Fall 11-30-2022

2023 Draft Butte Priority Soils Operable Unit Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan (QAPP)

Woodard & Curran

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November 30, 2022

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RE: Silver Bow Creek Butte Area NPL Site 2023 Draft Butte Priority Soils Operable Unit Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan. Consent Decree- Civil Action No. CV 89-039-BU-SHE

Agency Representatives:

I am writing to you on behalf of Atlantic Richfield Company to submit the Silver Bow Creek/Butte Area NPL Site 2023 Draft Butte Priority Soils Operable Unit Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan for your review and approval. The plan summarizes the proposed site-wide surface water data collection to be conducted during the 2023 monitoring period. The 2023 SW QAPP differs from the approved Final 2022 BPSOU Surface Water QAPP in that the in-stream and sub-drainage wet weather (WW) monitoring network has been reduced.

- In-stream WW monitoring sites have been reduced to Silver Bow Creek compliance stations SS-06G and SS-07 and Blacktail Creek stations SS-01 and SS-01.35, thus eliminating SS-06A, SS-05A, SS-05, and SS-04. These reductions are an effort to focus on compliance monitoring, with the two upstream Blacktail Creek stations being retained to assess WW water quality entering the BPSOU. Also, the SS-06A, SS-05A, SS-05, and SS-04 monitoring sites will be impacted by upcoming BPSOU remedial construction projects.
- Subdrainage diagnostic WW monitoring sites have been reduced to MSD-CLV-3A, which monitors the BPSOU subdrain channel at Kaw Avenue, and MG-CLV-0, which monitors the Missoula Gulch overflow channel near its intersection with Silver Bow Creek. This eliminates upper Silver Bow Creek sites TX-HD-OUT and LC-CLV-1, West Side drainage sites GG-CLV-C, GG-CLV-D, GG-CLV-I, and MPTP-CLV-1, as well as GG-CLV-1 and BG-CLV-1.
    - Upper Silver Bow Creek sites TX-HD-OUT and LC-CLV-1 have been monitored since 2013 and 2015, respectively, providing adequate data to characterize WW water

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quality in these drainages. Downgradient upcoming remedial projects also eliminate the need for continued monitoring of these sites.

- Diagnostic sites GG-CLV-C, GG-CLV-D, GG-CLV-I, and MPTP-CLV-1 associated with the BPSOU uncaptured drainages have been monitored since 2019. The minimal data that has been collected from these stations during that time demonstrates that these drainages make negligible WW contributions to Silver Bow Creek.
- WW data has been collected at BG-CLV-1 and GG-CLV-1 for over ten years. These sites will be impacted by upcoming remedial construction projects; thus, continued monitoring of these sites is no longer needed.

The Draft 2023 BPSOU Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan, along with the QAPP crosswalk, have been attached for your review and approval. The plan summarizes the proposed site-wide surface water, sediment, BMI, and habitat data collection to be conducted during the 2023 monitoring period.

The full report and appendices may be downloaded at the following link:

2023 Final BPSOU Interim Site-Wide Surface Water Monitoring QAPP

If you have any questions or comments, please call me at (406) 723-1834.

Sincerely,

Josh Bryson, PE, PMP
Liability Manager & Global Risk Champion
Remediation Management Services Company
An affiliate of **Atlantic Richfield Company**

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EPA REGION 8 QA DOCUMENT REVIEW CROSSWALK

QAPP/FSP/SAP for: *(check appropriate box)* ☐ **GRANTEE** ☐ **CONTRACTOR** ☐ **EPA** ☐ **Other**	**Entity** *(grantee, contract, EPA AO, EPA Program, Other)* Atlantic Richfield Company	**Regulatory Authority** **and/or** **Funding Mechanism**	**___ 2 CFR 1500 for Grantee/Cooperative Agreements** **___ 48 CFR 46 for Contracts** **___ Interagency Agreement (FFA, USGS,)** **___ EPA/Court Order** **___ EPA Program Funding** **___ EPA Program Regulation** **___ EPA CIO 2105**
Document Title *[Note: Title will be repeated in Header]*	2023 Draft Butte Priority Soils Operable Unit Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan		
QAPP/FSP/SAP Preparer	Woodard & Curran for Atlantic Richfield Company		
Period of Performance *(of QAPP/FSP/SAP)*	**2023**	**Date Submitted for Review**	11/30/22
EPA Project Officer **EPA Project Manager**	 Nikia Greene	**PO Phone #** **PM Phone #**	 (406) 457-5019
QA Program Reviewer or Approving Official	Nikia Greene	**Date of Review**	

Documents Submitted for QAPP Review **(QA Reviewer must complete)*:***

1. QA Document(s) submitted for review:

QA Document	Document Date	Document Stand-alone	Document with QAPP
QAPP		Yes / No	
FSP		Yes / No	Yes / No
SAP		Yes / No	Yes / No
SOP(s)			Yes / No

2. WP/SOW/TO/PP/RP Date ___________
WP/SOW/TO/RP Performance Period _____________

3. QA document consistent with the:
WP/SOW/PP for grants? Yes / No
SOW/TO for contracts? Yes / No

4. QARF signed by R8 QAM Yes / No / NA
Funding Mechanism IA / contract / grant / NA
Amount _____________

Notes for Document Submittals:

1. A QAPP written by a Grantee, EPA, or Federal Partner must include for review: Work Plan(WP) / Statement of Work (SOW) / Program Plan (PP) / Research Proposal (RP) and funding mechanism
2. A QAPP written by Contractor must include for review:
   - **a)** Copy of Task Order Work Assignment/SOW
   - **b)** Reference to a hard or electronic copy of the contractor's approved QMP
   - **c)** Copy of Contract SOW if no QMP has been approved
   - **d)** Copy of EPA/Court Order, if applicable
   - **e)** The QA Review must determine (with the EPA CO or PO) if a QARF was completed for the environmental data activity described in the QAPP.
3. **a**. Field Sampling Plan (FSP) and/or Sampling & Analyses Plan (SAP) must include the Project QAPP ***or*** must be a stand-alone QA document that contain all QAPP required elements (Project Management, Data Generation/Acquisition, Assessment and Oversight, and Data Validation and Usability).
   b. SOPs must be submitted with a QA document that contains all QAPP required elements.

Summary of Comments *(highlight significant concerns/issues)***:**

1. Comment #1

2. Comment #2
3. Comment #3
4. **The** Atlantic Richfield Company **must address the comments in the Summary of Comments, as well as those identified in the Comment section(s) that includes a "Response (date)" and Resolved (date)".**

Element	Acceptable *Yes/No/NA*	Page/ Section	Comments
A. Project Management			
A1. Title and Approval Sheet			
a. Contains project title		1st page	
b. Date and revision number line (for when needed)		2nd cover page and x	
c. Indicates organization=s name		cover and i	
d. Date and signature line for organization=s project manager		i	
e. Date and signature line for organization=s QA manager		i	
f. Other date and signatures lines, as needed		i	
A2. Table of Contents			
a. Lists QA Project Plan information sections		v-vii	
b. Document control information indicated		v-vii	
A3. Distribution List			
Includes all individuals who are to receive a copy of the QA Project Plan and identifies their organization		ii-iv	
A4. Project/Task Organization			
a. Identifies key individuals involved in all major aspects of the project, including contractors		2.1	
b. Discusses their responsibilities		2.1	
c. Project QA Manager position indicates independence from unit generating data		2.1	
d. Identifies individual responsible for maintaining the official, approved QA Project Plan		2.1	
e. Organizational chart shows lines of authority and reporting responsibilities		Figure 1	
A5. Problem Definition/Background			
a. States decision(s) to be made, actions to be taken, or outcomes expected from the information to be obtained		1.0	

b. Clearly explains the reason (site background or historical context) for initiating this project		2.2	
c. Identifies regulatory information, applicable criteria, action limits, etc. necessary to the project		2.4.1, Tables 2 & 3	
A6. Project/Task Description			
a. Summarizes work to be performed, for example, measurements to be made, data files to be obtained, etc., that support the project=s goals		2.3, Table 1	
b. Provides work schedule indicating critical project points, e.g., start and completion dates for activities such as sampling, analysis, data or file reviews, and assessments		2.3, Table 1	
c. Details geographical locations to be studied, including maps where possible		2.4.1, Step 4, Tables 4-6, Figures 2 & 3	
d. Discusses resource and time constraints, if applicable		NA	
A7. Quality Objectives and Criteria			
a. Identifies - performance/measurement criteria for all information to be collected and acceptance criteria for information obtained from previous studies, - including project action limits and laboratory detection limits and - range of anticipated concentrations of each parameter of interest		2.4.2 Tables 8 Tables 11, 12, 14	
b. Discusses precision		2.4.2, Precision	
c. Addresses bias		2.4.2, Accuracy/Bias	
d. Discusses representativeness		2.4.2, Representativeness	
e. Identifies the need for completeness		2.4.2, Completeness	
f. Describes the need for comparability		2.4.2, Comparability	
g. Discusses desired method sensitivity		2.4.2, Sensitivity	
A8. Special Training/Certifications			

a. Identifies any project personnel specialized training or certifications		2.5	
b. Discusses how this training will be provided		2.5	
c. Indicates personnel responsible for assuring training/certifications are satisfied		2.5	
d. identifies where this information is documented		2.5	
A9. Documentation and Records			
a. Identifies report format and summarizes all data report package information		2.6.6 & 4.3 5.1.3, 5.1.4, Appendix G	
b. Lists all other project documents, records, and electronic files that will be produced		2.6	
c. Identifies where project information should be kept and for how long		2.6	
d. Discusses back up plans for records stored electronically		2.6	
e. States how individuals identified in A3 will receive the most current copy of the approved QA Project Plan, identifying the individual responsible for this		2.1	
B. Data Generation/Acquisition			
B1. Sampling Process Design (Experimental Design)			
a. Describes and justifies design strategy, indicating size of the area, volume, or time period to be represented by a sample		3.1	
b. Details the type and total number of sample types/matrix or test runs/trials expected and needed		3.1	
c. Indicates where samples should be taken, how sites will be identified/located		3.1.2 &3.1.4, Figures 2 & 3, Tables 4-6	
d. Discusses what to do if sampling sites become inaccessible		Final paragraph of 3.1	
e. Identifies project activity schedules such as each sampling event, times samples should be sent to the laboratory, etc.		2.4.1, step 4, Tables 4-6 3.3.1, 3.3.2	
f. Specifies what information is critical and what is for informational purposes only		3.1.2, 3.1.5, 3.1.6	

g. Identifies sources of variability and how this variability should be reconciled with project information		2.4.2, 3.1.2, 3.5.3	
B2. Sampling Methods			
a. Identifies all sampling SOPs by number, date, and regulatory citation, indicating sampling options or modifications to be taken		3.2.1, Table 15	
b. Indicates how each sample/matrix type should be collected		3.2.2	
c. If in situ monitoring, indicates how instruments should be deployed and operated to avoid contamination and ensure maintenance of proper data		3.2.2.2, 3.2.2.3	
d. If continuous monitoring, indicates averaging time and how instruments should store and maintain raw data, or data averages		3.2.2.1, 3.2.2.2	
e. Indicates how samples are to be homogenized, composited, split, or filtered, if needed		3.2.1 SOPS Table 15, Appendix A	
f. Indicates what sample containers and sample volumes should be used		3.2.2.3, Table 17; 3.2.2.4, Table 18, 3.2.2.5	
g. Identifies whether samples should be preserved and indicates methods that should be followed		3.2.2.3, Table 17; 3.2.2.4, Table 18, 3.2.2.5	
h. Indicates whether sampling equipment and samplers should be cleaned and/or decontaminated, identifying how this should be done and by-products disposed of		3.2, 3.2.2.2, 3.2.2.3. 3.2.2.4	
i. Identifies any equipment and support facilities needed		3.2.3	
j. Addresses actions to be taken when problems occur, identifying individual(s) responsible for corrective action and how this should be documented		4.1	
B3. Sample Handling and Custody			
a. States maximum holding times allowed from sample collection to extraction and/or analysis for each sample type and, for in-situ or continuous monitoring, the maximum time before retrieval of information		3.3.1, Tables 11, 12, & 14	

b. Identifies how samples or information should be physically handled, transported, and then received and held in the laboratory or office (including temperature upon receipt)		3.3.2	
c. Indicates how sample or information handling and custody information should be documented, such as in field notebooks and forms, identifying individual responsible		3.3.3	
d. Discusses system for identifying samples, for example, numbering system, sample tags and labels, and attaches forms to the plan		3.3.4	
e. Identifies chain-of-custody procedures and includes form to track custody		3.3.2, 3.3.5, Appendix E	
B4. Analytical Methods			
a. Identifies all analytical SOPs (field, laboratory and/or office) that should be followed by number, date, and regulatory citation, indicating options or modifications to be taken, such as sub-sampling and extraction procedures		3.4, Tables 11, 12, & 14	
b. Identifies equipment or instrumentation needed		3.4.3	
c. Specifies any specific method performance criteria		N/A	
d. Identifies procedures to follow when failures occur, identifying individual responsible for corrective action and appropriate documentation		3.5.2, Table 9, 4.1	
e. Identifies sample disposal procedures		3.4.4	
f. Specifies laboratory turnaround times needed		5.1.3	
g. Provides method validation information and SOPs for nonstandard methods		N/A	
B5. Quality Control			
a. For each type of sampling, analysis, or measurement technique, identifies QC activities which should be used, for example, blanks, spikes, duplicates, etc., and at what frequency		3.5.1, 3.5.2	
b. Details what should be done when control limits are exceeded, and how effectiveness of control actions will be determined and documented		3.5.2, Table 9	
c. Identifies procedures and formulas for calculating applicable QC statistics, for example, for precision, bias, outliers and missing data		2.4.2, Table 8	

B6. Instrument/Equipment Testing, Inspection, and Maintenance			
a. Identifies field and laboratory equipment needing periodic maintenance, and the schedule for this		3.6.1, 3.6.2	
b. Identifies testing criteria		3.6.1, 3.6.2	
c. Notes availability and location of spare parts		3.2.3	
d. Indicates procedures in place for inspecting equipment before usage		3.6.1, 3.6.2	
e. Identifies individual(s) responsible for testing, inspection and maintenance		3.6.1, 3.6.2	
f. Indicates how deficiencies found should be resolved, re-inspections performed, and effectiveness of corrective action determined and documented		3.6.1, 3.6.2, 4.1	
B7. Instrument/Equipment Calibration and Frequency			
a. Identifies equipment, tools, and instruments that should be calibrated and the frequency for this calibration		3.7	
b. Describes how calibrations should be performed and documented, indicating test criteria and standards or certified equipment		3.7	
c. Identifies how deficiencies should be resolved and documented		3.7, 4.1	
B8. Inspection/Acceptance for Supplies and Consumables			
a. Identifies critical supplies and consumables for field and laboratory, noting supply source, acceptance criteria, and procedures for tracking, storing and retrieving these materials		3.8	
b. Identifies the individual(s) responsible for this		3.8	
B9. Use of Existing Data (Non-direct Measurements)			
a. Identifies data sources, for example, computer databases or literature files, or models that should be accessed and used		N/A	
b. Describes the intended use of this information and the rationale for their selection, i.e., its relevance to project		N/A	
c. Indicates the acceptance criteria for these data sources and/or models		N/A	
d. Identifies key resources/support facilities needed		N/A	

e. Describes how limits to validity and operating conditions should be determined, for example, internal checks of the program and Beta testing		N/A	
B10. Data Management			
a. Describes data management scheme from field to final use and storage		3.9	
b. Discusses standard record-keeping and tracking practices, and the document control system or cites other written documentation such as SOPs		3.9	
c. Identifies data handling equipment/procedures that should be used to process, compile, analyze, and transmit data reliably and accurately		3.9	
d. Identifies individual(s) responsible for this		3.9	
e. Describes the process for data archival and retrieval		3.9	
f. Describes procedures to demonstrate acceptability of hardware and software configurations		N/A	
g. Attaches checklists and forms that should be used		N/A	
C. Assessment and Oversight			
C1. Assessments and Response Actions			
a. Lists the number, frequency, and type of assessment activities that should be conducted, with the approximate dates		4.0	
b. Identifies individual(s) responsible for conducting assessments, indicating their authority to issue stop work orders, and any other possible participants in the assessment process		4.0, 4.1, 4.2	
c. Describes how and to whom assessment information should be reported		4.0, 4.1, 4.2	
d. Identifies how corrective actions should be addressed and by whom, and how they should be verified and documented		4.1, 4.2	
C2. Reports to Management			
a. Identifies what project QA status reports are needed and how frequently		4.3	
b. Identifies who should write these reports and who should receive this information		4.3	
D. Data Validation and Usability			

D1. Data Review, Verification, and Validation			
Describes criteria that should be used for accepting, rejecting, or qualifying project data		5.2.2, Table 19, Table 20	
D2. Verification and Validation Methods			
a. Describes process for data verification and validation, providing SOPs and indicating what data validation software should be used, if any		5.1, 5.2, Appendix B	
b. Identifies who is responsible for verifying and validating different components of the project data/information, for example, chain-of-custody forms, receipt logs, calibration information, etc.		5.1.1, 5.1.2, 5.2.2	
c. Identifies issue resolution process, and method and individual responsible for conveying these results to data users		5.1.1, 5.1.2	
d. Attaches checklists, forms, and calculations		Appendix H	
D3. Reconciliation with User Requirements			
a. Describes procedures to evaluate the uncertainty of the validated data		5.2.2	
b. Describes how limitations on data use should be reported to the data users		5.2.1, 5.2.2, 5.2.3	

SILVER BOW CREEK/BUTTE AREA NPL SITE

2023 Draft Butte Priority Soils Operable Unit Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan (QAPP)

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November 2022

SILVER BOW CREEK/BUTTE AREA NPL SITE

2023 Draft Butte Priority Soils Operable Unit Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan (QAPP)

Prepared for:

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Prepared by:

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November 30, 2022

APPROVAL PAGE

QUALITY ASSURANCE PROJECT PLAN FOR
BUTTE PRIORITY SOILS OPERABLE UNIT SURFACE WATER MONITORING
SILVER BOW CREEK/BUTTE AREA NPL SITE

Approved: ______________________________ Date: ______________
Nikia Greene, Site Project Manager, EPA, Region 8

Approved: ______________________________ Date: ______________
Daryl Reed, Project Officer, Montana DEQ

Approved: ______________________________ Date: ______________
David Gratson, Quality Assurance Manager, Environmental Standards

Approved: ______________________________ Date: ______________
Josh Bryson, Liability Manager, Atlantic Richfield Company

Plan is effective on date of last signature above.

DISTRIBUTION LIST

Silver Bow Creek/Butte Area NPL Site
Butte Priority Soils Operable Unit 2020/2021 Site-Wide Surface Water Monitoring Quality Assurance Project Plan (QAPP)
Butte, Silver Bow County, Montana

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REVISION SUMMARY

2023 Revision Number	Submittal Date	Previously Approved QAPP	Sections Revised	Changes/Comments	Signature Approval

LIST OF ACRONYMS AND ABBREVIATIONS

APHA	American Public Health Association
ARAR	Applicable Relevant and Appropriate Requirements
ARCO	Atlantic Richfield Company
ASA	American Society of Agronomy
ASTM	American Society of Testing and Materials
BDMS	Butte Data Management System
BG	Buffalo Gulch
BLM	Biotic Ligand Model
BMFOU	Butte Mine Flooding Operable Unit
BMI	Benthic Macroinvertebrate
BMMA	Bert Mooney Municipal Airport
BPSOU	Butte Priority Soils Operable Unit
BSB	Butte Silver Bow
BTC	Blacktail Creek
BTL	Butte Treatment Lagoons
CAP	Corrective Action Plan
CAR	Corrective Action Report
CD	Consent Decree
CFRSSI	Clark Fork River Superfund Site Investigations
COC	Contaminant of Concern
CPM	Contractor Project Manager
DEQ	Department of Environmental Quality
DI	Deionized Water
DMP	Data Management Plan
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DSR	Data Summary Report
EDD	Electronic Data Deliverable
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Tricoptera
EPTC	Relative abundance of EPT to Chironomidae ratio
EQUIS	Environmental Quality Information System
EWI	Equal Width Increment
FB	Field Blank

FRESOW	Further Remedial Elements Scope of Work
GG	Grove Gulch
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCC	Hydraulic Control Channel
HSP	Health and Safety Plan
ID	Identification
LAO	Lower Area One
LAP	Lab Analysis Plan
LCS	Laboratory Control Spike
LCSD	Laboratory Control Spike Duplicate
LD	Laboratory Duplicate
LM	Liability Manager
LWD	Large Woody Debris
MB	Method Blank
MDEQ	Montana Department of Environmental Quality
MDL	Method Detection Limit
MS	Matrix Spike
MS	MICROSOFT
MSD	Matrix Spike Duplicate
NELAP	National Environmental Laboratory Accreditation Program
NF	Normal Flow
NPL	National Priorities List
O&M	Operations & Maintenance
OSHA	Occupational Safety & Health Administration
OU	Operable Unit
PEC	Probable Effects Concentration
pH	negative log of the hydrogen concentration
PM	Project Manager
PPE	Personal Protective Equipment
PTD	Percent Taxonomic Disagreement
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
RBP	Rapid Bioassessment Protocol
RL	Reporting Limit
ROD	Record of Decision
RODA	Record of Decision Amendment
RPD	Relative Percent Difference

RSD	Relative Standard Deviation
SBC	Silver Bow Creek
SC	Specific Conductivity
SM	Standard Method
SNOTEL	Snowpack Telemetry
SOP	Standard Operating Procedure
SOW	Scope of Work
SQL	structured query language
SWMP	Surface Water Management Plan
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solids
uSBC	upper Silver Bow Creek
USGS	United States Geological Survey
WW	Wet Weather

1.0 INTRODUCTION

The purpose of this Quality Assurance Project Plan (QAPP) is to provide guidance for collecting enforcement quality data for site-wide surface water, sediment, benthic macroinvertebrate (BMI), and habitat monitoring activities at the Butte Priority Soils Operable Unit within the Silver Bow Creek/Butte Area National Priorities List (NPL) Site during the 2023 monitoring period and to reference the documents necessary to describe the quality assurance and quality control (QA/QC) policies and procedures to be used during data collection and analysis. Although this QAPP details not only Butte Priority Soils Operable Unit (BPSOU) interim site-wide surface water monitoring, but also sediment, BMI, and habitat monitoring, the title reflects only surface water monitoring to remain consistent with BPSOU Consent Decree (CD) (U.S.A and State of Montana, 2020) documents. This QAPP has been developed in accordance with the *EPA Requirements for Quality Assurance Project Plans*, *EPA QA/R-5* (EPA 2001a), the *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA AQ/G-4 (EPA 2006b), and the EPA *Region 8 Quality Assurance Document Review Crosswalk* checklist (EPA 2017). This QAPP was prepared in a manner consistent with the *Butte Area NPL Site Butte Priority Soils Operable Unit (BPSOU) Final Quality Management Plan* (QMP) (Atlantic Richfield, 2020a) and includes the four basic element groups:

- Project Management and Objectives;
- Measurement and Data Acquisition;
- Assessment and Oversight; and
- Data Review.

The four sections below provide these project plan elements and include the appropriate content needed for planning the sampling and analysis within the site. The sections in this stand-alone QAPP expand and reference information in other site wide documents to present project specific requirements.

2.0 PROJECT MANAGEMENT

This section addresses project concerns, goals and approaches to be followed during sampling activities on the site.

2.1 Project Organization and Responsibilities

An example organizational chart showing the overall organization of the project team is provided in Figure 1. Responsibilities of key individuals comprising the project team are described below.

<u>Environmental Protection Agency Project Manager – Nikia Greene (EPA)</u>

The Environmental Protection Agency (EPA) Project Manager is responsible for communicating and coordinating EPA requirements with the Atlantic Richfield Liability Manager (LM), such that Agency requirements are met. The EPA Project Manager must also coordinate with the Montana Department of Environmental Quality (DEQ) Project Manager to ensure that the state’s concerns and requirements are addressed.

Montana Department of Environmental Quality Project Manager – Daryl Reed (DEQ)

The Montana DEQ Project Manager is responsible for communicating and coordinating with the Atlantic Richfield LM and the EPA Project Manager such that the state's requirements are addressed.

Atlantic Richfield Liability Manager (LM) – Josh Bryson (Atlantic Richfield Company)

The Atlantic Richfield LM monitors the performance of the contractor(s). The LM consults with the Contractor Quality Assurance Officer and Contractor Project Manager(s) on deficiencies and aids in finalizing resolution actions. The Atlantic Richfield LM, or their designee, will be responsible for distributing this QAPP. This QAPP will be distributed electronically to all recipients.

Atlantic Richfield Quality Assurance Manager (QAM) – David Gratson (Environmental Standards)

The Atlantic Richfield QAM interfaces with the Atlantic Richfield LM for company policies regarding quality and has the authority and responsibility to approve quality assurance (QA) documents specific to the project including this QAPP.

Contractor Project Manager (CPM) – Scott Bradshaw (Woodard & Curran)

The CPM is responsible for ensuring that all monitoring addressed in this QAPP is completed and ensuring that the work is performed in accordance with the requirements contained herein. The CPM is also responsible for consulting with the quality assurance personnel identified for the project regarding any deficiencies and finalizing resolution actions. The CPM is also responsible for ensuring communication between all Atlantic Richfield entities that perform monitoring tasks within Blacktail Creek, Silver Bow Creek, and creek tributaries.

Field Team Leader – Alice Drew-Davies (Woodard & Curran)

The Field Team Leader ensures that the QAPP has been reviewed by all members of the field team and is properly followed when implementing field activities. The Field Team Leader is responsible for scheduling all monitoring addressed in this QAPP. The Field Team Leader will conduct daily safety meetings, assist in field activities, and assure that activities are documented in the logbook, or on field forms (either electronic or paper). The Field Team Leader is responsible for equipment, problem solving and decision making in the field, and for technical aspects of the project. In addition, the field team leader provides "on-the-ground" overview of project implementation by observing site activities to ensure compliance with technical project requirements, Health Safety Security and Environment (HSSE) requirements, and the Site Specific Health and Safety Plan. The field team leader identifies potential Integrity Management (IM) issues, as appropriate, and prepares required project documentation. The field team leader is the point of communication for other Atlantic Richfield contractors that perform monitoring tasks within Blacktail Creek, Silver Bow Creek, and creek tributaries. The field team leader is also the point of contact for Atlantic Richfield entities that are discharging water to Blacktail Creek, Silver Bow Creek, and creek tributaries.

Benthic Macroinvertebrate (BMI) Team Advisor – Barry Fulton (Benchmark Environmental)

The BMI Team Advisor will be responsible for training field personnel on how to perform habitat assessments, collect and field-process BMI samples, and calibrate field measurement instruments.

Contractor Quality Assurance Officer (QAO) – Tina Donovan (Woodard & Curran)

The QAO is responsible for field and laboratory data review and evaluation of data quality, including conducting on-site reviews and preparing site review reports for the QAM. The QAO is responsible for maintaining this QAPP.

The QAO represents their assigned projects as the primary spokesperson on matters relating to quality management system implementation. In matters of project QA, this individual will have a direct line of communication to the QAM to ensure issues are resolved.

The QAO is authorized to stop work if, in the judgment of that individual, the work is performed contrary to or in the absence of prescribed quality controls, or approved methods, and further work would make it difficult or impossible to obtain acceptable results. The QAO may also stop work if completion of quality corrective actions is not acceptable.

The QAO is responsible for carrying out field audits to ensure the integrity of field measurements, sample collection, and documentation.

QAOs are responsible for evaluating data and information from instances of nonconformance, inspection reports, surveillance reports, audit and assessment reports, quality system reviews (QSRs), corrective action reports (CARs), corrective action plans (CAPs), stop work orders, and other sources. These data should be used to identify trends or conditions averse to quality, which shall be brought to the attention of the QAM.

Project Safety and Health Manager – Nicole Santifer (Woodard & Curran)

The Project Safety and Health Manager will conduct the initial safety meeting prior to starting fieldwork for the QAPP. The Safety and Health Manager will ensure that work crews comply with all site health and safety requirements and will ensure revisions of the Health and Safety Plan (HSP), as necessary.

Analytical Contract Laboratory (Pace Analytical)

Pace Analytical Laboratory of Minneapolis, Minnesota will be the contract laboratory for BPSOU surface water and sediment monitoring. The Minnesota laboratory can be contacted at (612) 607-1700. Pace's QA personnel are familiar with the approved QAPP and are available to perform the work as specified. Contract Laboratory personnel are responsible for reviewing final analytical reports produced by the laboratory, coordinating scheduling of laboratory analyses and supervising in-house chain-of-custody procedures. Pace Analytical is accredited under the National Environmental Laboratory Accreditation Program (NELAP) and is certified under the Montana Department of Public Health and Human Services (DPHHS) public water supply laboratory certification program to perform organic and inorganic analyses. In addition, Pace is in Atlantic Richfield's Laboratory Management Program, thus is subject to annual auditing. Prior to making any changes in the contract laboratory, potential laboratories will review the QAPP to ensure analytical criteria can be met. Any future laboratory will be NELAP and state of Montana certified for applicable analyses, and the laboratory must be approved by BP's Laboratory Management Program.

Taxonomy Contract Laboratory (GEI)

GEI Consultant's Ecological Laboratory of Denver, Colorado will be the contract laboratory for macroinvertebrate monitoring. All taxonomists responsible for the identifications and QA/QC protocols will have one or more Level 2 Taxonomic Certification from the Society of Freshwater Science.

2.2 Problem Definition and Background

The BPSOU covers approximately 5 square miles and includes the town of Walkerville, along with a large portion of the city of Butte. A small stream, Silver Bow Creek (SBC), runs through the BPSOU. The upper reach of Silver Bow Creek (uSBC) begins near the intersection of Texas Avenue and Civic Center Road, but perennial flow in SBC does not exist above the creek's confluence with Blacktail Creek (BTC). Placer mining for silver and gold began in the Butte area in 1864, and by the 1870s multiple silver and copper mines, mills, and smelting facilities had been established in the area. Over 284 million pounds of copper had been produced by the Butte district by 1910, and the associated wastes "*were disposed of in ponds or dumped in Silver Bow Creek"* (EPA, 2006d). Mine waste, including tailings and waste rock dumps, accumulated across the Butte Hill for more than a century as mining and associated industries flourished. These accumulations impacted SBC via direct run-off to the creek and infiltration to the alluvial aquifer, with the affected groundwater eventually re-expressing as surface water in the creek. As a result of these impacts, SBC was designated a Superfund site by the EPA in September 1983. Given that SBC was impacted by wastes within the Butte area, the Silver Bow Creek Site was expanded to include the Butte Area in 1987.

Multiple remedial actions have been implemented to impact SBC water quality. From 1992 to 1997, over one million cubic yards of mine waste was removed in the western part of the BPSOU. From 1996-1998 storm water issues on the Butte Hill were addressed through constructing sediment basins, channelizing flow, regrading, revegetation, and reclamation. In 2003, Missoula Gulch wet weather flows were segregated from normal flows to allow gravitational removal of solids and metals in catch basins. In 2003, the BPSOU subdrain groundwater capture system was constructed to separate groundwater from wet weather flow in the SBC channel between Texas Avenue and Kaw Avenue. In 2006, additional Missoula Gulch BMPs were implemented to divert normal flow to the Butte Treatment Lagoons (BTL) and to enhance storm water retention of flows exiting catch basin 9. Approximately 7,200 cubic yards of mining impacted material were removed from the streambanks at the confluence of BTC and the SBC in 2010, as well as rip-rapping the streambanks and revegetating the area near the confluence after the removal. Between 2011 and 2013, hydrodynamic devices were installed in stormwater trunk lines at the base of the Butte Hill to capture sediments before water is discharged to SBC. The above remedial actions represent the subset most directly impacting SBC water quality of all remedial actions performed.

The Record of Decision (ROD) (EPA, 2006d) specifies guidelines for selected remedies for surface water within BPSOU. The goals of the remedies are to protect human and environmental health and reduce COC concentrations to quality standards in Grove Gulch, Blacktail Creek, and Silver Bow Creek. As stated in the 2006 ROD, the selected Remedy for surface water consists of the following components:

1. *The Surface Water Management Program which utilizes BMPs to address contaminated storm water runoff and improve storm water quality.*
2. *Excavation and removal to a repository of contaminated sediments from the stream bed, banks, and adjacent floodplain along Blacktail Creek and Silver Bow Creek, from just above the confluence of Blacktail Creek and Metro Storm Drain to the beginning of the reconstructed Silver Bow Creek floodplain at Lower Area One. Following removal of the in-stream sediments, further evaluation of surface water quality in this area will be conducted. If groundwater inflow is found to adversely affect surface water quality, additional hydraulic controls and groundwater capture shall be implemented.*
3. *Capturing and treating storm water runoff up to a specified maximum storm event, if BMPs implemented under the Surface Water Management Program do not achieve the goal of meeting surface water standards in Silver Bow Creek, Grove Gulch, and Blacktail Creek during storm water events.*
4. *Hydraulic control, capture, and treatment of contaminated groundwater to prevent its discharge to Silver Bow Creek surface water (as described above* [in reference to the ROD] *and in Section 12.3.2* [of the ROD]*).*
5. *In-stream flow augmentation as appropriate. Flow augmentation will not be considered until the major remedial components described in this ROD are designed and implemented.*

The Remedy includes the modifications stated in the 2020 Record of Decision Amendment (RODA), (EPA, 2020) as follows:

- *Waiver of the State of Montana's Circular DEQ-7 acute aquatic life standards for copper and zinc based on a total recoverable (unfiltered) sample and adopt the federal acute aquatic life standards based on a dissolved (filtered) sample as shown on in Table 2. This change to federal acute aquatic life standards based on a dissolved sample is protective of surface water in the BPSOU because all contaminated sediments will be removed and replaced with clean sediments and the contaminant pathways to these sediments will be addressed with the additional remedial actions now required.*
- *Adoption of the current Circular DEQ-7 allowance for one exceedance of water quality standards in 3 years. This exceedance rate allowance was accounted for in the TI evaluation and applies to both the chronic and acute standards.*
- *Adoption of the updated Circular DEQ-7 aquatic life standard for cadmium (May 2017). This change applies to both the chronic and acute standards (Tables 1 and 2). Because the cadmium standard is not waived initially, the new Circular DEQ-7 standard will apply unless the contingent post-construction waiver is invoked.*
- *Modification of point of compliance as described in Appendix A. As described in the 2006/2011 BPSOU Record of Decision, an overall remedial goal for Silver Bow Creek is to maintain the in-stream concentration of site-specific COCs below the numeric surface water quality standards identified in Circular DEQ-7 for all flow conditions throughout the length of Blacktail Creek, Grove Gulch Creek, and Silver Bow Creek below its confluence with Blacktail Creek within and directly downstream of the BPSOU. This surface water compliance requirement from the 2006/2011 BPSOU Record of Decision (Section 12.6.6.2) will be changed to two points of*

compliance at SS-06G and SS-07 only (Figure A-3). Other monitoring stations will remain in the network as needed, but compliance will be determined at these two farthest downstream stations. Effluent from the Butte wastewater treatment plant enters between SS-06G and SS-07. The surface water sampling methodology will be modified to allow for additional compositing methods at the compliance sampling locations.

In addition to the Remedy outlined in the ROD and in the 2020 RODA, Further Remedial Elements (FRE) are required under the BPSOU CD. These elements are described in the Further Remedial Elements Scope of Work (FRESOW), which is Attachment C to Appendix D of the BPSOU CD.

The BPSOU Surface Water Management Plan (SWMP), Exhibit 1 to Attachment A of Appendix D of the BPSOU CD, describes how the surface water remedy will be managed following construction of all surface water-related remedy elements and is the overarching plan for how to address all surface water monitoring activities identified in the RODA that are required under the BPSOU FRESOW to evaluate the effectiveness of both the surface water and groundwater remedies. Two requirements of the BPSOU SWMP are benthic macroinvertebrate (BMI) and sediment monitoring once certain further remedial elements have been implemented. The long-term purpose of surface water, groundwater, BMI, and sediment monitoring data is to assess the protectiveness of the surface water remedy throughout the compliance standard determination period and compliance monitoring period. BMI and sediment data collected in the 2023 monitoring period, as well as that collected since 2020, will assist in establishing interim monitoring period conditions. The data collected in accordance with this QAPP compliments and augments ongoing surface water and sediment data collection by other contractors, as well as USGS, within the BPSOU, Stream Side Tailings Operable Unit (SSTOU), and the Butte Mine Flooding Operable Unit (BMFOU). Note that site-wide BPSOU groundwater monitoring is addressed in the *Draft Butte Priority Souls Operable Unit 2023 Interim Site-Wide Groundwater Monitoring Quality Assurance Project Plan* (Atlantic Richfield, 2022c).

2.3 Project Description and Schedule

The purpose of BPSOU surface water monitoring is to assess compliance with performance standards, as well as the performance and protectiveness of the remedy. Additionally, the plan must provide data to evaluate surface water quality and quantity, and streambed sediment quality; and that data must be of adequate quality to enable remedy review. Results of BMI monitoring do not have triggers or benchmarks that lead directly to further action, but will be used, along with all other appropriate data sources, as lines of evidence to evaluate remedy protectiveness to aquatic life and to inform additional response actions following completion of required remedial actions.

Specific QAPP objectives are to:

1. Present the procedures required to collect surface water data necessary to assess compliance with performance standards;
2. Present the procedures required to collect sediment data;
3. Present the procedures required to perform BMI monitoring and habitat assessment that will be used with sediment data to assess remedy performance;

4. Describe specific requirements for collecting and analyzing surface water, sediment, BMI, and habitat data.

The surface water monitoring network specifically targets the following surface water areas and sub-drainages in order to meet these objectives:

- Silver Bow Creek;
- Blacktail Creek;
- uSBC to Kaw Avenue;
- Missoula Gulch Sub-drainage

Sediment and BMI monitoring targets BTC upstream of the BPSOU, SBC within the BPSOU, and SBC at the terminus of the BPSOU.

A summary of the tasks is provided in Table 1 below.

Table 1 - Summary of Project Tasks

Water Quality Sampling Tasks: Water quality samples will be collected monthly during normal flow conditions using the method described in Section 3.2.2.3. Water quality samples will be collected during wet weather conditions as defined in the Wet Weather Criteria SOP in Appendix A, using the method described in Section 3.2.2.3.

Flow Measurement Tasks: Flow measurements will be taken during normal flow water quality sampling. For wet weather water quality sampling, continuous flow recorders and stage-discharge curves will be used to determine flow. Flow measurement methods are detailed in Section 3.2.2.2

Surface Water Monitoring Schedule: Normal flow sampling will take place once a month, January through December, at eight locations along Silver Bow and Blacktail Creek. Wet weather sampling will take place up to two times a month at seven creek sites and two diagnostic stations, April through September, when flow in BTC or SBC exceeds the criteria identified in the Wet Weather Trigger SOP (see Appendix A).

Surface Water Analysis Tasks: Laboratory analysis for water quality parameters consistent with EPA approved test methods for inorganic constituents including: total and dissolved metals and metalloids, anions (nitrate + nitrite, phosphorous, and sulfate), alkalinity, dissolved organic carbon, hardness, nutrients (ammonia and total Kjeldahl nitrogen (TKN)), and total dissolved and suspended solids in accordance with EPA approved analytical methods.

Sediment Monitoring Tasks: Sediment samples will be collected annually using the method described in Section 3.2.2.4.

Sediment Monitoring Schedule: Sampling will be conducted annually on a schedule consistent with BMI monitoring, targeting mid-August to early September of each year.

Sediment Analysis Tasks: Samples will be analyzed for pH and particle size (clay, silt, sand), and bulk samples will be analyzed for total organic carbon (TOC), arsenic, cadmium, copper, lead, mercury, and zinc in accordance with EPA approved analytical methods.

BMI Monitoring Tasks: BMI community monitoring will be performed and physical habitat assessments made using the methods described in Section 3.2.2.5 and 3.2.2.6.

BMI Monitoring Schedule: BMI monitoring will be conducted annually. Habitat monitoring will be conducted every five years or more frequently as necessary. Both monitoring efforts will target a mid-August to early September timeframe.

BMI Analysis Tasks: Laboratory data generated from BMI monitoring will include taxonomic identification and macroinvertebrate density counts.

Quality Control Tasks: All laboratory analytical matrices (surface water and sediment samples) will have the following field QC samples analyzed: 1 field duplicate for every 20 primary samples, and 1 field blank collected for every 20 primary samples if sampling equipment is reused across sample locations. Laboratory QC samples will include method blanks, laboratory control samples, laboratory duplicate samples, and matrix spike samples, as applicable to the method and the sample matrix.

BMI sampling will include field replicate samples collected at each site. Laboratory QC for BMI assessment will include determining the Relative Percent Difference in Enumeration

(RPDE) and the Percent Taxonomic Disagreement (PTD). Both the RPDE and PTD are based on confirmation of original counts and taxonomic classifications.

Data Management Tasks: Analytical data will be reviewed and evaluated for quality by the project's QAO and placed in the site database. Taxonomic data will be reviewed by the BMI Team Advisor before being placed in the site database.

Documentation and Records: All surface water samples collected will have surveyed locations. Sediment and BMI samples are collected within stream reaches, and both midpoints and reach endpoints will have surveyed locations. Coordinates for exact sediment monitoring points will be captured with electronic tablets, thus, precise within 5 meters. All samples will have records of each sample collected and all field measurements will be appropriately documented.

Data Packages: Limited (standard) data packages will be provided for all analytical data and will include results in mg/L, or other applicable units, of all constituents analyzed. BMI data packages will present QC results as percentages and taxonomic data will be presented as counts and densities.

2.4 Quality Objectives and Criteria

This section discusses the internal quality control (QC) and review procedures used to ensure that all data collected for this project are of a known quality.

2.4.1 Data Quality Objectives

The DQO process 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 a 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* (EPA, 2006a)

The EPA DQO process consists of seven steps, as follows:

- Step 1: State the Problem;
- Step 2: Identify the Goals of the Study;
- Step 3: Identify Information Inputs;
- Step 4: Define the Boundaries of the Study;
- Step 5: Develop the Analytical Approach;
- Step 6: Specify Performance and Acceptance Criteria; and
- Step 7: Develop the Plan for Collecting Data.

The DQOs, which will be used to guide the data collection and analysis activities, are as follows:

Step 1: State the Problem.

"The purpose of this step is to describe the problem to be studied so that the focus of the investigation will not be ambiguous."

Surface water in BTC and SBC has been impacted by past mining activities. Multiple remedial actions (RAs) have been instituted to improve and protect BTC and SBC water quality including:

- Removing mine waste from the western part of the BPSOU and the confluence of BTC and SBC;
- Missoula Gulch wet weather flows were segregated from normal flows to allow gravitational removal of solids and metals in catch basins as well as diversion for treatment in Butte Treatment Lagoons (BTL);
- The BPSOU subdrain groundwater capture system was constructed to separate groundwater from wet weather flow in SBC between Texas and Kaw Avenues; and
- Hydrodynamic devices were installed in stormwater trunk lines at the base of the Butte Hill to capture sediments before water is discharged to SBC.

RAs are scheduled to occur in 2023 in the Grove Gulch sub-drainage along the eastern edge of Lexington Avenue and at the base of the Buffalo Gulch sub-drainage. These RAs will include stormwater basin construction as well as removal of any tailings, waste, and impacted soil.

In order to determine the effectiveness of these past BMPs and to assist in the design of additional BMPs, a monitoring program that assesses water quality compliance and performance monitoring standards during normal and wet weather flows will be implemented. Monitoring will occur for surface water Contaminants of Concern (COCs) which the BPSOU ROD identified as aluminum, arsenic, cadmium, copper, iron, lead, mercury, silver, and zinc. Water quality and flow data are necessary to characterize normal and wet weather flows in SBC and BTC. These data will subsequently be used to monitor water quality compliance and assess the efficacy of implemented BMPs.

The remedial action objectives for surface water monitoring as described in the Record of Decision (ROD, 2006) 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.

An additional RAO for groundwater and solid media, which affect surface water, is:

- *Prevent groundwater discharge that would lead to violations of surface water ARARs and RGs for the BPSOU*

This BPSOU Interim Site-Wide Surface Water Monitoring QAPP (Site-Wide SW QAPP) addresses the monitoring objectives outlined in the ROD and RODA. These same objectives will be addressed as monitoring moves into the compliance standard determination period, after the BPSOU remedial action construction, and into compliance monitoring, although the monitoring network and frequency may need to be modified for those periods.

The Surface Water Compliance Determination Plan (SWCDP), which is Attachment A to Appendix D of the BPSOU CD, sets forth water quality criteria meant to protect aquatic life within the water column, however the quality of the streambed sediment must also be assessed, as defined in the SWMP. Since site-specific performance standards for sediment have not been established for BPSOU, comparison of sediment concentrations to the Probable Effects Concentrations (PECs) that have been identified in literature for a subset of the BPSOU COCs (i.e., arsenic cadmium, copper, lead, mercury, and zinc), along with BMI data and other lines of evidence, shall be used to assess whether BPSOU streambed sediments are impaired. Along with surface water monitoring, this QAPP will address sediment, BMI, and habitat monitoring efforts to occur for the BPSOU. The BPSOU SWMP specifies that sediment performance monitoring should be conducted to determine concentrations of constituents, along with the temporal, depth, and geographical trends in sediment.

Step 2: Identify the Goal of the Study.

"This step identifies what questions the study will attempt to resolve and what actions may result.

Surface Water Monitoring

Surface water monitoring data collected under this QAPP prior to the CD defined Compliance Standard Determination Period is intended to establish interim monitoring period conditions for creek and sub-drainage concentrations and flows. Once the Compliance Standard Determination Period is initiated as defined in the CD, surface water monitoring data collected under this QAPP will be used to assess if diagnostic response and optimization or other additional response is necessary as specified in the SWMP.

During the interim monitoring period before the Compliance Standard Determination Period, surface water monitoring will provide details for collecting data necessary to:

- Evaluate compliance with Performance Standards at compliance monitoring stations SS-06G and SS-07;
- Evaluate performance of the remedy, in its various stages of implementation; and
- Evaluate any necessary diagnostic data collected for the purpose of identifying currently implemented remedial system component optimization or maintenance, and necessary to inform FRE design.

Sediment, BMI, and Habitat Monitoring

Sediment, BMI, and habitat monitoring data collected under this QAPP prior to the CD defined Compliance Standard Determination Period is intended to establish interim monitoring period conditions for sediment PEC concentrations and the BMI community structure for locations upgradient, within, and at the terminus of the BPSOU on an annual basis. Once the Compliance Standard Determination Period is initiated, as defined in the CD, sediment data collected under this QAPP will be used, supported by other lines of evidence from BMI and habitat data, to assess if diagnostic response and sediment removal is necessary as specified in the SWMP.

During the interim monitoring period before the Compliance Monitoring Period, sediment, BMI, and habitat data collected will provide details for collecting data necessary to:

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

Step 3: Identify Information Inputs.

"The purpose of this step is to identify the informational variables that will be required to resolve the study goals and determine which variables require environmental measurements."

The following data will be collected to supplement existing data to address the goals of the surface water monitoring program. There will be two main surface water areas monitored: within the Creek (SBC and BTC) and Diagnostic Monitoring in BPSOU sub-drainages.

- Meteorological Data
  - Continuous data including temperature, and precipitation
- Surface water flow monitoring data
  - Creek Normal Flow
    - Conduct manual flow measurements. Utilize data to develop stage-discharge curves
  - Creek Wet Weather
    - Incorporate continuous stage recorders and apply stage-discharge curves to determine flow
  - Sub-Drainage Wet Weather Diagnostic
    - Incorporate continuous flow recorders

        - Opportunistic manual flow measurements may be collected to supplement the continuous flow monitoring as necessary.
- Surface water quality monitoring data
    - Creek Normal flow
        - Enforcement level laboratory analyses for COC metals.
        - Field measurements of pH, specific conductance (SC), dissolved oxygen (DO), and temperature.
    - Creek Wet Weather
        - Enforcement level laboratory analyses for COC metals.
        - Continuous in-stream pH measurement.
    - Sub-Drainage Wet Weather Diagnostic
        - Enforcement level laboratory analyses for COC metals.

Enforcement level analytical data is required at stations used to determine compliance with water quality standards (SS-01, SS-06G, and SS-07), while analytical data from non-compliance creek stations and sub-drainages will be utilized for future operational optimization. Data will be obtained from sampling as described in Sections 3.2.2.1 through 3.2.2.3 The data will be used with previously collected data to assess water quality trends in SBC and BTC. Applicable water quality standards are provided in Table 2.

Table 2 - Creek Monitoring Performance Criteria

Analyte	Chronic Performance Standards (ug/L)[1]	Acute Performance Standards (ug/L)[2,3]
Dissolved Aluminum	87	750
Total Arsenic	10	340
Total Cadmium	0.26	0.49
Total Copper	2.85	3.60
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] Chronic (Normal Flow Conditions) Performance Standards based on 2020 RODA (using hardness of 25 mg/L).
[2] Acute (Wet Weather Conditions) Performance Standard based on 2020 RODA (using hardness of 25 mg/L).
[3] Per 2020 RODA, Acute Performance Standard for Copper and Zinc Standard are based on dissolved concentration.

Sediment data will include spatially composited sediment samples in stream reaches upstream and within, the BPSOU, targeting high deposition areas within each reach. Sediment samples will be collected at 0-2 inch, 2-6 inch, and 6-12 inch depth intervals, provided that substrate composition is sufficient to collect samples at these depths.

Data will be obtained from sampling as described in Section 3.2.2.4. The data will be used with any existing data to assess sediment quality trends in SBC and BTC. Performance Standards for sediment have not been established for BPSOU. Sediment concentrations from samples collected at the 0-2 inch and 2-6 inch depth increments will be compared to PECs to determine if further investigation is required. PECs are concentrations of individual metals above which adverse effects to the BMI community may be expected to occur but do not account for site-specific conditions such as habitat and sediment chemistry (Ingersoll et al. 2000, MacDonald et al. 2000). The PECs are listed in Table 3.

Table 3 – Sediment Probable Effect 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

BMI monitoring will include replicate BMI community samples and in-situ measurements of pH, temperature, dissolved oxygen, and specific conductance at each site. Data will be obtained from sampling as described in Sections 3.2.2.5.

Habitat characteristics will be assessed along entire monitoring reaches every five years, at a minimum, and annually at discrete stream transects. The annual assessment will employ EPA's Rapid Bioassessment Protocols (RBP) (Barbour et al, 1999), while the five-year assessments will include elements of EPA's Environmental Monitoring and Assessment Program (EMAP) (EPA, 1998). Both methods include 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; bank stability; vegetative protection; and the riparian vegetative zone. Habitat assessment monitoring is discussed in Section 3.2.2.6.

Step 4: Define the Boundaries of the Study.

"The purpose of this step is to identify the target population of interest and specify the spatial and temporal features of that population that are pertinent for decision-making."

Surface water monitoring will occur within and upstream of the BPSOU boundary, along BTC and SBC from Harrison Avenue to the western terminus of the BPSOU, and within SBC sub-drainages. Water quality sampling will be performed during wet weather when monitoring is not impeded by freezing conditions, generally between April and September, and year-round during normal flow conditions. Continuous stage and flow monitoring will occur throughout the year regardless of conditions.

Creek normal flow water quality sampling and flow monitoring will be conducted monthly, a total of 12 times per year. Normal flow events collected during the months of February through June will likely be high normal flow events with higher than average incoming flows from BTC, depending on snowpack, precipitation, and temperature. Normal Flow monitoring stations, specified in Table 4 and Table 5, were selected to monitor perennial drainages during normal flow. These stations are displayed in Figure 2 - Normal Flow, Wet Weather and Diagnostic Monitoring Locations. Section 3.0 details monitoring methods.

Creek wet weather sampling is not identified during freezing conditions due to the small probability that a storm will occur, and the difficulties associated with sampling equipment functionality under freezing conditions. Absent freezing conditions, generally between April and September, monitoring will occur at locations specified in Table 4, Table 5, and Figure 2 and as described in Section 3.0 , to assess conditions within the stream at compliance stations or to evaluate BMP efficacy. Wet Weather sampling criteria are described in the SOP which can be found in Appendix A. Creek stage data will be collected continuously.

Sub-drainage wet weather diagnostic sampling and monitoring will be performed during wet weather when monitoring is not impeded by freezing conditions, generally between April and September, within SBC sub-drainages. BPSOU sub-drainage sampling will occur throughout the wet weather season as described in Section 3.0. Sub-drainage wet weather diagnostic sampling and monitoring stations are shown in Figure 2 and listed in Table 4 and Table 5. Sub-drainage flow data will be collected continuously.

Opportunistic samples may be collected throughout the monitoring season in response to observed unusual in-channel conditions. These may include run-off occurring in the absence of precipitation or discolored water within a channel.

Table 4- Flow Measurement Sites, Frequency, and Monitoring Method

Site	Creek Normal Flow Monitoring	Creek Wet Weather Monitoring	Sub-Drainage Wet Weather Diagnostic Monitoring
SS-01	Monthly Manual Flow Measurement with portable flow meter	Continuous Stage Monitoring with ISCO Flow Meter and Solinst pressure transducer	N/A
SS-01.35	Monthly Manual Flow Measurement with portable flow meter	Continuous Stage Monitoring with ISCO Flow Meter. Monitored by USGS.	N/A
SS-04	Monthly Manual Flow Measurement with portable flow meter	N/A	N/A
SS-05	Monthly Manual Flow Measurement with portable flow meter	N/A	N/A

Site	Creek Normal Flow Monitoring	Creek Wet Weather Monitoring	Sub-Drainage Wet Weather Diagnostic Monitoring
SS-05A	Monthly Manual Flow Measurement with portable flow meter	N/A	N/A
SS-06A	Monthly Manual Flow Measurement with portable flow meter	N/A	N/A
SS-06G	Monthly Manual Flow Measurement with portable flow meter	Continuous Stage Monitoring with ISCO Flow Meter	N/A
SS-07	Monthly Manual Flow Measurement with portable flow meter	Continuous Stage Monitoring with ISCO Flow Meter. Monitored by USGS	N/A
MG-CLV-0	N/A	N/A	Continuous Flow Monitoring with ISCO A-V Meter
MSD-CLV-3A	N/A	N/A	Continuous Flow Monitoring with ISCO A-V Meter and Sutron Stage Recorder

Table 5 - Water Quality Sites, Frequency, and Sampling Method

Site	Creek Normal Flow Monitoring	Creek Wet Weather Monitoring[1]	Sub-Drainage Wet Weather Diagnostic Monitoring[2]
SS-01	Manual Monthly Sample	ISCO 3700 and D-TEC TIENet 301/ISCO Signature continuous pH	N/A
SS-01.35	Manual Monthly Sample	ISCO 3700 and D-TEC	NA
SS-04	Manual Monthly Sample	N/A	N/A
SS-05	Manual Monthly Sample	N/A	N/A
SS-05A	Manual Monthly Sample	N/A	N/A
SS-06A	Manual Monthly Sample	N/A	N/A
SS-06G	Manual Monthly Sample	ISCO 3700 and D-TEC TIENet 301/ISCO Signature continuous pH	N/A
SS-07	Manual Monthly Sample	ISCO 3700 and D-TEC TIENet 301/ISCO Signature continuous pH	N/A
MG-CLV-0[3]	N/A	N/A	ISCO 3700
MSD-CLV-3A	N/A	N/A	ISCO3700

[1] All Creek Wet Weather sites will be sampled at a frequency determined by actual rain events that cause creek conditions to meet the general wet weather sampling criteria as defined in the Wet Weather Criteria SOP in Appendix A.

[2] All Sub-Drainage Wet Weather Diagnostic sites will be sampled at a frequency determined by actual rain events over 0.15" and up to two events per month.

[3]Opportunistic sampling may occur at this location due to O&M activities at Missoula Gulch basins. Sampling event will be triggered by a notification from BSB that O&M activities are being conducted

USGS Station 12323242 is located in the same stream reach as Atlantic Richfield station SS-05. The USGS continual recorder for 12323242 is located on the upstream side of the Montana Street bridge, while the SS-05 continual stage recorders are located on the downstream side of the Montana Street bridge.

The geographic scope of sediment and BMI sampling includes sampling locations upstream of BPSOU, within BPSOU, and at the terminus of BPSOU. The locations upstream of the BPSOU boundary will establish the background/reference locations for the monitoring project. Sediment and BMI monitoring reaches are identified in Table 6 and on Figure 3. Sediment sampling locations will occur within the reaches specified in Table 6, but exact locations will be chosen in the field depending on sediment deposit availability. BMI monitoring will also occur within the Table 6 reaches, but exact sample points will be chosen in the field depending on observed habitats, such as riffles with cobble substrate. Habitat assessment will be conducted along the reach length. To the extent possible, sediment sampling locations will be collocated within previously established BMI sampling reaches as well as collocated with BMI and habitat sampling locations established in previous Streamside Tailings Operable Unit (SSTOU) biomonitoring projects.

Sediment and BMI monitoring will be conducted annually, while habitat monitoring will be conducted every five years at a minimum. These monitoring efforts will target a mid-August to early-September timeframe.

Table 6 — Proposed Sediment and BMI Monitoring Stream Reach Locations and Sampling Frequency

Reach	Description	Associated Surface Water Station	SW Station Location with respect to Reach	Frequency
1	BTC above BPSOU	SS-01	Endpoint, reach extends ~ 500 ft upstream	Annually
2	SBC within BPSOU, below the BTC and SBC confluence within LAO	SS-06A	Approximate midpoint, equal distances upstream and downstream	Annually
3	SBC near western boundary of BPSOU	SS-06G	Endpoint, reach extends upstream to just below BTL effluent	Annually

Step 5: Develop the Analytic Approach.
"The purpose of this step is to define the parameters of interest, specify action levels, and integrate any previous DQO inputs into a single statement that describes a logical basis for choosing among alternative actions."

Surface Water

Surface water normal flow creek monitoring will occur once a month, January through December, weather permitting, with four monthly events targeting high normal flow conditions. Normal flow monitoring will include sample collection and flow measurements, consistent with techniques employed by the USGS. Field measured parameters include stage, flow (completed after sampling to minimize sediment mobilization), water temperature, specific conductance, dissolved oxygen, and pH. Samples will be collected into clean laboratory bottles. Appropriate preservative (nitric acid for metals, sulfuric acid for DOC, NO_2/NO_3, NH_3, TKN, and phosphorus) will be present within or added to the sample bottle. Samples will be sent to the lab and analyzed for total and dissolved fractions of multiple metals, anions, nutrients, alkalinity, and solids.

Wet weather samples will be collected using automated samplers (ISCO 3700 and D-TECs) set to collect at a pre-determined stage, which ideally occurs within the first half hour of a wet weather event. Once triggered to sample, ISCO automated samplers will collect four time-composited samples in the first four hours of the runoff hydrograph. D-TEC automated samplers will collect one sample at the beginning of the runoff hydrograph and will be submitted for analysis in the event of an ISCO sampler failure. Samples will be retrieved quickly after sampling and transported to the office for sample preparation. Appropriate preservative, as specified above, will be present within or added to the sample bottle. Samples will be sent to the laboratory and analyzed for total and dissolved fractions of multiple metals, anions, nutrients, alkalinity, and solids. Field measured parameters include stage at all stations and continuous temperature and pH measurements at SS-01, SS-06G, and SS-07.

Diagnostic samples will be collected using automated samplers (ISCO 3700) set to collect within the first half hour of a wet weather event. Samplers will be collected if the rainfall criteria of greater than 0.15 inches is met. Once triggered to sample, ISCO 3700 automated samplers will collect six to eight samples throughout the runoff hydrograph. Samples will be retrieved quickly after they have collected, preserved on ice, and transported to the office for sample preparation. Appropriate preservative will be present within or added to the sample bottle. Samples will be sent to the laboratory and analyzed for total and dissolved fractions of multiple metals, sulfate, and TSS.

Opportunistic samples may be collected in response to unusual conditions, such as discolored water or significant overland flow appearing in the absence of wet weather conditions. Opportunistic samples may be either manually collected or collected with automatic samplers (ISCO 3700). Automatic sampler programming for opportunistic samples will be identical to that employed for wet weather sampling, but the number of samples collected will vary depending on the flow conditions which triggered the sampling. Samples from automatic samplers will be retrieved quickly after they have collected, preserved on ice, and transported to the office for sample preparation. Appropriate preservative (nitric acid for metals) will be present within or added to the sample bottle. Samples will be sent to the laboratory and analyzed for total and dissolved fractions of multiple metals, at a minimum.

Sediment

Qualitative and quantitative sediment data will be collected. Spatially composited sediment samples will be collected within the stream reaches identified in Table 6. The spatial interval will consist of ten sub-sample points, at five transects within each stream reach. Two sub-samples will be collected at each transect. If condition prevent collection of ten subsamples, as many as possible will be collected and the deviation will be recorded in the field notes. An attempt will be made to sample at an equal number of sub-sample points within each stream reach, and to collect an equal volume of sample material at each reach. Each sub-sample will be collected by hand pushing a sediment tube into the streambed and removing the tube in a manner which retains a sediment core. At each sub-sample point, the retained material will be separated into three depth intervals, 0-2 inches, 2-6 inches, and 6-12 inches, provided sediment composition is sufficient to sample to these depths. A brief description of sediment characteristics for each depth interval will be recorded. This description will include color, odor, an estimate of grain size (clay, silt, sand, etc.), and an estimate of grain size distribution (poorly sorted, well sorted).

Sediment samples will be sieved to < 2mm, and a split of the resulting sample will be sieved to three size fractions, < 0.063 mm, 0.063–1 mm, and 1-2 mm. Mass percent of each fraction will be determined, but individual fractions will not undergo analysis. The remaining < 2 mm bulk sample will be analyzed for pH, total organic carbon (TOC), arsenic, cadmium, copper, lead, mercury, and zinc by EPA approved methods.

Once sufficient (at least four) sampling rounds have occurred following completion of the further remedial elements specified in the FRESOW, sediment data for each depth interval will be assessed for trend analysis using standardized statistical procedures appropriate to the underlying distributions (normal, log-normal, etc.).

BMI

The biomonitoring sampling design described in this QAPP is adapted from EPA's long-term biomonitoring conducted in other portions of the Clark Fork River basin. BMI community structure metrics collected under this QAPP will include but not be limited to taxa richness, Shannon diversity, EPT richness, EPT/EPTC ratio, Hydropsychinae/Trichoptera ratio, Baetidae/Ephemeroptera ratio, density, biotic index, percent filter feeders, metal tolerance index, percent dominant, percent tolerant. These twelve BMI community structure metrics are presented in Table 7.

Table 7 – BMI Community Metrics

Metric	Definition
Taxa Richness	Number of BMI taxa per Hess sample, measures variety of assemblage. Historically the best measure of site conditions.
Shannon diversity	Influenced by taxa richness and distribution of individuals among taxa (evenness).
EPT/EPTC	Relative abundance of Ephemeroptera, Plecoptera, Trichoptera to Chironomidae ratio
Hydropsychinae/ Trichoptera	Hydropsychinae is relatively more tolerant of pollution than most other caddisflies.
Baetidae/ Ephemeroptera	Baetidae are most pollution-tolerant mayflies.
Density *+	Number of individuals per unit of area.
Biotic Index *	SUM (%RAi * ti), %RAi is the percent relative abundance of each taxon and ti is the tolerance value of the taxon.
Percent Filter Feeders *	Abundance of these functional feeding groups provides information on energy transfer, food resources, and organic loading.
EPT richness+	Richness of Ephemeroptera, Plecoptera, and Trichoptera
Metal Tolerance Index+	Quantifies changes in BMI community and based on Hilsenhoff's biotic index with tolerance values assigned to taxon.
Percent dominant	Percent of most dominant taxon in a sample.
Percent tolerant	Organisms (%) sensitive to perturbation.

(*) indicates metric is part of a subset used for indicating organic pollution and (+) indicates metric is part of a subset used for indicating metals pollution.

Step 6: Specify Performance or Acceptance Criteria.

"The purpose of this step is to specify the decision-maker's tolerable limits on decision errors, which are used to establish performance goals for the data collection design."

Acceptance criteria for analytical data are detailed in Section 2.4.2, and Section 3.5.2 provides even greater detail. Briefly, analytical data must be of screening or enforcement quality to be deemed usable. Data usability will be determined through the data validation and data quality assessment processes which will follow guidelines set forth in the *Data Validation Guidelines for Inorganic Chemistry Woodard & Curran Butte, MT* (Woodard & Curran, 2022) (W&C Data Validation Guidelines) and Section 5.2. The W&C Data Validation Guidelines aligns with those specified in the *National Functional Guidelines for Inorganic Superfund Methods Data Review* (EPA, 2020b), but relies on method specific control limits. The W&C Data Validation Guidelines document is provided as Appendix B.

The QA/QC protocols for BMI field sampling and laboratory subsampling, sorting, and taxonomy described in the Montana DEQ *Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Community SOP* (DEQ, 2012) (Appendix C) will be followed. Acceptance criteria are briefly described in Section 2.4.2, with Section 3.5.4 providing greater detail. Section 3.5.3 discusses QC and acceptance protocols for habitat assessment.

Step 7: Develop the Plan for Obtaining Data.

"The purpose of this step is to identify a resource-effective data collection design for generating data that are expected to satisfy the DQOs."

The data collection plan detailed in the following sections is designed to ensure that the data will be of sufficient quality and quantity to assess surface water quality in relation to performance standards. Data from the previous and current investigations will be comparable due to compatible approaches. The monitoring plan described in this QAPP is designed to provide adequate information to meet the objectives described in Section 2.4. The QAPP data collection design (sampling program) is described in detail in Section 3.0 Meteorological monitoring data will be collected continually at the sites indicated in Figure 5. Ambient meteorological data will include temperature and precipitation. Although wind direction and wind speed are also collected at the stations identified in Figure 5, several of these stations were sited to collect precipitation only. Thus, the wind data collected at a subset of the stations may not be reliable. Additionally, for the purposes of this QAPP, precipitation is the parameter of interest.

Normal Flow surface water monitoring will be performed monthly at the sites specified in Table 5, with a target of monitoring eight events under normal flow conditions and four events under seasonal high normal flow conditions. All aspects of normal flow monitoring will be performed consistent with techniques employed by the USGS. Water quality sampling will include both field parameter measurements and laboratory analyses. Field-measured data will include stage, flow, water temperature, specific conductance, dissolved oxygen, and pH. Laboratory measurements will include TDS, TSS, hardness, total recoverable and dissolved metals (aluminum, arsenic, cadmium, copper, iron, lead, molybdenum, mercury, silver, and zinc), dissolved calcium, dissolved magnesium, alkalinity, sulfate, and nitrate/nitrite. TKN, total phosphorus, ammonia, and dissolved organic carbon are measured each month at compliance stations as well as upstream stations SS-01 and SS-01.35.

Creek wet weather water quality data will be collected on average, when wet weather conditions exist, two times per month, from April to September depending on weather conditions. A wet weather event is defined in the Wet Weather Criteria SOP in Appendix A. Samples will be collected using automatic or mechanical samplers. Laboratory measurements will include TDS, TSS, hardness, total recoverable and dissolved metals (aluminum, arsenic, cadmium, copper, iron, lead, molybdenum, mercury, silver, and zinc), dissolved calcium and magnesium, alkalinity, sulfate, and nitrate/nitrite at all stations, during all sampling events. On the first wet weather event of each month, laboratory analysis will also include TKN, total phosphorus, ammonia, and dissolved organic carbon at compliance stations as well as upstream station SS-01. Creek stage data will be collected continuously and downloaded monthly. Continuous creek pH and temperature data will be collected at SS-01, SS-06G, and SS-07 to assist in ascertaining Biotic Ligand Model (BLM) standard parameters. BLM input parameters include sodium, potassium, and chloride, and estimates of humic acid; however, none of these parameters are collected under BPSOU site-wide surface water monitoring. Historical data exists for sodium, potassium, and chloride concentrations at SS-01, SS-06G, and SS-07.

Sub-drainage wet weather diagnostic water quality sampling data will generally be collected when the creek wet-weather criteria is met; but collection will be determined on a case by case basis. On average, and when wet weather conditions exist, two sub-drainage wet weather diagnostic water quality sample sets will be collected per month. Samples will be collected using automatic and mechanical samplers; therefore, no field measured data will be collected. Laboratory measurements will include TSS, sulfate, and total recoverable and dissolved trace elements (arsenic, cadmium, copper, iron, lead, mercury, and zinc). Sub-drainage flow data will be collected continuously, and data downloaded monthly.

Opportunistic surface water samples may be collected in response to unusual in-channel conditions such as run-off occurring in the absence of precipitation or discolored water within a channel. Opportunistic samples will be manually collected or collected with automatic samplers. Opportunistic sampling will not include field measured data. At a minimum, opportunistic samples will be analyzed for total recoverable and dissolved trace elements (arsenic, cadmium, copper, iron, lead, mercury, and zinc).

The sediment data collection plan outlined in this QAPP is designed to ensure that the data will be of sufficient quality and quantity to assess sediment quality in relation to PECs. Data from previous and current investigations will be comparable due to compatible approaches. Spatially composited sediment samples will be collected at three depth intervals, 0-2 inches, 2-6 inches, and 6-12 inches, as sediment depth allows. Sediment characteristics will be recorded in the field, and samples will be laboratory sieved to < 2 mm and analyzed for arsenic, cadmium, copper, lead, mercury, zinc, TOC, and pH. Additionally, mass percent of three size fractions, < 0.063 mm, 0.063-1 mm, and 1-2 mm, will be determined.

The BMI and habitat monitoring outlined in this QAPP are designed to ensure that the data will be of the quality and quantity needed for use as lines of evidence to inform further remedial actions, as well as to support the 5-year review process for assessing the protectiveness of the Remedy. The BMI and habitat sampling designs are described in Section 3.0 .

2.4.2 Measurement Performance Criteria for Data

All data collection will be conducted under CFRSSI or other applicable SOPs to maintain consistent techniques. Surface water and sediment sample analysis will be performed by an analytical laboratory which is NELAP accredited and certified under the Montana DPHHS public water supply laboratory certification program to perform the applicable analyses. Macroinvertebrate sample processing will be performed by a qualified taxonomic laboratory. In addition, analytical protocols will be consistent with those specified in the *Clark Fork River Superfund Site Investigations Laboratory Analytical Protocol (LAP)*, (ARCO, 1992a).

Measurement performance criteria are established by defining acceptance criteria and quantitative or qualitative goals (e.g., control limits) for accuracy, precision, representativeness, comparability and completeness of measurement data. The definitions of precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS) are provided below along with the acceptance criteria for data collected. Equations for calculation of precision, accuracy and completeness are provided in Table 8. Information pertaining to the analytical methods that will be employed, and the project's target quantitation limits can be found in Section 3.4.2.

Table 8 - Precision, Accuracy and Completeness Calculation Equations

Characteristic	Formula	Symbols
Precision (as relative percent difference, RPD)	$RPD = \frac{(x_i - x_j)}{\left(\frac{x_i + x_j}{2}\right)} \times 100$	x_i, x_j: replicate values of x
Precision (as relative standard deviation, RSD, otherwise known as coefficient of variation)	$RSD = \frac{\sigma}{\bar{x}} \times 100$	σ: sample standard deviation $\bar{x}$: sample mean
Precision (as percent taxonomic disagreement (PTD)	$PTD = \left\lfloor 1 - \left(\frac{comp_{pos}}{N}\right) \right\rfloor \times 100$	$comp_{pos}$: the number of agreements N: total number of organisms
Accuracy (as percent recovery, R, for samples without a background level of the analyte, such as reference materials, laboratory control samples and performance evaluation samples)	$R = \frac{x}{t} \times 100$	x: sample value t: true or assumed value
Accuracy (as percent recovery, R, for samples with a background level of the analyte, such as matrix spikes)	$R = \frac{SSR - SR}{SA} \times 100$	SSR: spiked sample result SR: sample result SA: spike added
Accuracy (as percent difference, D, for samples > 50X the MDL, which have undergone at least a five-fold dilution, with the result, S, corrected for the dilution)	$D = \frac{\lvert I - S \rvert}{I} \times 100$	I: initial sample result S: serial dilution result
Completeness (as a percentage, C)	$C = \frac{n}{N} \times 100$	n: number of valid data points produced N: total number of samples taken

<u>Precision</u>

Precision is the level of agreement among repeated measurements of the same characteristic. There are two general forms of uncertainty. The first is the random error component of the data collection process. The second is inherent stochastic variability, which cannot be eliminated but can be described.

