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Butte Priority Soils Operable Unit (BPSOU) Silver Bow Creek/Butte Area NPL Site

Atlantic Richfield Company

Butte Priority Soils Operable Unit (BPSOU)
Silver Bow Creek/Butte Area NPL Site

Draft 2021 Site-Wide Surface Water Data Summary Report

Normal Flow, Wet Weather, and Diagnostic Surface Water, Sediment, BMI, and Habitat Monitoring
January 2021 – December 2021

Atlantic Richfield

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

ARAR	Applicable Relevant and Appropriate Requirements
AV	Area-Velocity
BMFOU	Butte Mine Flooding Operable Unit
BMI	Benthic Macroinvertebrate
BMMA	Bert Mooney Municipal Airport
BMP	Best Management Practices
BPSOU	Butte Priority Soils Operable Unit
BTC	Blacktail Creek
BTL	Butte Treatment Lagoons
CD	Consent Decree
CFRSSI	Clark Fork River Superfund Site Investigations
COC	Contaminant of Concern
DM	Data Management
DOC	Dissolved Organic Carbon
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DSR	Data Summary Report
DSWMP	Butte Hill Diagnostic Surface Water Monitoring Plan
DVP	Data Validation Plan
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
EWI	Equal Width Increment
FG	Field Grab
FRE	Further Remedial Elements
ID	Identification
LAO	Lower Area One
NH3	Ammonia
NPL	National Priorities List
OU	Operable Unit
PEC	Probable Effects Concentration
pH	negative log of the hydrogen concentration
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAO	Remedial Action Objectives
RBP	Rapid Bioassessment Protocol
RG	Remedial Goals
ROD	Record of Decision
RODA	Record of Decision Amendment
RSD	Relative Standard Deviation

SBC	Silver Bow Creek
SCADA	Supervisory Control and Data Acquisition
SNOTEL	Snowpack Telemetry
SOP	Standard Operating Procedure
SW	Surface Water
SWE	Snow Water Equivalent
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1.0 INTRODUCTION

This Data Summary Report (DSR) presents surface water, sediment, habitat, and benthic macroinvertebrate (BMI) data collected on behalf of Atlantic Richfield between January 1, 2021 and December 31, 2021 in general compliance with the Silver Bow Creek/Butte Area NPL Site Final Butte Priority Soils Operable Unit Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan 2020 and 2021 Monitoring Period (QAPP) (Atlantic Richfield, 2020). Surface water monitoring occurred during normal flow and wet weather conditions. Normal flow exists in the absence of snowpack or precipitation runoff. The Record of Decision, Butte Priority Soils Operable Unit, Silver Bow Creek/Butte Area NPL Site (2006 ROD) (USEPA, 2006) defined wet weather conditions as flow greater than 50 cfs at SS-07 and greater than 35 cfs at SS-04. These criteria continue to be loosely applied, but adjustments were made to account for inputs from the Butte Mine Flooding Operable Unit (BMFOU) Pilot Project discharge, periods of prolonged high flows, and periods of sustained low flows. Wet weather monitoring did not occur during winter months due to freezing conditions and the low potential for wet weather flows.

Sediment, habitat, and BMI monitoring occurred in August 2021 during stable flow conditions.

The following information is included in this report:

- Description of field methods;
- Locations of sampling sites and methods of sampling;
- Results of laboratory analyses of surface water, sediment, and BMI samples;
- Hydrographs of continuous flow and stage measurements;
- Manual flow measurements and field parameter measurements;
- Discussion of quality assessments of water chemistry and flow data;
- Data validation checklists and Level A/B checklists; and
- Raw laboratory analytical data and raw field data.

Original field notebooks and data sheets for 2021 monitoring discussed in this DSR are located at TREC Inc.'s (TREC) field office in Butte, MT.

1.1 Objectives

The U.S. Environmental Protection Agency's (USEPA) 2006 ROD and the 2020 Record of Decision Amendment (RODA) (USEPA, 2020) set forth applicable surface water quality standards, and these are presented in Table 1.

The remedial action objectives (RAOs) for surface water, as defined in the ROD, 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 beneficial use.*
- *Prevent source areas from releasing contaminants to surface water that would cause the receiving water to violate surface water ARARs and RGs for the OU 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, etc.) meet ARARs.*
- *Prevent further degradation of surface water.*
- *Meet the more restrictive of chronic aquatic life or human health standards for surface water identified in Circular DEQ-7 (Table 8-2) through the application of B-1 class standards.*

The third and sixth objectives listed above were modified in the 2020 RODA. Performance standards for cadmium were revised to reflect the chronic and acute aquatic life standards in the May 2017 version of Circular DEQ-7, which applies to both normal and wet weather flow situations. The copper and zinc acute aquatic life wet weather performance standards were modified to be based on the federal criteria, which relies on the dissolved concentration, rather than the total recoverable concentration.

