern boundary of the Site and flows east to west. The current path of SBC along the northern boundary of the Site is not the historical one, as the creek channel was moved to the north and into its current alignment in the slag canyon as part of the operations of the BRW Smelter. This stream is subject to naturally changing flow dynamics including flooding. The section of SBC in the vicinity of the Site drains a basin area of approximately 97.8 square miles that is over 50% forested and also includes rangelands, bare earth, and urban areas, as discussed in Appendix A.1.

1.3.6 Stormwater Hydrology

The stormwater system located within the BPSOU consists of 15 sub-drainage areas that discharge to the SBC. The majority of the sub-drainage areas within the BPSOU have been impacted by historical mining activities. BPSOU is an urbanized area with constructed stormwater features to control and direct urban runoff. Several stormwater outlets discharge into SBC.

Drainage basins that drain to the Site are shown on Figure 2. Stormwater drainage from the Montana Street drainage basin will continue to drain to SBC at the east end of the Site near the tie-in/start of the realigned section of SBC to be constructed through the Site. The Idaho Street drainage basin currently drains into a portion of the SBC within the slag canyon at the north side of the Site. The Missoula Gulch drainage basin ultimately discharges to SBC between SS-05A and SS-05B. Conveyance of stormwater from the Idaho Street and Missoula Gulch drainage basins will be further discussed in the Intermediate 60% RD Report.

1.4 Cultural Resources

The goal of the remediation efforts is to preserve cultural resources and historical features, to the extent feasible, while performing cleanup activities consistent with the requirements in the BPSOU CD. The following sections describe the Site history and the historical features remaining within the Site.

1.4.1 Site History

The Site has had multiple industrial operations resulting in a complex Site history. Industrial operations at the Site began in 1883 (approximately) and continue to present day (GCM Services, Inc., 1991). The footprint of these operations over the years resulted in almost every portion of the Site being used. A summary timeline of activities at the Site is below.

- 1868 to 1900 (approximately): Silver mill and mine operations near Missoula Gulch dispose of mine and mill wastes into the gulch. The wastes flow downhill, onto the Site and into SBC.
- 1883 (approximately) to 1910: The BRW Smelter is constructed and operated by the Butte Smelting Co., Butte Reduction Co., William A. Clark, and/or Colusa Parrot Mining & Smelting Co., producing copper and copper tailings on the Site. A zinc concentrator is added in 1909. Additional wastes from zinc mills and concentrators in Missoula Gulch are disposed in the gulch, flowing downhill onto the Site and into SBC.
- 1910 to 1911: Atlantic Richfield's predecessor purchases the Site in 1910 and shuts down the copper smelter. The Site is leased back to Clark, who continues to process zinc ore on the Site until the zinc concentrator is destroyed in a fire in 1911.
- 1927 to 1945: Domestic Manganese processes and stores manganese on the Site. From 1943 to 1945, U.S. Agencies (General Services Administration, Department of Defense's Defense Logistics Agency) construct a flotation mill, produce manganese, dispose of manganese tailings, and store manganese ore on the Site.
- 1945 to 1992: Continued stockpiling of manganese ore on the Site by the U.S. Agencies.
- Early 1960s: Rocky Mountain Phosphates, Inc. operates active phosphate plant.
- Mid-1990s to Date: BSB operates Site as asphalt plant and materials storage area.

Response activities at the Site began with the removal of stockpiled manganese ore in 1992. Response activities on other land in the LAO area began in 1994 and continued until about 2014.

1.4.2 Historical Features and Infrastructure

Most of the durable historic infrastructure at the Site was removed after the industrial operations were discontinued. However, some infrastructure items were not demolished and remain, or potentially remain, at the Site.

An assessment of the infrastructure remaining from the industrial operations within the Site came from reviewing a variety of sources including historical reports/records, historical and present day aerial imagery and Light Detection and Ranging (LiDAR) contours, and previous Site investigations. Additionally, information gathered during the Phase I Field Investigation (refer to Section 2.1) was used to further understand the infrastructure remaining at the Site.

A summary of the information reviewed including conclusions regarding remaining historical infrastructure is provided in the *Butte Reduction Works (BRW) Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site Pre-Design Investigation*

(PDI) Evaluation Report (Atlantic Richfield Company, 2021a), referred to herein as the PDI ER. On Figure 4, the demolished or removed infrastructure is shown in gray, the potentially remaining infrastructure is shown in yellow, and the remaining infrastructure is shown in green. Figure 4 also shows the infrastructure that may be preserved during the Site RA such as portions of the slag walls and the manganese ore bins. Sanborn Insurance Company maps from 1900, 1914, and 1953, along with a historical plan of the smelting plant at BRW from *The Engineering and Mining Journal* (Wethey, 1909) were used to show the configuration of the BRW Smelter and Domestic Manganese structures.

1.4.3 Historically Significant Features

The Butte mining district was designated as a National Historic Landmark District in 1962 (2006 BPSOU ROD - Appendix A to the BPSOU CD) and the boundary expanded in 2005 (BSB, 2014). Two programmatic agreements are in place to predict the impact of Superfund activities to historic and cultural resources. This protection includes the slag walls surrounding the Site and the Abandoned Aqueduct (Figure 2). During operation of the smelter, large amounts of slag were produced as a by-product from the smelting operations. The molten slag was transported by electric-powered tramway and poured into wooden forms to form retaining walls to contain the smelter's tailings. The aqueduct was constructed as a means to divert SBC water through the Site and drain the tailings area (GCM Services, Inc., 1991).

A cultural resource inventory will be performed prior to construction activities to identify any historic features within the Site based on the current Site conditions. A Cultural Resource Report will be provided as part of the RD, as an attachment to the Remedial Action Work Plan (RAWP), and will document all the inventory results, Site evaluation, and recommendations.

1.5 Site Utilities and Current Site Conditions

There is a utility corridor running parallel to Montana Street at the east end of the Site. Figure 3 shows that the current utilities include electric, gas, water, sanitary sewer, communications, and the BPSOU subdrain pump system primary force main and alternate discharge line. Contractor will work with utility owners and will complete blind sweep and potholing to locate all utilities prior to completing work on Site, as directed by an Atlantic Richfield representative.

There are equipment and materials currently on the Site owned by BSB which will be removed prior to the start of construction, except for some materials that Atlantic Richfield may use as backfill during construction if the material meets the requirements listed in Table 2 or Table 3. Any remaining BSB operational infrastructure or unusable material will be removed by Atlantic Richfield during construction.

2.0 EXISTING DATA SUMMARY

2.1 Previous Investigations

Previous investigations are discussed in the *Butte Reduction Works (BRW) Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site Remedial Design Work Plan* (RDWP) (Atlantic Richfield Company, 2021b) and the *Butte Reduction Works (BRW) Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site Pre-Design Investigation (PDI) Work Plan* (WP) (Atlantic Richfield Company, 2021c) (included as an attachment to the RDWP).

2.2 Pre-Design Investigations and Evaluation Report

The PDI WP (Atlantic Richfield Company, 2021c) identified specific data gaps and references the three Quality Assurance Project Plans (QAPPs) applicable for the Site, which detail the procedures and methods of collecting field data to fill specific Site characterization data gaps that directly support design and construction. To collect the necessary information required to support the RD for the Site, the field investigation work has been split into three phases. Additional detail on each phase of the Site investigation is included in the RDWP (Atlantic Richfield Company, 2021b) and the PDI WP.

The Phase I Site Investigation was completed in three stages from August 2018 through February 2020. A summary of the work performed, including the data collected, is included in the PDI ER. These data have been incorporated into this Preliminary 30% RD Report. Additional data collection began in June 2020 and will continue through July 2021 as part of the Phase II and Phase III Site Investigations. At the completion of the investigations, Atlantic Richfield will incorporate the results, including an updated interpretation of the results, into the PDI ER and submit to Agencies for review and approval approximately 30 days prior to submission of the Intermediate 60% RD Report.

2.3 Nature and Extent of Impacted Soil

The Phase I Site Investigation collected substantial design-related data to help estimate the nature and extent of impacted soil within the Site. Additional data collection began in June 2020 and will continue through July 2021 as part of the Phase II and Phase III Site Investigations. The additional data will help refine the information in the sections below.

2.3.1 Waste

Using the data collected during the Phase I Site Investigation, the Leapfrog Works (Leapfrog) software was used to estimate the volume, distribution, and properties (i.e., COC concentrations) of solid materials (slag, demolition debris, ATO [alluvium, tailings, organic soil, and other materials [e.g., general fill from BSB operations]) within the Site. Based on the Leapfrog model, the total estimated waste within the Site is approximately 506,000 cubic yards (cy), which includes an estimated 305,000 cy of slag, 57,000 cy of demolition debris, 95,000 cy of ATO waste, and 49,000 cy of other materials (e.g., general fill from BSB operations). Of the total estimated waste within the Site, approximately 139,000 cy is within the waste removal corridor (Atlantic Richfield Company, 2021a).

These volumes of waste material include all the slag, demolition debris, and other materials (e.g., general fill from BSB operations) along with the ATO materials with COC concentrations above the waste identification criteria in Table 1 (i.e., ATO waste). The slag, demolition debris, and other materials are automatically considered waste within the Leapfrog model, regardless of the concentration of COCs. This determination was made to simplify the model since these material types (slag, demolition debris, and other) are often located where they would need to be removed to provide access for the installation of the creek within the waste removal corridor and/or to remove ATO waste below. Additional detail on the justification of this decision is included in the PDI ER.

2.3.2 Soil Impacted with Organic Pollutants

Using the data collected during the Phase I Site Investigation, Atlantic Richfield completed a preliminary risk evaluation for the materials within the Site impacted by petroleum compounds. The evaluation followed the Montana Department of Environmental Quality (DEQ) *Montana Risk-Based Corrective Action (RBCA) Guidance for Petroleum Releases* (RBCA Guidance) (DEQ, 2018a). The RBCA preliminary risk evaluation was completed to the extent possible based on the data collected during the Phase I Site Investigation and is included in the PDI ER. Based on the initial results from the RBCA evaluation, the majority of the petroleum-impacted soils exceeding DEQ risk-based screening levels (RBSLs) (Table 4) are within the southern part of the Site, and the primary petroleum compounds of concern are:

- Above the capillary fringe: C9 to C12 Aliphatics, C11 to C22 Aromatics, and C9 to C18 Aliphatics.
- Within or below the capillary fringe: C9 to C12 Aliphatics and C9 to C18 Aliphatics.

The RBCA evaluation was completed to the extent possible based on the data collected during the Phase I Site Investigation. For the current RBCA evaluation, the data collected from the Site were compared to Tier 1 and Tier 2 RBSLs to determine whether additional evaluation is needed. Due to the complexity of the Site, Atlantic Richfield intends to complete a Tier 3 evaluation and develop site-specific action levels for soil and groundwater impacted with organic pollutants (petroleum compounds, polychlorinated biphenyls (PCBs), pentachlorophenol (PCPs), and dioxins) within the Site. Once the Phase II and Phase III Site Investigations are completed, the RBCA evaluation will be revised to include a Tier 3 evaluation and proposed site-specific action levels. The revised RBCA evaluation will be resubmitted with the revised PDI ER. At that time, additional detail will be provided on the volume and extent of the petroleum-impacted soils, on the proposed Site-specific action levels established based on data collected during the site investigation, and on the proposed management of those petroleum-impacted soils with concentrations above the Site-specific action levels.

In addition to the petroleum-impacted soils, there is a potential for PCB-impacted soil within the Site. Based on historical records, there was a transformer yard located on the eastern portion of the Site. Due to existing infrastructure at the Site (BSB's asphalt plant), samples could not be collected as part of the Phase I and Phase II Site Investigations. Once the existing infrastructure is removed, soil samples will be collected from the approximate location of a historic transformer yard and analyzed for PCBs. The results will be incorporated into the RBCA evaluation and PDI ER.

2.4 Nature and Extent of Impacted Water

2.4.1 Groundwater

The nature and extent of COC-impacted groundwater within the Site is relatively well documented. As part of previous investigations and ongoing investigations as part of the RD, monitoring wells and piezometers have been installed in the alluvial aquifer underneath the Site and sampled for water levels and groundwater chemistry. Groundwater within the Site typically travels in a southeast to northwest direction towards SBC. In 2019, the highest groundwater elevations were observed in March, April, and October, while the lowest groundwater elevations were observed in the winter months (December through February).

Groundwater within the Site has elevated concentrations of arsenic, cadmium, copper, lead, and zinc that are above the remedial goals listed in Table 8-1 of the 2006 BPSOU ROD (Appendix A to the BPSOU CD). Concentrations of COCs are generally the highest on the western part of the Site, near piezometers BRW18-PZ01 and BRW18-PZ08 (Figure 3). Concentrations of COCs in the groundwater within the Site are likely elevated due to the overlying tailings, slag, and other historical mining waste materials. Percolation of water through these COC-impacted materials leaches metals and carries them into the groundwater system. Additional detail on the COC impacts to groundwater, including analytical results, can be found in the PDI ER.

Groundwater within the Site also has elevated concentrations of petroleum compounds that are above the Tier 1 RBSLs identified in DEQ RBCA Guidance (DEQ, 2018a) (Table 4). An RBCA evaluation has been completed to the extent possible based on the data collected during the Phase I Site Investigation and is included in the PDI ER. Based on the initial results from the RBCA evaluation, the primary petroleum compounds of concern are benzene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. As a part of the Phase I Site Investigation, select wells within the Site were also sampled for PCB; no PCBs were detected in the wells.

The Phase II and Phase III Site Investigations will include additional sampling for select organic pollutants including petroleum compounds, PCBs, PCP, and dioxins. Once the Phase II and Phase III Site Investigations are completed, the RBCA evaluation will be revised and resubmitted with the revised PDI ER. At that time, Atlantic Richfield will propose Site-specific action levels for organic pollutants (petroleum compounds, PCBs, PCP, and dioxins) in the groundwater based on data collected during the site investigations as well as provide details on the extent and proposed management of the groundwater within the Site impacted by select organic pollutants above the Site-specific action levels.

Some of the groundwater underneath the Site is passively captured by BRW-00 Pond. This water is then conveyed by the HCC to BTL for treatment. Treatment within BTL uses the addition of lime and a wetland environment to reduce the concentration of metal COCs below the appropriate discharge standards (BPSOU CD). Once the water meets standards, it is discharged into SBC.

2.4.2 Surface Water

The nature and extent of COC-impacted surface water in SBC has been well documented in the EPA 5-year reviews (EPA, 2000; EPA, 2005; EPA, 2011, and EPA; 2016). Chronic surface water quality in Silver Bow and Blacktail Creeks has significantly improved from 1998 to 2013 (EPA, 2016); however, seasonally variable amounts of COC-impacted groundwater from the Site appear to enter SBC. This interaction will be quantified further in the PDI ER as the Phase II and Phase III Site Investigations are completed.

3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section describes how remedial activities at the Site will comply with the identified ARARs. Table 5 contains the ARARs identified for the Site RD.

3.1 Compliance with ARARs

The BPSOU CD contains a complete list of the ARARs for RA implemented within BPSOU. The Site is subject to these ARARs, which are divided into the following three categories: chemical-specific, action-specific, and location-specific. The following presents the substantive compliance for the Site with these ARARs. This design document contains a complete list and description of ARARs from the BPSOU CD and whether or not each ARAR is applicable to the Site.

This section also lists the general status of the ARARs' evaluation relative to the Site RD. As indicated in *EPA CERCLA Compliance with Other Laws Manual Interim Final* (EPA, 1988a), the technical specifications developed during design must ensure attainment of ARARs.

In evaluating ARARs, Atlantic Richfield will be consistent with *EPA ARARs Q's and A's* (EPA, 1991), will recognize that determining the ARARs applicability to the Site relies on professional judgment, and will consider environmental and technical factors at the Site. Determining whether an ARAR is applicable requires flexibility in the relevance and appropriateness determination. A requirement may be relevant, in that it covers situations similar to that at the Site but may not be appropriate for various reasons not suited to the Site. In some situations, only portions of a requirement or regulation may be judged relevant and appropriate. If a requirement is applicable all substantive parts must be followed.

The *EPA CERCLA/SUPERFUND Orientation Manual* (EPA, 1992) further describes the -two-step procedure to determine whether a requirement is relevant and appropriate. First, to determine relevance, the requirement must address problems or situations sufficiently similar to the circumstances of the proposed response action. Second, for appropriateness, the determination must be made as to whether the requirement would also be well suited to the conditions of the Site. As stated earlier, in some cases only a portion of a requirement will be both relevant and appropriate. Once a requirement is deemed relevant and appropriate, it must be attained (or waived). If a requirement is not both relevant and appropriate, it is not an ARAR. This procedure is further defined in the *EPA CERCLA Compliance with Other Laws Manual Interim Final* (EPA, 1988a).

Only the substantive requirements (i.e., compliance with numerical standards, use of control/containment equipment, etc.) associated with ARARs apply to CERCLA on-site activities. According to CERCLA Section 121[e] [1], ARARs associated with administrative requirements, such as permitting, are not applicable to CERCLA on-site activities. In general, the CERCLA permitting exemption will be extended to all remedial activities conducted in the BPSOU. This Site RD incorporates the substantive requirements; the action-specific ARARs identified in the BPSOU CD.

3.2 Chemical-Specific ARARs

This section describes compliance of the Site RD with all the chemical-specific ARARs as outlined in Table 5.

3.2.1 Solid Media ARARs

The RAOs for solid media (COC-impacted soils, indoor dust, waste rock, and tailings) containing COCs are outlined by EPA in the BPSOU CD. The RAOs have been outlined in Section 5.2.

To comply with the RAOs for solids, waste materials within the agreed waste removal corridor will be removed, as feasible. The waste removal corridor is an average width of 275 feet from the toe of the BNSF railroad grade along the south of the Site and the north extent varies as required to remove waste materials that exceed the waste identification criteria in Table 1 while avoiding disturbance to Site features such as the manganese ore bins. The waste removal depth was generally designed to extend to the maximum depth of waste materials within the waste removal corridor. The waste removal corridor and depth of excavation are shown on the Construction Drawings. The horizontal and vertical delineation of tailings, waste and COC-impacted soils, and other waste along with an evaluation of critical infrastructure is being performed as part of this RD. Critical infrastructure will be protected during removals, and removal of waste around the critical infrastructure is not required as part of this RD.

In addition to the RAOs outlined in the BPSOU CD, the BPSOU SOW requires that all soils encountered during the RA that are impacted with organic pollutants (petroleum compounds, PCBs, PCP, and dioxins) above Site-specific action levels will also be removed and disposed of at an appropriate permitted facility. As part of the RD, DEQ RBSLs (Table 4) have been used to identify petroleum-impacted soils within the Site in accordance with the DEQ RBCA Guidance (DEQ, 2018a). Additional sampling will occur as part of the Phase III Site Investigation to determine if there are soils within the Site impacted with PCBs above Site-specific action levels. Based on historical information, it is not anticipated that soil within the Site will be impacted with PCP or dioxins. As the design progresses, Site-specific action levels will be determined based on data evaluation results from Site investigations. These Site-specific action levels will be described in the PDI ER and incorporated into the Intermediate 60% RD Report.

The PDI sampling is being conducted to define the removal areas. Data collected during the Phase I Site Investigation has been incorporated into this RD. Additional data are being collected as part of the Phase II and Phase III Site Investigations. The results of these additional Site investigations will be incorporated into the Intermediate 60% RD Report.

Removed tailings, wastes, and COC-impacted soils will be segregated and disposed of at a repository approved by EPA and in consultation with DEQ. The repository will be defined, along with the associated haul route(s), in upcoming project submittals. Inert, solid waste and construction debris may remain on the Site for use as backfill as long as it meets the requirements listed in Table 2. All other municipal wastes, if encountered at the Site, will be segregated and disposed of at an appropriate permitted facility. Materials meeting the general fill Criteria B in Table 2 will be reused on the Site. All soil cap materials used on the Site will meet the engineered caps material suitability criteria listed in Table 3. A management plan for soil impacted with select organic pollutants (petroleum compounds, PCBs, PCP, and dioxins) above Site-specific action levels will be included with the Intermediate 60% RD Report.

3.2.2 Groundwater ARARs (Safe Drinking Water Act)

3.2.2.1 COC-Impacted Groundwater

As outlined in the BPSOU CD, the National Primary Drinking Water Regulations (40 Code of Federal Regulations [CFR] Part 141), better known as maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs), are not applicable to groundwater within the Site because there are no performance standards for groundwater in the area of the BPSOU alluvial aquifer that are covered by the TI waiver boundary.

EPA determined that a waiver of groundwater standards was appropriate for the area within the zone defined in the TI evaluation for the BPSOU (EPA, 2006) for all standards. The waiver is based on section 121(d)(4)(C) of CERCLA, 42 U.S.C. Section 9621(d)(4)(C) and corresponding National Contingency Plan (NCP) provisions. Outside of the TI waiver zone, the standards do apply. EPA also noted that the aquifer discharges to SBC, which is designated as a potential source of drinking water. Because SBC is a potential source of drinking water, these standards are relevant and appropriate for that surface water as well.

Standards such as the MCL and MCLG are promulgated pursuant to both federal and state law (EPA, 2021). Under the Safe Drinking Water Act, EPA has granted the State of Montana primacy in implementation of the Safe Drinking Water Act. The State has promulgated its own public water supply groundwater standards through the Public Water Safety Act for most COCs, primarily through incorporation by reference of the federal standard (DEQ, 2019). The following standards for the Site, identified in the BPSOU CD, are no less stringent than the federally promulgated MCLs or non-zero MCLGs:

2006 BPSOU ROD Groundwater Action Levels

Contaminant of Concern	Standard (Dissolved)
Arsenic	10 µg/L
Cadmium	5 µg/L
Copper	1,300 µg/L
Lead	15 µg/L
Mercury	2 µg/L
Zinc	2,000 µg/L

µg/L – micrograms per Liter.

All retained or created COC-impacted waters associated with the implementation of the Site RA activities will be treated chemically for the identified BPSOU COCs, potential hydrogen (pH), and turbidity, with the exception of construction water meeting temporary variance standards (Section 3.2.3.2). For this Preliminary 30% RD, it has been assumed that water from construction dewatering will be managed in accordance with ARARs at time of construction.

3.2.2.2 Groundwater Impacted with Organic Pollutants

As required by the BPSOU SOW (Appendix D to the BPSOU CD), any groundwater encountered within the Site that is impacted with select organic pollutants (petroleum compounds, PCBs, PCP, and dioxins) above Site-specific action levels will be properly addressed during the RA. As part of the RD, DEQ RBSLs along with DEQ-7 groundwater standards (Table 4) have been used to identify impacted groundwater within the Site only as a screening step. Atlantic Richfield intends to propose Site-specific action levels based on data collected from site investigation activities that would trigger the need for management of the groundwater. The Site-specific action levels will be detailed in the Intermediate 60% RD Report.

All retained or created impacted waters associated with the implementation of the Site RA activities will be treated, as necessary, to meet the applicable ARARs for organic pollutants (petroleum compounds, PCBs, PCP, and dioxins). For this Preliminary 30% RD, it has been assumed that water from construction dewatering will be treated for organic pollutants prior to being conveyed to the BTL for metals treatment. Further details on the management of impacted groundwater will be detailed in the Intermediate 60% RD Report.

3.2.3 Surface Water ARARs

3.2.3.1 Ambient Water Quality Standards

As outlined in the BPSOU CD, the CERCLA and the NCP provide that federal water pollution criteria that match designated or anticipated surface water uses are the usual surface water standards to be used at Superfund cleanups, as relevant and appropriate standards, unless the state has promulgated surface water quality standards pursuant to the delegated state water quality act. The State of Montana has promulgated specific numeric surface water quality standards, which are detailed in the Circular DEQ-7 document (DEQ, 2019). The applicable organic pollutant surface water quality standards from the Circular DEQ-7 document are included in Table 4.

The BPSOU CD sets the COC-performance standards for in-stream surface water quality at downstream compliance stations SS-06G and SS-07. Performance standards have been provided for base flow and normal high flow conditions (chronic standards) along with wet weather events (acute standards) in the 2020 ROD Amendment (Appendix A to the BPSOU CD, Table 1 and Table 2). Surface water performance standards for COCs identified in the BPSOU CD are listed below.

In-Stream Surface Water Performance Standards

Contaminant of Concern	Chronic Standard	Acute Standard
Aluminum	87 µg/L, dissolved	750 µg/L, dissolved
Arsenic	10 µg/L, total	340 µg/L, total
Cadmium	0.26 µg/L, total	0.49 µg/L, total
Copper	2.85 µg/L, total	3.6 µg/L, dissolved
Iron	1,000 µg/L, total	No Standard
Lead	0.545 µg/L, total	13.98 µg/L, total
Mercury	0.05 µg/L, total	1.7 µg/L, total
Silver	No Standard	0.374 µg/L, total
Zinc	37 µg/L, total	36 µg/L, dissolved

µg/L = micrograms per Liter. total = total recoverable

Note: Chronic and acute standards are from Table 1 and Table 2 of the 2020 ROD Amendment (Appendix A to the BPSOU CD [EPA, 2020]), respectively. Chronic standards for cadmium, copper, lead and zinc and acute standards for cadmium, copper, lead, silver, and zinc are hardness-dependent. Values shown are calculated at a hardness of 25 milligrams per liter. Formulas to obtain chronic standards are included in the 2020 ROD Amendment (Appendix A to the BPSOU CD).

Because total recoverable copper and zinc are highly unlikely to meet acute standards during most wet weather flow conditions, these standards are waived as technically impracticable and replaced with federal recommended aquatic life criteria.

3.2.3.2 Point Source Discharges

As outlined in the BPSOU CD, for point source discharges of impacted water created by any BPSOU remediation activity, the applicable Clean Water Act standards would apply to those discharges. These include the general requirements and stormwater regulations found in 40 CFR Parts 122 and 125 (general conditions and industrial activity conditions). However, construction water meeting temporary variance standards (to be defined) will not require treatment (Attachment B.1 to Appendix D to the BPSOU CD) for COCs. The temporary variance standards along with protocols for management of the construction water will be defined in an updated Surface Water Monitoring QAPP.

During Site RA activities, Best Management Practices (BMPs) will be implemented to minimize or prevent any discharge of stormwater from the Site. The contractor's submitted Erosion Control Plan and/or Stormwater Pollution Prevention Plan (SWPPP) will detail the BMPs to be used during the Site RA activities. All retained or created impacted waters associated with the implementation of the Site RA activities that do not meet the temporary variance standards will be treated chemically for the identified BPSOU COCs, organic pollutants, pH, and turbidity.

For this Preliminary 30% RD, it has been assumed that any retained stormwater runoff will be managed along with construction dewatering waters and will not meet the temporary variance standards. Any water that does not meet these temporary variance standards will be treated at the BTL prior to discharge to surface water. If necessary, water will be treated for organic pollutants prior to discharge to the BTL for treatment.

3.2.4 Air ARARs (Clean Air Act)

These standards, promulgated pursuant to section 109 of the Clean Air Act, are applicable to releases into the air from any BPSOU cleanup activities, as listed below.

1. Lead: No person shall cause or contribute to concentrations of lead in the ambient air which exceeds 0.15 micrograms per cubic meter ($\mu g/m^3$) of air, measured over a rolling 3-month average.

2. Particulate matter that is 10 microns in diameter or smaller (PM-10): No person shall cause or contribute to concentrations of PM-10 in the ambient air which exceed:

    a. 150 $\mu g/m^3$ of air, 24-hour average, no more than 1 expected exceedance per calendar year;
    b. 50 $\mu g/m^3$ of air, annual average.

3. Particulate matter that is 2.5 microns in diameter or smaller (PM-2.5): No person shall cause or contribute to concentrations of PM-2.5 in the ambient air which exceed:

    a. 35 $\mu g/m^3$ of air, 98^{th} percentile, averaged over 3 years;
    b. 12.0 $\mu g/m^3$ of air, annual arithmetic mean, averaged over three years.

These standards are incorporated by reference into the ARM (ARM 17.8.202) as part of a federally approved State Implementation Plan (SIP), pursuant to the Clean Air Act of Montana, 75-2-101 et seq. Montana Code Annotated (MCA). Corresponding federal regulations are found at 40 CFR 50.

Ambient air standards under section 109 of the Clean Air Act are also promulgated for carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and ozone. If emissions of these compounds were to occur at the Site in connection with any cleanup action, these standards would also be applicable. See 40 CFR Part 50.

Compliance of the Clean Air Act are appropriate and relevant for the Site RD. Proposed compliance of the Clean Air Act is discussed in detail under the action-specific ARARs in Section 3.4.4.

3.3 Location-Specific ARARs

This section describes compliance of the Site RA with all location-specific ARARs as outlined in Table 5.

3.3.1 Endangered and Threatened Species

Compliance with this ARAR at the time of the original 2006 BPSOU ROD (Appendix A to the BPSOU CD) involved consultation with U.S. Fish and Wildlife Service (USFWS) to determine the presence of listed or proposed species or critical habitats present within the BPSOU. The USFWS indicated that general and informal consultation only was required, and a full biological assessment and biological opinion was not necessary. In July 1993, ARCO published a report titled *Wetlands and Threatened/Endangered Species Inventory with Determination of Functionally Effective Wetland Area* (ARCO, 1993). The bald eagle and the peregrine falcon were identified as potentially existing within the BPSOU. Section 3.3.2 and 3.3.3 describe protection of the migratory birds and bald eagle, respectively. Subsequently, the bull trout was listed by the USFWS as a threatened species.

Atlantic Richfield will contact the USFWS prior to any RA activities to identify any list or proposed species or critical habitats present within the Site. Atlantic Richfield will ensure that the Site RA activities are completed in a manner the protects any listed or proposed species or critical habitats identified.

3.3.2 Migratory Bird Treaty Act

Atlantic Richfield will coordinate a migratory bird nesting survey(s) to determine the presence of migratory birds. The survey(s) will be completed no more than 20 days prior to the commencement of clearing and grubbing activities that occur between April 1 and August 1. If nests are present within work zones, the contractor will place "no disturbance" buffers in the specific areas, as directed by an Atlantic Richfield representative, and construction activities within these buffers will be prohibited until either the nest has been abandoned or until August 1 (the end of the nesting season).

Atlantic Richfield will ensure that the Site RA activities are completed in a manner that avoids the taking or killing of protected migratory bird species: individual birds or their nests or eggs. With this approach, this Preliminary 30% RD meets the substantive requirements within the Migratory Bird Treaty Act as one of the ARARs.

3.3.3 Bald and Golden Eagle Protection Act

Atlantic Richfield will ensure that the Site RA activities meet the requirements of the Bald and Golden Eagle Protection Act by preventing the unpermitted taking, possession, sale, purchase, barter, offer to sell, offer to purchase, offer to barter, transport, or export or import of any bald or golden eagle, alive or dead, including any part, nest, or egg. If a bald or golden eagle is harmed during activities at the Site, EPA and USFWS will be notified immediately.

3.3.4 Wetlands

The USFWS National Wetland Inventory (NWI) mapping (www.fws.gov/wetlands/data/Mapper.html) for this area was reviewed to identify potential wetlands within the Site. The NWI mapping provides reconnaissance level information on the location, type, and size of wetlands in the U.S. Maps are prepared from the analysis of high-altitude imagery and wetlands are identified based on vegetation, visible hydrology, and geography. No jurisdictional wetlands were identified within the RA boundary.