Data precision is assessed by determining the agreement between replicate measurements of the same sample and/or measurements of duplicate samples. The overall random error component of precision is a function of the sampling. Precision in sample collection is determined by the collection and analysis of field duplicates, and laboratory precision is measured by replicate analyses of the same sample, or by analysis of sample splits. A laboratory duplicate is the preferred measure of analytical method precision. When analytes are present in samples at concentrations below or near the quantitation limit, precision may be evaluated using duplicate analyses of laboratory prepared samples such as duplicate laboratory matrix spike samples (MS/MSD), duplicate laboratory control spike samples (LCS/LCSD), and/or laboratory duplicate (LD) samples. Precision can be measured as relative percent difference (RPD) or as relative standard deviation (RSD, also known as a coefficient of variation). Formulae for both are presented in Table 8.

For surface water and sediment sampling, precision shall be determined by the analysis of field and laboratory duplicates and the evaluation of the RPD for the paired measurements. The RPD goals for measures of analytical precision are provided in Table 9, which is provided in the Tables section due to its size.

The RPD precision goal for surface water field duplicates will be 20 percent, while the target precision for sediment field duplicates will be 35 percent. For both surface water and sediment samples these precision goals are for sample pairs with both sample results being greater than five times the reporting limit (RL). For field and laboratory duplicate pairs with one or both sample results less than five times the RL, a difference of ≤ RL (surface water) or ≤ 2xRL (sediment) will be used as the precision goal. The precision goal for analytical duplicates ranges from 10-30%, depending on the analytical method, and these are provided in Table 9.

Table 9 – Summary of Laboratory Quality Control Checks (see Tables Section)

BMI sampling precision measures the extent of variability in the sampling method and is related to the variability of collecting replicate samples within a reach. BMI sampling precision is estimated by collecting replicate samples of the BMI communities within the same reach during the same day. Precision is estimated by comparing replicate samples with an RSD goal of 20% or less for the taxa richness metric.

To assess laboratory enumeration precision, 10% of the sample set is counted and identified by a second taxonomist. The RPD between the original and second count should be ≤ 10% (or > 90% similarity). Laboratory identification precision is measured by the Percent Taxonomic Disagreement (PTD), the formula for which is provided in Table 8. The assessment of PTD accounts for straight disagreements, hierarchical difference, and missing specimens. PTD is assessed in the same manner that RPD is assessed, by comparing results of the original taxonomic identification to the results obtained by a second taxonomist. Acceptance criteria for PTD is ≤ 15%.

<u>Accuracy/Bias</u>

Accuracy is the degree of difference between the measured or calculated value and the true value. It is a measure of the bias or systematic error of the entire data collection process. Potential sources of systematic errors include:

- sample collection methods;
- physical or chemical instability of the samples;
- interference effects during sample analysis;
- calibration of the measurement system; and

- contamination.

Field blanks (FBs) and laboratory method blanks (MBs) may be analyzed to assess artifacts introduced during sampling, transport and/or analysis that may affect the accuracy of the data. In addition, laboratory control samples (LCS) and matrix spike samples (MS) are used to verify that sample concentrations are accurately measured by the analytical instrument throughout the analytical run.

Bias in field activities shall be determined by the collection and analysis of FBs, as described in Section 3.5.1. Field blank accuracy goals include target analyte concentrations less than the method detection limit. Laboratory accuracy will be determined by the analysis of laboratory control samples, matrix spike samples, and laboratory blank samples. Accuracy/Bias goals for the specific analytical methods are summarized in Table 9.

Bias and accuracy for macroinvertebrate monitoring are qualitative, rather than quantitative measurements. Bias refers to the difference between the population mean and the true value. Bias usually describes a systematic difference reoccurring over time and is characteristic to both the sampling method and parameter(s) being measured. Bias may occur while sampling due to the same field investigator performing the same task at each site or due to consistent misinterpretation of protocols by a group of field investigators. Sampling bias will be minimized by ensuring all staff are experienced and qualified in conducting biomonitoring assessments and performing all tasks according to methods and procedures described in this QAPP and applicable SOPs.

Laboratory bias may occur from dichotomous keys or morphological features being misinterpreted consistently, inadequate sample processing, or equipment inadequacy. Accuracy is defined as the degree to which a measurement conforms to the true measure. Laboratories must utilize taxonomic references; and, these may be museum-based material, the most current and accepted taxonomic literature, or a verified reference collection.

Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point or environmental conditions. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling program. Representativeness of samples shall be achieved through the careful selection of sampling locations and methods. With respect to BMI monitoring, this includes selecting sites representative of minimally or least disturbed conditions in the sampled stream. The BMI and habitat protocols included in this QAPP are designed to produce consistent and repeatable results in each stream reach. Physical variability of habitat within a reach is accounted for through reach-wide sampling of the various water depths, substrates, and flow conditions throughout the stream. The monitoring networks defined in this QAPP will provide samples that are representative of the medium being sampled as well as sufficient samples to meet the project DQOs.

Sample representativeness may also be evaluated using the RPDs or RSDs for field replicate results.

Comparability

Data comparability is defined as the measure of the confidence with which one data set can be compared to another. Comparability is a qualitative parameter but must be considered in the design of sampling plans and selection of analytical methods, quality control protocols and data reporting requirements. Comparability shall be ensured by collecting and analyzing samples obtained in accordance with appropriate SOPs. BMI monitoring protocols in this monitoring plan are consistent with BMI protocols used in the Clark Fork River basin and incorporate EPA habitat protocols (Barbour et al., 1999; EPA 1998). Adherence to these commonly accepted protocols will result in standardized data collection.

The results of analyses collected under this QAPP will be compared with previously collected data for sites specified in Table 5 and Table 6. All data should be calculated and reported in units consistent with standard reporting procedures so that the results of the analyses can be compared with those of other laboratories, if necessary.

Completeness

Completeness refers to the amount of usable data produced during a sampling and analysis program. The procedures established in this QAPP are designed to ensure, to the extent possible, that data shall be valid and usable. To achieve this objective, every effort shall be made to collect each required sample and to avoid sample loss. The QAPP completeness goal is 95 percent for each matrix.

Sensitivity

Sensitivity refers to the capability to quantify an analyte at a given concentration, and this parameter is associated with the instrument and method detection limits, and the project reporting limits. The desired analytical sensitivity for surface water are method detection limits less than the applicable water quality standards specified in Table 2. The desired sensitivity for sediment analyses are method detection limits less than the PECs displayed in Table 3. Table 11, Table 12, and Table 14 in Section 3.1 display analytical sensitivity. Taxonomic sensitivity is the ability to identify specimens to the lowest practical taxonomic level. However, limitations such as specimen damage exist; thus, the required taxonomic sensitivity is to the family.

2.5 Special Training

All personnel engaged in on-site activities are required to have proper health and safety training as required by the Occupational Safety & Health Administration (OSHA) Regulation 29 CFR 1910.120 (HAZWOPER). Personnel who completed their initial HAZWOPER training more than 12 months prior to the start of the project must have completed an 8-hour refresher course within the appropriate time frame relative to their duties. The Project Safety and Health Manager is responsible for ensuring the field crews are compliant with HAZWOPER training.

Field personnel shall be trained in the requirements of this QAPP in a project meeting held prior to the initiation of any field activity. All personnel shall also read the QAPP document prior to the start of fieldwork and shall acknowledge that they have read the document at the time of the project meeting. In addition, prior to conducting sampling activities, the CPM, or designee, shall review field procedures and sampling requirements to better ensure that samples are collected and handled according to the QAPP requirements.

Field personnel will be trained in the use of field equipment, decontamination procedures and chain-of-custody procedures in accordance with field data collection SOPs used for the sampling event. This training will be documented within the appropriate section of each SOP. The CPM will be responsible for ensuring that training requirements are fulfilled.

One hard copy of the current approved version of this QAPP shall be maintained for ready reference purposes in the field vehicle or field office. All field team members shall have access to pdf files of the complete QAPP.

Laboratories providing analytical services will have a documented quality system that complies with EPA Requirements for Quality Management Plans (QA/R-2) (EPA, 2001b). The Laboratory Quality Manager will be responsible for ensuring that all personnel have been properly trained and are qualified to perform assigned tasks.

2.6 Documents and Records

This section briefly describes the procedures for management of project documentation and records for this QAPP from initial generation of the data to its final use and storage in the project files.

2.6.1 Property Access Agreements

Atlantic Richfield will request that property owners grant access for monitoring related activities which may occur on private property. The CPM or their designee will manage requests for access, track the status of access requests and maintain copies of completed agreements received from property owners. Completed agreements will be scanned and stored on a server with other project records.

2.6.2 Field Logbooks/Data Sheets

Documentation of observations in the field provides information on conditions at the time of sampling and a permanent record of field activities. Field records will be kept in a bound field logbook, in field forms (electronic or paper), or both. The logbook may reference more detailed records found in the electronic field forms, or vice versa. Each logbook shall have a unique document control number, and the logbooks will be bound and have consecutively numbered pages. The information recorded in the logbooks shall be written in indelible ink. Whenever a sample is collected, or a measurement is made, the sample site identification and any additional observations will be recorded in the field book. Electronic forms for the majority of tasks associated with this QAPP will be developed, and these forms will be available on digital tablets. Paper forms may be used for habitat assessment. Each form, whether electronic or paper, will have a unique document control number, and once completed, the forms will be checked for accuracy and completeness, and saved. The forms will be uploaded to a main server daily.

Field logbooks and electronic field forms will include the information listed below, at a minimum:

- Date of the field work
- Names and titles of field personnel;

- Meteorological conditions at the beginning of field work and any ensuing changes in the weather conditions;
- A description of the field task;
- Time field work started;
- All field measurements made;
- Any field analysis results;
- Personnel and equipment decontamination procedures.
- Identifying information of any field contacts or site visitors (e.g., agency representatives, auditors, etc.);
- Details of the field work performed and the field forms used, with special attention to any deviation from the QAPP or applicable SOPs.

For sample collection, the following entries will also be made, as applicable to the sample type:

- Calibration of any field equipment;
- Identification of field equipment, including make, model, and serial number if available;
- Sample location and ID number;
- Staff gauge reading;
- Date and time of sample collection;
- Sample type collected;
- Sample field preparation;
- Sample preservative;
- Final field parameters (temperature, pH, SC, etc.);
- Split samples taken by other parties (note the type of sample, sample location, time/date, name of person, person's affiliation and any other pertinent information);
- Sampling method, particularly any deviations from the SOPs;
- Documentation or reference of preparation procedures for reagents or supplies that will become an integral part of the sample (if any used in the field).

Changes or deletions in the field logbook will be recorded with a single strike mark through the changed entry, with the sampler's initials and the date recording the new entry. All entries must remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without having to rely on the sampler's memory.

Completed field data forms will be stored electronically on a main server, using a file structure that separates forms by project and date. No electronic field forms will be deleted, even if they contain inaccuracies that require a replacement document.

Within the time period this QAPP will be implemented, effluent may be entering Silver Bow Creek, near its confluence with Blacktail Creek, as part of the BMFOU Discharge Pilot Project. As stated above in Section 2.1, the field team leader will be the point of contact for communications regarding BMFOU related discharge. Prior to conducting normal flow monitoring, the Field Team Leader will be informed of the discharge status (steady-state, planned fluctuations, shut-down, etc.). This communication will be documented in the field logbook, or on electronic field forms, as appropriate. Should upset conditions occur during normal flow monitoring, this will be documented in the field logbook/field form. *The Silver Bow*

Creek/Butte Area NPL Site Butte Mine Flooding Operable Unit Draft Final Silver Bow Creek/Butte Area NPL Site Communication Plan (Atlantic Richfield, 2022b) details how the upset conditions are communicated to the Field Team Leader. Wet weather monitoring will occur, regardless of the discharge status; however, any upset conditions which occurred during the storm event hydrograph will be communicated to the field team leader and documented in the field logbook/field form.

2.6.3 Field Photographs

When photographs of field activities are taken, a digital camera will be used. Specifically, photographs should be taken of unexpected circumstances (i.e. a damaged staff gauge). Photographs should include a scale in the picture when practical. With respect to habitat assessments, photographs will be taken as necessary to document site conditions and stream habitat features to support and illustrate rating categories for the visual-based RBP.

The following items shall be recorded on the electronic field record for each photograph taken:

- The photographer’s name, date, time, and the general direction faced;
- A brief description of the subject and the fieldwork portrayed in the picture; and
- Sequential number of the photograph.

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

2.6.4 Chain of Custody Records

After samples have been collected, they will be maintained under strict chain-of-custody protocols in accordance with CFRSSI SOP-G-7. The field sampling personnel will complete a chain-of-custody form for each sample shipment (e.g., batch of coolers) delivered to the laboratory for analysis. The sampler is responsible for ensuring that the chain-of-custody is initiated and completed. The chain-of-custody for a sample shipment will list only the samples in that shipment.

Information contained on the chain-of-custody will include the following, as applicable to the sample media:

- Project name and identification number;
- Sampler’s signature and affiliation;
- Date and time of collection (date only for BMI samples);
- Sample identification number and matrix;
- Analyses requested;
- Preservative used;
- Remarks such as any additional notes to laboratory personnel (e.g., filter in lab or known sample hazards);
- Signature of persons relinquishing custody, dates and times; and
- Signature of persons accepting custody, dates and times.

Any documentation, including chain-of-custody forms, placed inside the cooler during sample shipment should be placed inside a re-closeable plastic bag.

The sampler whose signature appears on the chain-of-custody is responsible for the custody of the samples from the time of sample collection until custody of the sample is transferred to a designated laboratory, a courier or another project employee for the purpose of transporting the samples to the designated laboratory. The sample is considered to be in custody when the sample is: (1) in the responsible individual's physical possession; (2) in the responsible individual's visual range after having taken possession; (3) secured by the responsible individual so that no tampering can occur, (4) secured or locked by the responsible individual in an area in which access is restricted to authorized personnel; or (5) transferred to authorized personnel.

An electronic copy of each transmitted chain-of-custody will be stored on a main server, within project record files (refer to Section 3.9).

2.6.5 Laboratory Records

Results received from the laboratories will be documented both in report form and in an electronic format. Laboratory documentation includes copies of the signed chain-of-custody forms, laboratory confirmation reports including information on how samples have been batched and the analyses requested, data packages including the lab report and the electronic data deliverable (EDD), and any change requests or corrective action requests. Taxonomy laboratory reports will indicate whether the samples were sub-sorted. Section 5.1.3 presents the project's laboratory reporting requirements in detail. Electronic report deliverables ("data package" or "report") issued by the laboratories will include data necessary to complete validation of laboratory results in accordance with specifications in Section 5.2.2.

Original hard copy deliverables and electronic files received from laboratories will be maintained with the project quality records (refer to Section 3.9).

2.6.6 Project Data Reports

A Data Summary Report (DSR) will be prepared based on guidelines in the *CFRSSI Pilot Data Report Addendum* (ARCO, 2000b) following each year of data collection and evaluation. The DSR will describe the field activities performed during implementation of the QAPP and the physical characteristics of the study area. The DSR will include field documentation, documentation of field QC procedures, and results of all field and laboratory measurements and analyses. A detailed listing of any deviations from the approved QAPP will also be provided, with an explanation for each deviation and a description of the effect on data quality and usability, if any. A discussion of the data quality assessment, which is addressed in greater detail in Section 5.0, will be included in the DSR.

Annually, a Surface Water Compliance Comparison and Interpretation Report will be submitted in draft form to the EPA for review. This report will present validated COC data for all perennial surface water stations from the previous year's monitoring effort. Compliance station data and performance station data will be compared to the surface water Performance Criteria presented in Table 2. The total number of exceedances and deviations for each COC for the calendar year, as well as the running total of any previous exceedances, will be included. Should exceedances have occurred, the number of surface water deviations will be detailed. The report may include additional interpretation of surface water data collected under the QAPP, but interpretation is not necessary.

Quarterly reports will be submitted within 60 days of the end of each quarter. These reports will consist of a cover letter, Excel spreadsheets containing provisional analytical and field measured data collected in the previous quarter, and a link to Woodard & Curran's data portal. The submittal will be limited to data collected under this Interim Site-Wide Surface Water QAPP. The cover letter will inventory the attached spreadsheets and provide the validation status of the analytical data. The cover letter will also explain that validated analytical data will be provided in the forthcoming DSR.

The CPM and QAO are responsible for preparation of the DSR and the Compliance Comparison and Interpretation Report which will be submitted in draft form to the EPA for review. The DSR will be submitted annually, by May 31 of the year following monitoring. The Compliance Comparison and Interpretation Report will be submitted annually by June 30 of the year following monitoring. Within 60 days of receipt of Agency comments, the draft DSR will be revised to address the comments and resubmitted to the EPA for final approval. Numerical data presented in Annual Reports will be stored in the Butte Data Management System (BDMS) database. Finalized reports will reside on the BPSOU Document Sharepoint Site. Data management is fully described in the *Draft Final BPSOU Data Management Plan* (DMP) (Atlantic Richfield, 2020b)

2.6.7 Program Quality Records

Program quality records are defined as completed, legible documents that furnish objective evidence of the quality of items, services, or activities affecting quality, or the completeness of data. These records shall be organized and managed by the Atlantic Richfield contractor and shall include, at a minimum:

- This QAPP and any approved revisions or addenda;
- Approved versions of the Health and Safety Plan (HSP) and any addenda;
- Copies of SOPs for field data collection, with any updates, revisions or addenda to those SOPs;
- Incoming and outgoing project correspondence (letters, telephone conversation records, and e-mail messages);
- Electronic field forms;
- Habitat assessment forms
- Electronic copies of completed sample chain-of-custody forms;
- Copies of all laboratory agreements and amendments;
- As-received laboratory data packages;
- Documentation of field and/or laboratory audit findings and any corrective actions; and
- Draft and final delivered versions of all reports and supporting procedures such as statistical analyses, numerical models, etc.

3.0 MEASUREMENT AND DATA ACQUISITION

The elements in this section address all aspects of project design and implementation for the generation and acquisition of data. Implementation of these elements ensures that appropriate methods for sampling, sample handling, laboratory analysis, field and laboratory QC, instrument/equipment testing, inspection, and maintenance, instrument/equipment calibration, data management and data security are used for all phases of the investigation.

3.1 Sampling Process and Design

This QAPP has been developed to define the requirements for normal flow, wet weather, and diagnostic surface water monitoring within the BPSOU. The following provides a description of the monitoring objectives, locations, frequencies, and analytes.

3.1.1 Surface Water Monitoring Objectives

The objectives of the BPSOU Surface Water monitoring program are:

- Evaluate compliance with Performance Standards at point of compliance monitoring stations;
- Evaluate performance of the remedy, in its various stages of implementation; and
- Evaluate any necessary diagnostic data collected for the purpose of identifying currently implemented remedial system component optimization or maintenance, and necessary to inform FRE design.

3.1.2 Surface Water Monitoring Network, Frequencies, and Analytes

Surface water monitoring performed under this QAPP includes stage and flow measurements at the sites specified in Table 4, as well as collecting water quality samples at the sites specified in Table 5. These tables also specify the monitoring frequency. The monitoring locations are shown in Figure 2 for both Creek Monitoring and Sub-Drainage Diagnostic Monitoring. Site coordinates are provided in Table 10. Table 11 specifies field parameter measurements and laboratory analysis for creek stations, while Table 12 specifies laboratory analysis for sub-drainage stations. Contaminants of concern, aluminum, arsenic, cadmium, copper, iron, lead, mercury, silver, and zinc, are critical information; while additional parameters are considered informational data.

Table 10 – Surface Water Monitoring Site Coordinates and Location Description

Site	Coordinates		Description
	Latitude	Longitude	
SS-01	45.985271	-112.507762	Blacktail Creek (BTC) USGS Station at Harrison Ave, upstream of the BPSOU. USGS WQ monitoring to be discontinued at this site with the establishment of station 12323233 (SS-01.35)
SS-01.35	45.991139	-112.527239	Blacktail Creek USGS station upstream of Grove Gulch
SS-04	45.994635	-112.536114	Blacktail Creek upstream of its confluence with the SBC near George Street.
SS-05	45.995769	-112.539176	SBC station at Montana Street, downstream of the SBC-BTC confluence and below the BG outfall.
SS-05A	45.996215	-112.544249	Station located at the beginning of the SBC rebuilt floodplain at the east end of LAO; downstream of old SBC diversion channel.
SS-06A	45.994484	-112.551751	Station located in rebuilt SBC floodplain upstream of the Montana Pole Treatment Plant (MPTP) effluent discharge.
SS-06G	45.996413	-112.562797	Station located at end of the SBC rebuilt floodplain at the west end of LAO, downstream of the Montana Pole Treatment Plant and Butte Treatment Lagoons discharge points and upstream of the historic HCC outlet and the Butte Metro Sewage Treatment Plant effluent.
SS-07	45.996626	-112.563646	Station located downstream of all BPSOU drainage outfalls as SBC exits the OU near Interstate 90.
MG-CLV-0	45.996758	-112.544017	Provides diagnostic monitoring of Missoula Gulch discharge entering into SBC between SS-05A and SS-05B.
MSD-CLV-3A	45.995375	-112.530662	Post reclamation SBC station located upstream of its confluence with BTC, just east of Kaw Ave, and upstream of the end of the sub-drain collection pipe.

Table 11 - Creek Monitoring Parameter List and Associated Analytical Methods, Approximate Method Detection Limits, Reporting Limits, and Holding Times

Analyte	Resolution		Accuracy		Source	Event Monitored
Field Parameters - Field Measured with YSI Professional Plus						
Dissolved Oxygen (mg/L)	0.01		Greater of ± 2% or reading or 0.2 mg/L		CFRSSI SOPs	NF
Temperature (℃)	0.1		0.2		CFRSSI SOPs	NF
pH (s.u.)	0.01		0.2		CFRSSI SOPs	NF
Specific Conductivity (µs/cm)	0 to 500 µS/cm: 1 µS/cm 501 to 5000 µS/cm: 10 µS/cm		Greater of 1 µS/cm or ± 0.5% of reading		CFRSSI SOPs	NF
Trace Elements – Total Recoverable and Dissolved Fractions[1] (ug/L)						
Analyte	**MDL (µg/L)**	**Reporting Limit (µg/L)**	**Holding time (days)**	**Method**	**Source**	**Event Monitored**
Aluminum	9.1	30	180 Days	EPA 200.8	EPA	NF, WW
Arsenic	0.092	0.50	180 Days	EPA 200.8	EPA	NF, WW
Cadmium	0.022	0.080	180 Days	EPA 200.8	EPA	NF, WW
Dissolved Calcium	23	10	180 Days	EPA 200.8	EPA	NF, WW
Copper	0.42	1.0	180 Days	EPA 200.8	EPA	NF, WW
Iron	11	50	180 Days	EPA 200.8	EPA	NF, WW
Lead	0.056	0.50	180 Days	EPA 200.8	EPA	NF, WW
Dissolved Magnesium	7.1	30	180 Days	EPA 200.8	EPA	NF, WW
Mercury	0.0042	0.010	28 Days	EPA 245.1	EPA	NF, WW
Molybdenum	0.075	0.50	180 Days	EPA 200.8	EPA	NF, WW
Silver	0.13	0.50	180 Days	EPA 200.8	EPA	NF, WW
Zinc	1.9	5.0	180 Days	EPA 200.8	EPA	NF, WW
General Laboratory (mg/L)						
Analyte	**MDL (mg/L)**	**RL (mg/L)**	**Holding time (days)**	**Method**	**Source**	**Event Monitored**
Hardness (as $CaCO_3$)	0.086	0.14	180 Days	SM 2340B	Standard Methods	NF, WW

Alkalinity (as $CaCO_3$)	2.4	5	14 Days	SM 2320B[2]	Standard Methods	NF, WW
NO_2+NO_3	0.031	0.20	28 Days	EPA 353.2	EPA	NF, WW
Sulfate	0.39	0.10	28 Days	EPA 300.0	EPA	NF, WW
TDS	5.0	10	7 Days	SM 2540C[2]	Standard Methods	NF, WW
TSS	2.4	10	7 Days	SM 2540D[2]	Standard Methods	NF, WW
Additional Parameters (mg/L) (only applied to specific stations listed in the QAPP)						
Analyte	**Resolution**	**Accuracy**	**Holding time (days)**	**Method**	**Source**	**Event Monitored**
pH (s.u.)	0.01	0.1	Continuously field measured	TIENet 301/ISCO Signature	CFRSSI SOPs	WW
Analyte	**MDL (mg/L)**	**RL (mg/L)**	**Holding time (days)**	**Method**	**Source**	**Event Monitored[4]**
Ammonia	0.015	0.10	28 Days	EPA 350.1	EPA	NF, WW
Dissolved Organic Carbon	0.38	1.0	28 Days	SM 5310C[5]	Standard Methods	NF, WW
Total Phosphate	0.039	0.10	28 Days	SM 4500-P-F[2]	Standard Methods	NF, WW
Total Kjeldahl Nitrogen	0.45	0.50	28 Days	EPA 351.2	EPA	NF, WW

[1] Calcium and Magnesium dissolved fraction only

[2] Standard method run by 1997 edition

[3] Standard method run by1997 and 2000 editions

[4] NH_3, DOC, TKN, and Total P collected only for the first WW event of the month. NF and WW collected only at SS-01, SS-01.35 (NF only), SS-06G, and SS-07

[5]Standard method run by 2000 edition

Table 12 - Sub-Drainage Diagnostic Monitoring Parameter List and Associated Analytical Methods, Approximate Method Detection Limits, Reporting Limits, and Holding Times

Analyte	**MDL (µg/L)**	**RL (µg/L)**	**Holding time (days)**	**Method**	**Source**
Trace Elements – Total Recoverable and Dissolved Fractions (ug/L)					
Arsenic	0.092	0.50	180 Days	EPA 200.8	EPA
Cadmium	0.022	0.080	180 Days	EPA 200.8	EPA
Copper	0.42	1.0	180 Days	EPA 200.8	EPA
Iron	11	50	180 Days	EPA 200.8	EPA

Analyte	MDL (µg/L)	RL (µg/L)	Holding time (days)	Method	Source
Lead	0.056	0.50	180 Days	EPA 200.8	EPA
Mercury	0.072	0.020	28 Days	EPA 245.1	EPA
Zinc	1.9	5	180 Days	EPA 200.8	EPA
General Laboratory (mg/L)					
Sulfate	0.39	1.2	28 Days	EPA 300.0	EPA
TSS	5	10	7 Days	SM 2540D	EPA

Variability in surface water quality and flow data is expected considering the range of monitoring conditions which may occur. However, normal flow COC concentrations should remain within recent historical ranges. Wet weather flow COC concentrations are far more likely to have outliers, but extreme outliers will be investigated. To limit variability due to stage readings, flow measurements, sampling, and analysis, consistent methods will be used in accordance with applicable SOPs. Field documentation will occur during surface water monitoring, and should significant variability be found in stage, flow, or water quality results, this documentation will be consulted. In addition, unexpected analytical results will be verified by contacting the laboratory and requesting a data review, and by validating 100% of analytical data to ensure that laboratory QC criteria were met.

3.1.3 Sediment, BMI, and Habitat Monitoring Objectives

The objectives of the BPSOU sediment monitoring program are:

1. Evaluate if sediment sample concentrations exceed the PECs for specific sampling locations and depths in BTC and SBC within the BPSOU and in background/reference reaches in BTC upgradient of BPSOU;
2. Evaluate trends for streambed sediment sample concentrations of PEC metals in SBC within BPSOU and in background/reference reaches in BTC upgradient of BPSOU;
3. Evaluate benthic community structures and habitat conditions within BPSOU and in background/reference reaches upgradient of BPSOU; and
4. Evaluate trends in the benthic community structures and habitat conditions in BTC and SBC within BPSOU and in background/reference reaches in BTC upgradient of BPSOU.

3.1.4 Sediment, BMI, and Habitat Monitoring Locations, and Frequencies

Sediment and BMI samples will be collected annually in the reaches specified in Table 6. Both sediment and BMI sampling will occur in mid-August to early-September of each year. Habitat assessment will be conducted every five years or more frequently as necessary. Table 13 provides approximate coordinates of sediment/BMI monitoring stream reach endpoints and the reaches are displayed on Figure 3.

Reach lengths for BMI and habitat assessments will be determined as 40 times the channel width or a minimum of 150 meters (~ 500 ft). Each reach is determined by measuring the wetted width at five representative locations within the proposed reach. The average of the five widths is calculated to the nearest meter, and the reach length is defined as 40 times the average width or a minimum of 150 meters. Starting at the estimated midpoint of the sampling reach, a distance of 20 channel widths is measured downstream using a tape measure. The distance is measured by walking along the streambank and paralleling the middle of the channel to avoid disturbing the stream channel prior to sampling activities. The downstream endpoint of the 20 channel widths is flagged as transect “A”. Subsequently, one-tenth of the required stream length is measured upstream from the starting point (transect A), and this location is flagged as the next cross-section transect (transect B). This process is continued in the upstream direction at intervals equal to one-tenth of the reach length, flagging the positions of the eight additional transects (labeled “C” through “J”). These transects will serve as monitoring locations in years that habitat assessments are made. Figure 4 presents an example of a sample reach layout.

Sediment and BMI sampling during wet weather events will be avoided because of the unsafe conditions associated with high flows and the difficulty performing the monitoring in high flows. Additionally, biological and chemical conditions of the stream may be significantly different during wet weather events than those during base flow. The decision to sample during or following any precipitation will be based on the judgment of the field team and documented as appropriate.

Care will be taken to minimize seasonal variation by sampling as close as possible to the same date each year. Mid-August to early-September provides a target index period appropriate for biomonitoring in this region for several reasons. First, adequate time has passed for the stream habitat to stabilize following snowmelt runoff. Second, the representation of the BMI community reaches a maximum from mid-spring to late summer.

Table 13 – Sediment, BMI, and Habitat Monitoring Stream Reach Coordinates

Reach number Associated SW Site	Approximate Upstream Endpoint		Approximate Downstream Endpoint		Description
	Latitude	Longitude	Latitude	Longitude	
Reach 1 SS-01	45.9852	-112.5062	45.985271	-112.50776	BTC above BPSOU Reach extends upstream from SS-01
Reach 2 SS-06A	45.9946	-112.5511	45.99429	-112.55208	BTC within BPSOU Reach midpoint
Reach 3 SS-06G	45.9963	-112.5616	45.996413	-112.5628	SBC at BPSOU terminus Reach extends upstream from SS-06G

3.1.5 Sediment Monitoring Analytes

Sediment samples will be sieved to less than 2 mm and analyzed for the parameters listed in Table 14. Particle size analysis will include percent clay, silt, and sand; but the differing particle sizes will not undergo chemical analysis. Metals concentrations are critical data, while all other analyses are informational.

Table 14 - Sediment Monitoring Parameter List and Associated Analytical Methods, Approximate Method Detection Limits, Reporting Limits, and Holding Times

Analyte	MDL (mg/Kg)	RL (mg/Kg)	Holding time (days)	Method	Source
Arsenic	0.14	0.50	180 Days	EPA 6020B	EPA
Cadmium	0.029	0.080	180 Days	EPA 6020B	EPA
Copper	0.31	1.0	180 Days	EPA 6020B	EPA
Lead	0.093	0.50	180 Days	EPA 6020B	EPA
Mercury	0.0087	0.02	28 Days	EPA 7471B	EPA
Zinc	1.2	5.0	180 Days	EPA 6020B	EPA
TOC	25.5	100	28 Days	Walkley-Black	EPA
pH (s.u.)	0.10	0.10	NA	ASA 10-3.2	ASA
Particle Size	0.1%	0.1%	NA	ASA 15-5	ASA

3.1.6 BMI Monitoring Parameters

The stream reaches specified in Table 6 will be sampled for BMI community structure, and Table 7 lists the metrics used for BMI assessment. In-situ measurements of pH, temperature, dissolved oxygen, and specific conductance will be made during BMI monitoring efforts. BMI community data are considered critical information, while other parameters are informational.

3.1.6.1 Physical (Habitat) Parameters

Habitat characteristics assessed will include 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; bank stability; vegetative protection; and the riparian vegetative zone. Habitat assessment is considered informational data.

Should a surface water, sediment, or BMI monitoring site become inaccessible on a temporary basis, if possible, the monitoring schedule will be revised to provide accessibility. Should a monitoring site become permanently inaccessible, the need for the site will be evaluated. If it is determined that the monitoring objectives can be achieved without the inaccessible site, with Agency approval, it will be removed from the monitoring network. Should the site be deemed necessary, actions to provide access will be implemented or an alternate site will be proposed.

3.2 Sampling Methods

This section details methods that will be used to carry out all aspects of surface water, sediment, and BMI monitoring and habitat assessments.

3.2.1 Applicable Standard Operating Procedures (SOPs)

A list of the SOPs used for the site investigation are listed below in Table 15 and included in Appendix A. SOPs may be updated as needed, upon approval from the Agencies. All samples will be collected following guidelines set forth in the Clark Fork River Superfund Site Investigations Standard Operating Procedures (CFRSSI SOPs) (ARCO, 1992) or Woodard & Curran internal SOPs.

Table 15 - Project SOP References

Reference Number	Title, Revision Date	Originating Organization
G-4	Field Logbook/Photographs	ARCO
G-5	Sample Packaging and Shipping	ARCO
G-6	Field Quality Control Samples	ARCO
G-7	Sample Custody	ARCO
SOP G-8	Decontamination of Equipment Used to Sample Soil and Water	ARCO
SOP-H-01	Water Sampling Equipment Decontamination	Woodard & Curran
SOP-H-02	Downloading Transducers	Woodard & Curran
SOP-H-03	Download Weather Station	Woodard & Curran
SOP-H-05	Calibrate YSI Professional Plus Multi-Meter	Woodard & Curran
SOP-H-08	Transducer Installation	Woodard & Curran
SOP_H-09	Shipping Ethanol preserved BMI Samples	Woodard & Curran
SOP-S-01	Bump Testing the VENTIS MX4 Gas Meter	Woodard & Curran
SOP-SS-02	Streambed Sediment Sample Collection	Woodard & Curran
SOP-SW-01	Surface Water Sampling	Woodard & Curran
SOP-SW-02	Flow Measurements in Wadable Streams	Woodard & Curran
SOP-SW-03	Change H350 Stage Recorder Data Card	Woodard & Curran
SOP-SW-04	Download ISCO Stage Recorder	Woodard & Curran
SOP-SW-05	Download Sutron Stage Recorder	Woodard & Curran
SOP-SW-06	Read Staff Gauge	Woodard & Curran
SOP-SW-07	Change ISCO Batteries and Adjust Stage	Woodard & Curran
SOP-SW-08	Automatic and Mechanical Sampler Setup - Creek and Diagnostic	Woodard & Curran
SOP-SW-09	Collect Sample from DTEC Sampler	Woodard & Curran
SOP-SW-10	Collect Sample from ISCO Sampler	Woodard & Curran
SOP-SW-11	D-TEC Sample Preparation	Woodard & Curran
SOP-SW-12	Surface Water Wet Weather Sample Preparation	Woodard & Curran

Reference Number	Title, Revision Date	Originating Organization
SOP-SW-16	Signature Bubbler Setup, Stage Adjustment, and Battery Replacement	Woodard & Curran
SOP-SW-18	Calibrate TieNet 301 pH Sensor (Signature Bubbler)	Woodard & Curran
SOP-SW-19	Download Signature Data Files	Woodard & Curran
SOP-SW-20	Wet Weather Trigger Criteria	Woodard & Curran
SOP-SW-21	Stage-Discharge Curve Creation	Woodard & Curran
SOP-SW-22	Setup and download of ISCO 2150 Area Velocity Meters	Woodard & Curran
SOP-SW-24	Checks of R-Processed A-V Meter Data	Woodard & Curran

3.2.2 Data Collection Method

Data collection methods for all aspects of surface water monitoring, sediment monitoring, BMI monitoring, and habitat assessment are described within this section.

3.2.2.1 Meteorological Data

Meteorological monitoring will occur throughout the monitoring period, including during wet weather events, so that relationships between rainfall and runoff can continue to be evaluated. Figure 5 identifies the sites for which meteorological measurements will be made. Precipitation is currently being monitored at CB-1, Kelley Mine, Blacktail Canyon, BMMA, BTL/LAO, and the Basin Creek SNOTEL site. The frequency of measurements varies by station. BMMA and Basin Creek stations report daily data, Blacktail Canyon reports hourly data, and CB-1 reports 30-minute data. BTL/LAO data are reported on a 15-minute frequency, while Kelley Mine data are reported every 6 minutes. Weather stations Kelley Mine, CB-1, and BTL/LAO make measurements with a Davis Instruments Vantage Pro2, which measures wind direction and speed, precipitation, and temperature, along with several other meteorological parameters. Woodard & Curran maintains the weather stations at Kelley Mine and CB-1, while Pioneer Technical Services is responsible for the BTL/LAO station. The Kelley Mine and BTL/LAO weather stations upload data to Weather Underground, thus have infinite storage capacity. Storage capacity for the CB-1 weather stations is approximately 45 days at a 30-minute recording rate. Weather stations other than Kelley Mine, CB-1, and BTL/LAO are maintained by other entities and use various equipment to report weather parameters.

3.2.2.2 Flow Measurements

Surface water flow measurements will be performed according to the applicable Woodard & Curran and CFRSSI SOPs (ARCO 1992d). Surface water flow measurements are to be conducted with equipment consistent with CFRSSI SOPs, unless updated equipment is available, in which case that equipment can be used with the appropriate SOPs. Table 4 identifies the sites for which surface water flow measurements will be made, along with the frequency for normal flow and wet weather monitoring. Table 16 identifies the precision for each type of flow monitoring equipment that will be used for BPSOU surface water monitoring. Equipment listed in Table 16 will be maintained in accordance with manufacturer's instructions. Much of the equipment in Table 16 is permanently deployed at dedicated sites and is in contact only with the water body in which it is deployed. Thus, cross-contamination or contamination from outside sources is not applicable. However, the equipment will be inspected on a regular basis, and fouling agents removed if necessary. At several sites, ISCO equipment is removed during winter months; and prior to re-deployment, that equipment will be thoroughly cleaned.

Table 16 - Flow Measurement Equipment Specifications

Parameter	Equipment	Unit	Resolution
Manual Flow	Hach FH950	ft/s	±2% of reading
Continual Flow	ISCO 2150 A-V meter	cfs	0.01 cfs
Continual Stage	ISCO 4230 Flow Meter	feet	0.01 ft
Continual Stage	Water Log H350/355 Bubbler System	Feet	0.01 ft
Continual Stage	Solinst Pressure Transducer	Feet	0.01 ft
Continual Stage	Sutron 9210 XLITE Bubbler System	Feet	0.01 ft

Creek Normal Flow Conditions

Staff gauges will be read to an accuracy of 0.01 feet before and after flow measurements are taken. Staff gauges are installed and secured with a cement foundation or other method to prevent movement during higher flows. Manual flow measurements will be made with a Hach FH950 portable flow meter in accordance with SOP-SW-02. Continual water depth measurements will be made with continuous stage recorders such as ISCO Signature, ISCO 4230, Water Log H350, and Sutron 9210 X-Lite bubbler systems, and Solinst pressure transducers. Continual stage monitoring equipment will be set to collect a data point every 15 minutes. Water Log, Sutron, and Solinst equipment are set in linear mode, while ISCO equipment is set in roll-over mode. The minimum storage capacity for these devices is 75 days; thus, data loss should not occur if data is downloaded monthly. Although storage capacity is sufficient to prevent data loss, several of the ISCO stage recorders run on battery power, and health and safety concerns beyond the control of Atlantic Richfield may prevent regular battery maintenance, resulting in data losses. Table 4 shows the flow measurement method to be used for each site. Table 16 identifies the precision for each type of flow monitoring equipment.

Creek Wet Weather Conditions

Continuous stage recorders, in combination with stage-discharge curves developed from manual flow measurements, will be used for continuous flow monitoring at Creek sites. Continuous stage recorders will be downloaded with a laptop computer, or a hand-held field device specific to the recorder type, with appropriate communication cables. Stage-discharge curves are developed according to USGS protocol (Sauer 2002). Stations SS-01.35, SS-05, and SS-07 continuous flows are maintained by USGS, and the USGS developed curves are used. Table 4 shows the flow measurement method to be used for each site. Table 16 identifies the precision for each type of flow monitoring equipment.

Sub-Drainage Wet Weather Conditions (Diagnostic Monitoring)

For diagnostic continuous flow measurements, ISCO 2150 area-velocity (A-V) meters will be used. A-V meters record water velocity and flow depth, then calculate flow, based on these parameters. This method will be applied to storm drain pipes, culverts, and/or weirs installed in channels. A-V meters are set to record at 5-minute intervals. A-V meters will be downloaded with a laptop computer, an electronic tablet, or a hand-held field device specific to the recorder type, with appropriate communication cables. Table 4 shows the flow measurement method to be used for each site. Table 16 identifies the precision for each type of flow monitoring equipment.

3.2.2.3 Surface Water Sample Collection

Surface water sampling and sample handling, preservation, custody, and other associated activities will be performed per the applicable Woodard & Curran and CFRSSI SOPs for surface water sampling and sample water filtration. Surface water sampling is to be conducted with equipment consistent with CFRSSI SOPs, unless updated equipment has been made available, in which case updated equipment can be used. Table 5 identifies the sites for which surface water samples will be collected along with the frequency. Table 5 also identifies the type of sampling equipment used at each wet weather and diagnostic location. Water quality samples will be taken in accordance with SOP-SW-01 for normal flow, and SOP-SW-09, SOP-SW-10, SOP-SW-11, and SOP-SW-12 for wet weather flow. Table 17 provides a bottle count and preservative used for each laboratory analysis. Table 11 provides a list of analytical parameters for creek normal flow and wet weather sampling events, while Table 12 lists analytical parameters for sub-drainage wet weather diagnostic events.

Table 17 – Surface Water Monitoring Analytical Bottle Count and Preservative Addition

Analytes	Sampling Container	Preservative	Filter	Comments
General Laboratory				
Alkalinity (as CaCO3)	Polyethylene, 1 x 1 L	None, refrigerate 0°C-6°C	None	1 container for all four analyses
Sulfate	Polyethylene, 1 x 1 L	None, refrigerate 0°C-6°C	None	
Total Dissolved Solids	Polyethylene, 1 x 1 L	None, refrigerate 0°C-6°C	None	
Total Suspended Solids	Polyethylene, 1 x 1 L	None, refrigerate 0°C-6°C	None	
Inorganic Chemicals				
Ammonia	Polyethylene, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	None	1 container for all three analyses
Nitrate+Nitrite	Polyethylene, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	None	
Total Phosphorous	Polyethylene, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	None	
Metals				
Dissolved Metals[A,B]	Polyethylene, 1 x 250 mL	pH<2 nitric acid, refrigerate 0°C-6°C	0.45-micron filter	1 container for all metals

Analytes	Sampling Container	Preservative	Filter	Comments
Total Metals[C]	Polyethylene, 1 x 250 mL	pH<2 nitric acid, refrigerate 0°C-6°C	None	1 container for all metals
Additional Parameters				
Dissolved Organic Carbon	Amber Glass, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	0.45-micron filter	-
Total Kjeldahl Nitrogen	Polyethylene, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	None	-

[A]Dissolved metals analysis includes: Aluminum, Arsenic, Cadmium, Calcium, Copper, Iron, Lead, Magnesium, Mercury, Molybdenum, Silver, and Zinc.

[B]Hardness determined by SM2340B; calculation using dissolved Calcium and Magnesium concentrations.

[C]Total metals analysis includes: Arsenic, Cadmium, Copper, Iron, Lead, Mercury, Molybdenum, Silver, and Zinc.

Creek Normal Flow Conditions

Samples will be collected as per SOP-SW-01. Samples will be collected using equal width increment (EWI) sampling techniques; and at areas where the stream is not well mixed, a churn splitter will be used to adequately mix stream water. To minimize impacts from sediment mobilization, sites will first be sampled for water quality, and flow measurements will follow; additionally, sites will be sampled in a downstream to upstream order. Samples to be analyzed for dissolved metals and dissolved organic carbon will be field filtered through 0.45-micron disposable filters into clean laboratory bottles. Appropriate preservative (nitric acid for metals, sulfuric acid for DOC, NO_2/NO_3, NH_3, TKN, and phosphorus) will be present within or added to the sample bottle. Samples will be sent to the lab and analyzed for the parameters indicated in Table 11.

Field parameters will be measured using a hand-held field meter(s) which measures dissolved oxygen (DO), pH, specific conductivity (SC), and temperature. The meter bulkhead will be placed as near to mid-stream as possible, but this is controlled by the cord length. Field parameters will be allowed to stabilize prior to being recorded. Field parameter measurement units and precision are specified in Table 11.

Creek Wet Weather Conditions

Samples will be collected using automated samplers (ISCO 3700 and D-TECs) as defined in Section 2.4.1. Sample collection will be initiated at a pre-determined stage; and ideally this stage will be reached within the first half hour of a wet weather event. Once initiated, ISCO 3700 automated samplers will collect four time-composited samples through the first four hours of the runoff hydrograph. Each of the four samples will consist of six sample aliquots collected at ten-minute intervals, over one hour. D-TECs will collect one sample at the beginning of the runoff hydrograph and will be submitted for analysis in the event of an ISCO failure. Samples will be retrieved quickly after sampling, preserved on ice, and transported to the office for sample preparation. Samples to be analyzed for dissolved metals and DOC will be filtered through 0.45-micron disposable filters into the bottle type indicated in Table 17. Appropriate preservative (nitric acid for metals, sulfuric acid for DOC, NO2/NO3, NH3, TKN, and phosphorus) will be present within or added to the sample bottle. Samples will be sent to the lab and analyzed for the parameters detailed in Table 11.

Continuous pH measurements will be made at 15-minute intervals with a TIENet 301 – ISCO Signature pH sensors system at SS-01, SS-06G, and SS-07. With the TIENet/Signature system, an ISCO pH probe is placed in the water body and connected to the TIENet sensor device. The sensor device transmits to the Signature flow meter where the data is recorded and stored. Measurement units, accuracy, and resolution for all parameters are specified in Table 11.

Sub-Drainage Wet Weather Conditions (Diagnostic Monitoring)

Samples will be collected using automated samplers (ISCO 3700) set to collect within the first half hour of a wet weather event as defined in Section 2.4.1. Samplers will be set to trigger/collect at a stage as low as practical but will only be collected if meeting the rainfall criteria of greater than 0.15 inches, and the frequency criteria of up to two sample events per month. Once triggered to sample, ISCO 3700 automated samplers will collect eight samples throughout the runoff hydrograph, until the programming routine has completed, or runoff ceases. Samples will be collected quickly after collecting, preserved on ice, and transported to the office for sample preparation. Samples to be analyzed for dissolved metals will be filtered through 0.45-micron disposable filters into clean laboratory bottles. Appropriate preservative (nitric acid for metals) will be present within or added to the sample bottle. Samples will be sent to the laboratory and analyzed for the parameters detailed in Table 12**.**

BSB will perform occasional Operations and Maintenance (O&M) activities on the Missoula Gulch catch basins that may result in a discharge from CB-9. Woodard & Curran will be informed by BSB of O&M activates prior to commencement of the activity. If discharge from CB-9 occurs and water flows through channel to SBC during the wet weather season, a sample will be collected by the automated sampler at MG-CLV-0 and will be labeled as such. If discharge from CB-9 occurs and water flows through channel to SBC outside of wet weather season, when automated samplers are not deployed, an opportunistic field grab sample will be collected as per SOP-SW-01 using equal width increment sampling techniques if flow width deems it necessary. Samples will be prepped and preserved as stated above and sent to the laboratory to be analyzed for parameters listed in Table 12.

ISCO 3700 samplers will be deployed in-situ during wet weather season. When automatic samplers collect, polyethylene sample bottles are filled. Prior to re-use, these bottles will be thoroughly decontaminated. When deployed, ISCO 3700 samplers include intake tubing and an intake screen. New tubing will be used and the intake screen will be thoroughly cleaned at the beginning of each sampling season. The tubing and screen will be periodically checked for damage or fouling throughout the wet weather season and cleaned or replaced as necessary.

3.2.2.4 Sediment Sample Collection

Sediment samples will be collected using the methods in SOP SS-02 along the stream reaches specified in Table 13 and displayed on Figure 3. Spatially composited samples will be collected within each stream reach. The spatial interval will consist of ten sub-sample points, at five transects within each stream reach. Two sub-samples will be collected at each transect. If conditions prevent collection of five subsamples, as many as possible will be collected and the deviation will be recorded in the field notes. Sediment sampling tubes will be used to obtain the samples, providing variable depth-controlled samples. Sub-sample locations will be spread along the stream reach. Exact sub-sample locations will be determined in the field, since these will be dependent on the location of sediment deposits. For each stream reach, the sub-samples will be composited into a single sample for each of three depth intervals. Target depth intervals will be 0-2 inches, 2-6 inches, and 6-12 inches; thus, each stream reach will result in a maximum of three spatially composited samples. Although an attempt will be made to identify and sample depositional areas, sediment depth may limit collection of the deeper intervals.

Sample collection will proceed in a downstream to upstream order. Bed sediment samples will be collected at each sub-sample location by directly pushing a plastic sediment sampling tube or auger straight down into the streambed. The sampling device may be a clear tube or a clam-digger type device. The sampler will be pushed by hand, without the aid of any additional means (i.e., hammering). Once the sampler has been pushed into the bed sediment, sampling personnel will provide suction by either sealing the top of the tube (i.e., tube cap or gloved hand) or sealing the clam-digger by covering the suction hole, and slowly extract the tube, in a manner that retains the sample. Once extracted, a sampling depth will be determined for each subsample location by measuring the length of sediment in the tube. This depth, along with sediment characteristics (color, texture, odor, grain size and sorting estimate) will be recorded in the field book or appropriate field form. Subsamples from each location will be composited into a single site sample by depositing all subsamples (specific to each depth increment) into a stainless-steel bowl, homogenizing the sample (as described in SOP-SS-02), and recovering a portion of the sample for laboratory submittal. An attempt will be made to collect equal volumes at each sub-sample location, and to produce equal volume samples for each of the three stream reaches. Table 18 specifies container and preservative requirements for sediment samples. Since the subsamples will be composited, it is unnecessary to decontaminate the tube between subsample locations. Bowls will be dedicated to each site, disposable mixing devices will be used, and a new tube or dedicated clam-digger will be used at each sample site. Although no equipment will be re-used, any equipment which is not disposed of will be decontaminated both prior to and after use.

Whenever possible, samples will be collected over the full depth of sediment to the hard bottom. If no hard bottom is present, the maximum depth of sampling will be 12 inches. The depth of each sub-sample will be recorded in the field book, or on the electronic field form, along with soil characteristics of each sub-sample.

Table 18 – Sediment Monitoring Sample Container Requirements

Analytes	Sampling Container	Preservative
Metals[A]	4 oz Amber Glass Jar or equivalent volume in quart re-sealable plastic bag or	None, refrigerate 0°C-6°C
TOC	4 oz Amber Glass Jar	None, refrigerate 0°C-6°C
pH, Particle Size	Quart re-sealable plastic bag (500 g minimum sample volume)	None, refrigerate 0°C-6°C

[A]Metals analysis includes: Arsenic, Cadmium, Copper, Lead, Mercury, and Zinc.

3.2.2.5 BMI Sample Collection

At each site, four replicate BMI samples will be collected from riffle habitats using a Hess sampler with 1,000-micron mesh netting. BMI sampling will be conducted in riffle habitats from the least embedded, most heterogenous cobble substrates found at each site. In the event where a riffle is not found, a run will be sampled instead.

When the field team arrives to the stream site, they will first confirm the stream is not unduly influenced by rain events and that stream conditions are safe. The sampling reach from within which all subsequent sampling activities are conducted is first established (Section 3.1.4). In-situ water chemistry measurements are made followed by BMI sampling and then habitat assessments if in a 5-year cycle monitoring period. Sediment monitoring will occur within seven days of BMI monitoring and surface water monitoring may occur within the same week as BMI monitoring. If manual surface water monitoring is conducted in the same week as BMI monitoring and BMI monitoring precedes surface water monitoring, a minimum of two days will pass between BMI monitoring and surface water monitoring. Sediment monitoring will follow both BMI and surface water monitoring. If surface water and BMI monitoring are conducted in separate weeks, sediment monitoring may immediately follow BMI monitoring; however, BMI monitoring will be completed at each stream reach prior to sediment monitoring. This sequence of sampling events will avoid instream disturbances that may influence water chemistry, in-situ water measurements, and BMI samples.

BMI samples are collected by placing the Hess sampler (see Figure 6) on the stream bottom with the net portion downstream and the screened opening of the cylinder facing into the current. The Hess sampler is placed quickly and firmly to the stream bottom to ensure fast-moving invertebrates are enclosed within the cylinder portion of the sampler. Once the sampler is in place with the screened opening of the Hess sampler facing the current, the net is stretched, and invertebrates are collected in the sample device. Gravel and cobble are lightly scrubbed by hand inside the cylinder portion of the sampler to dislodge and carry specimens by the current through the downstream window into the net and sample device. Each stone is examined for organisms, larval or pupal cases that may be clinging to it before discarding. After cleaning off all cobble and larger gravel within the sampler, the remaining gravel and sand are stirred by hand to dislodge bottom-dwelling organisms.

After removing the sampler from the stream, the net is rinsed from the outside into the collection bucket and carefully examined for small organisms clinging to it. If present, these are removed with forceps and placed in the sample.

Replicate samples (4) from each sampling reach are collected and transferred into pre-cleaned, 1-liter wide-mouthed plastic containers and preserved in the field with 95% ethanol. Fish or other non-BMI organisms are excluded from the sample.

3.2.2.6 Habitat Sampling

The objective of habitat assessments is to characterize geomorphology, riparian and in-stream habitat, and physical characteristics that influence the structure and function of BMI communities. Habitat assessment employs EPA's RBP (Barbour et al, 1999) and EPA's EMAP stream habitat procedure (EPA, 1998). RBPs will be performed concurrently with BMI monitoring and the EMAP stream habitat procedure will be performed immediately following BMI sample collection in years that habitat assessments are completed.

The RBP is a visual-based stream assessment in which field biologists record observations of catchment and stream characteristics that are useful for future data interpretation. The RBP method will be applied during each annual biomonitoring event. The EMAP procedure employs more quantitative data collection on physical habitat. The full EMAP method (provided in Appendix D) will be applied during the first biomonitoring event and on five-year cycles, at a minimum. Select components (e.g., slope, sinuosity, canopy cover) of these assessments which are not expected to significantly change may be reduced or eliminated following the initial biomonitoring events.

The RBP procedure involves rating 10 habitat parameters on a scale from 0 to 20 according to EPA's scoring criteria (Barbour et al, 1999) along each stream reach. Ratings for each parameter are based on a continuum of conditions including optimum, suboptimal, marginal, and poor. Field forms and field assessment guidelines for rating each parameter are provided in Appendix D. The following provides a brief description of each parameter.

1. **Epifaunal Substrate/Available Cover:** includes relative quantity and variety of natural structures in the stream, such as riffles, substrate type, woody debris, and bank structure.
2. **Embeddedness/Pool Substrate Characterization:** includes degree to which substrate are covered or embedded with fine-grain sediment.
3. **Velocity / Depth / Pool Variability:** includes the variety of pools found in the reach considering depth, size, and velocity.
4. **Sediment Deposition:** includes the degree of sediment accumulation and deposition on stream substrates.
5. **Channel Flow Status:** includes the extent to which the stream channel is filled with water including over stream substrates.
6. **Channel Alteration:** includes channel configuration and/or channel alteration (channelization or other channel modifications).
7. **Frequency of Riffles/Channel Sinuosity:** includes the frequency of riffle habitat (heterogeneity of instream physical habitats) and degree of sinuosity.
8. **Bank Stability:** includes condition of banks/potential for bank erosion considering steepness (incision), vegetative cover, and overall stability.
9. **Vegetative Protection:** includes extent of vegetative protection to streambank and near-stream portion of the riparian zone.
10. **Riparian Vegetative Zone:** includes the width of vegetation from streambank through riparian zone.

Each RBP metric is summed to provide an overall habitat score for the site which can range from 0 to 240.

In the EMAP procedure, measurements are taken systematically along the entire sample reach. The sample reach, established as 40 times the wetted width or a minimum of 150 m, is divided into 11 channel cross-sections at equal intervals along the reach length, as described in Section 3.1.4. Flagging or other markers are placed on streambanks to mark the 11 channel cross-sections. Figure 4 presents a plan view diagram of a sample reach layout for conducting the EMAP habitat assessment.

There are four components of EPA's 1998 EMAP physical habitat characterization: Thalweg Profile, the Large Woody Debris Tally, Channel and Riparian Cross-Sections, and Stream Discharge. Note that discharge measurements are not necessary at sites co-located with USGS gaging stations which supply 15-minute interval discharge data. Elements of the remaining three EMAP components are provided in Appendix D, following the RBP assessment forms.

3.2.3 Sampling Equipment

The complete field equipment needs for sampling are:

- Hard or electronic copy of the QAPP;
- Electronic field tablet, which is loaded with appropriate sampling forms;
- Bound and numbered field notebook;
- Long and short impervious gloves
- Sample labels and waterproof marker;
- Sample containers
- Sample coolers and ice;
- Required Level D Personal Protective Equipment (PPE) including hard hat, safety glasses with side shields, high visibility vest (or shirt), long-sleeved shirt, and safety-toed boots/waders

Surface Water

- Padlock keys;
- Churn Splitter;
- Multi-meter, or individual DO, pH, SC, and temperature meters;
- Peristaltic pump;
- Appropriate tubing;
- 0.45-micron disposable filters;
- Sample bottles
- Decontamination water, decontamination solutions
- Portable flow meter, wading rod, and cloth tape measure (English scale with 1/10th markings)

Sediment

- GPS device
- Sampling device (tubes or clam-digger type samplers)
- Stainless-steel bowls
- Disposable plastic scoops
- Sample containers, amber jars and re-sealable plastic freezer bags
- Decontamination water, decontamination solutions

BMI

- Field measurement forms
- Field operations and methods manual
- Procedure tables and quick reference guide
- 1-gallon re-sealable plastic freezer bags
- GPS device
- Multi-meter, or individual DO, pH, SC, and temperature meters
- Modified Hess sampler (0.1 m^2 diameter)
- 2 White buckets/containers, 8-quart capacity
- 2 Forceps
- Small spatula, spoon, or scoop for sample transfer
- Funnel with large bore spout
- Sample jars
- Ethanol preservative

Habitat Assessment

- Pencils (#2)
- Channel/Riparian cross-section and Thalweg forms
- Slope and bearing form
- Rapid bioassessment form for riffle/run prevalent streams
- Rapid bioassessment form for pool/glide prevalent streams
- Assessment form for visual stream assessment
- Hip chain (metric) for measuring stream lengths
- 50-m fiberglass measuring tape/reel
- Surveyor's flagging or flags/stakes
- Surveyor's telescoping rod (metric scale, 7.5 m extended)
- Digital camera or camera capable tablet
- Clinometer (or Abney level) with percent and degree scales
- Spherical convex canopy densiometer, modified with taped "V"
- Bearing compass (backpacking style)

Unexpected problems relating to data collection may include samples being spilled and equipment failures. In the event of a sample spill in the field, the site will be re-sampled. Since surface water sampling is synoptic and associated with specific flow conditions, re-sampling a single surface water site at a later date is not judicious. Thus, the chance of surface water spills in route to the lab will be minimized by packing coolers in a manner which eliminates void spaces and retains sample bottles in an upright position. Although sediment and BMI sites can be re-sampled, within reasonable time frames, if sample spills occur during shipping, these samples will also be packed in a manner which eliminates void spaces and minimizes the chance of spills. Field team members will be responsible for resampling when sample spills occur in the field. The Field Team Leader will be informed of sample spills which occur during storage or shipment and will document such spills in the project records (field logbook, electronic forms).

Equipment failures may occur with pumps, batteries, field meters, laptop computers, communication cables, or manufacturer specific download devices. Spare pumps, batteries, laptop computers, and communication cables will be kept on hand. Two field multi-meters will be available, and spare probes will be kept on hand for the meters. However, there may be meter failures which require factory repair, in which case a rental meter will be obtained. Solinst® transducers are downloaded with manufacturer specific download devices (Bluetooth® device); however, a laptop computer can be used in the event of Bluetooth® failure. The Field Team Leader will be responsible for maintaining an inventory of spare equipment, as well as ordering replacement or rental equipment.

3.3 Sample Handling and Custody

3.3.1 Sample Holding Time

Maximum holding times between sample collection and sample laboratory analysis are provide in Table 11 and Table 12 (surface water) and Table 14 (sediment). BMI samples can be held indefinitely, providing preservative is changed every three months. Continuous water level monitors at BPSOU sites are set to record data on 5-minute (A-V meters) or 15-minute intervals, and these recorders will typically be downloaded on a monthly basis. Since continuous water level monitors deployed at BPSOU sites have a 75-day storage capacity, there is adequate storage capacity for a monthly download schedule. However, several of the ISCO continuous recorders run on battery power, and health and safety concerns beyond the control of Atlantic Richfield may prevent batteries being maintained on a schedule which avoids data loss.

3.3.2 Sample Handling and Storage

After collection and labeling, surface water and sediment samples will be placed in coolers and kept between 0 and 6°C. BMI samples have neither temperature nor holding time requirements; thus, will be stored in coolers at room temperature. All samples will be maintained under strict chain-of-custody protocols. Field sampling personnel will complete a chain-of-custody form for each laboratory delivery/shipment. The chain-of-custody form(s) will be placed in a re-sealable plastic bag and placed in the cooler with the samples. CFRSSI SOP G-5 states that samples will be shipped within two weeks of sample collection; however, an attempt will be made to ship/deliver surface water samples collected under this QAPP within one day of sample collection/preparation. Analyses for TDS and TSS have a 7-day holding time, which requires that samples are shipped as soon as possible after collection. Sediment and BMI samples will be shipped at least weekly. Surface water and sediment samples will be placed in coolers, along with a sufficient volume of double-bagged ice to maintain a sample temperature of 0 to 6°C up until the time of sample receipt by the laboratory. Since BMI samples do not have a temperature requirement, they will be placed in coolers, without ice, for laboratory shipment. Should void spaces exist in coolers containing any of the three sample medias, these spaces will be filled with non-contaminating packing material to prevent samples from shifting, and possibly spilling, during shipment. Coolers which are shipped will be custody sealed, securely taped shut, and have a shipping label securely adhered to the cooler. Sample containers hand delivered to the laboratory do not need to be prepared for shipping, but surface water and sediment sample temperature must be maintained between 0 and 6 °C.

The sampling personnel whose signature appears on the chain-of-custody is responsible for the custody of the samples from the time of sample collection until custody of the samples is transferred to a designated laboratory, a courier, or to another project employee for the purpose of transporting the samples to the designated laboratory. Custody is transferred when both parties to the transfer complete the portion of the chain-of-custody under "Relinquished by" and "Received by". Signatures, printed names, company names, dates and times are required. Upon transfer of custody, the sampling personnel who relinquished the samples will retain the third sheet (pink copy) or photocopy of the chain-of-custody. When the samples are shipped by a common carrier, a Bill of Lading supplied by the carrier will be used to document the sample custody. The tracking number of any sample container shipped will be recorded in the logbook. Copies, receipts, and carbons of Bills of Lading will be retained as part of the permanent documentation in the project file. It is not necessary for courier personnel to sign the chain-of-custody as long as custody seal(s) remain intact until receipt by the intended entity.

Upon laboratory receipt, the samples will be inspected for sample integrity. The chain-of-custody will be immediately signed, dated and reviewed by laboratory personnel to verify completeness. Any discrepancies between the chain-of-custody and sample labels and any problems or questions noted upon sample receipt will be communicated immediately to the Field Team Leader. The laboratory shall provide the Field Team Leader and Contractor Quality Assurance Officer with the associated sample-receipt information within two working days of sample receipt. The sample-receipt information routinely provided will include sample receipt date, sample IDs transcribed from the chain-of-custodies, sample matrix type and list of analyses to be performed for each sample. Broken custody seals, damaged sample containers, sample labeling discrepancies between container labels and the chain-of-custody form, and analytical request discrepancies shall be noted on the chain-of-custody form. The Field Team Leader and Contractor Quality Assurance Officer shall be notified of any such problems; and discrepancies or non-conformances shall be resolved and addressed before the samples are analyzed.

The laboratory will be responsible for following their internal custody procedures from the time of sample receipt until sample disposal. Samples and extracts shall be stored in a secure area controlled by the laboratory's designated sample custodian. Samples shall be removed from the shipping container and stored in their original containers unless damaged. Damaged samples shall be disposed of in an appropriate manner after notifying the Field Team Leader and Contractor Quality Assurance Officer, and authorization to dispose is received and documented. In addition, samples shall be stored after completion of analyses in accordance with contractual requirements.

3.3.3 Field Documentation

All field entries will be recorded in a bound logbook, on electronic or paper field forms (habitat assessment), or both the logbook and form. Logbook entries and field forms will be completed prior to proceeding to the next sample location. All field logbook and field form entries will be consistent with CFRSSI SOP G-4. Specific entries will include but are not necessarily limited to the following: sample location; sample date and time; staff gauge reading (as applicable); sample identification number; sample analysis, sample field preparation, sample preservative, final field parameters (as applicable), sampling equipment decontamination, weather conditions, personnel present and associated organization, and any deviations from the QAPP protocol.

3.3.4 Sample Identification and Labeling

All samples collected will have a unique sample ID that follows an alpha-numeric code. A label will be placed on each sample container, and every label will contain the following information: sample ID, sample date, sample time, requested analysis, preservative added, field preparation method (i.e. filtered), and samplers' initials. The same information will be recorded on the field form, along with the sample site. The sample ID on the bottle will exactly match the sample ID on the field form and on the chain-of-custody.

The field sample identification scheme consists of letters to identify the sample type, followed by a 3 or 4-digit number to identify sample number. The sample number is followed by 6 digits representing the monitoring date. The following are examples of sample identification codes:

Sample Code: SWWW0073-081223

SW	=	Surface Water Sample
WW	=	Wet Weather Sample (BF=Normal Flow) (SD=Storm Drain) (OM=Operations and Maintenance sample)
0073	=	Sample number of 73
081223	=	Monitoring date of 8/12/2023

Sample Code: SED001-081223-0612

SED	=	Bed Sediment
001	=	Sample number of 1
081223	=	Sample date
0612	=	Depth interval (inches)

Sample Code: BTC SS-01 Rep A 1 of 2

BTC	=	Creek identifier, BTC or SBC
SS-01	=	Sample site within the creek
Rep A	=	Replicate A of sample BTC-SS-01
1 of 2	=	Container 1 of 2 containers for BTC-SS-01 Rep A

3.3.5 Sample Chain of Custody

The sampler is responsible for initiating and filling out the chain-of-custody. Each sample in the shipment will be listed on the chain-of-custody; and, the chain-of-custody will contain the project code, the project name, sample IDs, sample dates, samples times, analyses requested, preservative used for each sample analysis, any remarks, name and signature of person relinquishing samples, date and time samples were relinquished, name and signature of sample recipient, and date and time samples were received. Sample time is not required on the BMI chain of custody. Example chain of custody forms can be found in Appendix E.

3.3.6 Sample Disposal

Disposable equipment and all other solid waste associated with sample collection will be immediately placed in trash bags to avoid cross-contamination and to maintain an orderly work environment. The bagged trash will be disposed of at a waste disposal facility.

3.4 Laboratory Methods

Surface water and sediment samples will be analyzed using the appropriate methods consistent with the CFRSSOU LAP, (ARCO, 1992a), American Public Health Association (APHA) Standard Methods for the Examination of Water and Wastewater, EPA, and American Society of Agronomy (ASA) protocols. The analytical method and detection limit requirements will be updated as required by the governing regulatory agency. BMI samples will be processed using protocols for laboratory subsampling, sorting, and taxonomy described in the Montana DEQ *Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Community SOP* (DEQ, 2012).

3.4.1 Sample Preparation Methods

Surface water and sediment samples will be prepared for analysis as the EPA approved methods dictate. BMI samples will be prepared for processing as outline in the Montana DEQ *Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Community SOP* (DEQ, 2012).

3.4.2 Sample Analysis Methods

Surface water and sediment samples will be analyzed in accordance with the appropriate EPA approved method. A summary of sample analyses and methods is provided for Creek monitoring in Table 11, for Sub-drainage diagnostic monitoring in Table 12, and for sediment monitoring in Table 14. These tables include current detection and reporting limits, but these are determined on an annual basis; thus, they will fluctuate and will be updated in the annual revisions to this QAPP as necessary. BMI samples will be processed as outline in the Montana DEQ *Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Community SOP* (DEQ, 2012).

3.4.3 Laboratory Equipment

Required laboratory equipment are an inductively coupled plasma mass spectrometer, an autosampler, and an analytical balance for metals/metalloids analysis by EPA 200.8 and SW846 6020B. Mercury analysis requires a cold vapor atomic adsorption analyzer, an autosampler, a block digester, and an analytical balance. Anion analysis requires an ion chromatograph and TKN analyses require a discrete analyzer. Alkalinity analysis requires a pH meter, magnetic stir plates and magnetic stir bars, an autotitrator system, a hot plate, and an analytical balance. Gravimetric samples require an analytical balance, drying ovens, a muffle furnace, a vacuum filtration system, and a desiccator.

Additional laboratory equipment needs are a colorimetric analyzer, stir plates, magnetic stirrers, a block digestor, a vortex mixer, a carbonaceous analyzer, a pH meter, a spectrophotometer, and appropriate gases, oils, glassware, pipettes, tubing.

Sediment sample preparation equipment requirements are a drying cabinet, number 10 sieves, pipettes, digestion cups, plunge filters, a hot block, and an analytical balance. Sediment pH measurements require a pH meter, spatula, cups with caps, funnels, a vacuum pump, filter paper, filter holder, test tubes with stoppers, weigh pans, an analytical balance, and an oven. Additional equipment requirements are a spectrophotometer for sediment TOC analysis and appropriately sized sieves, a hydrometer, a mechanical shaker, a sedimentation cylinder, and shaker bottle for sediment particle size analysis.

BMI laboratory equipment requirements are a microscope, associated slide and slide mounting materials, and taxonomy reference materials.

3.4.4 Sample Disposal

Disposable equipment associated with laboratory analyses will be immediately placed in trash receptables and disposed of at appropriate waste disposal facilities. Samples which are shipped to the laboratory will be archived for six months, and after that time the laboratory is responsible for sample disposal.

3.5 Quality Control

Field and laboratory QC requirements are similar for surface water and sediment sampling; however, QC requirements for BMI and habitat monitoring differ considerably. Therefore, QC requirements for surface water and sediment samples are discussed first, and BMI and habitat QC assessments follow.

Field sample QC protocols for surface water and sediment sampling will be consistent with CFRSSI SOP G-6 and will include 1 field duplicate for every 20 primary samples and 1 field blank collected for every 20 primary samples. Any deviation from the CFRSSI or other SOPs, or this QAPP, will be identified in the logbook and discussed in a data summary report, or similar, if required.

3.5.1 Surface Water and Sediment Field Quality Control Samples

Field quality control samples are introduced into the measurement process to provide information on transport, storage and field handling biases, and field sampling precision. The QC samples that follow will be collected for analysis identical to that which is required on primary samples. Brief descriptions of the QC samples to be utilized during surface water and sediment sampling are provided below, along with instructions for their frequencies of collection and analysis.

<u>Field Duplicate</u>

A field duplicate is a second sample collected from the same location in immediate succession to the primary sample, using identical techniques. Duplicate samples will be collected for surface water and sediment sampling. The duplicate sample will have its own unique sample identification number, but will be sealed, handled, shipped, and analyzed in the same manner as the primary sample. Analysis will be identical for the primary and duplicate sample. The analytical results of the duplicate sample will be compared to determine sampling precision, with a target precision of ≤ 20% RPD for aqueous samples and ≤ 35% RPD for sediment samples. The 20%/35% RPD between the sample and duplicate are applicable if both the sample and duplicate are ≥ five times the RL. If either the sample or duplicate is < five times the RL, the control limit is an absolute difference between the sample and duplicate ≤ RL for aqueous samples and ≤ 2X RL for solid samples. Field duplicate samples will be collected at a frequency of one per 20 samples or once per sampling event.

Field Blank

Field Blanks will be used to help identify possible contamination from the sampling environment, from sampling equipment, or from sample handling. A Field Blank (FB) for aqueous samples is deionized water and appropriate preservatives prepared in the field. The FB is contained in a sample container randomly chosen from each lot of containers received from the supplier. Aqueous field blanks will be collected by pouring ASTM Type II DI water into a single-use plastic container and triple rinsing. The container will then be filled with ASTM Type II DI water, and sample aliquots requiring filtration will be pumped from this container. Sample aliquots which do not require filtration will be poured from the DI carboy, directly into the sample bottle.