Table 1 – BPSOU Creek Monitoring Performance Criteria

Analyte	Normal Flow Standard (ug/L)[1]	WW Flow Standard (ug/L)[2,3]
Dissolved Aluminum	87	750
Total Arsenic	10	340
Total Cadmium	0.26	0.49
Total Copper	2.85	3.6
Total Iron	1000	NA
Total Lead	0.545	13.98
Total Mercury	0.05	1.7
Total Silver	NA	0.374
Total Zinc	37	37

[1] Normal Flow Standard based on more conservative of either DEQ7 Chronic Aquatic Life Standard (using hardness of 25 mg/L) or Human Health Standard

[2] WW Flow Standard based on DEQ 7 Acute Aquatic Life Standard (using hardness of 25 mg/L)

[3] Per 2020 RODA, WW Flow Copper and Zinc Standard based on dissolved concentration

The objectives of surface water monitoring collected under the QAPP prior to the BPSOU Consent Decree (CD) (U.S.A and State of Montana, 2020) defined Compliance Standard Determination Period is to establish interim monitoring period conditions for creek and sub-drainage concentrations and flows. Thus, the goals of 2021 surface water monitoring were to collect data necessary to:

1. Evaluate compliance with Performance Standards at compliance monitoring stations SS-06G and SS-07;
2. Evaluate performance of the remedy, in its various stages of implementation; and
3. Evaluate any necessary diagnostic data collected to identify currently implemented remedial system component optimization or maintenance, and necessary to inform Further Remedial Elements (FRE) design.

The intent of 2021 sediment, BMI, and habitat monitoring was to establish interim monitoring period conditions for sediment probable effects concentrations (PEC), the BMI community structure, and habitat conditions for stream reaches upgradient and within the BPSOU. These data will assist in:

1. Evaluating if sediment sample concentrations exceed the PECs in Table 2 for specific sampling locations and depths in Blacktail Creek (BTC) and Silver Bow Creek (SBC) within the BPSOU and in background/reference reaches in BTC upgradient of BPSOU;
2. Evaluating trends in streambed sediment sample concentrations at sampling locations and routine depths in BTC and SBC within BPSOU and in background/reference reaches in BTC upgradient of BPSOU;
3. Evaluating BMI community structure and habitat conditions within BPSOU and in background/reference reaches upgradient of BPSOU; and
4. Evaluating BMI community structure and habitat condition trends in relation to the abiotic media collected in background/reference reaches upgradient of BPSOU and SBC reaches within BPSOU.

Table 2 – Sediment Probable Effects Concentrations
(Ingersoll et al. 2000, MacDonald et al. 2000)

Analyte	Probable Effect Concentration (mg/kg, dry weight, bulk sample)
Arsenic	33
Cadmium	4.98
Copper	149
Lead	128
Mercury	1.06
Zinc	459

2.0 MONITORING SUMMARY

Surface water monitoring conducted under the QAPP included monitoring conducted under normal flow and wet weather conditions in SBC and BTC; diagnostic wet weather surface water monitoring conducted in several SBC and BTC tributaries or subdrainages; and streambed sediment, BMI, and habitat monitoring conducted in SBC and BTC.

2.1 Normal Flow and Wet Weather Monitoring

Normal flow monitoring occurred monthly, with water quality samples collected and stream flow measurements made. Wet weather monitoring was conducted May through September, and this monitoring included water quality sampling, continual stage monitoring, and calculated continual flow measurements. Stations monitored for normal flow, wet weather, and continuous stage and flow are presented in Table 3.

The normal flow and wet weather monitoring stations are presented in Figure 1. A schematic of the hydraulic connectivity and flow pattern of BPSOU surface water is presented in Figure 2. Precipitation data were collected at seven climate stations within the SBC basin. Climate station locations are presented in Figure 3. Water quality results are presented in Appendix A.

The field sample identification (ID) scheme consisted of four letters identifying the sample type, four numbers identifying the sample number, and six numbers identifying the monitoring date. An example is provided below.

Field Sample ID:		**SWBF0025-051521**
SW	=	Surface Water Sample
BF	=	Normal Flow (WW= Wet Weather Sample)
0025	=	Sample Number 25
051521	=	Monitoring Date of 5/15/2021

2.2 Diagnostic SW Monitoring

Diagnostic monitoring consisted of water quality sampling, continuous level and velocity measurements, and calculated flow measurements at the stations presented in Table 4. Diagnostic monitoring stations are presented in Figure 4. Hydraulic connectivity and flow patterns are presented in Figure 5. Diagnostic monitoring water quality results are presented in Appendix F.

The field sample ID scheme consisted of four letters to identify the sample type, four numbers identifying the sample number, and six numbers identifying the monitoring date. An example is provided below.

Field sample ID:		**SWSD0005-051521**
SW	=	Surface Water Sample
SD	=	Storm Drain Sample
0005	=	Sample Number 5
051521	=	Monitoring Date of 5/15/2021

2.3 Sediment Monitoring

Streambed sediment was sampled in three stream reaches within BTC and SBC presented in Table 5 and Figure 6. Streambed sediment analytical results are presented in Appendix J.

The field sample ID scheme consisted of three letters identifying the sample type, three digits identifying the sample number, six digits identifying the monitoring date, and four digits identifying the depth interval. An example is provided below.