In June of 2019, Pioneer conducted a wetlands assessment to determine Functional Evaluation Wetlands Area (FEWA) units (defined as delineated wetland acreage adjusted by an overall rating for functional value) at the Site. For the purpose of the FEWA evaluation, methods set forth in the *U.S. Army Corps of Engineers (USACE) Wetland Delineation Manual* (Environmental Laboratory, 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region* (USACE, 2010) were used. In total, 3.14 acres of wetland areas were identified and mapped within the Site. The full wetland delineation report is included in the PDI ER.

The proposed end land use will include the reconstruction of SBC and 100-year floodplain riparian area, as well as create an upland environment within the Site for future use by the public. Approximately five years following construction, the Site will be re-delineated, and re-evaluated to determine the post-construction FEWA scores in accordance with the “no net loss” Superfund goal for wetlands. Due to the nature of the project, it is anticipated that from pre- to post-construction, wetland acreage and function will improve. If there is a net wetland loss, Atlantic Richfield will assess options for mitigation/offset within the upper Clark Fork River Superfund Sites watershed.

3.3.5 National Historic Preservation Act

Compliance with the National Historic Preservation Act was described in the First and Second Programmatic Agreements (Programmatic Agreement, April 6,1992, and Second Programmatic Agreement, December 14, 1994). The First and Second Programmatic Agreements were developed to provide appropriate protection of historic properties as allowed under 36 CFR 800.14. The Second Programmatic Agreement also provides the notification and consultation process that will be implemented at the Site for unanticipated cultural resources found during construction.

A cultural resource inventory will be performed prior to RA activities to identify any historic features within the Site based on the current Site conditions. A Cultural Resource Report will be provided as part of the RD, as an attachment to the RAWP, and will document all the inventory results, Site evaluation, and recommendations.

3.3.6 Archaeological and Historic Preservation Act

Compliance with the Archaeological and Historical Preservation Act will be the same as discussed in Section 3.3.5.

3.3.7 Resource Conservation and Recovery Act

A repository will be required to properly dispose of the wastes from the Site. As specified in the BPSOU SOW (Appendix D to the BPSOU CD), the repository will be located outside the 100--year flood plains of Blacktail Creek and SBC and will comply with the siting restrictions and conditions in 40 CFR 264.18 (a) and (b). The repository will be defined, along with the associated haul route(s), in forthcoming project submittals.

3.3.8 Historic Sites, Buildings, and Antiquities Act

The Site is located within the Smelter District Historic Neighborhood, and a small portion of the north area is inside of what has been defined as the National Historic Landmark District in the *Butte-Silver Bow County Comprehensive Historic Preservation Plan* (BSB, 2014). The Site had multiple industrial operations, mainly ore stockpiling, milling, and smelting, and continues to operate as an asphalt plant; the plan will be relocated prior to remedial construction. Most of the infrastructure was removed after industrial operations ceased, but some remains as discussed in Section 1.4.2.

A cultural resource inventory was conducted in 1991 (GCM Services, Inc., 1991) to identify remaining features as described in Section 2.1. An additional, more recent, cultural resource inventory will be performed as part of the RD to identify any historic features within the Site based on the current Site conditions. A Cultural Resource Report will be provided prior to the Intermediate 60% RD Report, as an attachment to the PDI ER, which will document all the inventory results, Site evaluations, and recommendations.

Currently, the RD includes preservation of a majority of the slag walls within the Site and an existing ore bin structure assumed to be from the manganese plant. However, this is dependent on further evaluation of waste removal within the Site and results from the Cultural Resource Report. Further detail on the avoidance, preservation in place, and/or impact mitigation of historical features will be defined in the Intermediate 60% RD Report. If unknown antiquities are encountered during the Site RA activities, the same notification and consultation process outlined in the Second Programmatic Agreement (Section 3.3.5) will be implemented.

3.3.9 Native American Grave Protection and Repatriation Act

If, during the Site RA activities, there is an unanticipated discovery of Native American human remains or related objects, the RA activities within the discovery area will be stopped and EPA, DEQ, and appropriate Indian tribes will be notified of the discovery. After the discovery, the response activity will cease, and a reasonable effort made to protect the Native American human remains or related objects. Depending on the facts of the discovery and location, RA activities may later resume.

3.3.10 Fish and Wildlife Coordination Act

Fish and wildlife coordination standards are found at 16 U.S.C. 661 et seq. and 40 CFR 6.302(g). They require that federally funded or authorized projects ensure that any modification of any stream or other water body affected by a federally funded or authorized action provide for adequate protection of fish and wildlife resources. The Site RA activities require modification of SBC, therefore compliance of the Fish and Wildlife Coordination Act must be met. Compliance incudes EPA, USFWS, and the State of Montana Department of Fish, Wildlife, and Parks consultation to ensure cleanup selection, implementation, and other measures are identified to achieve compliance. The purpose of consultation is to develop measures to prevent, mitigate, or compensate for project-related losses to fish and wildlife. Mitigative measures must be performed by the individuals who implement any selected remedy.

3.3.11 Floodplain Management Order

The floodplain management order requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,988) mandates that federally funded or authorized actions within the 100-year floodplain avoid, to the maximum extent possible, adverse impacts associated with development of a floodplain. Compliance with this requirement is detailed in EPA's August 6, 1985 *Policy on Floodplains and Wetlands Assessments for CERCLA Actions*. If the selected RA adversely impacts the SBC floodplain, specific measures to minimize adverse impacts may be identified following EPA consultation with the appropriate agencies.

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 will identify measures that will be taken to ensure that the substantive requirements of the Joint Application and applicable requirements are met during the RA activities. Protection of the environment during RA activities will be addressed through implementation of short-term construction BMPs. General descriptions of the BMPs to be implemented to minimize the project impacts to the floodplain/wetland area within the Site are provided in Section 6.8.

The Federal Emergency Management Agency (FEMA) Flood Map Service Center was used to generate the official Flood Insurance Rate Map (FIRM) for the Site (Figure 5). The FEMA Flood Map Service Center is the official public source for flood hazard information to the National Flood Insurance Program (NFIP). Floodplains in BSB are regulated by Title 18 - Floodplain Regulations of the BSB Municipal Code. The most recent FIRMs for BSB were adopted in January of 2012 by the BSB Council of Commissioners to replace those issued in the 1980s. The FIRM for the Site was reviewed for the possible existence of floodplains in the vicinity (refer to Figure 5). The FIRM depicting the Site includes a Special Flood Hazard Area (SFHA) Zone A without base flood elevation. The Site RA activities include reconstruction of SBC and construction of a 100-year floodplain through the Site, therefore compliance of the Floodplain Management Order must be met.

3.3.12 Natural Streambed and Land Preservation Act

The Natural Streambed and Land Preservation Act *Sections 87-5-502 and 504, MCA, (substantive provisions only)* is a State of Montana location-specific ARAR. The act provides that a state agency or subdivision shall not construct, modify, operate, maintain, or fail to maintain any construction project or hydraulic project which may or will obstruct, damage, diminish, destroy, change, or modify the natural existing shape and form of any stream or its banks or tributaries in a manner that will adversely affect any fish or game habitat. The requirement that any such project must eliminate or diminish any adverse effect on fish or game habitat is applicable to the state in concurring upon any RAs to be conducted. *The Natural Streambed and Land Preservation Act of 1975, MCA 75-7-101 et seq*. includes substantive requirements and is applicable to private parties as well as government agencies.

Because the Site RA requires that Atlantic Richfield relocate SBC from its current location into a new alignment through the southern portion of the Site and construct the associated 100-year floodplain, the Natural Streambed and Land Preservation Act is considered an ARAR. While the administrative/procedural requirements, including the consent and approval requirement set forth in these statutes and regulations, are not ARARs, Atlantic Richfield intends to consult with the Montana Department of Fish, Wildlife and Parks and any conservation district or board of county commissioners (or consolidated city/county government) as provided in the referenced statutes, to assist in the evaluation of factors discussed above.

ARM 36.2.410 establishes minimum standards that are applicable because the planned RA alters or affects a streambed, including any channel change. The project will be designed and constructed using methods that minimize adverse impacts to the stream (both upstream and downstream) and future disturbances to the stream. All disturbed areas will be managed during construction and reclaimed after construction to minimize erosion. Temporary structures used during construction will be designed to handle high flows reasonably anticipated during the construction period. Temporary structures will be completely removed from the stream channel at the conclusion of construction and the area must be restored to a natural or stable condition. Channel alternation will be designed to provide hydrologic stability. Streambank vegetation will be protected except where removal of such vegetation is necessary for the completion of the project. When removal of vegetation is necessary, it will be kept to a minimum. Riprap, rock, and other material used in a project will be of adequate size, shape, and density and will be properly placed to protect the streambank from erosion. The project will also protect the use of water for any useful or beneficial purpose.

3.4 Action-Specific ARARs

The following sections discuss compliance of the Site RA with all action-specific ARARs as outlined in Table 5.

3.4.1 Hazardous Waste

The implementation of the Site RA is being conducted to remove mine wastes and COC-impacted native soils from within the average 275-foot wide corridor through the Site. Although the materials to be excavated from the Site are Bevill wastes that are not considered hazardous wastes, EPA has determined that Bevill wastes are solid wastes and thus are subject to Subtitle D requirements. Solid waste requirements, including the management, processing, waste handling, and disposal of non-municipal solid waste, are promulgated in the State of Montana, Solid Waste Management Rules and Standards, and are potentially applicable. The Site RA will require the removal, transport, and potential stockpiling of mine waste and COC-impacted native soils for final disposal at a repository to be identified in forthcoming project submittals. Stockpiling materials will comply with the requirements for waste management.

Construction of a repository for the Site RA activities will be in accordance with State of Montana, Solid Waste Management Rules and Standards. The repository and associated haul route(s) will be identified in forthcoming project submittals.

3.4.2 EPA Administered Permit Programs

The contractor's submitted Erosion Control Plan and/or SWPPP will fulfill the ARARs regarding the EPA-administered National Pollutant Discharge Elimination System (NPDES) permit program for water quality. The SWPPP will demonstrate compliance for water quality and will meet the substantive requirements of the NPDES permit. The contractor will submit this plan to Atlantic Richfield as part of the Environmental Protection Plan. Atlantic Richfield will approve the plan prior to construction activities starting. Refer to Section 3.2.3 for additional compliance with water quality criteria.

3.4.3 Groundwater

The excavation of wastes from the Site and reconstruction of SBC will require construction dewatering. Groundwater beneath the Site is within the TI waiver zone (EPA, 2006) and is not required to meet water quality standards (refer to Section 3.2.2 for more details). However, temporary variance standards may apply to water produced from dewatering activities (Section 3.2.3.2) to be discharged to SBC. All water produced from dewatering activities that does not meet the temporary variance standards will be treated chemically to meet the appropriate standards for COCs, pH, and turbidity prior to discharge to SBC. For this Preliminary 30% RD, it has been assumed that all water from construction dewatering will be treated at the BTL prior to discharge to surface water.

3.4.4 Air Quality

Various BMPs will be used to minimize dust emissions. Specifically, dust will be controlled primarily through proper watering of potential dust generation areas and applying water on haul roads. The construction contractor will monitor the Site activities to ensure dust is kept to a minimum and verify that no significant quantities of contaminants become airborne and migrate from the Site, as directed by an Atlantic Richfield representative. The construction contractor will complete air monitoring during the remedial activities for the following: PM-10, PM-2.5, and lead, arsenic, and asbestos. The contractor will submit a Dust Management Plan to Atlantic Richfield as part of the Environmental Protection Plan. Atlantic Richfield will approve the plan prior to construction activities starting.

Meteorological conditions, such as temperature and wind, will also be informally evaluated. These conditions will factor into Site operations to minimize dust generation and emissions. Water trucks will be used to suppress dust on temporary haul road and excavation sites when conditions and access warrant. Other techniques, such as the controlled loading of trucks and minimizing the agitation of materials during excavation and loading, will also be considered and applied where appropriate. All loads during transportation will be tarped.

These control measures for particulate matter will keep air quality in compliance with the primary and secondary air quality standards.

3.5 Permitting/Regulation Requirement

Only the substantive requirements (i.e., compliance with numerical standards, use of control/containment equipment, etc.) associated with ARARs apply to CERCLA on-site activities. According to CERCLA Section 121[e][1], ARARs associated with administrative requirements, such as permitting, are not applicable to CERCLA on-site activities. In general, the CERCLA permitting exemption will be extended to all remedial activities conducted in the BPSOU. The RD for the Site will incorporate the substantive requirements; in particular, the action-specific ARARs identified in the BPSOU CD.

4.0 CONCEPTUAL SITE MODEL

This section describes the BRW CSM. The CSM shows the current level of understanding of physical and contaminant conditions at the Site and is a key factor in developing a RA. Additional information regarding the Site and the recent data collection activities is discussed in Section 2.0. The following sections summarize the Site's COC sources, COC release mechanisms, and COC transport.

4.1 Impacted Materials

Mine waste materials located at the Site include fill and overburden, demolition debris from previous operations, tailings and other mine wastes (e.g., slag), and native alluvial sediments. The COCs at the Site are metals and metalloids that include arsenic, cadmium, copper, lead, zinc, and mercury. Additionally, soil and groundwater within the Site has been impacted with organic pollutants resulting from past industrial operations within and adjacent to the Site. The organic pollutants identified as a potential threat to human health and/or the environment include extractable petroleum hydrocarbons (EPH), volatile petroleum hydrocarbons (VPH), and polycyclic aromatic hydrocarbons (PAH). Initial data suggest that soil and groundwater within the Site are not impacted by PCB, PCP, or dioxins. However, additional data will be collected as part of the Phase II and Phase III Site Investigations prior to making this confirmation.

4.2 Release Mechanisms

The release of metals to the environment from mine waste materials at the Site is primarily associated with the movement of water through waste materials (i.e., surface water percolating through the mine wastes to groundwater and groundwater flowing through COC-impacted materials at the Site). The primary release mechanism is surface and groundwater flowing through waste materials and the dissolution of metals (arsenic, cadmium, copper, lead, and zinc) and organic pollutants into the water.

The primary release mechanism for organic pollutants (petroleum compounds, PCBs, PCPs, and dioxins) within the Site is associated with migration of petroleum products and movement of water through soil impacted with organic pollutants. However, unlike the migration of metal COCs throughout the Site, the migration of organic pollutants within the Site has not been fully confirmed. Additional details on the release mechanisms and potential exposure pathways for organic pollutants are included in the PDI ER and will be incorporated into the Intermediate 60% RD Report once the RBCA evaluation is complete.

4.3 Transport

The primary transport mechanisms of COC-impacted water and sediments are the percolation of surface water, the flow of groundwater through the aquifer beneath the Site, and stormwater runoff events as follows:

- Precipitation infiltrates directly into the Site and percolates through the tailings, mine wastes, and other material to the underlying shallow groundwater.
- During rainfall and rapid snowmelt, runoff from the Site and upgradient areas has the potential to carry suspended sediments and metals from the Site and/or through the Site as surface runoff into SBC.

The primary transport mechanisms of organic pollutants (petroleum compounds, PCBs, PCPs, and dioxins) within the Site are the flow of groundwater through the aquifer beneath the Site and percolation through impacted soils within the Site. However, unlike the transportation of metal COCs throughout the Site, the transportation of organic pollutants within the Site has not been fully confirmed. Additional details on the potential exposure pathways for organic pollutants are included in the PDI ER and will be incorporated into the Intermediate 60% RD Report once the RBCA evaluation is complete.

5.0 DESIGN CRITERIA

5.1 BPSOU Statement of Work Requirements

In general, the BPSOU SOW (Appendix D to the BPSOU CD) requires the removal of waste within a 275-foot average width corridor along the southern portion of the Site, managing groundwater through hydraulic control after removing the waste material, and rerouting SBC from its current path through the slag canyon on the northern portion of the Site through the excavated area. The following is a summary of the requirements of the BPSOU SOW that are applicable to the Site.

- *Tailings, Waste, Impacted Soils, Slag Excavation, Removal, and Disposal* - Tailings, waste, COC-impacted soils, and slag that exceed the Waste Identification Screening Criteria (Table 1) will be removed as feasible from within the waste removal corridor to a depth determined during RD.
    - The removal depth will generally include all tailings, waste, COC-impacted soils, and slag that exceed the Waste Identification Screening Criteria (Table 1). An excavation surface will be developed during the design and will consider the results of the Site investigations as well as construction limitations (e.g.,

dewatering capabilities, excavation slope stability, etc.). The excavation surface will be subject to EPA approval, with consultation from DEQ.

  - The width of the waste removal corridor will be an average of 275 feet beginning at the toe of the railroad extending north across the Site, and will be sufficient to accommodate the relocation of the reconstructed SBC and 100-year floodplain.
  - Removed tailings, waste, COC-impacted soils, and slag will be disposed of at a repository approved by EPA, in consultation with DEQ.
  - Municipal waste, timbers, and other construction debris will be disposed of at an appropriately permitted facility.
  - All soils encountered within the waste removal corridor that are impacted with select organic pollutants (petroleum compounds, PCBs, PCP, and dioxins) above Site-specific action levels will also be removed and disposed of at an appropriate permitted facility, or may be land-farmed at an appropriate location. The Site-specific action levels will be included in the Intermediate 60% RD Report.
  - Critical infrastructure (e.g., main utility services near Montana Street) will be protected during removal actions, and removal of waste around those features will not be required, as determined by EPA, in consultation with DEQ.
  - Removed tailings, waste, COC-impacted soils, and slag will be replaced to existing or appropriate elevations in and outside of the floodplain with material suitable for protection of SBC and for establishing native vegetation. These materials will meet the requirements as defined in Table 2 and Table 3.

- *Hydraulically Control and Treat COC-Impacted Groundwater within the Site* – The discharge of COC-impacted groundwater to surface water and sediments from the Site specifically, and BPSOU in general, will be appropriately controlled.
  - Control of COC-impacted groundwater may be required in areas where tailings, waste, and COC-impacted soils will be left in place to limit the discharge of COC-impacted groundwater to surface water and sediments. The extent and location(s) of groundwater control to be constructed will be determined following the Phase II and Phase III Site Investigations (Section 2.0).
  - Design of the initial hydraulic control system will be coordinated with other efforts to expand and optimize the current BPSOU groundwater remedy.
  - Any COC-impacted groundwater captured by the hydraulic control will be conveyed to a treatment system, whether the existing BTL system, a modified or expanded BTL system, or an alternative system approved by EPA, in consultation with DEQ.
  - Monitoring will be implemented to assess protection of surface waste and sediments as described in the BPSOU Surface Water Management Plan (SWMP) (Exhibit 1 to Attachment A to Appendix D to the BPSOU CD).

- *Realign SBC Below the Confluence with Blacktail Creek and Construct 100-Year Floodplain* – Relocate SBC and construct the associated 100-year floodplain in a new alignment through the Site, from Montana Street to the reconstructed LAO area.

    - The reconstructed creek will be located in the waste removal corridor and away from existing slag walls and associated impacted sediments.
    - The floodplain will be designed adequate to contain the peak flow resulting from a 100-year flood event with a minimum capacity to convey 493 cubic feet per second (cfs).
    - The reconstructed creek and 100-year floodplain will be isolated from remaining waste left in place at the Site. Soft armoring may be used to limit lateral migration within and at the margins of the reconstructed floodplain.
    - The reconstructed creek will be designed to aid in the hydraulic control of COC-impacted groundwater. Lining of the reconstructed creek may be considered to reduce capture and treatment of surface water.
    - The stream corridor will be constructed from suitable clean materials and using native riparian vegetation.
        - All replacement floodplain and in-stream materials will meet the requirements in Table 2 and Table 3, as applicable for the location of the material being replaced.
        - Streambed materials within the channel of the reconstructed creek must meet Criteria C in Table 2 if the sediments are at or above a two-foot scour depth with an added safety factor to be determined as part of the RD.

- *Regrade and Construct Cap(s)* – Regrading will be conducted outside of the waste removal corridor to produce a land surface acceptable for future land uses.
    - A cap will be constructed over the area where waste is left in place that will ensure protectiveness of human health and surface water. The cap will be constructed in accordance with Table 3.
    - The future land use will be coordinated with BSB and will be evaluated by EPA in consultation with DEQ by looking at information such as local ordinances and zoning, patterns of development in the area, and information from local planning officials and information provided by the public.

5.2 Remedial Action Objectives

The RAOs are the media-specific statements regarding the objectives to be achieved by the RA, and the remedial goals (RGs) are numerical cleanup goals (i.e., RA levels) for the environmental media. The RAOs for solid media (tailings, waste, COC-impacted soils, and slag), surface water, and groundwater are outlined in Section 8 of the 2006 BPSOU ROD (Appendix A to the BPSOU CD) and are summarized in the sections below. The RGs (i.e., RA levels) are included in Section 5.3.

5.2.1 Solid Media

The RAOs for solid media (contaminated soil, indoor dust, waste rock, and tailings) are outlined by EPA in Section 8 of the 2006 BPSOU ROD (Appendix A to the BPSOU CD), and are listed below.

- *"Prevent the ingestion of, direct contact with, and the inhalation of, contaminated soils, indoor dust, waste rock, and / or tailings or other process waste that would result in an unacceptable risk to human health assuming current or reasonably anticipated future land uses.*

- *Prevent releases of contaminated solid media to the extent that they will not result in an unacceptable risk to aquatic environmental receptors.*

- *Prevent releases of contaminated water from solids media that would result in exceedances of the Montana State Water Quality Standards for surface water.*

- *Prevent releases of contaminated water from solid media that would result in exceedances of the Montana State Water Quality Standards for groundwater, except where ARAR waivers are appropriate and other means to protect from associated risks are available.*

- *Remediate contaminated solid media to the extent that it will not result in an unacceptable risk to human health and/or aquatic environmental receptors.*

- *Prevent release of contaminated water from solid media that would result in degradation of surface water, in accordance with the surface water RGs."*

5.2.2 Surface Water

The RAOs listed in the 2006 BPSOU ROD for contaminated surface water remain unchanged for the 2020 ROD Amendment (BPSOU CD), except for the need to waive certain Circular DEQ-7 standards (DEQ, 2019), which will be replaced by federal water quality criteria. The surface water RAOs are:

- *"Prevent ingestion or direct contact with contaminated surface water that would result in an unacceptable risk to human health.*

- *Return surface water to a quality that supports its beneficial uses.*

- *Prevent source areas from releasing contaminants to surface water that would cause the receiving water to violate surface water ARARs and remedial goals (or replacement standards for ARARS appropriately waived) for the BPSOU and prevent degradation of downstream surface water sources, including during storm events.*

- *Ensure that point source discharges from any water treatment facility (e.g., water treatment plant, wetland) meet ARARs.*

- *Prevent further degradation of surface water.*

- *Meet or appropriately waive and replace the more restrictive of chronic aquatic life or human health standards for surface water identified in Circular DEQ-7 through the application of B-1 class standards."* B-1 class standards are as defined by the Montana Clean Water Act.

5.2.3 Groundwater

The RAOs for groundwater are outlined by EPA in Section 8 of the 2006 BPSOU ROD (Appendix A to the BPSOU CD), and are listed below.

- *"Prevent ingestion or direct contact with contaminated groundwater that would result in an unacceptable risk to human health.*
- *Prevent groundwater discharge that would lead to violations of surface water ARARs and RGs for the BPSOU.*
- *Prevent degradation of groundwater that exceeds current standards."*

5.3 Remedial Action Levels

5.3.1 Solid Media

The primary COCs for solid media in the BPSOU are arsenic and lead. The RA levels as outlined in the 2006 BPSOU ROD (Appendix A to the BPSOU CD) for arsenic and lead are as follows:

2006 BPSOU ROD Solid Media Action Levels

Contaminant of Concern	Exposure Scenario	Concentration
Lead	Residential	1,200 mg/kg
	Non-Residential	2,300 mg/kg
Arsenic	Residential	250 mg/kg
	Commercial	500 mg/kg
	Recreational	1,000 mg/kg

mg/kg = milligrams per kilogram.

The BPSOU SOW (Appendix D to the BPSOU CD) outlines the waste identification criteria (Table 1), the backfill material suitability criteria (Table 2), and the engineered caps material suitability criteria (Table 3).

For organic pollutants (petroleum compounds, PCBs, PCPs, and dioxins), Atlantic Richfield intends to identify Site-specific action levels through the RBCA evaluation process. Details on the RBCA evaluation process and Atlantic Richfield's current interpretation are included in the PDI ER. The Site-specific action levels will be submitted for Agency review and approval in the Intermediate 60% RD Report.

5.3.2 Surface Water

The primary COCs for surface water are aluminum, arsenic, cadmium, copper, iron, lead, mercury, silver, and zinc. The RA levels were updated with the 2020 ROD Amendment (Appendix A to the BPSOU CD) and are as follows:

In-Stream Surface Water Performance Standards

Contaminant of Concern	Chronic Standard	Acute Standard
Aluminum	87 µg/L, dissolved	750 µg/L, dissolved
Arsenic	10 µg/L, total	340 µg/L, total
Cadmium	0.26 µg/L, total	0.49 µg/L, total
Copper	2.85 µg/L, total	3.6 µg/L, dissolved
Iron	1,000 µg/L, total	No Standard
Lead	0.545 µg/L, total	13.98 µg/L, total
Mercury	0.05 µg/L, total	1.7 µg/L, total
Silver	No Standard	0.374 µg/L, total
Zinc	37 µg/L, total	36 µg/L, dissolved

µg/L = micrograms per Liter. total = total recoverable.
Note 1: Chronic and acute standards are from Table 1 and Table 2 of the 2020 ROD Amendment (Appendix A to the BPSOU CD [EPA, 2020]), respectively. Chronic standards for cadmium, copper, lead and zinc and acute standards for cadmium, copper, lead, silver, and zinc are hardness-dependent. Values shown are calculated at a hardness of 25 milligrams per liter. Formulas to obtain chronic standards are included in the 2020 ROD Amendment (Appendix A to the BPSOU CD).

For organic pollutants (petroleum compounds, PCBs, PCPs, and dioxins), Atlantic Richfield will comply with the applicable human health standards identified in the Circular DEQ-7 document (DEQ, 2019) (Table 4).

5.3.3 Groundwater

The primary COCs for groundwater in the BPSOU are arsenic, cadmium, copper, lead, mercury, and zinc. The RA levels as outlined in the 2006 BPSOU ROD (Appendix A to the BPSOU CD) are as follows:

2006 BPSOU ROD Groundwater Action Levels

Contaminant of Concern	Standard (Dissolved)
Arsenic	10 µg/L
Cadmium	5 µg/L
Copper	1,300 µg/L
Lead	15 µg/L
Mercury	2 µg/L
Zinc	2,000 µg/L

µg/L = microgram per Liter.

The above RA levels are waived for the alluvial aquifer within the Groundwater TI Waiver area (Figure 1). Because the Site is within the Groundwater TI Waiver area, the RA levels do not apply to the Site but are used as a reference for the design to delineate COC-impacted groundwater within the Site.

Per the BPSOU SOW (Appendix D to the BPSOU CD), the BRW hydraulic control must limit COC-impacted groundwater (within the Site specifically and BPSOU in general) from discharging to SBC and limit the loading of COCs in groundwater to sediments within SBC. For BPSOU, the primary goal is to prevent exceedances of surface water performance standards (Section 5.3.2) at performance and compliance monitoring stations, which are identified in the BPSOU SWMP (Exhibit 1 to Attachment A of the BPSOU SOW in the BPSOU CD). The following additional lines of evidence will provide data to evaluate the effectiveness of the groundwater control for the Site, as required by the BPSOU SWMP:

- Comparison of sediment concentrations to probable effects concentration threshold values identified in the BPSOU SWMP.
- Interpretation of groundwater gradients.
- Interpretation of groundwater quality as it relates to impacts to sediment and surface water quality.

For organic pollutants (petroleum compounds, PCBs, PCPs, and dioxins), Atlantic Richfield intends to identify Site-specific action levels through the RBCA evaluation process. Details on the RBCA evaluation process and Atlantic Richfield's current interpretation are included in the PDI ER. The Site-specific action levels will be submitted for Agency review and approval in the Intermediate 60% RD Report.

5.4 Other Design Criteria

5.4.1 BSB Public Works Criteria

The design of the stormwater components will follow the BSB Municipal Storm Water Engineering Standards (BSB, 2011), unless specific rational is described in Section 6.0 and approved by BSB. From the Municipal Storm Water Engineering Standards document, potential stormwater criteria relevant to the BRW design include:

- The methods set forth in Chapter 7.1.5 of the HEC-22 Urban Drainage Design Manual will be used for storm drain outfalls:
    - Flowline or invert elevation of the proposed outlet should be equal to or higher than the flowline of the outfall.
    - The starting point for the tailwater hydraulic grade line should be either the design tailwater elevation or the average of the critical depth and the height of the storm drain conduit (dc +D)/2, whichever is greater.

  The invert of any outfalls will discharge at the bankfull water surface elevation (2-year storm) in open channels or streams (note that this is different than bullet #1 of the HEC-22 Manual).
- Energy dissipation must be provided when exit velocities are in excess of 10 feet per second (ft/s).

- Minimum freeboard requirement for open channels will be 0.5 feet below the top of bank for the design flow rate.
- Outlet structure will be designed with debris barriers or trash racks to protect the outlet from blockage or plugging.
- The orientation of the outfall should be pointed in the downstream flow direction and must include considerations for scour at the outlet.

The BSB Public Works Department maintains *Material Specifications for: Water Mains, Water Service Lines, and Firelines* (BSB, 2015). The following criteria apply to any water service connection at BRW:

- Pipe will be made of copper, polyethylene, or polyvinyl chloride (PVC) and ductile-iron.
- If pipe extends over 100 feet from the BSB main, it is recommended that nothing smaller than a 1-inch service line be installed from the main to the curb cock.
- Contractor will refer to the materials specifications for installation, appurtenances, and service details.
- Trench will be dewatered if water is encountered.
- Minimum cover over top of pipe is 6.5 feet.
- Concrete reaction or thrust blocking will be applied at all tees, plugs, valves, reducers, caps, and at bends deflecting 11-1/4 degrees or more.
- All new valves will be placed on property lines and a minimum of 10 feet of new pipe will extend out of valve before coupling into existing steel mains.
- When a water pipe crosses within 18 inches to the top of a sewer pipe (sanitary and/or storm), the sewer must be installed or replaced with PVC pressure pipe (SDR21) for a distance of 10 feet on each side of the crossing. Also, one length of the water pressure pipe is to be centered over the point of the crossing. The top of the water pipe may be installed 18 inches or more below a sewer provided the sewer pipe is replaced or installed with pressure pipe and the pipe lengths are centered at the point of crossing as outlined above. The crossing will be backfilled with compacted gravel for support of each pipe.

The BSB Public Works Department provides criteria for minimum cover over sanitary sewer lines of 42 inches to prevent damage from frost. Montana *Circular DEQ-2 Design Standards for Public Sewage Systems* (DEQ, 2018b) prescribes a more restrictive cover of 48 inches, which will be maintained instead of the 42-inch cover.

5.4.2 NorthWestern Energy Utility Protection Requirements

Contractor will work in conjunction with Northwestern Energy to properly remove, relocate, or protect existing utilities at BRW. Utility protection requirements, including setbacks, minimum cover, and on-site personnel during construction, have not been provided by NorthWestern Energy at the time of this Preliminary 30% RD Report. In addition to any requirements by NorthWestern Energy, all Atlantic Richfield requirements will be maintained for ground disturbance and working near overhead power.

5.4.3 Floodway Criteria

The reconstructed portion of SBC and floodplain through the Site will meet the Montana Department of Natural Resources and Conservation (DNRC) Floodplain Management design criteria. The floodplain as defined by 44 CFR 59.1 is "*the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height*." The regulatory floodplain will be remapped after the RA construction activities are completed.