Creek normal flow surface water sampling involves use of a churn splitter at SS-05 and SS-07. A separate site-dedicated churn splitter is used at each site, and the churn splitters are thoroughly decontaminated in the field laboratory after each use. For normal flow sampling, the field blank will be collected quarterly at a site which requires use of a churn splitter. Since churn splitters are decontaminated in the field laboratory after each use, the field blank will be collected prior to sample collection. ASTM Type II DI water will be poured into the churn splitter and a small amount of DI water will be briefly run through the spigot. Bottles designated for sample analyses that do not require filtration will be collected first, and aliquots which require filtration will be collected last. Unfiltered samples will be collected by dispensing DI water through the spigot. Filtered samples will be collected by dropping tubing into the churn splitter and pumping water through the filter into the sample bottles. The exterior portion of the tubing will be rinsed with DI water prior to dropping it into the churn splitter. Field blanks collected in this manner mimic the procedures used for dispensing primary samples through a churn splitter.

Field blanks for solid samples will consist of clean silica sand poured over decontaminated sampling equipment, into the sample container.

The FB sample will be given its own sample identification, but will be sealed, handled, shipped, and analyzed in the same manner as the primary sample. With the exception that sediment field blanks will not include particle size and pH analysis, field blank analysis will be identical to the primary samples. Field Blanks will be prepared at a frequency of one per 20 samples collected, or one per sampling event, whichever is more frequent. The target is to achieve concentrations less than the method detection limit (MDL) in field blanks.

3.5.2 Surface Water and Sediment Laboratory Quality Control Samples

Laboratory QC samples are introduced into the measurement process to evaluate laboratory performance and sample measurement bias. Laboratory QC samples may be prepared from environmental samples or generated from standard materials in the laboratory. The appropriate type and frequency of laboratory QC samples are described in the associated method. Examples of typical laboratory QC samples are listed in Table 9. Note that Table 9 details laboratory acceptance criteria, while validation criteria can be found in Table 19.

Method Blank

Method blanks should be prepared and analyzed for every 20 samples analyzed. The method blank is laboratory DI water which has gone through the applicable sample preparation and analysis procedure. Control limits are a concentration < ½ RL. The complete control limits and corrective actions for control limit failures are outlined in Table 9.

Laboratory Control Sample

A laboratory control sample (LCS) consists of a laboratory blank sample with a known concentration of the target analyte. The LCS sample is prepared and analyzed in the same manner as field samples. Percent recovery of the target analytes in the LCS helps determine whether the laboratory's methodology is accurate. For the majority of analyses, one LCS should be analyzed for every 20 samples analyzed. As Table 9 shows, control limits vary depending on the analysis. If the LCS fails to meet the specified control limit, the analysis must be terminated, the problem corrected, and samples in the failed LCS batch must be re-analyzed.

Laboratory Duplicates

Laboratory duplicate (LD) samples test laboratory precision, and one LD sample should be analyzed for every 10 to 20 samples, as indicated in Table 9. Samples which are known to be field blanks cannot be used for LD samples. Control limits vary depending on the analysis, and these are summarized in Table 9. The relative percent differences (RPD) between the sample and duplicate are specified in these tables and are applicable if both the sample and duplicate are ≥ five times the RL. If either the sample or duplicate is < five times the RL, the control limit is an absolute difference between the sample and duplicate no greater than the RL. Should LD samples fail to meet control limits, and the samples in the associated batch are of a similar matrix, then associated sample results should be flagged. If samples in the associated batch are not similar to the parent sample used for the LD, then only the parent sample used to prepare the duplicate should be flagged.

A laboratory control spike duplicate (LCSD) is a duplicate of the LCS. The LCSD tests laboratory reproducibility. As Table 9 indicates, LCSD samples are not required for all analyses. In the event of LCSD precision outside of control limits, affected data should be flagged.

A matrix spike duplicate (MSD) is a duplicate of the matrix spike (MS). The MSD is used to determine analytical precision and bias of a method in a sample matrix. As Table 9 indicates, MSD samples are not required for all analyses, and criteria vary depending on the method. In the event of MSD precision outside of control limits, the parent sample and samples in the associated batch will be flagged. If the batch associated samples of a dissimilar matrix to the parent sample, only the parent sample shall be flagged.

Matrix Spike

Matrix spike (MS) samples evaluate the effect of the sample matrix on sample preparation and measurement methodology. One MS must be analyzed for each group of 10-20 samples, as indicated in Table 9. The control limit for MS samples varies depending on the analysis, and these are stated in Table 9. The control limits are applicable when the parent sample concentration is < four times the spike added. If the parent sample concentration is ≥ four times the spike added, this recovery criterion is waived. Samples which are known to be field blanks cannot be used for MS samples. In the event of MS recovery outside of control limits, the parent sample and samples in the associated batch will be flagged. If the batch associated samples are of a dissimilar matrix to the parent sample, only the parent sample shall be flagged.

3.5.3 BMI and Habitat Assessment Field Quality Control

Field sampling precision measures the extent of variability in the sampling method and is related to the variability of collecting replicate samples within a reach. Sampling precision is estimated by collecting four replicate samples of the BMI communities within the same reach during the same day. The precision goal is an RSD of ≤ 20% among the four replicate samples for the taxa richness metric.

The habitat assessment is based on field measurements and observations so there is no sample collection associated with this procedure. Each biologist will be trained and experienced in the visual-based RBP and EMAP procedure for application to western U.S. streams. A team of two biologists will observe all habitat features along the stream corridor and come to a consensus on determining the quality and ratings. Ratings will be supported via photo documentation of relevant habitat features.

The data sheets on which the habitat measurements are recorded in the field at each site will be reviewed for reasonableness, completeness, and transcription errors. Calculations necessary to compute the various habitat parameters described will be checked for accuracy. Before leaving a stream sampling reach, all field forms will be checked for completeness by a second person.

3.5.4 Taxonomy Laboratory Quality Control

The QA/QC protocols for laboratory subsampling, sorting, and taxonomy described in the Montana DEQ Benthic Macroinvertebrate Community SOP will be followed in addition to those described below.

Completeness

All samples will be checked for completeness after sorting by the taxonomist. Ten percent of the samples will be checked by a second taxonomist. A sample passes this check if the second taxonomist finds less than a 5% difference in the number of organisms found by the original taxonomist. If there is greater than a 5% difference between the original and second count, then extraction continues in those portions picked, and the sample is rechecked until there is less than a 5% difference between the subsequent and original counts.

Taxonomy and Enumeration

Quality assurance for taxonomy and enumeration (Whittaker, 1975; Stribling, 2003) is conducted on a randomly assigned set of 10% of the samples. Under this protocol, a second taxonomist re-identifies and counts all organisms in the sample, and an abundance-weighted similarity index is calculated between the results from the two taxonomists. A percent similarity greater than 95% is required to pass. If the percent similarity is less than 95% and the sample is rejected as a result of a misidentification, then all other samples with the same misidentification are rechecked and an additional sample is selected for a QA check. This process continues until the percent similarity for identifications and counts for the selected sample is greater than 95%

3.6 Instrument/Equipment Testing, Inspection and Maintenance

In order to ensure continual quality performance of any instrument or equipment, testing, inspection and maintenance shall be performed and recorded as described in this section.

3.6.1 Field Equipment

Field equipment will be examined to certify that it is in proper operating order prior to its first use. Equipment, instruments, tools, gauges and other items requiring preventative maintenance will be serviced in accordance with the manufacturer's specified recommendations. Field equipment will be cleaned and safely stored between each use. Any routine maintenance recommended by the equipment manufacturer will also be performed and documented in field logbooks or appropriate data sheets. Equipment will be inspected and the calibration checked, if applicable, before it is transported to a field setting for use. Personnel responsible for field equipment examination, cleaning, maintenance, and storage include the field team leader, the QAO, and field team personnel.

3.6.2 Laboratory Equipment

Instruments used by the laboratories will be maintained in accordance with each laboratory's Quality Assurance Plan and analytical method requirements. All analytical measurement instruments and equipment used by the laboratory shall be controlled by a formal calibration and preventive maintenance program.

The laboratories will keep maintenance records and make them available for review, if requested, during laboratory audits. Laboratory preventive maintenance will include routine equipment inspection and calibration at the beginning of each day or each analytical batch, per the laboratory's internal SOPs and method requirements. Laboratory personnel are responsible for laboratory equipment examination, cleaning, maintenance, and storage.

3.7 Instrument/Equipment Calibrations and Frequency

Field multi-meters will be calibrated, prior to use as necessary. Meters will be calibrated following manufacturer's instructions, and using manufacturer recommended calibration solutions. Calibration logs will be stored electronically within project files, recorded within project field logbooks, or both. Calibration failures will result in meters being immediately removed from service. Once repaired, and successfully calibrated, meters will be returned to service. Calibration of multi-meters will be done in accordance with updated versions of CFRSSI SOPs HG-7 and HG-8 and calibration of the TieNet 301/ISCO Signature pH sensor will be done in accordance with SOP SW-18.

3.8 Inspection/Acceptance of Supplies and Consumables

All supplies and consumables received for the project (e.g., sampling equipment, calibration standards, etc.) will be checked for damage and other deficiencies that would affect their performance. The types of equipment that will be needed to complete sampling activities are described in the relevant SOPs. Inspections of field supplies will be performed by the Field Team Leader or Field Team Members.

The personnel at each laboratory will be responsible for performing inspections of laboratory supplies in accordance with their QA program.

3.9 Data Management Procedures

This section describes the management of data for the project including field and laboratory data. The program quality records will be maintained by Atlantic Richfield. These records, either electronic or hard copy in form, may include:

- Project work plans with any approved modifications, updates, and addenda;
- Project QAPP, including this QAPP, with any approved modifications, updates, addenda, and any approved corrective or preventative actions;
- Field documentation;
- Chain-of-custody records;
- Laboratory documentation (results received from the laboratory will be documented both in report form and in an electronic deliverable format); and
- DSRs.

Hard-copy field and laboratory records shall be maintained in the project's central data file, where original field and laboratory documents are filed chronologically for future reference. These records are also scanned to produce electronic copies. These electronic copies, along with all electronic field and laboratory records, are maintained on a central server system with backup scheduled daily, as described in the BPSOU Final Data Management Plan (DMP) (Atlantic Richfield, 2020b). The Server Administrator is responsible for data backups, and potential data restoration.

Before field and laboratory data are incorporated into the project database, the data and supporting documentation shall be subject to appropriate review to ensure the accuracy and completeness of original data records. Field data that has been reviewed in a hard-copy format will be entered into electronic data files for upload to the project database. All manual data entry into an electronic format will be reviewed by a separate party before such data are incorporated into the database. Laboratory electronic data deliverables (EDDs) and related data packages will be reviewed as part of the internal data review process. The data flow process is described in greater detail below. The Data Base Coordinator will be responsible for ensuring data integrity prior to database uploads. Following these review steps, field and laboratory electronic data files will be imported to the project database. Procedures for data storage, archival, and retrieval are fully explained in the DMP (Atlantic Richfield, 2020b).

The DMP describes the complete data flow process, from data acquisition to data production, storage, and retrieval. Data collectors (acquisition) collect data, and provide documentation in logbooks, electronic field forms, and paper field forms (habitat assessment) in conformance with this QAPP. For data collected under this QAPP, laboratories will provide data directly to Atlantic Richfield's EQuIS data management system. Once analytical data is submitted, the data undergoes QA/QC, to verify the data was collected and produced in accordance with the QAPPs, and once verified, the data is incorporated into the database. Macro-enabled Excel spreadsheets have been developed to enable data retrieval for validation. These spreadsheets are populated during the data validation process and resubmitted to the data management team. The validated data, including associated validation qualifiers, codes, quality designation for each data point and Level A/B status for each sample, is then uploaded to the database. Validated data will be submitted to the EQuIS system once review and validation is complete. QA/QC checks are in place to ensure that data upload is successful, and that data quality is preserved. Once data has been uploaded to the database, only the data management system coordinator has access to perform any edits. Data can be retrieved through the EQuIS system, or by written request to the database coordinator.

Currently geospatial data is stored in a Geodatabase, non-geospatial data is stored in Microsoft (MS) Structured Query Language (SQL) databases or MS Access databases. This SQL/Geodatabase combination allows integration of spatial data (site locations, property information, geographic place names, site features, topography, and aerial collected imagery) with non-spatial information (analytical data) to provide a comprehensive database that contains all relevant site information.

As part of the duties of operating and maintaining the database, the Database Coordinator, including the EQuIS system administrator, shall develop specific procedures, forms, and systems for accurate import and export of data. For instance, the Database coordinator shall work with Data Collectors or Data Producers to identify appropriate formats and procedures for receiving data into the system. Part of these formats will include a confirmation that the data was collected following the correct standardized procedure. This may mean that Data Producers supply laboratory data in standard, approved EDDs. The Database Coordinator shall verify the accurate import of data supplied by Data Collectors and Data Producers. This shall include working with Data Collectors/Producers to perform appropriate QA and input of appropriate supplemental information (e.g., metadata) to document and describe the receipt and handling of the data. The Database Coordinator will also develop standard request forms or procedures by which Data Users may request data to be exported from the database.

4.0 ASSESSMENT AND OVERSIGHT

Assessment and oversight of data collection and reporting activities are designed to verify that sampling, chemical analyses, and taxonomic processing are performed in accordance with the procedures established in this QAPP. The audits of field and laboratory activities include two independent parts: internal and external audits. Internal audits will be performed by the QAO and/or QAM as necessary, and audit reports will be submitted to the CPM. External audits will be performed by the EPA as necessary.

Performance and systems audits of field and laboratory data collection and reporting procedures are described in this section.

4.1 Corrective Actions

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

Nonconforming equipment, items, activities, conditions, and unusual incidents that could affect data quality and attainment of the project's quality objectives will be identified, controlled, and reported in a timely manner. The person finding the nonconformity is responsible for reporting to the field team leader and ensuring that the condition is reported to the project manager. In regard to equipment nonconformity, the field team leader, or their designee is responsible for recording the nonconformity in the electronic equipment log, and for ensuring that the nonconformity is corrected. In regard to conditions that are not equipment related, the person finding the irregular condition is responsible for providing documentation in the field book and the electronic field form. The field book entry may reference a more thorough entry on the electronic form, or vice versa, but the cross-reference must be provided. For this QAPP, a nonconformance is defined as a malfunction, failure, deficiency or deviation that renders the quality of an item unacceptable or indeterminate in meeting the project's quality objectives.

Corrective action in the laboratory may occur prior to, during and after initial analyses or taxonomic processing and will be reported to the LM and QAO. Several conditions such as broken sample containers (taxonomy or analytical laboratory), preservation or holding-time issues and potentially high-concentration samples may be identified during sample log-in, just prior to analysis, or during analysis. Corrective actions to address these conditions will be taken in consultation with the LM and QAO and reported on a CAR, an example of which is included in Appendix F. If corrective action requests are not in complete accordance with approved project planning documents, the LM will consult with EPA, and concurrence will be obtained before the change is implemented.

If during analysis of the samples, the associated laboratory QC results fall outside of the project's performance criteria, the laboratory should initiate corrective actions immediately. Table 9 indicates the performance criteria for specific analytical methods and the appropriate corrective actions to be completed if QC results are outside of the project specifications. Following consultation with lab analysts and section leaders, it may be necessary for the Laboratory Quality Manager to approve the implementation of a corrective action. These conditions may include dilution of samples, additional sample extract cleanup, automatic re-analysis when certain QC criteria are not met, etc. If the laboratory cannot correct the situation that caused the nonconformance and an out-of-control situation continues to occur, or is expected to occur, then the laboratory will immediately contact the QAO and request instructions regarding how to proceed with sample analyses.

If problems associated with BMI or habitat assessment fieldwork or laboratory processing are identified prior to the end of the index period (June 21 to October 15), a CAR will be completed and the CAP will include a review of the protocols and methods described within this QAPP. After this review, a repeat site visit may be made to re-collect the sample if the dataset is incomplete or incorrectly collected. If problems are identified in the BMI data, those problems should be addressed by again collecting all in-situ water chemistry and BMI parameters. However, because habitat is mostly constant within an index period, if the data in question are related to habitat, only the missing habitat information needs to be collected. Before the second sampling, the investigator must review the biomonitoring portions of this QAPP and supporting information, where appropriate, to understand the protocols.

If problems associated with biomonitoring are identified after the index period, a CAR, and subsequent CAP, will be completed, the data will be flagged and a narrative explaining the problem will be included in the DSR. If the data are incomplete, or if a DQO was not met, the data will not be considered as having met the objectives of BPSOU biomonitoring.

Completion of any corrective action should be evidenced by data once again falling within the project's performance criteria. If this is not the case, and an error in laboratory procedures or sample collection and handling procedures cannot be found, the results will be reviewed by the LM, or their designee, with input from others to assess whether re-analysis or re-sampling is required.

All corrective actions taken by the laboratory will be documented in writing by the Laboratory Project Manager and reported to the CPM and QAO. If corrective action requests are not in complete accordance with approved project planning documents, EPA will be consulted, and concurrence will be obtained before the change is implemented. All corrective action records will be included in the program's quality records.

4.2 Corrective Action during Data Assessment

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

4.3 Quality Assurance Reports to Management

Quality Assurance Reports to management will include DSRs, quarterly data reports, Field Audit Reports, CARs, and Data Assessment Reports (within DSRs). Atlantic Richfield will prepare a DSR for the sampling activities described in this QAPP annually. The DSR will contain a discussion of the data quality assessment, which is also referred to as a data validation report, as an appendix. The data quality discussions/data validation report will contain, on a routine basis, the results of any associated field and laboratory measurements and analyses, information generated on the achievement of specific DQOs, and a summary of any corrective actions that were implemented and their immediate results on the project.

The CPM and QAO are responsible for preparation of the DSR. The DSR will be submitted in draft form to the EPA for review in May of the year following data acquisition. Upon receipt of comments, the draft DSR will be revised to address the comments and resubmitted to the EPA within 60 days for final approval.

Any Field Audit Reports and CARs associated with the project will be submitted to management on a quarterly basis.

5.0 DATA VALIDATION AND USABILITY

The following sections address the final project checks conducted after the data collection phase of the project is completed to confirm that the data obtained meet the project objectives and to estimate the effect of any deviations on data usability.

5.1 Data Review and Verification

The process to be used for reviewing and verifying field data and the internal laboratory data review and reporting process are described in the following sections. Laboratory data reporting requirements, which describe how results are conveyed to data validators, are also discussed.

5.1.1 Field Data Review

Raw field data shall be entered in field logbooks, on electronic field forms, or on paper forms (habitat assessment), which shall be reviewed for accuracy and completeness by either the Field Team Leader or the BMI Team Leader, as appropriate, before those records are considered final. The Field Team Leader or the BMI Team Leader may designate a qualified team member to review field logbooks and field forms. The overall quality of the field data from any given sampling round shall be further evaluated during the process of data review and reporting.

Field data review and reporting procedures will be minimal in scope compared to those implemented in the laboratory setting. Field data review will include verification that any QC checks and calibrations, if necessary, are recorded properly in the field logbooks and/or on electronic forms and that any necessary and appropriate corrective actions were implemented and recorded. QC checks, calibrations, and any corrective actions will be written into field logbook and/or recorded on forms immediately after they occur. If errors are made in logbooks or on habitat assessment forms, results will be legibly crossed out, initialed, and dated by the field team member, and corrected in a space adjacent to the original (erroneous) entry. If mistakes are made in electronic forms, the original form and output file are preserved, a revised output file is developed, and the data in the replacement file is entered into the database. In a reasonable time frame, the Field Team Leader, the BMI Team Leader, or a designee, will proof the field logbooks and electronic field forms to determine whether any transcription errors have been made by the field crew. If transcription errors have been made, the Field Team Leader and field crew will address the errors to provide resolution.

Appropriate field measurement data will be uploaded from electronic field forms for project database entry. Data entries will be made directly from electronic field forms which have been reviewed for accuracy and completeness by a separate party, prior to submittal to the database manager. Electronic files of field measurement data will be maintained as part of the project's quality records.

Should the database manager, or a data user, find suspect data, the suspect data point will be investigated. If the data point is found to be in error, it will be corrected in the database, and the database manager will be responsible for any necessary notifications of the data revision or redistributions of the data.

5.1.2 Laboratory Data Review

Internal laboratory data review and reporting procedures will be per each laboratory's Quality Management Plan. At a minimum, records shall be maintained by the analysts to document sample identification number with sample results and other details, such as the analytical method used (e.g., method SOP #), name of analyst, the date of analysis, matrix sampled, reagent concentrations, instrument settings, and the raw data. These records shall be signed and dated by the analyst. Minimal requirements for taxonomy laboratories include records maintained by the taxonomist to document sample identification number with sample results, name of the taxonomist and the date(s) of subsampling, sorting, and taxonomic identification, with the records signed and dated by the taxonomist. Secondary review of records by the laboratory's supervisor (or designee) shall take place prior to final data reporting to Atlantic Richfield. Laboratories shall appropriately flag unacceptable data in the data package. Shall any deficiencies with the potential to change analytical results be found during laboratory review of previously reported data, Atlantic Richfield, or their representative, will be immediately notified, and a revised report and EDD will be issued.

5.1.3 Laboratory Data Reporting Requirements

Laboratories shall prepare electronic data packages for transmittal of results and associated QC information to Atlantic Richfield or their designee. Analytical data will undergo Stage 2a validation for all surface water and sediment samples. A Limited (Stage 2a validation) analytical data package shall include at a minimum, the case narrative, all sample results, units and quality control sample results. Limited data packages shall be transmitted to Atlantic Richfield or their designee within 14 days of laboratory sample receipt. Refer to Appendix G for the components of a Limited analytical data packages.

The analytical laboratory shall prepare electronic data packages for transmittal of results and associated QC information to Atlantic Richfield, or their designee, in a format compatible with EQuIS requirements. Deviations from these specifications may be acceptable provided the electronic report presents all requested types of information in an organized, consistent, and readily reviewable format.

Taxonomic laboratory packages will include a case narrative, all sample results, and QA/QC sample results, at a minimum. Taxonomic laboratory data packages will be transmitted to Atlantic Richfield or their designee within a six-month turnaround time.

5.1.4 Laboratory Electronic Data Deliverable

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

5.1.5 Specific Quality Control/Assessment Procedures

The accuracy, precision, completeness, representativeness, and sensitivity of analytical data will be described relative to the project's control limits through a process of field and laboratory data quality review. Results from these reviews will be documented in a Data Quality Assessment Report prepared for all data users. Any qualification of the data resulting from that review will also be incorporated into the project's electronic database so that all data users are aware of any uncertainties associated with individual results.

5.2 Internal Data Review

Data review is the process of verifying that information generated relative to a given sample is complete and accurate. Data review involves examining each data point to see that it meets frequency, accuracy, and precision criteria. Data review procedures shall be performed for both field and laboratory operations as described below and in accordance with the criteria in Table 19. A thorough review of data enables the subsequent data assessment, which is further described below.

Table 19 – Validation Criteria for Analytical Laboratory and Field Quality Control Samples (see Tables section)

5.2.1 Field Quality Control Data

The results of field quality control sample analyses associated with each laboratory data package will be reviewed to allow for evaluation of field blanks and other field QC samples and further indications of the data quality. If a problem is identified through the review of field QC data, all associated field samples will be identified, and if possible, corrective actions can be instituted and documented on a CAR. If corrective action requests are not in complete accordance with approved project planning documents, the EPA will be consulted, and concurrence will be obtained before the change is implemented. If data are compromised due to a problem identified via field QC sample review, appropriate data qualifications will be used to identify the data for future data users. These qualifiers will be included with tabulated data presented in the Data Assessment section of DSRs.

The handling, preservation and storage of samples collected during the sampling program will be monitored on an on-going basis. The project laboratories will document sample receipt including proper containers and preservation at the time samples are logged in by the laboratory. The sample receipt records (a required data package deliverable), as well as the chain-of-custody documentation, will also be assessed during data review.

5.2.2 Analytical Laboratory Data

The second level of analytical data review will be performed by the QAO, or their designee, and will include a review of laboratory performance criteria and sample-specific criteria. One hundred percent of project data will be reviewed and validated. Data validation will follow the Woodard & Curran Data Validation Guidelines which incorporate validation guidelines from the National Functional Guidelines for Inorganic Superfund Methods Data Review (EPA, 2020b), but align with method-specific criteria. An additional responsibility of the QAO will be to determine whether the DQOs have been met and calculate the data completeness for the project.

Data quality review is a process to determine if the data meet project DQOs. Data quality review will include verification of the following:

- Compliance with the QAPP,
- Proper sample collection and handling procedures,
- Holding times,
- Field QC results,
- Laboratory blank analysis,
- Laboratory control sample percent recovery,
- Detection limits,
- Laboratory duplicate relative percent differences,
- MS/MSD percent recoveries and relative percent differences,

- Data completeness and format, and
- Data qualifiers assigned by the laboratory.

Refer to Appendix H, Exhibit 1 for components of Stage 2a data quality review. Qualifiers that may be applied to the data include the following:

U The analyte was analyzed for but was not detected above the method detection limit.

J The analyte was positively identified but was not detected above the reporting limit; the associated numerical value is an estimate of the concentration of the analyte in the sample.

UJ The analyte was not detected above the sample reporting limit. However, the reporting limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Additional qualifiers can be found in Appendix H, Exhibit 4.

A Data Quality Assessment (DQA) will be performed to determine whether the project-specific DQOs have been satisfied. The DQA consists of five steps that relate the quality of the results to the intended use of the data:

Step 1: Review DQOs and sampling design

Step 2: Conduct preliminary data review

Step 3: Apply Statistical test(s) as described in this QAPP to the data set

Step 4: Verify assumptions

Step 5: Draw conclusions about the quality of the data (data report will not include interpretation of results, but will state conclusions regarding the quality of the results).

Data points may be assigned a qualifier during data review based on a failure to meet frequency, accuracy, or precision criteria. Appendix H, Exhibit 4 provides a description of data validation qualifiers. Data assessment involves assigning a status of Enforcement (E), Screening (S), or Rejected (R) to each data point. Table 20 provides a summary of status assignment. Data that are only qualified as a result of the value reported between the laboratory reporting and the detection limit (A qualifier) are considered enforcement quality. Enforcement quality data meet all QA/QC and documentation requirements. Screening quality data do not meet the applicable QA/QC requirements and/or documentation requirements. Unusable data (R) may result from inappropriate sampling, analysis, or documentation procedures. In reviewing documentation requirements, a Level A/B checklist is completed. This checklist is provided as Exhibit 3 in Appendix H. Level A data partially meets documentation requirements; while level B data meets all documentation requirements. Level A/B status is not assigned to individual data points, but rather to samples (all data points for an individual sample). A Stage 2a laboratory data validation checklist is included in Appendix H as Exhibit 1 and a field QC checklist is provided as Exhibit 2.

Table 20 – Summary of Status Assignment (Enforcement/Screening/Unusable)

Data Validation Qualifier	Level A/B Designation		
	Level B	Level A	Rejected
No qualifier, U, or A	Enforcement	Screening	Unusable
J or UJ	Screening	Screening	Unusable
R	Unusable	Unusable	Unusable

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

Results of the QA review and/or validation will be included in any subsequent report, which will provide a basis for meaningful interpretation of the data quality and evaluate the need for corrective actions. The QAO is responsible for review of project QA and/or validation.

5.2.3 Taxonomic Laboratory Data

Taxonomy data quality review will include verification of the following:

- Compliance with the QAPP;
- Proper sample collection and handling procedures;
- Proper sample preservation;
- Field QC results;
- Data completeness and format;
- Taxonomy QA/QC procedures (Section 3.5.4); and
- Data qualifiers or taxonomic assumptions (resolution) assigned by the laboratory.

If, as a result of the DQA process, it is determined that data do not satisfy all DQOs, then corrective action will be recommended and documented in the data reporting. Corrective actions can include, but are not limited to, revising the DQOs, based on the results of the investigation, or collecting more information. It could be determined that corrective actions are not required, or the decision process should continue with the existing data, with recognition of the limitations of the data.

The results from the DQA process will be presented as an appendix to the DSR. If the need for corrective actions are identified during collection of field data or laboratory processing of BMI samples and warrant additional field sampling that same year as described in Section 4.1, EPA will be notified, and corrective actions will be proposed to occur as soon as practical.

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TABLES

Table 1 - Summary of Project Tasks

Water Quality Sampling Tasks: Water quality samples will be collected monthly during normal flow conditions using the method described in Section 3.2.2.3. Water quality samples will be collected during wet weather conditions as defined in the Wet Weather Criteria SOP in Appendix A, using the method described in Section 3.2.2.3.

Flow Measurement Tasks: Flow measurements will be taken during normal flow water quality sampling. For wet weather water quality sampling, continuous flow recorders and stage-discharge curves will be used to determine flow. Flow measurement methods are detailed in Section 3.2.2.2

Surface Water Monitoring Schedule: Normal flow sampling will take place once a month, January through December, at eight locations along Silver Bow and Blacktail Creek. Wet weather sampling will take place up to two times a month at seven creek sites and two diagnostic stations, April through September, when flow in BTC or SBC exceeds the criteria identified in the Wet Weather Trigger SOP (see Appendix A).

Surface Water Analysis Tasks: Laboratory analysis for water quality parameters consistent with EPA approved test methods for inorganic constituents including: total and dissolved metals and metalloids, anions (nitrate + nitrite, phosphorous, and sulfate), alkalinity, dissolved organic carbon, hardness, nutrients (ammonia and total Kjeldahl nitrogen (TKN)), and total dissolved and suspended solids in accordance with EPA approved analytical methods.

Sediment Monitoring Tasks: Sediment samples will be collected annually using the method described in Section 3.2.2.4.

Sediment Monitoring Schedule: Sampling will be conducted annually on a schedule consistent with BMI monitoring, targeting mid-August to early September of each year.

Sediment Analysis Tasks: Samples will be analyzed for pH and particle size (clay, silt, sand), and bulk samples will be analyzed for total organic carbon (TOC), arsenic, cadmium, copper, lead, mercury, and zinc in accordance with EPA approved analytical methods.

BMI Monitoring Tasks: BMI community monitoring will be performed and physical habitat assessments made using the methods described in Section 3.2.2.5 and 3.2.2.6.

BMI Monitoring Schedule: BMI monitoring will be conducted annually. Habitat monitoring will be conducted every five years or more frequently as necessary. Both monitoring efforts will target a mid-August to early September timeframe.

BMI Analysis Tasks: Laboratory data generated from BMI monitoring will include taxonomic identification and macroinvertebrate density counts.

Quality Control Tasks: All laboratory analytical matrices (surface water and sediment samples) will have the following field QC samples analyzed: 1 field duplicate for every 20 primary samples, and 1 field blank collected for every 20 primary samples if sampling equipment is reused across sample locations. Laboratory QC samples will include method blanks, laboratory control samples, laboratory duplicate samples, and matrix spike samples, as applicable to the method and the sample matrix.

BMI sampling will include field replicate samples collected at each site. Laboratory QC for BMI assessment will include determining the Relative Percent Difference in Enumeration (RPDE) and the Percent Taxonomic Disagreement (PTD). Both the RPDE and PTD are based on confirmation of original counts and taxonomic classifications.

Data Management Tasks: Analytical data will be reviewed and evaluated for quality by the project's QAO and placed in the site database. Taxonomic data will be reviewed by the BMI Team Advisor before being placed in the site database.

Documentation and Records: All surface water samples collected will have surveyed locations. Sediment and BMI samples are collected within stream reaches, and both midpoints and reach endpoints will have surveyed locations. Coordinates for exact sediment monitoring points will be captured with electronic tablets, thus, precise within 5 meters. All samples will have records of each sample collected and all field measurements will be appropriately documented.

Data Packages: Limited (standard) data packages will be provided for all analytical data and will include results in mg/L, or other applicable units, of all constituents analyzed. BMI data packages will present QC results as percentages and taxonomic data will be presented as counts and densities.

Table 2 - 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

Table 3 – Sediment Probable Effect 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

Table 4- Flow Measurement Sites, Frequency, and Monitoring Method

Site	Creek Normal Flow Monitoring	Creek Wet Weather Monitoring	Sub-Drainage Wet Weather Diagnostic Monitoring
SS-01	Monthly Manual Flow Measurement with portable flow meter	Continuous Stage Monitoring with ISCO Flow Meter and Solinst pressure transducer	N/A
SS-01.35	Monthly Manual Flow Measurement with portable flow meter	Continuous Stage Monitoring with ISCO Flow Meter. Monitored by USGS	N/A
SS-04	Monthly Manual Flow Measurement with portable flow meter	NA	N/A
SS-05	Monthly Manual Flow Measurement with portable flow meter	NA	N/A
SS-05A	Monthly Manual Flow Measurement with portable flow meter	NA	N/A
SS-06A	Monthly Manual Flow Measurement with portable flow meter	NA	N/A
SS-06G	Monthly Manual Flow Measurement with portable flow meter	Continuous Stage Monitoring with ISCO Flow Meter	N/A
SS-07	Monthly Manual Flow Measurement with portable flow meter	Continuous Stage Monitoring with ISCO Flow Meter. Monitored by USGS	N/A
MG-CLV-0	N/A	N/A	Continuous Flow Monitoring with ISCO A-V Meter
MSD-CLV-3A	N/A	N/A	Continuous Flow Monitoring with ISCO A-V Meter and Sutron Stage Recorder

Table 5 - Water Quality Sites, Frequency, and Sampling Method

Site	Creek Normal Flow Monitoring	Creek Wet Weather Monitoring[1]	Sub-Drainage Wet Weather Diagnostic Monitoring[2]
SS-01	Manual Monthly Sample	ISCO 3700 and D-TEC TIENet 301 /ISCO Signature continuous pH	N/A
SS-01.35	Manual Monthly Sample	ISCO 3700 and D-TEC	NA
SS-04	Manual Monthly Sample	N/A	N/A
SS-05	Manual Monthly Sample	N/A	N/A
SS-05A	Manual Monthly Sample	N/A	N/A
SS-06A	Manual Monthly Sample	N/A	N/A
SS-06G	Manual Monthly Sample	ISCO 3700 and D-TEC TIENet 301 /ISCO Signature continuous pH	N/A
SS-07	Manual Monthly Sample	ISCO 3700 and D-TEC TIENet 301 /ISCO Signature continuous pH	N/A
MG-CLV-0[3]	N/A	N/A	ISCO 3700
MSD-CLV-3A	N/A	N/A	ISCO3700

[1] All Creek Wet Weather sites will be sampled at a frequency as determined by actual rain events that cause creek conditions to meet the general wet weather sampling criteria as defined in the Wet Weather Criteria SOP in Appendix A.

[2] All Sub-Drainage Wet Weather Diagnostic sites will be sampled at a frequency as determined by actual rain events over 0.15" and up to two events per month.

[3]Opportunistic sampling may occur at this location due to O&M activities at Missoula Gulch basins. Sampling event will be triggered by a notification from BSB that O&M activities are being conducted

Table 6 –- Proposed Sediment and BMI Monitoring Stream Reach Locations and Sampling Frequency

Reach	Description	Associated Surface Water Station	Station Location with respect to Reach	Frequency
1	BTC above BPSOU	SS-01	Endpoint, reach extends ~ 500 ft upstream	Annually
2	SBC within BPSOU, below the BTC and SBC confluence within LAO	SS-06A	Approximate midpoint, equal distances upstream and downstream	Annually
3	SBC near western boundary of BPSOU	SS-06G	Endpoint, reach extends upstream to just below BTL effluent	Annually

Table 7 - BMI Community Metrics

Metric	Definition
Taxa Richness	Number of BMI taxa per Hess sample, measures variety of assemblage. Historically the best measure of site conditions.
Shannon diversity	Influenced by taxa richness and distribution of individuals among taxa (evenness).
EPT/EPTC	Relative abundance of Ephemeroptera, Plecoptera, Trichoptera to Chironomidae ratio
Hydropsychinae/ Trichoptera	Hydropsychinae is relatively more tolerant of pollution than most other caddisflies.
Baetidae/ Ephemeroptera	Baetidae are most pollution-tolerant mayflies.
Density *+	Number of individuals per unit of area.
Biotic Index *	SUM (%RAi * ti), %RAi is the percent relative abundance of each taxon and ti is the tolerance value of the taxon.
Percent Filter Feeders *	Abundance of these functional feeding groups provides information on energy transfer, food resources, and organic loading.
EPT richness+	Richness of Ephemeroptera, Plecoptera, and Trichoptera
Metal Tolerance Index+	Quantifies changes in BMI community and based on Hilsenhoff's biotic index with tolerance values assigned to taxon.
Percent dominant	Percent of most dominant taxon in a sample.
Percent tolerant	Organisms (%) sensitive to perturbation.

(*) indicates metric is part of a subset used for indicating organic pollution and (+) indicates metric is part of a subset used for indicating metals pollution.

Table 8 - Precision, Accuracy and Completeness Calculation Equations

Characteristic	Formula	Symbols
Precision (as relative percent difference, RPD)	$RPD = \frac{(x_i - x_j)}{\left(\frac{x_i + x_j}{2}\right)} \times 100$	x_i, x_j: replicate values of x
Precision (as relative standard deviation, RSD, otherwise known as coefficient of variation)	$RSD = \frac{\sigma}{\bar{x}} \times 100$	σ: sample standard deviation $\bar{x}$: sample mean
Precision (as percent taxonomic disagreement (PTD)	$PTD = \left[1 - \left(\frac{comp_{pos}}{N}\right)\right] \times 100$	$comp_{pos}$: the number of agreements N: total number of organisms
Accuracy (as percent recovery, R, for samples without a background level of the analyte, such as reference materials, laboratory control samples and performance evaluation samples)	$R = \frac{x}{t} \times 100$	x: sample value t: true or assumed value
Accuracy (as percent recovery, R, for samples with a background level of the analyte, such as matrix spikes)	$R = \frac{SSR - SR}{SA} \times 100$	SSR: spiked sample result SR: sample result SA: spike added
Accuracy (as percent difference, D, for samples > 50X the MDL, which have undergone at least a five-fold dilution, with the result, S, corrected for the dilution)	$D = \frac{\lvert I - S \rvert}{I} \times 100$	I: initial sample result S: serial dilution result
Completeness (as a percentage, C)	$C = \frac{n}{N} \times 100$	n: number of valid data points produced N: total number of samples taken

Table 9 - Summary of Laboratory Quality Control Checks

Laboratory QC	Analysis	Method	Frequency[1]	Control Limits[1]	Corrective Action[2]
Method Blank (MB)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	One in every 20 samples	1/2 RL	Re-analyze associated samples unless: sample results are non-detect, sample results are >10X the MB result. If this is not true, all associated samples > MDL & < 10X MB result should be redigested (if applicable) and reanalyzed. If insufficient sample for re-analysis, report results with qualifier.
	Mercury	SW846 7470/7470A SW846 7471/7471B EPA 245.1			
	Alkalinity	SM2320B			
	Sulfate	EPA 300.0			
	$NO_2 + NO_3$	EPA 353.2			
	NH_3	EPA 350.1			
	TKN	EPA 351.2			
	DOC	SM 5310C			
	Total Phosphorus	SM45000-P-F			
	TDS	SM 2540C			
	TSS	SM2540D			
	TOC	Walkley Black			
	pH	ASA 10.3.2			
Laboratory Control Spike (LCS)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	One in every 20 samples	80-120% of true value EPA 200.8 - 85-115% of true value	Terminate analysis, correct problem, redigest (if applicable) and reanalyze all samples prepared with non-compliant LCS.
	Mercury	SW846 7470/7470A SW846 7471/7471B EPA 245.1		80-120% of true value EPA 245.1 - 85-115% of true value	
	Alkalinity	SM2320B		90-110% of true value	
	Sulfate	EPA 300.0			
	$NO_2 + NO_3$	EPA 353.2		90-110% of true value	
	NH_3	EPA 350.1			
	TKN	EPA 351.2			
	DOC	SM 5310C		80-120% of true value	
	Total Phosphorus	SM45000-P-F		90-110% of true value	
	TDS	SM 2540C		80-120% of true value	
	TSS	SM 2540D			
	TOC	Walkley Black		40-179%, varies with standard	
	pH	ASA 10.3.2		Varies with standard	Evaluate associated samples for impact, and reanalyze as necessary. Qualify data at a minimum.

Table 9 - Summary of Laboratory Quality Control Checks

Laboratory QC	Analysis	Method	Frequency[1]	Control Limits[1]	Corrective Action[2]
Laboratory Control Spike Duplicate (LCSD)	Alkalinity	SM2320B	One in every 20 samples	≤ 20% RPD	Terminate analysis, correct problem, redigest (if applicable) and reanalyze all samples prepared with non-compliant LCS.
Laboratory Duplicate Sample (LDS)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	One in every 20 samples (MSD serves as LDS)	≤ 20% RPD	Should LDS samples fail to meet control limits, and the samples in the associated batch are of a similar matrix, then associated sample results should be flagged. If samples in the associated batch are not similar to the parent sample used for the LDS, then only the parent sample used to prepare the duplicate should be flagged.
	Mercury	SW846 7470/7470A SW846 7471/7471B EPA 245.1			
	Alkalinity	SM2320B	One in every 10 samples (MSD serves as LDS)		
	Sulfate	EPA 300.0			
	$NO_2 + NO_3$	EPA 353.2			
	NH_3	EPA 350.1			
	TKN	EPA 351.2	On in every 20 samples	≤ 10% RPD	
	DOC	SM 5310C		≤ 25% RPD	
	Total Phosphorus	SM45000-P-F	One in every 10 samples (MSD serves as LDS)	≤ 20% RPD	
	TDS	SM2540C	One in every 10 samples	≤ 5% RPD	Qualify data. If RPD > 50% reanalyze parent sample in duplicate to confirm results.
	TSS	SM2540D			
	TOC	Walkley Black		≤ 20% RPD	Report with a qualifier
	pH	ASA 10.3.2			Evaluate associated samples for impact, and reanalyze as necessary. Qualify data at a minimum.

Table 9 - Summary of Laboratory Quality Control Checks

Laboratory QC	Analysis	Method	Frequency[1]	Control Limits[1]	Corrective Action[2]
Matrix Spike (MS)/Matrix Spike Duplicate (MSD)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	MS One in every 20 samples EPA 200.8 MS - One in every 10 samples MSD one in every 20 samples	75-125% of true value EPA 200.8 - 70-130% of true value ≤ 20% RPD	Should MS/MSD samples fail to meet control limits, and the samples in the associated batch are of a similar matrix, then associated sample results should be flagged. If samples in the associated batch are not similar to the parent sample used for the MS/MSD, then only the parent sample used to prepare the spike should be flagged. MS/MSD% recovery criteria are waived if parent sample concentration is > 4X spike concentration.
	Mercury	SW846 7470/7470A SW846 7471/7471B EPA 245.1	One per batch EPA 245.1 - 1 per batch & if > 11 samples in a batch, an additional MS is required.	7000 series: 80-120% of true value EPA 245.1 - 70-130% of true value ≤ 20% RPD	
	Alkalinity	SM2320B	One in every 10 samples	80-120% of true value ≤ 20% RPD	
	Sulfate	EPA 300.0			
	$NO_2 + NO_3$	EPA 353.2		80-120% of true value ≤ 20% RPD	
	NH_3	EPA 350.1		90-110% of true value ≤ 20% RPD	
	TKN	EPA 351.2		90-110% of true value no MSD	
	DOC	SM 5310C	One in every 20 samples	80-120% of true value No MSD	
	Total Phosphorus	SM45000-P-F	One in every 10 samples	80-120% of true value ≤ 20 % RPD	
Post Digestion Spike	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	If reporting by 6020 and MS/MSD fails 75-125% recovery	6020/6020A: 80-120% 6020B: 75-125%	Qualify data
Serial Dilution (SD)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	One in every 20 samples	6020/6020A/EPA 200.8 - 1:5 dilution 10% difference of original result when original sample is ≥ 50X the MDL 6020B - 20% difference of 1:5 dilution of MS or samples with concentration 25X the lower limit of quantification (LLOQ) in parent sample	Should SD fail to meet control limits, and the samples in the associated batch are of a similar matrix, then associated sample results should be flagged. If samples in the associated batch are not similar to the parent sample used for the SD, then only the parent sample used to prepare the duplicate should be flagged.

[1]Frequency and control limits are based on SW846 and EPA Methods. For analyses performed by Standard Methods, ASTM, Walkley Black, and ASA methods, frequency and control limits are based on Pace Analytical SOPs.

[2]Corrective actions are sequential for cases indicating multiple corrective actions. If the first corrective action is not sufficient to bring analysis back into control, the second action noted will be implemented.

Table 10 - Surface Water Monitoring Site Coordinates and Location Description

Site	Coordinates		Description
	Latitude	Longitude	
SS-01	45.985271	-112.507762	Blacktail Creek (BTC) USGS Station at Harrison Ave, upstream of the BPSOU. USGS WQ monitoring to be discontinued at this site with the establishment of station 12323233 (SS-01.35)
SS-01.35	45.991139	-112.527239	Blacktail Creek USGS station upstream of Grove Gulch
SS-04	45.994635	-112.536114	Blacktail Creek upstream of its confluence with the SBC near George Street.
SS-05	45.995769	-112.539176	SBC station at Montana Street, downstream of the SBC-BTC confluence and below the BG outfall.
SS-05A	45.996215	-112.544249	Station located at the beginning of the SBC rebuilt floodplain at the east end of LAO; downstream of old SBC diversion channel.
SS-06A	45.994484	-112.551751	Station located in rebuilt SBC floodplain upstream of the Montana Pole Treatment Plant (MPTP) effluent discharge.
SS-06G	45.996413	-112.562797	Station located at end of the SBC rebuilt floodplain at the west end of LAO, downstream of the Montana Pole Treatment Plant and Butte Treatment Lagoons discharge points and upstream of the historic HCC outlet and the Butte Metro Sewage Treatment Plant effluent.
SS-07	45.996626	-112.563646	Station located downstream of all BPSOU drainage outfalls as SBC exits the OU near Interstate 90.
MG-CLV-0	45.996758	-112.544017	Provides diagnostic monitoring of Missoula Gulch discharge entering into SBC between SS-05A and SS-05B.
MSD-CLV-3A	45.995375	-112.530662	Post reclamation SBC station located upstream of its confluence with BTC, just east of Kaw Ave, and upstream of the end of the sub-drain collection pipe.

Table 11 - Creek Monitoring Parameter List and Associated Analytical Methods, Approximate Method Detection Limits, Reporting Limits, and Holding Times

Analyte	Resolution	Accuracy	Source	Event Monitored
Field Parameters - Field Measured with YSI Professional Plus				
Dissolved Oxygen (mg/L)	0.01	Greater of ± 2% or reading or 0.2 mg/L	CFRSSI SOPs	NF
Temperature (°C)	0.1	0.2	CFRSSI SOPs	NF
pH (s.u.)	0.01	0.2	CFRSSI SOPs	NF
Specific Conductivity (µs/cm)	0 to 500 µS/cm: 1 µS/cm 501 to 5000 µS/cm: 10 µS/cm	Greater of 1 µS/cm or ± 0.5% of reading	CFRSSI SOPs	NF

Trace Elements – Total Recoverable and Dissolved Fractions[1] (ug/L)

Analyte	MDL (µg/L)	Reporting Limit (µg/L)	Holding time (days)	Method	Source	Event Monitored
Aluminum	9.1	30	180 Days	EPA 200.8	EPA	NF, WW
Arsenic	0.092	0.50	180 Days	EPA 200.8	EPA	NF, WW
Cadmium	0.022	0.080	180 Days	EPA 200.8	EPA	NF, WW
Dissolved Calcium	23	10	180 Days	EPA 200.8	EPA	NF, WW
Copper	0.42	1.0	180 Days	EPA 200.8	EPA	NF, WW
Iron	11	50	180 Days	EPA 200.8	EPA	NF, WW
Lead	0.056	0.50	180 Days	EPA 200.8	EPA	NF, WW
Dissolved Magnesium	7.1	30	180 Days	EPA 200.8	EPA	NF, WW
Mercury	0.0042	0.010	28 Days	EPA 245.1	EPA	NF, WW
Molybdenum	0.075	0.50	180 Days	EPA 200.8	EPA	NF, WW
Silver	0.13	0.50	180 Days	EPA 200.8	EPA	NF, WW
Zinc	1.9	5.0	180 Days	EPA 200.8	EPA	NF, WW

Table 11 - Creek Monitoring Parameter List and Associated Analytical Methods, Approximate Method Detection Limits, Reporting Limits, and Holding Times

General Laboratory (mg/L)						
Analyte	**MDL (mg/L)**	**RL (mg/L)**	**Holding time (days)**	**Method**	**Source**	**Event Monitored**
Hardness (as $CaCO_3$)	0.086	0.14	180 Days	SM 2340B	Standard Methods	NF, WW
Alkalinity (as $CaCO_3$)	2.4	5.0	14 Days	SM 2320B[2]	Standard Methods	NF, WW
Nitrate + Nitrite	0.031	0.10	28 Days	EPA 353.2	EPA	NF, WW
Sulfate	0.39	1.2	28 Days	EPA 300.0	EPA	NF, WW
TDS	5.0	10	7 Days	SM 2540C[2]	Standard Methods	NF, WW
TSS	5.0	10	7 Days	SM 2540D[2]	Standard Methods	NF, WW
Additional Parameters (mg/L) (only applied to specific stations as listed in the QAPP)						
Analyte	**Resolutio n**	**Accuracy**	**Holding time (days)**	**Method**	**Source**	**Event Monitored**
pH (s.u.)	0.01	0.1	Continuously field measured	TIENet 301/ISCO Signature	CFRSSI SOPs	WW
Analyte	**MDL (mg/L)**	**RL (mg/L)**	**Holding time (days)**	**Method**	**Source**	**Event Monitored[4]**
Ammonia	0.015	0.10	28 Days	EPA 350.1	EPA	NF, WW
Dissolved Organic Carbon	0.38	1.0	28 Days	SM 5310C[5]	Standard Methods	NF, WW
Total Phosphate	0.039	0.10	28 Days	SM 4500-P-F[2]	Standard Methods	NF, WW
Total Kjeldahl Nitrogen	0.45	0.50	28 Days	EPA 351.2	EPA	NF, WW

[1] Calcium and Magnesium dissolved fraction only

[2] Standard method run by 1997 edition

[3] Standard method run by 1997 and 2000 editions

[4] NH_3, DOC, TKN, and Total P collected only for the first WW event of the month. NF and WW collected only at SS-01, SS-01.35 (NF only), SS-06G, and SS-07.

[5] Standard method run by 2000 edition

Table 12 - Sub-Drainage Diagnostic Monitoring Parameter List and Associated Analytical Methods, Approximate Method Detection Limits, Reporting Limits, and Holding Times

Analyte	MDL (μg/L)	RL (μg/L)	Holding time (days)	Method	Source
Trace Elements – Total Recoverable and Dissolved Fractions (ug/L)					
Arsenic	0.092	0.50	180 Days	EPA 200.8	EPA
Cadmium	0.022	0.080	180 Days	EPA 200.8	EPA
Copper	0.42	1.0	180 Days	EPA 200.8	EPA
Iron	11	50	180 Days	EPA 200.8	EPA
Lead	0.056	0.50	180 Days	EPA 200.8	EPA
Mercury	0.072	0.020	28 Days	EPA 245.1	EPA
Zinc	1.9	5	180 Days	EPA 200.8	EPA
General Laboratory (mg/L)					
Sulfate	0.39	1.2	28 Days	EPA 300.0	EPA
TSS	5	10	7 Days	SM 2540D	EPA

Table 13 – Sediment, BMI, and Habitat Monitoring Stream Reach Coordinates

Reach number Associated SW Site	Approximate Upstream Endpoint		Approximate Downstream Endpoint		Description
	Latitude	Longitude	Latitude	Longitude	
Reach 1 SS-01	45.9852	-112.50619	45.985271	-112.507762	BTC above BPSOU Reach extends upstream from SS-01
Reach 2 Ss-06A	45.9946	-112.55107	45.99429	-112.55208	BTC within BPSOU Reach midpoint
Reach 3 SS-06G	45.9963	-112.56158	45.996413	-112.562797	SBC at BPSOU terminus Reach extends upstream from SS-06G

Table 14 - Sediment Monitoring Parameter List and Associated Analytical Methods, Approximate Method Detection Limits, Reporting Limits, and Holding Times

Analyte	MDL (mg/Kg)	RL (mg/Kg)	Holding time (days)	Method	Source
Arsenic	0.14	0.50	180 Days	EPA 6020B	EPA
Cadmium	0.029	0.080	180 Days	EPA 6020B	EPA
Copper	0.31	1.0	180 Days	EPA 6020B	EPA
Lead	0.093	0.50	180 Days	EPA 6020B	EPA
Mercury	0.0087	0.020	28 Days	EPA 7471B	EPA
Zinc	1.2	5	180 Days	EPA 6020B	EPA
TOC	25.5	100	28 Days	Walkley-Black	Soil Science
pH (s.u.)	0.1	0.1	NA	ASA 10-3.2	ASA
Particle Size	0.1%	0.1%	NA	ASA 15-5	ASA

Table 15 - Project SOP References

Reference Number	Title, Revision Date	Originating Organization
G-4	Field Logbook/Photographs	ARCO
G-5	Sample Packaging and Shipping	ARCO
G-6	Field Quality Control Samples	ARCO
G-7	Sample Custody	ARCO
SOP G-8	Decontamination of Equipment Used to Sample Soil and Water	ARCO
SOP-H-01	Water Sampling Equipment Decontamination	Woodard & Curran
SOP-H-02	Downloading Transducers	Woodard & Curran
SOP-H-03	Download Weather Station	Woodard & Curran
SOP-H-05	Calibrate YSI Professional Plus Multi-Meter	Woodard & Curran
SOP-H-08	Transducer Installation	Woodard & Curran
SOP_H-09	Shipping Ethanol preserved BMI Samples	Woodard & Curran
SOP-S-01	Bump Testing the VENTIS MX4 Gas Meter	Woodard & Curran
SOP-SS-02	Streambed Sediment Sample Collection	Woodard & Curran
SOP-SW-01	Surface Water Sampling	Woodard & Curran
SOP-SW-02	Flow Measurements in Wadable Streams	Woodard & Curran
SOP-SW-03	Change H350 Stage Recorder Data Card	Woodard & Curran
SOP-SW-04	Download ISCO Stage Recorder	Woodard & Curran
SOP-SW-05	Download Sutron Stage Recorder	Woodard & Curran
SOP-SW-06	Read Staff Gauge	Woodard & Curran
SOP-SW-07	Change ISCO Batteries and Adjust Stage	Woodard & Curran
SOP-SW-08	Automatic and Mechanical Sampler Setup - Creek and Diagnostic	Woodard & Curran
SOP-SW-09	Collect Sample from DTEC Sampler	Woodard & Curran
SOP-SW-10	Collect Sample from ISCO Sampler	Woodard & Curran
SOP-SW-11	D-TEC Sample Preparation	Woodard & Curran
SOP-SW-12	Surface Water Wet Weather Sample Preparation	Woodard & Curran
SOP-SW-16	Signature Bubbler Setup, Stage Adjustment, and Battery Replacement	Woodard & Curran
SOP-SW-18	Calibrate TieNet 301 pH Sensor (Signature Bubbler)	Woodard & Curran
SOP-SW-19	Download Signature Data Files	Woodard & Curran
SOP-SW-20	Wet Weather Trigger Criteria	Woodard & Curran
SOP-SW-21	Stage-Discharge Curve Creation	Woodard & Curran
SOP-SW-22	Setup and download of ISCO 2150 Area Velocity Meters	Woodard & Curran
SOP-SW-24	Checks of R-Processed A-V Meter Data	Woodard & Curran

Table 16 - Flow Measurement Equipment Specifications

Parameter	Equipment	Unit	Resolution
Manual Flow	Hach FH950	ft/s	±2% of reading
Continual Flow	ISCO 2150 A-V meter	cfs	0.01 cfs
Continual Stage	ISCO 4230 Flow Meter	feet	0.01 ft
Continual Stage	Water Log H350/355 Bubbler System	Feet	0.01 ft
Continual Stage	Solinst Pressure Transducer	Feet	0.01 ft
Continual Stage	Sutron 9210 XLITE Bubbler System	Feet	0.01 ft

Table 17 – Surface Water Monitoring Analytical Bottle Count and Preservative Addition

Analytes	Sampling Container	Preservative	Filter	Comments
General Laboratory				
Alkalinity (as CaCO3)	Polyethylene, 1 x 1 L	None, refrigerate 0°C-6°C	None	1 container for all four analyses
Sulfate	Polyethylene, 1 x 1 L	None, refrigerate 0°C-6°C	None	
Total Dissolved Solids	Polyethylene, 1 x 1 L	None, refrigerate 0°C-6°C	None	
Total Suspended Solids	Polyethylene, 1 x 1 L	None, refrigerate 0°C-6°C	None	
Inorganic Chemicals				
Ammonia	Polyethylene, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	None	1 container for all three analyses
Nitrate+Nitrite	Polyethylene, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	None	
Total Phosphorous	Polyethylene, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	None	
Metals				
Dissolved Metals[A,B]	Polyethylene, 1 x 250 mL	pH<2 nitric acid, refrigerate 0°C-6°C	0.45-micron filter	1 container for all metals
Total Metals[C]	Polyethylene, 1 x 250 mL	pH<2 nitric acid, refrigerate 0°C-6°C	None	1 container for all metals
Additional Parameters				
Dissolved Organic Carbon	Amber Glass, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	0.45-micron filter	-
Total Kjeldahl Nitrogen	Polyethylene, 1 x 250 mL	pH<2 sulfuric acid, refrigerate 0°C-6°C	None	-

[A]Dissolved metals analysis includes: Aluminum, Arsenic, Cadmium, Calcium, Copper, Iron, Lead, Magnesium, Mercury, Molybdenum, Silver, and Zinc.

[B]Hardness determined by SM2340B; calculation using dissolved Calcium and Magnesium concentrations.

[C]Total metals analysis includes: Arsenic, Cadmium, Copper, Iron, Lead, Mercury, Molybdenum, Silver, and Zinc.

Table 18 – Sediment Monitoring Sample Container Requirements

Analytes	Sampling Container	Preservative
Metals[A]	4 oz Amber Glass Jar or equivalent volume in quart re-sealable plastic bag or	None, refrigerate 0°C-6°C
TOC	4 oz Amber Glass Jar	None, refrigerate 0°C-6°C
pH, Particle Size	Quart re-sealable plastic bag (500 g minimum sample volume)	None, refrigerate 0°C-6°C

[A]Metals analysis includes: Arsenic, Cadmium, Copper, Lead, Mercury, and Zinc.

Table 19 - Validation Criteria for Analytical Laboratory and Field Quality Control Samples

Laboratory QC	Analysis	Method	Frequency[1]	Validation Criteria	QC Sample Result	Action for Non-Detect Sample Result	Action for Detect Sample Result
Method Blank (MB)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	One in every 20 samples	< MDL	< MDL	No action	No action
	Mercury	SW846 7470/7470A SW846 7471/7471B EPA 245.1					
	Alkalinity	SM2320B					
	Sulfate	EPA 300.0			> MDL	No action	if ≥ MDL but ≤ 5X MB U
	$NO_2 + NO_3$	EPA 353.2					
	NH_3	EPA 350.1					
	TKN	EPA 351.2					
	DOC	SM 5310C					
	Total Phosphorus	SM45000-P-F					if > 5X MB No action
	TDS	SM 2540C					
	TSS	SM2540D					
	TOC	Walkley Black					
	pH	ASA 10.3.2					
Laboratory Control Spike (LCS)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	One in every 20 samples	80-120% of true value EPA 200.8 - 85-115% of true value	<40%	R	J-
	Mercury	SW846 7470/7470A SW846 7471/7471B EPA 245.1		80-120% of true value EPA 245.1 - 85-115% of true value	40% to lower limit	UJ	J-
	Alkalinity	SM2320B		90-110% of true value			
	Sulfate	EPA 300.0					
	$NO_2 + NO_3$	EPA 353.2			Between lower limit and upper limit	No action	No action
	NH_3	EPA 350.1					
	TKN	EPA 351.2					
	DOC	SM 5310C		80-120% of true value	Upper limit to 150%	No action	J+
	Total Phosphorus	SM45000-P-F		90-110% of true value			
	TDS	SM 2540C		80-120% of true value			
	TSS	SM 2540D			> 150%	No action	R
	TOC	Walkley Black		40-179%, varies with standard			
	pH	ASA 10.3.2		Varies with standard			

Table 19 - Validation Criteria for Analytical Laboratory and Field Quality Control Samples

Laboratory QC	Analysis	Method	Frequency[1]	Validation Criteria	QC Sample Result	Action for Non-Detect Sample Result	Action for Detect Sample Result
Laboratory Duplicate Sample (LDS) Laboratory Control Spike Duplicate (LCSD) Matrix Spike Duplicate (MSD)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	One in every 20 samples (MSD serves as LDS)	≤ 20% RPD or Delta < RL (aquesous) ≤ 35% RPD or Delta < 2XRL (solids)	Both original and duplicate result ≥ 5X RL and RPD ≤ method criteria	No action	No action
	Mercury	SW846 7470/7470A SW846 7471/7471B EPA 245.1					
	Alkalinity	SM2320B	One in every 10 samples (MSD serves as LDS)	≤ 20% RPD or Delta < RL	Both original and duplicate result ≥ 5X RL and RPD > method criteria	UJ	J
	Sulfate (MSD)	EPA 300.0		≤ 20% RPD			
	$NO_2 + NO_3$	EPA 353.2					
	NH_3	EPA 350.1					
	TKN	EPA 351.2	On in every 20 samples	≤ 10% RPD	Original or duplicate result, or both, < 5X RL and the absolute difference between the two results is < RL (aqueous) or 2X RL (solids)	No action	No action
	DOC	SM 5310C		≤ 25% RPD			
	Total Phosphorus	SM45000-P-F	One in every 10 samples (MSD serves as LDS)	≤ 20% RPD			
	TDS	SM2540C	One in every 10 samples	≤ 10% RPD			
	TSS	SM2540D			Original or duplicate result, or both, < 5X RL and the absolute difference between the two results is ≥ RL	UJ	J
	TOC	Walkley Black		≤ 20% RPD or Delta < RL (aquesous) ≤ 35% RPD or Delta < 2XRL (solids)			
	pH	ASA 10.3.2					
Matrix Spike (MS)/Matrix Spike Duplicate (MSD)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	MS One in every 20 samples EPA 200.8 MS - One in every 10 samples MSD one in every 20 samples	75-125% of true value EPA 200.8 - 70-130% of true value ≤ 20% RPD	< 30%	R	J-
	Mercury	SW846 7470/7470A SW846 7471/7471B EPA 245.1	One per batch EPA 245.1 - 1 per batch & if > 11 samples in a batch, an additional MS is required.	7000 series: 80-120% of true value EPA 245.1 - 70-130% of true value ≤ 20% RPD	30% to lower limit	UJ	J-
	Alkalinity	SM2320B	One in every 10 samples	80-120% of true value ≤ 20% RPD			
	Sulfate	EPA 300.0			Lower limit to upper limit	No action	No action
	$NO_2 + NO_3$	EPA 353.2					
	NH_3	EPA 350.1		90-110% of true value ≤ 20% RPD			
	TKN	EPA 351.2		90-110% of true value no MSD	> Upper limit	No action	J+
	DOC	SM 5310C	One in every 20 samples	80-120% of true value No MSD			
	Total Phosphorus	SM45000-P-F	One in every 10 samples	80-120% of true value ≤ 20 % RPD			

Table 19 - Validation Criteria for Analytical Laboratory and Field Quality Control Samples

Laboratory QC	Analysis	Method	Frequency[1]	Validation Criteria	QC Sample Result	Action for Non-Detect Sample Result	Action for Detect Sample Result
Post Digestion Spike	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	If reporting by 6020 and MS/MSD fails 75-125% recovery	6020/6020A: 80-120% 6020B: 75-125%	MS < 30% R and PDS < method limit	R	J-
					MS < 30% R and PDS ≥ method lower limit	UJ	J
					MS 30% to lower limit and PDS < lower limit	UJ	J-
					MS 30% to lower limit and PDS ≥ lower limit	UJ	J
					MS > upper limit and PDS > upper limit	No action	J+
					MS > upper limit and PDS ≤ upper limit	No action	J
Serial Dilution (SD)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	One in every 20 samples	6020/6020A/EPA 200.8 - 1:5 dilution 10% difference of original result when original sample is ≥ 50X the MDL 6020B - 20% difference of 1:5 dilution of MS or samples with concentration 25X the lower limit of quantification (LLOQ) in parent sample	< 20% Difference	No action	No action
					> 20% Difference and original sample concentration is < 50X MDL	No action	No action
					> 20% Difference and original sample concentration is ≥ 50X MDL	UJ	J
Field Quality Control Samples							
Field Blank	All Analyses	All Methods	A minimum of 1 per 20 primary samples collected or 1 per sampling event, whichever is more frequent (SW samples)	≤ MDL	< MDL	No action	No action
					> MDL	No action	if ≥ MDL but ≤ 5X FB U
							if > 5X FB No action
Field Duplicate	All Analyses	All Methods	A minimum of 1 per 20 primary samples collected or 1 per sampling event, whichever is more frequent	≤ 20% RPD or Delta < RL (aqueous) ≤ 35% RPD or Delta < 2X RL (solids)	Both original and duplicate result ≥ 5X RL and RPD ≤ method criteria	No action	No action
					Both original and duplicate result ≥ 5X RL and RPD > method criteria	UJ	J
					Original or duplicate result, or both, < 5X RL and the absolute difference between the two results is < RL (aqueous) or 2X RL (solids)	No action	No action
					Original or duplicate result, or both, < 5X RL and the absolute difference between the two results is ≥ RL (aqueous) or 2X RL (solids)	UJ	J

[1]Frequency is based on EPA Methods. Acceptance criteria is based on Atlantic Richfield Consistent Data Quality Indicators for Montana Sites (CDQIMS), with CDQIMS precedence order of analytical method requirements, Atlantic Richfield laboratory Statement of Work, EPA National Functional Guidelines for Inorganic Superfund Methods Data Review.

[2]If frequency is not met, professional judgement is used. The validator investigates why the frequency criteria was not met and the impact on the sample results.

[3]MS/MSD and PDS recovery criteria are waived if the parent sample concentration is ≥ 4X she spike concentration.