Field sample ID:		**SED001-092221-0002**
SED	=	Bed Sediment
001	=	Sample number of 1
092221	=	Monitoring date of 9/22/2021
0002	=	0-2 inch depth interval (0206 = 2-6 inch, 0612 = 6-12 inch)

2.4 BMI and Habitat Monitoring

Benthic macroinvertebrate (BMI) samples and habitat data were collected in the three stream reaches within BTC and SBC presented in Table 5 and Figure 6. Four replicate BMI samples were collected within each reach. Each replicate was submitted to the laboratory as a separate sample to undergo taxonomic analyses. BMI sample and habitat transect location coordinates are presented in Table 6. BMI analytical results are presented in Tables 15 through 19. Habitat data are presented in Appendix K.

The field sample ID scheme for BMI samples consisted of an alphanumeric identifying the stream and sample site, letters Rep A-D identifying the sample replicate, and a parenthetical identifying which bottle, of the total number of bottles for that replicate, was labeled. An example is provided below.

Field sample ID:		**SBC SS-06G Rep D (1 of 2)**
SBC	=	Silver Bow Creek
SS-06G	=	Sample Site
Rep D	=	Fourth replicate of SS-06G sample
(1 of 2)	=	Indicates bottle was one of two bottles for replicate D

2.5 Data Quality Objectives and Assessment

This section summarizes the Data Quality Objective (DQO) and Data Quality Assessment (DQA) methods and steps taken in the field and laboratory to ensure data quality.

2.5.1 Data Quality Objectives

The DQO process, defined in the QAPP, is used to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Each step of the DQO process defines criteria that will be used to establish the final data collection design following the Guidance on Systematic Planning Using the Data Quality Objectives Process (USEPA, 2006a).

The surface water data collected under the QAPP aid in developing stage-discharge ratings, modeling wet weather flow, identifying the effects of wet weather discharges on SBC, and determining the efficacy of existing BMPs for controlling contaminant of concern (COC) inputs during wet weather flow. Additionally, compliance with normal flow and wet weather performance standards for monitoring stations SS-06G and SS-07 can be evaluated with data collected under the QAPP. Sediment data collected under the QAPP assist in determining sediment COC concentrations in stream reaches upgradient and within the BPSOU and will provide interim monitoring period sediment COC concentrations that can be used in trend evaluation. BMI and habitat data collected under the QAPP provide interim monitoring period information on the BMI community structure and habitat conditions in stream reaches upgradient and within the BPSOU. These data can be used to assess BMI and habitat trends in relation to abiotic media for the monitored stream reaches.

2.5.2 Data Quality Assessment

DQA is performed to determine whether the DQOs identified in the QAPP were satisfied. The DQA process, as outlined in the Data Management/Data Validation Plan (DM/DVP) (ARCO, 1992c and 2000a), and DQA results are discussed in greater detail in Appendix A (normal flow and wet weather), Appendix E (diagnostic wet weather) and Appendix I (sediment). Data validation was completed by TREC and included data review, statistical testing, verifying assumptions, and assigning data to utilization categories.

The three data utilization categories described in the DM/DVP are enforcement quality data, screening quality data, and rejected data. Enforcement quality data meet all QA/QC and documentation requirements. Screening quality data do not meet all applicable QA/QC requirements and/or documentation requirements. Rejected data may result from inappropriate sampling, documentation, or analysis procedures. Only enforcement and screening quality data are used for evaluation of surface water quality.

2.6 General Monitoring Activities

2021 BPSOU site-wide surface water monitoring included normal flow and wet weather monitoring conducted in BTC and SBC, diagnostic monitoring conducted in select BTC and SBC sub-drainages, and sediment, BMI, and habitat monitoring conducted in BTC and SBC. These monitoring efforts were conducted in general compliance with the QAPP, with any deviations noted in Section 4.0.

2.6.1 Normal Flow and WW

Monitoring activities consisted of water quality sampling, field parameter measurements, stage and flow measurements, and precipitation and snow water equivalent (SWE) measurements. Monitoring activities were performed in accordance with Clark Fork River Superfund Site Investigation (CFRSSI) Standard Operating Procedures (SOPs) (ARCO, 1992c), as well as TREC's internal SOPs. These SOPs are provided in the QAPP and briefly summarized in the following sections of this document. Wet weather water quality samples were collected by mechanical and automated samplers. Wet weather stage data were primarily collected using continuous recorders, although field observations of staff gauges were collected opportunistically and used to adjust continuous recorders as necessary. Water quality samples, flow data, stage data, and field parameters were collected during normal flow sampling. Precipitation and SWE data were collected by private parties, governmental agencies, or Atlantic Richfield contractors. A summary of the types of monitoring performed at each continuous monitoring station and a description of station locations are presented in Table 3. Stage and flow data are presented in Appendices B and C. Precipitation and SWE data are presented in Table 7a-c and Figure 7a-g.

2.6.1.1 Normal Flow Monitoring Activities

Normal flow monitoring was performed monthly throughout the year and consisted of water quality sampling, field parameter measurements, and stage and flow measurements. A summary of the types of monitoring performed at each station and a description of station locations are presented in Table 3. Normal flow monitoring is discussed in more detail in Section 3.1.1.