5.5 Design Assumptions

The RA design incorporates the following design assumptions:

- All BSB equipment and materials will be removed from the Site prior to RA construction activities, except for some materials that Atlantic Richfield may use as backfill during construction if the material meets the requirements listed in Table 2.
- The main utility lines along Montana Street will be avoided.
- The BPSOU subdrain pump system alternate discharge line is approximately 50 feet below the existing surface of the Site and will not be disturbed.
- A portion of the BPSOU subdrain pump system primary force main through the Site will be removed during excavation of the waste material and that portion of the line will be replaced, as required.
- A designated repository or repositories will be available for disposal of all waste materials removed from the Site.
- Use of railroad for transportation of wastes is not available.
- The Site will be secured by fencing for the duration of the RA construction activities.
- Waste materials will be conveyed to an approved repository location in street-legal trucks on public streets and highways. Other methods of waste material conveyance may be considered.
- Imported materials meeting the respective criteria are available and will be conveyed to the Site in street-legal trucks on public streets and highways.
- The Site will be regraded to accommodate construction of proposed end land features and amenities, which may include an amphitheater[2].
- Final cap in the uplands areas will consist of 6 inches of topsoil and 12 inches of Helehan borrow soils.
- End land use will be constructed in general accordance with the conceptual plan and guidance presented in the *Silver Bow Creek Conservation Area Master Plan* (LDI, 2020).

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[2] Design, construction, and operation and maintenance of amphitheater requires mutual agreement of Atlantic Richfield Company and Butte-Silver Bow, and identification and commitment of a third-party investor and operator.

- Public access to the completed Site will be allowed year-round, with certain areas designated for maintenance access only.
- Operation and maintenance of remedial features will be performed by Atlantic Richfield for the duration of the Compliance Determination Period and transferred to BSB thereafter as described in the RA operation and maintenance (O&M) Plan.
- Water from construction dewatering that meets temporary variance standards (Section 3.2.3.2) can be discharged directly to SBC. Water from construction dewatering that does not meet temporary variance standards will need to be treated appropriately prior to discharge.
- It is anticipated that construction activity will require dewatering of the aquifer to a minimum depth of 2 feet below design subgrades (refer to Figure 6) to accommodate equipment operation, excavation, and backfilling.
- Waste materials will remain in place adjacent to any existing infrastructure and utilities that will remain on Site and the areas will be capped with the appropriate type engineered cap.
- Management of groundwater and soil within the Site impacted by organic pollutants (petroleum compounds, PCBs, PCPs, and dioxins) above Site-specific action levels will be included as part of the RD and in a manner that is complementary with the remedy. Organic pollutants are secondary concerns for the Site. Soil and groundwater within the Site that have been impacted by these pollutants will be properly addressed/managed as part of the remedy. However, additional remediation of the soil and groundwater impacted with organic pollutants (i.e., treatment of organic pollutant sources) is not required by the BPSOU CD.

5.6 Design Constraints

The following are the design constraints associated with the RD for the Site:

- The railroad and right-of-way to the south of the Site cannot be disturbed.
- Waste removal and regrading design will accommodate preserving historical features (e.g., the manganese ore bins and slag walls) to the extent possible. Further detail on the avoidance, preservation in place, and/or impact mitigation of historical features will be defined in the Intermediate 60% RD Report.
- There is limited space for construction activities and stockpiling and staging of materials.
- Existing utility infrastructure includes electric, gas, water, sanitary sewer, communications, and the BPSOU subdrain pump system primary force main and alternate discharge line.
- Critical infrastructure near Montana Street will be protected and will limit the removal of waste and designed alignment of SBC at the east end of the Site.
- There is limited treatment capacity at BTL for both construction dewatering waters and COC-impacted groundwater captured with hydraulic control.

- Construction dewatering and hydraulic control must not adversely impact treatment efforts for PCP, dioxin, and other chemicals at adjacent sites and/or the extent of groundwater impacted with these chemicals.
- There is limited vertical grade available for reconstructed creek alignment options.
- End land use infrastructure must interface with surrounding city streets and tie into existing infrastructure and utilities.

5.7 Project Challenges

The following are the project challenges associated with the RD for the Site:

- Excavation depths exceed 20 feet bgs in some areas.
- Significant construction dewatering is required to lower the groundwater below the designed excavation surface to remove waste material and reconstruct SBC through the Site.
- There are pieces of infrastructure that may be challenging to remove with typical heavy equipment, specifically the stack foundation, the Blacktail Creek Flume, portions of the slag wall (particularly on the east side of the Site), and remaining building foundations.
- Transportation of wastes and imported materials on public streets and highways.
- Identification of potential repository locations within reasonable proximity of Site and associated haul route(s) that will be safe for both the public and truck drivers.
- Construction dewatering and hydraulic control must anticipate any potential impact from/to adjacent impacted areas (e.g., MPTP) and gains/losses of flow and load to/from the existing and relocated Silver Bow Creek reach.

6.0 DESIGN APPROACH

This section details the RD approach for the Site. Major elements of the design are presented with respect to the design criteria and project objectives. The major elements of the design as stated in the BPSOU SOW (Appendix D to the BPSOU CD) include the following:

- Remove and dispose of tailings, waste, COC-impacted soil, and slag excavation.
- Hydraulically control and treat COC-impacted groundwater within the Site.
- Realign SBC and construct 100-year floodplain.
- Regrade and construct engineered cap(s).

6.1 Excavation Designs

The primary objective for the excavation design is to remove waste materials that exceed the waste identification criteria (Table 1) extending to the modeled bottom of waste surface, as feasible within the average 275-foot wide corridor through the Site. The designed excavation will remove the required mine wastes (including slag and demolition debris), provide adequate area to accommodate the relocation of the reconstructed SBC and the 100-year floodplain, provide a stable subgrade for the construction of the new stream channel and floodplain, and be the foundation for future land use.

The list below summarizes the excavation design approach for the Site RA:

- Existing ground surface information was generated using information from a 2016 LiDAR survey and leveling out some of the ever-changing stockpile areas.
- Site characterization test pits, borehole drilling logs, and analytical results from the Phase I Site Investigation were used to generate a 3-dimensional statistical model to estimate the volume, distribution, and properties (i.e., COC concentrations) of solid materials (slag, demolition debris, ATO, and other) within the Site. The 3-dimensional model was created using the Leapfrog software. The model will be updated once the Phase II and Phase III Site Investigations are complete. The updated model will be included in an updated PDI ER, which will be submitted to Agencies for review approximately 30 days prior to the Intermediate 60% RD Report.
- The modeled extents were then imported into AutoCAD Civil3D where a constructable excavation surface was created.
    - The waste removal corridor is an average width of 275 feet from the toe of the BNSF railroad grade along the south of the Site. The northern extent varies as required to remove waste materials that exceed the waste identification criteria in Table 1 while avoiding disturbance to Site features such as the manganese ore bins and slag walls. To ensure the average width requirement is achieved, Atlantic Richfield calculated the surface area assuming a waste removal corridor that is 275 feet wide along the length of the Site (east to west), which is approximately 1,700 feet. Atlantic Richfield then ensured that the designed waste removal corridor (shown on Sheet C1.0 in the Construction Drawings) achieved the calculated surface area.
    - The waste removal depth was generally designed to extend to the maximum depth of waste materials within the waste removal corridor. Excavation depths were increased where required to accommodate construction of the end land use and obtain the optimal stream and floodplain design.
- Once the excavation surfaces were finalized, earthwork volumes were determined using both the average end method and the Triangular Irregular Network (TIN) surface comparison in AutoCAD®. The average end method averages volumes between cross sections by taking the average of 2 adjacent cross-sectional areas and multiplying it by the distance between the cross sections to determine the overall earthwork volumes between the 2 cross sections. The average end method information will be provided primarily to the contractor, so they know how much waste needs to be removed between stations. The TIN volumes are provided for comparison because that is typically the method used for final reporting of pay quantities; therefore, those are the volumes discussed in this report.
- Any additional excavation/regrading outside the waste corridor is considered "optional regrading" and not required as part of the BPSOU CD.

The removal of waste material within the Site will be to the design lines and grades as shown on the Construction Drawings. Atlantic Richfield does not intend to conduct any field confirmation sampling to ensure all waste materials are removed during the RA.

Excavation depths exceed 20 feet bgs in some areas. Excavation boundary slopes will generally be constructed with a maximum side slope of 2:1 horizontal:vertical (H:V). The waste removal corridor has an average width of 275 feet from the toe of the railroad extending north into the Site. Outside of the average 275-foot waste removal corridor, additional material may be excavated and/or regraded as needed to accommodate Site regrading for the designed end land use.

The current excavation design accommodates preserving historical features (e.g., the manganese ore bins and slag walls) to the extent possible. However, the preservation of the historical features depends on further evaluation of waste removal within the Site to ensure the remedy is effective, the results from a cultural resource inventory to be conducted in 2021, and completion of a structural evaluation to determine if the features are safe to preserve. During 2021, Atlantic Richfield will complete a cultural resource inventory of the Site to determine the historical significance of the various remaining structures within the Site. Atlantic Richfield will then determine the amount of material that will need to be left in place (both material that fails the waste criteria and material that is leachable to groundwater) to preserve the historic features. Atlantic Richfield will weigh the findings of the cultural resource inventory against the potential effects on the remedy of preserving the historic features and then determine whether the historical features will be preserved. Further detail on the avoidance, preservation in place, and/or impact mitigation of historical features will be defined in the Intermediate 60% RD Report.

Using AutoCAD Civil3D and the TIN surface comparison of the existing topographical surface with the excavation surface, the total excavation volume for the Site was estimated to be approximately 156,200 bcy. This estimated volume is slightly different then the values presented in the PDI ER from the Leapfrog model since AutoCAD Civil3D calculates volumes slightly differently and the excavation surface designed in AutoCAD Civil3D accounts for additional removal to construct the new stream channel and subgrade and incorporates construction feasible side slopes and grade along the deepest parts of the site.

6.1.1 Waste Repository Location(s)

Waste repository locations and associated haul route(s) are being evaluated at the time of this Preliminary 30% RD Report submittal. The information will be updated in upcoming project submittals once a designated repository site or sites has been selected.

6.1.2 Waste Transportation

Based on the total excavation volume for the Site, it is assumed that approximately 156,200 bcy of waste will be excavated, loaded, and hauled to an off-Site repository.

As part of the repository selection process, material transportation logistics will be analyzed to assess haul routes and the associated risks. In defining the haul routes to the repository, the goals will be to minimize hauling on public streets to the extent possible and develop a route that is safe for both the public and haul truck drivers. This may result in longer haul routes using less traveled streets, highways, and secondary roads and multiple handling. The haul routes or other alternative conveyance systems for the transportation of waste to the designated waste repository will be further defined in upcoming project submittals.

6.1.3 Construction Dewatering Design

It is anticipated that the construction activities occurring at the Site as part of the RA will require construction dewatering. Some of the waste materials to be excavated are below the water table, and heavy construction equipment will need to travel on the material safely and effectively at the bottom of the excavation. It is anticipated that construction activity will require dewatering the aquifer to a minimum of 2 feet below the design bottom of excavation to accommodate equipment operation, excavation, and backfilling. Initial reconnaissance of this area suggests that most of the Site construction area will require at least nominal construction dewatering, while deeper portions of the construction area may require that the water table be lowered by up to 16.5 feet (Figure 6). Because of this, it will be necessary to install an appropriate construction dewatering system.

Given the limited data available for the Site aquifer, a conceptual construction dewatering design has not been completed. It is anticipated that the Site dewatering design may include, but not be limited to, some or all of the following components:

1. Partial dewatering from additional specified hydraulic control system(s).
2. Dewatering wells and/or sumps.
3. Dewatering trenches.

To complete the dewatering design for the Intermediate 60% RD Report, Site characterization data gaps will be addressed during the Phase II Site Investigation (Section 2.2). The Phase II Site Investigation will collect the necessary information to design the construction dewatering design; therefore, the dewatering design will be further defined in the Intermediate 60% RD Report to include the following:

1. Selected construction dewatering system/technology (e.g., hydraulic control system, wells, etc.).
2. Anticipated range of flow rates necessary to effectively dewater to designed excavation depths that allow heavy construction equipment to travel on the material safely and effectively at the bottom of the excavation.
3. Plan for operation of the dewatering system during winter months, if needed.

4. Evaluation of treatment capacity at BTL, including suggested sequence of dewatering and/or excavation.
5. Assessment on how the selected construction dewatering system will affect the existing groundwater capture remedy, adjacent impacted areas (e.g., MPTP), and groundwater storage in the aquifer.

6.2 Backfill and Site Grading

Upon removal of waste material from the designated waste removal corridor, the Site will be regraded to accommodate the reconstructed portion of SBC through the Site as well as for end land use features and amenities. Additional regrading of material outside of the designated waste removal corridor will be conducted as required to achieve final Site grade. To achieve final Site grade, approximately 73,000 bcy of general fill material (Criteria B), 34,200 cy of upland cover material (Criteria E), 5,700 cy of riparian growth subsoil material (Criteria D), 11,400 cy of topsoil (Criteria D and E), and 1,700 cy of in-stream media (Criteria C) will be imported. Material criteria are listed in Table 2 and Table 3, and general construction detail for fill materials is shown on Sheet CD1.0 of the Construction Drawings. The Site regrading will require construction dewatering to accommodate the placement and compaction of backfill. Additional Site grading details will be provided in the Intermediate 60% RD Report.

6.2.1 Borrow Area

The general fill required for this project will be obtained from the Interstate Pit borrow area and/or another Atlantic Richfield-designated borrow area(s). The location of the Interstate Pit borrow area and respective haul route is identified on Sheet G5.1 of the Construction Drawings. If additional structural materials are required to complete the project, the contractor will be responsible for obtaining the materials from a local source approved by Atlantic Richfield. Imported general fill materials will meet the criteria outlined in the backfill material criteria in Table 2.

The road base materials will be obtained by the contractor from the West Side Soil rock quarry or local sources as approved by Atlantic Richfield. The contractor will be responsible for submitting the required sample results for review and approval. Road base materials will meet the gradations outlined in the Technical Specifications.

Other materials specified for this project will be obtained by the contractor from local sources as approved by Atlantic Richfield. The contractor will be responsible for submitting the required sample results for review and approval.

6.2.2 Engineered Cap

Activities for the project will require borrow materials that meet the engineered caps/cover system material suitability criteria (Table 3). The cover soil meeting the Upland Cover System (Criteria E) will be obtained from the Helehan borrow area. The cover soil meeting the meeting the Riparian Area Cover System (Criteria D) will be obtained from the Helehan borrow area, Racetrack topsoil stockpile, or Kaw Avenue topsoil stockpile. Any cover soil designated for use as an engineered cap/cover system on the Site will be sampled and the results provided to EPA for their approval, in consultation with DEQ, prior to project use.

The location of the Helehan borrow and respective haul route is identified on Sheet G5.0 of the Construction Drawings.

6.2.3 Geotechnical Stability Analysis

A geotechnical investigation is included in the BRW PDI WP (Atlantic Richfield Company, 2021c) as part of the Phase III Site Investigation. At the time of this Preliminary 30% RD Report, the results of that investigation have not yet been analyzed. The analysis will be completed and included in the Intermediate 60% RD Report.

6.3 Silver Bow Creek Reconstruction

Stream reconstruction of SBC through the Site includes the design of stream channel run sections that are similar to the reference reaches located immediately downstream of the Site adjacent to BTL/LAO and further downstream in subarea 1 west of Interstate 15/90. A hydrologic analysis report was completed for the Streamside Tailings Operable Unit (SST OU) in 2018 (Pioneer, 2018) and identified SBC as a channel run system. Consequently, the reconstruction design has been developed as a channel run system with a bankfull capacity equivalent to a flood with a 1.5-year recurrence interval ($Q_{1.5}$). The following sections provide the reconstruction details for the SBC design.

6.3.1 Hydrology and Hydraulics

There are nearly 30 years of stream flow gaging data available from U.S. Geological Survey (USGS) gaging stations located upstream (12323240 – Blacktail Creek at Butte MT) and downstream (12323250 – Silver Bow Creek Below Blacktail Creek at Butte MT) of the Site. Peak annual flow statistics from these gaging stations for the period of record from 1989 through 2017 have been used to complete a flood frequency analysis. The upstream gaging station (12323240) was discontinued on April 20, 2020, because treated discharge water from the Butte Mine Flooding Operable Unit (BMFOU) was being added to SBC just above the confluence with Blacktail Creek, and this added flow was affecting the rating curve at station 12323240 and thus making the flow readings erroneous. A new location was added downstream of the confluence with Blacktail Creek on June 11, 2020 (USGS 12323242 Silver Bow Creek at Montana Street, at Butte, MT); however, due to the short period of record, no data from station 12323242 have been used in this report. Peak flow measurements were used to estimate the flood recurrence intervals using the Weibull Plotting Position Formula, as described in *Guidelines for Determining Flood Flow Frequency Bulletin #17B* (USGS, 1982). Methods and procedures for the flood frequency analyses are described in detail in Appendix A.1.

The Weibull method requires a minimum of 10 years of data and uses the magnitude of historic peak flow measurements to estimate flood recurrence intervals at a gaged location. Historical flows are first ranked in order of magnitude to estimate the approximate flood recurrence interval of the recorded flow. Historical flows are then plotted against the estimated flood recurrence interval and a linear regression equation is developed to estimate peak flows corresponding to the desired flood recurrence interval. The BPSOU CD specifies that the floodplain be adequate to contain the peak flow resulting from a 100-year flood event with a minimum capacity to convey 493 cfs. The flood frequency analysis completed (Appendix A.1) for the upstream and downstream locations estimated an average 100-year flood event of 482 cfs, which is within 2.3% of the specified design flow.

One important consideration for these analyses is that they do not consider the detention / retention basins that will reduce the peak flows of storm flows from SBC east of its confluence with Blacktail Creek by temporarily detaining flows up to the 10-year storm flow. Removing these flows from the storm hydrograph will make the design flows more conservative. However, future growth and development within the watershed could lead to more impervious surfaces, which could over time, increase the runoff during storm events, so it is good to be conservative for floodplain design in this case. Treated water from the BMFOU is discharged into SBC immediately upstream of the confluence with Blacktail Creek. The treated flows from BMFOU are estimated at 15 cfs, which could approximately double the base flow in SBC. The channel is sized for the $Q_{1.5}$ flow of 122 cfs, which is conservative based on the upstream basins, so an additional 10 to 20 cfs of base flow will have little to no effect on the channel sizing. Additionally, there is a possibility for in-stream flow augmentation from an engineered SBC east (upstream) of its confluence with Blacktail Creek in a reserved corridor. Based on these considerations, the floodplain is designed to convey the 100-year event flow of 493 cfs as specified in the BPSOU CD.

Bankfull flows are typically defined as the incipient elevation on the streambank where flooding begins. The bankfull stage is associated with the flow that fills the channel to the top of its banks and water begins to enter the floodplain. The bankfull flow serves as the defined flow for channel sizing in the design and reconstruction of SBC. The USGS defines this bankfull stage as the $Q_{1.5}$ (predicted to occur one every 1.5 years) or the $Q_{2.33}$ (predicted to occur once every 2.33 years). For this design, a bankfull $Q_{1.5}$ flow recurrence of 122 cfs, as calculated using the flood frequency analysis of gage data (Appendix A.1), was used as the bankfull design flow rate for SBC reconstruction through the Site. As stated above, this flow rate is conservative because it is based on existing real-world data, and the RD will retain/detain a portion of these storm flows in the future.

The hydraulic properties of the reconstructed SBC were modeled using the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) software to ensure that the new stream channel design is within the parameters set forth by anticipated flow events for SBC. To streamline the iterative process of running HEC-RAS models and modifying the reconstructed surface grades in AutoCAD Civil 3D, GeoHecRas was used to import and export data directly to and from AutoCAD Civil 3D. Cross sections were imported from AutoCAD Civil 3D at evenly spaced stationing. Additional cross sections may be added, as necessary, into the HEC-RAS model in the Intermediate 60% RD to account for variability as the riffle, run, pool sections are refined within the design.

One-dimensional steady flow computations were performed for the 1.5, 5, 10, 25, and 100-year flow recurrences to estimate velocities, shear stresses, and sediment transport capacity within the reconstructed SBC. The HEC-RAS model calculated velocities ranging from 2.9 ft/sec to 7.9 ft/sec. The highest velocities occurred during the highest flow recurrence (Q_{100}) within the channel. An average channel velocity of 4.2 ft/sec was calculated for the $Q_{1.5}$ in channel run sections. The HEC-RAS model calculated shear stresses in the channel ranging from 0.20 pounds per square foot (lb/sq ft) to 1.26 lb/sq ft. Calculations from the reconstructed SBC HEC-RAS model are shown in Appendix A.2.

Reconstructed stream channel bedding sizing was completed using the U.S. Bureau of Reclamation (USBR) *Reclamation Managing Water in the West Rock Ramp Design Guidelines* (USBR, 2007). This document recommends sizing step rocks using USACE methods for "*steep slope riprap design*." This method uses the slope of the channel and unit discharge to calculate a recommended minimum rock size (D_{30}) for step rock sizing as shown in Appendix A.2. Using the $Q_{1.5}$ modeled channel flow properties, the riprap sizing methods results in a maximum D100 stone size equal to 6 inches. Using the Q_{100} modeled channel flow properties, the riprap sizing method results in a riprap maximum D_{100} stone size equal to 9 inches. The reconstructed stream channel armor will be specified to have a maximum D_{100} equal to 9 inches. The armor will be keyed into a minimum depth of 2 times the D_{50} or approximately 18 inches. These details may be further refined in the Intermediate 60% RD.

6.3.2 Streambanks and Stream Channel Sections

The reconstruction of SBC through the Site includes the design of stream channel sections that are similar to the sections observed in the downstream reference reach running through LAO as shown on Figure 2. The reference reach is a riffle-pool-run system reach with a sinuosity of 1.25 and an average gradient of 0.3%. The reference reach is stable due to heavy vegetation and woody debris, but it does have a mobile substrate. Dense vegetation exists along the streambanks in the reference reach, which provides some overhead cover for fish.

The designed stream channel sections include construction of typical channel sections. Existing conditions, reference reach assessment, and channel grades were the determining factors in the decision to create a riffle-pool-run system. The preliminary streambank design is shown on Sheet CD1.0 of the Construction Drawings, and more construction details will be incorporated into the Intermediate 60% RD Report. The streambed material will consist of 9-inch minus cobbles and gravel bedding materials. Amended cover soil placed in the floodplain will be blended to the edge and into the installed riprap, creating a smooth transition from the streambank to the floodplain. Amended cover soils blended into the installed riprap will provide planting locations for riparian seeding and plantings within the streambank. Over time, the additional floodplain area adjacent to the reconstructed SBC will promote a more naturally functioning stream channel and floodplain system through the Site.

Special considerations were incorporated into the design to appropriately size and stabilize the SBC channel. A new stream channel alignment design for SBC through the Site is shown on Sheets C3.0 and C3.1 of the Construction Drawings. The location of the proposed stream alignment was selected, in part, because it will maximize the floodplain area adjacent to the reconstructed stream channel and aligns with the waste removal corridor.

Channel run sections, as shown in Sheets C3.0 through C3.1 of the Construction Drawings, will be used to reconstruct the stream channel. Riffles and pools will be added with more detail in the Intermediate 60% RD Report. The reconstructed stream channel design provides the basis for a semi-stable stream channel, with deformable banks, which over time will function as a natural stream with sediment transport and deposition. It is anticipated that any excessive sediment deposited within the stream channel will be flushed downstream during the next high-water event. Removing the mine waste and COC-impacted native soils at the Site removes the potential for recontamination from localized sediments. Soft armoring may be necessary along the 100-year floodplain boundary or waste removal corridor boundary to ensure stability of the railroad to the south, the proposed RA infrastructure to the north (i.e., trails, parking, amenities, etc.), and remaining COC-impacted materials. It is important to protect the infrastructure and this armoring will allow the stream to migrate within the floodplain over time while ensuring that the stream channel stays within the waste removal corridor. The RA effectiveness monitoring will monitor SBC sediments at the Site post RA.

6.3.3 Riparian Seeding and Planting

Short-term revegetation/stabilization will consist of placing amended cover soil and hand-broadcasting riparian seed to provide vegetative growth along the streambanks. During streambank construction, the soils will be seeded using a riparian seed mix that will be defined in the Intermediate 60% RD Report. Riparian tubelings will also be strategically planted along the streambank edge and typically at the boundary of the 5- to 10-year flow level. Tubelings varieties will be defined in the Intermediate 60% RD Report.

6.4 Hydraulic Control

The BPSOU SOW (Appendix D to the BPSOU CD) specifies hydraulic control, as follows:

"*...control of contaminated groundwater is required in areas where all tailings, wastes, and contaminated soils have not been removed to limit contaminated groundwater from impacting surface water and sediments. Depending on the findings of further investigation, control of groundwater may be accomplished by hydraulic capture and treatment, and/or other methods to be approved by EPA in consultation with DEQ.*

...Any groundwater collected shall be conveyed to a treatment system, whether the existing BTL system, a modified or expanded BTL system, or an alternative system as approved by EPA, in consultation with DEQ."

6.4.1 Hydraulic Control Technologies

An evaluation of hydraulic control technologies will be completed as per the guidance in Chapter 4 of the *Guidance for Conducting Remedial Investigations* [RI] *and Feasibility Studies* [FS] *Under CERCLA* (EPA, 1988b; referred to herein as RI/FS Guidance). The screening evaluation will include the following objectives:

- Identify the source and location of groundwater requiring control.
- Develop potential alternate process options for groundwater within BPSOU, following criteria provided in the RI/FS Guidance.
- Select viable and applicable technologies from the initial development of potential technologies.
- Screen the technologies using the RI/FS Guidance criteria, effectiveness, implementability, and cost via technology-specific literature review.
- Summarize the results of the screening evaluation and provide the rationale for focusing the screening-level technologies.

As per the RI/FS Guidance, availability, reliability, and maintainability will be used in the comparative analysis. The screening evaluation will be provided to Agencies for their review and approval as the Phase II and Phase III Site Investigations are completed. As the Site Investigations are completed, Atlantic Richfield will revise the PDI ER. The completed PDI ER will be submitted to Agencies for review approximately 30 days prior to the submittal of the Intermediate 60% RD Report.

6.4.2 Hydraulic Control Modeling

Preliminary modeling and assumptions were used to evaluate potential hydraulic control alternatives. The Phase II and Phase III Site Investigations will collect additional data needed to determine the hydraulic properties of the aquifer in the conceptual area of the hydraulic control remedy component. The data collected will be used to support refinement of the model and select the final hydraulic control remedy component at the Site.

The primary objectives of the hydraulic control modeling are to effectively simulate options with respect to the construction dewatering design (Section 6.1.3) and the hydraulic control design (Section 6.4.1). To accomplish this, the model will need to represent key characteristics of the Site with respect to groundwater and surface water as well as the distribution of COCs. The general steps in completing this model will include, at a minimum, the following:

1. Development of a groundwater conceptual model and numerical model to provide estimates of the following:
    a. Flux of groundwater and load of COCs traveling through the Site.
    b. Interaction with adjacent surface water in SBC.
    c. Location and volume of materials that leach notable quantity of COCs.
    d. Location and quantities of upgradient COCs entering the Site.
2. Construction and calibration of the numerical groundwater model that has sufficient detail to estimate effects from the following:
    a. Seasonal and long-term groundwater elevation fluctuations.
    b. Effectiveness of various construction dewatering technologies (pumping wells, dewatering trenches, French drains, etc.).
    c. Removal of groundwater from storage during construction dewatering.

   d. Winter operations.
   e. Quantity of water requiring treatment during construction.
   f. Evaluation of the preferred sequence of material excavation.
3. Evaluation of options for construction dewatering and hydraulic control will include the following:
   a. Effectiveness at meeting normal flow groundwater standards in SBC at different times of the year.
   b. Effectiveness of limiting impacts from groundwater to sediments located in the bed of SBC.
   c. Interactions of the relocated SBC with groundwater and hydraulic control.
   d. Estimates of the quantity of water requiring short-term and long-term treatment at BTL.
4. Other relevant design information.

Additional details and the results of the hydraulic control modeling will be provided as the Phase II and Phase III Site Investigations are completed. As the Site Investigations are completed, Atlantic Richfield will incorporate the results of the hydraulic control modeling into the PDI ER and submit to Agencies for review and approval. The completed PDI ER will be submitted to Agencies for review approximately 30 days prior to the submittal of the Intermediate 60% RD Report.

6.4.3 Increased Treatment Capacity at BTL

The maximum design flow of BTL is estimated to be 1,880 gallons per minute, but it is possible this limit may be increased. A stress test will be completed under the forthcoming 2021 BPSOU BTL Stress Test QAPP. The work completed under this effort will determine the actual maximum design flow at BTL and the results are anticipated to identify any additional physical and chemical opportunities available to improve the BTL system. Additional effort will be made in creating capacity within the existing groundwater remedy by implementing flow reduction opportunities and/or existing treatment capacity opportunities. These efforts and associated objectives are summarized in the BPSOU *Capture and Treatment System Performance Evaluation Scoping Document* (Atlantic Richfield Company, 2020).

6.5 Haul Road Design

Due to the large excavation over a majority of the Site, it is assumed that no temporary haul roads will be constructed within the Site. Site access locations and off-site haul routes will be determined by Atlantic Richfield, in cooperation with BSB. Additional haul road design information and details will be included in forthcoming project submittals.

6.6 Management of Soil and Groundwater Impacted with Organic Pollutants

Initial data suggest that soil and groundwater within the Site are not impacted by PCB, PCP, or dioxins but petroleum-impacted soils are present on the Site. To determine the best management approach for soil and groundwater within the Site impacted with petroleum compounds above

Site-specific action levels, Atlantic Richfield completed a preliminary risk evaluation following the DEQ RBCA Guidance (DEQ, 2018a) and based on the data collected during the Phase I Site Investigation (Section 2.3.2 and Section 2.4.1). The RBCA preliminary risk evaluation is included in the PDI ER.

Based on the initial results from the RBCA evaluation, the majority of the petroleum-impacted soils exceeding DEQ RBSLs are within the southern part of the Site and will be removed as part of the excavation within the waste removal corridor, as a result of metals contamination. These petroleum-impacted soils will need to be segregated during excavation and sampled prior to disposal at a repository or another appropriate permitted facility. Based on the petroleum compound concentrations, the soils may require treatment prior to disposal.

Regarding petroleum-impacted groundwater, the RBCA evaluation identified two different types of petroleum compounds that are dissolved in the groundwater within the Site that exceed DEQ RBSLs (Section 2.4.1). However, additional evaluation is needed to refine the extent and nature of the petroleum-impacted groundwater within the Site, including collecting additional data to characterize the aquifer within the Site, evaluating the impact of pumping on natural attenuation processes and fate and transport of the petroleum compounds, and establishing Site-specific action levels.

Initial data suggest that soil and groundwater within the Site are not impacted by PCB, PCP, or dioxins. However, additional data will be collected as part of the Phase II and Phase III Site Investigations. Additional detail on the extent and volume of groundwater and soil impacted by select organic pollutants (petroleum compounds, PCBs, PCP, and dioxins) above Site-specific action levels and a management plan for these soils and groundwater will be included with the Intermediate 60% RD Report.