Table 20 – Summary of Status Assignment (Enforcement/Screening/Unusable)

Data Validation Qualifier	Level A/B Designation		
	Level B	Level A	Rejected
No qualifier, U, or A	Enforcement	Screening	Unusable
J or UJ	Screening	Screening	Unusable
R	Unusable	Unusable	Unusable

FIGURES

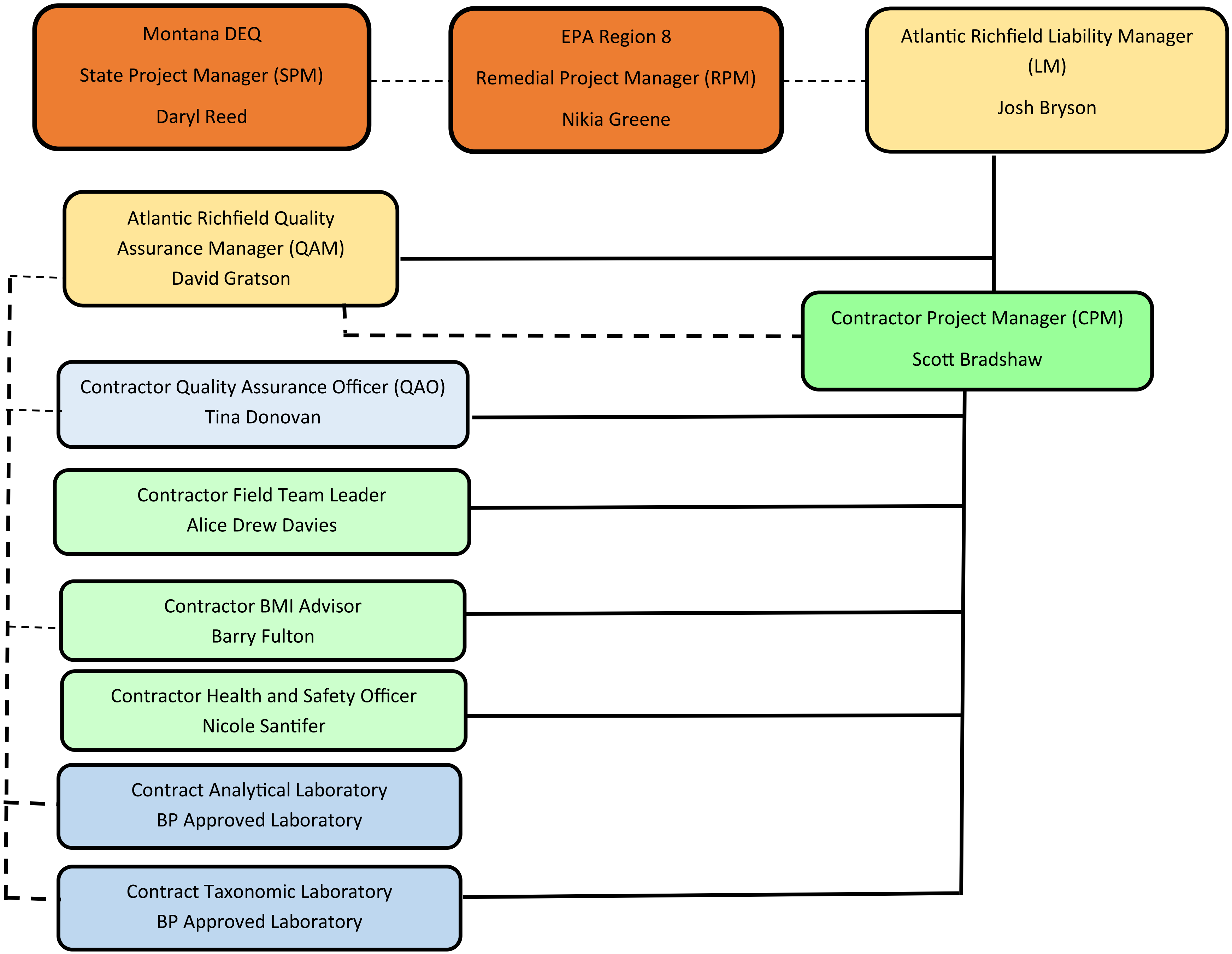

Figure 1—BPSOU Surface, Sediment, and BMI Water Monitoring Team Organization

Atlantic Richfield Company
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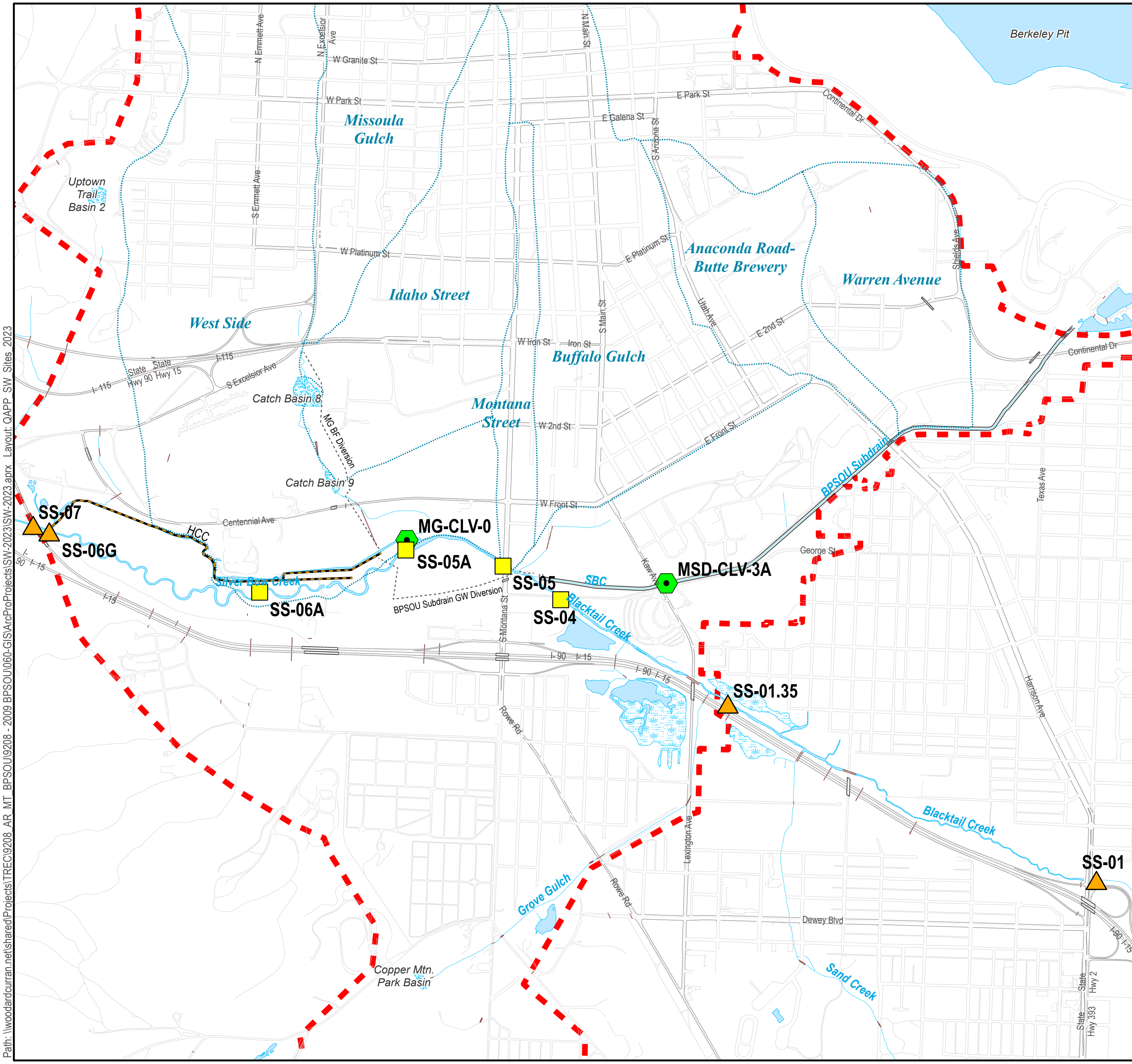
2023 Surface Water Quality Assurance Project Plan

Butte Priority Soils Operable Unit

Normal Flow, Wet Weather and Diagnostic Monitoring Locations - Figure 2



N

Legend

- Wet Weather & Normal Flow Sampling, Continuous Stage
- Normal Flow Sampling
- ISCO Sampler and Continuous Flow
- BPSOU Boundary

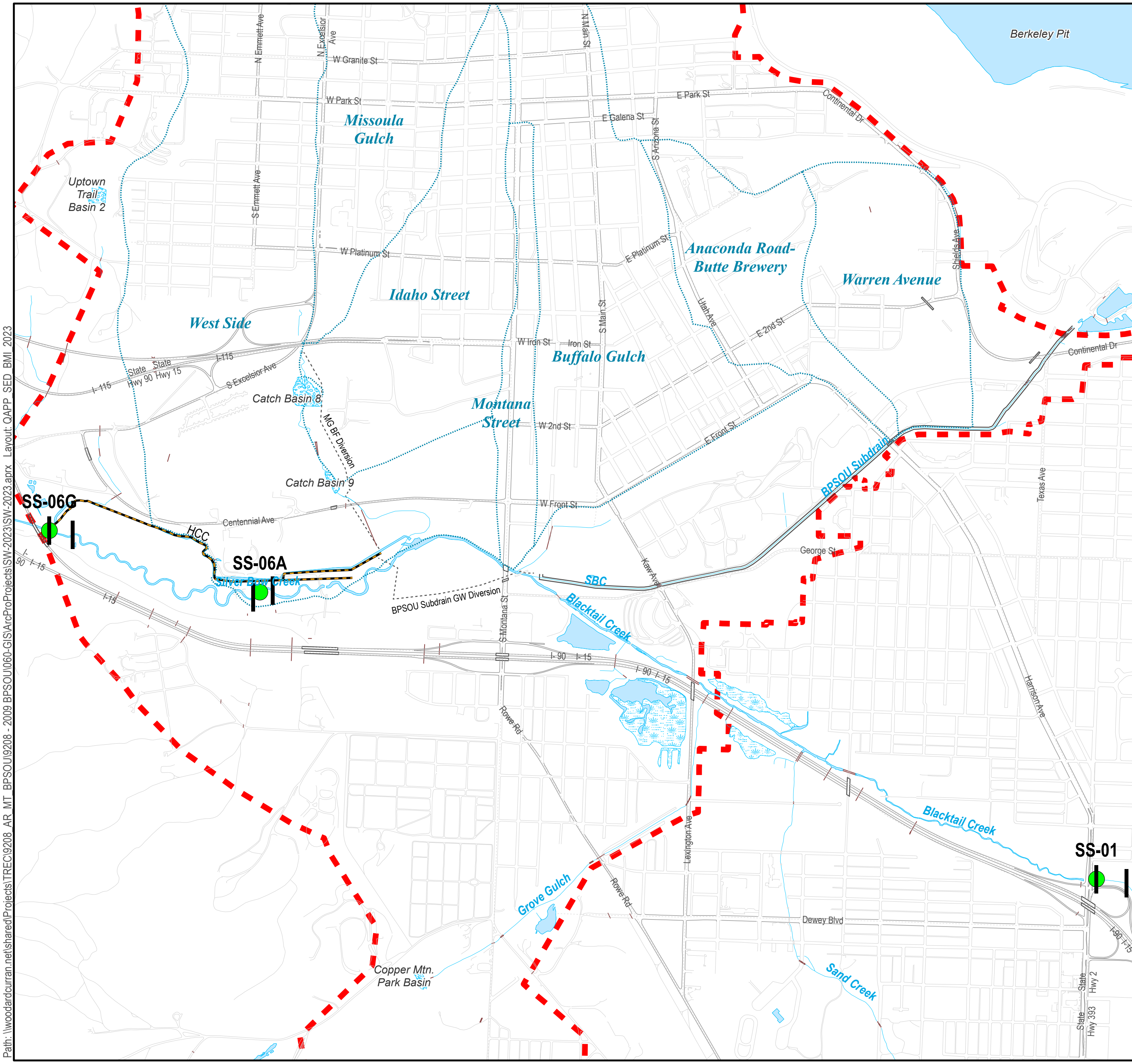
900 450 0 900 1800 Feet

Woodard & Curran

Project #: 0231347.04
Map Created: October 2022

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:**

Path: \\woodardcurran.net\shared\Projects\TREC\9208_AR_MT_BPSOU\9208 - 2009 BPSOU\0060-GIS\ArcProjects\SW-2023\SW-2023.aprx Layout: QAPP_SW_Sites_2023



Atlantic Richfield Company
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2023 Surface Water Quality Assurance Project Plan

Butte Priority Soils Operable Unit

Sediment, BMI and Habitat Monitoring Locations - Figure 3

N

Legend
- Sampling Reach
- Reach SW Site
- BPSOU Boundary

900 450 0 900 1800 Feet

Woodard & Curran

Project #: 0231347.04
Map Created: October 2022

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:**

Path: \\woodardcurran.net\shared\Projects\TREC\9208_AR_MT_BPSOU\9208 - 2009 BPSOU\060-GIS\ArcProProjects\SW-2023\SW-2023.aprx Layout: QAPP_SED_BMI_2023

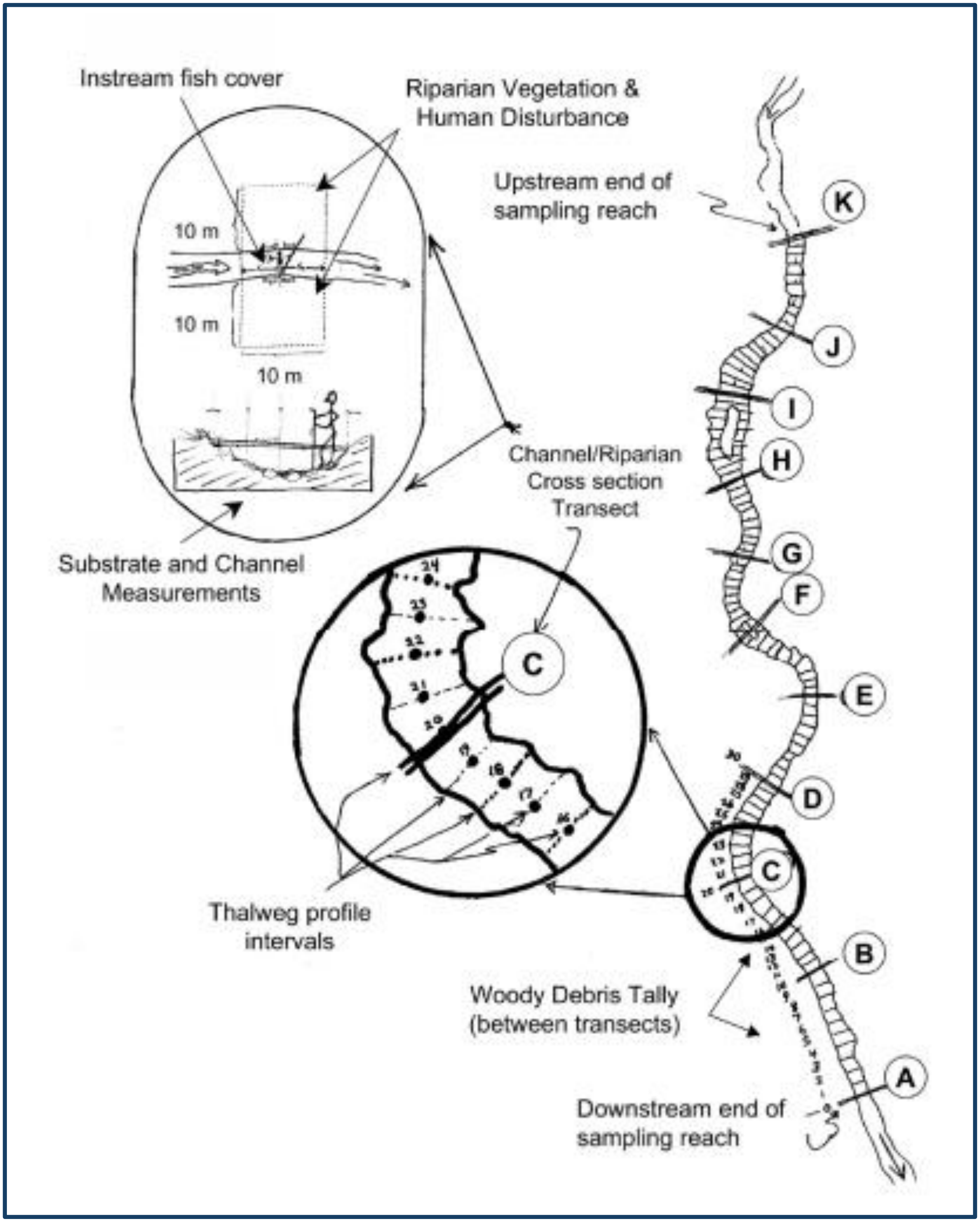
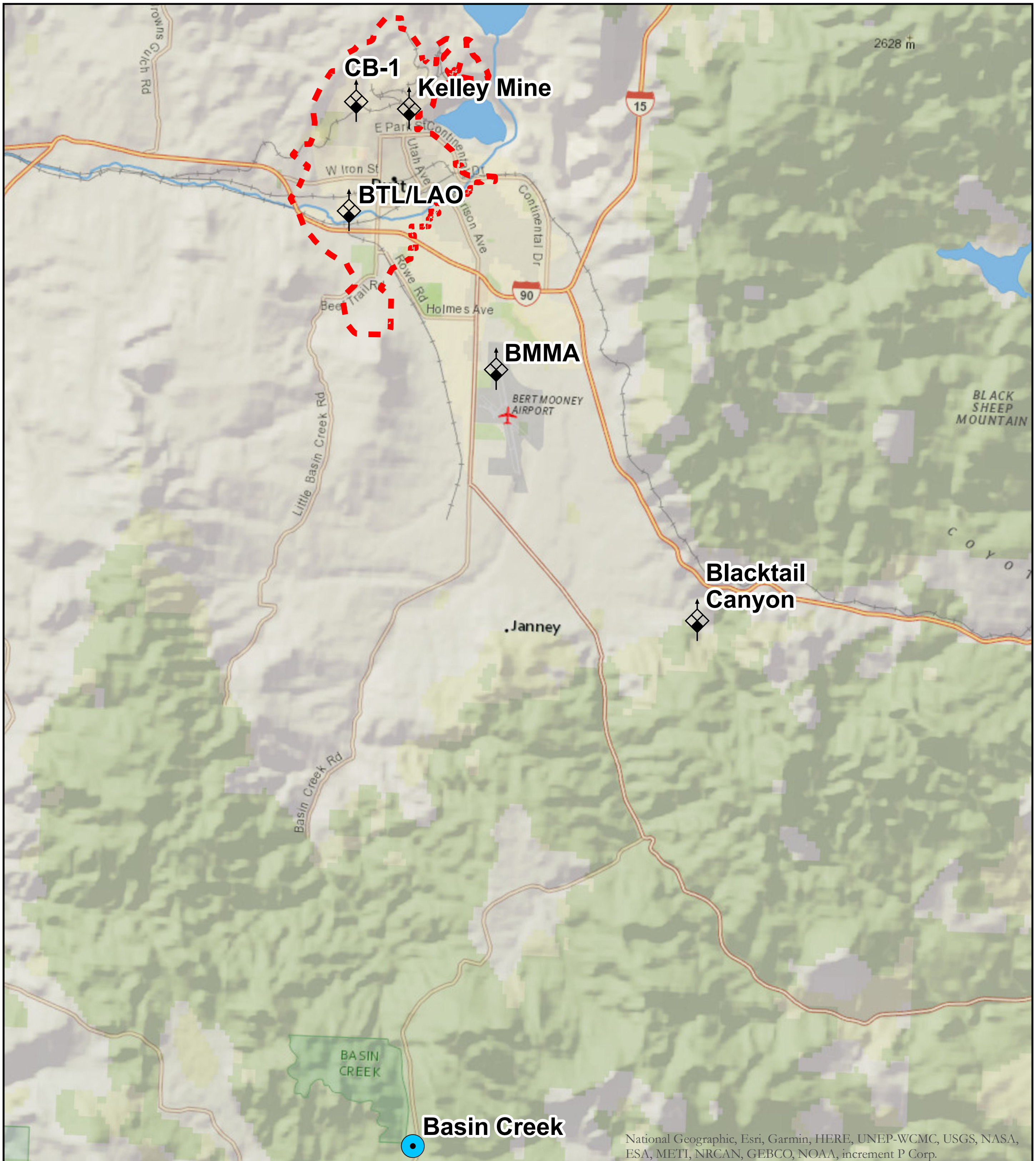


Figure 4 – Example Reach Layout. From Kaufman and Robinson (1998) and EPA (1998)



Atlantic Richfield Company
a BP affiliated company

2023 Surface Water Quality Assurance Project Plan

Butte Priority Soils Operable Unit

Vicinity Climate Stations - Figure 5

Legend

Precipitation Guage

Snow Pillow

BPSOU Boundary

N

0 0.5 1 2 Miles

Woodard & Curran

Project #: 0231347.04
Map Created: October 2022

Path: \\woodardcurran.net\shared\Projects\TREC\9208_AR_MT_BPSOU\9208 - 2009 BPSOU\060-GIS\ArcProProjects\SW-2023\SW-2023.aprx Layout: QAPP_SW_Climate_2023

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:**

Figure 6 - Hess Sampler

APPENDICES

Appendix A - Standard Operating Procedures

Appendix B – Woodard & Curran Data Validation Guidelines

Appendix C – MDEQ Sample Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Communities Standard Operating Procedure

Appendix D – Rapid Bioassessment Protocol Forms, Environmental Monitoring and Assessment Program (EMAP) Physical Habitat Characterization Summary, and EMAP Forms

Appendix E – Example Chain of Custody

Appendix F – Example Corrective Action Report

Appendix G – Components of Limited Analytical Laboratory Package

Appendix H – Data Validation Checklists

Appendix A - Standard Operating Procedures

SOP – H – 01

WATER SAMPLING EQUIPMENT DECONTAMINATION

Authorized for use: 04/13/2020
Revision 3
Reviewed: 01/27/2022

SCOPE	This SOP addresses decontamination of water sampling equipment. Procedures for both surface water and ground water sampling equipment are included.
RTRA(s) Referenced/ Reviewed	TRA1-001: Common Hazards Driving Manual Handling TRA1-003: GW Sampling And Monitoring TRA1-005: Surface Water Sampling
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme Wind Unsafe conditions Inadequate PPE or equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc Battery Acid 5% HNO_3 Laboratory grade detergent
PPE REQUIRED	If on site items: 1-7 are required. If off site: items 3, 5, 6 and 7 are required. 1. Hard Hat 2. Safety Toe Boots (if surface water sampling rubber (or comparable) soled waders 3. Safety Glasses 4. High Visibility Shirt/Vest 5. Clean Impervious Gloves 6. Long Sleeve Shirt 7. Long Trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Laboratory grade detergent 5% Nitric acid Deionized/distilled/tap water Decontamination solution container
Trained, Competent and Authorized Employees in this SOP	Tina Donovan Alice Drew-Davies Joel Arbaugh Mat Erickson Matt Kilsdonk Dalen Longfield Kirsten Vose Joe Moodry
PROCEDURES	
PERISTALTIC PUMP DECONTAMINATION- IF PUMP HAS INTERNAL TUBING	1. Store decontamination solutions in clearly marked, dedicated containers. 2. Wear clean impervious gloves to avoid contamination of equipment/solutions. 3. Sampling in field with peristaltic pump with internal tubing: At each site place clean (new) tubing on the pump. Have pump situated so tubing does not touch the ground or other surfaces, such as the tailgate. If working off the tailgate, assure surface has been cleaned and situate pump at edge of tailgate so tubing does not touch the surface. 4. Attach filter to outlet end of tubing. 5. Rinse the end of inlet tubing with source water by pouring a small amount of water over tubing. 6. Place the decontaminated end of the pump tubing into the container of source water. 7. Pump source water through the new tubing with filter attached for at least 5 seconds after water begins to discharge from filter to thoroughly rinse line and filter before collecting filtered sample. 8. Dispose of decontamination solution to the ground surface unless the sampling/work plan states otherwise. 9. Sample preparation in lab: Add a generous quantity of 5% nitric acid to deionized water in a clean dedicated container. Internal tubing will be re-used for each site with adequate decontamination between

	all samples collected. 10. After prepping initial sample, use a dedicated squirt bottle of deionized water, rinse the end of the inlet tubing by squirting a small amount of water over tubing. 11. Place tubing end into decontamination solution and run decontamination solution through tubing. Run tap water in the sink during this step as a safety precaution. 12. Before collecting the filtered sample, attach filter to outlet end of tubing and rinse the tubing and filter with sample water to remove all traces of nitric acid. Repeat steps 9 through 11 for each time interval sample (3 Litres per each time collection) starting with last sample collected at the site and ending with first sample collected. 13. Remove and dispose of pump outlet tubing. 14. Cut a new length of pump outlet tubing in preparation for the next sample collection site. 15. If using peristaltic pump (modified Isco head) for ground water sampling, decontamination will be conducted using the technique described below in the Ground Water Sampling Pump Decontamination, but the term tubing will replace pump.
FIELD DECONTAMINATION OF CHURN SPLITTER	1. Store decontamination solutions in clearly marked, dedicated containers 2. Wear clean impervious gloves to avoid contamination of equipment/solutions 3. Fill the churn splitter half-way full of deionized water and add approximately 1 cup of 5% HNO_3 to the water. 4. Swirl the water in the churn splitter, taking care to rinse all inside surfaces. Move the churn up and down. Dispense a portion of the water through the spigot and pour the remaining water out of the top of the churn splitter. 5. Repeat steps 3 and 4 two times with deionized water only. 6. At the next site, rinse the churn splitter as described in steps 3 and 4 with source water.
OFFICE DECONTAMINATION OF CHURN SPLITTER	1. Store decontamination solutions in clearly marked, dedicated containers 2. Wear clean impervious gloves to avoid contamination of equipment/solutions 3. Fill the churn splitter half-way full of tap water and a small quantity (~1/8 teaspoon) of laboratory grade detergent (Liquinox). 4. When cleaning churn splitter, use the brush dedicated to the specific churn splitter. SS-05 and SS-07 are the sites the churn splitter is used at during normal flow sampling and each site has a dedicated brush to use for cleaning. The brush should be stored in a labeled plastic bag on the shelf in the back room of the lab. 5. Swirl the water in the churn splitter, taking care to rinse all inside surfaces. Move the churn up and down. Use a clean dedicated brush with a handle (such as a bottle brush) to scrub inside seams and the spout. Use a small brush (toothbrush) to scrub the spigot. Dispense a portion of the water through the spigot, unscrew spigot and brush threads. Pour the remaining water out of the opening where the spigot was removed and the top of the churn splitter. When dispensing water out of the spigot, rinse the lid of the churn splitter. 6. Rinse the churn splitter three times with tap water. 7. Fill the churn splitter half-way full of deionized water and add approximately 1 cup of 5% HNO_3 to the water. 8. Swirl the water in the churn splitter, taking care to rinse all inside surfaces. Move the churn up and down. Dispense a portion of the water through the spigot, unscrew spigot and pour the remaining water out of the opening where the spigot was removed and the top of the churn splitter. When dispensing water out of the spigot, rinse the lid of the churn splitter. 9. Reassemble the churn splitter and repeat the rinse process described above (steps 7 and 8) 3 times with **deionized** water only. 10. **Immediately** cover the spigot with lab wrap or comparable material. Immediately place the decontaminated churn splitter in two plastic bags which can be pulled shut. 11. Label the bag that the churn splitter is being stored in, with the name of the dedicated site it is being used at. Store the decontaminated churn splitters on the shelf in the back room of the lab or another clean area until the next use.
GROUND WATER SAMPLING PUMP DECONTAMINATION	1. Store decontamination solutions in clearly marked, dedicated containers. 2. A tall, slender container is recommended for submersible pump decontamination. A plastic 2-liter volumetric cylinder works well. 3. Wear clean impervious gloves to avoid contamination of equipment/solutions. 4. Place a very small amount (one drop) of dilute laboratory grade detergent in the decontamination container (Liquinox). Review and follow all manufacture's instructions before dilution. 5. Fill the decontamination vessel with decontamination solution. For ground water monitoring, cleanliness of the source water along with the anticipated purge volume, can be considered when choosing a decontamination solution. a. If utilizing low flow sampling techniques, distilled or deionized water must be used. b. If utilizing the three-casing volume technique, tap water can be used. i. If the total purge volume is small (< 3 gallons) and the source water is clean (expected to meet drinking water standards) distilled or deionized water shall be used for decontamination even when utilizing the three-casing volume technique. 6. Ensure that the outlet end of the pump tubing is secured in the appropriate collection container before

	pumping commences. 7. Place pump (tubing if using modified ISCO head) into the decontamination solution. 8. Connect the pump to the power source and pump until the decontamination solution has purged through the entire tubing length. Add water to the decontamination vessel to ensure that the pump intake remains submerged. If sampling in BPSOU, all decontamination water will be containerized. Disconnect the pump power source before the level of the decontamination solution is below the pump intake. 9. Pour any soapy water out of the decontamination vessel. Rinse the vessel to remove all detergent residue. Place the pump back in the vessel and pour decontamination water into the vessel to the top of the pump. Do not add detergent. 10. Connect the pump to the power source and pump until the rinse water has purged through the entire tubing length. Add water to the decontamination vessel to ensure that the pump intake remains SUBMERGED. If sampling in BPSOU, all decontamination water will be containerized. Disconnect the pump power source before the level of the decontamination solution is below the pump intake. Place pump and tubing into dedicated bucket for storage between sampling sites.
DOCUMENTATION	1. Note in the field book that equipment has been decontaminated

SOP – H – 02

DOWNLOADING TRANSDUCERS

Authorized for use: 01/27/2022
Revision 3

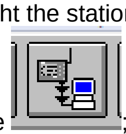
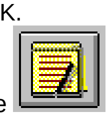
SCOPE	This SOP addresses downloading Solinst Transducers by various methods. A Depth to Water measurement or SG measurement must always be recorded when downloading data.
TRA(s) Referenced/ Reviewed	R-L1- Common Hazards Driving Manual Handling R-L1- Download Transducers
STOP WORK TRIGGERS	1. Lightning (30 second rule) 2. Extreme Wind 3. Unsafe conditions 4. Inadequate PPE or equipment 5. Inability to access the work area safely 6. Defective equipment 7. Improper tools
MSDS	1. Arsenic 2. Cadmium 3. Copper 4. Lead 5. Mercury 6. Zinc 7. Manganese 8. Iron 9. White Lithium 10. PCB's 11. Wasp Killer
PPE REQUIRED	1. Hard Hat 2. Safety Toe Boots 3. Safety Glasses 4. High Visibility Shirt/Vest 5. Gloves 6. Long Sleeve Shirt 7. Long Trousers
P&IDs/Other Relevant Drawings	1. N/A
OTHER INSTRUCTIONS/SOPs	1. Other applicable TRA's/SOPs: Water Level Measurement, Read Staff Gage, Remove Manhole Cover
REQUIRED TOOLS	1. Levelogger App Interface 2. Computer with Optical Reader 3. Water level tape 4. Decontamination equipment (when applicable) 5. Manhole Hook (MSD and sub drain sites) 6. Socket Wrench 7. Screw Driver 8. Hammer
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Joel Arbaugh 4. Mat Erickson 5. Matt Kilsdonk 6. Dalen Longfield 7. Kirsten Vose 8. Joe Moodry

Lessons Learned (observations, near misses, etc. to be considered during 2-yr SOP review)	
PROCEDURES	
DOWNLOADING TRANSDUCERS WITH BLUETOOTH SOLINST LEVELOADER APP INTERFACE	1. Measure the depth to water in the well following SOP-GW-01_GW-LevelMeasurement when downloading transducers in wells. Record the water level on the field sheet and in the appropriate doForm. Read and record the water level of the staff gage according to SOP-SW-06_ReadStaffGauge when downloading surface water transducers. Record the water level on the field sheet and in the appropriate doForm. 2. If a direct read cable is deployed in the well or surface water, remove the cap from the direct read and screw the interface to the direct read cable. If a direct read is not deployed in the well or surface water, the transducer extension or direct read dongle is attached by screwing it directly onto the App interface (Bluetooth receiver). Remove the transducer from the well and remove the cap. Use a paper towel to dry the transducer off, so the water will not run into the dongle. Also, take the time to visually inspect the transducer and then line up the eyes and pinhole of the transducer with the eyes and pin of the transducer dongle and firmly screw onto the dongle. 3. Press the button on the interface until the light turns on. A green flashing light means the device is on. A blue flashing light means the Bluetooth is connected to your tablet. 4. Go into the settings of your tablet. Select the Bluetooth section. Your device will automatically be recognized. If there is only one Bluetooth interface device listed under “My Devices” and it is the serial number interface you possess, then no further action is required. If there are two serial devices listed under “My Devices” then you may have to remove the one that you are not using. Next to the status (Connected, Not Connected) of your Bluetooth, there is a blue circle with an “i” inside. Press that and an option to “Forget This Device” will show up. Two different serial numbers of the same type of device may cause conflict with connection. 5. Go into the Solinst app. If the device disconnects while opening this app, you will have to toggle back to the Settings and manually connect the device again. Otherwise, you can either give the app a few seconds to recognize the transducer you are connected to, or you can drag down the left menu until you see a loading bar and a message to refresh the attempt to connect to the transducer. The connected transducer should show up at the top of the left menu. If you receive communication error messages, you may have to try to download with a laptop and optical reader (next section of the SOP). 6. Once connected to the transducer, click the “All Data” button below the picture of the transducer. If a download progress bar does not show up below the picture of the transducer, then simply click on the picture of the transducer and it should show up. Pay attention to make sure that it fully downloads (100%). Once the download is complete, the App will play a little tune. 7. After all data has downloaded, click the “Start/Stop/Edit” button below the picture of the transducer. In the detail view to the right, under the Datalogger Sampling Mode section, there is a red “Stop Now” button, press it. Again, the App will alert you when the action is complete with a tune. Under the Datalogger Status section, the Status should now say “Stopped” in red. Under the “Datalogger Sampling Mode” click on “Linear”, make sure “Continuous” is selected, if not, select it. Click on “Future Start”. The iPad will display the current day and time, scroll to the next 15-minute increment (to avoid data loss) and then click on “Future Start” in green. A dialog box will come up to confirm. Click “Start”. Again, the App Interface will play a little tune. Ensure that the Status says “Waiting to Start” in orange before moving to the next well. 8. Disconnect from the transducer by removing the transducer from the extension port/dongle or unscrewing the direct read port. Replace cap on direct read end and return to well. 9. To remove downloaded data from the tablet to the computer, you must have iTunes. 10. Connect the iPad to your laptop via USB. Open iTunes. A popup may ask for permission to connect the device, and you will have to follow prompts on the tablet and computer to complete this step. 11. In the top right, there is a tablet icon, click on it. In the left menu, select “File Sharing.”

	Select Solinst in the Apps menu that shows up to the right. The downloaded files should show up to the right in the Solinst Documents menu. 12. Select all files and drag to the current month folder within \\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\ARCO\BPSOUGW\ContinualData\RawFiles
DOWNLOADING TRANSDUCERS WITH A LAPTOP	1. Measure the depth to water in the well following SOP-GW-01_GW-LevelMeasurement when downloading transducers in wells. Record the water level on the field sheet and in the appropriate doForm. Read and record the water level of the staff gage according to SOP-SW-06_ReadSG when downloading surface water transducers. Record the water level on the field sheet and in the appropriate doForm. 2. Turn the laptop on and open the Solinst software. You can use either an optical reader (USB to “drop-in” transducer port) or the USB to direct read cord (with transducer extension port for non-direct read installation). Select the appropriate cord for the connection type (direct read or transducer). 3. In the Solinst software on the laptop, make sure you are in the Datalogger Settings tab. Click the first icon in the top left, a transducer with a green arrow to a computer; this is “Retrieve Datalogger Settings.” 4. Once connected, go to the Data Control tab. Click the first icon in the top left, a green arrow pointing down; this is “Download Data.” Select “All Data” in the drop-down menu that pops up. If all three methods of connection fail, there may be an issue with the transducer; manufacturer maintenance or technical support should be sought and documented. 5. Once all data is downloaded, a graph will show the data. Go to File and select **Save As**. Make sure it is an XLE file and save it to the appropriate folder on the desktop. 6. To restart the logger. Go to the “Datalogger Settings” tab, and click the red stop sign in the bottom right of the screen that says, “Stop Now”. Make sure the Datalogger Memory Mode is set to “Continuous” if it is set to “Slate” click and change to “Continuous”. To start the logger, choose “Future Start”, adjust the time to the next 15-minute increment (to avoid data loss). Then click on the green play button in the bottom right of the screen that says, “Future Start”. Ensure that the Status says “Future Start” before moving to the next well. 7. The downloaded can be transferred from the field laptop to the network via thumb drive. Transfer all data to the current month folder at; \\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\ARCO\BPSOUGW\ContinualData\RawFiles\2022 (or current year) and current month folder (mm-yyyy).
DOCUMENTATION	1. At each site, record the date and time, depth to water or staff gage measurement, and any comments or notes that affect the water level in the appropriate site fields in the ground water levels doForm and printed sheet. If the transducer cannot be downloaded, document in the field book and seek maintenance or technical support.

SOP – H – 03
DOWNLOAD WEATHER STATION

Authorized for use: 04/22/2020
Revision 4

SCOPE	Download weather stations. Data is downloaded directly to a laptop computer.
TRA(s) Referenced/ Reviewed	TRA-001: Common Hazards Driving Manual Handling TRA-008: SG Readings Download Sutron ISCO H350 Weatherstation
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme wind Unsafe conditions Inadequate PPE or equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc
PPE REQUIRED	Hard Hat Safety Toe Boots Safety Glasses High Visibility Shirt or Vest Gloves Long Sleeve Shirt Long Trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Laptop computer with appropriate Weatherlink software loaded Laptop computer with a USB port USB to Mini-USB interface cable
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Joel Arbaugh 4. Mat Erickson 5. Kirsten Vose 6. Matt Kilsdonk 7. Joe Moodry 8. Dalen Longfield
PROCEDURES	
OPEN HOUSING	1. Wearing work gloves, unlatch the stays, open the housing door.
DOWNLOADING DATA	1. Turn the laptop computer on 2. Connect laptop to weather station recorder using USB to Mini-USB interface cable. 3. Open Weatherlink software 4. Choose Setup, Communications Port; ensure that Communications is set to **USB**. 5. Select the "test" option to find station locations; Click OK 6. Go to File, Open Station, highlight the station location you wish to download; click OK. 7. Go to File, Download or click the ; confirm by clicking OK. 8. After the download is complete, choose File, View Log, or click the  9. Choose Browse, Export Records, highlight desired dates, and click OK. 10. Choose a name (ex. BSB-Shop_121914) and location to save your exported data; click Save. 11. Open the data file and check for completeness by examining start and end date/times. 12. X out of Weatherlink, or use File, Exit. 13. Disconnect the communication cable. 14. Store the laptop.
CLOSE HOUSING	1. Wearing work gloves, close the door of the weather station housing.
DOCUMENTATION	1. In the field book, record the arrival date/time and the site name. Document that data was downloaded from the recorder and the name and location of the exported file.

SOP – H – 05
Calibrate YSI Professional Plus Multi-Meter

Authorized for use: 08/04/2022
Revision 5
Reviewed: 08/04/2022

SCOPE	This SOP addresses the manual calibration of YSI Professional Plus Multi-Meter.
TRA(s) Referenced and/or Reviewed	R-L1-Equipment_Calibration
STOP WORK TRIGGERS	Unsafe conditions Inadequate PPE or equipment Inability to access the work area safely Defective equipment Improper tools
SDS	1413 µS/cm Conductivity Solution Buffer Solution pH 7.00 Buffer Solution pH 4.00 Buffer Solution pH 10.00 ORP Standard Solution DO electrolyte Solution
PPE REQUIRED	Closed-toe shoes Safety glasses Gloves (nitrile, impervious) Long sleeve shirt Long trousers
OTHER INSTRUCTIONS and/or SOPs	
REQUIRED TOOLS	Philips screwdriver to change batteries, if low (3 C Batteries)
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Joel Arbaugh 4. Mat Erickson 5. Matt Kilsdonk 6. Dalen Longfield 7. Kirsten Vose 8. Joe Moodry
PROCEDURES	
Dissolved Oxygen (DO %)	Note: Check batteries on unit before calibrating by looking at battery display in lower right of handheld screen. Change batteries according to usage time expected (e.g. If batteries are half and team is going out for full day of sampling, change them. If batteries are half and going out for baseflow, should be sufficient.) Note: DO Membranes should be changed regularly and generally last 2-8 weeks depending on use and storage. Note: Once a month, ensure the Pro Plus barometer is reading accurately. Do this by comparing barometer reading on the YSI to barometric pressure at 7-Day Forecast 46.01N 112.52W (weather.gov) (Bert Mooney report). The airport barometric pressure is in inches of Hg and is standardized to sea level pressure. Use the conversion $BP_{local} = BP_{airport}*2.54 – 2.5(local elevation/100)$ to determine local pressure in mm Hg. Use the office elevation, 5483 ft., in your notes. 1. Turn the meter ON. 2. Make sure that there is a good DO membrane tip with fresh electrolyte solution (there should be no air bubbles or wrinkles, also the tip should not be corroded). 3. Gently Blot dry the DO membrane and the temperature probe with a paper towel. 4. Add a small amount of water to the calibration/storage cup such that the water does not touch any of the sensors. Lightly screw on the calibration/storage cup,1/2 -1 turn making sure the temperature probe and DO membrane remain dry. 5. Press CAL, use the arrows to highlight DO and press ENTER. Wait approximately 5 to 15 minutes for the storage container to become completely saturated and the sensor to stabilize. 6. From the calibration screen, record the barometer value. 7. After stabilization, press ENTER to accept calibration. Record the final calibration value (%) from the meter display.

<table>
<tr>
<td>pH (Su)</td>
<td>
Note: Always calibrate over the entire expected pH range (3-point pH calibration for BPSOU and Rocker).
Note: Clean and recondition the pH sensor if a slow response in the field has been reported or if it takes more than 90 seconds to stabilize in pH buffer. See Calibration and Troubleshooting manual for reconditioning instructions.
1. Always start with the neutral buffer (pH 7.00) and complete a 3-point calibration.
2. Pour buffer solution rinse into the calibration/storage cup. Tighten cup and gently shake probes to rinse. Discard the rinse solution in the sink.
3. Fill cup with fresh buffer solution (from the gallon bottles). All the probes should be completely covered, including the conductivity orifice.
4. Press CAL, use the arrows to highlight pH and press ENTER. Allow the pH reading to stabilize by monitoring both the pH and voltage values.
a. These numbers might bounce back and forth but you shouldn’t see a trend. Don’t proceed to the next buffer until both pH and voltage values have stabilized.
b. See Calibration and Troubleshooting manual if values will not stabilize
5. For pH, the temperature-adjusted calibration value will automatically populate, so you won’t have to manually change it. Record the temperature-adjusted calibration values in the logbook calibration table. Here is a table showing what the temperature adjusted calibration values and voltage ranges should be:
<table>
<tr><td>Calibration Temperature (ºC)</td><td>pH 7.00
voltage range (±50 mV)</td><td>pH 4.00
voltage range (+165 to +180 from buffer 7.)</td><td>pH 10.00
voltage range (-165 to -180 from buffer 7.)</td></tr>
<tr><td>10</td><td>7.07</td><td>4</td><td>10.19</td></tr>
<tr><td>15</td><td>7.05</td><td>4</td><td>10.12</td></tr>
<tr><td>20</td><td>7.02</td><td>4</td><td>10.06</td></tr>
<tr><td>25</td><td>7</td><td>4</td><td>10</td></tr>
</table>
6. After stabilization, record initial value and temperature (ºC) from meter display. Then, use arrows to highlight accept calibration value and <u>press ENTER once</u>. At the very bottom of the calibration screen, you should see “Ready for Point 2”.
7. Repeat steps 2-6 for pH 4 and pH 10.
8. When you have accepted the final calibration value press CAL to complete pH calibration. Record the final pH calibration value and temperature.
</td>
</tr>
<tr>
<td>SC (µS/cm)</td>
<td>
Note: For all conductivity calibrations, only use the 1413 µS/cm conductivity solution. As stated in the YSI Calibration Tips document and confirmed by a YSI representative, “Never calibrate with a conductivity solution that is less than 1.0 mS/cm. You are setting the slope on a linear device so a good strong conductivity signal will give you the best performance.”

1. Pour the 1413 µS/cm conductivity solution rinse into the calibration/storage cup. Tighten cup and gently shake probes to rinse. Discard the rinse solution in the sink.
2. Fill cup with fresh 1413 µS/cm conductivity solution (from the gallon bottle). All the probes should be completely covered, including the conductivity orifice. Document the initial conductivity value.
a. After placing the sensor into the solution, gently rotate the sensor as needed to release any air bubbles that may be trapped in the conductivity sensor.
3. Press CAL, use the arrows to highlight conductivity, then highlight specific conductance, press ENTER, then highlight µS/cm and press ENTER. Allow the SC reading to stabilize.
4. After stabilization, record the initial calibration value.
5. For SC, the default calibration value must be changed. Use the arrow keys to scroll up to the calibration value (it should read the same as the meter), press ENTER to edit, and use the arrow keys to backspace and edit the calibration value to the value of standard which you are using. Press ENTER to take you back to the calibration screen.
6. Press CAL to complete and record the final calibration value.
</td>
</tr>
<tr>
<td>ORP (mV) (Typically only calibrated for groundwater monitoring)</td>
<td>
1. Pour ORP rinse solution into the calibration/storage cup. Tighten cup and gently shake probes to rinse. Discard the rinse solution into the sink.
2. Fill cup with fresh ORP solution (from the brown liter bottle). All the probes should be completely covered, including the conductivity orifice.
3. Press CAL, use the arrows to highlight ORP, then ENTER.
4. For ORP, the default calibration value must be changed because the temperature adjusted calibration value will not automatically populate. As directed by YSI tech support, when using Geotech ORP 220 ±5 mV calibration standard, enter 220 mV.
</td>
</tr>
</table>

DOCUMENTATION	1. In the field book you will log the following fields: calibration standard, initial value (except for DO), final value, temperature (ºC), and lot and expiration date of the calibration standards used. See example below. The field book information is also submitted electronically via a calibration doForm, under the correct project. 2. On the iPad, fill out an equipment calibration doForm (Butte/Rocker – Equip Calibr). Download GLP files monthly to the GLP folder: \\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\Equipment\YSI ProPlus\YSI Data
REPORTING	1. Download the equipment calibration form and save it with the sampling event that it is associated with.
TROUBLESHOOTING	1. If a problem occurs, see ProPlus User Manual and/or ProPlus Calibration and Troubleshooting Tips or the ProPlus User Manual in the lab or at: \\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\Equipment\YSI ProPlus 2. If troubleshooting does not correct the problem, contact GeoTech 1-800-833-7958 or YSI Technical Support directly at 1-800-897-4151.

Param	Std.	Initial	Final	Temp (°C)	Lot #	Exp.
pH (su)	7.02	7.02	NA	20	1GG111	6/23
pH (su)	4.00	4.01	NA	20	1GB111	6/23
pH (su)	10.06	10.05	10.06	20	1GV111	6/23
SC (µS/cm)	1413.0	1416.0	1413.0	20	1GG1101	6/23
ORP (mV)	220.0	229.0	220.0	20	1GB124	6/23

DO is saturated to 81.0% at 616.6 mmHg at 5483' elevation.

pH standard value is adjusted for calibration temperature.

SOP–H–08

Transducer Installation

Authorized for use: 01/24/2022

Revision: 1

SCOPE	This SOP covers the installation of a data logger and pressure transducer for continuous water level measurements in wells and or surface water bodies.
RTRA(s) Referenced/ Reviewed	R-L1- GW sampling and Monitoring R-L1-Download Transducers
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme Wind Unsafe conditions Inadequate PPE or equipment
MSDS	1. Arsenic 2. Cadmium 3. Copper 4. Lead 5. Mercury 6. Zinc 7. Manganese 8. Iron 9. White Lithium 10. PCB's 11. Wasp Spray
PPE REQUIRED	Hard Hat Safety Toe Boots Safety Glasses High Visibility Shirt/Vest Gloves Long Sleeve Shirt Long Trousers
P&IDs/Other Relevant Drawings	
OTHER INSTRUCTIONS /SOPs	1. Other applicable TRAs/SOPs; Water Level Measurement, Read Staff Gage, Remove Manhole Cover, Automatic and Mechanical Sampler Set-Up – Creek and Diagnostic
REQUIRED TOOLS	1. Levelogger App Interface 2. Computer with Optical Reader 3. Water level tape (when applicable) 4. Decontamination equipment (when applicable) 5. Manhole Hook (MSD and sub drain sites) 6. Socket Wrench 7. Drill 8. Hammer
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Joel Arbaugh 4. Mat Erickson 5. Matt Kilsdonk 6. Dalen Longfield 7. Joe Moodry 8. Kirsten Vose
Lessons Learned (observations, near misses, etc. to be considered during 2-yr SOP review)	

PROCEDURES

Site evaluation

1. Selection of the transducer type is dependent on the maximum head of water above the transducer. The following table provides a list of transducer types and conditions for use. There are vented and none vented units available.

Type of Transducer (psi)	Maximum Transducer Immersion (feet)	Accuracy (feet)
5	11.5	+/- 0.010
10	23	+/- 0.023
15	35	-
30	69	-
50	115	+/- 0.115
100	230	+/- 0.230

Solonist	Maximum Transducer Immersion (feet)	Accuracy (feet)
M5	16.4	+/- 0.010
M10	32.8	+/- 0.016
M20	65.6	+/- 0.32
M30	98.4	+/- .064
M100	328.1	+/- .164

Groundwater Installation	1. To determine the transducer requirements for a specific well, reference the table above. 2. Onsite, using a water level tape, obtain a Depth to Water and document in the logbook. 3. When installing a transducer with a direct read cable in a well that already has a transducer installed by other means, pull the old logger and cord out of the well. Measure the length of cord. Determine the length of direct read cable needed, to ensure the logger is immersed correctly in the column and set at the appropriate depth. The transducer should be set at a depth equal to the depth to water plus approximately half of the maximum transducer immersion (in feet). Regardless of the determined deployment depth, a transducer should never rest on the bottom of a well or water body. When installing a transducer in a well that hasn't had one before, obtain the well completion log to determine the installation depth. Use the chart above to order the transducer rated for that depth. 4. When installing a transducer with paracord, follow the steps above to ensure the transducer is deployed at the correct depth. 5. Once proper depth is determined, if you are using a direct read cable that is a little long, spool up the extra cable and fasten (zip tie or other similar fastener), to keep it organized, inside the well casing. 6. Securely fasten the direct read cable to the well leaving enough length for the communication end of the direct read connection to easily reach the blue tooth device. It is unnecessary to leave extra length of paracord. 7. Connect the direct read cable/paracord securely to the well casing. This can be accomplished by drilling a hole in the outer well casing (if metal) to attach a fastener or the inner well casing (PVC) can be cut to allow room for the cord. If attaching to the PVC, apply a fastener on each side of the slot so the cable/paracord cannot move up or down. For paracord, tie a knot in the cord on the outside of the casing to ensure it does not slip down the pipe. 8. If a vented cable is being used, ensure the desiccant is a color indicating it is effectively removing moisture. 9. The fastener type may vary from well to well. Professional judgement should be used on a case-by-case basis. Do not install the cable/paracord near sharp metal edges that could damage it. Ultimately, the cable/paracord needs to be secure so it does NOT slip up or down, as that would change the level of the transducer in the water column, resulting in inaccurate data. 10. Once the direct read cable/paracord is installed, attach the transducer to the cable/paracord and slowly lower into the well. For direct read cables, confirm communication with the logger, so data retrieval is possible.

Surface Water Installation	1. To determine the transducer requirements for a specific surface water body, reference the table above. 2. Onsite, read the staff gage, or other device which indicates water level, and document in the logbook. 3. If the transducer is being newly installed at the SW site attach an appropriate length of 2.0 inch slotted, if available PVC pipe to the T-post securing the staff gage. Drill a hole at the top of the PVC pipe for securing the transducer. Suspend the pipe so that water will enter the pipe ensuring that the water level in the pipe is able to equilibrate with the water level in the water body. If a staff gage is not present at the installation site, install a T-post following the procedure in SOP-SW-08 and then attach the PVC pipe to the post along with a staff gage. 4. Use a direct read cable ONLY in situations where the top of the cable will not be submerged in the event of high water. This precludes using direct read cables in creeks and some ephemeral drainages. If a direct read cable is replacing paracord, pull the old logger and cord out of the PVC pipe. Measure the length of cord. Determine the length of direct read cable needed to ensure the logger is immersed at the correct level. Surface water levels may change significantly over short time periods, so suspend the transducer near the streambed/bottom of the pond, but not resting on the bottom. Be sure the transducer is not resting in silt/sediment because this will clog the transducer. 5. When installing a transducer with paracord, follow the steps above to ensure the transducer is deployed at the correct level. 6. Once proper level is determined, if you are using a direct read cable that is a little long, spool up the extra cable and fasten (zip tie or other similar fastener), to keep it organized, inside the PVC pipe. 7. Securely fasten the direct read cable/paracord to the PVC pipe leaving enough length for the communication end of the direct read connection to easily reach the blue tooth device. It is not necessary to leave an extra length of paracord. 8. Connect the direct read cable/paracord securely to the top of the PVC pipe. This can be accomplished by drilling a hole in the pipe to attach a fastener. If attaching to the PVC, apply a fastener on each side of the slot so the direct read cable cannot move up or down. For paracord, tie a knot in the cord on the outside of the PVC pipe to ensure it does not slip down the pipe. 9. It would be unusual to use a vented cable on a surface water body, but if one is being used, ensure the desiccant is a color indicating it is effectively removing moisture. 10. The fastener type may vary from site to site. Professional judgement should be used on a case-by-case basis. Do not install cable/paracord near sharp edges that could damage it. Ultimately, the cable/paracord needs to be secure so it does NOT slip up or down, as that would change the level of the transducer in the water body, resulting in inaccurate data. 11. Once the direct read cable/paracord is installed, attach the transducer to the cable/paracord and slowly lower into the PVC pipe. If using a direct read cable, confirm communication with the logger, so data retrieval is possible.

SOP – H – 09

Shipping Ethanol-preserved BMI Samples

Date Validated/Authorized for use: 01/26/2022

Revision: 3

SCOPE	This SOP addresses packaging, labelling, marking, and shipping BMI samples
RTRA(s) Referenced/ Reviewed	R-L1-Common Hazards Driving Manual Handling RNON-L1-BMI_Sampling
STOP WORK TRIGGERS	1. Unsafe conditions 2. Inadequate PPE or equipment 3. Incorrect labelling, marking, or packaging
MSDS (attach)	1. Ethanol
PPE Required	1. Safety glasses 2. Impervious gloves 3. Long-sleeve shirt 4. Long trousers
P&IDs/Other Relevant Drawings	NA
Other Instructions/SOPs	NA
Required Materials	1. 99% Ethanol 2. Electrical tape 3. Masking tape 4. UN 4GV cardboard container 5. Packing peanuts 6. Poly bag 7. Zip ties
Trained, Competent and Authorized Employees in this SOP	Mat Erickson
Lessons Learned (observations, near misses, etc. to be considered during 2-yr SOP review)	

PROCEDURES

1. Check Sample Containers

Note: Check each sample container one at a time. If new containers or new labels are needed, working with only one sample container at a time will help ensure samples are not mislabeled.

1. Check whether ethanol is leaking through threads of container lid. If ethanol is leaking, electrical tape around the lid may be peeling up or the sample information on the label may be faded, distorted, or in some way illegible. If ethanol leaked during transport to the lab, the source of the leak will need to be located and the sample container will need to be topped off with ethanol. Sample containers should be full, or very nearly full, of ethanol in order to minimize movement of invertebrates during transport. Zero headspace is not a requirement.
    a. Leaking can occur due to container lid not being closed completely; due to fine grains stuck in the threads of the container or in the threads of the lid; or due to small nicks in the lip of the container. Nicks in the container lip can be pressed down with your thumbnail; fine grains can be wiped from the threads with a paper towel, and the lid can be tightened. Replace the electrical tape after topping off ethanol, correcting reason(s) for leak, and tightly closing the container.
    b. If leak cannot be stopped, visually inspect threads and lid to check for leaks in a new sample container. Use tap water to check for leaks if unsure new container will leak. If new container does not leak, decant ethanol from old sample container into new container, then transfer sample into new container, and ensure no debris is left in old container. Top off new sample with ethanol, wipe threads of lid and container with paper towel, tightly close container with lid, and tape threshold of lid and container using a few turns of electrical tape.
2. Check whether sample containers are labelled correctly with sample ID, container number, creek name, and date, ex. SS-01_A, 1 of 1, Blacktail Cr, 9/9/99. Add missing sample information. If sample information is unreadable due to ethanol leaking, replace label with new masking tape and rewrite sample information. Sample information must be legible. If more room on the masking tape is needed to write all of the sample information, replace label with new masking tape and rewrite sample information. Be sure to not mislabel the sample container if applying a new label.

2. Prepare shipping documents and labelling

Note: Class 3 materials, which ethanol solution is classified as, must be sent Priority Overnight when shipping with FedEx.

Note: Shippers must undergo IATA training on a three year schedule.

Note: Shippers must be available via their cell phone at all times while the shipment is in route to its destination.

Note: Three Shipper's declarations and one Cargo aircraft only sticker are required for each UN-spec box in the shipment. One 10in x 10in x 10in UN-spec box is large enough to ship 4L of samples. The airport of departure listed on the Shipper's declaration is listed as Bozeman, which is the location associated with our FedEx account. This is ok, per FedEx guidance

Note: Because the ethanol is necessarily mixed with some creek water in the sample containers, we are shipping an ethanol solution. Ethanol solution must be selected in the Dangerous goods entry page and must be written on the outside of the UN-spec box. If these do not match, the shipment will be rejected, resulting in additional shipping charges, and we could also be fined.

1. Open Shipper's Declaration red hash mark template and the Cargo aircraft only sticker in the Shipping documents folder. Print three copies of the red hash mark template and one cargo aircraft only stickers for each package in the shipment.
2. Cut the white borders off the cargo only sticker. The sticker should be orange and black only.
3. The FedEx Ship Manager software will print the shipping label for each box and then the Shipper's declarations, so you must load the printer tray with the correct number of blank sheets for each shipping label and one Shipper's declaration (for our records), followed by the correct number of red hash sheets for three copies of the Shipper's declaration for each package in the shipment.
4. In FedEx Ship Manager Ship tab then Shipment details tab:
    a. Complete the Recipient information section.
    b. The Sender information section auto populates.
    c. Complete the Package and shipment details section.
        i. Enter number of packages and select identical packages.
        ii. 4L of sample packed in 10in x 10in x 10in UN-spec boxes weigh ~13lbs.
        iii. Service Type is 1 – FedEx Priority Overnight
        iv. Package Type is 1 – Your Packaging
        v. Package Dimensions is Z - Enter Dimensions Manually
        vi. Ship Date auto populates. The default declared value is $100 (which is not displayed) unless you change it to a higher value and are at that point subject to additional surcharges. The $100 default value covers the value of our samples

and so this field does not need to be filled out.

d. Complete Billing details section.
    i. Bill transportation is to 1 – Sender. Our account number will auto populate.
    ii. The P.O. number is the SW Sediment and BMI project number 0231347.03-002-0005. The P.O. number helps the person processing the invoice to bill to the correct project.
e. The Additional references section does not need to be filled out.
f. Select Dangerous goods under Shortcuts section (Identical packages must be selected next to number of packages, for the dangerous goods shortcut to appear). The Dangerous goods window will open.
    i. Complete the first four fields in the 1 – Other tab. The shipper is the signatory. Enter your title, name, place (Enter Bozeman, MT because this is the location our account is linked to even though we are shipping from Butte), and your cell number in case you need to be contacted at anytime while the shipment is in route to it's destination.
    ii. Complete the 2 – Dangerous goods entry tab.
        1. Select 1170 – 1170 under Dangerous goods ID dropdown. This will cause the relevant fields to populate. 1170 – 1170 is the name of the saved information for shipping our ethanol-preserved BMI samples in the 4L per box configuration.
        2. Confirm following fields populate correctly and edit them as necessary.
            a. UN#/ID# is 1170
            b. # of packages is 1. The number of packages is 1 on the dangerous goods tab because each of the packages are identical. The total number of packages is in the Package and shipment details section of the Shipment details tab.
                i. If you edit this value to whatever is on the Package and shipment details section, an error will occur indicating the number of dangerous goods packages must be fewer than the number of packages in the shipment. Leave the # of packages field set to 1.
            c. Packing instruction is 364. The packing instruction must be 364 because we are sending more than 1L of ethanol solution by cargo plane only. Packing instruction 364 a cargo plane only instruction because of the larger quantities that may be sent.
            d. Net quantity is 4L. This is the net quantity per package within the shipment, not the net quantity of all the packages in the shipment.
            e. The technical name field is left blank.
            f. Aircraft type must be selected Cargo aircraft only.
            g. Qualifying word does not need a selection. Ethanol solution is already in the proper shipping name. Solution does not need to be selected.
            h. Ethanol solution, 3, II, must be highlighted in dangerous goods table in middle of window.
        3. When all of the fields are correctly populated, click "add to shipment" at the bottom right of the dangerous goods table in middle of window. This will populate the Ethanol solution information in the Dangerous goods in shipment table at the bottom of the window.
        4. When tabs 1 – Other and 2 – Dangerous goods entry are filled out correctly, click Ok in the lower left of the window. You will be returned to the Shipment details tab.
        5. When all the above fields and information are correct, click the purple "Ship" button at the lower right of the window.
        6. A courtesy quote window will appear. This is not the exact charge for shipment.
            a. Confirm in the upper right hand corner that there are the same number of quote pages as there are packages in the shipment.
        7. Click Ok in the lower left to print the shipping labels and Shipper's Declarations.
        8. If errors occur before or during printing, See troubleshooting section of this SOP.

3. Packing samples and labelling and marking packages	Note: The Cargo Aircraft Only sticker must be applied to the same side of the package as the DOT FLAMMABLE LIQUID 3 sticker using packaging tape. Because this side also contains fields for Proper Shipping Name and UN Identification Number, this side of the box is crowded. Check placement of stickers before adhering them to ensure there is room to legibly write the Proper Shipping Name and UN Identification Number. 1. Build UN spec box and label it. a. Put the two inner bottom flaps end to end and then the outer bottom flaps end to end. The outer bottom flaps have markings indicating the specs of the box. Those should be visible during shipping. Ensure the bottom of the box is taped. Along with all the lettering, there are arrows on the outside of the box that indicate which end goes up on the box. i. Offset two strips of packaging tape so the overlap about an inch and a half to secure the outer bottom flaps. ii. Use a strip of packaging tape to seal along the lengths of the two edges where the outer bottom flaps and the sides of the box have created gaps. iii. Using overlapping tape and sealing the gaps along the edges will help ensure the samples will not fall out of the bottom of the box during transport. b. On the side of package with fields for the DOT Proper Shipping Name and UN Identification Number, apply a red and white FLAMMABLE LIQUID 3 sticker over the diamond. c. Write Ethanol Solution in Proper Shipping Name field write UN 1170 in UN Identification Number field.

SOP –S – 01

Bump Testing the VENTIS MX4 Gas Meter

Authorized for use: 01/17/2018
Revision 2

SCOPE	This SOP addresses bump testing the VENTIS MX4 gas monitor. The gas monitor needs to be bump tested before use each day.
TRA(s) Referenced/ Reviewed	TRA1-001: Common Hazards TRA1-016: Calibrate-Bump Test
STOP WORK TRIGGERS	Unsafe conditions Inadequate PPE or equipment
MSDS	Non-Flammable Gas Mixture (Industrial Scientific Calibration Gas)
PPE REQUIRED	Safety Glasses Safety Toe Boots
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Ventis MX4 Portable Multi-gas Monitor Positive flow regulator Calibration tubing with t-fitting Gas cylinder
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Michael 4. Joel Arbaugh 5. Nicole Santifer 6. Caleb Arbaugh
PROCEDURES	
DOWNLOADING TRANSDUCERS IN SURFACE WATER BODIES	1. Attach the regulator with tubing attached to the gas cylinder and turn clockwise to tighten, Do Not attach the tubing to the monitor at this time. 2. Turn on the gas monitor by pressing the ON button until the screen turns on 3. Press the ON button until ø(zero) is displayed 4. Press the ENTER button, a clock will appear at the top of screen, when it is finished it will beep and return to the home screen 5. Press ON button until BT is displayed 6. Press the ENTER button 7. Connect the tubing to the pump inlet 8. Turn the regulator knob counterclockwise to start the flow of gas (clock icon flashes to indicate the test is in-progress) 9. Verify that the monitor is beeping and vibrating in response to the gas 10. If the bump test passes a P will be displayed for all four sensors, If it fails a b F will display and the monitor will need to go through a full calibration. 11. Turn the regulator knob clockwise to turn off the flow of gas immediately after the test is complete. 12. If the monitor passes the bump test it will continue to alarm until the gas level falls under the low alarm level. 13. Press the ON button until the peak reading screen displays (looks like a mountain with an arrow in top right corner) 14. Press the ENTER button to clear the peak readings 15. Zero the monitor in fresh air (not in the area you bump tested in) by following steps 3 and 4 above
DOCUMENTATION	1. Document bump test and results in field book / other documentation

SOP - SS – 02

Streambed Sediment Sample Collection

Date Validated/Authorized for use: 02/01/2022

Revision: 0

SCOPE	This SOP addressed collecting streambed sediment samples. The SOP is for wet sediment.
TRA(s) Referenced/ Reviewed	R-L1- Common Hazards, Driving Manual Handling-BPSOU
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme Wind Unsafe conditions Inadequate PPE or equipment Water depth greater than three feet and life jacket, throw ring, and rescue skiff or railing are not on hand Inability to access the work area safely
MSDS (attach)	Arsenic Cadmium Copper Lead Mercury Zinc
PPE Required	Hard hat Waders If using boot foot waders, ankle support required. Safety glasses High visibility shirt or vest Gloves (leather, impervious, and shoulder length gloves (calving gloves)) Long-sleeve shirt Long trousers
Other Instructions/SOPs	SOP-G-01 Field Documentation SOP-G-02 Sample Packing and Shipping SOP-03 Sample Custody SOP-G-04 Field Quality Control Samples
Required Tools	Grab Samples Wide-mouthed sample jar Telescoping pole with clamp Sediment dredge Core Samples Sampling tubes Sample extraction tool Stainless-steel or plastic bowls, or 2-3 gallon plastic buckets Measuring tape Water-proof markers Long-handled scrub brush 5-gallon buckets or sprayer for decontamination
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Dalen Longfield 4. Joe Moodry 5. Caleb Arbaugh 6. Joel Arbaugh

PROCEDURES

GENERAL	Sediment sampling can consist of grab samples obtained from the top of the sediment layer or cores obtained by hand drilling or other means. Grab samplers collect only disturbed samples and should be used only after the sampling of the overlying water has been completed. A core sampler should be used when an undisturbed sample is required. When sediment sampling in a stream, sampling should occur in a downstream to upstream direction. In most cases, composite sediment samples should be collected along a cross-section of a river or stream to characterize the bed material adequately. A common practice is to sample at quarter points along the cross-section of the site selected. When the sampling technique or equipment requires that the samples be extruded or transferred at the site, they can be combined into a single composite sample. However, samples of dissimilar composition should not be combined, but should be stored for separate analysis. When collecting sediment samples in lakes, ponds, and streams the site should be approximately at the center of the water mass. This is particularly true for reservoirs that are formed by the impoundment of rivers or streams. Generally, the coarser grained sediments are deposited near the headwaters of the reservoirs, and the bed sediments near the center of the water mass will be composed of fine-grained materials. The shape, inflow pattern, bathymetry, and circulation must all be considered when selecting sediment sampling sites in lakes or reservoirs. In rivers or streams, fine grained sediments are deposited on the outside of bends and downstream from islands or obstructions.
GRAB SAMPLES – EQUIPMENT	Grab samples are applicable only to the top sediment layer. If the goal is to sample sediment greater than two inches deep, a core sampler should be used. In small, low flowing streams or near the shore of a pond or lake, a grab sample can be obtained by scraping up the sediments with a sample container. To obtain sediments from larger streams or farther from the shore of a pond or lake, a wide-mouthed beaker type sample container clamped to a telescoping pole may be used to dredge sediments. To obtain grab samples of sediments from rivers or in deeper lakes and ponds, a spring-loaded sediment dredge may be used by lowering the sampler to the appropriate depth with a rope or cable. Spring-loaded samplers close automatically when raised or can be closed with a messenger.   Telescoping pole with sample container Dredge Sampler

DISCRETE INTERVAL SAMPLES - EQUIPMENT	Discrete interval samples are most easily collected with sampling tubes. Tubes come in various lengths and diameters. The water depth and sediment coarseness should be considered when choosing a tubing length and diameter. The courser the material, the smaller diameter tube should be used. When choosing a tubing length, a length which will allow the top of the tube to remain above the water surface when penetrating the streambed to the desired depth is preferred. 
GRAB SAMPLE COLLECTION	To collect a grab, or surface, sediment sample, simply drag the sampling devices across the top surface of the sediment.
DISCRETE INTERVAL SAMPLE COLLECTION	1. Mark sampling tube: With a water-proof marker, pre-mark sampling tubes near one end of the tube with an arrow pointing towards the end of the tube and the word "TOP". This will help distinguish the top layer of sediment and the bottom sediment layer. If ground disturbance permits have not been completed, make an easily identifiable mark at 12-inches from the bottom of the tube. Penetration shall not exceed 12-inches without obtaining ground disturbance permits and completing all requirements of the permit. 2. If separate depth intervals will be collected, prepare a container for each interval. Containers can be clean (phosphate-free detergent washed and rinsed) stainless-steel bowls, plastic bowls, or 2 to 3 gallon plastic buckets. Mark each container with the intended depth increment. If sediment is not to be separated into depth intervals, have a single clean container ready. This (these) container(s) will be used for compositing the samples. 3. Push the tube by hand, without the aid of any additional means (i.e. hammering) into the streambed to the desired depth, or until resistance is met. Be certain that the arrow marking the top of the tube points skyward. Once the tube has been pushed into the bed sediment, seal the top of the tube (i.e., with a gloved hand or a plunger), and slowly extract the tube, keeping the tube straight and not turning the tube. The depth to which sediment can be successfully extracted will depend on the grain size of the sediments; the finer the sediments, the more likely the full depth will be successfully extracted. Even fine-grained sediments are extremely difficult to extract from depths greater than three feet. 4. Once extracted, determine the sample depth by measuring the length of sediment in the tube with a tape measure. The 0 depth starts nearest the end marked "top". Measure increments from the top of the sediment surface downward. Hold the sampling tube horizontally to avoid sample material falling out of the tube. 5. Record the sample depth in the field book, or appropriate electronic form. If required by the QAPP, photograph the sample tube. Record a brief description (color, texture, and odor) of the sediment characteristics in the field book or on appropriate field forms. 6. Remove the sediment from the tube. If the sediment is loose. It will slide out on its own. If depth-integrated samples are being collected, remove the bottom increment from the tube, and work upward until the top increment has been removed. If sediments are not loose, use an extraction tool to push the sediment from the tube.
COMPOSITE TRANSECT SUB-SAMPLES, GRAB or DISCRETE SAMPLES	1. At each sampling transect, collect a minimum of four sub-samples. Five sub-samples are preferred, but if five depositional areas cannot be located within a transect, four will suffice. Collect no more than ten sub-samples at each transect. 2. Composite subsamples from each location into a single site sample by depositing all subsamples (for each depth increment if applicable) into a plastic bowl. Stir the sample to thoroughly mix it. Divide the sediment in the bowl into quarters. Put an equal number of sample portions from each quarter into a labeled sample container.
EQUIPMENT DECONTAMINATION	1. Any re-usable equipment must be decontaminated between sampling sites. First, rinse the equipment in stream water to remove any large particles. Use a two bucket (or sprayer) process for the remainder of the decontamination process. After removing large particles by rinsing in stream water, use a long-handled scrub brush to clean the equipment in a bucket of tap, distilled or DI water containing a small amount of laboratory grade detergent. As the final step, rinse the equipment in a bucket of tap, distilled, or DI water to remove detergent. Let the equipment air dry. Since wet sample material will be placed into containers, it is not critical that equipment completely dries. 2. Place decontaminated equipment in clean plastic bags for transport to the next site.

DOCUMENTATION	1. In the field book, at the beginning of the sampling job, record date, personnel involved, safety topics for the day, and weather conditions. Record any unusual circumstances in the field notes and/or electronic field form, if applicable. If notes are recorded only on the field form, cross-reference the form in the field book, and vice-versa. At the end of the day record any deviations from the Work Plan/Sampling Plan. 2. Each sample shall be clearly labeled in waterproof ink with a unique sample ID, sample date, sample time, sample analysis, sample preparation (i.e. filtered, preservative used), and sampler's initials.

SOP – SW – 01
SURFACE WATER SAMPLING

Authorized for use: 04/12/2021
Revision 13
Reviewed:

SCOPE	This SOP addresses the manual collection of surface water samples.
RTRA(s) Referenced/ Reviewed	R-L1- Common Hazards, Driving, Manual Handling R-L1- Surface Water Sampling
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme wind Unsafe conditions Inadequate PPE or equipment Water depth greater than three feet and life jacket, throw ring, and rescue skiff or railing are not on hand Inability to access the work area safely Defective equipment
MSDS (attach)	Arsenic Cadmium Copper Lead Mercury Zinc HCl HNO_3 H_2SO_4 pH buffers (4.00 s.u., 7.00 s.u., 10.00 s.u.) Conductivity Standard (<3 ms/cm) EDTA
PPE REQUIRED	Hard hat Waders (rubber soles) Safety glasses High visibility shirt or vest Gloves (leather, impervious, and shoulder length gloves (calving gloves)) Long-sleeve shirt Long trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Sample bottles Filters Peristaltic Pump and appropriate cords Appropriate 12-V battery Tubing Deionized water for decontamination Churn Splitter YSI Pro Plus meter Turbidity meter Crescent wrench 5 Gallon bucket Table
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Matt Kilsdonk 4. Caleb Arbaugh 5. Joel Arbaugh 6. Mat Erickson 7. Dalen Longfield 8. Kirsten Vose 9. Joe Moodry 10. Nate Beinemann

PROCEDURES

BEFORE SAMPLING BEGINS

1. When conducting normal flow sampling or substrate monitoring, contact WOOD (or current Polishing Plant operators). Alert them to the fact that we are conducting sampling, ask them the current flow rate and confirm that the flow rate can be maintained throughout the sampling event. In the logbook, record that the Plant was contacted and alerted to the sampling and document the current flow value. After the sampling and flow team have moved past SS-05, immediately notify the Plant that both teams are above the discharge, confirm the flow rate and document in the field book. The sampling team must be notified by WOOD (or current Polishing Plant operators) if unexpected problems occur that adversely affect the discharge during the duration of the sampling event. Upon notification, contact field team lead to discuss.
2. Current Operator Contact Information follows:

	Name	Phone number	email
1.	**Name**	**Phone number**	**email**
2.	Mike Tidwell	(530) 307-8819	Mike.tidwell@woodplc.com
3.	Hope Mariska	(808) 306-4419	Hope.mariska@woodplc.com
4.	Plant Operator	(406) 792-1002	
5.	Plant Operator cell	(406) 603-0961	

Surface Water Sample Collection

Bottle and preservation requirements for creek baseflow samples are as follows:

- Total Metals 250 mL plastic, HNO_3 preserved
- Dissolved Metals 250 mL plastic, filtered, HNO_3 preserved
- NO_2/NO_3 250 mL plastic, H_2SO_4 preserved
- Alkalinity, TDS, TSS, SO_4, 1000 mL plastic, no preservative, zero headspace
- Dissolved Organic Carbon 250 mL amber glass, filtered, H_2SO_4 preserved (required at SS-07, SS-06G, SS-01.35 and SS-01)
- TKN 250 mL plastic, H_2SO_4 preserved (required at SS-07, SS-06G, SS-01.35 and SS-01)
- NH_3, Total Phosphorous, 250 mL plastic, H_2SO_4 preserved (analysis from NO_2/NO_3 bottle) (required at SS-07, SS-06G, SS-01.35 and SS-01)
- **Note: The field QC set will be collected on a rotating basis at SS-07, SS-06G, SS-01.35, and at SS-01, with the field QC set being collected at SS-07 quarterly (e.g., collect the field QC set at SS-07 four months out of the year in January, May, September, and again in December.) When the field QC is collected at SS-07 and you are using the churn splitter, the blank will be collected "before" the sample because we are testing to see if the decontamination of the churn splitter is adequate. Due to the way the COC transformer works, the sample ID of the blank will not be the first ID of the day but rather the third sample ID for the day. For example, if you are starting the day with increment 001 at SS-07, on the PrePrep tab you still need to enter SS-07 (FG) as increment 001 and SS-07 (FG-D) as increment 002 and the blank SWQC (ECB/FB) will be increment 003.**
- **Note: The lab QC requires extra metals bottles at either SS-07, SS-06G, SS-01.35, or SS-01 (Does not have to be collected at the same site we do our QC but it can be, your choice). These extra bottles are collected in case the lab needs to re-run analyses due to the lab QC not meeting criteria. Collect two total metals and two dissolved metals bottles. Change the bottle number on the COC for the site used for lab QC to 8 to reflect the correct number of bottles sent to the lab. Add the comment "Use for Lab QC" to the COC on the appropriate line (site) that you collected the extra bottles.**

1. Read and record staff gage according to SOP-SW-06_ReadStaffGuage.
2. Surface water samples are collected by submerging a sample container into the water body, or in the case of the dissolved portion of a sample, pumping source water through a 0.45-micrometer filter and into a sample container. If sample bottles are pre-preserved, the raw general chemistry bottle is used to collect all sample aliquots. The sample is then poured (or filtered) from the raw bottle to the acidified bottles. This is repeated until all bottles are filled. If using the Raw bottle to collect samples and filter out of, rinse the bottle again before beginning to collect the raw sample itself. Samples can be collected two ways. Equal width increment sampling consists of crossing the stream and collecting the sample at equal intervals (composite) and the other is by collecting the entire sample at one spot (point source sampling). Always wear clean impervious gloves when collecting samples to protect both skin and sample integrity. Shoulder length gloves are available when necessary and should be worn in conjunction with impervious nitrile gloves. Always change gloves between sites to avoid cross-contamination.
3. Entrance into a water body always requires the buddy system. At least two people must be present for sampling in a water body to take place.
4. Surface water samples can be collected by entering the stream or from the side of the stream, depending on the stream reach. For streams greater than three feet in width, the equal width increment method will be used. For streams less than three feet wide or less than six inches deep, (surface water puddles, ponded areas, or end-of-pipe sampling), a sample can be collected from one point (See Point-source Sample Collection in this SOP). When sampling stream reaches that are not completely mixed, a churn splitter will be used to collect the sample. When sampling water bodies that are difficult to access by hand, a Water Thief (long handled sampling device) should be used. Always wear impervious gloves when collecting water samples.
5. When entering a stream, always face upstream. Cross the stream cautiously, stepping sideways. Do not rush. Make sure to enter below the sampling point.