2.6.1.2 Wet Weather Monitoring Activities

Wet weather monitoring consisted of collecting water quality samples and recording stage during wet weather conditions. A summary of the types of monitoring performed at each station and a description of station locations are presented in Table 3.

Water quality samples were primarily collected by automated samplers manufactured by Teledyne ISCO (ISCO). These samplers, along with mechanical self-closing D-TEC samplers, were deployed for the season in March once freezing conditions abated. Samples obtained by D-TEC samplers were retained if ISCOs failed to collect during wet weather events.

ISCOs were set to collect at specific time increments after the stage height at which the sampler was set to trigger was reached. Once ISCOs were triggered, the samplers collected four discrete samples at one-hour intervals. The initial sample stage was set to collect the first sample on the rising limb of the wet weather hydrograph. The second and third samples were expected to be collected near the peak of storm flow. The fourth sample was expected to be collected on the falling limb of the hydrograph. Three surface water stations (SS-01, SS-06G, and SS-07) were equipped with a second ISCO for parallel sampling. These second samplers (SS-01-P, SS-06G-P, and SS-07-P) were triggered at the same time as the parent sampler but collected four time-composited samples. The time-composited samples are comprised of aliquots collected every ten minutes over an hour. It is assumed all ISCOs effectively sampled throughout the wet weather hydrograph; however, normal flow stages used to program ISCO actuator triggers, as well as the magnitude and duration of flow may have resulted in other points on the hydrograph being sampled. Wet weather monitoring is discussed in more detail in Section 3.1.2.

D-TECs were set to collect at the stage their corresponding ISCOs were set to trigger. D-TECs were assumed to collect samples on the rising limb of the hydrograph. Stages at which samplers were set to collect, and any changes made to the height throughout the season, are presented in Table 8.

2.6.1.3 Surface Water Stage and Flow

Surface water stage data were recorded on 15-minute intervals by continuous recording devices at 15 surface water stations, with three of those devices also recording flow. These stations are presented in Table 3. Stage data were recorded throughout the year and include both wet weather and normal flow conditions, with occasional data gaps due to equipment maintenance or operational problems. Note that three additional sites presented in Table 3 collect continuous data for projects outside of the scope of this DSR. Flow data at SS-MPTP, CT-EFS7 and SS-STP were recorded daily. A Supervisory Control and Data Acquisition (SCADA) system at SS-MPTP controls a constant discharge. A SCADA system is also used at CT-EFS7, however, this system does not control a constant discharge. Stage and flow hydrographs are presented in Appendix B. Surface water stage and flow are discussed in more detail in Section 3.1.3.

Stage-discharge relationships were developed for stations SS-01, SS-05, SS-05A, SS-06A, SS-06G, and MSD-3A by TREC on behalf of Atlantic Richfield and at SS-01.35 and SS-07 by the United States Geological Survey (USGS). Stage-discharge relationships allow continuous stage records to be transformed to continuous discharge records. Stage-discharge rating tables and rating curve figures developed by TREC are presented in Appendix C. The USGS discontinued continuous stage monitoring at SS-04 on April 30, 2020 and ceased producing a stage-discharge relationship at this site on October 31, 2019. Backwater created by the Butte Mine Flooding Operable Unit (BMFOU) Pilot Project discharge prohibited development of a reliable stage-discharge relationship. The USGS established continual stage monitoring at SS-01.35 on April 30, 2020. Atlantic Richfield maintains a continual stage recorder at SS-04, but stage-discharge relationships are not developed for this site. An SS-04 stage hydrograph is presented in Appendix B.

Continuous stage and/or flow records are obtained by the controlling parties for stations SS-MPTP, CT-EFS7, SS-STP, SS-01.35, and SS-07.

2.6.1.4 Precipitation

Precipitation measurements were recorded at seven stations, as presented in Figure 3, by a mix of governmental agencies and private parties. Station BMMA is located at Bert Mooney Memorial Airport approximately one mile south of I-90 and Basin Creek SNOTEL site (Site ID 12d09s) is in the Basin Creek drainage to the south of Butte and includes a snow pillow to record SWE. Both are operated by the National Climactic Data Center. Blacktail Canyon weather station is located southeast of Butte in Blacktail Canyon and is operated by a private party. Station Kelley Mine is at the Atlantic Richfield office on Anaconda Road, just west of the Berkeley Pit. Station CB-1 is located on Empire Street, which is centrally located in the Missoula Gulch sub-drainage. Station BTL/LAO is located due west of the Chemical Addition System at the Butte Treatment Lagoons. Stations Kelley Mine, CB-1, and BTL/LAO are operated by Atlantic Richfield. Station BSB-Shop that was previously operated by Atlantic Richfield was removed at the beginning of April 2021 due to dismantling of the former BSB road maintenance shop. Therefore, the BSB-Shop data set terminates April 1, 2021. Data are reported daily at BMMA and Basin Creek and hourly at Blacktail Canyon and CB-1. BTL/LAO data are reported at variable intervals but are commonly reported every 15 minutes. Kelley Mine data are reported every five minutes. Precipitation and SWE data are presented in Table 7a - 7c and Figure 7a -7g.