6.7 Reclamation Design

The reclamation design for the Site RA consists of the reclamation cap types provided in the BPSOU CD and the end land use infrastructure as generally outlined in the *Silver Bow Creek Conservation Area Master Plan* (LDI, 2020). Based on the required reclamation cap types and the end land use infrastructure, the reclamation has been separated into the following reclamation cap types:

1. Uplands Cover Soil.
2. Riparian Cover Soil.
3. In-Stream Materials.
4. Asphalt Pavement.
5. Concrete.
6. Road Base.

A detailed description of the reclamation cap types is below. Locations of the proposed cap areas are on Sheet C2.5 of the Construction Drawings.

Upland Cover – The upland cover system will meet the Criteria E as outlined in Table 3. The upland cover design will consist of 18 inches of cover soil, organic soil amendments (as necessary), and fertilizing, seeding, and hydromulching efforts. To obtain an in-place thickness of 18 inches, 22 inches of loose cover soils will be installed. The upland cover will consist of 12 inches (14+ inches loose) of soil obtained from the Helehan borrow area with 6 inches (7+ inches loose) of topsoil meeting the Criteria E specifications or 6 inches of amended Helehan soils. The Helehan soils will be mixed with organic amendments to meet the Criteria E.

Riparian Cover – The riparian cover system will meet Criteria D as outlined in Table 3. The riparian cover design will consist of 18 inches of cover soil, organic amendments (as necessary), and fertilizing, seeding, and hydromulching activities. To obtain an in-place thickness of 18 inches, 22 inches of loose cover soils will be installed. The riparian cover will consist of imported topsoil meeting Criteria D or 18 inches of amended soil obtained from the Helehan borrow area meeting the Criteria D specifications. The Helehan soils may be mixed with organic amendments to meet the Criteria D specifications.

In-Stream Materials – Streambed materials will be used to construct the channel armoring system in the reconstructed portion of SBC. The materials will include 9-inch minus rounded rock and gravel bedding material that will meet the metals parameters for Criteria C in Table 2. The material will be placed to a minimum 18-inch thickness within the reconstructed channel alignment. Soft armoring, including riparian cover soil, may also be placed as part of the channel armoring system and will be discussed in greater detail in the Intermediate 60% RD Report.

Asphalt Pavement – Paved areas will consist of trails through the Site, parking areas, and site access roads. The cap beneath the paved areas will consist of 8 inches of compacted road base materials overlaid by 3 inches of compacted asphalt depending on the location.

Concrete – A concrete cap may be installed as sidewalks, curb and gutters, restrooms, hardscape plazas, or other end land use feature or amenity. The concrete cap will consist of a minimum 6 inches of road base materials with 4 to 6 inches of M-3000 concrete. Concrete thickness will be determined based on location and anticipated loads. Further detail on the design of maintainable concrete will be included in the Intermediate 60% RD Report.

Road Base – Road base materials will be used along the walking trails. Road base materials will be used as a subbase under asphalt pavement and concrete areas. Road base materials will be imported to the Site from a local supplier or from stockpiles from an Atlantic Richfield-designated source area.

6.8 Best Management Practices

During RA construction activities, stormwater BMPs will be installed to prevent pollution from leaving the Site. The BMPs will be temporary and implemented prior to and during construction activities. During RA activities, the contractor's submitted Erosion Control Plan and/or SWPPP will fulfill the ARARs regarding point discharges. The SWPPP will demonstrate compliance for water quality and meet the substantive requirements of the NPDES and Montana Pollutant Discharge Elimination System (MPDES) permits. End land use design (Section 6.9) includes long-term BMPs that will be constructed during construction activities. The BMPs will be further identified in the Intermediate 60% RD Report.

Various BMPs will be used to minimize dust emissions. Specifically, dust will be controlled primarily through proper watering of potential dust generation areas and applying water on haul roads. The construction contractor will monitor the Site activities to ensure dust is kept to a minimum and verify that no significant quantities of contaminants become airborne and migrate from the Site, as directed by an Atlantic Richfield representative. The contractor will submit a Dust Management Plan to Atlantic Richfield as part of the Environmental Protection Plan. Atlantic Richfield will approve the plan prior to construction activities starting.

6.9 End Land Use Design

The end land use design for the Site will be completed in a manner consistent with the conceptual plan and guidance provided within the *Silver Bow Creek Conservation Area Master Plan* (LDI, 2020). The primary objective of the design will be to create continuity in the design between the other sites within the SBC Conservation Area and to provide useable space for the community based on the outcome of the community workshops and visioning sessions. The Site will be an open area with trails, landscaping, a potential amphitheater[3], and the reconstructed portion of SBC as shown on Sheet 4.0 of the Construction Drawings. Further end land use design details will be provided in the Intermediate 60% RD Report.

6.9.1 Amphitheater

A preliminary, conceptual plan for a potential amphitheater is shown on Sheet C4.0 of the Construction Drawings. More detail will be included in the Intermediate 60% RD Report, if necessary.

6.9.2 Trails

The trails on and adjacent to the Site will adhere to the SBC Conservation Area site-wide trail and sidewalk network goal to establish a consistent look and feel. Additionally, the design of the trails on and adjacent to the Site will take into consideration basic safety for various transportation activities that may occur on them (pedestrian, bicycle, wheelchair, etc.). Depending on the level of anticipated activity and the need for accessibility, the materials for the trails and sidewalks may include gravel, asphalt, and/or concrete. Comments from the community conveyed a desire to have trails that offer opportunity for neighborhood and community connection and wildlife viewing. As such, these requests will be reflected in the trail design. Trail design will include the following considerations:

- **Trail and Sidewalk Width** - Taking into consideration the different uses that may occur on the Site as well as winter maintenance and snow removal, hardscaped sidewalks will allow for bicycles, pedestrians, and Americans with Disabilities Act (ADA) movements.

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[3] Design, construction, and operation and maintenance of amphitheater requires mutual agreement of Atlantic Richfield Company and Butte-Silver Bow, and identification and commitment of a third-party investor and operator.

- **Clearance Height** - Shade is desirable along trails and sidewalks and the design must keep branches and overhangs out of the user's way. The design will include a safe level of clearance above all trails and sidewalks. In the design, snow load will also be taken into consideration during winter months to ensure that no branches bow into the trail and create an overhead clearance conflict.
- **Clearance Width** - Similar to the clearance height, the clearance width will be designed so that it allows users a safe and easily navigable experience. Shrubs will be located a moderate distance from the trail edge on both sides of the sidewalk or trail. Seed mixes will allow for plants to be kept short on either side to provide a shoulder and visibility to the sides of the pedestrian facility without requiring heavy maintenance. Trees and shrubs will be planted at appropriate distances to reduce damage to the trail/sidewalks caused by root upheave.
- **Slopes** - Site topography and trail slopes will be designed to promote a positive user experience and interpretation of Site features. Slopes and trail elevations may vary across the Site to present an alternate perspective to the user and more immersive Site experience. All slopes will be designed and constructed in accordance with ADA requirements.

6.9.3 Maintenance Roads

It is anticipated that the primary trail network will accommodate BSB maintenance vehicles and provide adequate space for all vehicles to be safely maneuvered. All maintenance roads will be constructed with a minimum 10-foot width. The entrance off Montana Street will be designed to accommodate access for utility maintenance vehicles and emergency response vehicles. Operation and maintenance details will be provided in a RA O&M plan. More details on the maintenance roads will be provided with the Intermediate 60% RD Report.

6.9.4 Trail Signage

Signs will be installed throughout the Site to provide for interpretation and act as aesthetic design features. Signs will:

- Create a distinct project Site identity.
- Provide organization cues and establish hierarchy for navigation.
- Speak to the historical and remedy context.
- Promote connection to place through education and curiosity.
- Create an artistic element or have art value.
- Tell the story of the Site.

In addition to the overall signage concept, subcategories of signs will have different purposes and functions as follows:

- **Entry Sign** – Creating the first and last impression of the BRW project site, the entry sign will announce and differentiate BRW from remaining components of the SBC Conservation Area.
- **Wayfinding Signs** - Wayfinding signs will provide visual cues and recognition to assist users in Site navigation and interpretation. Wayfinding will be developed in a way that has a consistent, understandable pattern (possibly through symbolism) and color scheme.
- **Educational Signs** - The educational signs will provide an opportunity to communicate the Site history and remedial systems and illustrate the functions taking place. These signs must be able to be understood by community members and visitors alike.

6.9.5 Potable Water

The BSB potable water works facilities use water from three source locations: Moulton Reservoir, Basin Creek Reservoir, and the Big Hole River. The Site service connection is in the south side pressure zone, which is supplied by Basin Creek Reservoir south of Butte. There is currently a water service line that supplies water to BSB operations. This line is located within the proposed waste removal corridor (Figure 3), and it is anticipated that the water line will need to be abandoned up to its connection at Montana Street.

A new service line and fire line will be installed to service the Site. Service lines will be connected to the main line along Montana Street. The design and installation of any new water service and fire lines to Site amenities will be completed according to all BSB, American Water Works Association (AWWA), and MCA Montana Public Works Standard Specification (MPWSS) guidelines and specifications (MCA, 2010). More detail will be included in the Intermediate 60% RD Report.

6.9.6 Sanitary Sewer

There is a public sanitary sewer system at the east end of the Site that is operated and maintained by the BSB Department of Public Works Metro Sewer Division. This line is located within the proposed waste removal corridor (Figure 3), and it is anticipated that the existing sanitary sewer service line will need to be abandoned up to its connection at Montana Street. Potential future facilities at the Site will connect to the existing concrete sewer main that runs through the east end of the Site, along Montana Street. Due to Site topographic restrictions and RD elements, sanitary sewer conveyance may not be achievable by gravity. At locations with these limitations, flow will be provided by an appropriately sized lift station and force main. The design and installation of sanitary sewer service connections to any future Site amenities are to be completed according to all BSB, Montana DEQ, and MCA MPWSS guidelines and specifications (MCA, 2010). More detail will be included in the Intermediate 60% RD Report.

6.9.7 Electrical Power and Natural Gas

NorthWestern Energy provides electricity and natural gas to residential and commercial/ industrial customers within BSB. A natural gas service line enters the Site at the east end from the main supply line along Montana Street and is currently in use for BSB operations. Overhead electrical power is available at the south side of the Site near the BNSF railroad right-of-way where it is currently suppling power via underground lines to existing BSB operations at the Site. Additional overhead power lines cross Montana Street near SBC and underground electrical service lines run parallel with Montana Street at the east end of the Site. It is anticipated that the gas service line will be abandoned up to its connection at Montana Street. Underground electric on the Site in the waste removal corridor will be disconnected from the overhead power lines and verified to be non-energized prior to construction activities. Overhead power lines may be preserved for a portion of the construction to provide power to construction dewatering pumps and equipment. It is anticipated that the electric service required for any future Site amenities will be secured from the overhead power line near Montana Street. Where appropriate, underground service laterals will be installed to provide power as necessary. More detail will be included in the Intermediate 60% RD Report.

6.9.8 Site Lighting

Adequate lighting will be included to illuminate the parking lot(s), site-wide trail, and end land use amenities. All Site lighting will be directed away from adjoining properties and will adhere to BSB Planning Department guidelines. More detail will be included in the Intermediate 60% RD Report.

6.9.9 Other Utilities

Additional utilities that use NorthWestern Energy power poles in Butte include CenturyLink internet and telephone infrastructure; Fatbeam fiber-optic internet; and Charter Spectrum cable TV, internet, and telephone. There is an existing communication service line into the Site, and it is anticipated that this service line will be abandoned and a new service line will be installed if necessary for the end land use amenities. More detail on the additional utilities will be included in the Intermediate 60% RD Report.

The BPSOU subdrain pump system alternate discharge line will not be disturbed during construction. A portion of the BPSOU subdrain pump system primary force main through the Site will be removed during excavation of the waste material and that portion of the line will be replaced, as required. More detail on the work associated with the BPSOU subdrain force main will be included in the Intermediate 60% RD Report.

6.9.10 Parking Lots

Access to parking is an important final design consideration. An off-street parking lot may be constructed on the Site, and additional parking lots will be constructed at the other SBC Conservation Area sites. Each parking lot will be constructed with ADA-compliant parking. At each location, the total number and size of spaces, striping, and signage will adhere to BSB Planning Department guidelines. More detail including pavement thickness and parking space configuration will be included in the Intermediate 60% RD Report.

6.9.11 Curb and Gutter

Concrete curb and gutter sections will be installed along the edges of streets, parking lots, and other pavements on grade throughout the project area. These sections will primarily be designed to facilitate the drainage of runoff water from rain or melted snow and ice into the existing municipal storm drain system. Additionally, the curb and gutter will function to separate traffic lanes from pedestrian walkways, confine pavement structures, reduce maintenance, and contribute to the aesthetic appearance. Once installed, curb and gutter will provide easily definable borders between traveled and untraveled surfaces and discourage drivers from parking or driving on sidewalks and landscaped areas. The installation of all concrete curb and gutter sections will be completed according to the latest BSB Road Division Standard Drawings and MCA MPWSS guidelines and specifications (MCA, 2010). More detail will be included in the Intermediate 60% RD Report.

6.10 Revegetation

Various native trees, shrubs, forbs, and wetland plantings will be planted and seeded throughout the SBC Conservation Area. More detail will be included in the Intermediate 60% RD Report.

6.10.1 Upland Seed Mix

The seed mix for the upland soils will be incorporated for erosion control, biodiversity, wildlife habitat, ecosystem enhancement, and visual appeal. These mixes will use native Montana species to the maximum extent possible and require low supplemental moisture from irrigation systems for establishment and maintenance.

6.10.2 Riparian Seed Mix

In areas with inundated planting zones, a combination of seeding and plugs will be installed to facilitate rapid establishment. Seeds and plugs will have root systems that are shallow and provide soil stabilization. All will be available commercially, and they will be native Montana species. A diversity in species is desirable to avoid monocultures and to provide a wide range of benefits. These benefits will include species that:

- Have documented reducing conditions.
- Provide wildlife cover and food.
- Tolerate varying soil conditions (pH, inundation, texture, etc.).
- Provide aesthetic appeal.

6.10.3 Irrigation

The guiding principles of the irrigation system design include using proven technologies for easy installment, management, and replacement. The irrigation system design will consider the following design drivers:

- Soil type (include constituent components).
- pH.
- Profile depth in inches.
- Local evapotranspiration (ET) rates.
- Prevailing winds (direction and intensity).
- Plant species.

The irrigation system will incorporate the following components/situations:

- Locally available parts and service support.
- Automated system capability to allow the use of a central control to provide remote monitoring and control over all sites.
- Capacity for flow monitoring and leak detection to prevent unnecessary waste of water due to broken pipes, heads, or other components.
- Soil moisture sensors to provide the correct amount of water at the right time to the diverse plant communities and minimize percolation of irrigation water to groundwater.

7.0 DATA GAPS

The specific Site characterization data gaps needed to support RD and construction for the Site have been identified by the design team after reviewing existing data and documents and are discussed in Section 2.2 of the RDWP (Atlantic Richfield Company, 2021b) and the PDI ER. Field investigation work to collect the necessary information required to support the RD for the Site is discussed in the PDI WP (Atlantic Richfield Company, 2021c).

At the completion of the Phase II and Phase III Site Investigations, Atlantic Richfield will incorporate the results, including an updated interpretation of the results, into the PDI ER and submit to Agencies for review and approval. The updated PDI ER will be submitted to Agencies for review approximately 30 days prior to submittal of the Intermediate 60% RD Report.

8.0 ACCESS/EASEMENTS

Atlantic Richfield owns the Site property. If Atlantic Richfield needs access to adjacent private property to complete the RA-related activities (including sampling and monitoring), Atlantic Richfield will request that all private property owners grant access to their properties for all RA-related activities. Atlantic Richfield and/or its representatives will maintain copies of completed agreements received from property owners. Completed agreements will be photocopied and scanned with the electronic version stored on a networked server.

9.0 SUMMARY

The Site RA design presented in this Preliminary 30% RD Report is consistent with the RAOs outlined in the BPSOU CD and comply with the required ARARs described previously. In summary, the RA consists of the following:

- Excavating, loading, and hauling approximately 156,200 cy of mine waste and COC-impacted materials from the Site to a repository location approved by EPA, in consultation with DEQ.
- Installing appropriate hydraulic control. Additional details and the results of the hydraulic control modeling will be provided in the Intermediate 60% RD Report.
- Removing the existing portion of SBC north of the Site and constructing approximately 2,000 linear feet of SBC through the southern portion of the Site, within the waste removal corridor.
- Importing approximately 73,000 bcy of general fill (Interstate Pit) material (Criteria B), 34,200 cy of upland cover (Helehan Pit) material (Criteria E), 5,700 cy of riparian growth subsoil material (Criteria D), 11,400 cy of topsoil (Criteria D and E), and 1,700 cy of in-stream media (Criteria C) to implement the RA. Material criteria are listed in Table 2 and Table 3.
- Constructing end land use amenities general consistent with the conceptual plans and guidance presented within the *Silver Bow Creek Conservation Area Master Plan* (LDI, 2020).

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FIGURES

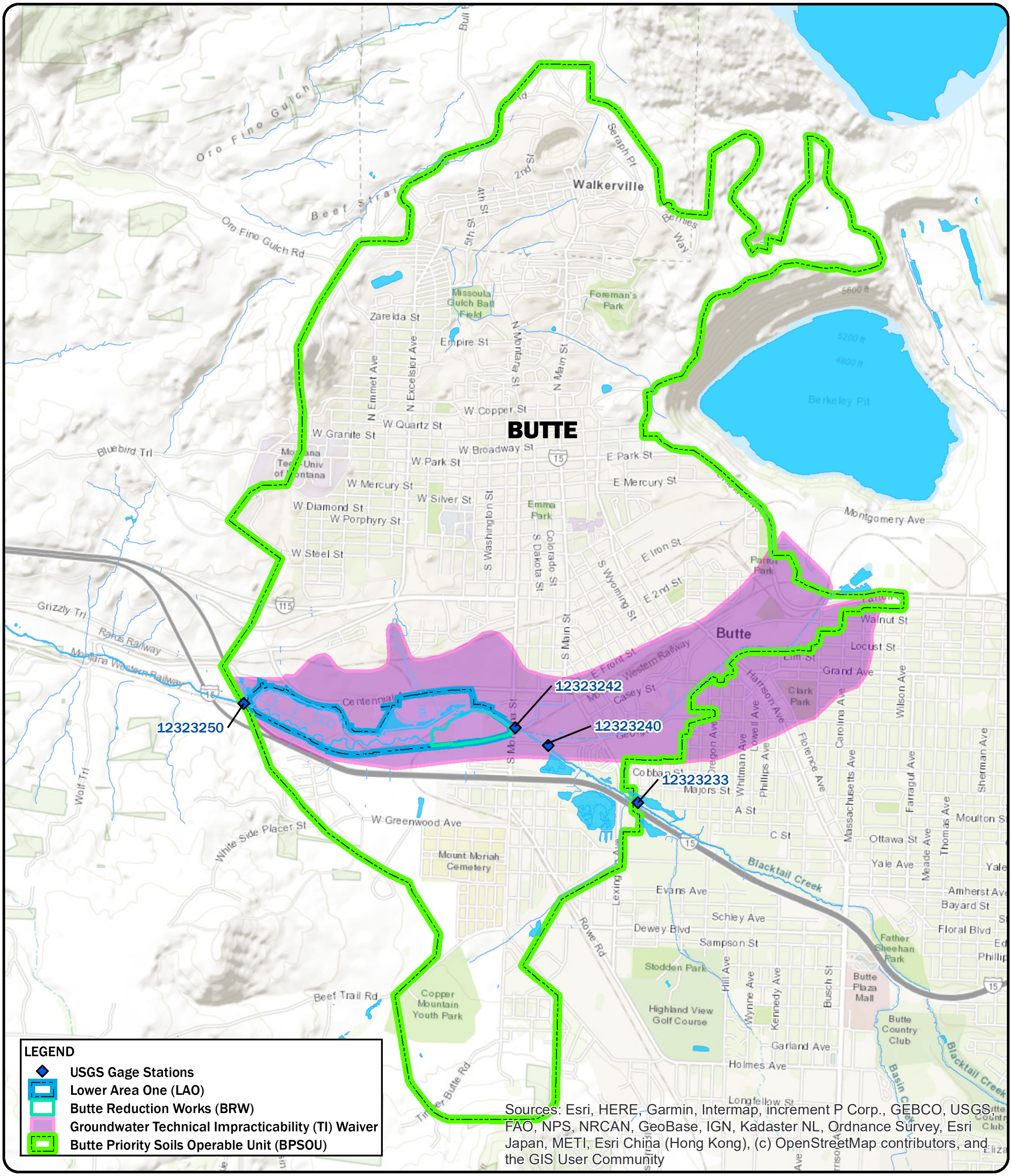

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FIGURE 1

PIONEER TECHNICAL SERVICES, INC.

BUTTE PRIORITY SOILS OPERABLE UNIT SITE LOCATION

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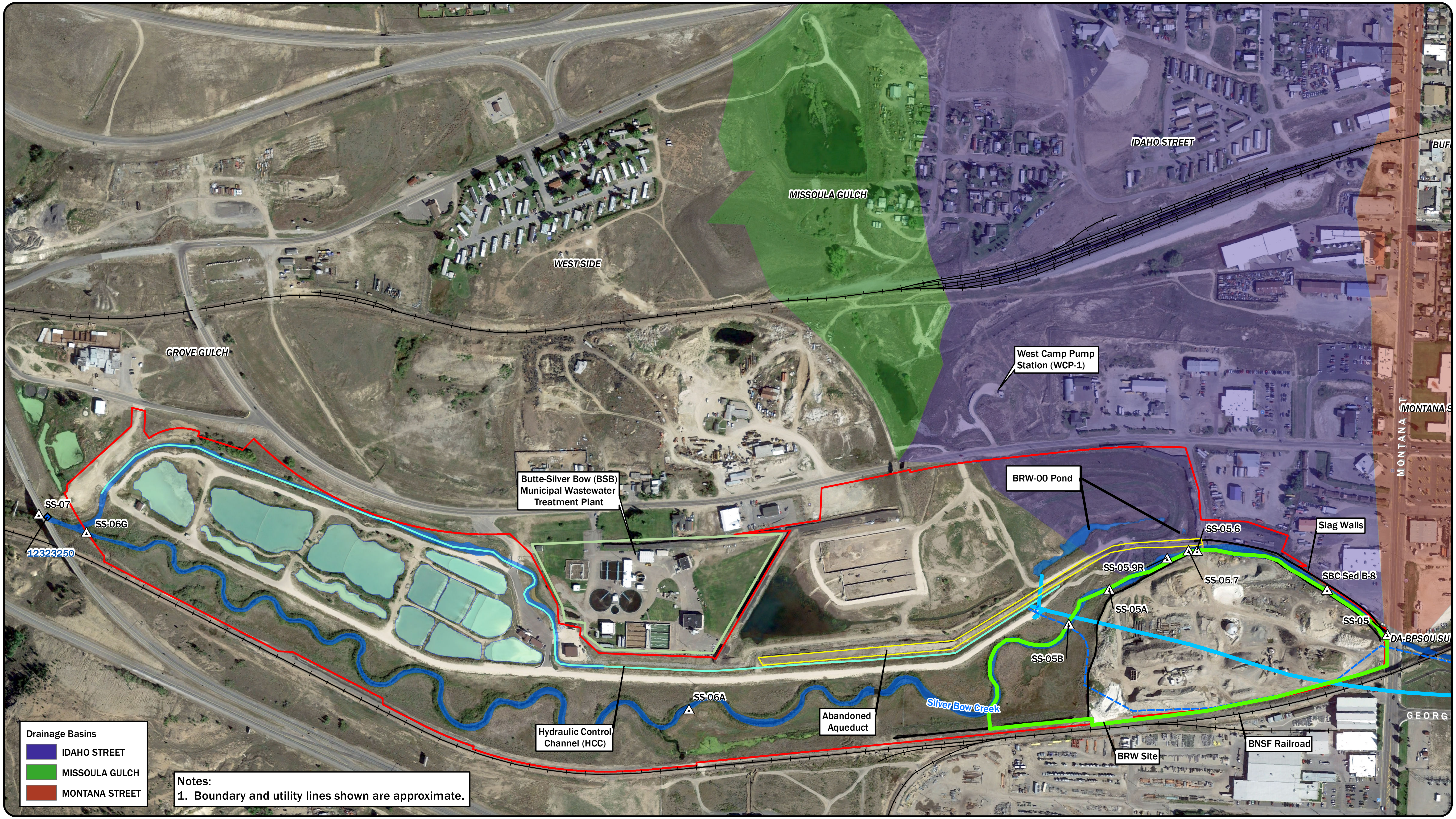

Notes:
1. Boundary and utility lines shown are approximate.

- Lower Area One (LAO) Boundary
- Butte Treatment Lagoons (BTL)
- Butte Reduction Works (BRW) Site Boundary
- BSB Municipal Wastewater Treatment Plant Boundary
- BRW-00 Pond
- Abandoned Aqueduct
- BPSOU Subdrain Pump System Force Main
- BPSOU Subdrain Pump System Alternate Discharge Line
- Hydraulic Control Channel (HCC)
- Slag Walls
- Current Railroads
- Staff Gages
- USGS Gage Stations

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FIGURE 2

LOWER AREA ONE SITE MAP

PIONEER TECHNICAL SERVICES, INC.

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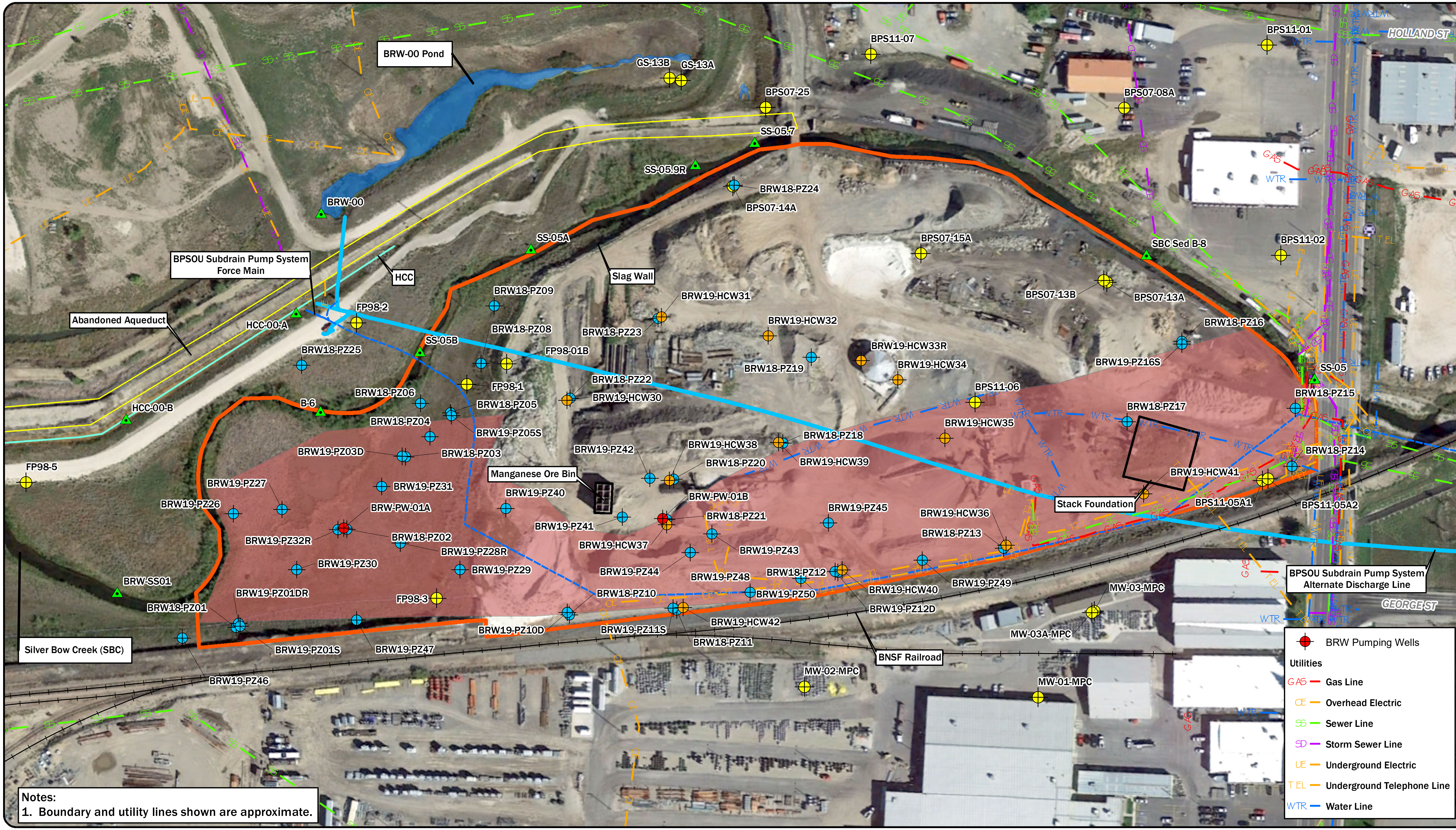

BRW Pumping Wells
BRW Piezometers
BRW Hydrocarbon Wells
Staff Gages
Existing Monitoring Wells
BPSOU Subdrain Pump System Force Main
BPSOU Subdrain Pump System Alternate Discharge Line
Hydraulic Control Channel (HCC)
Current Railroads
Abandoned Aqueduct
BRW-00 Pond
BRW Smelter Area Site Boundary
Proposed Waste Removal Corridor (Average 275' Width) and SBC Reconstruction Area

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FIGURE 3

BUTTE REDUCTION WORKS
SMELTER AREA SITE MAP

PIONEER TECHNICAL SERVICES, INC.