6. Place YSI meter in stream to collect the necessary parameters following the Field Parameter Measurement Section in this document.
7. To sample by the grab method, decontaminate the sample container by submerging the container to collect a small portion of water. Replace the container lid and invert the container several times, ensuring that the water within the container has washed all surfaces of the container. Discard the decontamination water downstream stand in one position. Then fill the container. To sample using the Water Thief, follow the same decontamination procedure as grab method. Use care that the stream bed is not contacted. Transfer the sample from the rinsed Water Thief into the sample container.

Equal Width Increment sampling:

1. Prior to collecting water along the transect, decontaminate the sample container by submerging the container to collect a small portion of water. Replace the container lid and invert the container several times, ensuring that the water within the container has washed all surfaces of the container. Discard the decontamination water downstream of the transect start point. If sample containers are not certified, the rinse process should be carried out three times. Certified containers require only one rinse.
2. Do not rinse pre-acidified bottles.
3. During equal width increment collection, before beginning each pass or transect across the stream, stand at one edge of the stream. Note your start point by selecting a landmark on the bank, e.g. a boulder, the sampler, a tree branch. Look across the stream and select another landmark. Carefully note a stop point on the opposite bank, a few feet upstream of your start point. You will collect samples along this imaginary, diagonal transect between the start and stop points. Visually divide the stream reach into equal increments. Narrower sites will require fewer increments and more volume at each increment. Wider sites will require more increments and less volume. Between 10-20 increments are appropriate for the majority of our established creek sites.
4. To begin collecting water along the transect, dip the bottom lip of the 1L raw sample container (s) opening just below the surface of the water collecting a small portion of water into the sample container. To avoid suspending and collecting sediments, do not touch the streambed with the sample container and do not drag your feet through the sediment as you move across the stream. Deliberately lift and drop each foot as you traverse the transect.
5. Step sideways along the previously identified transect toward your landmark, on the other side of the stream. Remember, each transect needs to be just upstream of the previous transect to avoid collecting suspended sediments stirred up by your movements. Continue in this manner across the stream until you reach the stop point landmark you have previously selected on the opposite bank. Do not allow the sample container to overfill, to avoid secondary circulation and enrichment of heavy particles.
6. Return to the opposite bank and exit the stream below your start point landmark. Fill your sample bottles from the 1L raw sample container.
7. For the last transect, completely fill the 1L raw sample container. Collect a zero-headspace sample, (a sample with no air in the container). At the last increment of this last transect, submerge the container, and cap it underwater. Invert the cap to allow all bubbles to leave the cap before screwing it onto the container. Remove the capped sample container from the water and invert it to see if there are bubbles. If there are bubbles, you can hold the container at a slight angle and squeeze it slightly until a trickle of water comes out indicating all the air is pushed out of the container.
8. **Because the sample volume required for all samples may necessitate multiple transects across the stream, the start and stop points of each subsequent transect will be upstream of the previous transect start and stop points, respectively. Do not cross your previous transects. Always sample in an upstream manner.**
9. **See Photos section at the end of this SOP for diagram of EWI sampling**.
10. **Avoid sampling near obstructions to flow and do not collect coarse particulate organic matter.**
11. If turbidity is required, triple-rinse turbidity vial using the raw bottle filled by the equal width increment method. Fill the vial with sample water, dry the exterior of the vial with Kim wipe, line up the arrow and insert the vial into meter. Run the test and record result in logbook and doForm.
12. The dissolved metals and the DOC sample requires filtration. Collect the filtered portion out of the non-preserved container(s) which have been previously filled using the equal width increment method. Rinse the outside of the pump tubing as well as the inside with this water. Place a short (1 foot) piece of tubing in the pump and place a filter on the outlet end of the tubing. For the outside rinse, pour a small amount of water, over the intake tubing end. Submerge the intake tubing into the bottle and pump for approximately 3 seconds after the water begins to flow through the filter, thereby, conducting a brief decontamination of the tubing and filter. Immediately after the decontamination, collect the sample. If collecting a grab sample, the filtered aliquot can be pumped directly from the stream, if it is convenient to do so.
13. To sample with a churn splitter, use the non-acidified container to collect the sample water. Before collecting the sample, rinse the decontaminated churn splitter with sample water by pouring several bottles of source water into the churn splitter. Swirl the water in the churn splitter, covering all surfaces, and then empty the churn splitter of the rinse water by dispensing some through the spigot and pouring

	the remaining water out of the top of the churn splitter. Using the equal width increment method described above, collect sample water and transfer it into the churn. Be sure to collect adequate water to fill all sample aliquots as well as to rinse any tubing used for filtered aliquots. Once adequate water has been poured into the churn splitter, begin "churning" the water by slowly raising and lowering the handle, taking care to not break the water surface. While the water is being churned, the samples should be dispensed out of the spigot. Collect the total metals aliquot first then dispense any total dissolved solids (TDS)/total suspended solids (TSS). The TDS/TSS aliquot should never be the first or last sample dispensed. At this point, collect all sample bottles that do not require filtration. Lastly, collect any dissolved/filtered aliquots. To collect the filtered aliquot(s), rinse the intake end of tubing and place in the churn splitter. Churning is not necessary when collecting filtered aliquots. Pump the sample out of the churn splitter, through the filter, into the sample bottle. Churn splitters will be used at SS-07 and SS-05. After sampling with the churn splitter write, "Churn splitter will be deconned in lab prior to next use. No other re-usable equipment to decon." 14. Returning to the lab, decontaminate the churn splitters following the procedure located in the lab. After decontamination, document the decontamination on the log located in the lab. When preparing for the next sampling event, after recording the calibration tables in the logbook, record when the churn splitters were decontaminated i.e., "SS-07 dedicated churn splitter deconned MM/DD/YY after use on MM/DD/YY. SS-05 dedicated churn splitter deconned MM/DD/YY after use on MM/DD/YY." 15. In cases that sample portions do not need preservation, no air space should be left in the sample container. In cases that sample portions do need preservation, minimal air space should be left in the sample container; however, take care to not overfill to ensure that preservative is not lost. 16. If not using pre-acidified bottles, return to vehicle for sample preservation (when applicable). If not practical to return to vehicle, find a level, clean working surface. Set all sample portions on the working surface and separate by type of preservative required. The outer shoulder length gloves can be removed, but inner nitrile or impervious gloves must be worn. Be certain that safety glasses are on. Do not handle preservatives or empty preservative vials without protective gloves or safety glasses. Set appropriate preservative next to appropriate sample portion. Remove lid of sample container and add the appropriate type and amount of preservative to the sample. Replace lid and tighten securely. Discard empty preservative vials. Remove protective gloves. 17. Label all samples following the instructions in #2 in the Documentation section below. 18. Place samples in cooler containing ice. 19. Discard tubing and filter after sampling. 20. Write "No re-usable equipment to decon." at all sites that do not require a churn splitter. Move on to the next site until all sites are completed.

BMFOU Discharge Structure Sample Collection	1. Sampling the BMFOU discharge structure requires a crescent wrench; a battery; a peristaltic pump; a 5gal bucket or a table; ~7ft of hard tubing; ~12in of soft tubing; two 250mL HNO_3, two 250mL H_2SO_4, one 250mL amber glass H_2SO_4, one 1L raw bottle; and a 0.45-micrometer filter. Use a cart to haul equipment if necessary. 2. Confirm sampling coordination email has been sent copying Todd Church, Dave Griffis, and Adam Logar. Email should be sent about one week prior to sampling. 3. Approach the discharge structure by staying on the gravel path on the north side of the structure. Avoid walking on the riprap that borders the other sides of the structure. 4. Confirm discharge is occurring by listening or, if necessary, looking through grate on top of structure. If you can't hear or see water discharging out of the outflow pipe, do not sample. **5.** If water is discharging out of the outflow pipe, open the east well casing, using the crescent wrench to loosen the bolts if necessary, and locate a stilling well that doesn't already contain sample equipment. There should be two stilling wells in the east well casing that do not already contain sample equipment. Do not sample from the stilling wells in the west well casing because they each contain sample equipment. **See Photos section at the end of this SOP to identify which well casing to open.** 6. Don impervious gloves. Place the pump on the 5 gallon bucket or table on the gravel path. Place soft tubing in the pump in such a way that the curvature of the tubing points the ends of the tubing away from contaminating surfaces. Attach hard tubing to soft tubing and run the inlet end of the hard tubing down the stilling well to the discharge water that will be sampled. 7. Insert YSI probes into Flow Cell. Attach outlet end of soft tubing to Flow Cell tubing. Power on YSI and pump discharge water through Flow Cell until parameters stabilize. Record parameter values. If the parameters will not stabilize, make a note in the logbook along with the parameter values indicating the values will not stabilize then continue with sampling. 8. Change impervious gloves to a new pair. Disconnect outlet end of soft tubing from Flow Cell being careful not to contaminate the outlet end. Triple-rinse the turbidity vial using discharge water. Fill the vial with discharge water, dry the exterior of vial with a Kim wipe, then insert the vial into the turbidity meter and run the test. Record the result. 9. Be careful not to contaminate outlet end of soft tubing. Use raw bottle to pump into and rinse outlet end if it was touched by a contaminating surface. Triple rinse raw bottle with discharge water and then collect raw sample with zero headspace. Collect the other unfiltered samples, being careful not to contaminate the outlet end of the soft tubing. 10. Attach 0.45-micrometer filter to outlet end of soft tubing. Pump water for approximately 5 seconds after the water begins to flow through the filter then collect filtered samples, being careful not to contaminate the outlet end of the filter. 11. Label all samples following the instructions in #2 in the Documentation section below. 12. **BMFOU samples are not composite samples like other baseflow sites. Make sure to check that the BMFOU (DS-50001) sample is listed as "G" instead of "C" in the Sample Details section on COC.** 13. Place samples in cooler containing ice. 14. Discard tubing and filter. 15. Move on to the next site.
Point-source Sample Collection	**Note: Samples can be collected from a single point on ditches, puddles, ponded areas, discharge from pipes, and streams that are less than three feet wide and/or 6 inches deep.** 1. If surface water is not deep enough to submerge sample container, determine the best location and method to sample the source, e.g. deepest spot of puddle, end of pipe, etc. If the end of a pipe cannot be reached by tubing, the pool below the discharge may be sampled. **Use care that the bottom of the source is not contacted and the sediments are not disturbed.** 2. Don impervious gloves. Place the pump on the 5 gallon bucket or table. Place soft tubing in the pump so that the curvature of the tubing points the ends of the tubing away from contaminating surfaces. Attach hard tubing to soft tubing and run the inlet end of the hard tubing down to waterbody and secure it. 3. Insert YSI probes into Flow Cell. Attach outlet end of soft tubing to Flow Cell tubing. Power on YSI and pump discharge water through Flow Cell until parameters stabilize. Record parameter values. 4. Use T-valve to collect turbidity sample before the Flow Cell. Triple-rinse the turbidity vial. Fill the vial, dry the exterior of vial with a Kim wipe, then insert the vial into the turbidity meter and run the test. Record the result. 5. Decontaminate the raw sample containers by pumping water into or submerging the container to collect a small portion of water. Do not decontaminate preserved sample containers. Replace the container lid and invert the container several times, ensuring that the water within the container has washed all surfaces of the container. 6. Discard the decontamination water downstream of source or onto the ground if discarding to waterbody will stir up sediments. To sample using the Water Thief, follow the same decontamination procedure as grab method. Transfer the sample from the rinsed Water Thief into the sample container. 7. Repeat decontamination three times (triple rinse). 8. Be careful not to contaminate outlet end of soft tubing. Use raw bottle to pump into and rinse outlet end if it was touched by a contaminating surface. Collect raw sample with zero headspace. Collect the other

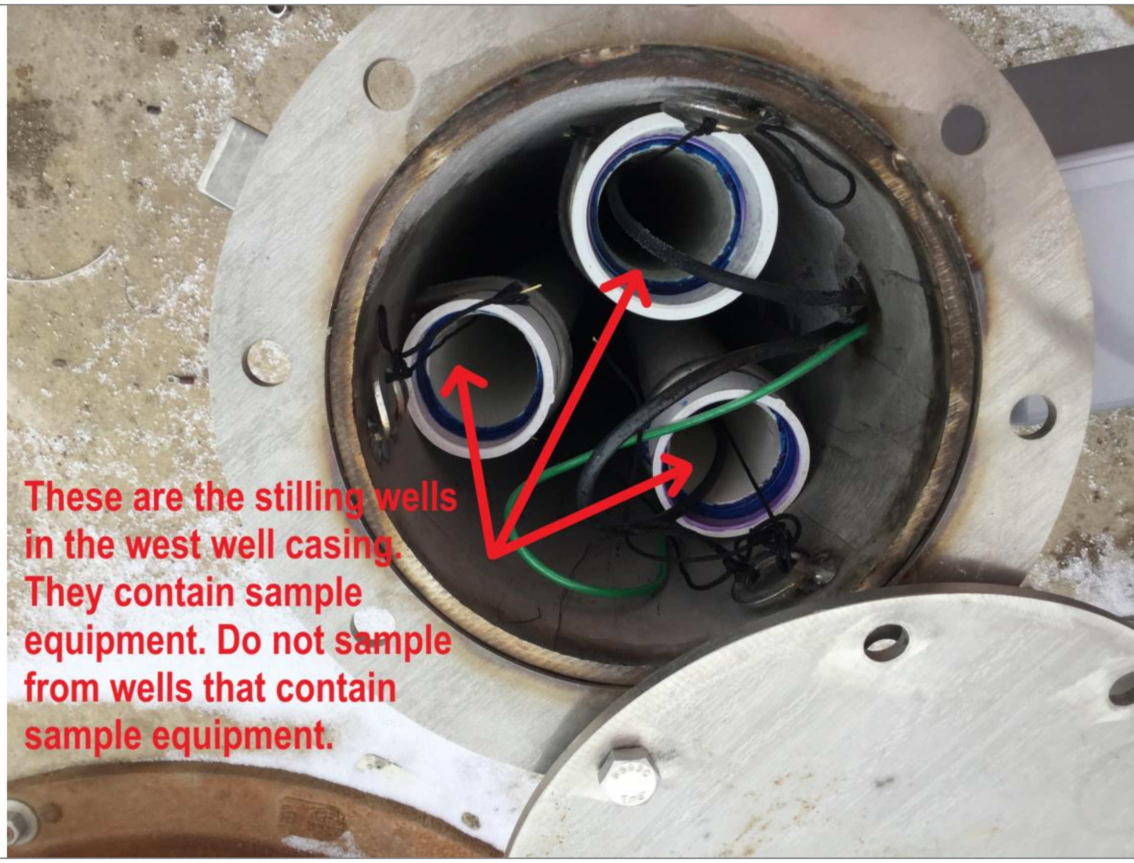
	unfiltered samples, being careful not to contaminate the outlet end of the soft tubing. 9. Attach 0.45-micrometer filter to outlet end of soft tubing. Pump water for approximately 5 seconds after the water begins to flow through the filter then collect filtered samples, being careful not to contaminate the outlet end of the filter. 10. Label all samples following the appropriate naming convention for the project. 11. Place samples in cooler containing ice. 12. Discard tubing and filter.
FIELD PARAMETER MEASUREMENT	1) Field parameter meters shall be calibrated within 24 hours of use, following the manufacturer's instructions. Calibration will be documented in doForms and the field book. The doForm to use is located on the iPad at: Project: Butte Form: Butte-Rocker – Equip Calibr r3. 2) To measure parameters, remove plastic cover from bulkhead of meter. Replace with protective metal cover containing holes to allow water to flow over probes. To place multi-meter in the stream, don impervious gloves, using shoulder length gloves, where necessary, and carry the multi-meter to approximately mid-stream, as the cord length allows. Place the meter far enough below the sampling site to avoid a tripping hazard as you enter and exit the stream. Gently place the meter on the streambed with the probes perpendicular to flow and allow it to equilibrate. After sampling is complete, record field parameters. Once parameters are recorded, enter the stream and retrieve the meter, to reduce unnecessary stress on the cord. 3) If meter type or sample location does not allow for immersion in the stream use the Flow Cell to submerge probes. Attach Flow Cell tubing to peristaltic pump and pump water through the Flow Cell. Allow field parameters to stabilize then record the parameters. **Note: Always use Flow Cell when sampling Orphan Boy Discharge**.
DOCUMENTATION	Prior to base flow monitoring, open a "Butte-YYYY-BF_COC" file located at: \\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\ARCO\BPSOUSW\BaseFlow\SampleCollectionRecords 1. All documentation and processing steps are listed on the Microsoft Teams site in an Excel file called yyyy_Butte-Data-Tracking.xlsm. When completing the post sampling data processing and generating a COC, open this document and complete all applicable steps and document with initials and date when each step was completed. 2. Collection Records. Follow **Butte – BF Processing Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20BF%20Processing%20Steps.aspx. This is an older site and you may have to copy the link into your browser to access. Some changes may have been made since this site was made, but it is good general overview. 3. In the field book, at the beginning of the sampling job, record date, personnel involved, safety topics for the day, and weather conditions. Also indicate which iPad will be used to for the day so that records can be easily found if necessary. Complete a "Butte – BF Smpl Clctn r0" doForm on the iPad for each location and document each location sampled in logbook as well. The completed doForms will be used to record sampling field data and generate the COC. Follow **BF I-Pad Steps -smpl** located at **Butte –** https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20BF%20I-Pad%20Steps%20-smpl.aspx **Rocker –** https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Rocker%20-%20BF%20I-Pad%20Steps%20-smpl.aspx This is an older site and you may have to copy the link into your browser to access. Some changes may have been made since this site was made, but it is good general overview 4. Record any unusual circumstances in the notes of the doForm as well as the field book. At the end of the day record any deviations from the current year QAPP. 5. Each sample shall be clearly labeled in waterproof ink with a unique sample ID, sample date, sample time, sample analysis, sample preparation (i.e. filtered, preservative used), and sampler's initials. 6. In addition to the electronic folders and files created when making the COC, please include the following folders and files: a. Equipment: rental and calibration pdfs; b. Scanned documents: Discharge and water sample logbook entries, shipping receipt, and COC pdfs; **7. Note: Scanned logbook files should be labelled with either discharge or water sample titles along with the logbook number to reduce confusion about what part of the sampling process the logbook entries refer to.** **a. To Copper Environmental: Copies of the Equipment and Scanned documents folders, streamflow and COC in pdf and excel format.** **8. Note: Zip the To Copper Environmental folder and email the zip file to Shanna Law at Copper Environmental.** **9. Note: Streamflow Excel files should be combined into a single file when two streamflow teams have collected discharge data. Unused streamflow tabs should be deleted. The names of the compiled**

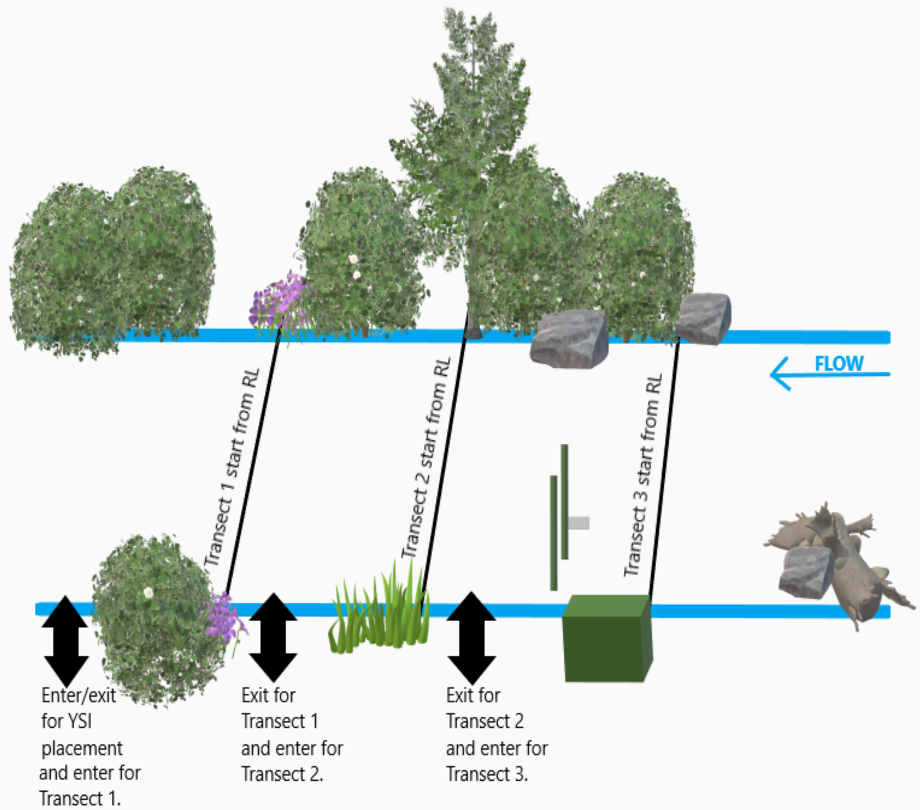
	streamflow files should only contain 1_StreamFlowExcel, the sample date, and the team member initials (e.g. 1_StreamFlowExcel_012720_DCC_MMP)
REPORTING	1. Download doForms, process files with transformer, and organize output forms: a. Download appropriate doForms by following **DoForms Online Download Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms%20Online%20Download%20Step.aspx b. Follow **BF Processing Steps** located at • **Butte –** https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20BF%20Processing%20Steps.aspx • **Rocker –** https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Rocker%20-%20BF%20Processing%20Steps.aspx c. Ensure that all files are complete and organized as instructed in **BF File Organization Details** located at • **Butte –** https://woodardcurran.sharepoint.com/sites/docs/DoForms/Butte%20-%20BF%20File%20Organization%20Details.aspx 10. **Rocker –** https://woodardcurran.sharepoint.com/sites/docs/DoForms/Rocker%20-%20BF%20File%20Organization%20Details.aspx Again these are older sites but may still be useful. If you can't access the site using the links, copy and paste into your browser. 11. All documentation and processing steps are listed on the Microsoft Teams site in an Excel file called yyyy_Butte-Data-Tracking.xlsm. When completing the post sampling data processing and generating a COC, open this document and complete all applicable steps and document with initials and date when each step was completed. 2. Editing and revisions: a. If missing data (date, time, units, etc.) or grammatical errors are discovered, corrections may be made to original doForms and re-import can be performed, or the original output file can also be edited. b. Before submitting the output file to the database, if there are found to be incorrect entries while checking the output file, save the output file as a revision with a date stamp (file-name_revised-mmddyy) and make the appropriate edits, but preserve the original raw doForms. c. After an output file is submitted to the database, and an error is found, save the submitted output file as a resubmit with a date stamp (file-name_resubmit-mmddyy) and make the appropriate edits, but preserve the original raw doForms. Resubmit the file to BPSOU DATA and ask that the previously submitted file be replaced by the recently revised file. Ensure that all revisions are saved to the submittal folder (monthly file) as well as the original file location.
SHIPPING	1. Make sure the number of containers listed on the COC is correct to the number of sample bottles. Check to make sure that the sample ID and date stamp, date, and time match the COC. Ensure that there are initials of the preppers on the "sampled by" line and that the appropriate label (analysis) is on the correct bottle. Confirm that all lids are sealed properly and use duct tape to secure the lids on the 500 mL and 1000 mL bottles. 2. Make any necessary changes to labels or the COC before packing. When the COC is correct, the person who is in the "Sampler's Name" box should sign under "Relinquished By / Affiliation" column on each page of the COC. Copy the COC, make enough copies of the original COC for each cooler and one for the file cabinet. Place the original COC and the copies in zip lock bags and add one to each cooler on top of the ice, making sure the original is sent with the samples. File one copy with the shipping label receipt in the file cabinet in the copy room. 3. Special packing instructions for specific bottles: • Duct tape all raw bottle lids to the bottle. The lids on these bottles do not seal well, and often spill during shipment. • All amber glass bottles must be wrapped in bubble wrap and placed in a cooler of their own. If the glass bottles must be included in a cooler with other samples, surround all the bubble wrapped amber bottles with additional bubble wrap to separate them from the other samples in the cooler. Line the bottom of the cooler with a bubble sheet, and then top the bubble-wrapped bottles with another bubble sheet before closing and securing the cooler. 4. Fill all coolers as full as you can without squeezing bottles in too tight. If on the last cooler, there are not enough sample bottles to completely fill the space, use any kind of appropriate filler to prevent bottles from falling over or sliding during shipment. 5. Confirm that all coolers contain a temperature blank and place the temperature blank on top of the samples. 6. Place ice bags in a zip-lock bag or place all ice bags in a large plastic bag on top of the samples and seal. A minimum of two bags of ice should be used in the winter and a minimum of three bags of ice should be used in the summer. Place the bags of ice on top of the sample bottles in the cooler. Close the lid tightly and duct tape the seal twice over. Place a custody seal over the front latch of the cooler. Using packing tape, secure the custody seal from the front of the cooler to the back. A minimum of three separate strips should be applied in this fashion across the top of the cooler. After the top is taped, proceed to tape over the duct tape seal twice with the packing tape. 7. Either call for a pickup from FedEx or deliver the coolers to FedEx. 8. If calling FedEx for a pickup then you will need the following information for the digital shipping label. Make sure to place the online request as early as possible for same day shipping:

- In the From section: fill out the Date, Sender's Name, Phone, Company (TREC, Inc.), Address (1015 S. Montana St., Ste. C), City (Butte), State (MT), and Zip (59701).
- In the To section: fill out Recipient's Name (Sample Receiving), Phone (612-607-1700), Company (Pace Analytical), Address (1700 Elm St. SE), City (Minneapolis), State (MN), and Zip (55414-2485).
- In Express Package Service, check FedEx Standard Overnight when shipping Monday through Thursday, or "FedEx Priority Overnight" if shipping on a Friday.
- In Special Handling and Delivery Signature Options, check SATURDAY Delivery if shipping on a Friday only. Check No under Does this shipment contain dangerous goods?
- In Payment, check Recipient and fill in the FedEx Acct. No. as 9860-02219. Fill in the number of coolers being sent under Total Packages. Each coolers weight is approximately 65 pounds. 65 * total number of coolers is entered in "Total Weight".

9. Coolers must never be left unattended (locked in lab is fine) until delivered for shipment or pick-up by carrier is complete. If not calling for a pickup and delivering to FedEx then once the coolers are taped drop them off at FedEx.
10. FedEx has PACE's account information on file and they will print off shipping labels to stick on coolers. **STAY UNTIL ALL COOLERS HAVE LABELS. Remember to request or confirm samples are shipping "Priority Overnight" unless shipping on a Friday then request "Priority Overnight with a Saturday Delivery" so the samples are delivered the next day instead of sitting somewhere and having them delivered on Monday (very important due to the temperature requirements on some samples).**
11. Make sure to take the Sender's Copy of the shipping label (receipt) to secure to the copy of the COC and place the COC and shipping information in the appropriate month in the filing cabinet.
12. At a minimum, record in the field book, the date and time samples were shipped and that they were shipped on ice under COC. Address and phone number of lab samples are being shipped to, number of coolers shipped, tracking number, first sample ID - last sample ID if sample numbers are sequential, or, the date(s) samples were collected.
13. TDS and TSS analysis have short hold times of seven days. Email Shawn Davis Shawn.Davis@pacelabs.com or contact him at Pace (612-607-6378) to notify him that short-hold samples are being shipped.

Photos

	 These are the stilling wells in the west well casing. They contain sample equipment. Do not sample from wells that contain sample equipment.



- Always wear impervious gloves when collecting water samples.
- Because the sample volume required for all samples may necessitate multiple transects across the stream, the start and stop points of each subsequent transect will be upstream of the previous transect start and stop points, respectively.
- Visually divide the stream reach into equal increments. Narrower sites will require fewer increments and more volume at each increment. Wider sites will require more increments and less volume. Between 10-20 increments is appropriate for our sites.
- Do not cross your previous transects.
- Always sample in an upstream manner.
- Dip the bottom lip of the sample container opening just below the surface of the water to collect a small portion of water
- Do not allow the sample container to overfill in order to avoid secondary circulation and enrichment of heavy particles.
- Do not touch the streambed with the sample container in order to avoid suspending and collecting sediments.
- Do not drag your feet through the sediment as you move across the stream. Lift and drop each foot deliberately in order to avoid suspending sediments.
- Avoid sampling near obstructions to flow and do not collect coarse particulate organic matter.

SOP – SW – 02

FLOW MEASUREMENT IN WADABLE STREAMS

Authorized for use: 01/20/2022
Revision 10 01/21/2022
Reviewed:

SCOPE	This SOP addresses the manual measurement of surface water flows in streams which can be waded, with a Marsh McBirney flow meter.
RTRA(s) Referenced/ Reviewed	R-L1- Common Hazards, Driving, Manual Handling R-L1- Measure Stream Flow
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme wind Unsafe conditions Inadequate PPE or equipment Water depth greater than three feet and life jacket, throw ring, and rescue skiff or railing are not on hand Inability to access the work area safely Defective equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc PCP
PPE REQUIRED	Hard hat Waders Rubber Footed Safety glasses High visibility shirt or vest Gloves Long-sleeve shirt Long trousers
REQUIRED TOOLS	Wading rod Flow meter Vessel with known volume e.g. graduated cylinder Cloth measuring tape marked in 0.1foot increments Spring clamps iPad
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Mat Erickson 4. Joel Arbaugh 5. Matt Kilsdonk 6. Kirsten Vose 7. Dalen Longfield 8. Joe Moodry
PROCEDURES	
STREAM FLOW MEASUREMENT	1. Prior to conducting flow measurement in conjunction with normal flow sampling and substrate monitoring, confirm the sampling team has contacted WOOD (BMFOU Operator's Office) to get their flow measurement of the discharge and ascertained the plant's ability to keep steady flow below the discharge structure for the duration of the sampling event. BMFOU Operator's Office (1-406-792-1002). 2. When the flow team has completed their measurement at SS-05, they will confirm with the flow team measuring flow at SS-04 that the measurement there is complete also (if two teams are out). After contacting the other flow team, and confirming the measurement is complete, the flow team at SS-05 will contact the Operator's Office. Ask the Operator what the current discharge rate is and whether there were any major fluctuations in discharge when the crew was sampling. Inform him that all crews are above the discharge structure, and they are no longer required to keep the flow steady. Document the time of the call and the flow rate in the field book. 3. As a quick confirmation that the equipment is functioning properly, compare the flow obtained in cfs at SS-05 (below discharge) with the flow obtained in cfs at SS-04 or other Blacktail Creek near upstream sites (upstream of discharge). The flow at the near upstream sites plus the discharge rate obtained from BMFOU Operator should roughly equal the flow obtained at SS-05.

	4. Stream flow is measured by dividing a channel cross section into even increments and measuring velocity at 60% of the total depth of each increment. (At depths greater than 2.5 feet, velocity is measured at 20% and 80% of the depth, and the average of the two measurements is used to calculate flow). Velocity and depth are measured at each increment. Flow in any one increment should not exceed five percent of the total cross section stream flow. The stream should be divided into enough increments so that this criterion is met. 5. Find an appropriate site for measuring flow. Flow should be measured on a straight stream section, not on a bend. If possible, use a cross section of uniform depth and velocity. Avoid areas of excessive in-stream vegetation. If not possible to avoid in-stream vegetation, remove the vegetation prior to commencing flow measurements. Once measurements have begun, nothing should be removed from or added to the stream bed. 6. The flow meter averaging period should be set between 30 and 45 seconds (45 seconds is recommended by USGS). A lower averaging period can be used in storm flow situations, but never reduce the averaging period below 10 seconds. In base flow situations, never reduce the averaging period below 25 seconds. 7. Confirm, by looking at the display, that the measurements are being recorded in FT/S. If not, press and hold ON/C button and OFF button at the same time until the units change. 8. String a cloth tape measure across the stream, so that the tape is perpendicular to flow. 9. If a staff gage is present, read and record the staff gage level at the commencement of flow measurements. Record the time. 10. Proceed to measure flow by measuring and recording distance from the REW, velocity, and depth at the mid-section of each increment. 11. Begin flow measurements at the right edge of water (REW) and document the time the measurements start in the notes of the spreadsheet (REW is the right-hand bank when facing downstream). 12. Set the wading rod at the starting point on the REW with the bulb pointing upstream, observe and call out the distance on the tape that the rod is located at; observe and call out the depth (depth is determined by using the Depth Gauge Rod, one line is a 0.1-foot measurement, two lines indicates the 0.5-foot measurement, and three lines is the 1.0-foot measurement) then set the wading rod to the proper depth. This is accomplished by depressing the sliding rod lock and sliding the rod with the bulb on it until the line on the rod matches up with the observed depth. To obtain a velocity measurement, press the ON/C button. A bar will appear on the bottom of the display screen next to the word period. When the bar reaches the small sideway triangle the period is complete, and the average velocity measurement will appear in the display window. Call out the velocity displayed. Move to the next increment and repeat. 13. If the depth is greater than 2.5 feet, velocity is measured at 20% of the depth and 80% of the depth (two-point method) and averaged. For example, depth is 3 feet. To set the sensor at 20% of the depth multiply the total depth by 2 (3*2) = 6 ft. Set the rod at the 6 on the foot scale and make a velocity measurement over the averaging period. Call out the velocity reading at the end of the averaging period. To set the sensor at 80% of the depth, divide the total depth by 2 (3/2) = 1.5 ft. Set the rod, align the 1 on the foot scale (sliding rod) with the 5 on the tenth scale (the fixed handle). Make a velocity measurement over the averaging period. Call out the velocity reading at the end of the averaging period. Take the average of the 80% measurement and the 20% measurement and the calculated velocity value will be entered into the spreadsheet. In storm flow situations, do not use the two-point method, but the 60% method. Stage changes so quickly in storm flow situations that more accuracy will be lost making two velocity measurements than making only one. 14. If a staff gage is present, read and record the staff gage level at the completion of flow measurements. Record the time. 15. Remove measuring tape from cross section. 16. Exit stream. 17. Move on to next site.
FLOW FROM POINT SOURCE	1. If unable to measure flow with a Marsch McBirney or other mechanical device, and the configuration of the pipe or weir is known, a measurement of the depth of the water and the slope of the surface is needed. After obtaining the information, Mannings Equation is used to calculate the flow. 2. Another flow calculation can be obtained by filling a bucket with a known volume. Measure the amount of time required to fill. Repeat, filling the bucket and timing, 3 times. Take the average of the times you obtained. Example: a bucket that holds five gallons of water takes an average of 30 secs to fill. Convert the gallon measurement to cubic ft. (1 US liquid gallon = 0.133681 cubic foot). Therefore, 5*0.133681=0.668405 cubic foot. Since it took 30 second (average) to fill the bucket the flow would be 0.668405 cubic foot / 30 seconds = 0.02 cfs.

DOCUMENTATION	1. In the field book, before entering the field, record date, personnel involved, safety topics for the day, and weather conditions. Also indicate which iPad will be used to for the day so that records can be easily found if necessary. Once in the field, complete a "Butte – BF Dschrg Msrmnts r0" doForm on the iPad that will be used to record discharge measurement data. Follow **BF I-Pad Steps –dschrg** located at a. **Butte –** https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20BF%20I-Pad%20Steps%20-dschrg.aspx b. **Rocker –** https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Rocker%20-%20BF%20I-Pad%20Steps%20-dschrg.aspx This is an older site so you may have to copy and paste the link into your browser. 2. Record any unusual circumstances you encounter throughout the day in the notes section of the doForm as well as the field book. At the end of the day, record any deviations from the applicable QAPP. 3. Fill out a base flow discharge measurement doForm for each site. 4. Before going into the field, navigate to the OneDrive account and open the Butte folder and then the StreamFlow folder and open the 1_StreamFlowExcelToolbyDRH – Butte.xltm (1_StreamFlowExcelToolbyDRH – Rocker.xltm for Rocker). Select the file and save a copy of the file to the appropriate folder location (Completed Measurements) and rename with the convention StreamFlow_YYYY-MM-DD-initials.xlsx. Use the appropriate (correct site name) worksheet tab and record measurements, the file should autosave. Due to the possibility of data loss, take a screen shot of each completed flow measurement. This can be accomplished by having the tab open and pushing the home screen button and the lock button simultaneously. The lock button can be found on the top of the Ipad (if you are holding the Ipad with the screen facing you) and the home screen button is located bottom center (if you are holding the Ipad with the screen facing you). **Immediately** upon returning to the office (or at a minimum before you leave the office that day), go to the completed file on OneDrive, click the three dots in the top right corner, and select share. On the (To: Name Group or Person) line enter your name and multiple email addresses will pop up, select your email information and your work partner's, for the day, and send the spreadsheet. Go to your Outlook and confirm the file was sent to you and the file is attached email and it contains the data.
REPORTING	1. Download and save the OneDrive excel file that discharge measurements were recorded in to <\\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\ARCO\BPSOUSW\BaseFlow\SampleCollectionRecords\Discharge Measurements>. Also save the file as a PDF. 2. Download doForms, process files with transformer, and organize output forms: a. Download appropriate doForms by following **DoForms Online Download Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms%20Online%20Download%20Step.aspx b. Follow **BF Processing Steps** located at • **Butte –** https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20BF%20Processing%20Steps.aspx • **Rocker –** https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Rocker%20-%20BF%20Processing%20Steps.aspx c. Ensure that all files are complete and organized as instructed in **BF File Organization Details** located at • **Butte –** https://woodardcurran.sharepoint.com/sites/docs/DoForms/Butte%20-%20BF%20File%20Organization%20Details.aspx • **Rocker –** https://woodardcurran.sharepoint.com/sites/docs/DoForms/Rocker%20-%20BF%20File%20Organization%20Details.aspx • **As stated before, these files were created some time ago so you may have to copy the link into your browser to access.** A few steps may have changed over time but these should provide some useful information. 3. Editing and revisions: a. If missing data (date, time, units, etc.) or grammatical errors are discovered, corrections may be made to original doForms and re-import can be performed, or the original output file can also be edited. b. Before submitting the output file to the database, if there are found to be incorrect entries while checking the output file, save the output file as a revision with a date stamp (file-name_revised-mmddyy) and make the appropriate edits, but preserve the original raw doForms. c. After an output file is submitted to the database, and an error is found, save the submitted output file as a resubmit with a date stamp (file-name_resubmit-mmddyy) and make the appropriate edits, but preserve the original raw doForms. Resubmit the file to BPSOU DATA and ask that the previously submitted file be replaced by the recently revised file.

	d. Ensure that all revisions are saved to the submittal folder (monthly file) as well as the original file location.

SOP – SW – 03

CHANGE H350 STAGE RECORDER DATA CARD

Authorized for use: 01/21/2022
Revision 3
Reviewed:

SCOPE	Data cards are changed monthly. Data is retrieved from continual recorders at SS-CB9 and SS-05 using the procedures described in this SOP.
TRA(s) Referenced/ Reviewed	R-L1- Common Hazards Driving Manual Handling TRA1-008: SG Readings Download Sutron ISCO H350 Weather Station
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme wind Unsafe conditions Inadequate PPE or equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc
PPE REQUIRED	Hard Hat Safety Toe Boots/Rubber Soled Waders Safety Glasses High Visibility Shirt or Vest Gloves Long Sleeve Shirt Long Trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Data cards Keys
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Joel Arbaugh 4. Mat Erickson 5. Matt Kilsdonk 6. Joe Moodry 7. Dalen Longfield 8. Kirsten Vose
PROCEDURES	
OPEN H350 HOUSING	1. Wearing work gloves, unlock the lock on the housing, remove the lock, and open the housing door. Store the lock inside the housing.
CHANGE DATA CARD	1. Turn on the H350 interface box. 2. Using the down arrow, key down to Change Data Card, hit enter, and follow the prompts on the display. When the new data card is inserted, a FORMAT CARD? Prompt will appear. To format the card, hit enter. Otherwise hit the down arrow. Only format the card after it has been downloaded. 3. Store the data card that you removed from the logger in the plastic cover provided, and then insert the card into the container of all data cards. Carry these cards in a secure area (pocket that it will not fall out of, zippered bag) 4. On the H350 interface, hit escape to go back to the main menu 5. Read the staff gage to the nearest 0.01 foot. (See SOP: SOP-SW-06 Read Staff Gauge) 6. Look at the bubbler orifice in the creek, if it is covered with debris, remove debris before starting step 7. 7. Read the stage level on the H350 recorder. If the recorder stage is not in agreement with the staff gage, purge the bubbler system as directed below.

	8. After the purge is complete, hit the enter key and the H350 will make a measurement. If the recorder stage is still not in agreement with the observed stage, purge a second time. If it still isn't in agreement the air line may be plugged and maintenance may be required.
FORMATTING DATA CARD	1. All data will be erased when cards are formatted. Never format a data card until all data has been retrieved from the card. 2. Data cards should be reformatted every three to four months. If problems occur retrieving data from a card, the card should be reformatted **AFTER** the data has been retrieved. 3. Using the down arrow, key down to Change Data Card, hit enter, and follow the prompts on the display. When the new data card is inserted, a FORMAT CARD? Prompt will appear. To format the card, hit enter. Otherwise hit the down arrow.
CHECKING LOGGING PARAMETERS	1. Logging parameters should be checked and corrected if necessary at least one time per month. 2. From the main menu, use the down arrows to go to the Logging Parameters menu, hit enter at the Logging Parameters prompt. Use the down arrow to go through the parameters and left/right/up/down arrows to make changes to the logging parameters. Ensure that all logging parameters are correct (Date, Time, Start time, File Name, Logging ON). If a change is made to the time, ensure that the start time is correct. For example, if the current time is 1316, and the recorder time is 1312, enter the correct time (1316). The start time must be updated from 1315 to 1330 or logging will not begin until the following day at 1315. Make sure the Logging is ON. Escape out to the main menu
ADJUST RECORDER STAGE	1. From the main menu, use the down arrows to go to the Edit Coefficients menu. Hit enter. Use the down arrow to go to the EDIT STAGE SCALAR menu. Hit enter and the recorder stage will appear. Use the left, right, up, and down arrows to change the scalar to the observed stage. It is important to enter an accurate stage reading. Once the recorder stage has changed, use the escape key to go out to the main menu. **2. Never adjust the stage when the bubbler is out of the water or encased in ice.**
PURGING BUBBLER SYSTEM	1. The bubbler system should be purged at least once a month and more often in times of high flows or in areas that are prone to sedimentation. 2. Open the compressor system housing which is located directly below the H350 interface housing. 3. Locate the circuit card (against the left-hand housing wall). 4. Towards the front and middle of the circuit card, find the small, white button. Press the button. The compressor will purge. 5. Watch the pressure gage, it should increase to 40 psi as pressure builds, then drop steadily to 0 psi as air is blown out of the bubbler tubing. After dropping to zero, the system should re-pressure slightly. If the pressure does not drop steadily repeat the purge process two to three times. If the pressure still fails to drop steadily, the tubing is plugged and it will be necessary to blow the tubing out with compressed nitrogen. Refer to the appropriate SOP for that process. 6. Once the purge process is complete, close and latch the compressor housing door. 7. If the bubbler outlet is encased in ice, there is no need to purge the system. The system will read an ice pressure until the ice melts.
DEPARTING FROM THE H350 STAGE RECORDER	1. Turn off the H350 interface. Close and latch the doors of the H350 interface and compressor housing. Wearing gloves, close and lock the housing door of the H350 system.
DOCUMENTATION	1. In the field book, record the arrival time, the site name, the staff gage level, and the level on the recording system. Record all tasks performed. At a minimum, the following should be recorded: Arrive at site-include arrival time. Observed staff gage level, level on H350 Any edits made to the stage scalar Change data card-indicate if new card is formatted on site. Check logging parameters Date ok/corrected Time ok/corrected Start time ok/corrected Logging on Purge system

SOP – SW – 04

DOWNLOAD ISCO STAGE RECORDER (4200 or 2150 models)

Authorized for use: 01/22/18
Revision 2
Reviewed: 01/21/2022

SCOPE	ISCO stage recorders (flow meters) are downloaded monthly, or more often during wet weather season. Data is downloaded directly to a laptop computer.
TRA(s) Referenced/ Reviewed	R-L1- Common Hazards Driving Manual Handling TRA1-008: SG Readings Download Sutron ISCO H350 Weather Station
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme Wind Unsafe conditions Inadequate PPE or equipment Defective equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc
PPE REQUIRED	Hard Hat Safety Toe Boots Safety Glasses High Visibility Shirt or Vest Gloves Long Sleeve Shirt Long Trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Laptop computer with ISCO Flowlink 5.1 software loaded ISCO USB-6 pin communication cable (communication cable with threads for ISCO 4200s and communication cable with square tab lock for ISCO 2150s) Keys
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Joel Arbaugh 4. Mat Erickson 5. Matt Kilsdonk 6. Dalen Longfield 7. Kirsten Vose 8. Joe Moodry
PROCEDURES	
OPEN ISCO HOUSING	1. Wearing work gloves, unlock the metal housing. If possible, visually inspect the lock area prior to placing hands in the area. Insects are often within the lock area. Remove the lock(s) from hasp and store it/them on the handles of the metal housing. 2. Open lid and use small S-hook or lock to secure the hinge lock to the lid.

DOWNLOAD DATA	1. Turn the laptop computer on. 2. Lift the flow meter out of the storage box and set it in a stable spot (ie. on top of the sampler). 3. Connect the USB port end of the interface cable to the USB port on the laptop. Connect the 6-pin end of the cable to the interrogation port on the flow meter. 4. Open Flowlink 5.1 software. 5. A Connect window will appear. Select a com port from dropdown window. If you leave on default, it will not connect. After selecting com port, click on the picture of the type of logger you're interrogating (ie. 4200 series for 4230, or 2100 series for 2150). 6. On the drop-down menu, go to Actions/Retrieve Data, click the retrieve data button, or press F8. Wait for the data to be downloaded. 7. After data has been downloaded successfully, look to the left on the computer screen. Click on Graphs and Tables to expand menu. Right click on (either 2150 or 4200) 4 weeks and select Copy to DEFAULT. Return to center of screen. Click DEFAULT Graph button. The graph will be visible. Check the graph for the data you are looking to retrieve. If it is not visible in the screen or if part of it is missing, look at the header and find the small magnifying glass with the negative sign. Using this allows you to expand the dates of the data you are viewing. Once desired data is present in the default graph, export it to the computer. 8. On the drop-down menu, go to File and select Export from the list. An export box will appear. Click the Select button, Desktop, and "Creek Downloads" for creek sites and "Diagnostic Downloads" for diagnostic sites. If there is not a folder for the month you are downloading to, create one. Example: 2018-01. Within the folder, save the file using the site name and date it is downloaded. Example: SS-05A_012218. Click Save. 9. Upon returning to the export box, click export. A message will appear "The data was exported successfully", click okay. Click close. 10. Click to close Default graph. A message will appear, Save changes to DEFAULT – SS-05? Select no. 11. On the drop-down menu, go to File and choose Close, select the Disconnect button, or press F2 to close the program. 12. Disconnect the communication cable. 13. Separate the communication cable from the laptop. Store the laptop computer and communication cable. For 4230 only: 14. Read and record the staff gage to the nearest 0.01 foot, following SOP-SW-06 for reading staff gages. 15. Check the end of the bubbler in the water, if debris is visible, remove. 16. Read and record the stage on the ISCO flow meter. 17. If the flow meter is not in agreement with the staff gage, open the front of the ISCO flow meter (4230). 18. Using the keys on the front of the flow meter, press the manual purge button. Give the unit ample time to purge and return the air to equilibrium before proceeding to next step. 19. If the stage is not within 0.02' of the observed stage, it must be adjusted. Using the keys on the front of the flow meter, press Go To Program Step, then press 3. 20. This brings up the Parameter to Adjust Menu, use the right arrow key to choose Level. In the Level Menu, enter the correct stage using the numbers on the keyboard and hit enter. Use the Exit Program key to get to the main display. 21. Check the date and time on the flowmeter and make any necessary corrections. 22. To correct date or time, press the ENTER PROGRAM STEP key. Use the arrow key and go to Setup, press ENTER PROGRAM STEP. Choose Clock, press ENTER PROGRAM STEP. The program steps through year, month, day, hour, and minute. Adjust any value as needed with the keypad numbers. After each adjustment, or to step to the next choice, press the ENTER PROGRAM STEP key. Continue pressing the ENTER PROGRAM STEP key until returned to the Setup menu. Press EXIT PROGRAM to return to the main screen. 23. Close and latch the door of the flow meter. 24. Replace the flow meter in the storage box. If there is water in the bottom of the box do not set directly on the bottom. This protects the meter from becoming wet in case sampler problems occur. Ensure that all tubing is not kinked or lying underneath the flow meter or sampler. 25. When all recorders have been downloaded, exit the Flowlink program by going to the drop-down menu and choosing File, Exit.
CLOSING ISCO HOUSING	1. Wearing work gloves, replace the lid on the housing box. 2. Lock housing box (if applicable). 3. Proceed to next site.

DOCUMENTATION	1. In the field book, record the arrival time, the site name, the staff gage level, and the level on the recording system. Document that data was downloaded from the recorder and any adjustments made to the recorder level, date, or time and any maintenance done or required in the future.

SOP – SW – 05
DOWNLOAD SUTRON STAGE RECORDER

Authorized for use: 04/15/2020
Revision 3
Reviewed 01/21/2022

SCOPE	There is one Sutron stage recorder present in the BPSOU. It is downloaded monthly, or more often during wet weather season. Data is downloaded directly to a laptop computer.
TRA(s) Referenced/ Reviewed	R-L1- Common Hazards Driving Manual Handling TRA1-008: Download Sutron, ISCO, H350, Weather Station
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme wind Unsafe conditions Inadequate PPE or equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc
PPE REQUIRED	Hard Hat Safety Toe Boots Safety Glasses High Visibility Shirt or Vest Gloves Long Sleeve Shirt Long Trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Laptop computer with Xterm software loaded Laptop computer with a serial port, or a USB/serial port adaptor Laptop/recorder interface cable (stored in Sutron housing) Screwdriver Keys
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Joel Arbaugh 4. Mat Erickson 5. Matt Kilsdonk 6. Kirsten Vose 7. Joe Moodry 8. Dalen Longfield
PROCEDURES	
OPEN SUTRON HOUSING	1. Wearing work gloves, unlock the lock on the housing and remove the lock. 2. Use a flathead screwdriver and loosen each of the screws on the housing. 3. Unlatch the stays, open the housing door, and store the lock on top of the housing.
DOWNLOADING DATA, READING STAFF GAUGE AND CONFIRMING/CORRECTING STAGE	1. If water is present in channel, read the staff gauge following SOP-SW-06 Read Staff Gauge and record the measurement in the field book. 2. Turn the laptop computer on. 3. Connect laptop to Sutron data logger using USB to serial port adapter. 4. Open the Xterm software. 5. Depending on which field laptop you are using, choose a COM port. Try COM 2 and/or COM 6 and the default baud rate from drop-down menus. If the unit still won't connect, try other COM ports listed in the drop-down menu until you are able to connect. Click the bubble for direct connection and hit the ENTER key. 6. Choose either SETUP or RETRIEVAL ACCESS. 7. Go to LOG tab and click EXPORT. 8. Choose COMMA DELIMITED or other format.

	9. Enter your START TIME and END TIME or choose SINCE LAST EXPORT, depending on what data range you need to retrieve. 10. Click OK and Save As. (Use a conventional name with the date and site name and save into dedicated folder on desktop of computer). 11. Click SAVE and then CLOSE data window. 12. Ensure logging is still turned ON and the DATE/TIME is correct in X-Term. 13. If logging is turned off, click button to turn on. If DATE/TIME is incorrect in X-Term, highlight and type in correct DATE/TIME. 14. If observed stage from step 1 differs from stage set on SUTRON, adjust stage. To adjust inside stage reading, click * from the Sutron display. Scroll right until you see "Calibrate", then hit * again to enter calibration screen. You'll see the inside staff gage reading displayed, use the arrows to scroll to the digit to be edited, * to edit, and arrows again to change digit values. Once the desired value is input, use the arrow keys to scroll to the left, hit * once more to exit calibration. Do not adjust stage if bubbler is under ice/snow in channel. A dry channel relates to 0.14 ft. 15. X out of X-term or use LOGOUT. 16. Disconnect the communication cable. 17. Store the laptop.
CLOSE SUTRON HOUSING	1. Wearing work gloves, close the door of the Sutron housing. 2. Using a flathead screwdriver, tighten each of the screws. 3. Replace the housing lock and ensure it is locked.
DOCUMENTATION	1. In the field book, record the arrival time, the site name, the staff gage level, and the level on the recording system. Document that data was downloaded from the recorder and date and time were checked and found to be correct or adjusted.

SO P – SW – 06
READ STAFF GAGE

Authorized for use: 09/02/2021
Revision 3
REVIEWED:01/24/2022

SCOPE	This SOP addresses reading a staff gage in an open water body.
TRA(s) Referenced/ Reviewed	R-L1- Common hazards Driving Manual Handling TRA1-008: SG Readings Download Sutron ISCO H350 Weather Station
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme Wind Unsafe conditions Inadequate PPE or equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc PCB's
PPE REQUIRED	Hard Hat If in the water, rubber soled waders If not in the water, Safety Toe Boots Safety Glasses High Visibility Shirt or Vest Gloves Long Sleeve Shirt Long Trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	At times, steel bar for ice removal and brush for cleaning staff gage
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Mat Erickson 4. Kirsten Vose 5. Joel Arbaugh 6. Matt Kilsdonk 7. Dalen Longfield 8. Joe Moodry
PROCEDURES	
READ STAFF GAGE	1. Locate the staff gage 2. Remove any debris which has built up around/on the staff gage 3. Chip out any ice around the staff gage. Use an appropriate tool to chip ice and always wear heavy gloves. If ice is thin (< 0.5 inch) it can be removed with a shovel. If ice does not easily clear with a shovel or stick, use a steel bar. Hold the bar with both hands and very near the staff gage. 4. Wipe the staff gage clean so that markings can be clearly discerned (use brush, plastic or steel). 5. Read the staff gage to the nearest 0.01 foot. 6. If the type of staff gage pictured below left is utilized (standard USGS), each mark represents 0.02 feet. Therefore, values between marks are estimated as accurately as possible. On the staff gage pictured on the right, each mark is associated with 2 measurements. For example, the line that points toward the number 4 pictured below, the top of the line (pointed) would represent a stage of 0.40 feet. The lower part of the same line (indent), however, would represent 0.39 feet.

SS-05 USGS T-POST CURRENT CREEK STAGE READING

Note: **Do not use the USGS website to adjust the stage reading on the 4230 bubbler.**

Note: Before arriving at SS-05, the field team needs to measure the distance from the water's surface to the top of one of the USGS T-posts, RP-3 and RP-4, at the confluence of Grove Gulch and Silver Bow Cr on the east side of Montana St. Park vehicles on the grassy area just north of the creek and turn on your vehicle's flashers.

1. Using your yardstick, measure the distance from the surface of the water to the top of the T-post. The RP-4 T-post is on shore and should only be used when the stage of the creek is higher than the bankfull height. The image of the T-posts are at the end of this SOP.
2. If your yardstick has increments in the standard 1/8 in., divide the distance measured by 12 to get your distance in 1/10 ft, e.g. 2 ÷ 12 = 0.16 2 in. is 0.16 ft.
3. If your yardstick is in 1/10 increments, you do not need to divide your distance by 12.
4. If the water's surface is above the top of T-post, the distance you measure will need to added to the datum of the T-post. If the water's surface is below the top of the T-post, the distance you measure will need to be subtracted from the datum of the T-post.
5. Enter the time and stage you calculated in the logbook and then go to SS-05. Manually purge the ISCO 4230 bubbler, check the stage the bubbler is reading, and adjust the stage if the difference between the observed stage and the bubbler's stage is > 0.02 ft. The H350 will be adjusted to the historic staff gage attached to the cement bridge structure on the north side of the creek.

DOCUMENTATION

6. In the field book, and on the field sheet, if required, record the time, site name, and staff gage reading. If comparing the open water staff gage reading to a site recorder, and recorder stage is adjusted to the observed, note in field book that the stage on the recorder was adjusted.

REPORTING

1. Enter site name, date, time, and staff gage reading in the appropriate spreadsheet.
   2. Spreadsheet can be found at: \\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\ARCO\LAO\SW
   3. File name: SGReadings_2018 (or appropriate year).

USGS T-POST IMAGE	

SOP – SW – 07
CHANGE ISCO 4230 BATTERIES and ADJUST STAGE

Authorized for use: 04/15/2020
Revision 4
Reviewed:

SCOPE	This SOP addresses changing 12-volt batteries on ISCO flow meters and samplers.
TRA(s) Referenced/ Reviewed	R-L1-Common Hazards Driving Manual Handling R-L1- Change ISCO Battery Ground Level
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme wind Unsafe conditions Inadequate PPE or equipment
MSDS	Lead Acid Battery
PPE REQUIRED	Hard Hat Safety Toe Boots / Felt-Soled Waders Ankle Braces (if necessary) Safety Glasses High Visibility Shirt/Vest Gloves Long Sleeve Shirt Long Trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	ISCO battery
Trained, Competent and Authorized Employees in this SOP	Tina Donovan Alice Drew Davies Joel Arbaugh Mat Erickson Kirsten Vose Dalen Longfield Joe Moodry
PROCEDURES	
OPENING ISCO HOUSING	1. Wearing work gloves, unlock the metal housing. If possible, visually inspect the lock area prior to placing hands in the area. Insects are often within the lock area. Remove the lock(s) from hasp and store it/them on the handles of the metal housing. 2. Open lid and use small S-hook or lock to secure the hinge lock to the lid.
CHANGING ISCO 4230 FLOW METER and/or SAMPLER BATTERY	1. During Offseason (Sampler NOT Present) a. Remove the battery on the flow meter by unscrewing the battery connection on the side of the flow meter. b. Remove the battery from the sampler box. Handle the battery by the molded handles of the battery case. Tuck the cord attached to the battery lid inside the battery box to prevent damage to cord and/or personnel. c. Place the new battery on the cinder block (if there is one in the sampler box) next to the equipment. On the 4230 attach the battery directly to the Flow meter. d. Ensure that the flow meter has power and is turned on and note in the field book. e. During Storm Sampling Season (Creek sites with 4230 Flow Meter, Signature series flow meter and Sampler present). If Signature flow meter is not present, then the sampler will power the flow meter. The sampler will be in line between the battery and the flow meter utilizing a six-pin cord, therefore, the battery will be attached to the back of the sampler. Steps below are for samplers with an inline flow meter as well as those without. a. Unhook the closures on the lid to the sampler (if fastened). b. Remove lid. c. Unscrew the battery connection from the sampler. d. Remove the plastic case that contains the battery from the sampling box. Use the handles on the case to lift the battery. Do not lift by the cord on the outside of the plastic box and never remove batteries from plastic boxes. Tuck the cord attached to the battery lid inside the battery box to prevent damage to cord and/or personnel. e. If maintenance is required on internal tubing or any other moving parts of the sampler, complete all maintenance on equipment while the power source is unhooked. For example, if internal tubing needs to be looked at and/or replaced, unhook power source, unscrew the pump case and check the tubing for wear or holes and replace as needed. Replace the pump case. Do not reconnect the battery until all maintenance is complete. f. Place the new battery in the security box and screw the connection into the proper port. g. Turn on sampler. h. Check the date and time on the sampler, make any necessary corrections. To make changes, first hit the STOP key. Press the ENTER PROGRAM key. Use the arrow key to choose Configure Sampler. At the Select Option (← →) Clock display, press the ENTER PROGRAM key. The

	display reads HH:MM DD MM YY. Make any necessary changes and proceed through the screen by pressing the ENTER PROGRAM key. Continue through the program until taken to the next screen. Press the EXIT PROGRAM key to return to the main display, which will read Program Halted. Press start sampling, and press ENTER two times in quick succession to inhibit sampler. i. Ensure that the sampler display reads Sampler Inhibited. j. Replace the lid onto the sampler, attach the three closures (when necessary). k. As a final precaution, trace all sampler/bubbler tubing in the box. Make sure that no equipment is resting on any of the lines or that the lines are not kinked.
CHECK ISCO STAGE LEVEL ON CREEK SAMPLERS	1. Lift the flow meter onto the top of the sampler. If no sampler is present, set the flow meter on the corner of the storage box, ensuring that it is resting on two walls of the box 2. Read and record the staff gage level and remove debris from bubbler according to SOP-SW-06. Read and record the level on the flow meter. If the two levels agree proceed to step 9, however, if the two levels aren't in agreement, proceed to step 3. 3. Open the front of the 4230 ISCO flow meter by releasing the latches and opening the door. 4. Push and hold down the manual purge button. Purge the bubble line for 10 seconds. Allow ample time for the purge to finish and the air to reach equilibrium before beginning step 5. 5. Using the keys on the front of the flow meter, press GO TO PROGRAM STEP, then press 3. 6. This brings up the Parameter to Adjust Menu, use the right arrow key to choose Level. In the Level Menu, enter the correct stage using the numbers on the keyboard and hit enter. Use the EXIT PROGRAM key to get to the main display. 7. Check the date and time on the flow meter, make any necessary corrections. 8. To correct date or time, open the front of the ISCO flow meter by releasing the latches and opening the door. Press the ENTER PROGRAM STEP key. Use the arrow key and go to Setup, press ENTER PROGRAM STEP. Choose Clock, press ENTER PROGRAM STEP. The program steps through year, month, day, hour, and minute. Adjust any value as needed with the keypad numbers. After each adjustment, or to step to the next choice, press the ENTER PROGRAM STEP key. Continue pressing the ENTER PROGRAM STEP key until returned to the Setup menu. Press EXIT PROGRAM to return to the main screen. Proceed to step 10. 9. Open the front of the ISCO flow meter by releasing the latches and opening the door. Push and hold down the manual purge button. Purge the bubble line for 10 seconds. 10. Close and latch the door of the flow meter following directions in CLOSING ISCO HOUSING. 11. Lifting it by the handle, replace the flow meter to its original position within the metal housing. 12. As a final precaution, trace all sampler/bubbler tubing in the box. Make sure that no equipment is resting on any of the lines.
CLOSING ISCO HOUSING	1. Place the metal lid onto the housing, taking care to line up the lock cover(s) with the hasp tab(s). 2. Place the hasp(s) over the tab(s), lock the lock(s). (where applicable) 3. Proceed to the next site following all applicable SOPs.

SOP – SW – 08

AUTOMATIC AND MECHANICAL SAMPLER SET-UP – CREEK AND DIAGNOSTIC

Authorized for use: 01/25/2022
Revision 4
REVIEWED:

SCOPE	This SOP is for the initial installation of mechanical (D-TEC) and automatic (ISCO) samplers.
TRA(s) Referenced/ Reviewed	R-L1- Common Hazards Driving Manual Handling R-L1- DTEC Sampler Operation R-L1-Above Ground Sampler Collection and Maintenance
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme wind Unsafe conditions Inadequate PPE or equipment Working around water policy
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc PCP
PPE REQUIRED	Hard Hat Safety Toe Boots Rubber Soled Waders Safety Glasses High Visibility Shirt or Vest Gloves Long Sleeve Shirt Long Trousers Ear Protection
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Metal fence posts, heaviest gage steel, 5.5 feet in length recommended. Post pounder Clear vinyl $^3/_8$" ID tubing Bubbler line ($^1/_8$" ID clear vinyl tubing from ISCO) $^1/_8$" stainless steel tubing, with a 90º bend at one end ISCO sampler strainer Cable ties Duct tape Scissors or tubing cutters D-TEC sampler D-TEC sampler bracket D-TEC bracket clamp ¼ " Hex wrench Hose clamps ISCO sampler/flow meter communication cable Elbow length gloves 12-V ISCO batteries Hand Tools Measuring Tape
Trained, Competent and Authorized Employees in this SOP	1. Tina Donovan 2. Alice Drew Davies 3. Joel Arbaugh 4. Mat Erickson 5. Matt Kilsdonk 6. Dalen Longfield

	7. Kirsten Vose 8. Joe Moodry
PROCEDURES	
SETTING THE SAMPLER POSTS IN CREEK	1. If posts will be installed greater than 12", see section "Requirements For Setting Sampler Posts". 2. Find an appropriate location to set the posts. Avoid areas in which large (>1 ft diameter) rocks are known to exist in the streambed. 3. In areas that the stream is not well mixed, the sampler will need to be set mid-stream. It is best to secure the sampler tubing to the stream bed if possible. If that is not possible, insert the vinyl tubing in flexible conduit. 4. In areas that the stream is well mixed, the sampler can be set near the bank from which the site is accessed. If possible, bubbler tubing should always be placed near the bank from which the site is accessed. 5. Keep in mind that in high flows debris and water will travel downstream; and if the tubing is lying across the water surface, it may become kinked, preventing water from being pumped to the sampler or it could get ripped out potentially damaging sampler. 6. It is best to minimize the number of posts in the stream, so if conditions allow, the bubbler tubing, ISCO sampler tubing, and D-TEC sampler should all be secured to the same set of posts. 7. Site the posts so that once tubing is attached to the posts, the lengths of tubing will not create a tripping hazard to personnel accessing the site.
REQUIREMENTS FOR SETTING SAMPLER POSTS	1. A ground disturbance permit is needed if the post goes deeper than 12". Mark the post at 12" before pounding, if it reaches the mark, stop work and obtain a ground disturbance permit. Another method for preventing the post from entering the ground less than 12" is to fasten a hose clamp to the t-post, allowing you to see it when it becomes covered with water. 2. One person shall loosely hold the post in place, near the base of the post, but above the water level. The post will move once pounding begins. 3. The other person shall slip the post pounder over the top of the post once the post is in position. 4. Before pounding the post, be certain that all hands are clear of area of impact of the pounder. Remember that the post will move once it is pounded, so do not have a tight grip on the post. If it is possible for the post to remain in place without being held, then the post need not be held up by the second person. 5. Put on the appropriate ear protection before proceeding. Pound the post once by holding the pounder firmly in two hands. Raise the pounder towards the top of the post and then bring it down with force onto the top of the post. When raising the pounder, do not bring the bottom of the pounder above the top of the post. After the post has been pounded one time (it may take a few times), if the post remains in place on its own, the second person should remove their hands from the post. 6. The second person will remain on-site and watch for debris floating into the work area. 7. Continue pounding the post until the post is secure but no farther than 12" unless a ground disturbance permit has been issued.
PREPARING TUBING	1. Bubbler tubing is procured from Teledyne ISCO. A length of bubbler tubing sufficient to reach from the flow meter to the stream is needed. One end of the tubing is placed on the appropriate fitting on the flow meter; the other end of the tubing is fitted over the $^{1}/_{8}$" stainless steel tubing. Ensure that the connection between the flow meter and tubing is tight. 2. An adequate length of $^{3}/_{8}$" ID clear vinyl tubing is used for the ISCO sampler. One end of the tubing is placed on the appropriate fitting on the sampler. The strainer is placed on the other end of the tubing and secured to the tubing with a hose clamp. The protective cover which is part of the strainer is slid over the strainer/tubing connection point unless the size of the tubing won't fit under it. 3. Measure and record the sampler tubing length. This measurement must be entered in the sampler setup program. 4. At many sites, it is necessary to run the tubing through flexible conduit or steel flex pipe to prevent damage to the tubing and/or damage from vandalism. (For example, where the tubing will be placed mid-channel or where animals may chew through the tubing or places where samplers are located near high traffic areas.) In such cases, run the tubing through the conduit prior to attaching the stainless-steel piece, flow meter tubing, sampler tubing or the strainer. A mechanical device designed to pull items through piping such as a Fish Tape should be used to pull the tubing through the conduit unless the old tubing was left for that

	purpose. In that case, attach the new tubing to the old tubing with duct tape and pull the old tubing out of the conduit and the new tubing into the conduit.
ATTACHING SAMPLER/TUBING TO POSTS	1. The intake (strainer) of the automatic sampler is attached to the post. The strainer should be submerged but secure. It should never touch the bottom of the stream because once the sampler begins to pump and the strainer is in the sediment, it may pull sediment from the streambed along with the water and sample bias may occur. Attach the strainer to the fence post with strong cable ties. Trim the ends of the cable ties. 2. With the ISCO flow meter, either 4230 or Signature, the inlet end of stainless-steel tubing will be submerged in the water body. Be certain that the tubing inlet is submerged to a depth that it will remain under water should the water level drop. Attach to something solid (t-post, bridge abutment, etc.). Attach securely with cable ties or screws, depending on the application but in a way that it metal will not move up or down. Trim the end of the cable ties, if applicable.
PROGRAMMING SAMPLER on CREEK	1. The ISCO sampler and flow meter must be programmed for the proper length of tubing, the vertical rise, and sampling regime. 2. Attach a battery to the ISCO sampler/flow meter following the steps in SOP-SW-07 Change 4230 ISCO Batteries and Adjust Stage and on the Signature flow meter follow SOP-SW-16 Signature Bubbler Set-up. The 4230/sampler set-up, only uses one battery while the Signature/sampler set-up utilizes separate batteries for the Signature and the sampler (Signature flow meters in use on creek are charged by solar power except for SS-01). 3. On the sampler, press Enter Program 4. Use the right arrow key to go to Configure Sampler 5. Ensure that the date and time are correct 6. At Bottles and Sizes, choose Portable, 24, 1000ml 7. At Suction Line, choose 3/8, Vinyl 8. At Suction Line Length, enter the length of suction line that was measured previously. 9. At Liquid Detector, choose Enable 10. Choose 1 Rinse Cycle 11. At Enter Head Manually, choose Yes and enter the estimated head. 12. Enter Retry Up to 1 Times When Sampling 13. Press Exit Program 14. Press Enter Program 15. Choose Program Sampler- Complete with appropriate sampling routine. Sampling routines can be found on-line on One Drive. The folder name is Programming. File is called Configure-Program Creek ISCO Samplers (regulatory monitoring). 16. Press Exit Program
PROGRAMMING 4230 FLOW METERS CREEK	1. The following are directions to program ISCO 4230. 2. On the flow meter, press Go to Program Step, 5 3. At Sampler Pacing, choose Conditional 4. At Condition, choose Level 5. At Level, choose Greater Than 6. At Level Greater Than, enter 0.001 foot less than the level at which the sampler should collect. (This level should have been recorded prior to leaving the office.) For example, if the sampler should collect at 1.50 ft, enter 1.499 feet. 7. At Operator enter Done 8. At Condition True Pacing Interval, enter Pace every 60 Minutes 9. At Condition False Pacing Interval, enter Pace every 60 Minutes 10. At Sampler Enable Mode, choose Conditional 11. At Condition, choose Level 12. At Level, choose Greater Than 13. At Level Greater Than, enter the same level that was entered above. 14. At Operator, choose done 15. At When Enable Condition is No Longer Met, choose Keep Enabled 16. At Plotter On/Off with Enable, choose No 17. At Plotter Speed, choose Off 18. Press Exit Program 19. For instructions to program Signature Flow Meter for sampling, refer to SOP-SW-16 Signature Bubbler Setup.