2.6.1.5 pH Monitoring

Surface water pH was monitored by automated devices at stations SS-01, SS-06G, and SS-07. pH measurements were collected continuously at 15-minute intervals throughout the year and include both wet weather and normal flow conditions. Data gaps and suspect data were attributed to ice, equipment failure, and pH probe replacement. After pH probe calibration there is a period of equilibration that can last over an hour during which the pH readings may not be accurate. Continuous pH data are presented in Appendix B.

2.6.2 Diagnostic SW Monitoring

Diagnostic monitoring consisted of continuous flow monitoring and water quality sampling performed in accordance CFRSSI and TREC SOPs as outlined in the QAPP. Previously, in the *Butte Hill Diagnostic Surface Water Monitoring Plan* (DSWMP) (Atlantic Richfield, 2017), diagnostic stations were given a level rating depending on their location within the basin. Level 1 stations are located at the bottom of the basin, level 2 stations are located part way up the basin and level 3 stations are located at the top of the drainages. Diagnostic monitoring in 2021 only included level 1 and level 3 monitoring stations. Level 2 stations monitored in 2013 and 2014 have been discontinued.

2.6.2.1 Water Quality Monitoring

Diagnostic water quality sampling consisted of collecting water quality samples during runoff conditions, primarily by automated samplers. These samplers were installed in late March and early April. Diagnostic water quality stations are presented in Figure 4 and a hydraulic schematic is presented in Figure 5. Sampling locations, descriptions, and monitoring equipment are presented in Table 4.

ISCO automatic samplers collect following initiation by an actuator device which detects the presence of water at a manually set stage. Actuators are set to initiate sampling during the rising limb of the hydrograph. The magnitude and duration of flow and actuator position may have resulted in sampling at different points on the hydrograph.

2.6.2.2 Flow Monitoring

Diagnostic surface water flow was recorded by automated devices at surface water stations within the BPSOU monitoring network. Water depth and velocity data were collected by area-velocity (AV) Meters as presented in Table 4. Hydrographs are presented in Appendix F.

2.6.3 Sediment, Habitat, and BMI Monitoring

Sediment sampling was conducted August 12 and 13, 2021 at three stream reaches, each approximately 500 feet long. The reaches were located at surface water stations SS-01, SS-06A, and SS-06G. Table 5 and Figure 6 identify the sediment sampling reaches. Each sample consisted of a 5-point composite sampled along the entire reach. An effort was made to evenly space the sub-sample collection points along the reach, but exact sub-sample points were controlled by the location of available sediment. Three depth intervals were attempted at each reach, 0-2 inches, 2-6 inches, and 6-12 inches. An inadequate amount of sediment was obtained for the 6-12 inch interval at SS-06A, so pH, TOC, and particle size analyses were omitted. No sediment was obtained for the 6 to 12 inch interval at SS-06G.

Benthic macroinvertebrate (BMI) sample collection and habitat monitoring were conducted August 9 and 10, 2021 at three stream reaches collocated with the sediment sampling reaches. The reaches were located at surface water stations SS-01, SS-06A, and SS-06G. Table 5 and Figure 6 identify the BMI and habitat monitoring reaches. Four replicate BMI samples were collected within each reach. Each replicate was submitted to the laboratory as a separate sample to undergo taxonomic analyses. BMI sample and habitat transect location coordinates are presented in Table 6. BMI samples were collected in riffle habitats from the least embedded, most heterogenous cobble substrates found at each site, using a Hess sampler with 1,000-micron mesh netting. In-situ measurements of pH, water temperature, dissolved oxygen, and specific conductance were made concurrently with BMI sample collection.

BMI sample collection was followed by habitat monitoring. Habitat monitoring was conducted using EPA's Rapid Bioassessment Protocols (RBP) (Barbour et al, 1999), as well as elements of EPA's Environmental Monitoring and Assessment Program (EMAP) (EPA, 1998). The characteristics sampled in 2021 included epifaunal substrate and available cover; embeddedness and pool substrate characterization; velocity, depth, and pool variability; sediment deposition; channel flow status; channel alteration; frequency of riffles and channel sinuosity; and bank stability. The next scheduled vegetation monitoring will occur in 2022. To employ the RBP and EMAP, sample reaches, established as 40 times the average wetted width, were divided into 11 channel cross-sections (transects) at equal intervals along the reach length. These transects were labeled A through K. Transect A represented the most downstream transect within the reach and transect K represented the most upstream transect within the reach. Transect coordinates are provided in Table 6.

3.0 DATA SUMMARY

3.1 Normal Flow and WW

Monitoring activities during 2021 consisted of water quality sampling, field parameter measurements, stage and flow measurements, and acquisition and review of precipitation and SWE data. These activities were performed in accordance with CFRSSI and TREC SOPs and are outlined in the QAPP. The following sections present analytes, field conditions, frequency of sampling events, and counts of natural samples. Appendix A presents the normal flow and wet weather data.