DATE: 4/16/2021

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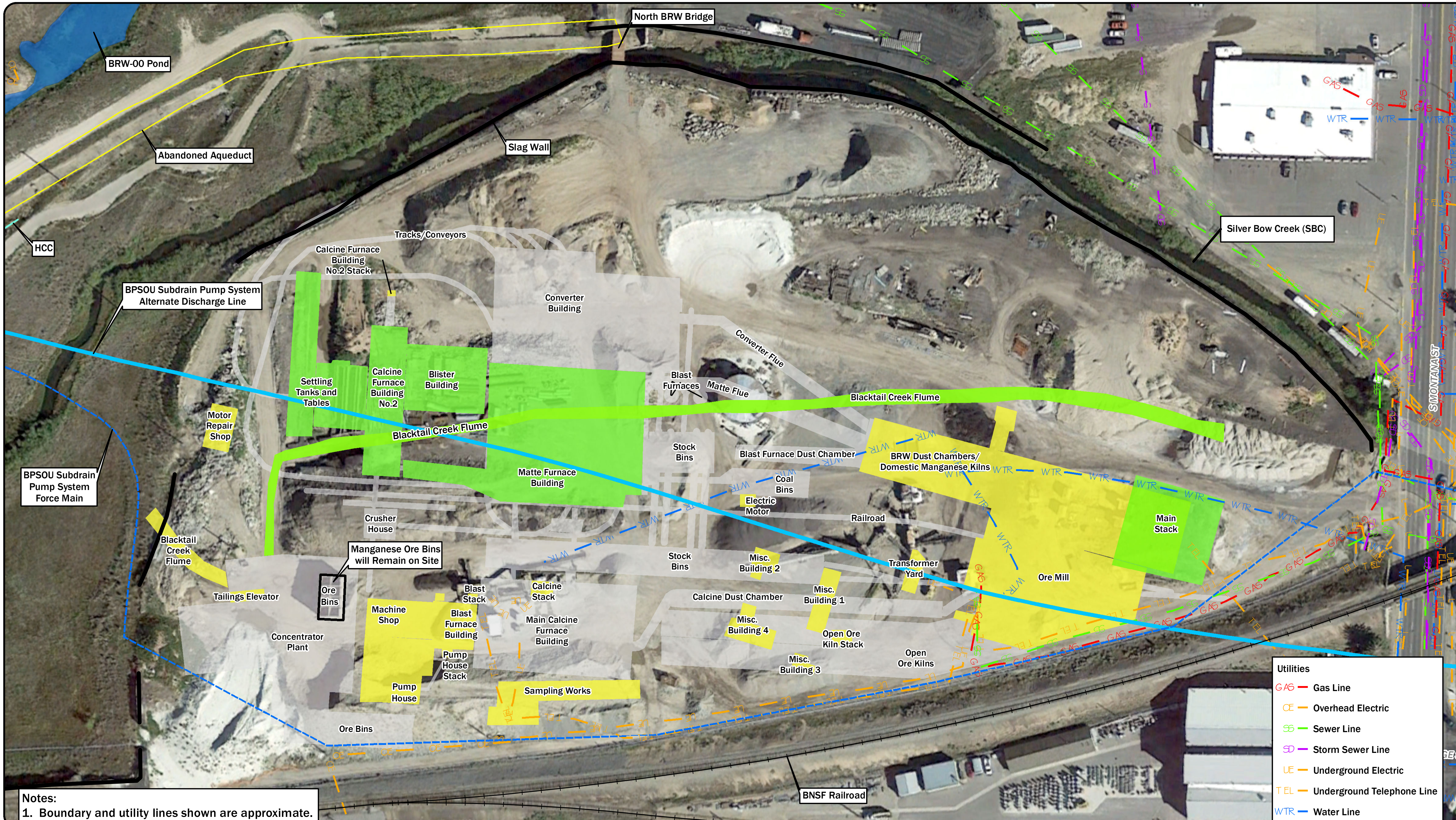

Potentially Remaing Infrastructure	BRW-00 Pond
Demolished Historic Infrastructure	BPSOU Subdrain Pump System Force Main
Confirmed Remaining Infrastructure	BPSOU Subdrain Pump System Alternate Discharge Line
Abandoned Aqueduct	Hydraulic Control Channel (HCC)
Slag Walls	Current Railroads

Note: Additional details on the infrastructure are included in Table 1 of the Pre-Design Investigation Work Plan.

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FIGURE 4

BUTTE REDUCTION WORKS SMELTER AREA HISTORICAL FEATURES AND INFRASTRUCTURE

PIONEER TECHNICAL SERVICES, INC.

DATE: 4/15/2021

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National Flood Hazard Layer FIRMette

FEMA

112°32'48"W 45°59'58"N

112°32'11"W 45°59'33"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) *Zone A, V, A99*
		With BFE or Depth *Zone AE, AO, AH, VE, AR*
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
		Future Conditions 1% Annual Chance Flood Hazard *Zone X*
		Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
		Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard *Zone X*
		Effective LOMRs
		Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES	B 20.2 / 17.5	Cross Sections with 1% Annual Chance Water Surface Elevation
	8	Coastal Transect
	513	Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 1/19/2021 at 1:40 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

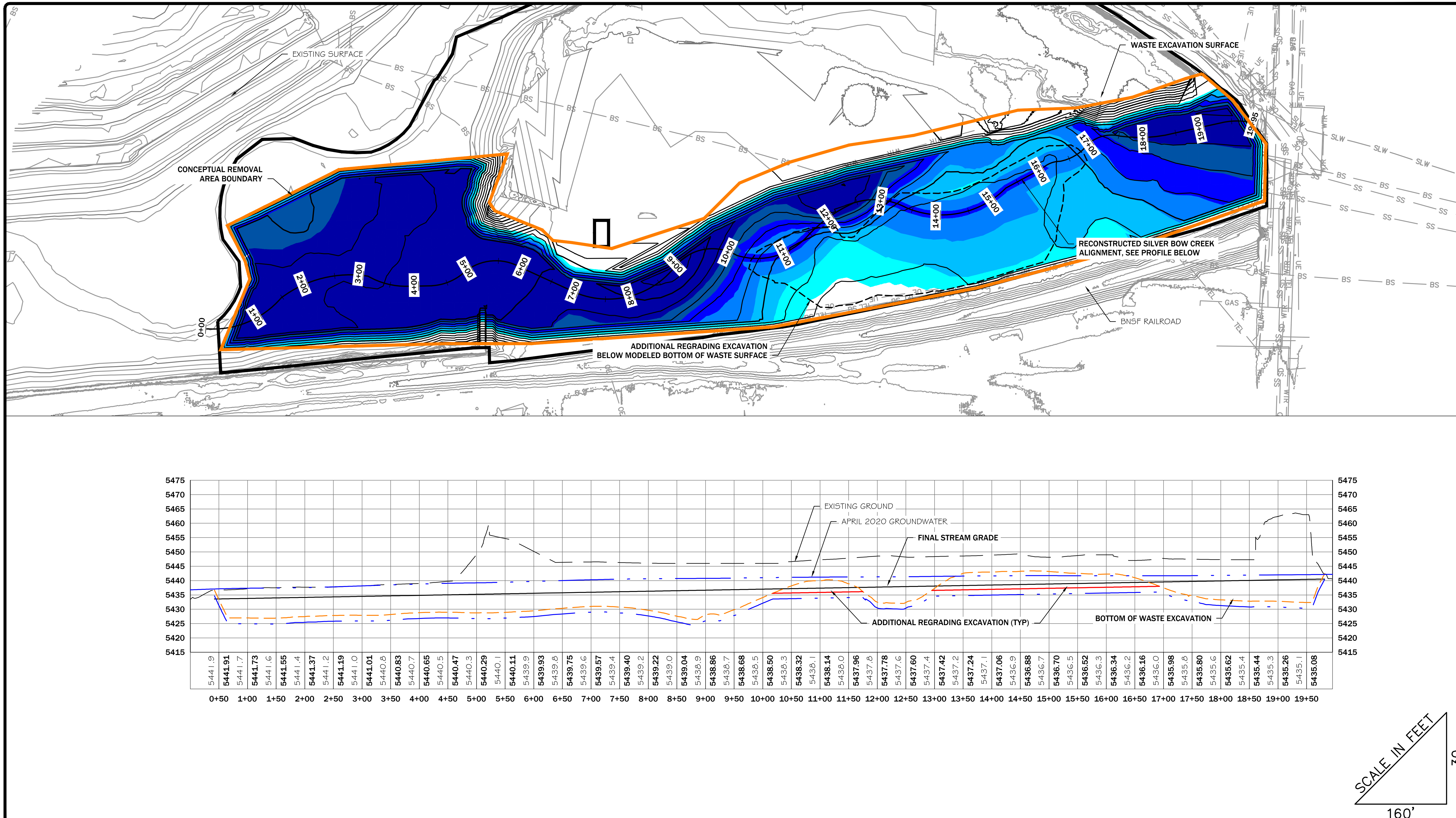
FIGURE 5

PIONEER TECHNICAL SERVICES, INC.

DATE: 4/15/2021

NATIONAL FLOOD HAZARD FIRMETTE

Path: Z:\Shared\Active Projects\ARCO\BPSOU\BRW\GIS\Z_Prelim30_Figures\BRW_30_005_FIRM_21.mxd



DEPTH TO TARGETED DRAWDOWN

Number	FEET BELOW GW	FEET BELOW GW	Color
1	-16.35	-10.0	
2	-10.0	-8.0	
3	-8.0	-6.0	
4	-6.0	-4.0	
5	-4.0	-2.0	
6	-2.0	0.0	

NOTE:

THE REQUIRED CONSTRUCTION DEWATERING DEPTH IS ANTICIPATED TO BE A MINIMUM OF 2 FEET MORE THAN THE DEPTH TO BOTTOM OF EXCAVATION.

N

DISPLAYED AS:
COORD SYS/ZONE: MSP
DATUM: NAD 83
UNITS: FEET
SOURCE: PIONEER

SCALE IN FEET
0 80 160

FIGURE 6

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

BRW ANTICIPATED CONSTRUCTION DEWATERING

DATE: 4/2021

5/10/2021 10:58:35 AM Z:\SHARED\ACTIVE PROJECTS\ARCO\BPSOU\BRW\CADD\FIGURES\BRW_FG_PLN-006-20.DWG

TABLES

Table 1
Waste Identification Criteria

If three of the six contaminant criteria listed are exceeded or any one contaminant is above 5,000 mg/kg then, the material is considered tailings, waste, or contaminated soil.

Arsenic	200 mg/kg
Cadmium	20 mg/kg
Copper	1,000 mg/kg
Lead	1,000 mg/kg
Mercury	10 mg/kg
Zinc	1,000 mg/kg
Any single analyte above 5,000 mg/kg	

From Field Screen Criteria and Procedures Phase 7 and 8 Remedial Action, SSTOU Subareas 4, Reach R and S (Pioneer 2011). Four of six contaminants need to be below the criteria for area to pass (see DEQ's "Field Screening Criteria and Procedures Remedial Action SSTOU Subarea 3, Reaches M, N, & O" (January 2013)

Table 2
Backfill Material Suitability Criteria

PARAMETER	CRITERIA A[1] RIPARIAN,WETLAND, AND SUB-IRRIGATED GROWTH MEDIA	CRITERIA B[2] GENERAL FILL	CRITERIA C[3] IN-STREAM MEDIA
Soil Texture			
USDA Texture	Not Sa, LoSa or Cl	Not clay soils	To be determined (TBD) during the 60% remedial design phase
Sand	20-70%		
Silt	10-60%		
Clay	5-30%		
Coarse Fraction (%>2mm)	<35%, Maximum fragment size = 3 inches	<60%, Maximum fragment size = 18 inches	
pH	5.5 to 8.5 S.U.		
EC/Salinity	<4.0 mmho/cm	<6.0 mmho/cm	TBD during the 60% remedial design phase
SAR	<12		
Soil Saturation Percentage	Between 25% and 85%		
Metals			
Arsenic	<30 mg/kg	<200 mg/kg	<30 mg/kg
Cadmium	<4 mg/kg	<20 mg/kg	<4 mg/kg
Copper	<100 mg/kg	<1,000 mg/kg	<100 mg/kg
Lead	<100 mg/kg	<1,000 mg/kg	<100 mg/kg
Mercury	<5 mg/kg	<10 mg/kg	<5 mg/kg
Zinc	<250 mg/kg	<1,000 mg/kg	<250 mg/kg
Nutrients			
Phosphorous (P)	P, K, and NO_3, will be used to verify fertilizer rates	Not Applicable (NA)	NA
Potassium (K)			
Nitrate + Nitrite (NO_3)			
Organic Matter	3% minimum organic matter on a dry weight basis in the upper 6 inches of cover soil		
Vegetation	Vegetation shall consist of native species appropriate to the riparian, wetland, or sub-irrigated setting. Final revegetation shall be determined as during the 60% remedial design phase.	NA	NA

Notes:

1 – Criteria A applies to all replacement growth media soils within the 100-year floodplain area of the BRW Site.

2 – Criteria B applies to general fill placed below the scour depth (TBD during the 60% remedial design phase) within 100-year floodplain area, and at greater than 18 inches below final grade in upland areas. On-Site inert solid wastes and construction debris includes only unpainted brick, dirt, rock, and concrete may be used as general backfill. Concrete shall not exceed 3 feet by 3 feet.

3 – Criteria C applies to all materials placed in Silver Bow Creek as the channel armoring system.

Table 3
Cover Systems Material Suitability Criteria

PARAMETER	CRITERIA D[1] RIPARIAN AREA COVER SYSTEM		CRITERIA E[2] UPLAND COVER SYSTEM	
	(0 to 6-inches)	(6 to 18 inches)	(0 to 6-inches)	(6 to 18 inches)
Soil Texture				
USDA Texture	Not Sa, LoSa or Cl	Cover soil shall be a friable material and the <2.0 mm fraction characterized as loam, sandy loam, sandy clay loam, sandy clay, clay loam, silty clay, silty clay loam, silt loam, or silt in accordance with the USDA Soil Conservation Service textural classification.		
Sand	20-70%			
Silt	10-60%			
Clay	5-30%			
Coarse Fraction (%>2mm)	<35%, Maximum fragment size = 3 inches	<45%, Maximum fragment size = 6 inches	<45%, Maximum fragment size = 3 inches	<45%, Maximum fragment size = 6 inches
pH	5.5 to 8.5 S.U.			
EC/Salinity	<4.0 mmho/cm			
SAR	<12			
Soil Saturation Percentage	Between 25% and 85%			
Metals				
Arsenic	<30 mg/kg		<97 mg/kg	
Cadmium	<4 mg/kg		<4 mg/kg	
Copper	<100 mg/kg		<250 mg/kg	
Lead	<100 mg/kg		<100 mg/kg	
Mercury	<5 mg/kg		<5 mg/kg	
Zinc	<250 mg/kg		<250 mg/kg	
Nutrients				
Phosphorous (P) Potassium (K) Nitrate + Nitrite (NO_3)	P, K, and NO_3, will be used to verify fertilizer rates	Not applicable	P, K, and NO_3, will be used to verify fertilizer rates	Not applicable
Organic Matter	3% minimum organic matter on a dry weight basis in the upper 6 inches of cover soil		3% minimum organic matter on a dry weight basis in the upper 6 inches of cover soil	
Cap and Cover Thickness and Vegetation	Engineered Cap minimum depth is 18 inches. Vegetation shall consist of native species appropriate to the riparian setting to the extent practicable. Final revegetation and capillary break design (if necessary) shall be determined as part of remedial design activities.		Engineered Cap minimum depth is 18 inches. Vegetation shall consist of native species appropriate to the upland setting to the extent practicable. Final revegetation and capillary break design (if necessary) shall be determined as part of remedial design activities.	

Notes:

1 – Criteria D applies to 100-year floodplain riparian areas.

2 – Criteria E applies to areas above the 100-year floodplain.

Table 4. Organic Pollutant Screening Levels and Standards

Chemical	**Soil Screening Levels (mg/kg)**[1] **Tier 1 Surface Soil (0-2 ft bgs) RBSL; Commercial**		**Groundwater Standards or Screening Levels (µg/L)** *RBSL - Risk-Based Screening Level*[1] *HHS - Groundwater Human Health Standard*[2]		**DEQ-7 Surface Water Human Health Standards**[2] **(µg/L)**
	0-10 feet to Groundwater	***10-20 feet to Groundwater***			
Volatile Petroleum Hydrocarbons					
MTBE	0.078[3]	0.16	30	HHS	30
Benzene	0.07	0.21	5	HHS	5
Toluene	21	65	1,000	HHS	57
Ethylbenzene	26	28	700	HHS	68
Xylenes, Total	310	310	10,000	HHS	10,000
Naphthalene	12	19	100	HHS	100
C9 to C10 Aromatics	130	470	1,100	RBSL	NE
C5 to C8 Aliphatics	220	290	650	RBSL	NE
C9 to C12 Aliphatics	360	360	1,400	RBSL	NE
Lead Scavengers					
1,2-Dibromoethane (EDB)	0.000086[3]	0.00022[3]	0.017	HHS	0.017
1,2-Dichloroethane (DCA)	0.019	0.052	4	HHS	5
Extractable Petroleum Hydrocarbons					
C11 to C22 Aromatics	370	1,300	1,100	RBSL	NE
C19 to C36 Aliphatics	200,000	200,000	1,000	RBSL	NE
C9 to C18 Aliphatics	540	540	1,400	RBSL	NE
1-Methylnaphthalene	2.1	7.1	11	RBSL	NE
2-Methylnaphthalene	6.9	23	36	RBSL	NE
Acenaphthene	27	91	70	HHS	70
Anthracene	2,600	8,800	2,100	HHS	300
Benz(a)anthracene	6.8	23	0.5	HHS	0.012
Benzo(a)pyrene	2.3	2.4	0.05[4]	HHS	0.0012
Benzo(b)fluoranthene	23	24	0.5	HHS	0.012
Benzo(k)fluoranthene	230	240	5	HHS	0.12
Chrysene	690	2,300	50	HHS	30
Dibenzo(a,h)anthracene	2.4	2.4	0.05[4]	HHS	0.0012
Fluoranthene	85	280	20	HHS	20
Fluorene	35	120	50	HHS	50
Indeno(1,2,3-cd)pyrene	24	24	0.5	HHS	0.012
Naphthalene	12	19	100	HHS	100
Pyrene	83	280	20	HHS	20
Persistent Organic Pollutants					
Polychlorinated Biphenyls (PCB)	Not Established	Not Established	0.5[5]	HHS	0.00064[5]
Pentachlorophenol (PCP)	Not Established	Not Established	1	HHS	0.3
Dioxin	Not Established	Not Established	$2x10^{-6}$[6]	HHS	$5x10^{-8}$[6]

(1)Montana Risk-Based Corrective Action Guidance for Petroleum Releases, Montana Department of Environmental Quality, May 2018.
(2) Circular DEQ-7 Montana Numeric Water Quality Standards. June 2019.
(3)The best achievable practical quantitation limit (0.20 mg/kg) is greater than the RBSL; therefore, if the compound is detected, additional evaluation may be
(4)The best achievable practical quantitation limit (0.1 µg/L) is greater than the RBSL; therefore, if the compound is detected, additional evaluation may be
(5) Sum of all Aroclor analyses (1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268)
(6) Calculation of an equivalent concentration of 2,3,7,8-TCDD is to be based on congeners of CDDs/CDFs and the toxicity equivalency factors (TEF) in Van den Berg, M: et al. (2006) *The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds. Toxicological Sciences 93(2):223-241.*

Table 5
BRW Smelter Area ARARs

Applicable or Relevant and Appropriate Requirements[1]	Summary of Requirements	Evaluation	Remedial Design Report Section Reference
CHEMICAL-SPECIFIC REQUIREMENTS			
Solid Media			
Remedial Action Objectives and Waste Removal Criteria in 2020 Butte Priority Soils Operable Unit Consent Decree (BPSOU CD) (EPA, 2020).	The primary contaminants of concern (COCs) in the BPSOU are arsenic and lead. The remedial action levels for arsenic and lead are outlined in the 2006 BPSOU Record of Decision. The BPSOU SOW (Appendix D to the BPSOU CD [EPA, 2020]) outlines the waste identification criteria (Table 1), the backfill material suitability criteria (Table 2), and the engineered caps material suitability criteria (Table 3).	Applicable, waste materials (as defined by the BPSOU CD) will be removed within the agreed removal corridor, as feasible. Removed waste materials will be segregated and disposed of at a repository approved by the EPA and in consultation with DEQ.	Section 3.2.1
Montana Department of Environmental Quality, Risk-Based Screening Levels (RBSLs) for Petroleum-Impacted Soils from Montana Risk-Based Corrective Action Guidance for Petroleum Releases (RBCA Guidance) (DEQ, 2018)	The goal of the RBCA Guidance is to identify and reduce risks to public health, safety, and welfare, and the environment. The RBSLs developed within the RBCA Guidance can be used as cleanup levels at sites in Montana without the need to perform site-specific leaching evaluations or risk analysis for each release and exposure scenario.	Applicable, all soils encountered during the remeidal action that are with organic pollutants (petroleum-based compounds, PCBs, PCP, and dioxins) shall also be removed and disposed of at an appropriate permitted facility. As part of the remedial design, RBSLs (Table 4) have been used to identify petroleum-impacted soils within the Site in accordance with the RBCA Guidance. As the design progresses, site-specific action levels may be determined.	Section 3.2.1
Groundwater Standards			
Federal Groundwater Standards, Safe Drinking Water Act, 42 U.S.C. 300f, et seq , National Primary Drinking Water Standards 40 CFR Part 141, et seq; Montana Requirements, MCA 75-5-303, 75-6-101, et seq, ARM 17.30.1006, and -1011, ARM 17.30. 701, et seq, ARM 17.28.203, and ARM 17.54.702	Establishes maximum contaminant levels (MCLs) as criteria for groundwater and surface water. Establishes classification of groundwaters and applicable water quality standards. Standards are designed to protect human health and the environment from adverse effects of inorganic contaminants in the water supply. Provides criteria for managing groundwater sources that may have potential impacts on surface water quality standards.	EPA has determined that a waiver of groundwater standards is appropriate for the area within the zone defined in the Technical Impracticability (TI) Evaluation for the BPSOU (EPA, 2006) for all standards. The waiver is based on section 121(d)(4)(C) of CERCLA, 42 U.S.C. Section 9621(d)(4)(C) and corresponding NCP provisions. For areas of the aquifer outside of the TI Zone, the State of Montana has promulgated maximum contaminant levels (MCLs) in groundwater public water supplies for cadmium, copper, lead, and mercury, which are the same or more stringent than Resource Conversation and Recovery Act (RCRA). Additionally, the State of Montana standards will apply to organic pollutants (petroleum-based compounds, polychlorinated biphenyls [PCBs], pentachlorophenol [PCP], and dioxins).	Section 3.2.2
Surface Water Standards			
Federal Surface Water Quality Requirements, Clean Water Act, 33 U.S.C. 1251, et seq, 40 CFR Parts 122 and 125; State of Montana Surface Water Quality Requirements, Montana Quality Act, MCA 75-5-101, et seq. MCA 75-5-103, MCA 75-5-303 and 308 , and Administrative Rules: ARM 17.30.607 (1) (a), ARM 17.24.633, ARM 17.30.1101 et seq, ARM 17.30.1203, ARM 17.30.1301, ARM 17.30.1342 – 1344, ARM 17.30.601, ARM 17.30.623, ARM 17.30.628, ARM 17.30.635 (4), ARM 17.30.637, ARM 17.30.701 et seq, and ARM 17.30.705	Establishes water quality standard criteria. Water quality standards are promulgated to protect, maintain, and improve quality and potability of surface water supplies and habitats. Establishes classification of surface water bodies and provides requirements/criteria for prevention of pollution/discharge. Categorizes requirements and ensures appropriate permits/controls are in place to prevent activities from adversely impacting surface water bodies.	Applicable to any discharges from remedial action that involve the collection, treatment, and discharge of groundwater and surface water. Any discharges to surface water will meet the State of Montana standards, which are the same or more stringent than federal standards will apply as detailed in the Circular DEQ-7 (DEQ, 2019). In addition Best Management Practices (BMPs) will be put in place and a Storm Water Pollution Prevention Plan (SWPPP) or similar plan will fulfill ARARs regarding point discharges. However, construction water meeting temporary variance standards (to be defined) will not require treatment (Attachment B.1 to Appendix D to the BPSOU CD [EPA, 2020]). The temporary variance standards will be defined in an updated Surface Water Monitoring QAPP.	Section 3.2.3
Air Quality Standards			
Clean Air Act 42 U.S.C 7401 et seq, National Ambient Air Quality Standards, 40 CFR 50; Montana Ambient Air Quality Regulations, ARM 17.8.202.	Establishes ambient air quality standards. For BPSOU, RA activities cannot cause or contribute to exceedances of the ambient air quality standards.	The substantive requirements of these regulations are relevant and appropriate to remedial actions that may involve the generation of fugitive dust (e.g., removal, transport, and consolidation of contaminated soil, waste rock, or sediments).	Section 3.2.4
LOCATION-SPECIFIC REQUIREMENTS			
Endangered Species Act			
Endangered Species Act, 16 U.S.C. 1531-1544, 40 CFR 6.302(h), 50 CFR Part 402	Requires that any activity may not jeopardize the continued existence of any threatened or endangered species known to live or have lived in the affected environment. Establishes appropriate administrative/procedural and consultation requirements with the appropriate agency(s).	Applicable to areas where remedial action is selected that may provide habitat to threatened or endangered species. Bull trout will be protected during the remedial action activities through applying BMPs and the treating waters to meet the water quality standards	Section 3.3.1

Table 5
BRW Smelter Area ARARs

Applicable or Relevant and Appropriate Requirements[1]	Summary of Requirements	Evaluation	Remedial Design Report Section Reference
Migratory Bird Treaty Act			
Migratory Bird Treaty Act, 16 U.S.C. 703, et seq.	Establishes a federal responsibility for the protection of international migratory bird resources and requires continued consultation by EPA with the USFWS during remedial design and remedial construction to ensure that activities do not unnecessarily impact migratory birds. Specific mitigative measures may be identified for compliance as appropriate for performance of persons who implement the remedy	The prohibition is relevant and appropriate to areas of the Site where remedial action is selected that may provide habitat to migratory birds.	Section 3.3.2
Bald Eagle Protection Act			
Bald Eagle Protection Act, 16 U.S.C. 668, et seq.	Establishes a federal responsibility for the protection of bald and golden eagles and requires continued consultation by EPA with the USFWS during remedial design and remedial construction to ensure that activities do not unnecessarily impact migratory birds. Specific mitigative measures may be identified for compliance as appropriate for performance of persons who implement the remedy	The prohibition is relevant and appropriate to those areas where remedial action is selected that provide habitat to Bald and Golden Eagles.	Section 3.3.3
Protection of Wetlands			
Protection of Wetlands, 40 CFR Part 6, Appendix A, Executive Order No. 11990. 33 U.S.C 1344(b) (1)	Mandates that potentially responsible parties avoid, to the extent possible, the adverse impacts associated with the destruction of wetlands if a practicable alternative exists. Establishes requirements for dredge and fill activities into waters of the United States. These requirements establish a "no net loss" wetlands standard.	Applicable to areas where remedial action may impact wetlands.	Section 3.3.4
National Historic Preservation Act			
National Historic Preservation Act, 16 U.S.C. 470, et sep., 40 CFR 6.301(b), 36 CFR Part 800	Requires any activity to consider any building, structure, or object that is included in, or eligible for, the register of historic places. Establishes controls measures to minimize, mitigate, or avoid potential effects.	The substantive requirements are applicable to those areas where remedial actions are undertaken that include historic properties, cultural resources, or landmarks that are eligible for, or included in, the National Register of Historic Places.	Section 3.3.5
Archaeological and Historic Preservation Act			
Archaeological and Historic Preservation Act, 16 U.S.C. 469, et seq. 40 CFR 6.301(c).	Establishes requirements for the preservation of any scientific, prehistorical, or archaeological data discovered during site activities.	The substantive requirements are applicable to those areas where remedial actions are undertaken that include historic properties, cultural resources, or landmarks that are eligible for, or included in, the National Register of Historic Places.	Section 3.3.6
Resource Conservation and Recovery Act			
Resource Conservation and Recovery Act 40 CFR 264.18 (a) and (b)	These sections require management units to be designed, constructed, operated, and maintained to avoid washout, if they are within or near the current 100 year flood plain.	Applicable; however, as specified in the BPSOU SOW, the repository will be sited outside of the 100-year floodplain.	Section 3.3.7
Historic Sites, Buildings and Antiquities Act			
Historic Sites, Buildings and Antiquities Act, 16 U.S.C. 461, et seq., 40 CFR 6.301(a).	Requires any action to consider the existence and location of natural landmarks when conducting an environmental review to avoid undesirable impacts upon such landmarks	Applicable, historic features and antiquities encountered during remedial action activities will be handled following the Second Programmatic Agreement.	Section 3.3.8
Native American Grave Protection and Repatriation Act			
Native American Grave Protection and Repatriation Act, 25 U.S.C. 3001, et seq.; 43 CFR 10.1 - 10.17	Establishes requirements for activities that result in the discovery of Native American human remains or related objects. Ensures that reasonable effort is made to protect the remains or related objects.	The substantive requirements are applicable to those areas where remedial action is selected that includes Native American burial sites and funerary objects.	Section 3.3.9
Fish and Wildlife Coordination Act			
16 U.S.C. 661 et seq. and 40 CFR 6.302(g)	Establishes the requirements that ensure that any modification of any stream or other water body affected by a federally funded or authorized action provide for adequate protection of fish and wildlife resources. Establishes measures to prevent, mitigate, or compensate for project-related losses to fish and wildlife.	Applicable; the Site remedial action activities require modification of Silver Bow Creek, therefore compliance of the Fish and Wildlife Coordination Act must be met.	Section 3.3.10

Table 5
BRW Smelter Area ARARs

Applicable or Relevant and Appropriate Requirements[1]	Summary of Requirements	Evaluation	Remedial Design Report Section Reference
Floodplains			
Floodplain Management Order, 40 CFR Part 6., Appendix A, and Executive Order No. 11988.	Establishes criteria and due process for authorized actions within the 100 year floodplain.	The federal requirements for the Protection of Floodplains is applicable to remedial action activities.	Section 3.3.11
Montana Floodplain and Floodway Management Act and Regulations, MCA 76-5-401, MCA 76-5-402, MCA 76-5-403, MCA 76-5-406, ARM 36.15.601, ARM 36.15.701, ARM 36.15.602(6), ARM 36.15.605(2), ARM 36.15.703, ARM 36.15.604, ARM 36.15.216, ARM 36.15.605, ARM 36.15.602, ARM 36.15.603	Specifies types of uses and structures that are allowed or prohibited in the designated 100-year floodway and floodplain. Establishes considerations/requirements for said uses/structures.	Applicable; the Site remedial action activities require modification of Silver Bow Creek, therefore compliance of the Montana Floodplain and Floodway Management Act must be met.	Section 3.3.11
Streambeds			
Montana Natural Streambed and Land Preservation Act and Regulations, MCA § 75-7-101, et seq., MCA 87-5-502 AND 504, and ARM 36.2.404, 405, and 406.	Sets minimum standards applicable to any remedial action activities occurring in and around a natural streambed or any activity that could potentially affect the natural shape and function of a nearby stream.	Applicable; the Site remedial action activities require modification of Silver Bow Creek, therefore compliance of the Montana Natural Streambed and Land Preservation Act must be met.	Section 3.3.12
ACTION-SPECIFIC REQUIREMENTS			
Federal Solid Waste, Surface Mining Control and Reclamation, and RCRA Requirements			
Surface Mining Control and Reclamation Act (SMCRA), 30 U.S.C. 1201-1326, 40 CFR 257.3-1(a), 3-3, 3-4, and 3-5. 30 CFR Parts 816 and 784. RCRA Regulations 40 CFR 264.116, 40 CFR 264.119, 40 CFR 264.228	Establishes waste classification and waste management standards. Provides standards for waste handling, transportation, and storage. Establishes reclamation and closure regulations and pollution prevent control measures.	The substantive requirements are relevant and appropriate to the remedial action at the Site.	Section 3.4.1
Montana Solid Waste Management Act.			
MCA 75-10-206; ARM 17.50.505(2), ARM 17.50.506, ARM 17.50.511, ARM 17.50.523, ARM 17.50.530, ARM 17.50.530(1)(b), ARM 17.50.531	Establishes applicable requirements for the disposal and management of solid waste. Establishes criteria for waste management classification and sets requirements for the operation, maintenance, and closure of waste management facilities.	Applicable to the Remedial action activities at the Site.	Section 3.4.1
Federal Transportation of Hazardous or Contaminated Waste			
40 CFR Part 263	Establishes regulations for the transportation of hazardous waste (either on-site or off-site handling). Establishes applicable permitting and regulations for transportation of waste.	Applicable if hazardous waste is encountered, however; all materials to be excavated from the Site are Bevill wastes that are not considered hazardous wastes	Section 3.4.1
Federal Point Source Controls & Montana Pollution Discharge Elimination System (MPDES) - stormwater and other point sources.			
Clean Water Act, 33 U.S.C. 1251, et seq., 40 CFR Parts 121, 122, and 125, 40 CFR 122.44(i) and 40 CFR 440.148; ARM 17.24.633, ARM 17.30.1301, et seq., ARM 17.30.1332, ARM 17.30.134-1344, ARM 17.30.601, et seq.	States all Clean Water Act standards apply to any discharge. Establishes substantive requirements applicable to all MPDES permits (Ex, implementing BMPs for stormwater run-on/run-off control). Establishes proper operating procedures for treatment facilities. Sets requirements for all mine reclamation activities to minimize or prevent any discharge that could potentially impact human health or the environment.	The substantive requirements are applicable as they apply to the operation of and discharges from remedial activities that involve the collection, treatment, and discharge of groundwater, surface water, storm water, or other wastewaters.	Section 3.4.2 and Section 3.4.3
Montana Water Quality Statute and Regulations			
MCA 75-5-301(5)(c), MCA 75-5-303, MCA 75-5-317, MCA 75-5-605, ARM 17.30.701, et seq., ARM 17.30.705, ARM 17.30.715(1)(b), ARM 17.30.1011	Establishes water quality standards and prevents the pollution of any state waters. Establishes pollution prevention control requirements that regulate waste handling and storage to prevent pollution of any water supply. Establishes emergency response provisions to the regulations.	The substantive requirements are applicable as they apply to the operation of and discharges from remedial activities that involve the collection, treatment, and discharge of groundwater, surface water, storm water, or other wastewaters.	Section 3.4.3
Air Requirements			
Federal Clean Air Act 42 U.S.C 7401 et seq - Section 109, 40 CFR 50.6, 40 CFR 50.12; Montana Air Quality Regulations MCA 75-2-101, et seq. ARM 17.8.220, ARM 17.8.222, ARM 17.8.223, ARM 17.8.304(2), ARM 17.8.308, ARM 17.8.604, ARM 17.8.611, ARM 17.8.612, ARM 17.24.761	Establishes minimum ambient air quality standards and emission controls to prevent exceedances. Establishes best available control technology (BACT) standards for control any potential fugitive dust or substance likely to be released as a result of any activity.	The substantive requirements of these regulations are relevant and appropriate to remedial actions that may involve the generation of fugitive dust (e.g., removal, transport, and consolidation of contaminated soil, waste rock, or sediments).	Section 3.4.4