PREPARE SAMPLER FLOW METER FOR SAMPLE COLLECTION	1. Read and record the staff gage level according to SOP-SW-06 Read Staff Gauge for the 4230-flow meter and the Signature. 2. Set the ISCO 4230 level to the staff gauge level. To do so, press Go to Program Step 3. At Parameter to Adjust, choose Level, at Level enter the correct level. Press Exit Program. 3. Refer to SOP-SW-16 Signature Bubbler Setup to adjust stage on the Signature flow meter. 4. Attach the ISCO sampler/flow meter communication cable to the appropriate connections on the sampler and flow meter. 5. On the sampler, press start sampling, then press Enter 2 times. 6. The sampler display should say "Sampler Inhibited".
SETTING SAMPLER POSTS FOR DIAGNOSTICS	1. A ground disturbance permit is needed if the rebar or post goes deeper than 12". Mark at 12" before pounding, if it reaches the mark - stop work and obtain a ground disturbance permit before proceeding. 2. Before pounding the post, be certain that all hands are clear of area of impact of the pounder. Remember that the post will move once it is pounded, so do not have a tight grip on the post. If it is possible for the post to remain in place without being held, then the post need not be held up by the second person. 3. Don appropriate ear protection (if using post pounder). Ensure that the rebar/post are securely installed and won't be washed away with stormwater. Continue pounding the post until the post is secure but no farther than 12" unless a ground disturbance permit has been issued.
PREPARING TUBING FOR DIAGNOSTICS	1. An adequate length of 3/8" ID clear vinyl tubing is used for the ISCO sampler. One end of the tubing is placed on the appropriate fitting on the sampler. The strainer is placed on the other end of the tubing and secured to the tubing with a hose clamp. 2. Measure and record the sampler tubing length. This measurement must be entered in the sampler setup program. 5. At many sites, it is necessary to run the tubing through flexible conduit or steel flex pipe to prevent damage to the tubing and/or damage from vandalism. (For example, where the tubing will be placed mid-channel or where animals may chew through the tubing or places where samplers are located near high traffic areas.) In such cases, run the tubing through the conduit prior to attaching the stainless-steel piece, flow meter tubing, sampler tubing or the strainer. A mechanical device designed to pull items through piping such as a Fish Tape should be used to pull the tubing through the conduit unless the old tubing was left for that purpose. In that case, attach the new tubing to the old tubing with duct tape and pull the old tubing out of the conduit and the new tubing into the conduit.
ATTACHING SAMPLER/TUBING FOR DIAGNOSTICS	1. The intake (strainer) of the automatic sampler is attached at the base of the post, near the center of channel – if possible. If installing intake/actuator at a new location, both should be situated as low as possible (or approximately ½" from the bottom of channel.) Once site data (such as sample timing, drainage discharge, and ponding probability) have been acquired, the intake and actuator heights should be adjusted as appropriate. 2. With the ISCO area-velocity meter, secure the sensor to the tabs on either plate or ring – depending on diagnostic site location.
PROGRAMMING SAMPLER FOR DIAGNOSTICS	1. The ISCO sampler and flow meter must be programmed for the proper length of tubing, the vertical rise, and sampling regime. 2. Attach a battery to the ISCO sampler/flow meter 2150 following the steps in SOP-SW-07 Change ISCO Batteries. 3. On the sampler, press Enter Program 4. Use the right arrow key to go to Configure Sampler 5. Ensure that the date and time are correct 6. At Bottles and Sizes, choose Portable, 24, 1000ml 7. At Suction Line, choose 3/8, Vinyl 8. At Suction Line Length, enter the length of suction line that was measured previously. 9. At Liquid Detector, choose Enable 10. Choose 1 Rinse Cycle 11. At Enter Head Manually, choose Yes and enter the estimated head. 12. Enter Retry Up to 1 Times When Sampling 13. Press Exit Program 14. Press Enter Program 15. Choose Program Sampler- Complete with appropriate sampling routine. Sampling routines can be found online in One Drive. The folder name is Programming. File is called Configure-Program Diagnostic ISCO Samplers (either 2.5 hour or 5 hour routines) 16. Press Exit Program

PROGRAMMING AREA/VELOCITY METER	1. Connect communication cable (USB end to computer and 6-pin end to top of a/v meter). 2. Using the laptop, open Flowlink 5.1, select comport from dropdown, and click on 2100 series to connect to unit. 3. Complete Area/Velocity programming with inputs from spreadsheet on One Drive. The folder name is Programming. File is called Area Velocity Meter Programming.
SETTING D-TEC or T-TEC SAMPLERS	1. Mechanical samplers will be attached with the clamp that is provided as part of the sampler. A ¼ inch hex wrench is required for attaching the clamp to the fence post. Secure the bracket to the fence post and tighten the bracket. The bottom of the diagnostic D-TEC sampler is generally placed on or very near the bottom of the channel for diagnostics or on a t-post in the creek for creek storm samples. For diagnostics, using a tape measure, measure from the channel surface to the sampler intake and record this value in the logbook along with a description of sampler location in relation to bottom of channel. On the creek, DTEC samplers will be set to sample at the appropriate stage. At the staff gage, measure the difference of the water level and the stage designated for sample collection. Place the D-TEC on the t-post and slightly tighten, but still allowing the DTEC to move up and down. Move the DTEC (up or down) until the distance from the water surface to the intake of the DTEC matches the value (difference of the water level and the stage designated for sample collection) obtained at the staff gauge. Once the appropriate level is determined, tighten the DTEC bracket. 2. T-tec samplers may be utilized when extremely low flows are expected. They may be used alone or in conjunction with an ISCO sampler. T-tec samplers will be placed where we anticipate the minimal flow to occur. Staining on a culvert may be an indication of where to place the T-tec. The unit may rest on the surface or in some circumstances, it may be buried so the top of the device is flush with the ground surface, allowing the minimal flow to enter the sampler. 3. Remove the lid and set sampler to sample. After replacing in bracket, make sure the sampler is open and document in field book.
DOCUMENTATION	1. Record all installation information (serial numbers, tubing length, etc.) in the Butte-Rocker URI Form r0 and/or the field book. If you choose not to record all the information in the field book, at each site reference the doForm file name you used to document the installation. If installs are complete but maintenance is required at a site, record in the field book and fill out the doForm Butte-Rocker General Maintenance. Describe the maintenance completed in the form or use the form to describe the maintenance that needs to be completed at another time.

SOP – SW – 09

COLLECT SAMPLE FROM D-TEC SAMPLER

Authorized for use: 01/25/2022
Revision 7
Reviewed:

SCOPE	This SOP describes the sample collection and decontamination process of D-TEC mechanical samplers.
RTRA(s) Referenced/ Reviewed	R-L1- Common Hazards, Driving, Manual Handling TRA1-008: SG Readings Download Sutron, ISCO, H350, and Weather Station R-L1- D-TEC Sampler Operation
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme wind Unsafe conditions Inadequate PPE or equipment
MSDSs	Arsenic Cadmium Copper Lead Mercury Zinc PCP (SS-06A and downstream)
PPE REQUIRED	Hard Hat Rubber Soled Waders Safety Glasses High Visibility Shirt or Vest Gloves (leather, impervious) Long Sleeve Shirt Long Trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Spare sample bottles Decontamination sprayer filled with tap water
Trained, Competent and Authorized Employees in this SOP	Tina Donovan Alice Drew Davies Joel Arbaugh Mat Erickson Matt Kilsdonk Kirsten Vose Dalen Longfield Joe Moodry
PROCEDURES	
CHECK SAMPLER	1. Read and record the staff gage level following SOP-SW-06_Read Staff Gauge (If staff gage present) 2. Enter the stream or channel and proceed to the D-TEC sampler. 3. Remove any debris that has piled against the post holding the sampler. 4. Check the sampler to see if it has closed, if closed it is likely the sampler is full. 5. If the sampler is open, remove the pin holding it in the bracket, and lift it out of the bracket to ensure that it is empty. It is possible for the sampler to collect without closing. 6. If the sampler is empty, replace it in the bracket and replace the pin. If the sampler is full, proceed to Retrieve Sample step 1.
RETRIEVE SAMPLE	1. Remove the full bottle from the bracket. 2. Go to a level work area, the tailgate of the truck is preferable. 3. Using the decontamination sprayer filled with tap water, rinse any sediment/sand from the outside of the sample bottle. 4. Remove the sampling head from the bottle. Place a lid on the bottle. Place a label on the lid with the correct site name and date of storm. Store the sample in a cooler on ice.
SAMPLER DECONTAMINATION	1. Disassemble the sampling head. Remove the nut on top of the plexi-glass cover. Pull the metal screen off the lower portion of the sampler head. Remove the plexi-glass cover from the screen. 2. With a pressurized decontamination sprayer containing tap water, thoroughly rinse each portion of the sampler head. If the sample is to be discarded, thoroughly rinse the sample bottle. 3. Reassemble the sampling head. 4. Some DTEC's are modified. The automatic sampling head may be replaced with a solid white lid with a hole drilled in it. The sample bottle will contain a ping pong ball. Decon the lid and the ping pong ball using the pressurized decontamination water and replace the lid on a clean DTEC bottle after inserting the deconned ping pong ball.
RESET SAMPLER	1. With a clean replacement bottle (if a sample was collected) or a deconned bottle (if the sample was disposed of) and the deconned sampler head, return to the sampler bracket in the stream or channel.

	2. Reset the spring on the sampler, so that the sampler is open (sampler head). 3. Carefully replace the sampling head on the bottle, ensuring that the sampler remains open. 4. Place the sampler in the bracket. 5. Replace the pin holding the sampler in the bracket. 6. If DTEC sampler is modified, replace deconned sampler back into bracket.
DETERMINING SAMPLE TIME FOR CREEK SAMPLES AND DIAGNOSTIC SAMPLES	1. For DTEC's located in the stream, sample time is determined by downloading the ISCO flow meter. Follow SOP-SW-04 DOWNLOAD ISCO STAGE RECORDER to download (4200 or 2150 models). For stations with ISCO Signature flow meters, follow SOP-SW-16 SIGNATURE BUBBLER SETUP to download. After retrieving the stage file for the site in question, locate the nearest 15-minute interval, during the wet weather event, when the stage first reached the sample stage criteria (rising limb). Document the collection time in the field book and on the electronic form. 2. For DTEC's located at sites other than the creek or diagnostic sites with a 2150 flow meter, temperature data will be downloaded from the HOBO logger connected to the sampler. 3. Open HOBOware software on laptop. 4. Attach the USB end of the HOBO Pendant Coupler to the laptop. 5. Mate the logger to the coupler, assuring that the ridge on the HOBO logger aligns with the groove inside the Pendant Coupler. 6. Confirm you are connected, check lower right-hand corner, there will be a display of "1 device connected". 7. Click Device in the dropdown menu and select Readout or click the 2nd picture below the dropdown menu on the left. 8. Save file to desktop, HOBO downloads with site name and date. Example: MGEFS-5B_012318. 9. Hit Save and then plot. 10. A graph will appear on the screen. 11. Using the spreadsheet in the top half of the screen. Locate the approximate start time of the storm. Click on the temperature value and a red line will appear on the graph. Use the up and down arrows to scroll through the data to locate a significant temperature change (temperature change may be an increase or decrease depending on ambient conditions). 12. Record the date and estimated time the sampler collected in the field book and on the electronic collection sheet. 13. Click Device in the dropdown menu and select Launch or click the 1st picture below the dropdown menu on the left. 14. A Launch Logger box will appear. Confirm the name of the site, check the battery level, and check that the logging interval is set for 10 minutes and click start. A save data file box will appear, click Don't Save. 15. Remove logger from Pendant Coupler.
DOCUMENTATION	1. In the field book, at the beginning of the sampling job, record date, personnel involved, safety topics for the day, and weather conditions. Also indicate which iPad will be used to for the day so that records can be easily found if necessary. Complete a "Butte – StW Smple Clctn r0" doForm on the iPad that will be used to record field data. Under sample type, select D-TEC and then under Station Type select the appropriate site (creek or hill). Complete instructions can be found at the link below. 2. Follow **Butte – StW I-Pad Steps –smpl** located at: https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20I-Pad%20Steps%20-smpl.aspx. This is an older site; you may have to copy the link and paste you're your browser for it to work. There may be slight modifications since these were created but it is a good overview of the process. Record any unusual circumstances in the notes of the doForm as well as the field book. At the end of the day record any applicable deviations from the Clark Fork River SOPs/Work Plan/Sampling Plan. 3. Label the DTEC bottle lid with a label or duct tape marked with the site name, sample date and time sample collected.
REPORTING	1. Download doForms, process files with transformer, and organize output forms: a. Download appropriate doForms by following **DoForms Online Download Steps** located at: https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms%20Online%20Download%20Step.aspx b. Follow **Butte – StW Processing Steps** located at: https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20Processing%20Steps.aspx. c. Ensure that all files are complete and organized as instructed in **Butte – StW File Organization Details** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20File%20Organization%20Details.aspx. d. These are older sites; you may have to copy the link and paste into your browser for it to work. There may be slight modifications since these were created but it is a good overview of the process. 2. Editing and revisions: a. If missing data (date, time, units, etc.) or grammatical errors are discovered, corrections may be made to original doForms and re-import can be performed, or the original COC file can also be edited. b. Before submitting the completed COC file to the database, if incorrect entries are found while checking the completed COC file, save the file as a revision with a date stamp (file-name_r1-mmddyy) and make the appropriate edits, but preserve the original raw doForms. c. After a completed COC file has been submitted to the database, and an error is found, save the

	previously submitted COC file as a resubmit with a date stamp (file-name_resubmit-mmddyy), make the appropriate edits, but preserve the original COC file, as well as, the original raw doForms. Ensure that all revisions are saved to the submittal folder (Mo File), as well as, a copy of the revised COC in the original sample collection location. \\wc\shared\Offices\Bozeman\BUTTE\TREC\ARCO\BPS-Storm\SampleCollectionRecords

SOP – SW - 10

COLLECT SAMPLE FROM ISCO SAMPLER

Authorized for use: 04/16/2020
Revision 2
REVIEWED: 01/25/2022

SCOPE	This SOP addresses collecting samples from automatic (ISCO) samplers and checking automatic samplers for proper operation.
TRA(s) Referenced/ Reviewed	R-L1- Common Hazards Driving Manual Handling R-L1- Above Ground Sample Collection and Maintenance
STOP WORK TRIGGERS	1. Lightning (30 second rule) 2. Extreme wind 3. Unsafe conditions 4. Inadequate PPE or equipment 5. Other:
MSDS	1. Arsenic 2. Cadmium 3. Copper 4. Lead 5. Mercury 6. Zinc 7. PCP
PPE REQUIRED	1. Hard hat 2. Safety toe boots 3. Rubber Footed Waders 4. Safety glasses 5. High visibility shirt or vest 6. Gloves (impervious, leather) 7. Long sleeve shirt 8. Long trousers 9. Light colored pants (during tick season)
P&IDs/Other Relevant Drawings	
OTHER INSTRUCTIONS/SOPs	1. Samples from automatic samplers are collected by retrieving the sample bottle from the automatic sampler apparatus. Samples are prepared for laboratory submittal in the office, and this SOP does not address sample preparation. 2. Collection and checking of automatic samplers sometimes require that personnel be in a water body, or within six feet of a water body. The BP RM Site Technical Practice for Working Around Water has been reviewed, and it has been concluded that water bodies sampled as part of the BPSOU surface water monitoring program typically do not meet the criteria for which use of personal flotation devices, rescue skiffs, or fall protection is required. However, at high flows, the BP RM Work Around Water Standard may be applicable. Conditions must be assessed during each sampling event, and the standard shall be applied as applicable. If the site cannot be safely accessed, it should be skipped and returned to once the water level has receded. 3. Use the buddy system. Assess both depth and velocity and use common sense in deciding whether to enter a stream without additional PPE (lifejacket, throw ring). Do not enter unfamiliar water bodies without first discerning the depth of the water body. If the depth of a water body is unknown, use a wading rod or other device which will indicate depth to determine depth prior to entering the water body. Watch for debris traveling from upstream. 4. Step carefully and be sure of footing step side to side across stream when possible. Stream channel beds may be uneven and rocky. Rocks may be very slippery and stream channel sediment may be very soft. 5. Biological hazards may be present in water bodies due to contributions from storm sewers that drain a metropolitan area. Possible contribution of sewage from direct discharge of old homes in the area, and discharge from sewage treatment plants. Personnel working in/with surface water should have the full series of both hepatitis A and B shots 6. When working in water within and downstream of LAO, as defined by the area west of the slag canyon and from Centennial Avenue south through the MPTP property, nitrile gloves must be worn handling surface water and any equipment which has met surface water due to the potential presence of pentachlorophenol (PCP) in the water body. 7. Other applicable SOPs: SOP SW-06: Read Staff Gauge, SOP SW-04: Download ISCO Stage Recorder, SOP SW-07: Change ISCO Batteries
REQUIRED TOOLS	1. Sampler bottles, 2. Decontamination bottle 3. Decontamination solution, 4. Backpack
Trained,	Tina Donovan

Competent and Authorized Employees in this SOP	Alice Drew-Davies Joel Arbaugh Caleb Arbaugh Mat Erickson Matt Kilsdonk Joe Moodry Kirsten Vose Dalen Longfield
Lessons Learned (observations, near misses, etc. to be considered during 2-yr SOP review)	
PROCEDURES	
OPEN ISCO HOUSING	1. Wearing leather gloves, unlock the metal housing. If possible, visually inspect the lock area prior to placing hands in the area. Insects are often within the lock area. When removing the lock(s), lift the hasp(s) free of their catch(es). Remove the lock(s) and store them on the handles of the metal housing if possible. 2. Open lid and use small S-hook or lock to secure the hinge lock to the lid.
COLLECT SAMPLE BOTTLES	3. Remove the flow meter from the housing (if applicable), lifting by the clear plastic handle. Take care not to balance the flow meter on the edge of the box, but rather place it on the ground to prevent damage from it falling. 4. While still wearing leather gloves, unhook the closures on the lid to the sampler if attached. Remove the sampler lid and place with the inside of the lid upright. If the display reads "Done" or "Problem Occurred", samples have collected. On the diagnostic samplers, if the display reads "Sampler Inhibited", samples may or may not have collected, so it is imperative to check. 5. Unhook the three closures on the lower portion of the sampler. It may be necessary to adjust the position of the sampler within the metal housing to get all three closures unhooked. 6. Hang the S hook that is in the box on the side of the box. Hang it on a side away from the lower portion of the sampler so it is out of the way. 7. Lift the upper portion of the sampler off the lower portion, using the two handles. 8. Hang the upper portion of the sampler on the S hook by one of the two handles. Assure that the upper portion of the sampler is stable before proceeding. If an S hook is not available, place the upper body of the sampler on a clean base and proceed to Step #9. As a last resort, place the top of the sampler body upside down on the ground or in the lid of the sampler, so the inside of the sampler is facing up. Avoid placing the inside of the sampler body on the ground. 9. If samples have collected, first view and record results on the readout. Do this by pressing Display Status and choosing Review. Use the right arrow key to move through the menu and choose Results. In the Results menu, continue to press Enter until Bottle 1 is reached. The sample collection date and time will display. Record the start time and date and total number of samples collected in the field book and then complete a "Butte – StW Smpl Clctn r0" doForm on the iPad. Record all pertinent information in the doForm and reference the form you are using in the field book. 10. Place lids on the bottles. 11. Using two people, each grasp a handle of the base lifter and remove the samples from the box and place onto the tailgate of the truck, if possible. If not possible, place the base on another solid surface before proceeding to label the samples. If it is raining and the labels will not adhere to the sample bottles, it is okay to label the base with duct tape identifying the site. At the lab, labels will be attached to each bottle. At a minimum, the label will contain the site name, date collected, and the sample number. Samples are collected in threes, so the first three bottles will be labeled 1,1,1, and the next set will be labeled 2,2,2 until all bottles are labeled in this manner. Remove base lifter from base. 12. If it is necessary to remove the bottles from the base in the field, label the bottles as described above "BEFORE" removing. Free the three elastic cords from the sampler ring. Remove the upper portion of the frame, then, wearing impervious gloves, remove the bottles. Grasp the bottles with both hands around the body of the bottle, do not handle the full bottles by lifting/carrying around the lids/neck and place in backpack or cooler. 13. Put clean bottles in sampler. 14. Replace the sampler ring by securing the three elastic cords.
RESET SAMPLER	15. Place the upper portion of the sampler back onto the lower portion and hook the closures. 16. Replace sampler in box on top of base lifter and check to make sure all the lines and intake tube are not under the sampler. 17. On the creek samplers, go to the flow meter, and enter Program Step 5. Key through Step 5 and accept all entries except "Latch Key Reset". The default entry is no, but key over to "yes". This will re-initialize the sampler. 18. If sampler is tripped using an actuator, flip the switch once to "Latch" and then back to "Toggle/Reset".

	19. On the Sampler, press “Start Sampling” once, and then press “Enter Program” until the display reads “Sampler Inhibited”. If sampler won’t inhibit make sure actuator is dry, then try again. If sampler will not inhibit and it is underwater, you may have to return later to inhibit sampler. Actuators may be adjusted out of the water to inhibit, but this action must be documented in the logbook so as the water recedes, the actuator is once again lowered so samples aren’t missed the next storm. 20. Confirm date and time is correct. 21. Replace the lid onto the sampler.
REMOVE DEBRIS FROM TUBING/POSTS	22. If sampler is located on the creek, enter the stream, and approach the intake line to remove the debris. Always face upstream and cross a stream stepping sideways whenever possible. 23. When clearing the line of debris, wear a waterproof glove and stand facing upstream. 24. Remove all debris from the sampler intake line, the bubbler line, and all posts in the stream securing sampling equipment. Exit the stream. 25. At diagnostics sites, remove debris from intake and actuator. 26. If sediment is visible at the AV meter sensor, obtain an average depth and document in field book.
CHECK STAGE/RECORDER LEVEL ON CREEK	27. Read and record the staff gage level according to SOP-SW-06 Read Staff Gauge in the field book. 28. Read the level on the ISCO flow meter and record it in the field book. If it is not in agreement with the staff gage, adjust the level and make a record in the field book that the level was adjusted. 29. To adjust the level on the ISCO 4230 flow meter, press Go To Program Step, then press 3. 30. In the Parameter to Adjust menu, key over to level. 31. Key in the proper level, press Enter and then press Exit Program. 32. Lift the flow meter by the handle and place it in the housing, next to the sampler. 33. Place the flow meter on the two slats of wood in the bottom of the housing or the pumice block. Be sure that neither the sampler nor the flow meter is setting on any of the tubing. 34. To adjust the flow on the Signature Flow Meter stage, please see SOP-SW-16 Signature Bubbler Setup.
CLOSE ISCO HOUSING	35. Place the metal lid onto the housing, taking care to line up the lock cover(s) with the hasp tab(s). 36. Place the hasp(s) over the tab(s) and lock the lock(s) on the housing. 37. Proceed to the next site following all applicable SOPs.
DOCUMENTATION	1. In the field book, at the beginning of the sampling job, record date, personnel involved, safety topics for the day, and weather conditions. Also indicate which iPad and which doForms will be used for the day so that records can be easily found if necessary. Complete a “Butte – StW Smpl Clctn r0” doForm on the iPad that will be used to record field data. Follow **Butte – StW I-Pad Steps –smpl** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20I-Pad%20Steps%20-smpl.aspx. This is an older site so you may have to copy and paste the link into your browser. A few of the steps may have changed, but this should be a good general reference. 2. Record any unusual circumstances in the notes of the doForm as well as the field book. At the end of the day record any applicable deviations from the SW QAPP and SAP.
REPORTING	1. Download doForms, process files with transformer, and organize output forms: a. Download appropriate doForms by following **DoForms Online Download Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms%20Online%20Download%20Step.aspx b. Follow **Butte – StW Processing Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20Processing%20Steps.aspx. c. Ensure that all files are complete and organized as instructed in **Butte – StW File Organization Details** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20File%20Organization%20Details.aspx. These are older sites so you may have to copy and paste the link into your browser. A few of the steps may have changed, but this should be a good general reference. 2. Editing and revisions: a. If missing data (date, time, units, etc.) or grammatical errors are discovered, corrections may be made to original doForms and re-import can be performed, or the original COC output file can also be edited. b. Before submitting the COC output file to the database, if there are found to be incorrect entries while checking the COC output file, save the COC output file as a revision with a date stamp (file-name_revised-mmddyy) and make the appropriate edits, but preserve the original raw doForms and the original COC output form. c. If after a COC output file is submitted to the database, and an error is found, save the submitted COC output file as r1 and send to the database as a resubmit with a date stamp (file-name_r1_resubmit-mmddyy) in the Mo File and make the appropriate edits, but preserve the original raw doForms and the original COC output file. . Resubmit the file to BPSOU DATA and request the replacement of the originally submitted file with the revised file. d. Ensure that all revisions are saved to the submittal folder (monthly file) as well as the original file location.

SOP – SW - 11
D-TEC SAMPLE PREPARATION

Authorized for use: 01/26/2022
Revision 7
Reviewed:

SCOPE	This SOP addresses the in-office preparation of wet weather surface water samples from mechanical samplers for laboratory submittal. This SOP is specific to BPSOU Wet Weather samples collected in D-TEC samplers.
RTRA(s) Referenced/ Reviewed	R-L1- Common Hazards Driving Manual Handling R-L1- Prepping Preparing Sampling Lab
STOP WORK TRIGGERS	Unfit for duty Unsafe conditions Inadequate PPE or equipment Defective Equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc PCP HNO_3 H_2SO_4 Liquinox
PPE REQUIRED	Safety Glasses Impervious gloves Long Sleeve Shirt Long Trousers Closed-toe footwear
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Sample bottles Filters Peristaltic pump 12-Volt peristaltic battery or peristaltic pump AC adaptor Tubing
Trained, Competent and Authorized Employees in this SOP	Tina Donovan Alice Drew-Davies Joel Arbaugh Caleb Arbaugh Mat Erickson Matt Kilsdonk Joe Moodry Kirsten Vose Dalen Longfield Hannah Foster
PROCEDURES	
SET-UP	1. Wear safety glasses. 2. Prepare a clean, clutter free work area. 3. At all times, wear impervious gloves. Change gloves between samples, or more frequently if gloves become soiled. 4. If the sample volume available for rinsing containers is limited, or not enough to adequately rinse the bottles, use DI to rinse the bottles. 5. If using pre-preserved bottles, do not rinse the bottles. If using certified bottles, and the bottle is not pre-preserved, one rinse with a very small volume of sample or deionized water is enough. 6. Set laboratory bottles up in the order they will be filled. Write the distinct numeric portion of the sample identification number on the lid of each bottle. Write an "F" on the bottle to be used for dissolved metals analysis.
SAMPLE PREPARATION For D-TEC SAMPLES	1. Each sample will consist of one ½-gallon bottle. This bottle will be homogenized prior to pouring out sample aliquots. Invert the half-gallon bottle several times to re-suspend all sediment in the container. Use two hands. Do not shake the bottle vigorously. It may be necessary to swirl the bottle to re-suspend sediment sitting on the bottom of the bottle. 2. For all aliquots other than dissolved metals and dissolved organic carbon, carefully pour sample from the ½-gallon bottle into the sample bottles. Do not place hands inside any bottles. If necessary, use two

	hands to pour. The general chemistry bottle should be the second or third sample aliquot poured. If Alkalinity is requested, zero head space is required. Avoid overfilling pre-preserved sample bottles. 3. To prepare the dissolved metals and dissolved organic carbon aliquot, use the peristaltic pump with clean tubing. Place the clean pump tubing inside the ½-gallon bottle. Place a 0.45-micron filter on the outgoing end of the tubing. Pump from the bottle containing the raw sample into the DOC bottle, and then into the dissolved metals bottle. If the bottle is pre-preserved, avoid overfilling the bottle. The filtered aliquot is the last aliquot prepared for each sample. 4. Bottle and preservations requirements for creek are as follows: • Total Metals 250 mL plastic, HNO_3 preserved • Dissolved Metals 250 mL plastic, filtered, HNO_3 preserved • NO_2/NO_3 250 mL plastic, H_2SO_4 preserved • Dissolved Organic Carbon 250 mL amber glass, filtered, H_2SO_4 preserved (only required on sites SS-07, SS-06G, SS-01.35, and SS-01 and only on the first wet weather event of the month, if new sites are added to the sampling network, this may change.) • TDS, TSS, Alkalinity, SO_4 500 mL plastic, no preservative, zero headspace • TKN 250 mL plastic, H_2SO_4 preserved (only required on sites SS-07, SS-06G, SS-01.35 and SS-01 and only on the first wet weather event of the month, if new sites are added to sampling network, this may change) • NH_3, 250 mL plastic, H_2SO_4 preserved (analysis from NO_2/NO_3 bottle) (only required on sites SS-07, SS-06G, SS-01.35 and SS-01 and only on first wet weather event of the month, if new sites are added to the sampling network, this may change.) • Total Phosphorous 250 mL plastic, H_2SO_4 preserved (analysis from NO_2/NO_3 bottle) (only required on sites SS-07, SS-06G, SS-01.35 and SS-01 and only on the first wet weather event of the month, if new sites are added to the sampling network, this may change.) Bottle and preservations requirements for storm drains are as follows: • Total Metals: 250 mL plastic, HNO_3 preserved • Dissolved Metals: 250 mL plastic, filtered, HNO_3 preserved • TSS and SO_4: 500 mL plastic, unfiltered, no preservative 5. On creek samples, if there is inadequate sample volume to fill all bottles, fill metals and TKN (if applicable) bottles only half to three-quarters full. 6. Dry sample bottle, and immediately place appropriate label on appropriate bottle.
DECONTAMINATION	1. Since DTEC samples represent only one sample per site, peristaltic pump tubing will be disposed of after preparing the sample.
PRESERVING SAMPLES	1. If using pre-preserved sample bottles, no additional preservation is necessary. 2. If using sample bottles that have not been pre-preserved, wait until the end of the sample preparation shift to preserve samples. While preparing samples, set samples requiring differing preservatives in separate spaces. Raw (no preservative) samples should be stored in the refrigerator or on ice if refrigeration is not available. Bottles prepared for total and dissolved metals analysis should be set in a designated area. Bottles prepared for NO_2/NO_3, DOC, TKN, NH_3, and total phosphorous analysis should be set in an area separate from those prepared for metals analysis. Preserve all bottles prepared for metals analysis, then preserve all bottles prepared for nutrient analysis, or vice versa.
SAMPLE STORAGE	1. Refrigerate or cool all samples until laboratory delivery.
DOCUMENTATION	1. **Transformer Steps** Follow **Butte – StW Processing Steps: I Transformer Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20Processing%20Steps.aspx. 2. **Download doForms** Download "Butte – StW Smple Clctn r0" doForms by following **DoForms Online Download Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/DoForms%20Online%20Download%20Steps.aspx. 3. **Prep/COC Steps** Follow **Butte – StW Processing Steps: II Prep/COC Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20Processing%20Steps.aspx. 1, 2, and 3, refer to older documents and the links may not work so you may have to paste into your browser to access. Some steps may have changed since they were generated but should still provide a good overview of the process. 4. **Labels:** Use the appropriate pre-labeled ID or write in the ID associated with the sample. Add a dash and the date stamp recorded by the ISCO (-mmddyy) to the ID. Put the date of sample on the "date" line. If preparing the ECB/FB, the date and time will not be obtained from the ISCO but will be the actual date and time you are doing the prep. The Duplicate sample will be given the same date and time as the Natural sample. Put the time the sample was collected on the "time" line. Provide the initials of the people preparing the samples on the "sampled by" line. 5. **File Organization** Ensure that all documentation is complete and organized appropriately by following **Butte – StW File Organization Details** located at

	https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20File%20Organization%20Details.aspx This is an older document and the links may not work so you may have to paste into your browser to access. Some steps may have changed since they were generated but should still provide a good overview of the process.
SHIPPING	1. Make sure the number of containers listed on the COC is correct to the number of sample bottles. Check to make sure that the sample ID and date stamp, date, and time match the COC. Ensure that there are initials of the preppers on the "sampled by" line and that the appropriate label (analysis) is on the correct bottle. Confirm that all lids are sealed properly and use duct tape to secure the lids on the 500 mL and 1000 mL bottles. 2. Make any necessary changes to labels or the COC before packing. When the COC is correct, the person who is in the "Sampler's Name" box should sign under "Relinquished By / Affiliation" column on each page of the COC. Copy the COC, make enough copies of the original COC for each cooler and one for the file cabinet. Place the original COC and the copies in zip lock bags and add one to each cooler on top of the ice, making sure the original is sent with the samples. File one copy with the shipping label receipt in the file cabinet in the copy room. 3. Special packing instructions for specific bottles: • Duct tape all raw bottle lids to the bottle. The lids on these bottles do not seal well, and often spill during shipment. • All amber glass bottles must be wrapped in bubble wrap and placed in a cooler of their own. If the glass bottles must be included in a cooler with other samples, surround all the bubble wrapped amber bottles with additional bubble wrap to separate them from the other samples in the cooler. Line the bottom of the cooler with a bubble sheet, and then top the bubble-wrapped bottles with another bubble sheet before closing and securing the cooler. 4. Fill all coolers as full as you can without squeezing bottles in too tight. If on the last cooler, there are not enough sample bottles to completely fill the space, use any kind of appropriate filler to prevent bottles from falling over or sliding during shipment. 5. Confirm that all coolers contain a temperature blank and place the temperature blank on top of the samples. 6. Place ice bags in a zip-lock bag or place all ice bags in a large plastic bag on top of the samples and seal. A minimum of two bags of ice should be used in the winter and a minimum of three bags of ice should be used in the summer. Place the bags of ice on top of the sample bottles in the cooler. Close the lid tightly and duct tape the seal twice over. Place a custody seal over the front latch of the cooler. Using packing tape, secure the custody seal from the front of the cooler to the back. A minimum of three separate strips should be applied in this fashion across the top of the cooler. After the top is taped, proceed to tape over the duct tape seal twice with the packing tape. 7. Either call for a pickup from FedEx or deliver the coolers to FedEx. 8. If calling FedEx for a pickup then you will need the following information for the digital shipping label. Make sure to place the online request as early as possible for same day shipping: • In the From section: fill out the Date, Sender's Name, Phone, Company (TREC, Inc.), Address (1015 S. Montana St., Ste. C), City (Butte), State (MT), and Zip (59701). • In the To section: fill out Recipient's Name (Sample Receiving), Phone (612-607-1700), Company (Pace Analytical), Address (1700 Elm St. SE), City (Minneapolis), State (MN), and Zip (55414-2485). • In Express Package Service, check FedEx Standard Overnight when shipping Monday through Thursday, or "FedEx Priority Overnight" if shipping on a Friday. • In Special Handling and Delivery Signature Options, check SATURDAY Delivery if shipping on a Friday only. Check No under Does this shipment contain dangerous goods? • In Payment, check Recipient and fill in the FedEx Acct. No. as 9860-02219. Fill in the number of coolers being sent under Total Packages. Each coolers weight is approximately 65 pounds. 65 * total number of coolers is entered in "Total Weight". 9. Coolers must never be left unattended (locked in lab is fine) until delivered for shipment or pick-up by carrier is complete. If not calling for a pickup and delivering to FedEx then once the coolers are taped drop them off at FedEx. **10.** FedEx has PACE's account information on file and they will print off shipping labels to stick on coolers. **STAY UNTIL ALL COOLERS HAVE LABELS. Remember to request or confirm samples are shipping "Priority Overnight" unless shipping on a Friday then request "Priority Overnight with a Saturday Delivery" so the samples are delivered the next day instead of sitting somewhere and having them delivered on Monday (very important due to the temperature requirements on some samples).** 11. Make sure to take the Sender's Copy of the shipping label (receipt) to secure to the copy of the COC and place the COC and shipping information in the appropriate month in the filing cabinet. 12. At a minimum, record in the field book, the date and time samples were shipped and that they were shipped on ice under COC. Address and phone number of lab samples are being shipped to, number of coolers shipped, tracking number, first sample ID - last sample ID if sample numbers are sequential, or, the date(s) samples were collected. 13. TDS and TSS analysis have short hold times of seven days. Email Shawn Davis Shawn.Davis@pacelabs.com or contact him at Pace (612-607-6378) to notify him that short-hold

	samples are being shipped. The lab needs time to prepare to process these samples so if possible, notify him the day before you plan to ship. Be prepared to tell him the earliest sample collection time.

SOP – SW – 12

Surface Water Wet Weather Sample Preparation

Authorized for use: 01/26/2022
Revision 7

SCOPE	This SOP addresses the in-office preparation of surface water samples from mechanical and automatic samplers for laboratory submittal. This SOP covers the preparation of BPSOU Surface Water Wet Weather samples as well as Diagnostic Storm Drain samples.
RTRA(s) Referenced/ Reviewed	R-L1- Common Hazards Driving Manual Handling R-L1- Prepping Preparing Sampling Lab
STOP WORK TRIGGERS	Unfit for duty Unsafe conditions Inadequate PPE or equipment Defective equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc PCP HNO_3 H_2SO_4 Liquinox
PPE REQUIRED	Safety glasses Latex/nitrile gloves Long-sleeve shirt Long trousers Closed-toe footwear
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	Sample bottles Filters Peristaltic pump 12-Volt peristaltic battery or peristaltic pump AC adaptor Silicon tubing
Trained, Competent and Authorized Employees in this SOP	Tina Donovan Alice Drew Davies Joel Arbaugh Mat Erickson Matt Kilsdonk Dalen Longfield Kirsten Vose Joe Moodry
PROCEDURES	
SET-UP	1. Wear safety glasses. 2. Prepare a clean, clutter free work area. 3. At all times, wear latex or nitrile gloves. Change gloves between samples, or more frequently if gloves become soiled. 4. If using pre-preserved bottles, do not rinse the bottles. If using certified bottles, and the bottle is not pre-preserved, one rinse with a very small volume of sample or deionized water is sufficient. 5. Prepare samples requiring like analyses in batch. That is, first prepare all natural and quality control samples for sites SS-01, SS-06G, and SS-07. Next prepare all natural and quality control samples for sites SS-01.35, SS-04, SS-05, and SS-06A. 6. Set laboratory bottles up in the order they will be filled. Write the distinct numeric portion of the sample identification number on the lid of each bottle. Write an "F" on the bottle to be used for dissolved metals analysis and DOC if applicable.
SAMPLE PREPARATION	1. Try to prepare samples from "cleanest" to "dirtiest". Prepare samples from individual ISCO samplers in a consistent order (For eight bottle sample routine, the order is almost always ISCO sample 8 to ISCO sample 1. 2. Each sample will consist of three individual one-liter bottles. These bottles are composited at the time of collection, by filling each bottle 1/3rd full at set intervals. Since these samples are composites, it is not necessary to re-composite the sample during preparation. Prior to pouring samples, invert the 1-liter bottle several times to re-suspend all sediment in the container. Use two hands. Do not shake the bottle vigorously. It may be necessary to swirl the bottle to re-suspend sediment sitting on the bottom of the bottle. Even if sediment is not visible in the sample bottle, invert the bottle three times to mix the sample. 3. Do not place hands inside any bottles. Use two hands to pour if necessary. Ensure that sediment is remaining in suspension throughout the entire pouring process. If necessary, re-suspend between filling each bottle. 4. Chose a one-liter ISCO bottle from the sample set being prepared. This ISCO bottle will be used to pour the sample for general chemistry parameters. Preservation is not required, for the general chemistry sample, thus the laboratory bottle should be rinsed prior to pouring the source water into it. To rinse the bottle, invert the source water bottle (using the method described in step 2) to re-suspend sediment and pour a small amount of the water from the ISCO bottle into the sample bottle. Rinse the bottle by inverting it three times. Attempt to coat all interior walls of the bottle.

Discard the rinse water down the sink. If pouring the raw sample for the storm drains, continue to step 5. For natural, duplicate and ECB/FB samples, use a 500 mL bottle instead of a 1 Liter bottle when prepping the creek. Re-suspend any sediment in the sample by inverting the 1-liter ISCO bottle several times. Pour the entire contents of the mixed ISCO bottle into the rinsed 1-liter laboratory bottle (500 mL if QC set) attempting to capture all sediment. If this does not completely fill the 1 Liter bottle, thoroughly mix the second ISCO bottle, (using the method described in step 2). Top the 1-liter laboratory bottle off with water from the second ISCO bottle. The raw bottle (for the creek) must have zero head space due to the alkalinity analysis. After filling the bottle, cap it and invert it to see if there are any air bubbles. If there are air bubbles in the sample, tap the side of the bottle until all the bubbles collect at the top, flip the bottle back over so that the bubbles go into the lid. Take the cap off, fill the cap with a small amount of sample water, carefully pour the water from the lid into the bottle, and attempt to put the lid on without creating more air bubbles. Repeat this process until zero head space is achieved.

5. For raw diagnostic samples, rinse a 500 mL plastic sample bottle as described above. Fill the bottle, from the 1 Litre ISCO bottle. As there is no alkalinity analysis required, the zero-headspace requirement is omitted but sample bottles should be full when sent to the lab in case they have problems and must re-run any samples.
6. For creek samples, continue with the second 1 Liter sample bottle used in step 4. After re-suspending, fill a plastic 250 mL sulfuric acid preserved bottle for NO_2/NO_3 – (at SS-01, SS-06G, and SS-07 - NH_3 and total phosphate analysis is required from this bottle the first storm of the month). A second sulfuric acid preserved bottle is filled for TKN at these same sites the first storm of the month. Sites SS-01.35, SS-05, SS-04, and SS-06A only require one plastic 250 mL sulfuric acid preserved bottle for NO_2/NO_3 every storm of the month.
7. Each ISCO sample set uses the same internal tubing on the peristaltic pump. The tubing is decontaminated between samples as described below in the Decontamination section. At the beginning of each ISCO sample set, install clean tubing on the peristaltic pump. Place a 0.45-micron filter on the outlet end of the tubing (a new filter with each sample). Pour a small quantity of sample water onto the outside of the inlet tubing and place in the 1 Liter Isco bottle used in step 6. Pump the remaining volume from this bottle through the new (if first sample of the set) or previously decontaminated tubing and new filter. Allow the intake tubing to remain in the sample bottle until you are ready to filter the dissolved metals.
8. For the creek use the final 1 Liter ISCO bottle to prepare the total and dissolved metals and dissolved organic carbon aliquot (first storm of the month SS-01, SS-06G, and SS-07). Invert the bottle (as described previously) and pour sample water into a nitric preserved bottle for the total metals analysis. Remove the intake tubing from the empty sample bottle and insert into the bottle you poured the total metals out of (3rd ISCO bottle of this set). Turn the pump on and allow a small quantity of sample to flow through the tubing and filter before beginning to collect into a nitric acid preserved bottle (dissolved metals). Because the decon is done with nitric acid, the dissolved metals should be collected before the DOC (when applicable). Collect a filtered aliquot into the amber glass, sulfuric acid preserved bottle for DOC. For storm drain samples, invert the ISCO bottle (as described previously) and fill a 250 mL nitric preserved bottle. Pour a small quantity of the remaining sample water onto the inlet side of the tubing and place the tubing into the 1 L Isco bottle. Pump sample water through the new (if first sample of the set) or previously decontaminated tubing and new filter to rinse the system and then collect the filtered aliquot for the dissolved metals. Step 9 contains all bottle and preservation requirements for creek and storm drain samples.
9. Bottle and preservations requirements for creek baseflow samples are as follows:
   - Total Metals 250 mL plastic, HNO_3 preserved
   - Dissolved Metals 250 mL plastic, filtered, HNO_3 preserved
   - NO_2/NO_3 250 mL plastic, H_2SO_4 preserved
   - Dissolved Organic Carbon 250 mL amber glass, filtered, H_2SO_4 preserved (only required on sites SS-07, SS-06G, SS-01.35 and SS-01 and only on the first wet weather event of the month, if new sites are added to the sampling network, this may change.)
   - TDS, TSS, Alkalinity, SO_4 1000 mL plastic, no preservative, zero headspace
   - TKN 250 mL plastic, H_2SO_4 preserved (only required on sites SS-07, SS-06G, SS-01.35 and SS-01 and only on the first wet weather event of the month, if new sites are added to the sampling network, this may change.)
   - NH_3, 250 mL plastic, H_2SO_4 preserved (analysis from NO_2/NO_3 bottle) (only required on sites SS-07, SS-06G, SS-01.35 and SS-01 and only on the first wet weather event of the month, if new sites are added to the sampling network, this may change.)
   - Total Phosphorous 250 mL plastic, H_2SO_4 preserved (analysis from NO_2/NO_3 bottle) (only required on sites SS-07, SS-06G, SS-01.35 and SS-01 and only on the first wet weather event of the month, if new sites are added to the sampling network, this may change.)

   Bottle and preservations requirements for storm drains are as follows:
   - Total Metals: 250 mL plastic, HNO_3 preserved
   - Dissolved Metals: 250 mL plastic, filtered, HNO_3 preserved
   - TSS and SO_4: 500 mL plastic, unfiltered, no preservative.
10. If there is inadequate sample volume to fill all bottles, fill metals and TKN (if applicable) bottles only half to three-quarters full. If NH_3, and total phosphorous analysis is not required, fill NO_2/NO_3 bottle only half full. If the volume is so limited that one or more analysis must be omitted, the priority of analysis is as follows:
    - Total metals
    - Dissolved metals
    - Dissolved organic carbon
    - TDS, TSS, Alkalinity, SO_4
    - TKN (if applicable)
    - NO_2/NO_3
11. Dry sample bottles, and immediately place appropriate label on appropriate bottle.

DECONTAMINATION

1. Decontaminate all preparation equipment before proceeding to the next sample. To decontaminate the peristaltic pump, use a squirt bottle filled with DI to clean the end of the intake tubing. Place the intake tubing into a container containing a dilute HNO_3 solution (5% HNO_3 and deionized water). Pump through the tubing (run water into sink during this step).
2. Wipe down the work area between sample sites and install new pump tubing.
3. Always store tubing in a clean dry area.

	4. Change gloves between each ISCO sample.
PRESERVING SAMPLES	1. If using pre-preserved sample bottles, no additional preservation is necessary. 2. If using sample bottles that have not been pre-preserved, wait until the end of the sample preparation shift to preserve samples. While preparing samples, set samples requiring differing preservatives in separate spaces. Raw (no preservative) samples should be stored in the refrigerator or on ice if refrigeration is not available. Bottles prepared for total and dissolved metals analysis should be set in a designated area. Bottles prepared for NO_2/NO_3, DOC, TKN, NH_3, and total phosphorous analysis should be set in an area separate from those prepared for metals analysis. Preserve all bottles prepared for metals analysis, then preserve all bottles prepared for nutrient analysis, or vice versa.
SAMPLE STORAGE	1. Refrigerate or cool all samples until laboratory delivery.
DOCUMENTATION	1. **Transformer Steps** Follow **Butte – StW Processing Steps: I Transformer Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20Processing%20Steps.aspx. These are older sites so you may have to copy the link into your browser to access. The steps may have changed slightly but it should still be a good overview of the process. 2. **Download doForms** Download “Butte – StW Smple Clctn r0” doForms by following **DoForms Online Download Steps** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/DoForms%20Online%20Download%20Steps.aspx. These are older sites so you may have to copy the link into your browser to access. The steps may have changed slightly but it should still be a good overview of the process. 3. **Prep/COC Steps** Follow **Butte – StW Processing Steps: II Prep/COC Steps** located at https://woodardcurran.sharepoint.com/sites/docs/DoForms/Butte%20-%20StW%20Processing%20Steps.aspx. These are older sites so you may have to copy the link into your browser to access. The steps may have changed slightly but it should still be a good overview of the process. 4. **Labels:** Use the appropriate pre-labeled ID or write in the ID associated with the sample. Add a dash and the date stamp recorded by the ISCO (-mmddyy) to the ID. Put the date of sample on the “date” line. Put the time of the first bottle of the sample on the “time” line. Provide the initials of the samplers on the “sampled by” line. 5. **File Organization** Ensure that all documentation is complete and organized appropriately by following **Butte – StW File Organization Details** located at https://woodardcurran.sharepoint.com/sites/trec/docs/DoForms/Butte%20-%20StW%20File%20Organization%20Details.aspx These are older sites so you may have to copy the link into your browser to access. The steps may have changed slightly but it should still be a good overview of the process.
SHIPPING	1. Make sure the number of containers is correct to the number of sample bottles. Check to make sure that the sample ID and date stamp, date, and time match the COC. Ensure that there are initials of the preppers on the “sampled by” line and that the appropriate label (analysis) is on the correct bottle. Also, confirm that all lids are sealed properly. 2. Make any necessary changes to labels or the COC before packing. When the COC is correct, the person who is in the “Sampler’s Name” box should sign under “Relinquished By / Affiliation” column on each page of the COC. Copy the COC, make enough copies of the original COC for each cooler and one for the file cabinet. Place the original COC and the copies in zip lock bags and add one to each cooler on top of the ice, making sure the original is sent with the samples. File one copy with the shipping label receipt in the file cabinet in the copy room. 3. Special packing instructions for specific bottles: • Duct tape all raw bottle lids to the bottle. The lids on these bottles do not seal well, and often spill during shipment. • All amber glass bottles must be wrapped in bubble wrap and placed in a cooler of their own. Line the bottom of the cooler with a bubble sheet, and then top the bubble-wrapped bottles with another bubble sheet before closing and securing the cooler. 4. Fill all coolers as full as you can without squeezing bottles in too tight. If on the last coolers there are not enough bottles to completely fill the space, use any kind of appropriate filler to prevent bottles from falling over or sliding during shipment. 5. Confirm that all coolers contain a temperature blank and place the temperature blank on top of the samples. 6. Place ice bags in a zip-lock bag or place all ice bags in a large plastic bag on top of the samples and seal. A minimum of two bags of ice should be used in the winter and a minimum of three bags of ice should be used in the summer. Place the bags of ice on top of the sample bottles in the cooler or in the voids if applicable. Close the lid tightly and duct tape the seal twice over. Place a custody seal over the front latch of the cooler. Using packing tape, secure the custody seal from the front of the cooler to the back. A minimum of three separate strips should be applied in this fashion across the top length of the cooler. After the top is taped, proceed to tape over the duct tape seal twice with the packing tape. 7. Either call for a pickup from FedEx or deliver the coolers to FedEx 8. If calling FedEx for a pickup then you will need the following information for the digital shipping label. Make sure to place the online request as early as possible for same day shipping: • In the From section: fill out the Date, Sender’s Name, Phone, Company (TREC, Inc.), Address (1015 S. Montana St., Ste. C), City (Butte), State (MT), and Zip (59701). • In the To section: fill out Recipient’s Name (Sample Receiving), Phone (612-607-1700), Company (Pace Analytical), Address (1700 Elm St. SE), City (Minneapolis), State (MN), and Zip (55414-2485). • In Express Package Service, check FedEx Standard Overnight when shipping Monday through Thursday, or “FedEx Priority Overnight” if shipping on a Friday. • In Special Handling and Delivery Signature Options, check SATURDAY Delivery if shipping on a Friday

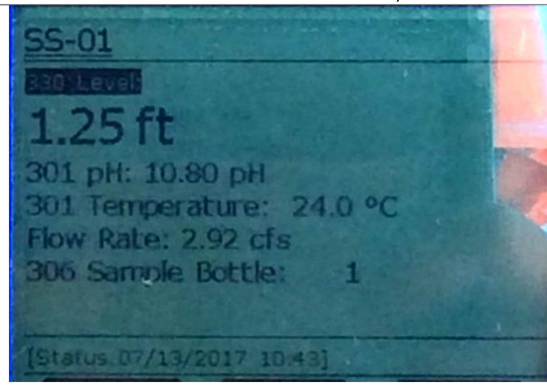
	only. Check No under Does this shipment contain dangerous goods? • In Payment, check Recipient and fill in the FedEx Acct. No. as 9860-02219. Fill in the number of coolers being sent under Total Packages. Each coolers weight is approximately 65 pounds. 65 * total number of coolers is entered in "Total Weight". 9. Coolers must never be left unattended (locked in lab is fine) until delivered for shipment or pick-up by carrier is complete. If not calling for a pickup and delivering to FedEx then once the coolers are taped drop them off at FedEx 10. FedEx has PACE's account information on file and they will print off shipping labels to stick on coolers. **STAY UNTIL ALL COOLERS HAVE LABELS. Remember to request or confirm samples are shipping "Priority Overnight" unless shipping on a Friday then request "Priority Overnight with a Saturday Delivery" so the samples are delivered the next day instead of sitting somewhere and having them delivered on Monday due to the temperature requirements.** 11. Make sure to take the Sender's Copy of the shipping label (receipt) to secure to the copy of the COC and place in the appropriate month in the filing cabinet. 12. At a minimum, record in the field book, the date and time samples were shipped and that they were shipped on ice under COC. Address and phone number of lab samples are being shipped to, number of coolers shipped, tracking number, first sample ID - last sample ID if sample numbers are sequential, if the numbers aren't sequential, the date(s) samples were collected. 13. TDS and TSS analysis have short hold times of seven days. Email Shawn Davis Shawn.Davis@pacelabs.com or contact him at Pace (612-607-6378) to notify him that short-hold samples are being shipped. The lab needs time to prepare to process these samples so, if possible, notify him the day before you plan to ship so he can alert the lab. Be prepared to tell him the earliest sample collection time.

SOP – SW – 16

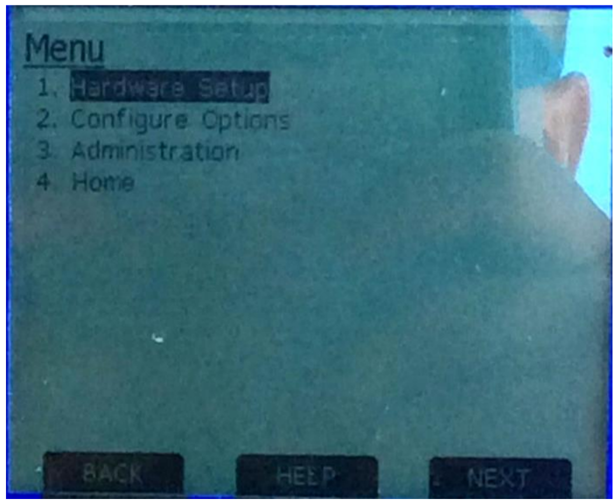
Signature Bubbler Set-Up, Stage Adjustment, and Battery Replacement.

Authorized for use: 01/24/2022
Revision 3
Reviewed:

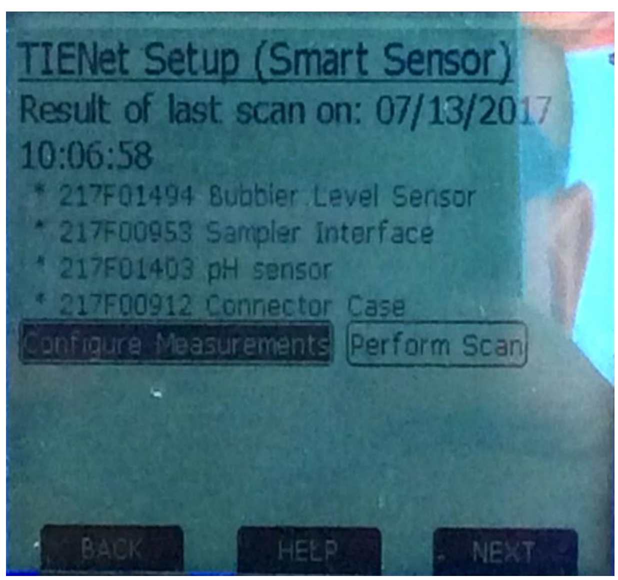
SCOPE	Programming and conducting necessary changes to the Signature Bubblers from ISCO currently at SS-01, SS-04, SS-05A, SS-06, and SS-07
TRA(s) Referenced/ Reviewed	TRA1-001: Common Hazards Driving Manual Handling
STOP WORK TRIGGERS	Lightning (30 second rule) Extreme wind Unsafe conditions Inadequate PPE or equipment
MSDS	Arsenic Cadmium Copper Lead Mercury Zinc
PPE REQUIRED	Hard Hat Safety Toe Boots Safety Glasses High Visibility Shirt or Vest Gloves Long Sleeve Shirt Long Trousers
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	USB Drive Micro USB to USB adaptor cable Bubbler Line and pH sensor attached
Trained, Competent and Authorized Employees in this SOP	1. Alice Drew Davies 2. Joel Arbaugh 3. Dalen Longfield 4. Mat Erickson 5. Matt Kilsdonk 6. Joe Moodry 7. Kirsten Vose
PROCEDURES	
OPEN HOUSING BOX	1. Wearing work gloves, unlock the lock on the housing and remove the lock. Hanging it on the side of the box 2. Unlatch the stays, open the housing door, and store the lock on the shelf the Bubbler is on or hang on the side of the box.
SCANNING FOR ATTACHED TIENETS	1. Press any button to awaken the bubbler, the backlight will turn on and you will be at the main menu screen.

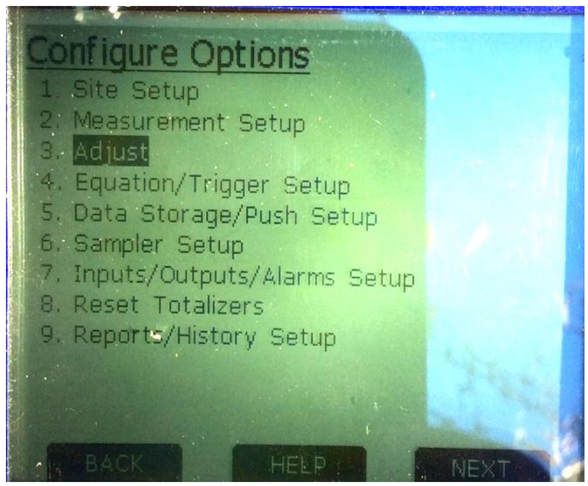


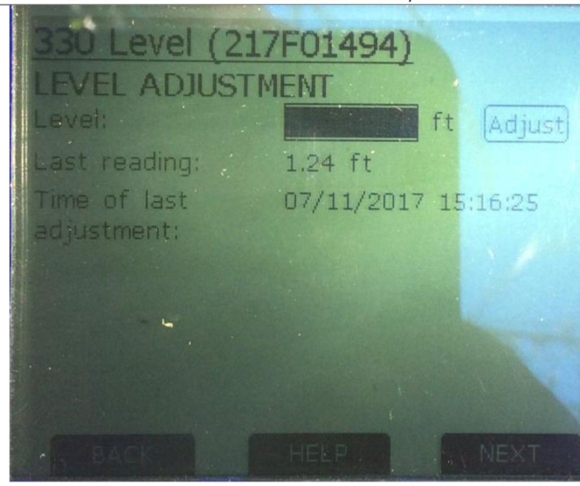
2. Press the “B” button to get to the menu and select the “C” or next button when “Hardware Setup” is selected



3. Once the Hardware Setup Menu has been opened select next when “TIENet Setup” (Smart Sensor) option is highlighted.
4. Scroll over to Perform Scan and click Next.
5. The Bubbler will display a message stating that it is loading.
6. Once it has finished loading it will display the screen below (this will depend on the amount of TIENets attached).



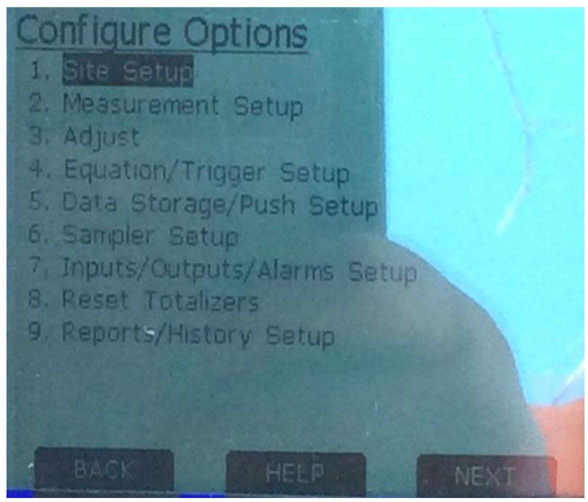
	7. Once all attached TIENets have been identified then proceed to the programming steps. 8. Press the House icon on the 4 way track pad to return to the home screen.
ADJUSTING THE STAGE	1. Obtain stage following the procedure outlined in SOP-SW-06-ReadSG 2. From the home screen press the "B" or "Menu" button and select "Configuration Options" 3. Once in the Configurations Menu select the "Adjust" option  4. Once "Adjust" has been selected then select the first option labeled "Level"  5. Select "Level" and the desired sampler then enter the desired stage into the space provided and hit "Adjust"



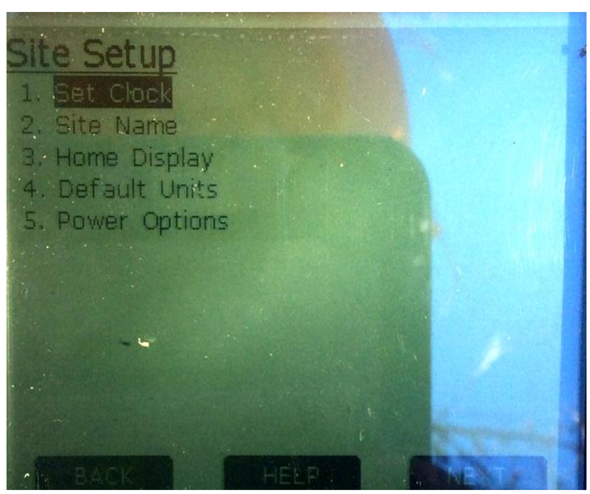
6. Wait until the last reading zone reads to within 0.01 of what was entered then press the “Home” button

SITE SET UP

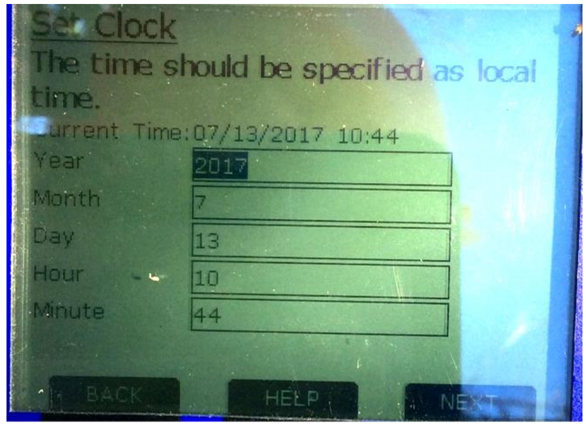
1. To set the site information and values begin at the home page.
2. See the previous section to get to the configuration menu and select “Site Setup”



3. Once site set up has been selected there will be multiple choices. From here the clock, site name, home display, default units and power options can be set.

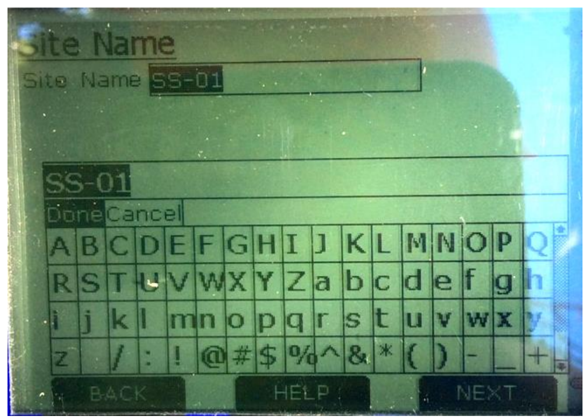


4. To set the clock select the “Set Clock” option

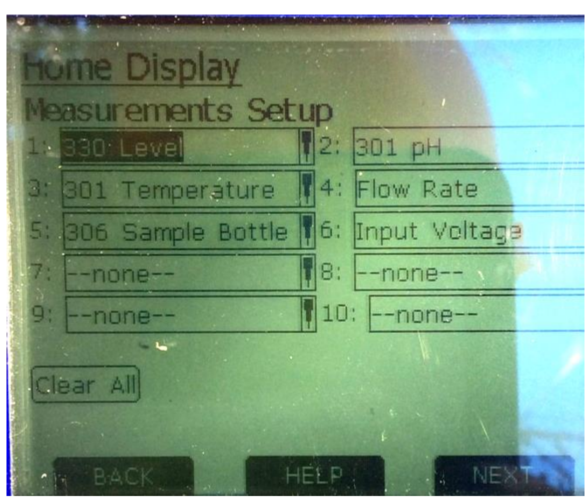


5. Once you have set the values for date and time to what is desired press the back button to get back to the site set up menu

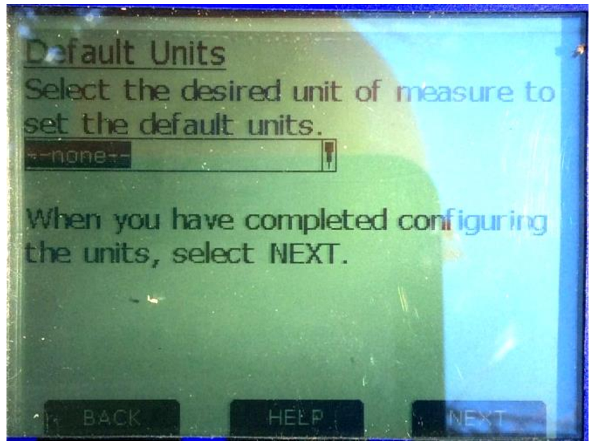
6. Once back in the Site Set Up menu select the Site Name option

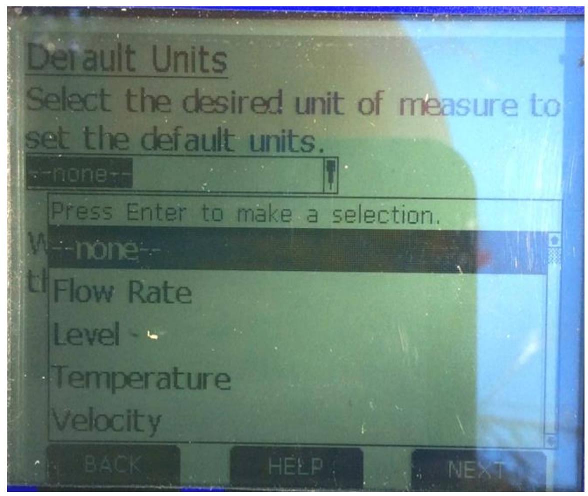


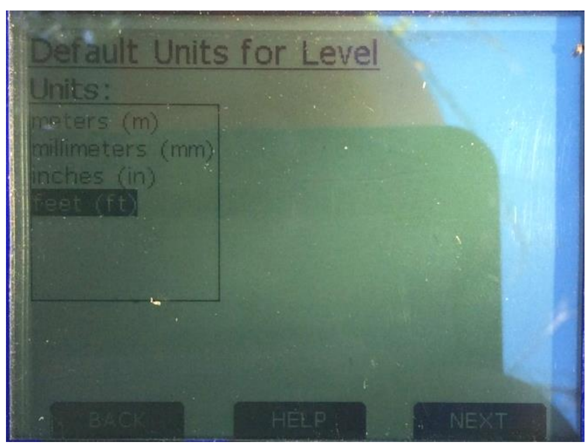
7. Use the keyboard to change the name of the site. Make sure to use the red x in the 4 way pad to backspace. NOTE: **you must click done when you are finished with the name otherwise it will not save the name.**
8. Once the name has been set then press the back button to return to the Site Set Up Menu
9. From the Set Up Menu select the third option "Home Display"
10. For each section select the drop down menu and then choose what you would like to be a part of the Home display.



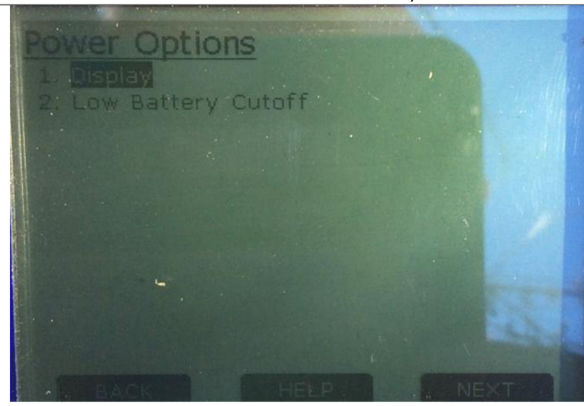
11. Once the different options have been chosen press the back button and return to the site setup menu.
12. From the Site Setup Menu select Default Units to set the units for different measurements
13. Use the drop down menu to select the measurement and indicate the units



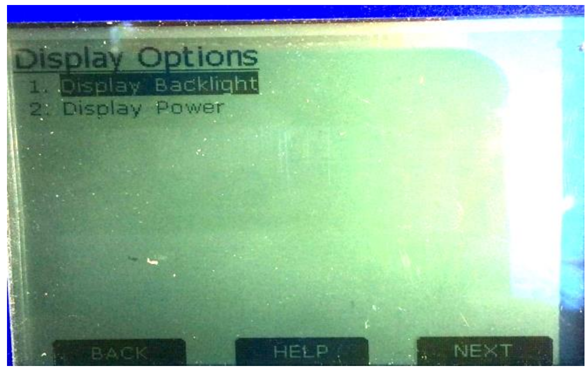




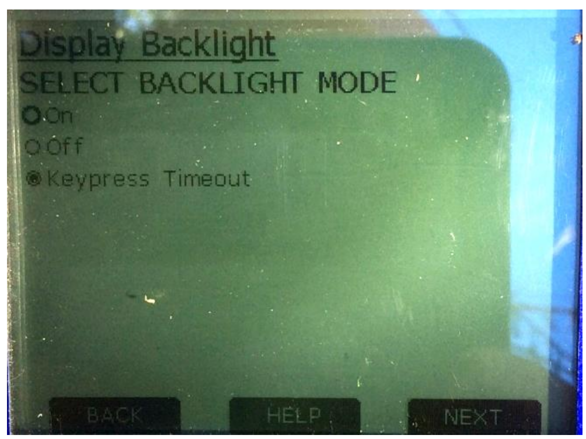
14. Once the units have been indicated press the back button to return to the Site setup Menu.
15. In the Site Setup Menu select Power Options



16. Selecting the display values opens up options for display customization

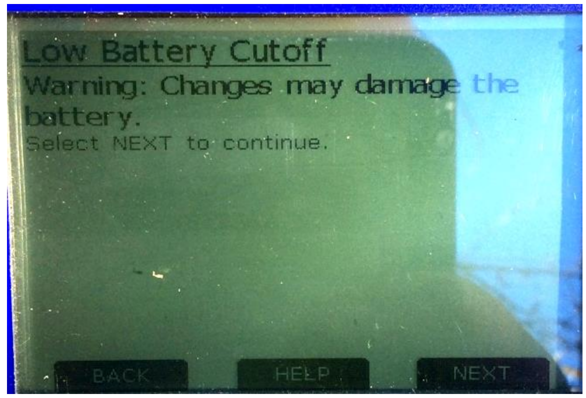


17. Select Display Backlight

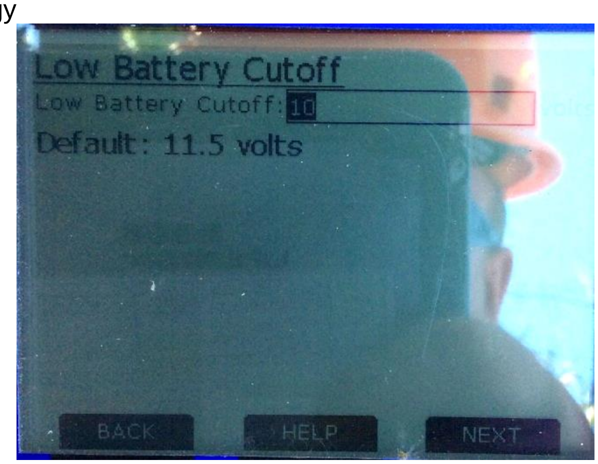


18. Alter the backlight options as needed then select the back button and select Display Power

19. Once Keypress Timeout has been selected press back to return to the Power Options Menu
20. Select the Low Battery Cutoff option



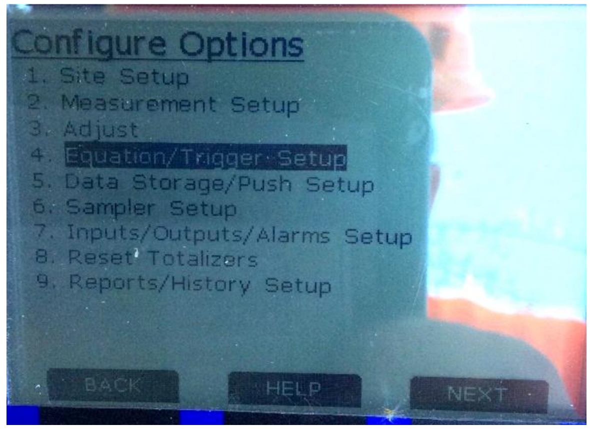
21. Click next when presented with a warning stating that changes may damage the battery
22. On the next screen enter the cut off voltage which will alert the machine to shut itself down to conserve energy



23. Once the value has been set click next to return to the power options menu
24. Press the home button to return to the main menu
25. To adjust the data storage settings for what is recorded press the Menu button.
26. Select Configure Options
27. Select option 5 titled Data Storage? Push Setup
28. Select Group Storage
29. In group storage select all the parameters you DON'T want by checking the boxes. Click Next
30. In the Primary Storage Rate select OFF. Click Next
31. Reselect the Group Storage Option
32. Using the check boxes select all the parameters you want to keep (Level, 301 pH, and temperature) Click Next
33. In the Primary Storage Rate select 15 Minutes. Select Next
34. Select Home
35. Return sometime in the next day or two to confirm that the parameters are stored correctly and with the correct rate.