3.1.1 Normal Flow Monitoring

During the 2021 monitoring period, normal flow water quality was monitored 12 times at SS-01, SS-01.35, SS-04, SS-05, SS-05A, SS-06A, SS-06G, and SS-07. A total of 144 samples were collected during this monitoring, 120 of which were primary samples, 12 were duplicates, and 12 were blanks. All normal flow samples were analyzed for dissolved metals, total metals, alkalinity, nitrate/nitrite, sulfate, TDS, and TSS. Samples collected at SS-01, SS-01.35, SS-06G, and SS-07 were also analyzed for dissolved organic carbons (DOC), phosphorus (P), Total Kjeldahl Nitrogen (TKN), and ammonia (NH_3). Duplicate and blank sample analysis included the extra analyses. In 2021, normal flow monitoring produced 2,864 natural sample data points. Because the shipment of a cooler was delayed by the courier in February, ten samples arrived outside the TDS and TSS holding time; thus, analysis for these parameters was cancelled. Additionally, a sulfate result from September monitoring was rejected due to not meeting holding time requirements, and an alkalinity result from November monitoring was rejected due to not being comparable to historical data. Thus, analytical completeness for normal flow monitoring was 99%. Completeness for normal flow field parameter measurements was 100%.

Normal flow conditions were potentially affected by fluctuations in upland snowmelt, in groundwater inputs, and in changes to controlled inputs to the stream. Normal flow water quality analytical results are presented in Table 9a through Table 9c, as well as in Appendix A. These tables present analytical results, associated laboratory and validation qualifiers, and data utilization category. Table 9d includes field parameter measurements and stage and flow data collected during normal flow monitoring. Normal flow data quality is discussed in detail in Appendix A. Tables A5a through A5d present field duplicate results, field blank results, sample holding times for each analytical parameter, and laboratory QC sample results. Deviations are listed in Section 4.1.

3.1.2 Wet Weather Monitoring

Given the difficulty in predicting wet weather events, the QAPP does not specify the frequency or number of samples to be collected for wet weather data.

During the 2021 monitoring period, eight wet weather events were sampled at eight stations between May 23 and August 21 as presented in Table 10. A total of 304 wet weather natural samples were analyzed for total metals, dissolved metals, alkalinity, nitrate/nitrite, sulfate, TDS, and TSS. Samples from SS-01, SS-01-P, SS-06G, SS-06G-P, SS-07, and SS-07-P collected in the first storm event of the month were also analyzed for DOC, phosphorus, TKN, and ammonia. A total of 320 samples were collected, 304 of which were primary ISCO samples, 14 were duplicate ISCO samples, and 14 were field blanks. In 2021, wet weather monitoring produced 8,896 natural sample data points. Seven AgTR results from May were rejected due to not meeting matrix spike recovery requirements. Thus, completeness for 2021 wet weather data was 99.9 %.

Wet weather sampling may include incomplete laboratory analysis due to insufficient volume. Although not a deviation, samplers may fail to collect or may collect incorrectly during a wet weather event because the initial sampler intake stage was set too high or too low; the sample intake or bubbler lines were damaged; the sampler lost power; or the flow meter failed. When ISCOs failed to collect and backup DTEC samples were available, the DTEC samples were submitted to the labs. Prior to the wet weather event on August 18, samplers at SS-01, SS-01-P, and SS-01.35 collected early on August 16 and 17 due to the initial sampler intake stage being set too low. Due to the early collection, these samplers were not triggered by the August 18 event.

Wet weather-associated field parameters are collected only when field grab (FG) samples are collected. There were neither DTEC nor FG wet weather samples collected in 2021. Wet weather water quality results are presented in Table 11a through Table 11c, as well as in Appendix A. These tables present analytical results and their associated laboratory and validation qualifiers and data utilization categories. Table 11d presents the stage and calculated flow associated with each wet weather sample. Wet weather data quality is discussed in detail in Appendix A. Tables A6a through A6d present field duplicate results, field blank results, sample holding times for each analytical parameter, and laboratory QC sample results. Deviations are listed in Section 4.1.

3.1.3 Stream Stage and Flow Monitoring

Locations of continuous stage recorders are presented in Table 3. Stage measurements at sites downstream of the BMFOU Berkeley Pit and Discharge Pilot Project (BMFOU Discharge Pilot Project) were affected by fluctuations of Pilot Project discharge throughout the year. Some continuous stage records were incomplete and contained data gaps or erroneous data. Data gaps and erroneous data were mainly attributed to freezing temperatures and equipment failure. Fifteen to thirty-minute data losses occurred at multiple sites throughout the year when maintenance was performed, such as battery and programming changes. Stage and discharge hydrographs are presented in Appendix B, and stage-discharge relationships are presented in Appendix C. Deviations are listed in Section 4.1.

3.1.4 Precipitation Data

Most of the 2021 calendar precipitation came between April and August, while the majority of high elevation snowmelt occurred in early May. February saw the greatest SWE gain of 2.3 inches. SWE peaked April 26 at 6.3 inches. The SWE at the Basin Creek SNOTEL site was first recorded as zero on May 14. Late May saw a short increase to 0.8 inches SWE, but quickly returned to 0 before snow accumulation resumed in October.