Table 5
BRW Smelter Area ARARs

Applicable or Relevant and Appropriate Requirements[1]	Summary of Requirements	Evaluation	Remedial Design Report Section Reference
Federal Dredge and Fill Requirements			
40 CFR Part 230	Addresses conditions or prohibitions against depositing dredge and fill material into a waters of the United States. Establishes the applicable permit requirements for such activities.	Not applicable because the remedial action activities do not require any dredging or filling in waters of the United States, but only reconstruction of Silver Bow Creek to near its original alignment.	N/A
Federal Underground Injection Control			
40 CFR 144	Establishes applicable controls measures and regulations for injections of treated groundwater back in to the aquifer.	Not applicable because the remedial action activities do not require any injections of groundwater back into the aquifer.	N/A
Montana Strip and Underground Mine Reclamation Act			
MCA 82-4-201 through 254; and administrative requirements ARM 17.24.501, ARM 17.24.505, ARM 17.24.519, ARM 17.24.631, ARM 17.24.633, ARM 17.24.634, ARM 17.24.635, ARM 17.24.636, ARM 17.24.637, ARM 17.24.638, ARM 17.24.639, ARM 17.24.640, ARM 17.24.641, ARM 17.24.643, ARM 17.24.645, ARM 17.24.646, ARM 17.24.701, ARM 17.24.702, ARM 17.24.703, ARM 17.24.711, ARM 17.24.713, ARM 17.24.714, ARM 17.24.716, ARM 17.24.717, ARM 17.24.718, ARM 17.24.719, ARM 17.24.721, ARM 17.24.723, ARM 17.24.724, ARM 17.24.726, ARM 17.24.728, ARM 17.24.733.	Establishes performance standards that mine reclamation should attain. Sets the precedent that all mine lands will be restored to an equal or greater function than pre-disturbance conditions. Establishes requirements for all phases of the mining and reclamation operations to prevent adverse impacts to human health and the environment. Provides a timeline for completion of reclamation activities and requirements for long-term performance monitoring. Basically, the reclamation handbook from start to finish.	EPA in conjunction with DEQ has developed a BSPOU Statement of Work (EPA, 2018) that defines the required components of the remedial design and remedial activities for the Site. The remedial design and remedial activities will complies with the BPSOU SOW. A RD/RA schedule has been developed for the project and has been provided along with the Preliminary 30% Remedial Design Report.	Section 5.0 and Section 6.0

Notes: 1. ARARs are from Identification and Description of Applicable or Relevant and Appropriate Requirements for Feasibility Study Analysis of Alternatives. Silver Bow Creek/Butte Area Superfund Site Butte Priority Soils Operable Unit (OU 8), September 2006

Appendix A
Calculations

Appendix A.1
Silver Bow Creek Stream Flows at the BRW Smelter Area

Date:	5/13/2021	Project:	Butte Reduction Works Smelter Area Remedial Design	Prepared By:	MSP
Rev. No.	1	Office:	Butte, MT	Checked By:	TPB
Rev. Date:		Calc. No.		Approved By:	
Subject:	Silver Bow Creek Stream Flows at the BRW Smelter Area				

Silver Bow Creek Stream Flows at the BRW Smelter Area

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1 Purpose and Objectives
2 Methods and Data
2.1 Flood Frequency Analysis
2.2 StreamStats and Regression Calculations
3 Results And Discussion
3.1 Flood Frequency Analysis Results
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3.3 Design Considerations
4 References
5 Document Revision Summary
ATTACHMENT A-1A
ATTACHMENT A-1B

1 PURPOSE AND OBJECTIVES

This document outlines the process to determine peak flood recurrence flows for Silver Bow Creek (SBC) as it flows through the Butte Reduction Works (BRW) Smelter Area Site (Site). Calculated flows will be used as design parameters for SBC design/reconstruction efforts.

2 METHODS AND DATA

U.S. Geological Survey (USGS) stream gages are located upstream and downstream of the Site. The USGS gaging station 12323250 is located approximately 1 mile downstream of the Site on SBC and gaging station 12323240 is located approximately 0.2 miles upstream of the Site on Blacktail Creek (BTC). Annual peak flow data from these gages are used to estimate the flood flows for the 1.5, 10, 25, 50, and 100-year flood recurrence intervals. Also, the USGS StreamStats software program was used to estimate the basin characteristics and estimate peak flows using regional regression equations to estimate peak flows to compare with the gage data.

2.1 Flood Frequency Analysis

Flow data are available from the two USGS gaging stations dating back to 1989 and 1984. To be consistent in comparing stream flow data from the 2 stations, Pioneer analyzed 29 years of annual peak flows from 1989 through 2017. Peak flow measurements were used to estimate the flood recurrence intervals using the Weibull Plotting Position Formula, as described in *Guidelines for Determining Flood Flow Frequency Bulletin #17B* (USGS, 1982). This method requires a minimum of 10 years of data and uses the magnitude of historic peak flow measurements to estimate flood recurrence intervals at a gaged location. Historical flows are first ranked in order of magnitude, and the equation shown below is used to estimate the approximate flood recurrence interval of the recorded flow.

Recurrence Interval (T) = (n+1)/m

(n) = number of years of record for the gaging site.
(m) = magnitude/rank of recorded event.

After determining the approximate recurrence interval, historical peak flows were plotted against the estimated flood recurrence interval and a best-fit line was drawn to estimate peak flows out to the desired interval.

2.2 StreamStats and Regression Calculations

StreamStats is an interactive software program that allows the user to identify a location within a drainage basin and determine the peak flow statistics for that specific location. Pioneer used StreamStats to complete flood recurrence calculations using regional regression equations as an alternate method of validating the flood recurrence flow calculations using the Weibull method with gage data described in the previous section.

The regional regression equations use drainage basin characteristics to determine peak flood flows. The regional regression equations identify three variables that must be determined prior to calculating peak flows at selected recurrence intervals: Drainage Area (DA), Annual Average Precipitation (P), and Mean Basin Elevation (E). These parameters are calculated within the software program. The drainage area had to be edited to not include the Berkeley Pit, Continental Pit, and Yankee Doodle Tailings Impoundment, as these areas are endorheic (i.e., allow no outflow, other than the Butte Mine Flooding Operable Unit [BMFOU] discharge) and do not contribute to the drainage basin area for the Site (refer to Section 3.3). Once these areas were removed from the basin, the calculated DA was 97.8 square miles, the P was 16.95 inches, and the E was 6,242 feet.

3 RESULTS AND DISCUSSION

Flood frequency data, analysis, and results are included in Attachment A-1A and USGS StreamStats results and analysis are included in Attachment A-1B.

3.1 Flood Frequency Analysis Results

The flood frequency results from the upstream gage 12323240 indicated a $Q_{1.5}$ flow (bankfull capacity equivalent to a flood with a 1.5-year recurrence interval) of approximately 92 cubic feet per second (cfs) and a Q_{100} flow rate of approximately 412 cfs. The downstream gage 12323250 indicated a $Q_{1.5}$ of approximately 153 cfs and a Q_{100} of approximately 552 cfs. The Consent Decree for the Butte Priority Soils Operable Unit (EPA, 2020) specifies that the 100-year floodplain be designed to convey a minimum capacity of 493 cfs. The average of the upstream and downstream Q_{100} flow rates is approximately 482 cfs, which is within 2.3% of the specified flow. The average of the upstream and downstream $Q_{1.5}$ flow is approximately 122 cfs (refer to the list below).

	Calculated Flow Rate (cubic feet per second)		Average Flow Rate from Upstream and Downstream
Recurrence	Upstream	Downstream	
Q100	412	552	482
Q25	306	421	363
Q10	236	334	285
Q5	184	268	226
Q2.33	114	181	147
Q1.5	92	153	122

3.2 StreamStats Analysis Results

The StreamStats analysis results correlated very closely with the gage data for the $Q_{1.5}$ flows, which are used to size and design the stream channel. The $Q_{1.5}$ estimated by StreamStats was 123 cfs which is just 1 cfs higher than the estimate from the gage data and is remarkably similar. The less frequent the flood recurrence interval, the further the variance became with the StreamStats results. StreamStats is a useful software for ungagged basins because it allows users to quickly estimate flows using the basin characteristics when there is no actual flow data. However, for a gaged basin, as is the case for the BRW Site, that has upstream and downstream gages with a nearly 30-year period of record, the real-world flow data should be used with much higher confidence than the StreamStats estimates.

3.3 Design Considerations

A conservative approach would be to use the higher downstream flows from USGS gage 12323250 for the design flows. This conservative approach could help to account for increased storm water runoff caused by increased impervious surfaces from future urban development. However, oversizing the channel could result in too infrequent flooding and a less robust riparian habitat. Another approach would be to use the average values of the two gages as discussed in the previous section. This approach may still overestimate the flow rates when the remedial activities of the upstream SBC Corridor sites are considered.

The primary objective of the remedial activities upstream of BRW is to construct stormwater detention/retention basins to impound storm water runoff that currently enters SBC via the engineered upper SBC channel at the confluence immediately upstream of the BRW Site. The objective is to permanently retain the 6-month, 24-hour storm volume and to temporarily detain up to the 10-year, 24-hour storm volume to remove sediments and improve water quality. Because the storm flows from these tributaries will be retained/detained, those storm volumes will be removed from future flood events, thus reducing the storm event flow rates through the BRW Site.

One final consideration is that BMFOU discharge and/or discharge from a restored upper Silver Bow Creek may be added to the SBC flows in the future. The potential for this additional flow could significantly increase base flows, but the additional flow is unlikely to have a significant impact on the larger flood event flows. Because channel sizing is based on the $Q_{1.5}$, any additions to the base flow will have little to no effect on the channel sizing or design.

4 References

EPA, 2020. Consent Decree For The Butte Priority Soils Operable Unit Partial Remedial Design/Remedial Action and Operation And Maintenance. U.S. Environmental Protection Agency. February 13, 2020. Available at https://www.co.silverbow.mt.us/2161/ButtePriority-Soils-Operable-Unit-Conse.

USGS 1982. Guidelines for Determining Flood Flow Frequency Bulletin #17B. U.S. Geological Survey 1982.

5 Document Revision Summary

Revision No.	Author	Version	Description	Date
Rev 0	MSP	1	Initial Calculation	3/19/2021
Rev 1	MSP	2	Incorporate Atlantic Richfield internal review comments.	5/13/2021

ATTACHMENT A-1A

FLOOD FREQUENCY ANALYSIS FOR USGS GAGING STATIONS 12323240 AND 12323250

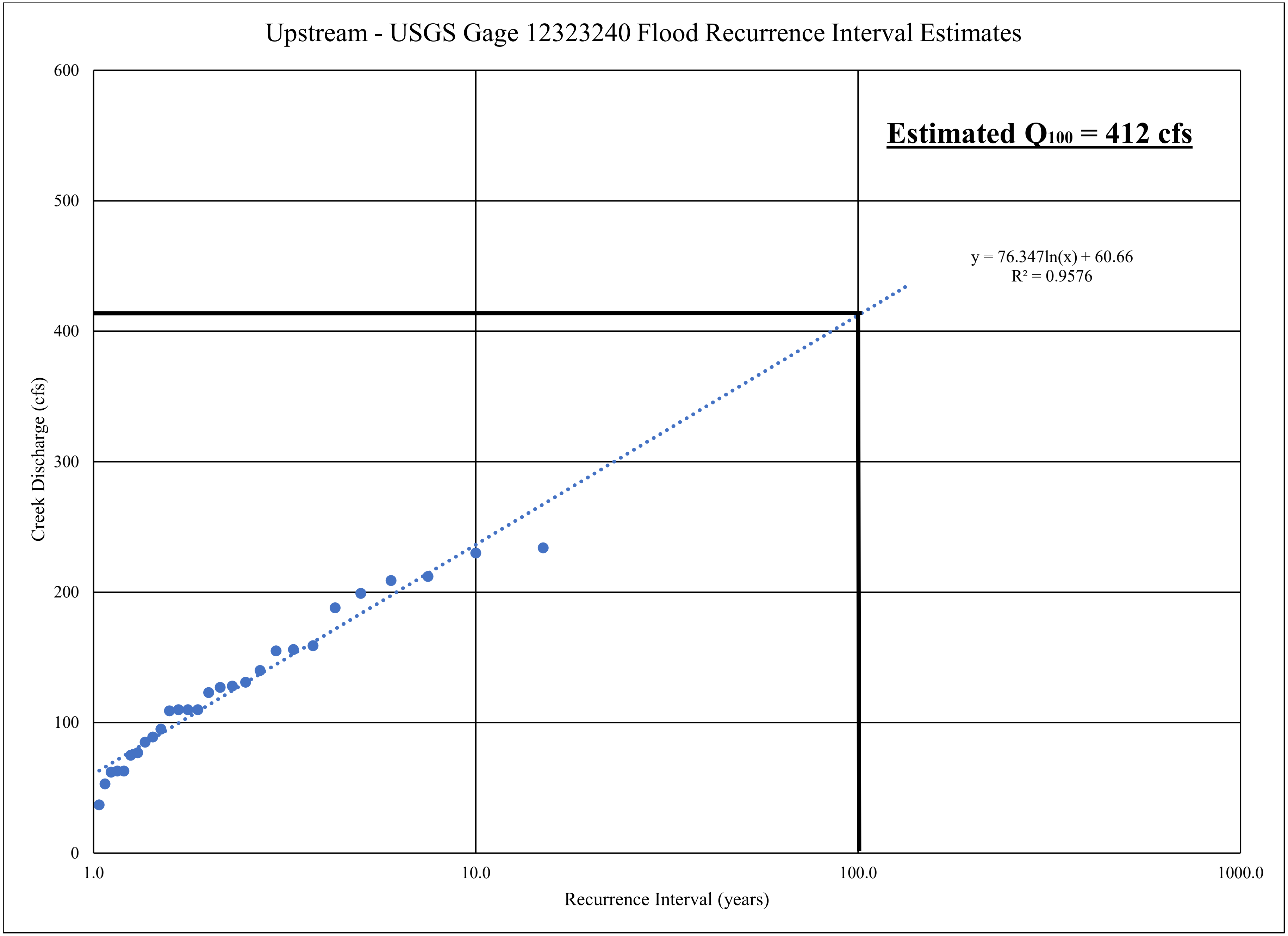
Upstream - USGS Gage 12323240 Flood Recurrence Interval Estimates

Year	Peak Discharge[1] (cfs)	Rank[2]	Recurrence Interval[3] (Years)	Notes[4]
1995	303	1	30.0	Inst.
2003	234	2	15.0	
2011	230	3	10.0	
1996	212	4	7.5	
1994	209	5	6.0	
1998	199	6	5.0	Inst.
1997	188	7	4.3	
1999	159	8	3.8	
2010	156	9	3.3	
1993	155	10	3.0	Inst.
2007	140	11	2.7	
2017	131	12	2.5	
2006	128	13	2.3	
2014	127	14	2.1	
2004	123	15	2.0	
2008	110	16	1.9	
2009	110	17	1.8	
2012	110	18	1.7	
2001	109	19	1.6	
1992	95	20	1.5	Inst.
2005	89	21	1.4	
1990	85	22	1.4	Inst.
2015	77	23	1.3	
2013	75	24	1.3	
1989	63	25	1.2	Inst.
2016	63	26	1.2	
2002	62	27	1.1	Inst.
1991	53	28	1.1	
2000	37	29	1.0	

1) Peak Discharge Measured at USGS Gaging Station 12323240
2) Rank (m) based on 29 years of record (n) = 29
3) Recurrence interval = (n+1)/m
4) Daily average peak flows (from USGS) replaced with instantaneous flows.

Recurrence	Calculated Flow Rate
Q100	412
Q25	306
Q10	236
Q5	184
Q2.33	114
Q1.5	92

Average Flow Rate from Upstream and Downstream
482
363
285
226
147
122



Upstream - USGS Gage 12323240 Flood Recurrence Interval Estimates
Estimated Q100 = 412 cfs
y = 76.347ln(x) + 60.66
R² = 0.9576
Creek Discharge (cfs)
600
500
400
300
200
100
0
1.0
10.0
100.0
1000.0
Recurrence Interval (years)

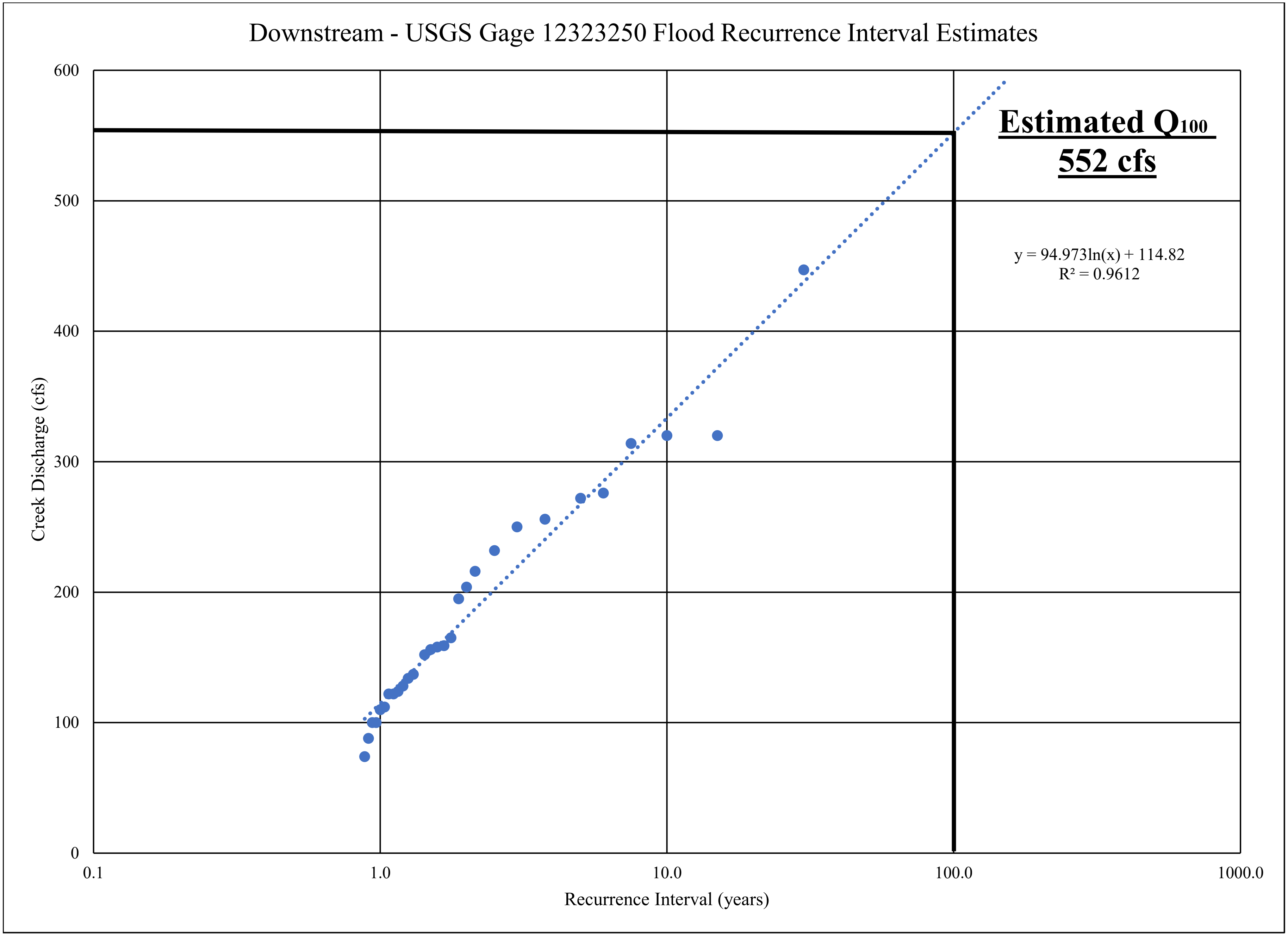
Downstream - USGS Gage 12323250 Flood Recurrence Interval Estimates

Year	Peak Discharge[1] (cfs)	Rank[2]	Recurrence Interval[3] (Years)	Notes[4]
1998	447	1	30.0	
1990	320	2	15.0	
1995	320	3	10.0	
2003	314	4	7.5	Inst.
1997	276	5	6.0	
1996	272	6	5.0	
2001	256	8	3.8	
2011	250	10	3.0	
1992	232	12	2.5	
1991	216	14	2.1	
1999	204	15	2.0	
2010	195	16	1.9	Inst.
1993	165	17	1.8	Inst.
1994	159	18	1.7	
2006	158	19	1.6	
2017	156	20	1.5	
1989	152	21	1.4	Inst.
2002	137	23	1.3	
2008	134	24	1.3	Inst.
2014	128	25	1.2	
2007	124	26	1.2	
2004	122	27	1.1	
2012	122	28	1.1	
2009	112	29	1.0	
2016	110	30	1.0	
2013	100	31	1.0	
2015	100	32	0.9	
2005	88	33	0.9	Inst.
2000	74	34	0.9	

1) Peak Discharge Measured at USGS Gaging Station 12323250
2) Rank (m) based on 29 years of record (n) = 29
3) Recurrence interval = (n+1)/m
4) Daily average peak flows (from USGS) replaced with instantaneous flows.

Recurrence	Calculated Flow Rate
Q100	552
Q25	421
Q10	334
Q5	268
Q2.33	181
Q1.5	153

Average Flow Rate from Upstream and Downstream
482
363
285
226
147
122

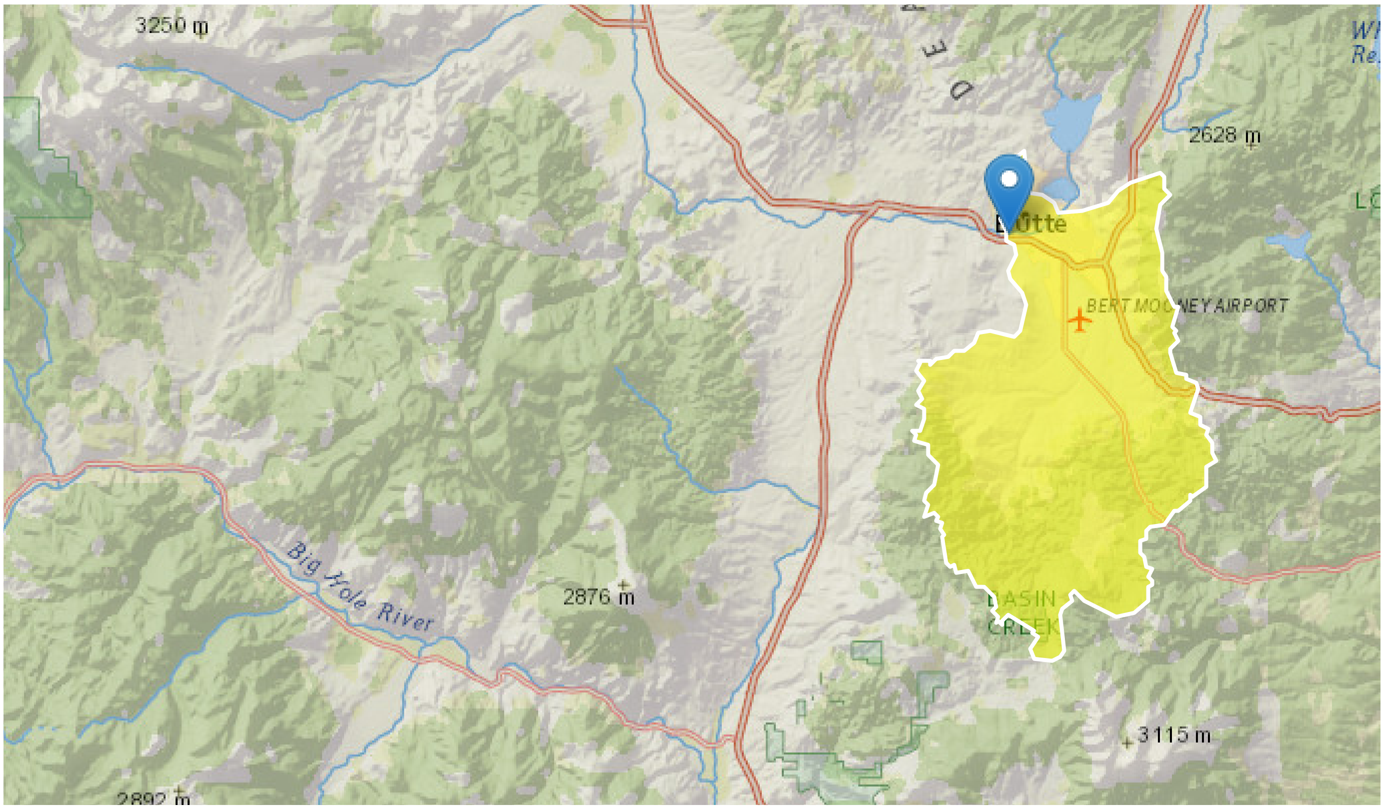

Downstream - USGS Gage 12323250 Flood Recurrence Interval Estimates
Estimated Q100
552 cfs
y = 94.973ln(x) + 114.82
R² = 0.9612
Creek Discharge (cfs)
0
100
200
300
400
500
600
0.1
1.0
10.0
100.0
1000.0
Recurrence Interval (years)

ATTACHMENT A-1B

USGS CALCULATIONS FOR SILVER BOW CREEK AT DOWNSTREAM BOUNDARY OF BRW SITE

StreamStats Report for BRW Site

Region ID: MT
Workspace ID: MT20210115172405610000
Clicked Point (Latitude, Longitude): 45.99470, -112.54704
Time: 2021-01-15 10:24:21 -0700



This Report is for Silver Bow Creek at the west (downstream) boundary of the Butte Reduction Works (BRW) Site. The basin was edited to exclude the drainage area for the Berkeley Pit, Continental Pit, and Yankee Doodle Tailings Impoundment because these areas are endorheic and do not contribute to the drainage basin for the selected site.

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
CONTDA	Area that contributes flow to a point on a stream	97.8	square miles
PRECIP	Mean Annual Precipitation	16.95	inches
FOREST	Percentage of area covered by forest	53.6	percent
ELEV	Mean Basin Elevation	6242.2	feet
BSLDEM30M	Mean basin slope computed from 30 m DEM	19.9	percent

Parameter Code	Parameter Description	Value	Unit
EL6000	Percent of area above 6000 ft	58.4	percent
RELIEF	Maximum - minimum elevation		feet
TEMP	Mean Annual Temperature		degrees F

General Disclaimers

This watershed has been edited, computed flows may not apply.

Peak-Flow Statistics Parameters[100 Percent (97.8 square miles) W Region BasinC 2015 5019F]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
CONTDA	Contributing Drainage Area	97.8	square miles	0.6	2470
PRECIP	Mean Annual Precipitation	16.95	inches	14.6	62.1
FOREST	Percent Forest	53.6	percent	20.4	99.1

Peak-Flow Statistics Flow Report[100 Percent (97.8 square miles) W Region BasinC 2015 5019F]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SEp
1.5 Year Peak Flood	123	ft^3/s	49.2	307	59.4
50_percent_AEP_flood	171	ft^3/s	70.8	413	56.5
2 33 Year Peak Flood	197	ft^3/s	82.3	471	55.7
20_percent_AEP_flood	324	ft^3/s	140	749	53.4
10_percent_AEP_flood	464	ft^3/s	202	1060	52.8
4_percent_AEP_flood	644	ft^3/s	280	1480	53.2
2_percent_AEP_flood	800	ft^3/s	341	1880	54.2
1_percent_AEP_flood	974	ft^3/s	407	2330	56
0_5_percent_AEP_flood	1160	ft^3/s	471	2860	58
0_2_percent_AEP_flood	1410	ft^3/s	548	3630	61.4

Peak-Flow Statistics Citations

Sando, Roy, Sando, S.K., McCarthy, P.M., and Dutton, D.M.,2016, Methods for estimating peak-flow frequencies at ungaged sites in Montana based on data through water year 2011: U.S. Geological Survey Scientific Investigations Report 2015–5019–F, 30 p. (https://doi.org/10.3133/sir20155019)

Application Version: 4.4.0

Appendix A.2
Reconstructed Silver Bow Creek Hydraulics Modeling for the BRW Smelter Area

Date:	5/13/2021	Project:	Butte Reduction Works Smelter Area Remedial Design	Prepared By:	MSP
Rev. No.	1	Office:	Butte, MT	Checked By:	
Rev. Date:		Calc. No.		Approved By:	
Subject:	Reconstructed Silver Bow Creek Hydraulics Modeling for the BRW Smelter Area				

Reconstructed Silver Bow Creek Hydraulics Modeling for the BRW Smelter Area

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1 Purpose and Objectives....1
2 Methods and Data....1
2.1 Reconstructed Stream Channel....2
2.2 Streambed Media Sizing....2
3 Results and Discussion....3
4 References....4
5 Document Revision Summary....4

ATTACHMENT A-2A
Manning's Roughness Coefficient (n) Values
ATTACHMENT A-2B
HEC-RAS Model and Sediment Transport Calculations
ATTACHMENT A-2C
Hydraflow Express Channel Sizing Calculations
ATTACHMENT A-2D
Streambed Material Sizing Calculations

1 Purpose and Objectives

The selected remedy for the Butte Reduction Works (BRW) Smelter Area Site (Site) is to remove mine wastes, slag, construction debris, and impacted alluvial sediments within the Silver Bow Creek (SBC) floodplain. This calculation summary describes the modeling performed for the reconstructed conditions for SBC through the Site. Modeled velocities and shear stresses within the reconstructed portion of SBC were used to evaluate the reconstructed conditions and ensure the stability of the designed stream channel. The sediment transport capacities will be added to the model during the Intermediate 60% Remedial Design efforts.