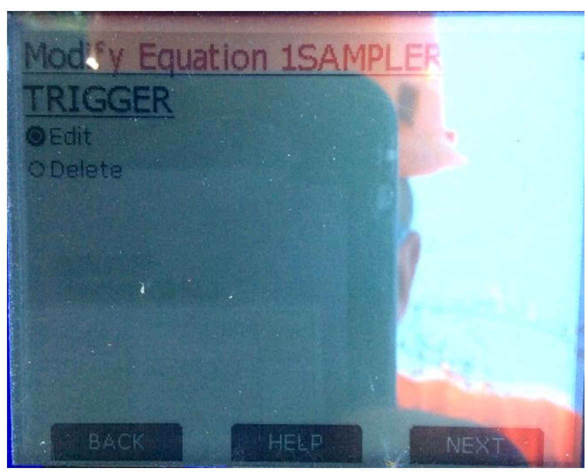
Sampler Trigger and Settings Set Up

1. From the Home Screen press the menu button

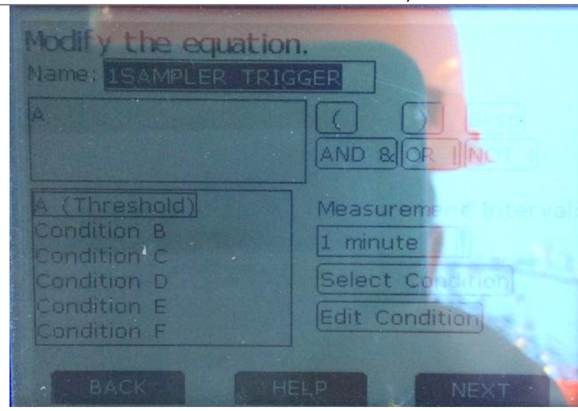


2. Select the "Equation/Trigger Setup" option

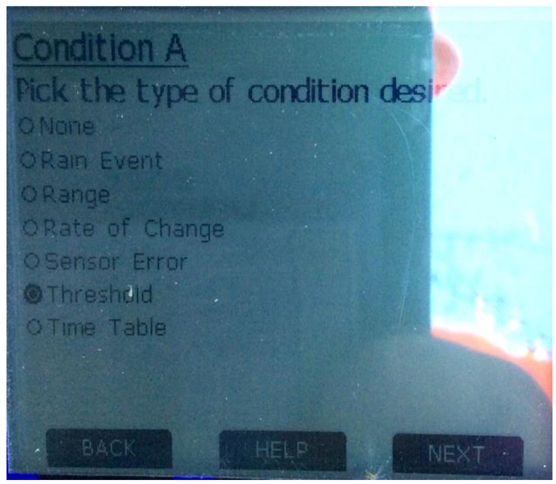
3. If multiple samplers then select the sampler you wish to set the parameter for



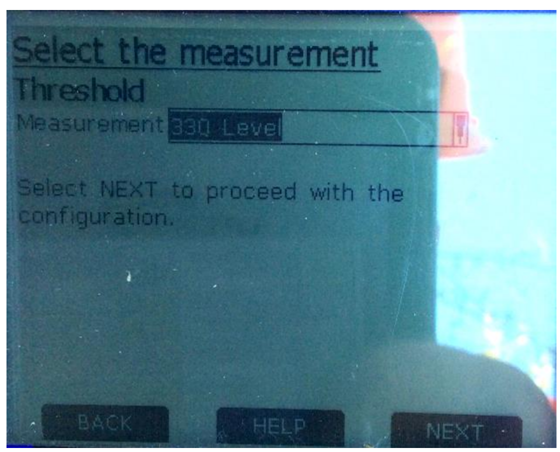
4. Select the Edit option in order to open the equation/trigger setup page NOTE: **DO NOT SELECT DELETE AND CLICK NEXT. THIS WILL DELETE THE TRIGGER EQUATION**
5. Once you click Next the "Modify the Equation" page will appear



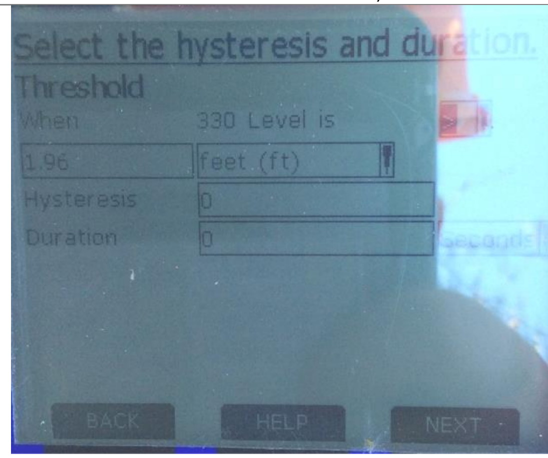
6. To edit the condition scroll down to the “Edit Condition” button **NOTE: MAKE SURE TO KEEP THE “A (THRESHOLD)” OPTION SELECTED. IF ANOTHER CONDITION IS SELECTED THEN THE EDITING WILL BE DONE FOR THAT CONDITION, NOT THE PERTINENT CONDITION**



7. For “Condition A” select the “Threshold” option by moving the circle selector then pressing “Next”

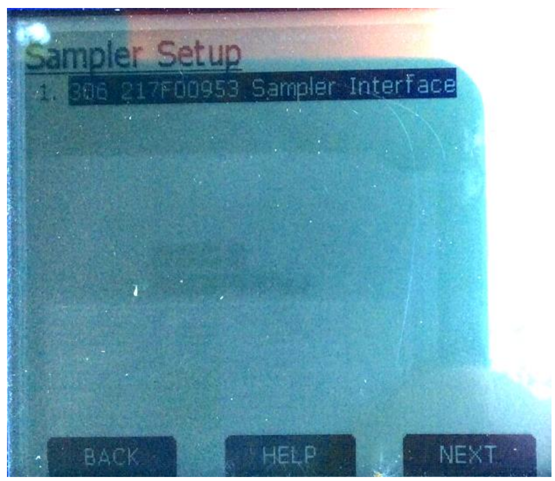


8. In the “Measurement” section select “330 Level” and press “Next”



9. On this screen you will set the condition required for the bubbler to trigger the sampler. You will designate the operator and function. For example: now the slide reads that when the 330 Level is greater than 1.96 feet the sampler will be triggered. You must specify whether the operator is greater than, less than or the equal to the trigger condition. When you know the level at which you wish to trigger enter it to the left of **feet (ft)**. Leave the Hysteresis and Duration values at 0. Click "Next" when you are finished.

10. Once you have clicked "Next" the Equation/Trigger Setup menu will appear again. Press the Home button to return to the homescreen
11. From the home screen select "Menu" option then select "Configure Options"
12. From here select "Sampler Setup". A list containing all connected and recognized samplers will appear



13. Select the appropriate sampler from the list and click “Next”. Most bubblers will have only one sampler attached but be careful to select the appropriate sampler if there are multiple.
14. Once the correct sampler has been selected the Sampler Interface setup screen will appear.
15. **Make sure every sampler has a trigger equation**
16. Select “Enable on Trigger” and make sure to select the previously created trigger condition in the “Enable on Trigger” pull down menu.

17. Select the “Trigger Enable Latched” checkbox
    a. **NOTE: THE “TRIGGER ENABLE LATCHED” CHECKBOX MUST BE UNCHECKED WHEN INHIBITING THE SAMPLER. WHEN INHIBITING THE SAMPLER:**
        i. **RETURN TO THIS MENU AND UNCHECK THE “TRIGGER ENABLE ON LATCHED” CHECKBOX AND CLICK NEXT**
        ii. **INHIBIT THE SAMPLER AND VERIFY SAMPLER READS “*SAMPLER INHIBITED*”**
        iii. **RETURN TO THE “SAMPLER SETUP” PAGE AND RECHECK THE “TRIGGER ENABLE LATCHED” CHECKBOX AND CLICK NEXT**
        iv. **THE SAMPLER IS NOW INHIBITED AND READY FOR SAMPLING**
18. Make sure the option “Pace None” is selected and click “Next”. This will return you to the Sampler selection page.
19. Press the Home button to return to the Home Screen

OPENING ISCO HOUSING

1. Wearing work gloves, unlock the metal housing. If possible, visually inspect the lock area prior to placing hands in the area. Insects are often within the lock area. Remove the lock(s) from hasp and store it/them on the handles of the metal housing.
2. Open lid and use small S-hook or lock to secure the hinge lock to the lid.

CHANGING SIGNATURE BATTERY WITHOUT SOLAR PANEL

1. No Solar Panel Attached
    a. If Signature flow meter is in use but not attached to a solar panel, firmly grasp the Signature side of the power cord, (the female end) and turn the battery side (the male end) of the power cable to disconnect the battery. Holding one side firmly and twisting the other, minimizes the risk of breaking the cable on the Signature side of the connection.
    b. Remove the battery from the sampler box. Handle the battery by the molded handles of the battery case. Tuck the cord attached to the battery lid inside the battery box to prevent damage to cord and/or personnel.
    c. Place the new battery on the cinder block (if there is one in the sampler box) next to the equipment. If the Signature flow meter is in use, firmly grasp the Signature side of the power cord, (the female end) and screw the battery side (the male end) of the power cable on carefully avoiding turning the female end.
    d. Ensure that the flow meter has power and is turned on and note in the field book. The Signature flow meter is being used it will take ~1-2 minutes for power to fully restore and level to be recorded. Remain and wait until this is observed.

e. (During Storm Sampling Season Signature Series Flow Meter and Sampler Present). With the Signature flow meter and a sampler, (no solar panel) the flow meter and the sampler will each have their own battery.
f. Unscrew the battery from the cable that is dedicated for Signature power.
a. Remove the plastic case that contains the battery from the sampling box. Use the handles on the case to lift the battery. Do not lift by the cord on the outside of the plastic box and never remove batteries from plastic boxes. Tuck the cord attached to the battery lid inside the battery box to prevent damage to cord and/or personnel.
b. If maintenance is required on internal tubing or any other moving parts of the sampler, complete all maintenance on equipment while the power source is unhooked.
c. Place the new battery in the security box and reattach the cord on the battery to the Signature power cord. Hold one side firmly and twisting the other, to minimizes the risk of breaking the cable on the Signature side of the connection.
d. Wait for Signature to power up and display stage. If sampler is attached to flow meter, turn on sampler and inhibit following the directions in SOP -SW - 08.
e. Check the date and time on the Signature flow meter. If the date and time are not correct, see previous section of this SOP to adjust.
f. Ensure that the sampler display reads Sampler Inhibited.
g. Replace the lid onto the sampler, attach the three closures (when necessary).
h. As a final precaution, trace all sampler/bubbler tubing in the box. Make sure that no equipment is resting on any of the lines or that the lines are not kinked.

CHANGING SIGNATURE BATTERY WITH SOLAR PANEL

1. Solar Panel Site
   A. If Signature is unresponsive after waiting ~ 1-2min after connection new battery, disconnect newly installed battery to remove power source
   B. Remove face plate of the solar controller mount, typically on the left-hand side of the Signature Box
   C. Then disconnect positive cable (+) of the solar panel on the Controller box, the solar cables are indicated on the controller box

   D. After disconnecting solar panel re-connect the new battery and wait ~1-2min for the Signature to respond
   E. After response the solar panel can be reconnected and the face plate re-installed
   F. If no response from signature call technical support 1-800-372-4328

Trouble Shooting:
The unresponsive signature is due to a power overload when connecting the new battery combined with the solar power. The regulator inside the signature will keep it dormant if a power threshold is exceeded. Removing the solar power and connecting to just a battery will allow the signature to come out of its dormant state.

SOP – SW – 18

Calibrate TieNet 301 pH Sensor (Signature Bubbler)

Authorized for use: 11/20/2020
Revision 4
REVIEWED:

SCOPE	This SOP addresses the manual calibration of TieNet 301 Sensor (connected to the ISCO Signature Bubbler.)
TRA(s) Referenced/ Reviewed	R-L1- Common Hazards, Driving, Manual Handling R-L1- Equipment Calibration
STOP WORK TRIGGERS	Unsafe conditions Lightning Inadequate PPE or equipment Inability to access the work area safely Defective equipment Improper tools Dark colored pants during tick season
MSDS	Buffer Solution pH 7.00 Buffer Solution pH 4.01 Buffer Solution pH 10.02
PPE REQUIRED	Safety-toed boots Safety glasses Gloves (nitrile, impervious) Long sleeve shirt Long trousers High vis shirt/vest Waders or Muck Boots (in water)
OTHER INSTRUCTIONS/ SOPs	Refer to product manual for troubleshooting, maintenance, and further information. SOP-H-5: CalibrateYSIPlusProfessionalMultiMeter-Rev4-01272022
REQUIRED TOOLS	Signature calibration kit: Buffer Solution pH 7.00 (rinse and buffer) Buffer Solution pH 4.01 (rinse and buffer) Buffer Solution pH 10.02 (rinse and buffer) Toothbrushes and/or Q-tips YSI Professional Plus Multi-Meter
Trained, Competent and Authorized Employees in this SOP	1. Joel Arbaugh 2. Mat Erickson 3. Matt Kilsdonk 4. Kirsten Vose 5. Dalen Longfield 6. Joe Moodry

PROCEDURES

pH (SU)

1. Calibrate YSI Professional Plus Multi-Meter according to SOP-H-5 Calibrate YSI Professional Plus Multi-Meter. Document the calibration in the Butte-Rocker-Equip Calibr r3 doForm. Choose the appropriate YSI from the drop-down menu in the form. Submit the form.
2. Before you go in the field to calibrate the probes, make sure to refresh the pH calibration kit in the lab. Dispose of the rinse buffers previously used and clean the bottles if necessary. Pour the buffer that was used previously on the creek calibration into the corresponding rinse bottle. Clean the buffer bottles if needed, and fill with the correct pH solution. Use the same buffer solution you calibrated the YSI with in the previous step, so the batch number and expiration date are documented. If you must use a different buffer solution, document the batch number and expiration date in the field book. Mark with duct tape on the pH calibration kit with the date that you refreshed the kit.
3. At each site, in the field book, document the initial pH and initial temperature on the Signature, create a small table in the field book so the proper values can be recorded.

Std (SU)	Initial pH	Final pH	Time (min)
7.00			
4.00			
10.00			

4. Open up doForms on the iPad and open the Butte-Rocker-Equip Calibr r3 form and fill in the necessary information for each site as you calibrate.

	5. Remove the probe from plastic enclosure in creek. 6. Very carefully, clean probe with toothbrush and/or Q-tips and rinse after cleaning. Glass bulb should be clear. 7. At the main Signature screen press Shortcuts (A) 8. Press (2) for "Calibrate pH" 9. Use the command numbers to highlight the desired calibration standard (in order,7, 4, 10). Follow the prompts on the screen until it asks you to wait for the probe to be placed in the standard. Wait for the person in the creek to place the standard in the correct buffer before continuing. 10. Once the probe is clean, the probe should be rinsed. Place the probe into the rinse bottle of the desired pH and swirl. Remove. 11. Place the probe in the fresh buffer solution bottle to calibrate. Swirl once or twice and ensure that the probe is submerged up to the metal. 12. Alert the person standing at the Signature that the probe is in the buffer and ready to calibrate. 13. The person at the Signature will then proceed to the active calibration screen by clicking next and record the first reading displayed that isn't 0. 14. Allow the pH readings to stabilize for at least 2 minutes; you need at least 2-3 readings <0.01 SU apart before you can accept calibration. In lower temperatures, it may be necessary to allow a few minutes (up to 10 according to Teledyne ISCO tech. support rep.) for the temperature probe to adjust from the colder water temperature to the warmer buffer temperature. 15. Once the pH has stabilized, record the final value and time it took to stabilize and accept. Then move on to the next standard. Follow steps 9-14 until all three standards have been calibrated. 16. Once all three standards have been calibrated, the main pH calibration screen will appear. Click done and follow the directions, place the probe back in the creek and select the corresponding option on the screen. 17. Place the YSI in the creek as close to the pH probe location as possible. While the pH probe is equilibrating let the YSI stabilize to compare the YSI temperature and pH against the pH probe. 18. Wait on site for the (c) on the pH reading on the Signature to go away. If this does not go away in 10 minutes, then select no on the bottom of the pH calibration doForm before sending. This will alert a BPSOU team member that the pH didn't stabilize successfully. Document in the field book. Proceed to the Troubleshoot Calibration section below. 19. Record the final temperature and pH from the Signature and YSI. Once at the office enter the temperature and pH information from both sources into the following excel sheet \\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\ARCO\LAO\SW\pH_Temp_data\Creek_calibration\pHCalibration2022.xlsx (for the appropriate year).
DOCUMENTATION	1. In the field book, record the arrival time and the site name. Record the task being performed and the calibration standard and temperature (ºC) observed on each point of the calibration. Document the calibration in the Butte-Rocker-Equip Calibr r3 doForm. Reference this form and the iPad you are using in the field book.
REPORTING	1. Update the last calibration date on the sign-in board and document in the spreadsheet for integrity management tracking.
Troubleshooting Calibration	1. If having difficulties and/or calibration is suspect, carefully place the YSI Pro Plus perpendicular to flow in the creek and compare the corresponding parameters. If the values are different and they don't change with re-calibration, continue to step 2. 2. Contact Technical support at (866) 298-6174.

SOP – SW – 19
Download Signature Data Files

Authorized for use: 01/26/2022
Revision 2

SCOPE	This SOP addresses the downloading of data files (level, pH, temperature) from the ISCO Signature bubblers.
TRA(s) Referenced/ Reviewed	NA
STOP WORK TRIGGERS	Unsafe conditions Lightning Inadequate PPE or equipment Inability to access the work area safely Defective equipment Improper tools
MSDS	NA
PPE REQUIRED	Safety-toed boots Safety glasses Gloves (nitrile, impervious) Long sleeve shirt Long trousers High vis shirt/vest Light colored pants during tick season.
OTHER INSTRUCTIONS/SOPs	Refer to product manual for troubleshooting, maintenance, and further information.
REQUIRED TOOLS	Laptop with FlowLink 5.1 software usb drive (PNY preferably) gold-plated micro-usb to usb cable
Trained, Competent and Authorized Employees in this SOP	1. Joel Arbaugh 2. Kirsten Vose 3. Mat Erickson 4. Matt Kilsdonk 5. Joe Moodry 6. Dalen Longfield
PROCEDURES	
Downloading and exporting the Signature Bubbler data with a field computer	1. Bring a field lap-top and the gold-plated micro-usb to usb cable. 2. Uncap the data terminal set into the bottom left-hand side of the bubbler face panel and plug the micro-usb into it. 3. Plug the usb end into the computer. 4. Open Flowlink (Once in Flowlink some troubleshooting may be required as the bubbler may not immediately connect) 5. In Flowlink the Quick Connect window will appear. Click on the drop-down menu for COM port selection and see if it recognizes a device with Isco4200 in the name 6. If it does then click on that option and then on the graphic on the far right at the top. This will connect to the Signature Bubbler. 7. If it does not recognize the bubbler then close out of the quick connect window and, on the far left of the Flowlink window, double-click on the site you are at. You may have to open a few folders to get here. 8. Once the site has opened in the main Flowlink window open Quick Connect again and repeat steps 5 and 6. 9. If the bubbler still will not connect then close Flowlink completely and unplug the bubbler. Then open Flowlink, plug in the cable into the bubbler then the computer, and then attempt steps 5 and 6. If this still does not work then mix and match the previously mentioned methods for connection from steps 5 through 9. 10. Once a secure connection has been established then click the Program tab on the top right of the minimized window within the main Flowlink window. This will take you to a copy of the Signature home screen, the bubbler can then be controlled from here. 11. Maximize this screen and look to the bottom left under the reproduced Signature home screen. Click on the button that reads “Interrogate (F8)” 12. The home screen will change reading that “The Data is being generated” and a smaller window will appear showing the progress of the data download. 13. Once all the data has been downloaded click “Done” on the smaller window. The Signature control window can then be minimized. 14. In the far-left pane in the Flowlink page, maximize the site name you are at, if it is not already, by

	clicking on the little plus sign. Do this for the site name again, and then again on Signature until all the signature parameters are listed. 15. At the bottom of the primary list open the graphs folder and double click on the 4200 Default Graph. This will open the default graph for that type of bubbler. 16. Once the default graph is open go back to the open list of Signature parameters. 17. Click on and drag 301 Temperature, 301 pH, and 330 Level into the graphical area. As this is done the different parameters will appear in their own graphs. Check to make sure that the scales and axis are correct. 18. Use the magnifying glass with a – in it at the top of the window to pan out to the data range you wish to export. 19. Click on File at the top left of the window. 20. Click Export. A window will appear detailing the export location and the progress. Do NOT click Export yet. 21. Click the browse button next to the file save location and go to the Creek Downloads file and name the file to be exported with the same format as the previously saved files. 22. Click Save 23. This will take you back to the export progress window in Flowlink. Click Export. This will take a short time. 24. Minimize the entire Flowlink window and open the Creek Downloads file that is on the desktop. 25. Open the Signature folder and the recently exported data file. Then check to make sure that the entire data range you wished to save is present. 26. Once confirmation has been made you can close the entire Flowlink window. 27. Disconnect the micro-usb from the Signature and the usb from the computer. Put the cord in the Ziploc bag it came in and the computer in its computer bag. 28. The download is complete.
Downloading and exporting the Signature Bubbler data with a usb flash drive	1. This is the preferred method of downloading Signature data as it is the most efficient and successful. Bring the usb drive (PNY works best) 2. Uncap the data terminal set into the bottom left-hand side of the bubbler face panel and plug the white usb cable that's attached to the door into it. 3. Plug the flash drive into the white cable. 4. The screen will display the flash drive options. 5. Select the download data option. 6. Select the date range download option and use the drop-down menus to select the dates you wish to download. 7. Select Go. 8. The signature will now display a loading screen. Allow it to complete loading. 9. Once it is done exporting unplug the flash drive and check the data on the computer. 10. The flash drive will automatically assign the data to a site and date. 11. Open the site and corresponding date and make sure the data is there. Check dates. If needed, you can make a quick hydrograph to look for data losses.
Documentation	1. In the field book, record the arrival time and the site name. Record the task being performed. Document that the continuous stage recorders were checked for correct time and stage and record any adjustments. List the file name of the data that was downloaded and where it was saved. Record if the bubbler system at each site was purged, and if any accumulated debris was removed from the bubbler line and/or staff gauge.

SOP – SW – 20

Wet Weather Trigger Criteria

Authorized for use: 06/18/2018

Revision 3

SCOPE	Determining proper sampling stage for wet weather samplers
TRA(s) Referenced/ Reviewed	
STOP WORK TRIGGERS	1. Lightning (30 second rule) 2. Extreme Wind 3. Unsafe conditions 4. Inadequate PPE or equipment
MSDS	1. Arsenic 2. Cadmium 3. Copper 4. Lead 5. Mercury 6. Zinc
PPE REQUIRED	1. Hard Hat 2. Safety Toe Boots 3. Safety Glasses 4. High Visibility Shirt or Vest 5. Gloves 6. Long Sleeve Shirt 7. Long Trousers
P&IDs/Other Relevant Drawings	1. N/A
OTHER INSTRUCTIONS/SOPs	
REQUIRED TOOLS	1. Laptop computer with correct download cable
Trained, Competent and Authorized Employees in this SOP	1. Alice Drew Davies 2. Padraic Stoy 3. Tina Donovan 4. Michael Picker

PROCEDURES

1.0 Preparation

1.1 Current Stream Conditions

Prior to starting, current stream conditions are checked using available USGS station data available online. While observing data, note diurnal fluctuations and average stream discharge at all available and applicable sites.

- Blacktail Creek above Grove Gulch - SS-01.35 – USGS 12323233
  https://waterdata.usgs.gov/mt/nwis/uv/?site_no=12323233&PARAmeter_cd=00060,00065,00010
- Normal SS-01.35 flows range from 10-20 CFS
- Silver Bow Creek - SS-07 – 12323250
  https://waterdata.usgs.gov/mt/nwis/uv/?site_no=12323250&PARAmeter_cd=00060,00065,00010
- Normal SS-07 flows range from 20-30 CFS

1.2 Data Collection

During initial installation or upon observing that Wet Weather sampling stage criteria need to be adjusted, all applicable and available stage data from stream sites should be downloaded to have the most current data. Sometimes during initial sampler installation in the spring, the wet weather criteria at SS-01.35 and SS-07 (See Section 3.1) and their corresponding stage heights have not yet occurred; thus, USGS stage-discharge curves from the previous year must be utilized until the creek reaches the intended criteria. While downloading is occurring, physical stream attributes should be noted, including turbidity, discharge from tributaries, etc.

After all data from applicable sites is obtained, enter the sites into a copy of the spreadsheet located:

\\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\ARCO\BPS-Storm\Events\Creek 2014_thru_2022\

Select the previous year folder and open the file named: creek-stage_stormXXXX

This spreadsheet uses the most recent stage-discharge curves to transform stage data to discharge data and plot all the stations on the same chart for comparison purposes. If using USGS data for sites SS-01.35 and SS-07, instead of the data from the field downloads, it is necessary to adjust the times from MDT to MST. These hydrographs are used in Section 3.0.

Historical weather and precipitation data from all available and applicable online stations also needs to be collected prior to selection of sampling criteria.

- BTL/LAO - https://www.wunderground.com/personal-weather-station/dashboard?ID=KMTBUTTE5
- Kelley Mine Yard - https://www.wunderground.com/personal-weather-station/dashboard?ID=KMTBUTTE2

2.0 Storm Selection

2.1 Criteria

Ideal recent-historical storm for selection of sampling criteria had: significant precipitation (usually > 0.10 in.) that was consistent across study area, occurred recently, an abrupt rising limb of the hydrograph, and a clear singular peak before decreasing into the tailing limb of the hydrograph. Checking all available online resources, including discharge and weather data, is necessary to pick an appropriate storm.

2.2 Comparisons

Looking at current stream conditions compared to selected storm for discharge differences. Ensure selected storm is at least 40% more than current flow when flow is less than 30 cfs, and at least 15 cfs more than current flow when flow is 30 cfs or more.

3.0 Sampling Flow Selection

3.1 Target Flow Levels

USGS station 12323233 (SS-01.35) was established in April 2020, and prior to that time USGS station 12323240 (SS-04) was used for determining WW criteria. The Berkeley Pit and Discharge Pilot Project (BMFOU Discharge Pilot Project) began discharging treated water to SBC in late 2019. The discharge causes backwater at SS-04 and interferes with the ability to develop a reliable discharge curve at this site; thus, the site was discontinued by the USGS in early 2020. However, data collected prior to that time allowed characterization of diurnal and WW driven flow variations.

After analysis of five years of empirical flow and precipitation data from SS-04, it was determined that the average diurnal flow variation at SS-04 (plus one standard deviation) is 7 cfs during baseflow. During wet weather events, the average variation in flow is roughly 15 cfs. For flow regimes less than 10 cfs, the average diurnal flow variation (plus one standard deviation) is 3 cfs. Typically, average diurnal variation is not more than ~40% at SS-04 during baseflow. Thus, until adequate empirical data exists for SS-01.35, the following equations should be used to determine the wet weather sampling trigger, but rather than applying these equations to SS-04, they should be applied to SS-01.35.

If current flow < 10 cfs, $Trigger\ (cfs) = Current\ (cfs) + 3\ cfs + 0.40 * Current\ (cfs)$

If 10 ≤ current flow ≤ 30 cfs, $Trigger\ (cfs) = Current\ (cfs) + 7\ cfs + 0.40 * Current\ (cfs)$

If current flow > 30 cfs, $Trigger\ (cfs) = Current\ (cfs) + 15\ cfs$

A spreadsheet calculating trigger flows (currently named Draft_June2018_WetWeatherTrigger_Calculations) can be

accessed at:
\\woodardcurran.net\shared\Offices\Bozeman\BUTTE\TREC\ARCO\BPS-Storm\Events\Creek 2014_thru_2022
Select the current year folder and open the file named: creek-stage_stormXXXX
When nearing the boundaries of the step functions (10 and 30 cfs), the trigger for flows just below the boundary may exceed trigger points at the boundary value. For example, using the above equations, 30 cfs current flow would trigger at 49 cfs, while 31 cfs current flow would trigger at 46 cfs. Professional judgement should be used when current flows are near the boundary of the step function.
Because these equations are based on statistical analysis of empirical data, and informed by professional judgement, the rising limb of storm events should be comprehensively captured by the automatic sampler with few unnecessary samples. Calculated trigger flow rates will need to be converted to creek stage heights.
Currently, less than three months of data are available for station SS-01.35, and the majority of that data is under high flow conditions. Based on the very limited data set, the following equations can be used as estimates for SS-01.35 wet weather sampling triggers.

If current flow < 10 cfs, $$Trigger\ (cfs) = Current\ (cfs) + 0.5\ cfs + 0.40 * Current\ (cfs)$$

If 10 ≤ current flow ≤ 30 cfs, $$Trigger\ (cfs) = Current\ (cfs) + 4\ cfs + 0.40 * Current\ (cfs)$$

If current flow > 30 cfs, $$Trigger\ (cfs) = Current\ (cfs) + 15\ cfs$$

3.2 USGS Stations

Using the ideal recent-historical storm hydrograph, sampling flows and stages will be set for USGS sites (SS-01.35 and SS-07) using the equations in section 3.1. It is important to note that samplers are always set to MST while data from USGS is reported consistent with the current time units (during daylight savings time, USGS sites report in MDT, during standard time, USGS sites report in MST). Therefore, when obtaining the date and time the creek reached criteria, the time needs to be converted to MST. These flow values are checked by using the assumed travel time between SS-01.35 and SS-07 (2 hours) and the actual timing between sampling that would have occurred on the ideal recent-historical storm. Assumed travel times between each station are listed below in Table 1.

Table 1. Estimated Wet Weather Travel Times

Station	Estimated Travel Time from previous station (minutes)
SS-01	--
SS-01.35	1:10
SS-04	0:15
SS-05	0:15
SS-06A	0:45
SS-06G	0:30
SS-07	0:15

3.3 BMFOU Inputs

As mentioned above, in late 2019 the **BMFOU Discharge Pilot Project began discharging treated water to SBC at its confluence with BTC. Since BMFOU Pilot Project discharge rates can vary daily, and throughout the day, the seasonal average inflow and resulting stage increase should be used when setting a trigger stage for stations downstream of SS-04.**

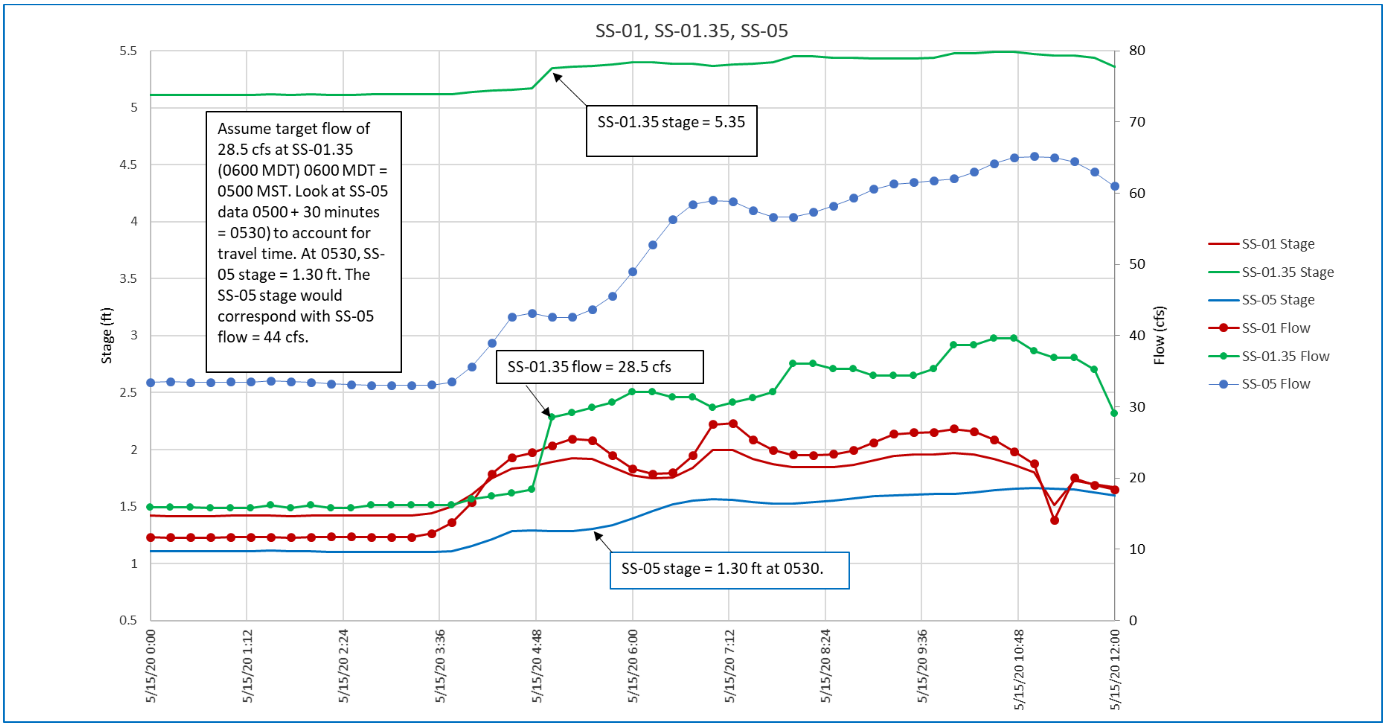
3.4 BPSOU Stations

Once target flow values are chosen for SS-01.35 and SS-07, using the hydrographs from the ideal recent-historical storm, determine estimated time of sample for all other stations using assumed travel times. If the hydrograph is changing at a very rapid rate, compare the stage you obtain with historical data to confirm.

4.0 Sampling Stage Selection

4.1 Stage-Discharge Relationship

Once estimated time of sample for each station is determined, target stage and flow for non-USGS stations can be decided. Using the recently downloaded stage data and the previous year's stage discharge relationship from the DSR (\\woodardcurran.net\\shared\\Projects\\TREC\\9208_AR_MT_BPSOU\\9208 - 2009 BPSOU\\9208-003_SW-GW_Monitoring\\01_SurfaceWater\\03_DSRs), create hydrographs for each station for the ideal recent-historical storm. Based on estimated time of sample for each site, use the hydrograph to determine target stage and the associated flow. While determining target stage and associated flow, use estimated time of sample for each site as a guide while also taking into account expected flow gains between stations and the cumulative flow gain that should be occurring between SS-01.35 and SS-07. Remember to account for the BMFOU Discharge Pilot Project flow gain.



Section 3 through Section 4.1 is an iterative process that may require finding another ideal recent-historical storm to confirm target flow selection and travel time between sites.

4.2 Recording

Once all target flows and their associated stages have been determined, do a final check of those stages with the previous target stages to confirm that the stage is being properly adjusted up or down. If all stages and flows are determined acceptable, record the changed stage for each station in the associated smplr_flow spreadsheet and calculate the necessary change up or down in tenths of a foot and inches. Necessary change in stage should be calculated in both units to assist field team members when they are adjusting ISCO and D-TEC samplers.

Authorization for use: 12/30/2019
Revision: 1

SOP-SW-21

Standard Operating Procedure

Stage-Discharge Curve Creation

Updating Rating Curve

Rating Curve updates are done in accordance with USGS procedures, which can be found here is additional questions aren't adequately answered in this SOP.
https://pubs.usgs.gov/wsp/wsp2175/wsp2175_vol2.pdf

1) Make sure all manually collected flow data from the previous year is available
2) Open stage-discharge database for specific site from the previous year
   a) Save as new database in the correct year's folder
   b) Remove previous years continuous data from this station and from USGS
3) Add manually collected flow data from previous year to RatingsTable
4) Make sure previously entered data shows up on the current figure showing the rating curve
   a) Add the new data as a separate series so it stands out from previous years' data
5) Determine if the new data fits well along the rating curve
   a) Do this through an eye test on the figure
   b) Check the residuals of the new data and see if there is a pattern
      i) If the residuals are consistently very (>10%) positive or negative a new curve may be needed
6) If no new curve is needed, apply stage shifts to each manual measurement
   a) Use shifts to get all residuals to within 5% in the adjusted residual
   b) If a measurement is significantly off and cannot reasonable be fixed by a shift, note this and potential reasons why in comments
7) If a new curve is needed
   a) Add new year data to ratings table
   b) Create new trendline curve for data, using a second order polynomial equation or exponential equation
   c) Record equation on chart and apply it to the new data
   d) Repeat step 6 to new data to get all residuals within 5%, if necessary
8) Get data dump for continual data
9) Apply stage-discharge curve to continual data
   a) Add continual data and manual data to the same time series
   b) Apply shifts to the continual data, interpolating between manual measured points
10) Create graph of continual data and look for potentially erroneous data
    a) Add comments on graph to potentially erroneous data calling out time period and reason for error

Authorization for use: 12/30/2019
Revision: 0

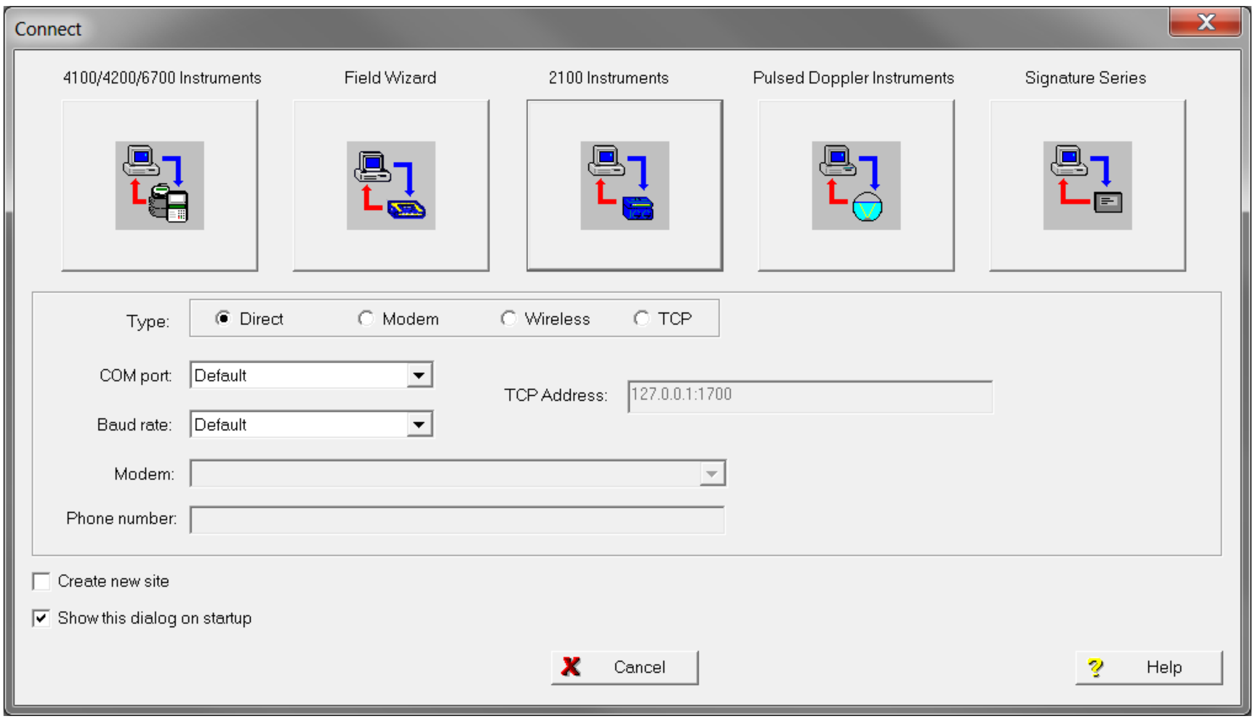
SOP-SW-22

Standard Operating Procedure

Setup and download of ISCO 2150 Area Velocity Meters

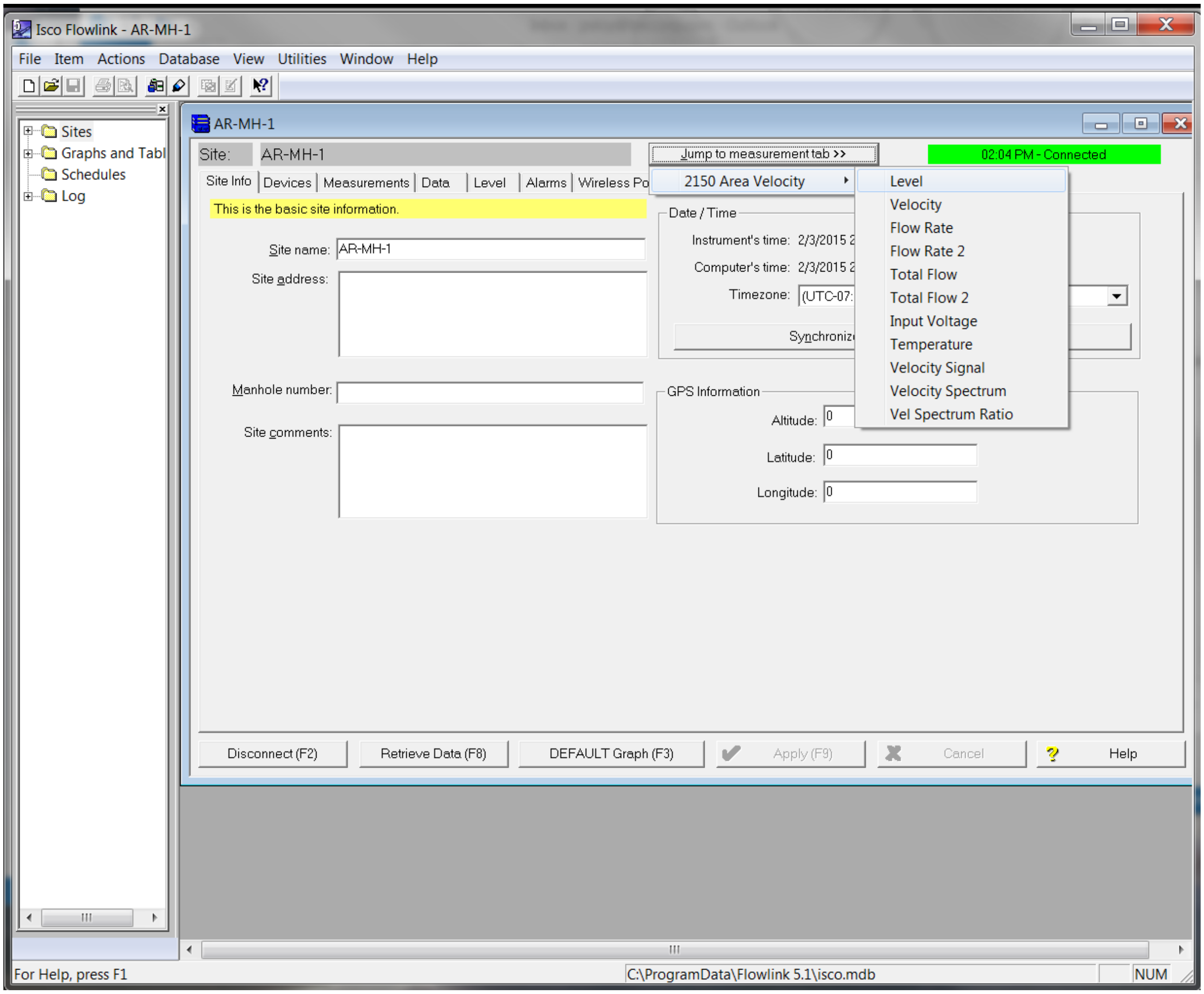
<u>Setting up AV Meter for new site</u>

1. Before connecting to ISCO 2150 meter (AV Meter), make sure batteries have been installed into the meter and the Area-Velocity module has been connected as well. If AV meter is already programmed for site then confirm the following values.
2. Use ISCO 2150 cord and attach it to communications port on top of AV meter.
3. Open up Flowlink on your computer. The quick connect window should open, but if it doesn't either go to the "File" dropdown menu and select "Quick Connect" or press F11

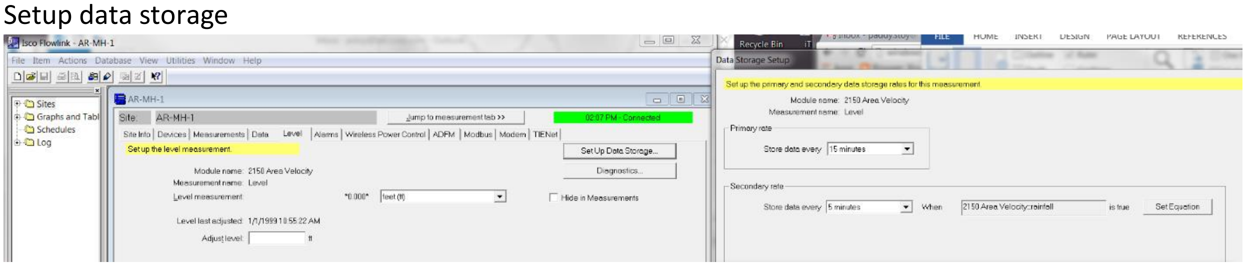


4. Check the "Create New Site" box, then click the button under "2100 Instruments"
   a. If you can't connect, look at the COM port drop down list, and select a specific COM port and try to connect again
5. Name the site and make any notes about location, etc. Make sure the time is in MST, otherwise synch to the computer's time
6. Choose the "Jump to measurements tab", highlighting "Level"

Authorization for use: 12/30/2019
Revision: 0



7. Make sure the units are correct (ft.)
8. Setup data storage



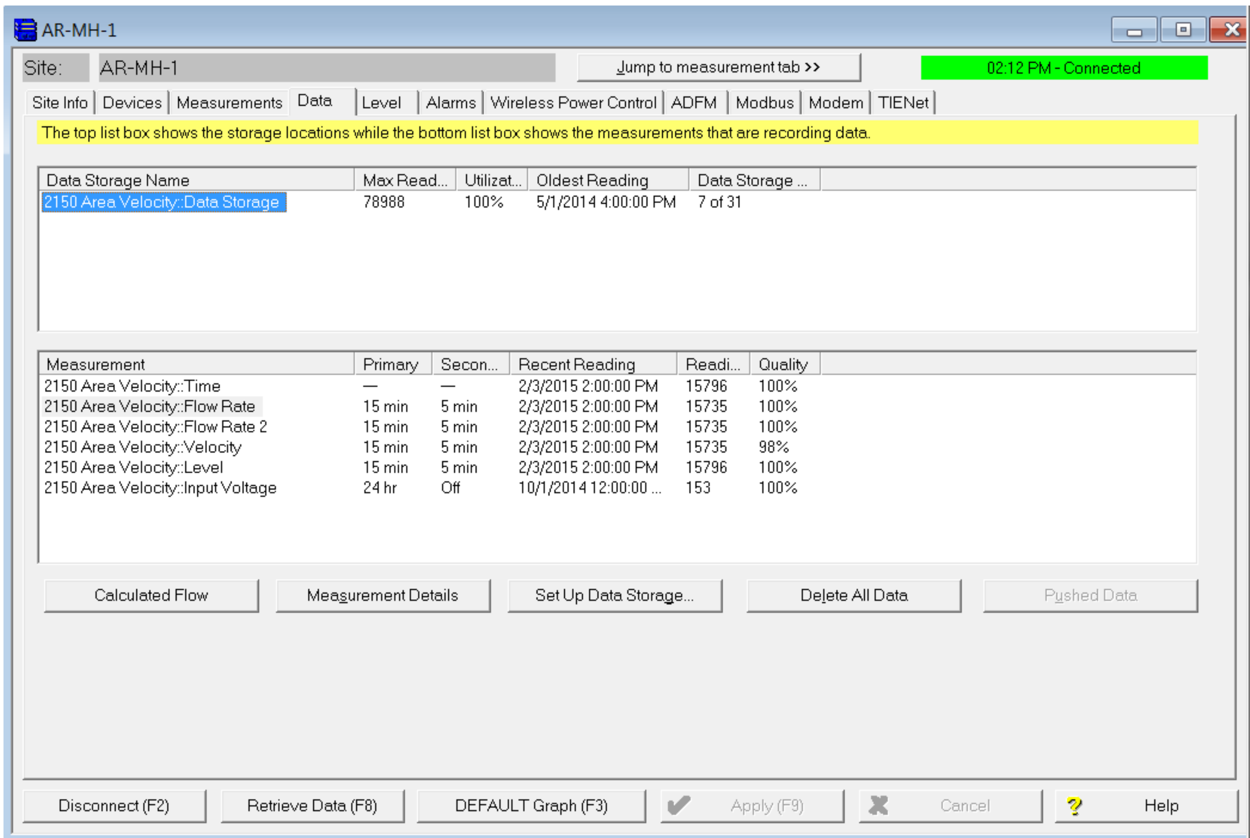
   a. Primary rate at 5 minutes
   b. Secondary rate at Off
   c. "Apply" or hit "F9"
   d. Repeat steps 6-8 for:
      i. Velocity
         1. Make sure velocity units are ft/sec
         2. Check "positive velocities only" and "prevent interference from other velocity measurements"

ii. Flow Rate
1. Make sure flow units are CFS
2. Area Velocity, in channel type (usually round or flume), set diameter to pipe diameter
3. Make sure level and velocity inputs are correct

iii. Input Voltage
1. Make sure primary data storage is set up for 24 hours

e. Go to the rest of the measurements and click the “hide in Measurements” box, the “Apply”

9. Go to Data tab to check the reading intervals are set for all measurements



a. In the data tab you can delete all data from the instrument if this particular meter has been installed before, or if reinstalling a meter for a new season. Deleting all data should only be done if it is known that all data has been downloaded and saved

10. During Install make sure to calibrate the sensor either prior to installation or during installation using the following method. Calibration can also be done to determine if probe is faulty. Use the secondary method prior to installation if time is available.

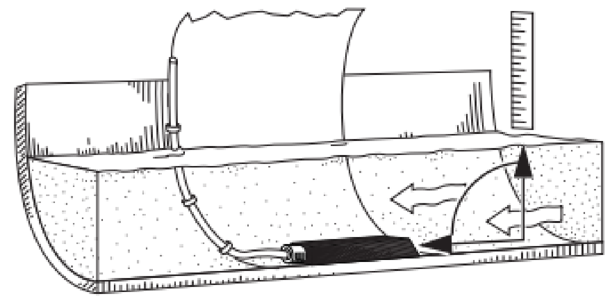
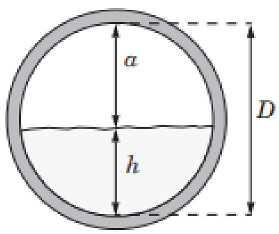


Figure 3-2 Preferred Measurement Location

Do not measure the level and channel dimensions right at the sensor, as the sensor and the mounting ring may cause a slight "jump" or localized rise in the level. At very low levels and high velocities, this jump in the liquid surface may become quite significant.



Level (h) = D – a

In round pipes you can measure the level without disturbing the stream surface. This method is preferred. Refer to the diagram to the left. First measure the inside diameter of the pipe (D). Then measure the airspace (a) from the liquid surface to the peak of the inside diameter. Average this measurement if the surface is not calm. The level measurement you enter (h) is calculated by subtracting the distance above the liquid (d) from the diameter (D).

If difficult channel conditions keep you from making the measurements as described above, another site should be considered. If this is impossible, you may opt for an alternative level calibration method. The method described below will often yield better results than entering a "best estimate" of the liquid level, but results within the listed performance specifications *may be compromised*.

Alternative Level Calibration

1. Fill a bucket with 6 to 12 inches (15 to 30 cm) of water.
2. Place the AV Sensor upside-down in the bucket of water to allow any air bubbles trapped under the sensor to escape.
3. After a few minutes, place the AV Sensor right-side up at the bottom of the bucket.
4. With the AV Sensor flat against the bottom of the bucket, measure the distance from the bottom surface of the bucket to the liquid surface. Enter the distance on the *Level* measurement tab in Flowlink.

3.3.2 Zero Level Offset

AV Sensors are sometimes offset in the channel to avoid heavy concentrations of silt, or to maximize the level resolution over a specific range. When the AV Sensor is offset, an offset distance must be entered on the *Velocity* measurement tab in Flowlink.

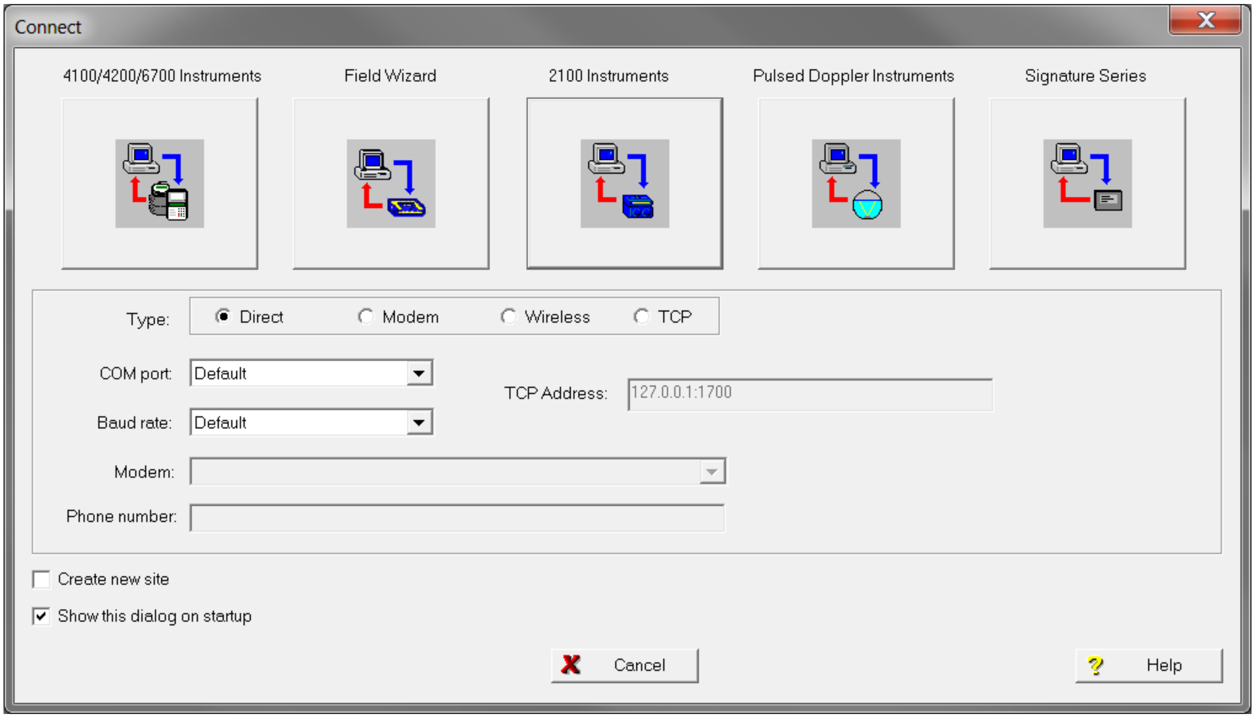
Refer to Figure **3-3**. Enter a value for the vertical distance the sensor is installed above the true zero level of the stream. For example, if the sensor is mounted on the side of the pipe two inches higher than the true zero level (the bottom center of the pipe), the Zero Level Offset is two inches. If the sensor is mounted at the bottom of the channel, enter zero.

11. "Disconnect" or F2 from meter, unhook cable, and cover up port to make sure it doesn't rust.

Authorization for use: 12/30/2019
Revision: 0

Downloading Data

1. Use ISCO 2150 cord and attach it to communications port on top of AV meter.
2. Open up Flowlink on your computer. The quick connect window should open, but if it doesn't either go to the "File" dropdown menu and select "Quick Connect" or press F11



3. Click the button under "2100 Instruments"
    a. If you can't connect, look at the COM port drop down list, and select a specific COM port and try to connect again
4. Once connected, make sure the site name as well as the date and time are correct. If date/time is wrong, "Synchronize Site's Time to Computer's". If site name is wrong, change it and hit "Apply" or F9
5. Hit "Retrieve Data" or F8 to download data
6. Once data is downloaded, view it in "Default Graph" or F3
    a. In the left side window open up the local selection under graphs and tables. Select 2150 Default Graph
    b. In the same window right click on the site name and click "Open with Default Graph"
7. Once the graph is generated select the appropriate data set
    a. Make sure to expand view using Zoom Out tool (magnifying glass with "-" in it) to all desired data points
    b. Review graph to check for anomalies or data losses
        i. Data losses will present and straight lines in the middle of non-zero data or 0's where there was flow.
        ii. Anomalies can include unexplained data spikes, numbers during flows that don't make sense, spikes in data that don't match other data, excessive negative numbers. (See end of document for examples)

8. Once the graph has been reviewed select Export from the File dropdown menu
9. Choose your destination folder for exported data (there should be a folder for all the types of sites on the desktop), name exported file with the site name and the date embedded (ex. BG-CLV-01_091420), and click “Export”
10. Before closing out of Flowlink open file explorer and open the data that was just downloaded.
11. Check data for completeness and correct date range
12. Once initial data check complete close out of graph in Flowlink. Click “No” when the dialogue box opens and asks if you want to save “Default Graph”.
    a. If you click yes this will overwrite the correct stored default graph.
13. Press “Disconnect (F2)” to disconnect from meter, unhook cable, and cover up port with attached lid to make sure it doesn’t rust.
14. If data lacks completeness and is not showing up correctly, remove the battery’s for 30 seconds and try again, per Tech support.

<u>To merge sites that were given different name</u>

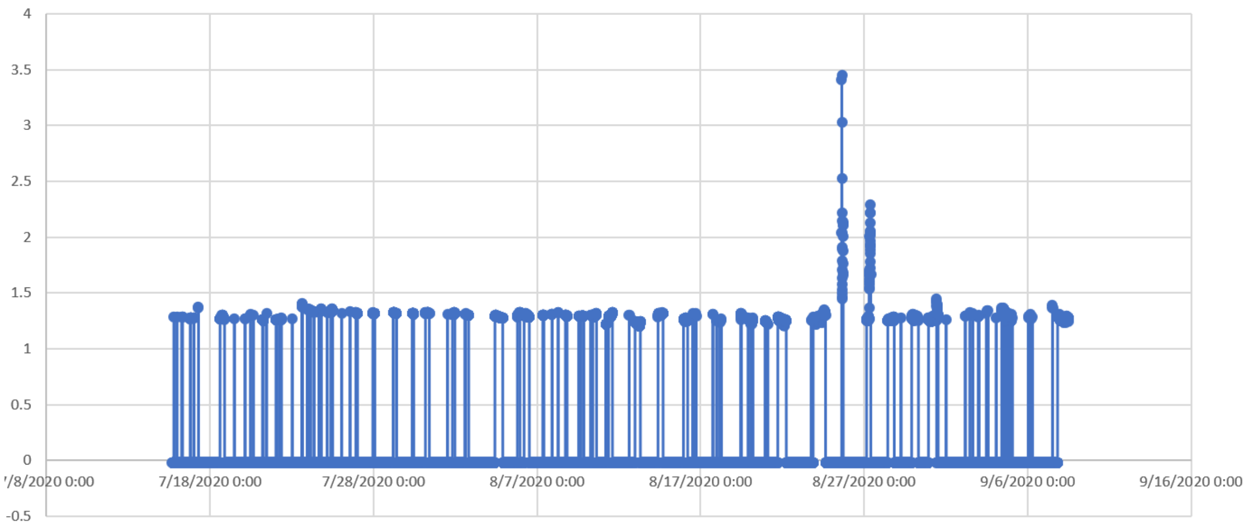
1. If an AV meter as a site malfunctions and it must be renamed, it is possible to merge the new site name with the previous site through the “Utilities” dropdown menu
2. Select most appropriate site (actual site name) for destination site, and select iterations of that site as sources. Do not delete data from source after transfer
3. “Merge” sites

Checklist for installing a previously installed AV Meter:

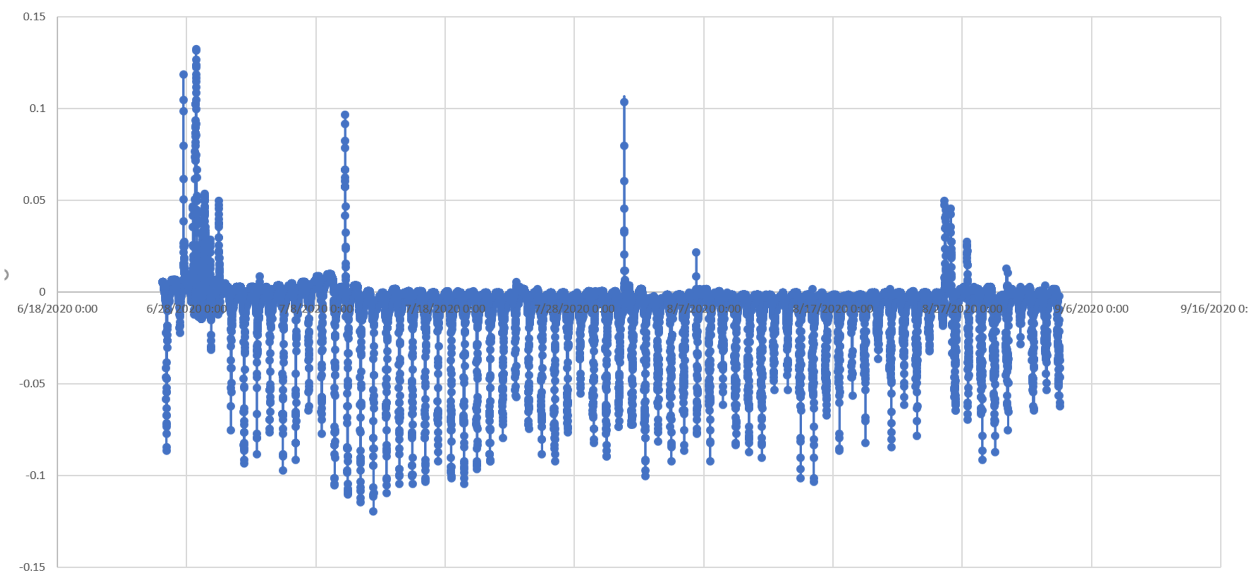
- Open/use quick connect to connect to the AV meter.
- Verify site name and Time zone on the first page.
- Under Measurements; in level, velocity and flow rate click on “Set Up Data Storage…”. Verify that the primary rate is **5 min.** and the secondary rate is set to **Off.** when **2150 Area Velocity::Level**
- Under measurements, in level, verify; units are in **ft.**, and the adjust level is **empty. Calibrate** if needed.
- Under measurements, in velocity, verify: units in **ft./sec**, that Set flow to zero is **unchecked**, prevent interference is **checked**, and positive velocities is **checked**.
- Under measurements, in flow rate, verify; units are in **cubic feet/second**, conversion type is **Area Velocity**, channel is **round**, level input is **2150 Area Velocity::Level**, diameter matches **culvert diameter in feet**, velocity input is **2150 Area Velocity::Velocity**, silt level is **0.00**.
- **RECORD THE SERIAL NUMBERS OF AV METER TOP AND BOTTOM AND THE PROBE CABLE.**

Authorization for use: 12/30/2019
Revision: 0

Anomaly Examples



Example 1 of anomaly in data



Example 2 of anomaly in data

Uninstalling ISCO 2150 For Storage

1. Download all continual Data for entire year
2. Confirm all Data is present and complete
3. Once you have confirmed data is present, it is safe to remove batteries and put into storage. Once batteries are removed there is a limited time data can be recovered

SOP-SW-24

Checks of R-Processed A-V Meter Data

Authorization for Use: 01/02/2020

Revision: 1 09/01/2021

Checks of R-Processed A-V meter data Standard Operating Procedure
Evan Genay
Created 1-2-2020
Nate Beinemann
Revised 9-1-2021

1) Introduction

The area-velocity meters collect flow data for the diagnostic sites around Butte. Although they are usually accurate, there are gaps in the data that need to be corrected for. Most of the manipulation of the data is done by a script in R, a coding language that allows for rapid processing of large datasets. The script works on the raw .csv downloads from the 2150 flowmeter, after being processed, the export is a .csv file along with a .pdf hydrograph. The exported data needs to be checked for any extraneous data that the code or meter did not catch. The following document describes the following: how to successfully process .csv files in R studio, what to look for when manually checking the data, and some basics of coding in R studio.

2) Running the R Script

1. Download R https://www.r-project.org/

2. Before downloading the site will ask you to pick a mirror. Select the mirror closest in location to you. (i.e., University of Oregon for running it in Butte.)

3. Download R Studio (optional but makes running code easier) https://rstudio.com/products/rstudio/download/#download

4. Take the folder labeled “R Program Files” inside, ARCO/BPS-Storm/Area-Velocity Meters/QA-QCinformation and copy it. Change the name of the copied folder to “year_R Program Files”. Place all .csv downloads from A-V meters in the folder as well. All R files and the AV data need to be in the same folder for the R program to run.

5. Make sure all the .csv downloads from A-V meters are in the same folder as the main R script (AVmeterdata_EG_112019.R), and sub-formula scripts (flowarea, f_d_approx, hydraulrad). The other scripts do not need to be open in the main script folder as they are sourced as part of the main script. These are present to provide needed flow information to the script (pipe diameter, sediment depth, sample times, etc.) All files should be present inside the “R files” folder.
    a. Do not copy script to another folder without making sure to include all associated files

6. Ensure .csv files with site information are up-to-date and in the same folder (MPTP-CLV-1_geometry, MSD-CLV_geometry, siteinfo). These files contain info on each of the monitoring sites. The code needs to read these files to calculate the wetted perimeter and hydraulic radius for the various water levels at each site
   a. Check to make sure culvert sizes are correct
   b. update sediment depth measurements
   c. load sample times

7. Open AVmeterdata_EG_112019 file in R or R Studio

8. Check working directory in main script by using the command getwd(). The working directory should be set to the same folder that you are working in.

   a. Set working directory to the same folder as the raw data files and R scripts by clicking session -> set working directory -> choose directory. All the scripts, source codes, and .csv files need to be in the same folder

9. Change site name on line 12 of main script under "Enter Site Name." The site name needs to match exact site name used in .csv file naming convention, as well as the R source codes.
   a. Site Naming Conventions in R Studio (what to put in line 12)
      i. BG-CLV-01
      ii. MG-CLV-0
      iii. MSD-CLV
      iv. GG-CH-01
      v. GG-CLV-C
      vi. GG-CLV-D
      vii. GG-CLV-I
      viii. LC-CLV-1
      ix. MPTP-CLV-1
      x. TX-HD-OUT

10. The code works in "sitename" _year.csv format. The rest of the raw data file name can be changed on line 25 accordingly. Again, the site name and the raw data file name need to match for the R code to work. Most errors that come up are from naming convention errors. For sites with multiple barrels, the site name lookup function does NOT include (L) or (R), but will need that added to the file name on line 25
    a. i.e. "-3A(L)_date.csv"

11. Also change line 196 & 205 at the bottom of the coding page to reflect what you want the hydrograph and Rprocessed .csv file to be called

   a. i.e. “-3A(L)_Rprocessed”

12. To run the script, select all lines of the main script (ctrl + A), and click the “Run Line Or Selction” button in the second line on the upper left hand corner, or press “Control + Enter”

13. The code will take a few seconds to run, and each line will pop up in the console (below the script). Check for errors once run is finished.

14. After the code finishes, there should be a new .csv file called “sitename”_Rproccesed”date”, check to make sure these files are correct

15. Transfer these files to the destination folder for manual checking…

3) Checking the files

1. Open the .csv for the site, saved as *sitename*_Rprocessed *year*.csv. Save this as an xlsx file with your initials at the end as the first check. Changing the file type from .csv allows for adding format. Add borders, widen the columns, and freeze the top row to make it easier to view the data. Make a graph of flow data and date.time to see if there are any gaps in the data indicating data loss.

2. Create a hydrograph in the excel file on another sheet and name the sheet “Hydrograph”. The hydrograph should be the dates/times on the x-axis, and the goodflow on the y-axis. This will allow for easier visualization of the data. If there are multiple culverts at one site, open the adjacent culvert file as well for a reference to the one being checked.

3. Open weather data for the year as a reference to see when storms occurred throughout our sampling season.

4. If the data is zero in all columns and logic column is no flow, quickly proceed down the time series

5. If there is a value in the good flow column, look at the logic and the columns in its row, do these seem to make sense?

6. For instance, If the level is 0.0001 and good flow is 100, that is suspect. This is what we are looking for, egregious errors in the data.

7. Do flows make sense in terms of site location (are flows much greater than would be suspected)?

8. Do flows make sense in terms of weather experienced?

9. Is there a flow if there is no velocity? Is there negative velocity for a series of measurements (sometimes the meters will export zero for one time step because they missed a reading)? If it is suspected that there is flow, but there should not be, potentially this should be set to zero.

10. Is there an NA is the calculated flow or good flow column? If so, set that value to 0.

11. If there are any issues, put a comment in the column adjacent to "logic" and make a note to let a knowledgeable coder know.

12. If there are no issues, have another person check it, and add their initials to the file. Open the tracking sheet and indicate your progress.

4) Logic Flow

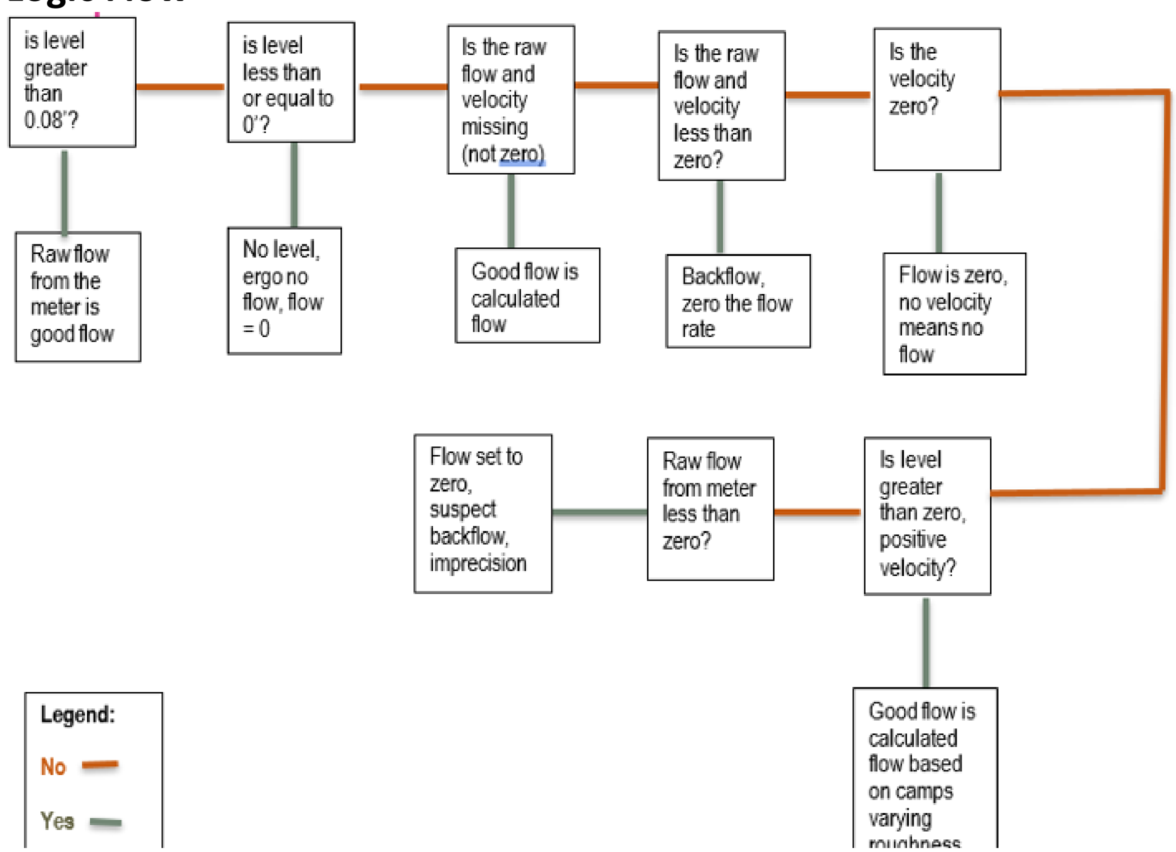


Figure 1: R Code Logic Flow

Figure 1 demonstrates the flow chart for logic behind what is exported as good flow in R studio. Calculated flow uses linear regression to calculate a hydraulic coefficient (sqrt(s) / n) term for manning's equation across all reliable velocity readings for the site. This value is then applied to every measurement using a linear approximation of Camp's varying roughness equation (see figure 3).