Of the precipitation stations monitored, Basin Creek had the greatest precipitation in 2021 (13.5 inches), followed by Blacktail Canyon (9.72 inches), CB-1 (8.61 inches), Kelley Mine (6.63 inches), and BMMA (6.48 inches). Station BTL/LAO recorded 4.95 inches of precipitation in 2021, but this station experienced a data loss from early August to mid-November. Station BSB-Shop was removed April 1, 2021 due to the BSB road maintenance shop being dismantled to allow for the Parrott Tailings removal project to proceed. In the three months prior to station removal, 1.02 inches of precipitation was recorded at BSB-Shop. Total 2021 SWE, at the Basin Creek SNOTEL site, was 9.6 inches gained and 9.6 inches lost for a net gain of 0.0 inches. Daily, monthly, and total precipitation data are presented in Table 7a and Table 7b. SWE data are presented in Table 7c. Daily precipitation results are presented in Figure 7a through Figure 7g.

The daily datasets for Blacktail Canyon, Basin Creek, CB-1, and BMMA were 100% complete, while the Kelly Mine was 88.49% complete (42 missing data points) and BTL/LAO was 69.31% complete (112 missing data points). Station BSB-Shop was operated through 1400 on April 1, 2021, and the data set was 100% complete for this period.

3.2 Diagnostic Monitoring

Monitoring activities during 2021 consisted of water quality sampling as well as stage and flow measurements. These activities were performed in accordance with CFRSSI and TREC SOPs and are outlined in the QAPP. The following sections present analytes, frequency of sampling events, and counts of natural samples.

3.2.1 Water Quality Monitoring

Given the difficulty in predicting wet weather events, the QAPP does not specify the frequency or number of samples to be collected for diagnostic wet weather data. During the 2021 monitoring period, twenty wet weather events were sampled at ten diagnostic stations between May 7 and October 8 as presented in Table 12. Diagnostic monitoring stations are presented in Table 4. A total of 295 wet weather diagnostic samples were collected, and of these 253 were natural samples, 21 were field duplicates, and 21 were field blanks. The intended analyses for each sample were total metals, dissolved metals, sulfate, and TSS. Due to inadequate sample volumes, numerous samples did not receive all analyses, with sulfate and TSS most often omitted, followed by dissolved metals. Of the intended 4,048 natural sample analyses, 3,841 were completed. Thus, analytical completeness for 2021 diagnostic wet weather was 95%. Diagnostic wet weather water quality results are presented in Table 13a through Table 13c, as well as in Appendix E. These tables present analytical results, associated laboratory and validation qualifiers, and data utilization category. Table 13d presents calculated flows associated with diagnostic wet weather sample times. Empty cells in Table 13d indicate that the level and velocity criteria to accurately calculate flow were not met, so flows were not calculated for those sample times. Level and velocity criteria are presented in Section 3.2.2. Diagnostic wet weather data quality is discussed in detail in

Appendix E. Tables E3a through E3d present field duplicate results, field blank results, sample holding times for each analytical parameter, and laboratory QC sample results.

3.2.2 Diagnostic Level and Flow Monitoring

AV meters were maintained at diagnostic stations as presented in Table 4. Diagnostic wet weather hydrographs are presented in Appendix F. Some flow records contain data gaps or suspect data that are mainly attributed to low water levels, standing water or backflow, and occasionally due to ice or equipment malfunction. At water levels less than 0.08 inches, velocity measurements are uncertain, and the level measurement is uncertain at levels below 0.033 inches. For levels between 0.033 inches and 0.08 inches where the velocity measurement is suspect, the stage measurement is used to calculate a discharge based on Manning's equation. Suspect data at specific continuous recorder stations are listed below. Deviations are listed in Section 4.2.

- MSD-CLV-3A: The sampling equipment in the culverts were removed on August 17 to accommodate the construction work required for the BTL stress test. The sampling equipment was re-installed August 27.
- BG-CLV-1: Suspect data points caused by standing water or backflow occurred in May through August.
- GG-CLV-I: Suspect data points occurred from April through June and in September.
- MG-CLV-0: Suspect data points occurred from April through the first week of May.
- TX-HD-OUT: Suspect data points occurred on March 31 and April 1.
- LC-CLV-1: Suspect data points caused by standing water or backflow occurred periodically from June 10 through October.

3.3 Sediment Monitoring

In 2021, sediment samples were collected August 12 and 13 along the three stream reaches presented in Table 5. Eight natural samples, 1 field duplicate, and 1 field blank were collected. The eight natural samples consisted of the 0-2 inch and 2-6 inch depth intervals at the SS-06G reach and the 0-2 inch, 2-6 inch, and 6-12 inch depth intervals at the SS-06A and SS-01 reaches. Each 0-2 inch and 6-12 inch sample consisted of a five-point composite sample, with the two depth intervals being collocated. At SS-01 and SS-06A, the 6-12 inch interval consisted of only two sub-samples (collocated with the 0-2 and 2-6 inch intervals). At SS-06G it was not possible to penetrate the armored streambed past six inches, thus, no 6-12 inch interval samples were collected. Each sub-sample point was field characterized for color, texture, grain size, and estimated sorting. Field characterization forms are provided in Appendix H. Each sample was to be analyzed for total arsenic, cadmium, copper, lead, mercury, zinc, pH, total organic carbon (TOC), and particle size; thus 108 natural sample analyses were anticipated. Note that particle size includes three size categories % clay, % silt, % sand. Based on the percentages of each category, texture is also reported. An inadequate amount of sediment was obtained for the 6-12 inch interval at SS-06A so pH, TOC, and particle size analyses were omitted. Of the anticipated 88 natural sample analyses, 83 were completed; thus, completeness was 94%.