2 Methods and Data

The reconstructed conditions within SBC were modeled primarily using three electronic programs: AutoCAD Civil 3D, Hydraflow Express Extension for AutoCAD Civil 3D, and U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) 5.0.7 one-dimensional modeling software. AutoCAD Civil 3D was used to prepare the reconstructed stream channel alignment, channel profile, and channel cross sections. The horizontal and vertical locations of the reconstructed stream channel were based on the designed excavation of mine waste materials and the associated final grading surface contours. The extent of the channel reconstruction was determined based on the final grading surface contours and existing topographical trends within SBC upstream and downstream of the Site.

The approximate 1.5-year flow of 122 cubic feet per second (cfs) was used as the bankfull flow for the reconstructed stream channel. Peak flows for SBC through the Site were calculated using flood frequency data from U.S. Geological Survey (USGS) gaging stations 12323240 and 12323250. The peak flow calculations and results are provided in Appendix A-1 of the Remedial Design Report for the BRW Smelter Area, to which this document is also an Appendix.

2.1 Reconstructed Stream Channel

A Manning's Roughness Coefficient (n) of 0.05 was selected for the stream channel based on the stream condition with a cobble, gravel, and woody debris substrate. A Manning's n-value of 0.04 was selected for overbank flow conditions in the reconstructed riparian area based on a floodplain cultivated with mature field crops. This n-value was chosen to best represent the riparian area during the initial years after reconstruction. It is anticipated that mature trees and brush will take longer to establish, so the conservative approach was used to model the riparian area as a cultivated zone. Guidance used for selecting Manning's n-values is provided in Attachment A-2A.

Initial sizing of the reconstructed stream channel was completed using the Hydraflow Express Extension for AutoCAD Civil 3D. The sizing calculations provided an initial estimate of the channel size required to convey the required flows at the reconstructed average grade of approximately 0.36%.

The hydraulic properties of the reconstructed SBC were modeled using the HEC-RAS software to ensure that the new stream channel design was within the parameters set forth by anticipated flow events for SBC. To streamline the iterative process of running HEC-RAS models and modifying the reconstructed surface grades in AutoCAD Civil 3D, the software program GeoHECRAS was used to import and export data directly to and from AutoCAD Civil 3D.

Cross sections were imported from AutoCAD Civil 3D into GeoHECRAS along with the reconstructed stream channel alignment. Cross sections were then modified within the GeoHECRAS environment during iterative model scenarios to appropriately define the channel and bank shape, elevation, and slopes. Additional cross sections will be added as the GeoHECRAS model is refined during the 60% Remedial Design efforts and as the run, riffle, and pool morphology are further defined within the design.

Peak flows were input into the GeoHECRAS model based on the flood frequency analysis for the 1.5, 5, 10, 25, and 100-year flow recurrences. A base flow discharge of 15 cfs was also input into the HEC-RAS model to illustrate normal base flow conditions at the Site. The GeoHECRAS model was used to determine the reconstructed condition floodplain extent, velocities, shear, and sediment transport capacity.

2.2 Streambed Media Sizing

Reconstructed stream channel bedding sizing was completed using the U.S. Bureau of Reclamation (USBR) document *Reclamation Managing Water in the West Rock Ramp Design Guidelines* (USBR, 2007). This document recommends sizing step rocks using USACE methods for "steep slope riprap design." This method uses the slope of the channel and unit discharge to calculate a recommended minimum rock size (D_{30}) for step rock sizing as shown in the following formula:

$$D_{30} = \frac{1.95 * S^{0.555} * q^{2/3}}{g^{1/3}}$$

Where:

S = slope of the channel.
q = design unit discharge with a 1.25 flow concentration factor such that q = 1.25*(Q/W).
g = acceleration due to gravity.
D_{30} = characteristic stone size 30 percent quantile.

Using the $Q_{1.5}$ modeled channel flow properties (bankfull capacity equivalent to a flood with a 1.5 year recurrence interval), the riprap sizing method results in a maximum D_{100} stone size equal to 6 inches. Using the Q_{100} modeled channel flow properties, the riprap sizing method results in a riprap maximum D_{100} stone size equal to 9 inches. The reconstructed stream channel armor will be specified to have a maximum D_{100} equal to 9 inches. The armor will be keyed into a minimum depth of 2 times the D_{50} or approximately 18 inches.

3 Results and Discussion

GeoHECRAS results are provided in Attachment A-2B. The calculations and program output for initial channel sizing using Hydraflow Express are shown in Attachment A-2C. The Hydraflow Express calculations closely match the bankfull locations modeled in GeoHECRAS for the reconstructed section of SBC. The standard channel bottom width of 12 feet, top width of 15 feet, depth of 1.5 feet, and average grade of 0.36% will allow at least 6 inches of water during base flows to provide fish passage and habitat and will convey the bankfull $Q_{1.5}$ flows of 122 cfs.

The GeoHECRAS model calculated velocities in the channel ranging from 2.9 feet/second to 6.5 feet/second during the $Q_{1.5}$ flow recurrence, and velocities ranging from 4.4 feet/second to 7.9 feet/second during the Q_{100} flow recurrence. Base flow velocities within the channel were calculated to range from 1.1 feet/second to 2.2 feet/second.

The GeoHECRAS results in Attachment A-2B include plan view flood extents shown for the Q_{100} flow recurrence event. The profile plots, velocity summary, shear summary, and HEC-RAS summary report will be added to the model during the Intermediate 60% Remedial Design efforts.

The USBR calculations for evaluating streambed materials sizing and placement are provided in Attachment A-2D. The analysis of streambed materials recommended a D_{100} of 9 inches placed to a depth of at least 18 inches.

4 REFERENCES

Pioneer, 2018. Physical Map Revision Silver Bow Creek Silver Bow County, Montana Hydrologic Analysis Report. Prepared for: State of Montana, Department of Environmental Quality. Pioneer Technical Services, Inc. 2018.

USBR, 2007. Reclamation Managing Water in the West Rock Ramp Design Guidelines. U.S. Bureau of Reclamation. September 2007.

5 DOCUMENT REVISION SUMMARY

Revision No.	Author	Version	Description	Date
Rev 0	MSP	1	Draft for Preliminary 30% Remedial Design Report	3/19/2021
Rev 1	MSP	1	Incorporate Atlantic Richfield internal review comments.	5/13/2021
Rev 2				
Rev 3				
Rev 4				

ATTACHMENT A-2A

Manning’s Roughness Coefficient (n) Values

Show

Manning's n Values

Reference tables for Manning's n values for Channels, Closed Conduits Flowing Partially Full, and Corrugated Metal Pipes.

Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Cultivated areas			
1. no crop	0.020	0.030	0.040
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.030	0.040	0.050
c. Brush			
1. scattered brush, heavy weeds	0.035	0.050	0.070
2. light brush and trees, in winter	0.035	0.050	0.060
3. light brush and trees, in summer	0.040	0.060	0.080
4. medium to dense brush, in winter	0.045	0.070	0.110
5. medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200
2. cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little			

undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160
4. Excavated or Dredged Channels			
a. Earth, straight, and uniform			
1. clean, recently completed	0.016	0.018	0.020
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.030
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.030
2. grass, some weeds	0.025	0.030	0.033
3. dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. earth bottom and rubble sides	0.028	0.030	0.035
5. stony bottom and weedy banks	0.025	0.035	0.040
6. cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.040
2. jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.050	0.080	0.120
2. clean bottom, brush on sides	0.040	0.050	0.080
3. same as above, highest stage of flow	0.045	0.070	0.110
4. dense brush, high stage	0.080	0.100	0.140
5. Lined or Constructed Channels			
a. Cement			
1. neat surface	0.010	0.011	0.013
2. mortar	0.011	0.013	0.015
b. Wood			
1. planed, untreated	0.010	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplaned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015
2. float finish	0.013	0.015	0.016
3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	

Manning's roughness coefficient values are used in the Manning's formula for flow calculation in open flow channels. Coefficients for some common used surface materials can be found in the table below:

Surface Material	Manning's Roughness Coefficient *- n -*
Asbestos cement	0.011
Asphalt	0.016
Brass	0.011
Brick	0.015
Canvas	0.012
Cast-iron, new	0.012
Clay tile	0.014
Concrete - steel forms	0.011
Concrete (Cement) - finished	0.012
Concrete - wooden forms	0.015
Concrete - centrifugally spun	0.013
Copper	0.011
Corrugated metal	0.022
Earth, smooth	0.018
Earth channel - clean	0.022
Earth channel - gravelly	0.025
Earth channel - weedy	0.030
Earth channel - stony, cobbles	0.035
Floodplains - pasture, farmland	0.035
Floodplains - light brush	0.050
Floodplains - heavy brush	0.075
Floodplains - trees	0.15
Galvanized iron	0.016
Glass	0.010
Gravel, firm	0.023
Lead	0.011
Masonry	0.025
Metal - corrugated	0.022
Natural streams - clean and straight	0.030
Natural streams - major rivers	0.035
Natural streams - sluggish with deep pools	0.040
Natural channels, very poor condition	0.060
Plastic	0.009
Polyethylene PE - Corrugated with smooth inner walls	0.009 - 0.015
Polyethylene PE - Corrugated with corrugated inner walls	0.018 - 0.025
Polyvinyl Chloride PVC - with smooth inner walls	0.009 - 0.011
Rubble Masonry	0.017
Steel - Coal-tar enamel	0.010
Steel - smooth	0.012
Steel - New unlined	0.011
Steel - Riveted	0.019
Vitrified Sewer	0.013 - 0.015
Wood - planed	0.012
Wood - unplaned	0.013
Wood stove pipe, small diameter	0.011 - 0.012
Wood stove pipe, large diameter	0.012 - 0.013

ATTACHMENT A-2B

HEC-RAS Model and Sediment Transport Calculations

HEC-RAS Version 4.1.0 Jan 2010
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX   XXXX        XXXX      XX     XXXX
X     X  X        X    X      X    X    X  X   X
X     X  X        X           X    X   X    X  X
XXXXXXX  XXXX     X     XXX   XXXX     XXXXXX   XXXX
X     X  X        X           X X      X    X       X
X     X  X        X    X      X  X     X    X       X
X     X  XXXXXX   XXXX        X   X    X    X   XXXXX
```

PROJECT DATA
Project Title: HEC-RAS Model
Project File : BRW-2.prj
Run Date and Time: 1/12/2021 3:15:47 PM

Project in English units

Project Description:
CRS Info=<SpatialReference> <CoordinateSystem Code="102700"
Unit="US_survey_Foot" AcadCode="" /> <Registration OffsetX="0" OffsetY="0"
OffsetZ="0" ScaleX="1" ScaleY="1" ScaleZ="1" /></SpatialReference>

PLAN DATA

Plan Title: Default Scenario
Plan File : P:\ARCO\BPSOU\BRW\BRW_Design\2019\StreamDesign\HecRas\BRW-2.p01

Geometry Title: Default Geometry
Geometry File : P:\ARCO\BPSOU\BRW\BRW_Design\2019\StreamDesign\HecRas\BRW-2.g01

Flow Title   : Default Steady Flow
Flow File   : P:\ARCO\BPSOU\BRW\BRW_Design\2019\StreamDesign\HecRas\BRW-2.f01

Plan Description:
Default Scenario

Plan Summary Information:
Number of: Cross Sections =   38   Multiple Openings =   0
Culverts   =   0   Inline Structures =   0
Bridges   =   0   Lateral Structures =   0

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.33
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: Default Steady Flow
Flow File : P:\ARCO\BPSOU\BRW\BRW_Design\2019\StreamDesign\HecRas\BRW-2.f01

Flow Data (cfs)

River	Reach	RS	QBase	Q1.5	Q2.33	Q5	Q10	Q25	Q100
SBC	1	1887	15	131	155	232	291	369	493

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
SBC	1	QBase	Critical	Critical
SBC	1	Q1.5	Critical	Critical
SBC	1	Q2.33	Critical	Critical
SBC	1	Q5	Critical	Critical
SBC	1	Q10	Critical	Critical
SBC	1	Q25	Critical	Critical
SBC	1	Q100	Critical	Critical

GEOMETRY DATA

Geometry Title: Default Geometry
Geometry File : P:\ARCO\BPSOU\BRW\BRW_Design\2019\StreamDesign\HecRas\BRW-2.g01

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1887

INPUT
Description:
Station Elevation Data num= 11

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5453	139	5444	148	5443.5	150	5441	156.5	5441
163	5441	165	5443.5	190.85	5444	204.81	5444.5	236.61	5445.5
313.89	5446								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148	.032	165	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148	165	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1836

INPUT
Description:
Station Elevation Data num= 18

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5447	52.64	5446.5	99.47	5445	118.21	5444.5	124.85	5444.2
131.51	5444	142	5443.6	148	5443.31	150	5440.81	156.47	5440.81
163	5440.81	165	5443.31	169.41	5443.5	188.51	5444.1	204.03	5444.5
220.35	5445	249.1	5445.5	313.7	5446				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148	.032	165	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148	165	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1785

INPUT
Description:
Station Elevation Data num= 33

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5448	26.39	5448	63.12	5447	87.56	5446	117.13	5445
123.8	5444.5	130.47	5444.2	137.14	5443.9	148.5	5443.12	150.5	5440.62
157	5440.62	163.5	5440.62	165.5	5443.12	176.76	5443.7	188.03	5443.9
210.88	5444.2	234.11	5445	251.72	5446	251.89	5447	252.06	5448
252.24	5449	252.41	5450	252.58	5451	252.76	5452	252.93	5453
253.1	5454	253.28	5455	253.45	5456	253.62	5457	253.79	5458

253.97	5459	254.3	5460	313.85	5460

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.5	.032	165.5	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.5	165.5	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1734

INPUT
Description:
Station Elevation Data num= 39

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5448	17.19	5448	47.52	5447	82	5446	115.08	5445
121.73	5444.5	128.4	5444.2	135.06	5443.9	148	5442.93	150	5440.43
156.5	5440.43	163	5440.43	165	5442.93	177.04	5443.8	183.69	5444.1
187.75	5444.2	200.1	5444.3	219.19	5444.5	238.09	5445	252.14	5446
254.27	5447	256.4	5448	258.53	5449	260.65	5450	262.92	5451
265.7	5452	268.49	5453	271.27	5454	274.05	5455	276.83	5456
280.02	5457	283.28	5458	286.53	5459	289.91	5460	293.58	5461
297.21	5462	301.22	5463	305.13	5464	312.73	5464		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148	.032	165	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148	165	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1683

INPUT
Description:
Station Elevation Data num= 31

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5448	12.88	5448	35	5447	64.1	5446	113.32	5444.4
120.11	5444	126.89	5443.7	133.68	5443.4	148	5442.74	150	5440.24
156.5	5440.24	163	5440.24	165	5442.74	178.82	5443.4	198.24	5443.7
216.23	5444	234.21	5445	245.68	5446	249.96	5447	254.25	5448
258.61	5449	263.71	5450	268.73	5451	273.55	5452	278.93	5453
284.11	5454	289.73	5455	295.4	5456	301.34	5457	307.58	5458
312.34	5458								

Manning's n Values num= 3

```
   Sta   n Val     Sta   n Val     Sta   n Val
     0    .045     148    .032     165    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         148     165           50.53   50.53   50.53            .1       .3
```

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1632

INPUT
Description:

```
Station Elevation Data    num=      31
    Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
      0    5447   22.34    5447   47.64    5446  106.03  5444.4  120.42    5444
 127.39  5443.6  133.84  5443.4   145.7  5443.1   149.5 5442.55   151.5 5440.05
    158 5440.05   164.5 5440.05   166.5 5442.55  181.26  5443.1  191.02  5443.2
 198.53  5443.4  206.04  5443.6  214.51    5444  223.15    5445  230.75    5446
 237.26    5447  243.93    5448  250.87    5449  258.25    5450  265.97    5451
 273.78    5452  281.96    5453  290.48    5454  299.34    5455  308.32    5456
 314.13    5456

Manning's n Values        num=       3
    Sta   n Val     Sta   n Val     Sta   n Val
      0    .045   149.5    .032   166.5    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        149.5   166.5           50.53   50.53   50.53            .1       .3
```

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1581

INPUT
Description:

```
Station Elevation Data    num=      26
    Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
      0    5446    2.91    5446   41.82    5445  113.41  5443.8  120.67  5443.6
 128.54  5443.4     144  5443.1     148 5442.36     150 5439.86   156.5 5439.86
    163 5439.86     165 5442.36     169  5443.1  191.35  5443.4  203.45  5443.6
 214.32    5444  223.87  5444.5  237.37    5446  246.72    5447  257.04    5448
 267.69    5449  278.34    5450  289.31    5451  300.78    5452  312.62    5453
 313.29    5453

Manning's n Values        num=       3
    Sta   n Val     Sta   n Val     Sta   n Val
      0    .045     148    .032     165    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         148     165           50.53   50.53   50.53            .1       .3
```

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1530

INPUT
Description:
Station Elevation Data num= 24

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	45.13	5444	98.7	5443.6	115.39	5443.4	132.83	5443.1
136.97	5443	147.5	5442.17	149.5	5439.67	156	5439.67	162.5	5439.67
164.5	5442.17	174.49	5442.9	181.83	5443.1	188.45	5443.3	199.7	5444
212.04	5445	226.11	5446	240.07	5447	252.46	5448	266.58	5449
282.08	5450	297.55	5451	312.54	5452	313.11	5452		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	147.5	.032	164.5	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
147.5	164.5	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1479

INPUT
Description:
Station Elevation Data num= 22

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	19.96	5444.5	62.8	5443.7	75.38	5443.5	135.54	5442.8
148	5442	150	5439.5	156.5	5439.5	163	5439.5	165	5442
178.17	5442.8	184.72	5443	191.27	5443.3	197.82	5443.6	204.37	5444
224.4	5445	244.87	5446	263.05	5447.5	280.42	5449	297.2	5450
313.51	5451	313.72	5451						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148	.032	165	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148	165	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1428

INPUT

Description:
Station Elevation Data num= 24

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	12.49	5445	52.62	5444.3	63.39	5444	109.61	5443.3
126.01	5443	133	5442.8	142.8	5442.7	149	5441.8	151	5439.3
157.5	5439.3	164	5439.3	166	5441.8	173	5442.7	180.8	5443
187.99	5443.3	194.92	5443.6	201.86	5444	210.22	5444.5	236.5	5445.5
259.13	5447	279.89	5448	299.67	5449	314.15	5449		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	149	.032	166	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
149	166	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1377

INPUT
Description:
Station Elevation Data num= 20

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	22.23	5444.5	60.83	5443.5	70.87	5443.2	133.62	5442.2
148.1	5441.61	150.1	5439.11	156.6	5439.11	163.1	5439.11	165.1	5441.61
174.4	5442.7	180.61	5443	187.56	5443.2	194.51	5443.5	201.42	5443.8
235.91	5445	261.53	5446	284.98	5447	306.99	5448	314.23	5448

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.1	.032	165.1	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.1	165.1	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1326

INPUT
Description:
Station Elevation Data num= 23

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5446	17.14	5446	20.71	5445	25.69	5444	63.08	5443.3
73.16	5443.1	83.25	5443	91.06	5442.9	138.72	5442	148.5	5441.43
150.5	5438.93	157	5438.93	163.5	5438.93	165.5	5441.43	169.01	5442
182.04	5442.8	188.79	5443	195.53	5443.2	222.82	5444	252.08	5445
277.26	5446	300.67	5447	315.01	5447				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.5	.032	165.5	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.5	165.5	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1275

INPUT
Description:
Station Elevation Data num= 23

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5447	6.67	5447	14.39	5446	22.12	5445	28.93	5444
59.82	5443.2	70.6	5443	81.46	5442.8	140.48	5441.6	148.25	5441.24
150.25	5438.74	156.75	5438.74	163.25	5438.74	165.25	5441.24	175.96	5441.5
185.57	5441.6	193.19	5441.8	200.97	5442	231.44	5444	258.38	5445
282.38	5446	305.06	5447	314.18	5447				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.25	.032	165.25	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.25	165.25	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1224

INPUT
Description:
Station Elevation Data num= 20

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5444	23.37	5444	55.74	5443	67.61	5442.9	80.35	5442.8
134.91	5441.4	148.42	5441.05	150.42	5438.55	156.92	5438.55	163.42	5438.55
165.42	5441.05	178.24	5441.5	185.57	5441.7	192.89	5441.9	200.11	5442.1
230.14	5444	253.52	5445	275.49	5446	297	5447	313.62	5447

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.42	.032	165.42	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.42	165.42	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1173

INPUT
Description:
Station Elevation Data num= 24

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	10.48	5445	30.49	5444	83.29	5443	94.99	5441.9
106.74	5441.7	119.86	5441.6	129.07	5441.5	132.79	5441.4	139.1	5441.3
148.33	5440.86	150.33	5438.36	156.83	5438.36	163.33	5438.36	165.33	5440.86
177.75	5441.3	184.36	5441.4	190.99	5441.5	222.44	5443	245.55	5444
265.52	5445	286.64	5446	307.69	5447	312.42	5447		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.33	.032	165.33	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.33	165.33	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1122

INPUT
Description:
Station Elevation Data num= 20

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5446	2.32	5446	21.37	5445	39.29	5444	57.21	5443
117.03	5441.4	124.64	5441.3	132.24	5441.2	148.33	5440.67	150.33	5438.17
156.83	5438.17	163.33	5438.17	165.33	5440.67	182.99	5441.2	196.58	5441.3
214.28	5442.4	242.83	5443	273.84	5444	296.07	5445	314.16	5445

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.33	.032	165.33	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.33	165.33	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1071

INPUT
Description:
Station Elevation Data num= 21

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5446	26.48	5446	44.4	5445	62.32	5444	80.24	5443

114.07 5441.4 121.91 5441.3 129.77 5441.2 139.79 5441 149.17 5440.48
151.17 5437.98 157.67 5437.98 164.17 5437.98 166.17 5440.48 169.94 5441
184.81 5441.1 204.12 5441.2 249.99 5442.4 285.29 5443 310.78 5444
313.27 5444

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	149.17	.032	166.17	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
149.17	166.17	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 1020

INPUT
Description:
Station Elevation Data num= 20

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5446	42.17	5446	59.68	5445	77.84	5444	95.83	5443
116.69	5441.3	123.45	5441.2	130.2	5441.1	139.63	5441	147.13	5440.3
149.13	5437.8	155.63	5437.8	162.13	5437.8	164.13	5440.3	172.08	5441
181.98	5441.1	188.66	5441.2	246.74	5442.6	298.55	5443	312.94	5443

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	147.13	.032	164.13	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
147.13	164.13	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 969

INPUT
Description:
Station Elevation Data num= 21

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5446	39.37	5446	56.67	5445	73.96	5444	89.88	5443
106.6	5442.2	122.38	5441.1	129.28	5441	136.16	5440.9	146.5	5440.1
148.5	5437.6	155	5437.6	161.5	5437.6	163.5	5440.1	177.8	5440.9
184.81	5441	199.87	5441.1	239.24	5442.3	283.79	5443	306.55	5444
312.86	5444								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	146.5	.032	163.5	.045

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
146.5 163.5 50.53 50.53 50.53 .1 .3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 918

INPUT
Description:
Station Elevation Data num= 23

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5446	13.49	5446	24.91	5445	36.32	5444	47.73	5443
64.48	5442.6	119.93	5441.2	127.31	5441.1	134.39	5441	144.98	5440.5
149.4	5439.91	151.4	5437.41	157.9	5437.41	164.4	5437.41	166.4	5439.91
185.37	5440.8	205.18	5441.5	221.84	5442.2	234.95	5442.4	245.85	5443
261.57	5444	288.29	5445	313.35	5445				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	149.4	.032	166.4	.045

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
149.4 166.4 50.53 50.53 50.53 .1 .3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 867

INPUT
Description:
Station Elevation Data num= 23

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	19.61	5445	28.11	5444	36.61	5443	45.11	5442.5
87.55	5442.2	101.93	5442	116.96	5441.9	140.81	5440.7	148.5	5439.72
150.5	5437.22	157	5437.22	163.5	5437.22	165.5	5439.72	178	5440.7
185.49	5441	192.16	5441.5	203.95	5442.1	219.21	5443	234.49	5444
249.97	5445	279.54	5446	312.94	5446				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.5	.032	165.5	.045

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
148.5 165.5 50.53 50.53 50.53 .1 .3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 816

INPUT
Description:
Station Elevation Data num= 26

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	50.56	5445	56.56	5444	62.81	5443	69.9	5442.3
89.21	5442	100.02	5441.9	110.89	5441.8	126.1	5441	134.31	5440.6
149	5439.53	151	5437.03	157.5	5437.03	164	5437.03	166	5439.53
169	5440	185.27	5441	193.46	5441.5	201.75	5442.1	210.1	5442.3
217.45	5443	224.8	5444	235.74	5445	264.1	5446	292.61	5447
314.68	5447								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	149	.032	166	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
149	166	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 765

INPUT
Description:
Station Elevation Data num= 29

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	75.79	5445	81.79	5444	87.78	5443	94.27	5442
100.75	5441.9	107.15	5441.8	116.49	5441.7	132.1	5441	136.84	5440.5
148.1	5439.34	150.1	5436.84	156.6	5436.84	163.1	5436.84	165.1	5439.34
172.05	5440.2	182.63	5441	189.32	5441.5	196.21	5441.8	203.16	5442
210.11	5443	217.05	5444	224	5445	230.95	5446	241.96	5447
251.64	5448	294.42	5448	297.24	5448	313.66	5448		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.1	.032	165.1	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.1	165.1	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 714

INPUT
Description:
Station Elevation Data num= 30

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	81.59	5445	89.07	5444	97.22	5443	105.75	5442

112.27 5441.7 116.61 5441.6 120.7 5441.5 134.91 5440.4 147.8 5439.15
149.8 5436.65 156.3 5436.65 162.8 5436.65 164.8 5439.15 177.17 5440.4
183.96 5441 190.75 5441.4 197.54 5441.7 204.32 5442 211.11 5443
217.9 5444 224.69 5445 231.64 5446 238.81 5447 245.99 5448
253.17 5449 264.59 5449 279.91 5448 295.18 5448 314.49 5448

Manning's n Values num= 3
Sta n Val Sta n Val Sta n Val
0 .045 147.8 .032 164.8 .045

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
147.8 164.8 50.53 50.53 50.53 .1 .3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 663

INPUT
Description:
Station Elevation Data num= 27
Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev
0 5445 72.72 5445 86.13 5444 99.38 5443 107.39 5442
113.75 5441.6 116.34 5441.5 118.93 5441.4 131.64 5440.3 147.6 5438.96
149.6 5436.46 156.1 5436.46 162.6 5436.46 165.6 5438.96 169.59 5440
180.3 5441.4 188.24 5441.5 196.76 5441.6 205.27 5441.7 213.66 5442
222.03 5443 230.37 5444 238.71 5445 247.05 5446 280.13 5447
301.5 5448 313.13 5448

Manning's n Values num= 3
Sta n Val Sta n Val Sta n Val
0 .045 147.6 .032 165.6 .045

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
147.6 165.6 50.53 50.53 50.53 .1 .3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 612

INPUT
Description:
Station Elevation Data num= 27
Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev
0 5445 37.71 5445 51.13 5444 64.55 5443 85.15 5442
108.42 5439.9 112.14 5439.7 115.96 5439.6 121.42 5439.5 148.3 5438.77
150.3 5436.27 156.8 5436.27 163.3 5436.27 165.3 5438.77 174.02 5439.2
183.64 5440.3 191.98 5441 200.32 5441.5 208.66 5441.6 219.68 5442
240.87 5443 259.46 5444 273.66 5445 287.02 5446 300.07 5447
312.63 5448 313.74 5448

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.3	.032	165.3	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.3	165.3	62.11	62.11	62.11	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 561

INPUT
Description:
Station Elevation Data num= 26

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5445	.69	5445	24	5444	50.81	5443	77.57	5442
104.33	5441	110.25	5440	115.84	5439.6	121.43	5439.3	137.45	5439.1
145	5438.58	147	5436.08	155.5	5436.08	165	5436.08	167	5438.58
183.35	5439.2	191.4	5439.5	209.98	5440	238.13	5441	264.34	5442
278.03	5443	288.81	5444	298.02	5445	304.77	5446	311.6	5447
312.99	5447								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	145	.032	167	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
145	167	54.58	54.58	54.58	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 510

INPUT
Description:
Station Elevation Data num= 21

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5444	14.34	5444	58.6	5443	89.21	5442	110.51	5441
117.17	5440	123.78	5439.2	130.39	5438.5	139.89	5438.4	148	5438.39
150	5435.89	156.5	5435.89	163	5435.89	165	5438.39	172.11	5438.4
177.85	5438.5	185.68	5438.7	191.88	5439	198.09	5439.2	273.19	5440
312.63	5441								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148	.032	165	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148	165	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 459

INPUT
Description:
Station Elevation Data num= 19

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5443	15.1	5443	52.12	5443	99.63	5442	106.61	5441
113.59	5440	120.56	5439	127.54	5438.4	134.85	5438.3	148.1	5438.2
150.1	5435.7	156.6	5435.7	163.1	5435.7	165.1	5438.2	178.58	5438.3
185.92	5438.5	193.21	5438.8	309.86	5440.5	313.73	5440.7		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.1	.032	165.1	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.1	165.1	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 408

INPUT
Description:
Station Elevation Data num= 21

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5443	27.06	5443	78.17	5442	108.65	5441	115.27	5440
121.88	5439	128.48	5438.2	135.08	5438.15	142.48	5438.1	148	5438
150	5435.5	156.5	5435.5	163	5435.5	165	5438	169.55	5438.1
178.04	5438.15	184.83	5438.3	191.66	5438.6	236.04	5439.5	269.38	5440
313.28	5440.5								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148	.032	165	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148	165	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 357

INPUT
Description:
Station Elevation Data num= 19

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5442	35.2	5442	89.56	5441	113.56	5440	120.34	5439
127.13	5438	133.91	5437.95	139.74	5437.9	148.5	5437.83	150.5	5435.33
157	5435.33	161.5	5435.33	165.5	5437.83	180.38	5437.9	187.48	5438
194.58	5438.2	217.8	5438.5	264.2	5439	312.88	5439.5		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.5	.032	165.5	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.5	165.5	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 306

INPUT
Description:
Station Elevation Data num= 19

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5441	29.98	5441	84.56	5440	115.33	5439	122.96	5438
130.56	5437.8	139.84	5437.7	148.6	5437.64	150.6	5435.14	157.1	5435.14
163.6	5435.14	165.6	5437.64	169	5437.7	184.81	5437.7	191.76	5437.75
196.34	5437.8	200.91	5437.9	236.72	5438.5	314.33	5440		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.6	.032	165.6	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.6	165.6	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 255

INPUT
Description:
Station Elevation Data num= 18

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5440	37.95	5440	100.47	5439	117.68	5438	130.99	5437.6
142.42	5437.5	148.2	5437.45	150.2	5434.95	156.7	5434.95	163.2	5434.95
165.2	5437.45	170.84	5437.5	176.61	5437.55	180	5437.6	189.89	5437.7
210.71	5438	232.97	5439	313.53	5440				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.2	.032	165.2	.045

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        148.2   165.2           50.53   50.53   50.53            .1       .3
```