Sediment data quality is discussed in detail in Appendix I and analytical results are presented in Table 14a through 14c. These tables include analytical results, associated laboratory and validation qualifiers, and data useability categories. Deviations are listed in Section 4.3.

3.4 BMI and Habitat Monitoring

In 2021, BMI samples were collected August 9 and 10 along the three stream reaches presented in Table 5. Four replicate BMI samples were collected at each stream reach; thus, 12 individual samples were submitted to the laboratory for taxonomic classification. The goal was to assess each sample for the metrics presented in Table 15. All of these assessments were completed. BMI sampling precision is related to variability and is assessed by comparing the replicate samples collected at each site. The goal was to have ≤ 20% relative standard deviation (RSD) in taxa richness and that was achieved. To measure laboratory enumeration precision, 10% of a sample set was counted by a second taxonomist, with a goal of having > 90% similarity. Laboratory identification precision is measured in a similar manner, with a goal of >85% agreement. Both enumeration and identification precision were achieved. Appendix L presents the BMI data.

BMI taxa, community metrics, and taxa tolerance levels for each of the three stream reaches monitored are presented in Table 16a through Table 16c, Table 17a through 17c, and Table 18a through 18c, respectively. Table 19 presents field parameter measurements collected at each monitoring reach.

Habitat monitoring was completed in tandem with BMI monitoring. Each site was first sampled for the BMI community, and habitat monitoring was then completed before moving on to the next site. Habitat monitoring field forms are presented in Appendix K. Deviations are listed in Section 4.4.

4.0 DEVIATIONS

4.1 Normal Flow and WW

Fifteen to thirty-minute data losses occurred at multiple sites throughout the year when maintenance was performed, such as battery or programming changes.

- Power failures at the SS-01 continuous data recorder resulted in a data loss from 07:00 to 16:15 on April 22 and from 07:30 on November 3 to 08:15 on November 4.
- A power failure at the SS-05A continuous data recorder resulted in a data loss from 13:45 on December 6 to 13:15 on December 23.
- An equipment failure at the SS-06A continuous data recorder resulted in a data loss from 08:00 to 10:00 on December 12.
- In-depth maintenance on the continuous stage data recorder at SS-06G resulted in a data loss from 10:30 to 12:15 on November 19.
- Due to off-specification flow at the BMFOU Pilot Project plant during the June 9 baseflow sampling event, water quality samples and flow measurements at SS-01 and SS-01.35 were collected first while waiting for Pilot Project discharge water to reach SS-07 after discharge resumed. It was agreed upon by field crews and the QAO that any sediments suspended in the water column caused by sampling these upstream sites would settle out before the water reached SS-07, where sampling was resumed in the usual downstream to upstream order.

4.2 Diagnostic

Fifteen to thirty-minute data losses occurred at multiple sites throughout the year when maintenance was performed, such as battery or programming changes. The sensors on AV meters are replaced as they near the end of their life expectancy.

- GG-CH-1: A data gap occurred from 14:55 on May 3 to 12:45 on May 7.
- MG-CLV-0: A data gap occurred from 15:30 on August 31 to 09:40 on September 16.
- LC-CLV-1: The AV meter was replaced on June 10. All data prior to June 10 are suspect.
- GG-CH-1: The AV meter was replaced on May 7. All data prior to May 7 are suspect.
- MSD-CLV-3A: The AV meters in both culverts were replaced on June 2. All data prior to June 2 are suspect.

4.3 Sediment

- An inadequate amount of sediment was obtained for the 6 to 12 inch interval at SS-06A, so pH, TOC, and particle size analyses were omitted.
- No photos were taken of sample cores.
- Inaccurate coordinates were obtained for SS-06G transect 1, and no coordinates were obtained for SS-06G transects 2 and 3.
- When completing the electronic field form, Site SS-06G was mistakenly chosen at SS-01 Transect 2. Thus the mapped sediment sample points for SS-01 in Appendix H name SS-01 Transect 2 as SS-06G Transect 2.

4.4 BMI and Habitat

- None

5.0 REFERENCES

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Tables

Figures

Appendix A
Normal Flow and Wet Weather Water Data Quality Assessment

Appendix B
Stage and Flow Data

Appendix C
Stage Discharge Curves

Appendix D
Norman Flow and Wet Weather Raw Data

Appendix E
Diagnostic Data Quality Assessment

Appendix F
Diagnostic Flow Data

Appendix G
Diagnostic Raw Data

Appendix H
Sediment Field Sheets

Appendix I
Sediment Data Quality Assessment

Appendix J
Sediment Raw Data

Appendix K
Habitat Monitoring Field Sheets

Appendix L
BMI Raw Data