CROSS SECTION

RIVER: SBC
REACH: 1   RS: 204

INPUT
Description:

```
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0    5440   10.18    5440   59.52    5439   71.12    5438   82.71  5437.6
   95.85 5437.45     140  5437.4     147 5437.26     149 5434.76   155.5 5434.76
     162 5434.76     164 5437.26  175.35  5437.4  182.06  5437.5  188.78  5437.8
  203.85  5438.2  312.75    5440

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .045     147    .032     164    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          147     164           50.53   50.53   50.53            .1       .3
```

CROSS SECTION

RIVER: SBC
REACH: 1   RS: 153

INPUT
Description:

```
Station Elevation Data    num=      19
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0    5440   42.94    5439   64.72    5438   75.21  5437.5   85.69  5437.4
  127.66  5437.3  134.13  5437.2  140.83  5437.2   148.7 5437.07   150.7 5434.57
   157.2 5434.57   163.7 5434.57   165.7 5437.07  169.88  5437.2  179.17  5437.2
  186.32  5437.4  193.48  5437.6  202.76  5437.8  313.35    5439

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .045   148.7    .032   165.7    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        148.7   165.7           50.53   50.53   50.53            .1       .3
```

CROSS SECTION

RIVER: SBC
REACH: 1   RS: 102

INPUT

Description:
Station Elevation Data num= 18

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5440	55.72	5439	80.39	5438	90.42	5437.5	100.45	5437.4
115.8	5437.3	129.18	5437.2	139.17	5437.2	147.5	5436.88	149.5	5434.38
156	5434.38	162.5	5434.38	164.5	5436.88	173.65	5437.2	180.27	5437.2
187.43	5437.3	194.57	5437.6	313.3	5439				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	147.5	.032	164.5	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
147.5	164.5	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 51

INPUT
Description:
Station Elevation Data num= 16

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5439	92.63	5438	102.72	5437.5	112.8	5437	130.03	5436.9
135.73	5436.8	148.7	5436.69	150.7	5434.19	157.2	5434.19	163.7	5434.19
165.7	5436.69	170.87	5436.8	181.35	5436.9	188.02	5437	198.28	5437.4
313.39	5439								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	148.7	.032	165.7	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
148.7	165.7	50.53	50.53	50.53	.1	.3

CROSS SECTION

RIVER: SBC
REACH: 1 RS: 0

INPUT
Description:
Station Elevation Data num= 15

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5439	93.83	5438	105.96	5437	116.57	5436.8	140.58	5436.6
147.6	5436.5	149.6	5434	156.1	5434	162.6	5434	164.6	5436.5
168.17	5436.6	177.34	5436.9	182.7	5437	202.46	5437.5	318.17	5439

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.045	147.6	.032	164.6	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
147.6	164.6	0	0	0	.1	.3

SUMMARY OF MANNING'S N VALUES

River:SBC

Reach	River Sta.	n1	n2	n3
1	1887	.045	.032	.045
1	1836	.045	.032	.045
1	1785	.045	.032	.045
1	1734	.045	.032	.045
1	1683	.045	.032	.045
1	1632	.045	.032	.045
1	1581	.045	.032	.045
1	1530	.045	.032	.045
1	1479	.045	.032	.045
1	1428	.045	.032	.045
1	1377	.045	.032	.045
1	1326	.045	.032	.045
1	1275	.045	.032	.045
1	1224	.045	.032	.045
1	1173	.045	.032	.045
1	1122	.045	.032	.045
1	1071	.045	.032	.045
1	1020	.045	.032	.045
1	969	.045	.032	.045
1	918	.045	.032	.045
1	867	.045	.032	.045
1	816	.045	.032	.045
1	765	.045	.032	.045
1	714	.045	.032	.045
1	663	.045	.032	.045
1	612	.045	.032	.045
1	561	.045	.032	.045
1	510	.045	.032	.045
1	459	.045	.032	.045
1	408	.045	.032	.045
1	357	.045	.032	.045
1	306	.045	.032	.045
1	255	.045	.032	.045
1	204	.045	.032	.045
1	153	.045	.032	.045
1	102	.045	.032	.045
1	51	.045	.032	.045
1	0	.045	.032	.045

SUMMARY OF REACH LENGTHS

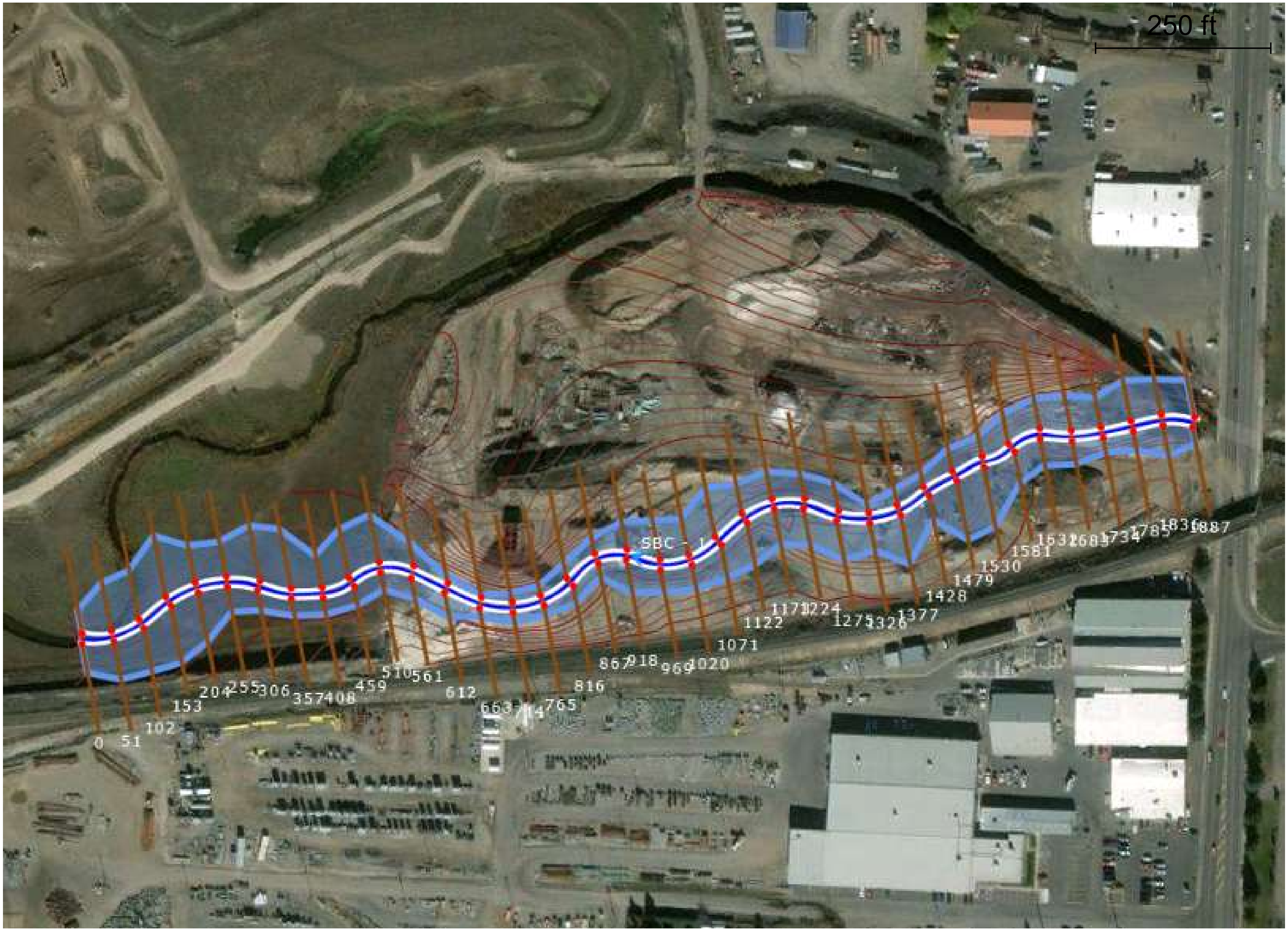
River: SBC

Reach	River Sta.	Left	Channel	Right
1	1887	50.53	50.53	50.53
1	1836	50.53	50.53	50.53
1	1785	50.53	50.53	50.53
1	1734	50.53	50.53	50.53
1	1683	50.53	50.53	50.53
1	1632	50.53	50.53	50.53
1	1581	50.53	50.53	50.53
1	1530	50.53	50.53	50.53
1	1479	50.53	50.53	50.53
1	1428	50.53	50.53	50.53
1	1377	50.53	50.53	50.53
1	1326	50.53	50.53	50.53
1	1275	50.53	50.53	50.53
1	1224	50.53	50.53	50.53
1	1173	50.53	50.53	50.53
1	1122	50.53	50.53	50.53
1	1071	50.53	50.53	50.53
1	1020	50.53	50.53	50.53
1	969	50.53	50.53	50.53
1	918	50.53	50.53	50.53
1	867	50.53	50.53	50.53
1	816	50.53	50.53	50.53
1	765	50.53	50.53	50.53
1	714	50.53	50.53	50.53
1	663	50.53	50.53	50.53
1	612	62.11	62.11	62.11
1	561	54.58	54.58	54.58
1	510	50.53	50.53	50.53
1	459	50.53	50.53	50.53
1	408	50.53	50.53	50.53
1	357	50.53	50.53	50.53
1	306	50.53	50.53	50.53
1	255	50.53	50.53	50.53
1	204	50.53	50.53	50.53
1	153	50.53	50.53	50.53
1	102	50.53	50.53	50.53
1	51	50.53	50.53	50.53
1	0	0	0	0

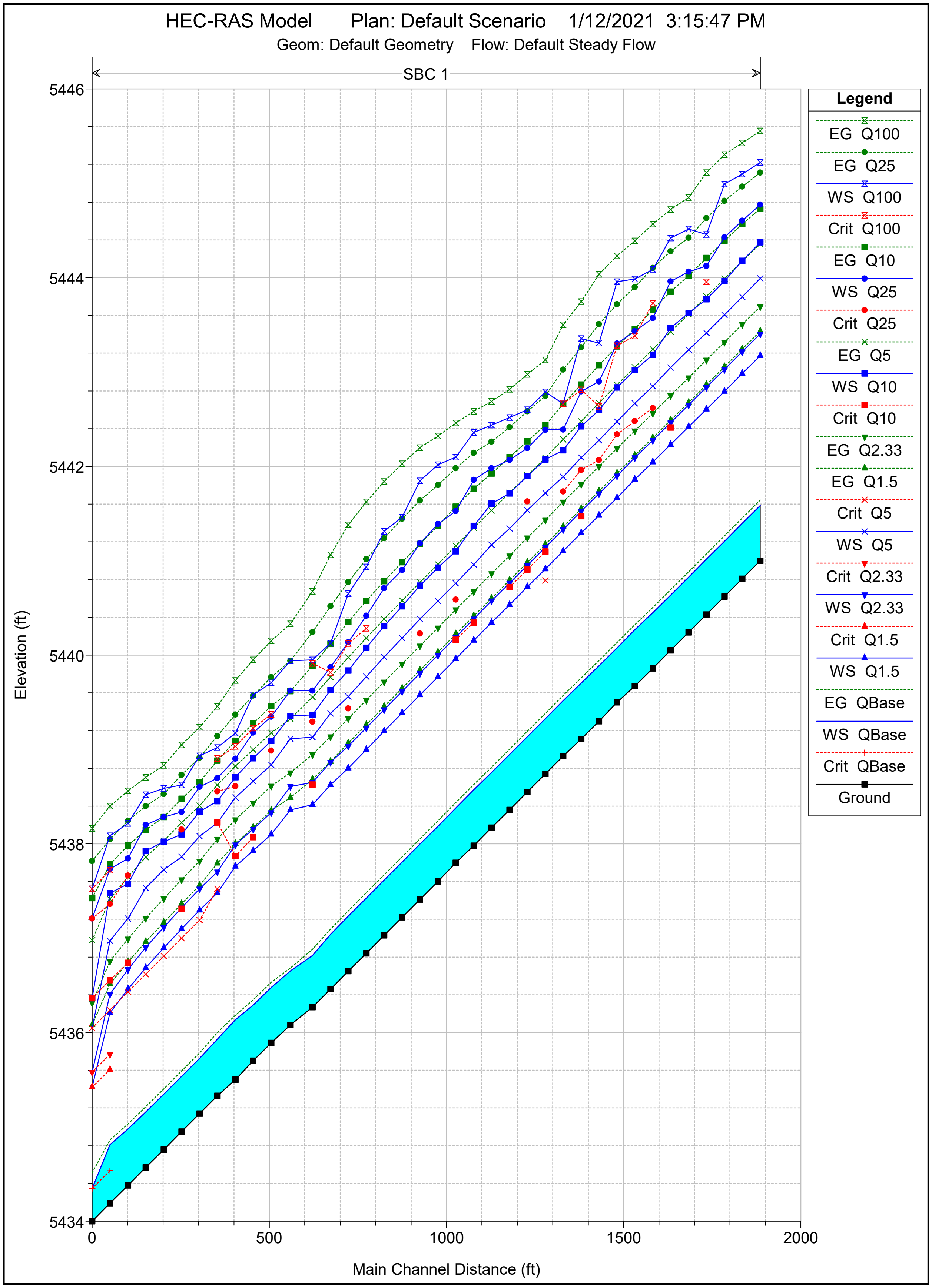
SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: SBC

Reach	River Sta.	Contr.	Expan.

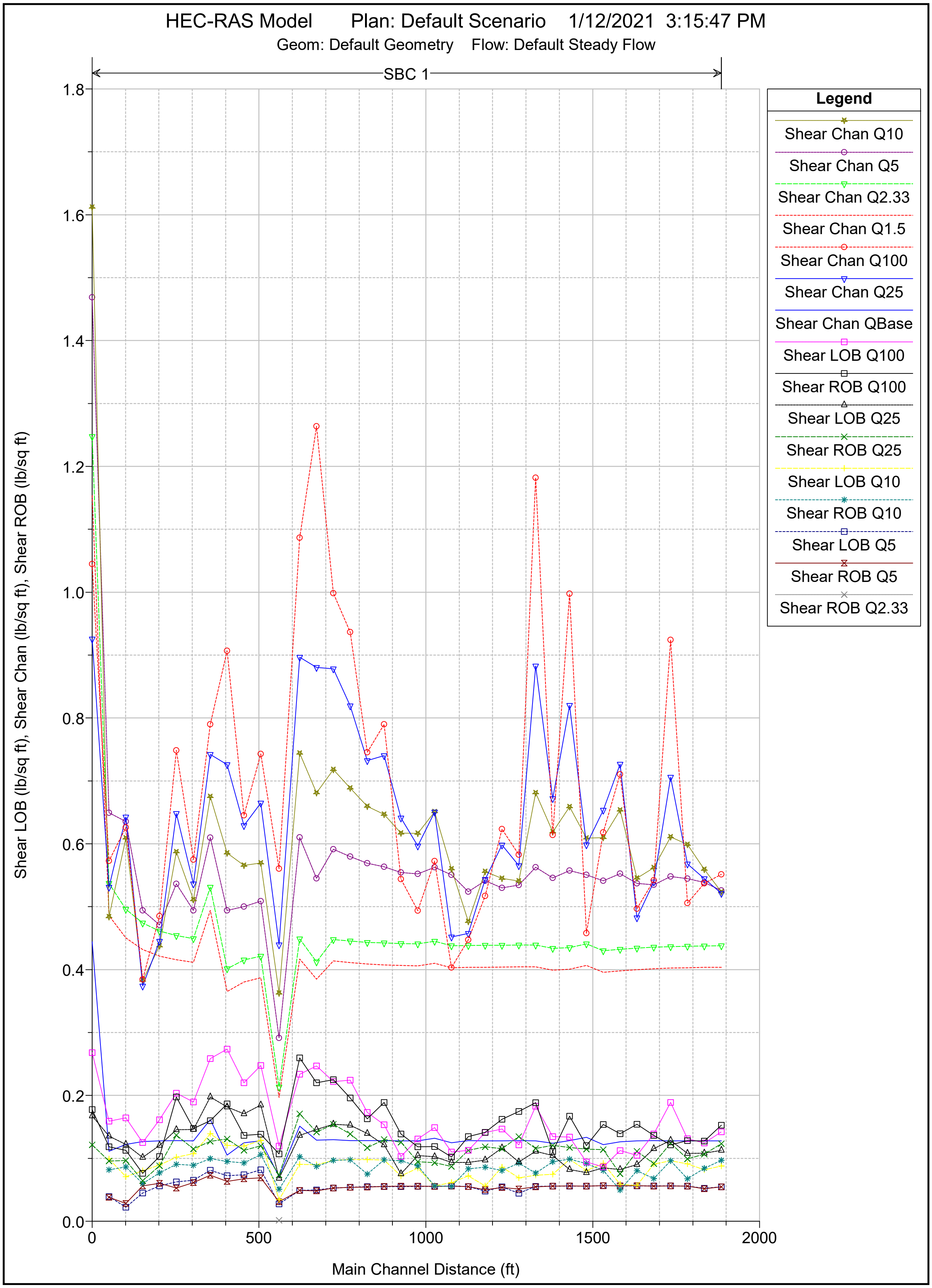
1	1887	.1	.3
1	1836	.1	.3
1	1785	.1	.3
1	1734	.1	.3
1	1683	.1	.3
1	1632	.1	.3
1	1581	.1	.3
1	1530	.1	.3
1	1479	.1	.3
1	1428	.1	.3
1	1377	.1	.3
1	1326	.1	.3
1	1275	.1	.3
1	1224	.1	.3
1	1173	.1	.3
1	1122	.1	.3
1	1071	.1	.3
1	1020	.1	.3
1	969	.1	.3
1	918	.1	.3
1	867	.1	.3
1	816	.1	.3
1	765	.1	.3
1	714	.1	.3
1	663	.1	.3
1	612	.1	.3
1	561	.1	.3
1	510	.1	.3
1	459	.1	.3
1	408	.1	.3
1	357	.1	.3
1	306	.1	.3
1	255	.1	.3
1	204	.1	.3
1	153	.1	.3
1	102	.1	.3
1	51	.1	.3
1	0	.1	.3



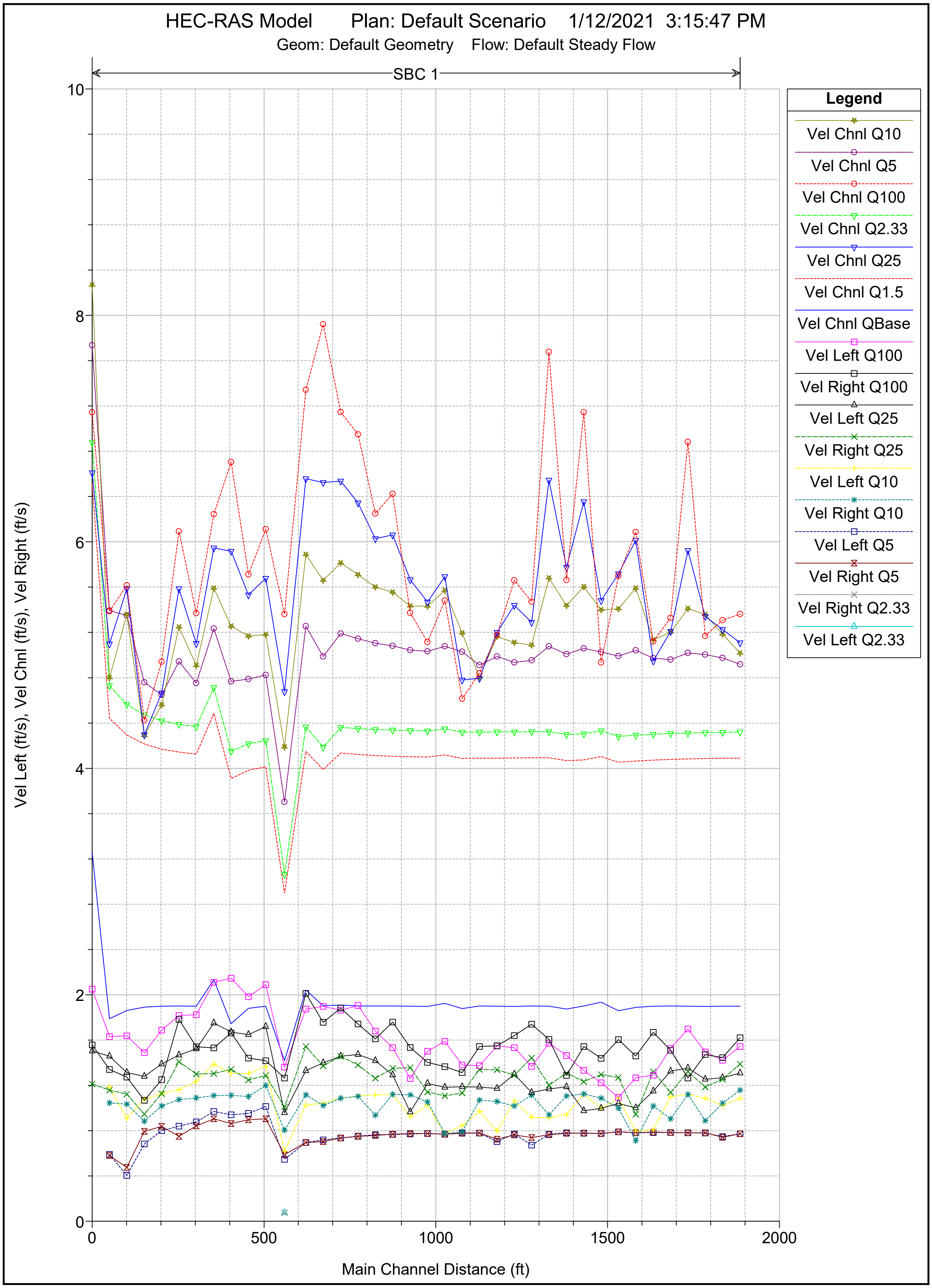
250 ft
SBC - 1
0
51
102
153
204
255
306
357
408
459
510
561
612
663
765
816
867
918
969
1020
1071
1122
1173
1224
1275
1326
1377
1428
1479
1530
1581
1632
1683
1734
1785
1836
1887



HEC-RAS Model Plan: Default Scenario 1/12/2021 3:15:47 PM
Geom: Default Geometry Flow: Default Steady Flow
SBC 1
Legend
EG Q100
EG Q25
WS Q100
Crit Q100
EG Q10
WS Q25
Crit Q25
EG Q5
WS Q10
Crit Q10
EG Q2.33
EG Q1.5
Crit Q5
WS Q5
Crit Q2.33
WS Q2.33
Crit Q1.5
WS Q1.5
EG QBase
WS QBase
Crit QBase
Ground
Elevation (ft)
5446
5444
5442
5440
5438
5436
5434
0
500
1000
1500
2000
Main Channel Distance (ft)



HEC-RAS Model Plan: Default Scenario 1/12/2021 3:15:47 PM
Geom: Default Geometry Flow: Default Steady Flow
SBC 1
Legend
Shear Chan Q10
Shear Chan Q5
Shear Chan Q2.33
Shear Chan Q1.5
Shear Chan Q100
Shear Chan Q25
Shear Chan QBase
Shear LOB Q100
Shear ROB Q100
Shear LOB Q25
Shear ROB Q25
Shear LOB Q10
Shear ROB Q10
Shear LOB Q5
Shear ROB Q5
Shear ROB Q2.33
Shear LOB (lb/sq ft), Shear Chan (lb/sq ft), Shear ROB (lb/sq ft)
Main Channel Distance (ft)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0
500
1000
1500
2000


HEC-RAS Model Plan: Default Scenario 1/12/2021 3:15:47 PM
Geom: Default Geometry Flow: Default Steady Flow
SBC 1
Legend
Vel Chnl Q10
Vel Chnl Q5
Vel Chnl Q100
Vel Chnl Q2.33
Vel Chnl Q25
Vel Chnl Q1.5
Vel Chnl QBase
Vel Left Q100
Vel Right Q100
Vel Left Q25
Vel Right Q25
Vel Left Q10
Vel Right Q10
Vel Left Q5
Vel Right Q5
Vel Right Q2.33
Vel Left Q2.33
Vel Left (ft/s), Vel Chnl (ft/s), Vel Right (ft/s)
Main Channel Distance (ft)
0
2
4
6
8
10
500
1000
1500
2000

ATTACHMENT A-2C

Hydraflow Express Channel Sizing Calculations

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. — Monday, Jan 18 2021

<SBC-BRW>

Trapezoidal

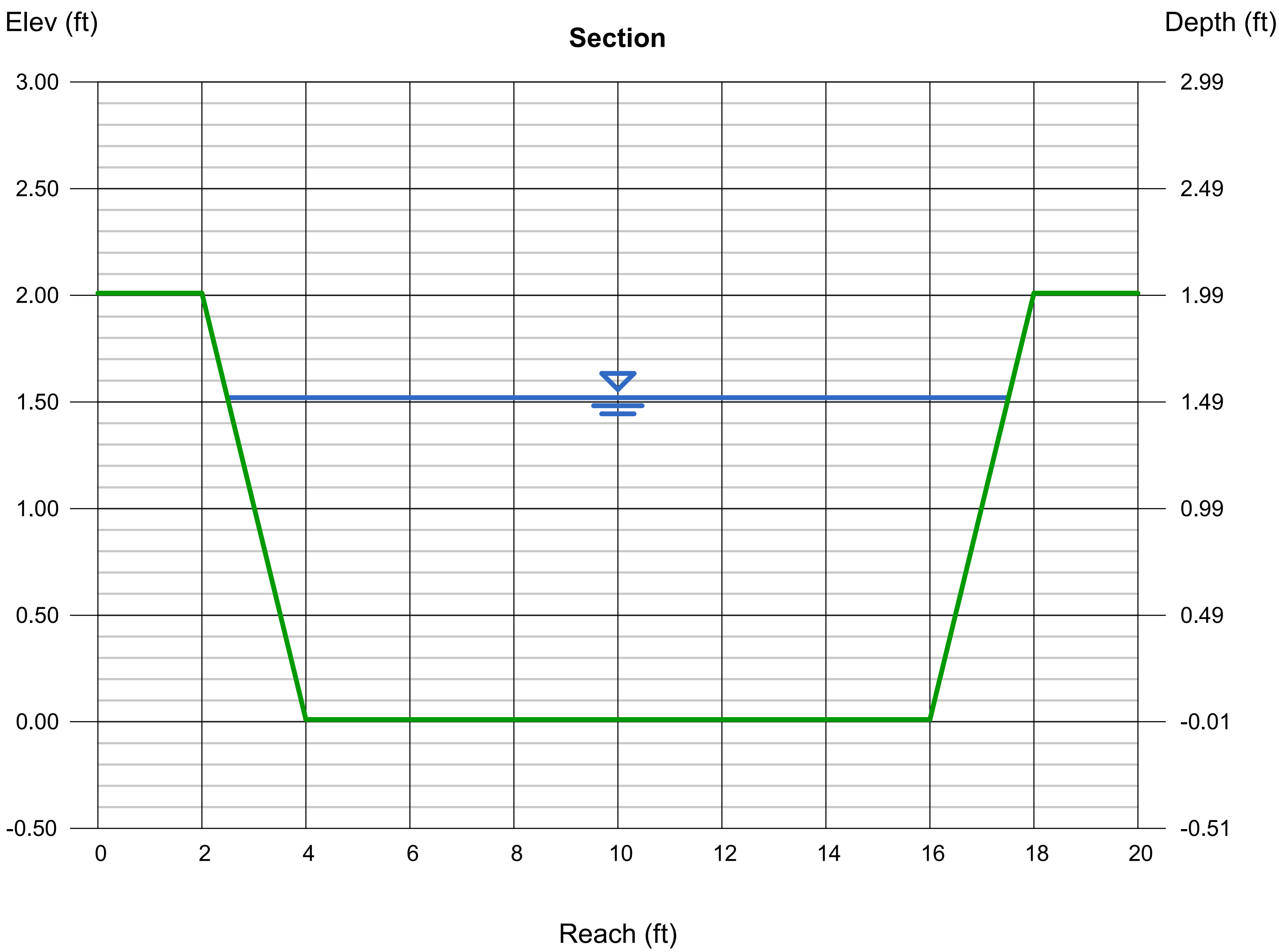
Bottom Width (ft)	=	12.00
Side Slopes (z:1)	=	1.00, 1.00
Total Depth (ft)	=	2.00
Invert Elev (ft)	=	0.01
Slope (%)	=	0.36
N-Value	=	0.050

Calculations

Compute by:		Known Q
Known Q (cfs)	=	122.00

Highlighted

Depth (ft)	=	1.51
Q (cfs)	=	122.00
Area (sqft)	=	20.40
Velocity (ft/s)	=	5.98
Wetted Perim (ft)	=	16.27
Crit Depth, Yc (ft)	=	1.42
Top Width (ft)	=	15.02
EGL (ft)	=	2.07



ATTACHMENT A-2D

Streambed Material Sizing Calculations

30% BRW SILVER BOW CREEK ROCK SIZING CALCULATIONS

OBJECTIVE: Determine sizes of rocks for construction of channel run sections.

1) USACE method for riprap design using the following equation:

$$D_{30} = \frac{1.95 \times S^{0.555} \times a^{2/3}}{g^{1/3}}$$

S = Channel Slope (preliminary design of 0.0036 ft/ft)

a = Unit discharge (ft^2/s)

g = Gravitational acceleration (32.2 ft^2/s)

2) Calculate the unit discharge using the following equation:

$$a = 1.25\left(\frac{Q}{\omega}\right)$$

Q = Design flow (Q1.5 = 122 cfs)

ω = Active channel width (assume max width = 15 ft)

$$a = 1.25\left(\frac{122}{15}\right) \quad \mathbf{= 10.2 \ ft^2/s}$$

3) Calculate the minimum step rock size using the D_{30} equation:

$$D_{30} = \frac{1.95 \times 0.0036^{0.555} \times 10.2^{2/3}}{32.2^{1/3}} \quad \mathbf{= 0.13 \ ft}$$

RESULTS: These results indicate that 6-inch minus riprap meets the minimum rock size for construction of the streambed, and will provide the required anchor rock for support and stability.

References:

Reclamation - Managing Water in the West - Rock Ramp Design Guidelines (U.S. BOR, 2007)

A Design Procedure for Sizing Step-Pool Structures (Thomas et. al., 2000)

30% BRW SILVER BOW CREEK ROCK SIZING CALCULATIONS

OBJECTIVE: Determine sizes of rocks for construction of channel run sections.

1) USACE method for riprap design using the following equation:

$$D_{30} = \frac{1.95 \times S^{0.555} \times a^{2/3}}{g^{1/3}}$$

S = Channel Slope (preliminary design of 0.0036 ft/ft)

a = Unit discharge (ft^2/s)

g = Gravitational acceleration (32.2 ft^2/s)

2) Calculate the unit discharge using the following equation:

$$a = 1.25\left(\frac{Q}{\omega}\right)$$

Q = Design flow (Q100 = 493 cfs)

ω = Active channel width (assume max width = 15 ft)

$$a = 1.25\left(\frac{122}{15}\right) \quad \mathbf{= 41.1 \ ft^2/s}$$

3) Calculate the minimum step rock size using the D_{30} equation:

$$D_{30} = \frac{1.95 \times 0.0036^{0.555} \times 10.2^{2/3}}{32.2^{1/3}} \quad \mathbf{= 0.32 \ ft}$$

RESULTS: These results indicate that 9-inch minus riprap meets the minimum rock size for construction of the streambed, and will provide the required anchor rock for support and stability.

References:

Reclamation - Managing Water in the West - Rock Ramp Design Guidelines (U.S. BOR, 2007)

A Design Procedure for Sizing Step-Pool Structures (Thomas et. al., 2000)