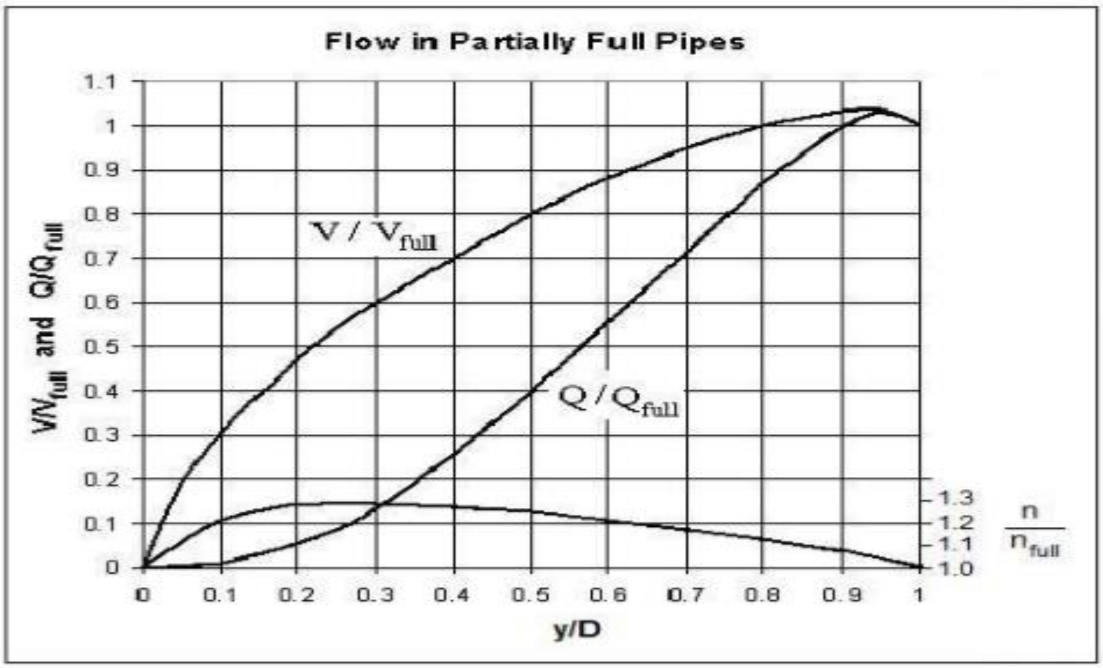


Figure 3. Flow in Partially Full Pipes

5) Basics of coding in R Studio

- Important Text
  - Green text: comments , these are lines preceded with a # sign, and are not read when the script runs, they are there to explain the actual code below it
  - Blue Text: formulas, formulas in R are like formulas in Excel (sum, concatenate, if, etc.) but often have slightly different names and syntax. The A-V meter code has a lot of "For loops" which are used to go through each line of the .csv meter file, and "if, else if" statements which are used to differentiate data situations and specify outcomes for the code.

- Purple Text: values; values in R are both numeric, and logical (i.e., “TRUE”, “FALSE”, “NA”). Whereas the raw .csv data may have blanks for gaps in the data, R assigns the value “NA” to blanks in order to run through each line.

- Dark Green: text; anything in “ “ quotes or ‘ ‘ apostrophes are read as text, not a formula. This is necessary to call file names into the code (e.g., "MSD-CLV_geometry.csv") and to create row or column names

- Black text: general code; everything else that gets read by R is in black

- Red text: error codes:

- Important Symbols

  - $: calls a column in a data frame, e.g., flowdata$date.time calls the column date.time from the flowdata data frame

  - <, >, =, == : less than, greater than, equal to, equal to a value

  - { }: follows a conditional statement like For (the duration), and specifies what to do (e.g. set flow equal to zero)

  - <- : assigns a value to a variable (e.g., “flowdata$goodflow[j] <- 0.000” sets the (“J”th value of the goodflow column to zero)

  - [ ] : specifies a significant value from a list, often used in conjunction with a for loop with “counter” variable like I, j, or k to go through each line of

  - # : makes line into a comment and is not read when the code runs

- Sourcing Other Scripts

  - Source(‘ ___.R’) calls other scripts in so that they can be used like other formulas, this keeps the main script shorter

- Running Scripts

- R studio has multiple windows in the user interface: the main script is in the majority of the upper left, the console is in the lower left, global variables are in the upper right, and the lower right shows files, plots, and a help screen. The script is already written. Once the script is "run" it appears in the console as it progresses, any associated errors appear in the console in red text.

- Troubleshooting

  - There is an abundance of information on coding in R on the internet. If encountering an error, copying and pasting it into a search engine is a great first step. Stack Overflow, and other websites have a lot of beneficial information on coding and R

Appendix B - Data Validation Guidelines for Inorganic Chemistry

DATA VALIDATION GUIDELINES FOR

INORGANIC CHEMISTRY

WOODARD & CURRAN BUTTE, MT

November 2022

Revision 12 November 2022

SIGN-OFF PAGE

TREC, Inc. Standard Operating Procedure for Validation of Inorganic Analytical Data
Revision 1

Accepted: Date:
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Accepted: Date:
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Accepted: Date:
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Accepted: Date:

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Accepted: Date:

Accepted: Date:

Accepted: Date:

DISTRIBUTION LIST

Data Validation Guidelines for Inorganic Chemistry, July 2021

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REVISION SUMMARY

Revision No.	Author	Version	Description	Date
0	TREC, Inc., JJ	1	SOP Validation of Inorganic Chemistry Data for CFRSSI 2014, aligns with Jan 2010 NFG	1st QTR 2014
1	TREC, Inc., JJ	1	SOP Validation of Inorganic Chemistry Data for CFRSSI 2015, aligns with Jan 2010 NFG	1st QTR 2015
2	TREC, Inc., JJ	1	SOP Validation of Inorganic Chemistry Data for CFRSSI 2016, aligns with Aug 2014 NFG	1st QTR 2016
3	TREC, Inc., JJ	1	SOP Validation of Inorganic Chemistry Data for CFRSSI 2017, aligns with Jan 2017 NFG	1st QTR 2017
4	TREC, Inc., JG	2	SOP Validation of Inorganic Chemistry Data for CFRSSI 2018, aligns with Jan 2017 NFG	1st QTR 2018
5	TREC, Inc. TD	2	SOP for Inorganic Chemistry Data Validation Aligns with method requirements, generally follows 2017 NFG guidance	March 2019
6	TREC, Inc. TD	3	Same as above, found mistakes in several tables, corrected and re-distributed	October 2019
7	TREC, Inc.TD	3	Corrected editorial mistakes, renamed the document as “Guidelines” rather than an SOP	February 2020
8	TREC, Inc. TD	3	Removed sections referencing project QAPP locations Removed detailed instructions on setting up field QC files Revised links to DV checklists and removed all but two of the links Changed MS/MSD acceptance criteria for EPA 300.0 from 90-110% to 80-120%. Added detail about assessing matrix similarity for lab duplicates and lab MS/MSD samples Added detail about assessing matrix similarity for field duplicate qualifications. Revised guidelines for assessing FB detections compared to MB detections. Revised to state that when there is both a FB and MB detection, and the FB detection is > the MB detection, the FB should be qualified for the MB detection. Professional judgement should	January 2021

Revision No.	Author	Version	Description	Date
			be used in qualifying the FB for a MB detection if the FB result is significantly higher than the MB result and the MB result is ≤ 2X MDL. Added a section about checking for obvious mis-labeling (poor duplicate precision, FB parameters all have detections, other sample all non-detects). Added several checks to final review	
9	TREC, Inc. TD	3	Based on Nov 2020 revision of NFG. ion of NFG. Lab blanks, changed blank result <(-2XMDL) to blank result ≤ (-RL). Changed sample result to non-detect qualify UJ, detect qualify J- Changed temperature criteria. Analyses with temperature criteria, samples received >6ºC but <10ºC qualify J or UJ (non-detects). Samples received >10ºC qualify J- or UJ (non-detects). Changed EPA 300.0 MS recovery criteria to 80-120% Added LCS, MS, duplicate criteria for EPA 300.1, Rev 1, 1999	November 2021
10	TREC Inc. TD	3	December 2021 revisions based on comparison of EPA ICP-AES and ICP-MS CLP requirements, NFG requirements, EPA 200.7 requirements, EPA 200.8 requirements, and BP LaMP requirements. CRDL Check: Added footnote that CRDL check is not required for any method other than 6010B, put limits apply if performed. Changed CRDL check limits for 6010B from 60-140% to 50-150% (BP LaMP, 2017). Internal Standards: 6010B/6010C changed from 70-125% to 60-125%. Removed text pertaining to 6020 in general. Changed 6020 A/B criteria from 70-125% to 70-130% (LaMP, 2017). Serial dilution: Revised acceptance criteria to ≤ 20% difference for all methods. Added a footnote that serial dilution is not required for 200.8, but limits apply if reported.	12/17/21

Revision No.	Author	Version	Description	Date
			Section 1.0, Introductory statement added that these guidelines pertain to data collected for Atlantic Richfield or other BP affiliates. Table 26 MS/MSD recovery criteria of SW846 6020 corrected from 25-125% to 75-125%. Table Changed duplicate precision criteria from ≤ 30% to ≤ 20%.	
11	Woodard & Curran, TD	3	Changed TREC, Inc. to Woodard & Curran throughout document (with exception of file paths)	3/22/22
12	Woodard & Curran, TD	4	Several criteria changed based on recommendations of Atlantic Richfield Quality Assurance Manager (QAM). Changes were made in an attempt to create consistent data quality indicators for Atlantic Richfield Montana sites. Changed blank qualification criteria to any result > the MDL and from concentrations ≤ 10X blank concentration to concentrations ≤ 5X blank concentration Changed "Contract Required Detection Limit (CRDL)" to "Calibration Check at the Reporting Limit (CCRL)" Changed CCRL criteria to 50-150% for all analyses Changed internal standards relative intensity criteria to > 70% for all analyses other than EPA 200.8. EPA 200.8 criteria retained at 60-125% RI Revised interference check sample qualification guidelines, Added R qualifier for non-detect results if <30% recovery. Added criteria for NO_2+NO_3 by EPA 353.2. Added criteria for orthophosphate by EPA 365.2 Added "A" qualifier for data "J" qualified by the laboratory. Deleted lengthy explanations to simplify text.	

LIST OF ACRONYMS AND ABBREVIATIONS

% D	percent difference
% R	percent recovery
°C	degrees Celsius
10X	10 times
2X	2 times
5X	5 times
ACM	Anaconda Mining Company
AES	atomic emission spectrometry
AMU	atomic mass unit
As	arsenic
ASTM	American Society of Testing and Materials
Ba	barium
BP	British Petroleum
BPSOU	Butte Priority Soils Operable Unit
CCB	cross contamination blank
CCB	continuing calibration blank
CCRL	calibration check at the reporting limit
CCV	continuing calibration verification
Cd	cadmium
Cl	chloride
COC	chain of custody
COD	chemical oxygen demand
Cr	chromium
CRDL	contract required detection limit
Cs	cesium
Cu	copper
CVAA	cold vapor atomic absorption
D	duplicate sample
DAR	data assessment report
DF	dilution factor
DI	deionized water
DM	data management
DOC	dissolved organic carbon
DSR	data summary report
DST	data summary table
DV	data validation
DVS	data validation spreadsheet
ECB	equipment contamination blank
F	fluoride
FB	field blank
Full	Full data package

LIST OF ACRONYMS AND ABBREVIATIONS

GW	groundwater
GWQC	groundwater quality control sample
HNO3	nitric acid
HT	holding time
I	initial sample result
ICB	initial calibration blank
ICP	inductively coupled plasma
ICV	initial calibration verification
ID	identification
ISC	interference check sample
J	estimated
J-	estimated low
J+	estimated high
L	Limited data package
L+	Limited plus data package
LaMP	laboratory management program
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LDS	laboratory duplicate sample
LFB	laboratory fortified blank
LIMS	laboratory information management system
MB	method blank
MDL	method detection limit
Mn	manganese
Mo	molybdenum
MS	matrix spike
MSD	matrix spike duplicate
NH3	ammonia
Ni	nickel
NO2	nitrite
NO3	nitrate
ORP	oxidation reduction potential
Pb	lead
PDS	post digestion spike
QAPP	quality assurance project plan
QC	quality control
R	rejected
Rb	rubidium
RB	rinsate blank
RL	reporting level
RSD	relative standard deviation

LIST OF ACRONYMS AND ABBREVIATIONS

S serial dilution result
S primary sample
SA spike added
Sb antimony
SC specific conductivity
SD serial dilution
SDG sample delivery group
SM standard method
SO4 sulfate
SOP standard operating procedure
SR sample result
SSR spiked sample result
SW surface water
SWQC surface water quality control sample
TB trip blank
TDS total dissolved solids
TKN total Kjeldahl nitrogen
TOC total organic carbon
TSS total suspended solids
U non-detect
U uranium
UJ estimated non-detect
USEPA United States Environmental Protection Agency
WO work order
Zn zinc
SA spike added
Sb antimony
SC specific conductivity
SD serial dilution
SDG sample delivery group
SM standard method
SO4 sulfate
SOP standard operating procedure
SR sample result
SSR spiked sample result
SW surface water
SWQC surface water quality control sample
TB trip blank
TDS total dissolved solids
TKN total Kjeldahl nitrogen
TOC total organic carbon

LIST OF ACRONYMS AND ABBREVIATIONS

TSS	total suspended solids
U	non-detect
U	uranium
UJ	estimated non-detect
USEPA	United States Environmental Protection Agency
WO	work order
Zn	zinc

1.0 INTRODUCTION

The data validation guidelines presented in this document use method specific criteria as well as criteria set forth in the BP Laboratory Management Program (LaMP) Technical Requirements For Environmental Laboratory Analytical Services (Remediation Management, 2017). Thus, these guidelines are to be used with data collected for Atlantic Richfield, or other British Petroleum (BP) affiliates that operate under the BP LaMP. The United States Environmental Protection Agency (USEPA) National Functional Guidelines for Inorganic Superfund Methods Data Review (NFGs) (EPA, 2020) should be referenced for data collected for entities who are not BP affiliated.

1.1 Review Guidance Documents

The main document that will guide project specific data validation is the applicable project QAPP. Each QAPP contains a table(s) of required laboratory calibration and quality control limits. Determine which QAPP applies and review it.

In addition to the QAPPs, general validation guidance documents can be consulted. Either print a copy of each guidance document listed below or open the documents and refer to an electronic version. Find digital copies of each of these documents here:

CFRSSI Data Validation/Data Management (DV/DM) Plan

File:
\\woodardcurran.net\shared\Projects\TREC\9208_AR_MT_BPSOU\9208-Butte-ARCO\A\DataValidation\Docs\Guidance Docs\CFR Guidance\CFRSS DVDM Rev2.pdf

CFRSSI DV/DM Plan Addendum

File:
\\woodardcurran.net\shared\Projects\TREC\9208_AR_MT_BPSOU\9208-Butte-ARCO\A\DataValidation\Docs\Guidance Docs\CFR Guidance\DVDM Plan Addendum.PDF

The USEPA National Functional Guidelines (NFGs) can be used as a general guidance document; but be aware that the limits within the NFGs are not necessarily applicable to the analytical methods used for the data that is being validated. This is only a general guidance document. Also note that NFGs are periodically updated (every 1-4 years) and the most recent version of NFGs should be referenced.

USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review (November 2020):

File:
\\woodardcurran.net\shared\Projects\TREC\9208_AR_MT_BPSOU\9208-Butte-ARCO\A\DataValidation\Docs\Guidance Docs\nfg_for_inorganic_superfund_methods_data_review_november_2020.pdf

BP Laboratory Management Program (LaMP) Technical Requirements (serves as the Statement of Work for BP contract laboratories). This data validation SOP has been written to be in compliance with BP's

LaMP Technical Requirements. The BP LaMP Technical Requirements are applicable only to Atlantic Richfield, or BP, data.

File: \\woodardcurran.net\shared\Projects\TREC\9208_AR_MT_BPSOU\9208-Butte-ARCO\A\DataValidation\Docs\Analytical_SOWs\BP_LaMP_TechRequirements2017.pdf

1.2 File Set-up

Open the laboratory report, which is a PDF file that the analytical laboratory provides to the client, or the client's contractor. A Limited (L) laboratory package includes a cover letter, sample summary, lab case narrative, sample report forms, lab quality control (QC) results, chain-of-custody, sample receipt forms, and any additional custody documentation (i.e. emails between samplers and the lab). Note that Limited data packages may also be referred to as standard data packages. A Limited Plus (L+) package contains laboratory calibration data and laboratory quality control sample results, as well as preparation logs and analysis run logs. Full laboratory packages contain all elements of Limited Plus packages and the full analytical run. The name of the laboratory report file matches that of the Sample Delivery Group (SDG) or work order (WO) number. SDG is a unit used to identify groups of samples inclusive under one (or more) Chain-of-Custody (COC). One Data Validation Checklist will be completed for each SDG. Checklists may be Stage 2a (L package), Stage 2b (Full package), Stage 3 (Full package), or Stage 4 (Full package). Project-specific checklist templates have been created.

Retrieve the data set to be validated using the appropriate Data Validation (DV) entry template. Immediately rename the template using the proper naming convention, then populate the file.

The data validation checklist guides the validation process and these checklists are completed as the validator goes through the data packages. Open the appropriate data validation checklist template and save it to the appropriate folder using an intuitive file naming convention.

2.0 HOLDING TIME AND SAMPLE PREPARATION

2.1 Check Holding Times

Check the holding time for each data point. This is performed in Excel by subtracting the sample collection date/time from the sample analysis date/time. Use the values in the DV entry file. The narrative within the laboratory report will also note any holding time violations and a laboratory qualifier will be applied.

Method specific holding times are listed below in Table 1– Holding Times and Preservation Requirements for typical analyses. A more thorough list of holding times can be found in Appendix B of these guidelines.

Table 1– Holding Times and Preservation Requirements

Analyte	Method	Holding Time	Preservative
pH	EPA 150.1	24 hours	Raw 0-6°C

Analyte	Method	Holding Time	Preservative
Anions by Chromatography (orthophosphate-P, nitrate, nitrite)	EPA 300.0	48 hours	Raw 0-6°C
Solids - Total Dissolved Solids, Total Suspended Solids	SM 2540C SM 2540D	7 days	Raw 0-6°C
Alkalinity: Total, Carbonate, Bicarbonate, & Hydroxide	SM 2320B	14 days	Raw 0-6°C
Anions by Chromatography (bromide, chloride, fluoride, sulfate)	EPA 300.0	28 days	Raw 0-6°C
Chloride	SM4500-Cl C	28 days	Raw 0-6°C
Sulfate	ASTMD 516	28 days	Raw 0-6°C
Dissolved Organic Carbon/Total Organic Carbon (DOC/TOC)	SM 5310 C	28 days	H_2SO_4 < pH 2 0-6°C
Mercury (aqueous) total and dissolved by CVAA	EPA 245.1, SW846 7470	28 days	HNO_3 < pH 2
Mercury in solids	SW846 7471B	28 days	None 0-6°C
Nitrogen - Ammonia	**EPA 350.1** SM 4500-NH3 B/C	28 days	H_2SO_4 < pH 2 0-6°C
Nitrogen - NO_2/NO_3	**EPA 353.2** **SM 4500-NO3 H** SM 4500-NO3 E SM 4500-NO2 B	28 days	H_2SO_4 < pH 2 0-6°C
Nitrogen - Total Kjeldahl Nitrogen	**EPA 351.2** SM 4500-Norg B	28 days	H_2SO_4 < pH 2 0-6°C
Phosphorus - Total/Dissolved	**SM 4500P-B**/E	28 days	H_2SO_4 < pH 2 0-6°C
Specific Conductivity	SM 2510B	28 days	Raw 0-6°C

Analyte	Method	Holding Time	Preservative
Hardness[1]	SM 2340B	180 days	HNO_3 < pH 2
Metals (aqueous) total and dissolved by ICP-AES	EPA 200.7, SW846 6010	180 days	HNO_3 < pH 2
Metals (aqueous) total and dissolved by ICP-MS	EPA 200.8, SW846 6020	180 days	HNO_3 < pH 2
Total Metals in Solids by ICP-MS (Sb, As, Ba, Cd, Cr, Cu, Pb, Mn, Mo, Ni, U, & Zn)	SW6020	180 days	None 0-6°C
Total Metals in Solids by ICP-MS (Sb, As, Ba, Cd, Cr, Cu, Pb, Mn, Mo, Ni, U, & Zn)	SW6020	180 days	None 0-6°C

2.2 Assign Data Qualifiers for Exceeded Holding Times

Assign data qualifiers for exceeding holding times using Table 2. With each data qualifier assigned, include reason code "HT". When using the calculation within the DV entry file, be aware that holding time is not exceeded at 0.1 days past holding time. For example, holding time for total dissolved solids (TDS) is 7 days. A sample that is analyzed at 7.1 days has not exceeded holding time. A sample that is analyzed at 8.00 days has exceeded holding time. Both collection date and time need to be considered.

Table 2 - Holding Time Action

Holding Time (HT) Result	Action for Samples
< Recommended HT	No Action
> Recommended HT	Qualify results that are ≥ MDL as estimated low (J-) Qualify non-detects as estimated (UJ)
>2X HT	Qualify all results unusable (R)

2.3 Verify Proper Sample Preservation

Verify that samples were properly preserved, received at the proper temperature, and filtered as required. You can find this information in the sample condition upon receipt (SCUR) form that follows the chain of custody within the laboratory report. Note that dissolved metals, mercury, and dissolved organic carbon samples must be field filtered with a 0.45 µm filter. If field filtering is not possible, preservative should not be added to the sample until it has been filtered.

2.4 Assign Data Qualifiers for Incorrect Sample Preservation

Assign data qualifiers for incorrect sample preservation using Table 3 - and applying reason code "IP". The actions apply to samples that have preservative and/or temperature criteria problems.

Table 3 - Preservation Action

Result	Action for Samples
Aqueous samples received with pH > 2 and pH not adjusted	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as estimated (UJ)
Aqueous or soil/sediment samples that are received >6ºC but ≤ 10ºC	Qualify results that are ≥ MDL as estimated **(J)** Qualify non-detects as estimated (UJ)
Aqueous or soil/sediment samples that are received >10ºC	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as estimated (UJ)

3.0 LABORATORY DATA VALIDATION

3.1 Read Laboratory Case Narrative

Read the laboratory cover letter and case narrative found in the (pdf) raw data deliverable. The case narrative will give insight to problems the laboratory had when running analyses (or lack thereof).

3.2 Check Sample ID Numbers

Upon database import, sample ID numbers, sample dates, and sample times in the laboratory EDD are checked for consistency with what is listed on the chain-of-custody. If there is a discrepancy, the laboratory is notified and must submit a revised report with correct sample IDs. If a sample ID does not exactly match what was on the chain-of-custody, the location for that sample defaults to GWQC or SWQC in the DV entry file. This can be checked by filtering for GWQC/SWQC. The associated sample type should be FB.

3.3 Laboratory J Qualified Data

The laboratory qualifier J indicates an analytical result is between the MDL and the RL. To maintain consistency with the Clark Fork River Superfund Site Investigations Data Management/Data Validation Plan (ARCO, 1992c) and EPA Region 8 data validation procedures, the validation qualifier "A" should be assigned to data which has been J qualified by the laboratory. "A" qualified data receives the validation code "J". If no other qualifiers have been applied, "A" qualified data is enforcement quality.

3.4 Verify Laboratory Quality Control (QC) Parameters.

The laboratory must adhere to method requirements for all calibrations and quality control (QC) samples. Calibration steps, calibration limits, and QC sample frequency and limits vary depending on the method. This section first explains laboratory calibration and QC samples and then explains the actions for out-of-compliance calibration or QC samples. Next calibration and QC sample control limits for individual analyses are provided. Several parameters can be analyzed by more than one analytical method, and it is not uncommon for differing methods to have different limits. Thus, within each analytical parameter listed below, more than one method may be listed. The information provided in laboratory reports differs depending on the report level. The tables below indicate which data are reported in Limited, Limited Plus, and Full laboratory packages.

Be aware that samples within a sample delivery group are not necessarily analyzed in a single batch. A laboratory QC batch can consist of up to 20 samples, thus, if more than 20 samples are submitted, samples will be associated with more than one QC batch. Samples within a single SDG may also be broken into more than one batch when fewer than 20 samples are submitted. This is common with total dissolved solids (TDS) and total suspended solids (TSS) analyses. Be certain that validation qualifiers are applied only to samples in the QC batch that is associated with the qualifier.

3.4.1 Instrument Tune

Instrument tuning is applicable only to ICP-MS analyses (SW846 6020 series and EPA 200.8). Prior to calibration, the ICP-MS tuning solution is analyzed. The tune solution contains a range of isotope masses and it establishes instrument accuracy, resolution, and precision prior to calibration. The tune solution must be analyzed five times, consecutively. Any necessary adjustments are made to bring the peak width within the manufacturer’s specifications and to adjust the resolution of the mass calibration to within 0.1 atomic mass unit (amu) over a specified amu range. The percent relative standard deviation (RSD) of the absolute signals for all target analytes in the tuning solution must but be ≤ 5%. An example tune report is presented in Figure 1. Tune criteria and corrective actions can be found in Table 4 and Table 5, respectively.

Figure 1 – Example Tune Report

US EPA Tune Check Sample Report

Batch Folder C:\Agilent\ICPMH\1\DATA\070518.b
Report Comment 10ICM8 WBS
Instrument Name G3281A JP13142395

[H2]

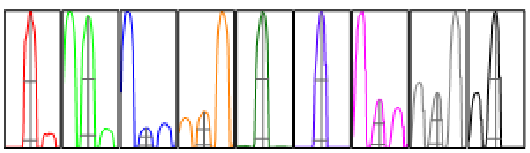
Mass	Count (Mean)	RSD% (Actual)	RSD% (Required)	RSD% (Flag)
9	7146	2.09		
24	86691	1.03		
25	12389	2.04		
26	15480	1.48		
59	122166	1.27		
115	477838	0.89		
206	130865	0.79		
207	110679	0.81		
208	276489	0.66		

All RSDs between the 5 replicates < 5%

5 replicates.

Mass	Replicate 1 Count	Replicate 2 Count	Replicate 3 Count	Replicate 4 Count	Replicate 5 Count
9	7161	7242	7312	7091	6924
24	87370	87489	87134	85887	85575
25	12302	12788	12480	12202	12175
26	15322	15736	15632	15174	15538
59	122093	122415	123724	119616	122980
115	474882	480417	483803	473415	476672
206	129915	132052	131715	130892	129750
207	110077	111322	111946	110043	110007
208	276423	278621	277094	276689	273618

Integration Time [sec] = 0.1



All within 0.1 amu of Axis Required

Mass	Peak Height	Axis (Actual)	Axis (Required)	Axis (Flag)	Width-X% (Actual)	Width-X% (Required)	Width-X% (Flag)
9	1152	8.9000	8.9 - 9.1		0.775	0.900	
24	13724	23.9000	23.9 - 24.1		0.788	0.900	
25	1953	24.9000	24.9 - 25.1		0.792	0.900	
26	2383	25.9000	25.9 - 26.1		0.788	0.900	
59	19730	58.9500	58.9 - 59.1		0.785	0.900	
115	84133	115.0000	114.9 - 115.1		0.740	0.900	
206	23672	206.0000	205.9 - 206.1		0.769	0.900	
207	19717	207.0000	206.9 - 207.1		0.776	0.900	
208	49222	208.0000	207.9 - 208.1		0.779	0.900	

X% = 5 **Integration Time [sec] =** 0.1 **Acquisition Time [sec] =** 212.5 **Y Axis =** Linear

Tune Parameters
Plasma Paramters

ParameterName	Value	Unit	ParameterName	Value	Unit	ParameterName	Value	Unit
RF Power	1550	W	Carrier Gas	0.70	L/min	S/C Temp	2	°C
RF Matching	1.50	V	Option Gas	0.0	%	Gas Switch	Dilution Gas	
Smpl Depth	8.0	mm	Nebulizer Pump	0.10	rps	Makeup/Dilution Gas	0.35	L/min

Lenses Parameters

ParameterName	Value	Unit	ParameterName	Value	Unit	ParameterName	Value	Unit
Extract 1	0.0	V	Omega Lens	8.1	V	Deflect	-2.0	V
Extract 2	-165.0	V	Cell Entrance	-40	V	Plate Bias	-60	V
Omega Bias	-80	V	Cell Exit	-60	V			

Cell Parameters

ParameterName	Value	Unit	ParameterName	Value	Unit	ParameterName	Value	Unit
Use Gas	true		3rd Gas Flow	0	%	Energy Discrimination	2.0	V
He Flow	0.0	mL/min	OctP Bias	-18.0	V			
H2 Flow	4.0	mL/min	OctP RF	200	V			

Table 4 – ICP MS Tune Criteria

Calibration Step[1]	Method	Frequency	Control Limits
Tune	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	Prior to calibration	Tune solution analyzed five times, consecutively Mass calibration within 0.1 amu % RSD of absolute signals < 5%

[1]Reported in Full packages

Table 5 – ICP MS Tune Actions

Calibration Step[1]	Method	Tune Result	Action for Samples	Qualifier Code
Instrument Tune	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	Not performed	Qualify all data as unusable (R)	Tune
		5 consecutive analyses of tune solution not performed	Use professional judgement. At a minimum qualify detects as estimated (J) and non-detects as estimated non-detect (UJ)	Tune
		Mass calibration resolution not within 0.1 amu	Qualify detects as estimated (J) Qualify non-detects as estimated non-detect (UJ)	Tune
		> 5% RSD	Qualify detects as estimated (J) Qualify non-detects as estimated non-detect (UJ)	Tune

3.4.2 Laboratory Calibration Data

Calibration data are provided in L+ and Full laboratory reports. A calibration curve is established with a blank and various standards. The calibration curve fit is a linear regression of results for the blank and calibration standards. The calibration curve fit can be found at the beginning of the raw data in Full laboratory reports only. Table 6 specifies criteria for calibration curves, while Table 7 details corrective actions for out of compliance calibration curves.

Initial calibration verification (ICV) and continuing calibration verification (CCV) results are reported as percent recoveries (%R). These are determined by:

$$\%R = \frac{Found\ Value}{True\ Value}\ x\ 100$$

No sample result should be reported between ICVs or CCVs which do not meet criteria, but before qualifying data based on ICV/CCV recoveries, consult the analysis run log to verify that sample results were reported between the out-of-control calibration standards. Figure 2 provides an example of ICV/CCV data reported by the laboratory. Note that several CCVs have > 110% recovery for Ca, Mg, Si, Na, and Zn. If this occurs, consult the analysis run log, which is provided in Figure 3. The out of compliance CCV is highlighted in Figure 3. Five samples were run between the out of compliance CCV and the next in compliance CCV. However, Ca, Mg, Si, Na, and Zn results were not reported from that run sequence, but from a later run sequence. Thus, these sample results should not be qualified.

Figure 2 - ICV/CCV Example from Full Laboratory Package

FORM II INORGANIC-2
INITIAL AND CONTINUING CALIBRATION VERIFICATION

Lab Name: Pace Analytical - Minnesota SDG No. : 10443691 Contract: Rocker

Initial Calibration Verification Source:

Continuing Calibration Verification Source: 174801

Concentration Units: ug/L Instrument ID: 10ICM3

	Continuing Calibration Verification									
	09/05/2018 00:10			09/05/2018 00:50			09/05/2018 01:29			Control Limit
Analyte	True	Found	%R	True	Found	%R	True	Found	%R	
Arsenic	80	86.8	108.6	80	86.7	108.4	80	86.2	107.8	90-110
Cadmium	80	84.6	105.8	80	84.1	105.1	80	84.0	105.0	90-110
Calcium	1000	1180	117.7	1000	1180	117.5	1000	1130	112.9	90-110
Copper	80	87.0	108.8	80	87.8	109.8	80	86.7	108.4	90-110
Iron	1000	1100	109.5	1000	1070	107.2	1000	1080	107.8	90-110
Lead	80	84.9	106.1	80	84.0	105.0	80	84.0	105.1	90-110
Magnesium	1000	1140	113.7	1000	1110	110.6	1000	1130	112.6	90-110
Manganese	80	87.2	109.0	80	85.8	107.2	80	85.7	107.2	90-110
Potassium	1000	1090	109.3	1000	1080	107.7	1000	1060	106.4	90-110
Silicon	1000	1170	117.4	1000	1100	110.3	1000	1120	112.2	90-110
Sodium	1000	1100	110.5	1000	1100	110.4	1000	1070	107.4	90-110
Zinc	80	88.5	110.6	80	87.9	109.9	80	87.5	109.4	90-110

Figure 3 – Analysis Run Log Example from Full Laboratory Package

FORM XIII INORGANIC-1
ANALYSIS RUN LOG

Lab Name: Pace Analytical - Minnesota SDG No. : 10443691 Contract: Rocker

Instrument ID: 10ICM3 Analysis Method: EPA 200.8

Start Date: 09/04/2018 22:03 End Date: 09/05/2018 02:17

Sample Name	Lab Sample ID	D/F	Date	Time	As	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Si	Zn
20496315CAL0	20496315CAL0	1	09/04/2018	22:03	X	X	X	X	X	X	X	X	X	X	X	X
20496316CAL1	20496316CAL1	1	09/04/2018	22:06	X	X	X	X	X	X	X	X	X	X	X	X
20496317CAL4	20496317CAL4	1	09/04/2018	22:10	X	X	X	X	X	X	X	X	X	X	X	X
20496318CAL5	20496318CAL5	1	09/04/2018	22:13	X	X	X	X	X	X	X	X	X	X	X	X
20496319CAL6	20496319CAL6	1	09/04/2018	22:17	X	X	X	X	X	X	X	X	X	X	X	X
20496320CAL2	20496320CAL2	1	09/04/2018	22:20	X	X	X	X	X	X	X	X	X	X	X	X
20496321CAL3	20496321CAL3	1	09/04/2018	22:24	X	X	X	X	X	X	X	X	X	X	X	X
20496322ICV	20496322ICV	1	09/04/2018	22:27	X	X	X	X	X	X	X	X	X	X	X	X
20496323ICB	20496323ICB	1	09/04/2018	22:34	X	X	X	X	X	X	X	X	X	X	X	X
20496326ICSA	20496326ICSA	1	09/04/2018	22:44	X	X	X	X	X	X	X	X	X	X	X	X
20496327ICSAB	20496327ICSAB	1	09/04/2018	22:48	X	X	X	X	X	X	X	X	X	X	X	X
20496328CCV	20496328CCV	1	09/04/2018	22:51	X	X	X	X	X	X	X	X	X	X	X	X
20496329CCB	20496329CCB	1	09/04/2018	22:58	X	X	X	X	X	X	X	X	X	X	X	X
20496330CCV	20496330CCV	1	09/04/2018	23:25	X	X	X	X	X	X	X	X	X	X	X	X
20496331CCB	20496331CCB	1	09/04/2018	23:29	X	X	X	X	X	X	X	X	X	X	X	X
20496332CRDL	20496332CRDL	1	09/04/2018	23:32	X	X	X	X	X	X	X	X	X	X	X	X
3028525BLANK	3028525	1	09/04/2018	23:36	X	X	X	X	X	X	X	X	X	X	X	X
PALMER-081318	10443691001	1	09/04/2018	23:39	X		X	X	X	X		X		X		
3038257SD	3038257	5	09/04/2018	23:42	X		X	X	X	X		X		X		
3028527MS	3028527	1	09/04/2018	23:49	X		X	X	X	X		X		X		
3028528MSD	3028528	1	09/04/2018	23:53	X		X	X	X	X		X		X		
3028526LCS	3028526	1	09/05/2018	00:07	X		X	X	X	X		X		X		
20496333CCV	20496333CCV	1	09/05/2018	00:10	X	X	X	X	X	X	X	X	X	X	X	X
20496334CCB	20496334CCB	1	09/05/2018	00:14	X	X	X	X	X	X	X	X	X	X	X	X
RH-06-081418	10443691008	1	09/05/2018	00:17	X		X	X	X	X		X		X		
RH-05-081418	10443691009	1	09/05/2018	00:20			X	X	X	X				X		
RH-47-081418	10443691010	1	09/05/2018	00:24	X		X	X	X	X				X		
RH-47D-081418	10443691011	1	09/05/2018	00:27	X		X	X	X	X				X		
3028529MS	3028529	1	09/05/2018	00:30	X		X	X	X	X				X		
MW-01-081418	10443691007	1	09/05/2018	00:44	X		X	X	X	X		X		X		
20496335CCV	20496335CCV	1	09/05/2018	00:50	X	X	X	X	X	X	X	X	X	X	X	X
20496336CCB	20496336CCB	1	09/05/2018	00:54	X	X	X	X	X	X	X	X	X	X	X	X
20496337CCV	20496337CCV	1	09/05/2018	01:29	X	X	X	X	X	X	X	X	X	X	X	X
20496338CCB	20496338CCB	1	09/05/2018	01:33	X	X	X	X	X	X	X	X	X	X	X	X
20496339CRDL	20496339CRDL	1	09/05/2018	01:36	X	X	X	X	X	X	X	X	X	X	X	X
20496340CCV	20496340CCV	1	09/05/2018	02:14	X	X	X	X	X	X	X	X	X	X	X	X
20496341CCB	20496341CCB	1	09/05/2018	02:17	X	X	X	X	X	X	X	X	X	X	X	X

Table 6 provides calibration curve correlation requirements, as wells as ICV and CCV percent recovery criteria for differing analyses. Both recovery and frequency criteria must be met. If frequency criteria were not met, qualify all affected results as estimated (J). Apply corrective actions in accordance with the rules in Table 7.

Table 6 – Calibration Criteria

Calibration Step	Analysis	Method	Frequency	Control Limits
Calibration Curve Fit	Mercury	SW846 7470 SW846 7470A EPA 245.1	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value EPA 245.1 - 95-105%
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	At beginning of run	r ≥ 0.998
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	Metals	SW846 6010B SW846 6010C SW846 6010D EPA 200.7	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value EPA 200.7 - 95-105%
CCV			Every ten samples, and after the last analytical sample	90-110% of true value SW846 6010B - The RSD of the CCV must be < 5%
Calibration Curve Fit	Alkalinity	SM 2320B	At beginning of run	slope 96-106% of true value
pH Calibration Check			Immediately after calibration of pH probe	± 0.10 pH units
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value

Calibration Step	Analysis	Method	Frequency	Control Limits
Calibration Curve Fit	NH_3	EPA 350.1	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	NO_2/NO_3	SM 4500 NO_3-H	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	TKN	EPA 351.2	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	DOC/TOC	SM 5310C	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure DOC/TOC analysis by SM 5310C calibration frequency is every six months or as needed. Thus ICV frequency may be six months.	90-110% of true value
High and Low Check Standards			Daily prior to sample analysis unless ICV is run that day.	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value

Calibration Step	Analysis	Method	Frequency	Control Limits
Calibration Curve Fit	Sulfate	ASTM D516-90	At beginning of run	r ≥ 0.990 Standard at or below RL must recover within 60-140% of true value
ICV			Immediately after instrument calibration and after a continuing calibration failure	80-120% of true value
CCV			Every ten samples, and after the last analytical sample	80-120% of true value
Calibration Curve Fit	Chloride	SM 4500-Cl E	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	Anions (Bromide, chloride, fluoride, sulfate)	EPA 300	At beginning of run	r ≥ 0.990 for each analyte
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	Fluoride	SM 4500-F-C	At beginning of run	slope 90-110%
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	Total Phosphorus	SM4500P-F	At beginning of run	r ≥ 0.995

Calibration Step	Analysis	Method	Frequency	Control Limits
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	Chemical Oxygen Demand (COD)	SM 5220D EPA 410.4	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure	SM5220D - 95-105% EPA 410.4 - 90-10%
CCV			Every ten samples, and after the last analytical sample	SM5220D - 95-105% EPA 410.4 - 90-10%
Calibration Curve Fit	Orthophosphate-P	SM4500-P B/E	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value
Calibration Curve Fit	Sulfide	SM4500-S^{2-}D	At beginning of run	r ≥ 0.995
ICV			Immediately after instrument calibration and after a continuing calibration failure Sulfide analysis by SM4500-S^{2-}D calibration frequency is every six months or as needed. Thus ICV frequency may be six months.	90-110% of true value
High and Low calibration checks			Daily prior to sample analysis unless ICV is run that day.	90-110% of true value
CCV			Every ten samples, and after the last analytical sample	90-110% of true value

Table 7 - Calibration Action

Calibration Results	Calibration Criteria	Action for Samples	Qualifier Code
Calibration not performed		Qualify all results unusable **(R)**	CQ
Correlation coefficient < the method requirement	See Section 3.5 Tables	Qualify results that are ≥ MDL as estimated **(J)** Qualify non-detects as estimated (UJ)	CR
ICV/CCV %R < 75%	80-120% 90-110% 95-105%	Qualify results that are ≥ MDL as estimated low **(J-)** or unusable (R) Qualify non-detects as unusable (R) For both detects and non-detects use professional judgement	ICV/CCV
ICV/CCV %R >75% but < lower limit	80-120% 90-110% 95-105%	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as estimated (UJ)	ICV/CCV
ICV/CCV %R > upper limit	80-120% 90-110% 95-105%	Qualify results that are ≥ MDL as estimated high **(J+)** No action for non-detects	ICV/CCV

3.4.3 Laboratory Blank Data

Ideally, all laboratory blanks including initial calibration blanks (ICBs), continuing calibration blanks (CCBs), method blanks (MBs) or preparation blanks (PBs), should be non-detect (U-flagged by the laboratory) or have a reported value ≤ MDL. MDL values are statistically calculated every 13 months at a minimum, and these may change year to year. When referencing laboratory QC requirements in project QAPPs, be aware that validation criteria for blanks differs from laboratory blank criteria. The validator assesses blanks to the MDL; whereas the laboratory blank criteria is a value < the RL or ≤ ½ the RL. Atlantic Richfield criteria is a value ≤ ½ RL. Were the laboratory to repeat an analysis until all blank results were non-detect, they could consume the entire client sample volume and be unable to perform laboratory QCs such as a matrix spike or duplicate sample.

All laboratory analyses require a MB (can also be identified as a preparation blank) at a frequency of one MB per batch of 20 or fewer samples. Nearly all analyses which require calibrations (calibration samples are not applicable to solids determinations, i.e. TDS and TSS) the laboratory must analyze an ICB at the beginning of the analytical run, immediately after the ICV, and a CCB every ten samples, immediately after the CCV. Ensure that the required frequency was met when assessing laboratory blank results; and qualify affected data as estimated (J) if the frequency was not met.

Where there are positive and negative blank detections, qualification is assigned based on the highest absolute blank value. Once a data validation qualifier has been applied, add reason code "ICB", "CCB", or "MB" as appropriate. For laboratory ICB/CCB results > than laboratory criteria, analysis should have been terminated, and the contamination source determined and corrected. If necessary, the instrument should have been recalibrated and any sample analyzed since the last in-control blank should have been re-analyzed. When assessing ICB/CCB results, ensure that sample results were reported between out of control blank detections. For method blank detections > criteria, each sample result <10x the blank value should have been re-digested (if applicable) and reanalyzed. If sample results are non-detect, this is not required. If re-analysis was not possible (sample volume was consumed), the sample results should be qualified. To assign qualification to sample results based on a laboratory blank detection, the instrument value must be used. The instrument value is calculated by dividing the sample result by the dilution factor.

Although sample results are assessed in comparison to laboratory blank results, a laboratory blank result should never be substituted for the MDL. A laboratory blank result is a single result at a single point in time; whereas MDLs are determined by a statistical process every thirteen months, at a minimum. MDLs are determined by analyzing a minimum of seven spiked samples and seven blank samples in at least three batches on three separate calendar days, with the analyses spread across all instruments to which the MDL will be applied. Statistical analysis is then applied to the sample results to determine the MDL.

Table 8 – Laboratory Blank Action

Lab Blank Result	Sample Results	Action for Samples
> MDL	Non-detect (< MDL)	No action
	> RL, but ≤ 5x blank	Qualify results as non-detect (U)
	>5x blank value	No action
> RL	See action above for > MDL	
Absolute value of negative results > (2x RL)	Non-detect (< MDL)	Qualify results as estimated non-detect (UJ)
	Detect ≤ 5x negative MB result	Qualify results as estimated (J)
Lab Sample	**Report Level**	**Frequency[1]**
ICB	L+, Full	At beginning of analytical run, immediately
CCB	L+, Full	One in every 10 samples, immediately after
MB	L, L+, Full	One per batch of 20 or fewer samples

[1]ICB/CCB samples not applicable to gravimetric (solids) analyses

3.4.4 Calibration Check at the Reporting Level

The calibration check at the reporting level (CCRL) sample is referred to as the contract required detection limit (CRDL) in laboratory packages. Not all analyses include a CCRL sample. These samples simply check the recoveries of standards which have analyte present at the CCRL. Recoveries are calculated by:

$$\%\boldsymbol{R} = \frac{\boldsymbol{Found\ Value}}{\boldsymbol{True\ Value}}\ \boldsymbol{x}\ \mathbf{100}$$

Frequency and recovery requirements for CCRL samples are detailed below in **Table 9**. Note that these laboratory samples will only be reported in L+ or Full packages. Corrective actions for out of control CCRL samples are presented in **Table 10**

Table 9 - Calibration Check at the Reporting Level Criteria

Calibration Step[1,2]	Analysis	Method	Frequency	Control Limits
CCRL	Mercury	SW846 7470 SW846 7470A EPA 245.1	At the beginning of each run.	50-150%
	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	At the beginning of each run for every analyte of interest 6020A – at the beginning of each run and at the end of each analytical batch	50-150%
	Metals	SW846 6010B EPA 200.7	At the beginning of each run for every analyte of interest	50-150%

[1]Reported only in Limited Plus and Full packages

[2]CCRL Check not required for any methods other than 6010B, but if performed limits apply

Table 10 – CCRL Action

Calibration Criteria	Action for Samples	Qualifier Code
CCRL < method criteria	J-	CRQL
CCRL > method criteria	J+	CRQL

3.4.5 Interference Check Sample (ISC) Results

An interference check sample (ICS) is applicable to ICP-MS and ICP-AES analyses, and the purpose is to determine the instrument's capability to overcome common interferences. These samples will be reported only in L+ or Full packages. The ICS consists of two solutions, solution A and solution AB. Solution A contains high concentrations of interferents, while solution AB contains the interferents and mid-range concentrations of the target analytes. The two solutions are run consecutively, at the beginning of the analytical sequence, but not before the ICV. The ICSA is run first, followed by the ICSAB, which is immediately followed by a CCV. ICS recovery are calculated by:

$$\%R = \frac{Found\ Value}{True\ Value}\ x\ 100$$

Table 11 states ICS criteria; while corrective actions for out of control results can be found in Table 12. Should data be qualified for out of control ICS recoveries, assign reason code "ICS".

Table 11 – Interference Check Sample Criteria

Calibration Step[1]	Analysis	Method	Frequency	Control Limits
Interference Check Sample (ICS)	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	At the beginning of each analytical sequence, or a minimum of twice per 8-hour shift, whichever is more frequent.	80-120% R for analytes included in the ICS < RL for analytes not included in the ICS
	Metals	SW846 6010B SW846 6010C SW846 6010D EPA 200.7		80-120% R for analytes included in the ICS, < RL for analytes not included in the ICS

[1]Reported only in Limited Plus and Full packages

Table 12 – Interference Check Sample Action

ICS Results	Action for Samples
ICS not analyzed at required frequency	Qualify all results as unusable **(R)**
ICS not analyzed in proper sequence	Use professional judgment
ICS %R <30%	Qualify results ≥ MDL as estimated low (J-) Qualify non-detects as unusable **(R)**
ICS %R 30-79%	Qualify results ≥ MDL as estimated low (J-) Qualify non-detects as estimated **(UJ)**
ICS %R >120% or > RL	Qualify results ≥ MDL as estimated high (J+) No action for non-detects
Apply to analyte results ≥ MDLs if samples have detections of analytes not present in ICS. Samples with level of interferents comparable to or higher than interferent levels in the ICS and analyte concentration near the ICS level	Qualify results ≥ MDL as estimated high (J+) No action for non-detects
Apply to negative sample results (but absolute value is ≥ MDL) for analytes that are not present in the ICS solution. Samples with level of	Qualify detects < 10x the │negative result│as estimated low **(J-)** Qualify non-detects as estimated (UJ)

ICS Results	Action for Samples
interferents comparable to or higher than interferent levels in the ICS	

3.4.6 Internal Standards Relative Intensity

Internal standards are applicable to ICP analyses, and these are reported only in L+ and Full packages. An internal standard is added to each client sample and the response is monitored throughout the run. The internal standard is made up of analytes which are not typically seen in environmental samples, such as thorium, germanium, scandium, or indium[115], among others. The purpose is to detect instrument drift. The internal standard response is compared to the standard's initial response in the calibration blank. Control limits for internal standards are presented in Table 13, while

Table 14 presents actions for out of control responses. Qualified data should be given the validation code "IS". Each internal standard has specific analytes associated to it; thus, only analytes associated with an out-of-compliance internal standard response should be qualified. Consult the analytical laboratory to determine which analyte is associated with each internal standard.

Table 13 – Internal Standards Relative Response Criteria

Calibration Step[1,2]	Analysis	Method	Frequency	Control Limits
Internal Standard Response	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	Monitor signal intensity throughout the analytical run.	**6020A/6020B** – Response in standards and samples >70% of response in associated blank **EPA 200.8** – Response in standards and samples 60-125% of response in associated blank
		SW846 6010B SW846 6010C EPA 200.7		Response in standards and samples >70% of response in associated blank

[1]Reported in Limited Plus and Full packages

[2]Intermal Standards are not required for 200.7, but if reported criteria apply

Table 14 – Internal Standards Response Action

Calibration Criteria	Action for Samples	Qualifier Code
Internal standard response < 30%	R for non-detects J- for detects	IS

Internal standard response < method criteria and sample was re-analyzed at 2-fold dilution	J- for associated detected analytes UJ for associated non-detect analytes	IS
Internal standard response > method criteria and sample was re-analyzed at 2-fold dilution	J for associated detected analytes No action for associated non-detect analytes	IS
Internal standard response < or > method criteria and sample was not diluted and re-analyzed	Use professional judgement J-, J or R for associated detected analytes UJ or R for associated non-detect analytes	IS

3.4.7 Laboratory Control Sample (LCS) Result

A laboratory control sample (LCS) is required for nearly all analyses. The LCS is DI water spiked with known concentrations of all target analytes. For soils analyses, the LCS is a spiked non-metal containing matrix. The LCS may also be referred to as a laboratory fortified blank (LFB). The LCS is assessed on percent recovery:

$$\%\boldsymbol{R} = \frac{\boldsymbol{Found\ Value}}{\boldsymbol{True\ Value}}\ \boldsymbol{x\ 100}$$

If the LCS recovery does not fall within control limits, the analysis should be terminated, the problem corrected, and associated samples reanalyzed. Occasionally, an LCS result is not within criteria, and analysis proceeds. This may occur if all client sample volume has been consumed. Frequency and control limits for the LCS are provided in Table 15, while Table 16 provides corrective actions.

Several analyses require a laboratory control sample duplicate. This is a separate sample from the laboratory duplicate. The LCSD is a duplicate sample of the LCS. The LCSD percent recovery is assessed identically to the LCS; and in addition, the LCS/LCSD are assessed in terms of relative percent difference (RPD) between the two sample results. This tests the laboratory's repeatability, or precision. The LCS/LCSD RPD is determined by:

$$\boldsymbol{RPD}\% = \frac{\left|\boldsymbol{LCS} - \boldsymbol{LCSD}\right|}{\frac{\boldsymbol{LCS} + \boldsymbol{LCSD}}{\boldsymbol{2}}} \times \boldsymbol{100}$$

Like the LCS, if the LCSD recovery does not fall within the control limits specified in Table 15, analysis should be terminated, the problem corrected, and affected samples re-analyzed. If LCS/LCSD precision (RPD) is outside of control limits, analysis should be terminated, the problem corrected, and affected samples re-analyzed. The frequency and control limits for the few samples which required LCSDs are included in Table 15, and the corrective action for unacceptable RPDs is at the end of Table 16.

Table 15 - Laboratory Control Sample/Laboratory Control Sample Duplicate Criteria

Calibration Step[1]	Analysis	Method	Frequency	Control Limits
Laboratory Control Spike (LCS)	Mercury	SW846 7470 SW846 7470A EPA 245.1	One in every 20 samples	80-120% of true value **EPA 245.1** - 85-115% of true value
	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8		80-120% of true value **EPA 200.8** - 85-115% of true value
	Metals	SW846 6010B SW846 6010C SW846 6010D EPA 200.7		80-120% **EPA 200.7** - 85-115% of true value
	Alkalinity (LCS & LCSD)	SM 2320B		90-110% of true value RPD ≤ 20%
	TDS/TSS (LCS & LCSD)[2]	SM 2540C/2540D		80-120% of true value RPD ≤ 10%
	NH_3	EPA 350.1		90-110% of true value
	NO_2/NO_3	EPA 353.2 SM 4500 NO_3-H		
	TKN	EPA 351.2		
	DOC/TOC	SM 5310C		80-120% of true value RPD ≤ 20%
	Sulfate (LCS & LCSD)	ASTM D516-90		
	Anions	EPA 300.1		Conc from RL to 10xRL 75-125% of true value Conc > 10x RL 85-115% of true value
	Chloride	SM 4500-Cl E		90-110% of true value
	Anions	EPA 300.0		

Calibration Step[1]	Analysis	Method	Frequency	Control Limits
	Fluoride	SM 4500-F-C		
	Total Phosphorus	SM4500P F		
	COD	SM 5220D EPA 410.4		
	Sulfide	SM4500-S^{2-}D		80-120% of true value
	Orthophosphate-P	SM4500-P B/E		90-110% of true value

[1]Reported in Limited, Limited Plus, and Full packages

[2]LCSD sample may be analyzed in place of laboratory duplicate at the analyst's discretion. TDS/TSS duplicate sample frequency criteria of 1 in 10 samples must be met.

Table 16 – Laboratory Control Sample/Lab Control Sample Duplicate Action

Calibration Results[1]	Calibration Criteria	Action for Samples	Qualifier Code
LCS not performed at required frequency	1 per batch of 20 or fewer samples	Use professional judgement. Investigate why LCS was not performed. At a minimum, qualify detects as estimated (J) and non-detects as estimated non-detect (UJ)	LCS
LCS %R < 40%	70-130% 80-120% 85-115% 90-110%	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects rejected (R)	LCS
LCS %R 40% to lower limit	70-130%	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as estimated non-detect (UJ)	LCS
	80-120%		
	85-115%		
	90-110%		
LCS %R upper limit to 150%	70-130%	Qualify results that are ≥ MDL as estimated high **(J+)** No action for non-detects	LCS
	80-120%		
	85-115%		

Calibration Results[1]	Calibration Criteria	Action for Samples	Qualifier Code
	90-110%		
LCS %R >150%	70-130% 80-120% 85-115% 90-110%	Qualify results that are ≥ MDL Rejected **(R)** No action for non-detects	LCS
LCS/LCSD RPD > criteria (10%, 20%)	≤ 10% RPD ≤ 20% RPD	Qualify affected results as estimated (J) Qualify non-detects as estimated non-detect (UJ)	RPD

[1]LCS results are reported in Limited, Limited Plus, and Full laboratory packages

3.4.8 Laboratory Duplicate Sample (LDS) Results

The purpose of the laboratory duplicate sample is to assess the laboratory and method precision. The LDS is a second aliquot of a client sample that is treated identically to the primary aliquot. Known field blanks should not be used for the LDS. LDS frequency and acceptance criteria are provided in **Table 17**. In many cases, the matrix spike duplicate (MSD) is used as the LDS. Refer to Section 3.4.9 for a discussion of MSD samples. As **Table 17** indicates, the LDS is assessed on the RPD between the primary and duplicate sample. The RPD is determined by:

$$\boldsymbol{RPD}\% = \frac{|\boldsymbol{S}-\boldsymbol{D}|}{\frac{\boldsymbol{S}+\boldsymbol{D}}{\boldsymbol{2}}} \times \boldsymbol{100}$$

Where S = sample

D = duplicate

Table 18 provides corrective actions for LDS RPDs greater than criteria. The criteria in Table 18 are applicable when both the primary and duplicate sample concentrations are ≥ 5X the RL. If either the primary or duplicate sample result is < 5X the RL, a difference ≤ the RL between the two results is acceptable. Several analyses require more than one LDS; thus, two LDS samples are analyzed per QC batch. If only one of the RPDs exceeds criteria, qualifications result. Data qualified for LDS precision is given the reason code “RPD”.

In assessing LDS RPDs, the sample matrix should be considered. If the parent sample used for the laboratory duplicate sample is dissimilar from other samples in the laboratory quality control (QC) batch, then only the parent sample and samples similar to the parent should be qualified. Matrix similarity can be assessed by considering sample field data (pH, SC, ORP), site and sampling documentation (sample location, soil moisture, soil type) and laboratory data such as TSS, TDS, alkalinity, reactive sulfide, and anions. The sample data itself can also be used, such as very high analyte concentrations compared to all other samples in the laboratory QC batch. Note that TSS and TDS analyses are not prone to matrix interference since analysis is simply filtration, not a chemical process. If a project-associated sample was not used for the LDS parent, do not qualify data. Nothing is known of sample collection or handling methods, nor of the sample matrix. In using professional judgement consider if analytical results were within historical ranges. Provide a brief explanation of the decision in the checklist. Since the sample matrix is considered, any field collected blank which consists of DI water should not be qualified because of LDS RPDs that exceed acceptance criteria. Known field blank samples should not be used as the LDS primary sample; but given that the analyst may not be aware of which samples are blanks, there are times that this occurs. Should LDS RPDs be greater than acceptance criteria, and the parent sample was a blank (DI water), the blank, along with all other samples in the QC batch, would be qualified. Although the blank matrix is dissimilar to the other samples, a duplicate sample of DI water with an RPD > acceptance criteria indicates a problem; thus, all associated data should be qualified.

Greater variability is expected in solid samples (soil) than in aqueous samples; thus, LDS criteria for solid samples is ≤ 35% RPD. For solid sample results < 5X the RL, a difference ≤ 2XRL between the primary and duplicate result is acceptable.

Table 17 – Laboratory Duplicate Sample Criteria

Calibration Step[1]	Analysis	Method	Frequency	Control Limits
Laboratory Duplicate Sample (LDS) LDS	Mercury (MSD)	SW846 7470 SW846 7470A EPA 245.1	One in every 20 samples	≤ 20% RPD
	Metals (MSD)	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	One in every 20 samples	≤ 20% RPD
	Metals (MSD)	SW846 6010B SW846 6010C SW846 6010D EPA 200.7	One in every 20 samples	≤ 20% RPD
	Alkalinity (MSD)	SM2320B	One in every 10 samples	≤ 20% RPD
	NH_3 (MSD)	EPA 350.1	One in every 10 samples	≤ 20% RPD
	NO2/NO3 (MSD)	EPA 353.2 SM 4500 NO_3-H	One in every 10 samples	≤ 20% RPD
	TKN (MSD or alternate)	EPA 351.2	One in every 20 samples	≤ 10% RPD
	TDS/TSS	SM 2540C/2540D	One in every 10 samples	≤ 10 % RPD

Calibration Step[1]	Analysis	Method	Frequency	Control Limits
	DOC/TOC	SM 5310C	One in every 20 samples	≤ 25% RPD
	Sulfate (MSD)	ASTM D516-90	One in every 10 samples	≤ 30% RPD
	Chloride (MSD)	SM 4500-Cl E	One in every 10 samples	≤ 20% RPD
	Anions (MSD)	EPA 300.0	One in every 10 samples	≤ 20% RPD
	Anions (MSD)	EPA 300.1	One in every 10 samples	RL -10xRL ≤ 20% RPD >10x RL ≤ 10% RPD
	Fluoride (MSD)	SM 4500-F-C	One in every 10 samples	≤ 20% RPD
	Total Phosphorus (MSD)	SM4500P F	One in every 10 samples	≤ 20% RPD
	COD (MSD or alternate)	SM 5220D EPA 410.4	One in every 10 samples	≤ 20% RPD
	Sulfide	SM4500-S^{2-}D	One in every 20 samples	≤ 20% RPD
	Orthophosphate-P (MSD)	EPA 365.2	One in every 10 samples	≤ 20% RPD
	Orthophosphate-P (MSD)	SM4500-P G	One in every 10 samples	≤ 20% RPD
LDS	Metals (soils/solids)[2]	Above applicable analyses	One in every 20 samples	≤ 35% RPD

[1]Reported in Limited, Limited Plus, and Full laboratory packages

Table 18 – Laboratory Duplicate Sample Action

Duplicate Sample Results[1]	Action for Samples
LDS not performed at required frequency	Use professional judgement. Investigate why LDS was not analyzed. At a minimum, qualify detects as estimated (J) and non-detects as estimated (UJ)

Duplicate Sample Results[1]	Action for Samples
Both original and duplicate sample results ≥ 5X RL and RPD > **Table 17** criteria	Qualify results that are ≥ MDL as estimated **(J)** Qualify non-detects as estimated non-detect (UJ)
Original sample or duplicate sample < 5X the RL (including non-detects) and absolute difference between sample and duplicate > RL	Qualify results that are ≥ MDL as estimated **(J)** Qualify non-detects as estimated non-detect (UJ)
Both original and duplicate sample results ≥ 5X RL and RPD < **Table 17** criteria	No action
Original sample or duplicate sample < 5X the RL (including non-detects) and absolute difference between sample and duplicate ≤ RL	No action

[1]Reported in Limited, Limited +, and Full packages

3.4.9 Matrix Spike (MS) Results

The matrix spike (MS) sample is a client sample spiked with a known amount of analyte. The purpose of the MS is to assess the effect of the sample matrix on the preparation and measurement methods. Often, the laboratory duplicate sample (LDS) requirement is met by analyzing a matrix spike duplicate (MSD) sample. The MSD is a duplicate of the MS, that is, the same parent sample that is used for the MS is used for the MSD. The spike concentration(s) of the MSD is identical to the concentration(s) used for the MS. MS/MSD frequency and acceptance criteria vary with analysis, and these can be found in Table 19. As Table 19 indicates, MS/MSD samples are assessed on recovery and, when an MSD is used as the LDS, the RPD between the two samples is assessed for laboratory precision. Since an MSD can serve as the LDS, the RPD assessment is identical to that for laboratory duplicate samples, which is discussed in Section 3.4.8. MS/MSD recoveries are assessed as:

$$\%\boldsymbol{R} = \frac{\boldsymbol{SSR - SR}}{\boldsymbol{SA}} \times \mathbf{100}$$

Where SSR = spiked sample result

SR = sample result

SA = spike added

When the sample result (SR) is < the MDL, use a value of zero for SR when calculating the recovery.

Table 20 provides corrective actions for out of control MS/MSD recoveries. Corrective actions for MS/MSD RPDs are discussed in Section 3.4.8. An exception to the qualification criteria in Table 20 is when the parent sample concentration is ≥ 4X the spike concentration. If this is the case, the recovery criteria are waived.

Many analyses require a matrix spike sample at a 10% frequency; thus, two MS samples, and possibly two MSDs are analyzed per QC batch. If only one of the spiked sample recoveries does not meet criteria, qualifications result. Data qualified for MS or MSD recoveries is given the reason code “MS”.

In assessing MS/MSD recoveries, the sample matrix should be considered in the same manner it is assessed for laboratory duplicates. If a project-associated sample was not used for the MS parent, professional judgement can be used in declining to qualify associated results as described under LDS samples. Provide a brief explanation of the decision to limit qualifications in the checklist. Since the sample matrix is considered, any field collected blank which consists of DI water should not be qualified because of MS/MSD recoveries that do not meet acceptance criteria. Known field blank samples should not be used as the MS parent sample; but given that the analyst may not be aware of which samples are blanks, there are times that this occurs. Should MS/MSD recoveries fall outside of acceptance criteria, and the parent sample was a blank (DI water), the blank, along with all other samples in the QC batch, would be qualified. Although the blank matrix is dissimilar to the other samples, out of control recoveries of spiked DI water indicate a problem; thus, all associated data should be qualified.

Table 19 – Matrix Spike/Matrix Spike Duplicate Criteria

Calibration Step[1]	Analysis	Method	Frequency	Control Limits
Matrix Spike (MS)/Matrix Spike Duplicate (MSD)	Mercury	SW846 7470 SW846 7470A EPA 245.1	One per batch of 20 samples **EPA 245.1 -** 1 per batch & if > 11 samples in a batch, an additional MS is required.	SW846 7470 - 80-120% of true value SW846 7470A - 75-125% of true value EPA 245.1 - 70-130% of true value ≤ 20% RPD
	Metals	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	MS One in every 20 samples **EPA 200.8** MS - One in every 10 samples MSD one in every 20 samples	75-125% of true value EPA 200.8 - 70-130% of true value ≤ 20% RPD
	Metals	SW846 6010B SW846 6010C SW846 6010D EPA 200.7	MS One in every 20 samples **EPA 200.7 -** 1 MS per 10 samples MSD 1 in 20	75-125% of true value EPA 200.7 - 70-130% of true value ≤ 20% RPD
	Alkalinity	SM2320B	One in every 10 samples	80-120% of true value ≤ 20% RPD
	NH_3 (MSD)	EPA 350.1		90-110% of true value ≤ 20% RPD
	NO_2/NO_3	SM 4500 NO_3-H		80-120% of true value ≤ 20% RPD

Calibration Step[1]	Analysis	Method	Frequency	Control Limits
	TKN	EPA 351.2	MS 1 in 10 MSD 1 in 20	90-110% of true value ≤ 20% RPD
MS	DOC/TOC	SM 5310C	One in every 20 samples No MSD	80-120% of true value
MS/MSD	Sulfate	ASTM D516-90	One in every 10 samples	80-120% of true value ≤ 30% RPD
	Chloride	SM 4500-Cl E		80-120% of true value ≤ 20% RPD
	Anions	EPA 300.0	More frequent of 1 per batch or 1 per 10 samples	80-120% of true value ≤ 20% RPD
	Anions	EPA 300.1	More frequent of 1 per batch or 1 per 10 samples	75-125% of true value ≤ 20% RPD for results between RL and 10x RL ≤ 10% RPD for results >10x RL
	Fluoride	SM 4500-F-C	One in every 10 samples	80-120% of true value ≤ 20% RPD
	Total Phosphorus	SM4500P F		80-120% of true value ≤ 30% RPD
MS/MSD (or alternate duplicate sample)	COD	SM 5220D EPA 410.4		SM 5220D 80-120% EPA 410.4 90-110% ≤ 20% RPD

Calibration Step[1]	Analysis	Method	Frequency	Control Limits
MS	Sulfide	SM4500-S^{2-}D	One in every 20 samples No MSD	75-125% of true value
MS/MSD	Orthophosphate-P	EPA 365.2	One in every 10 samples	85-115% ≤ 20% RPD
MS/MSD	Orthophosphate-P	SM4500-P G	One in every 10 samples	80-120% ≤ 20% RPD

[1]Reported in Limited, Limited +, and Full packages

Table 20 - Matrix Spike/Matrix Spike Duplicate Recovery Action

MS Sample Results[1]	Calibration Criteria	Action for Samples	Qualifier Code
MS not performed at required frequency	As specified in Table 15	Use professional judgement. Investigate why MS was not performed. At a minimum, qualify detects as estimated (J) and non-detects as estimated (UJ)	MS
MS/MSD %R < 30%	70-130% 75-125% 80-120% 90-110%	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects rejected (R)	MS
MS/MSD %R 30-to lower limit	70-130% 75-125% 80-120% 90-110%	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as estimated (**UJ**)	MS
MS/MSD %R >upper limit	70-130% 75-125% 80-120% 90-110%	Qualify results that are ≥ MDL as estimated high (**J+)** No action for non-detects	MS

[1]MS/MSD results are reported in Limited, Limited +, and Full packages

3.4.9.1 Post digestion spike

Post-digestion spike (PDS) samples are applicable to ICP data and are required for the analytical methods listed in Table 21 when the MS recovery falls outside of criteria, and the parent sample concentration is < 4X the spike concentration. The PDS must be assessed only for the analytes that did not meet MS criteria. A matrix spike sample is spiked at the beginning of the sample preparation process, while the PDS is spiked after the sample has gone through preparation. Table 21 provides PDS criteria, while Table 22 provides corrective actions for samples that do not meet MS and PDS criteria. If a PDS is analyzed, the results are reported only in L+ and Full packages. When assessing PDS recoveries consider sample similarity in the manner described in Section 3.4.9 Matrix Spike (MS) Results. Since a PDS sample is analyzed only when there is an MS result which does not meet criteria, the code "MS,PDS" should be used when samples are qualified for MS and PDS results.

Table 21– Post Digestion Spike Criteria

Laboratory QC[1]	Analysis	Method	Frequency	Control Limits[2]
Post digestion spike	Metals	SW846 6020 SW846 6020A SW846 6020B	One per QC batch if MS/MSD recovery outside of 75-125%	6020/6020A 80-120% of true value 6020B 75-125% of true value
	Metals	SW846 6010B SW846 6010C SW846 6010D	One per QC batch if MS/MSD recovery outside of 75-125%	6010B 85-120% of true value 6010C 80-120% of true value 6010D 75-125% of true value

[1]Reported in Limited Plus and Full packages

[2]Post digestion spike assessment is required only for elements failing MS recovery criteria

Table 22 – Post Digestion Spike Action

Spiked Sample Results	Applicable Method	Action for Samples
MS %R < 30% PDS %R < 75%	6020B 6010D	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as rejected (R)
MS %R < 30% PDS %R < 80%	6020 6020A 6010C	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as rejected (R)
MS %R < 30% PDS %R < 85%	6010B	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as rejected (R)
MS %R < 30% PDS %R ≥ 75%	6020B 6010D	Qualify results that are ≥ MDL as estimated **(J)** Qualify non-detects as estimated (UJ)
MS %R < 30% PDS %R ≥ 80%	6020 6020A 6010C	Qualify results that are ≥ MDL as estimated **(J)** Qualify non-detects as estimated (UJ)
MS %R < 30% PDS %R ≥ 85%	6010B	Qualify results that are ≥ MDL as estimated **(J)** Qualify non-detects as estimated (UJ)
MS %R 30-74% PDS %R < 75%	6020B 6010D	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as estimated (UJ)
MS %R 30-74% PDS %R < 80%	6020 6020A 6010C	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as estimated (UJ)
MS %R 30-74% PDS %R < 85%	6010B	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as estimated (UJ)
MS %R > 125% PDS %R > 125%	6020B 6010D	Qualify results that are ≥ MDL as estimated high **(J+)** No action for non-detects
MS %R > 125% PDS %R > 120%	6020 6020A 6010B	Qualify results that are ≥ MDL as estimated high **(J+)** No action for non-detects

Spiked Sample Results	Applicable Method	Action for Samples
	6010C	
MS %R > 125% PDS %R ≤ 125%	6020B 6010D	Qualify results that are ≥ MDL as estimated **(J)** No action for non-detects
MS %R > 125% PDS %R ≤ 120%	6020 6020A 6010B 6010C	Qualify results that are ≥ MDL as estimated **(J)** No action for non-detects
MS %R < 30% No PDS performed	All	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as rejected (R)
MS %R 30-74% No PDS performed	All	Qualify results that are ≥ MDL as estimated low **(J-)** Qualify non-detects as estimated (UJ)
MS %R 75-125% No PDS is required	All	No action
MS %R > 125% No PDS performed	All	Qualify results that are ≥ MDL as estimated high **(J+)** No action for non-detects

[1]Reported in Limited Plus and Full packages

[2]Post digestion spike assessment is required only for elements failing MS recovery criteria

3.4.10 Serial Dilution Sample Results

Serial dilution (SD) samples are applicable to ICP data. The SD is a client sample which is diluted by a factor of five. The dilution corrected result (SD result x 5) should be within a specific percent difference of the original sample result, for samples in which the original concentration is sufficiently high. The SD sample is an indication of physical or chemical interferences within the sample matrix. Serial dilution % difference is determined by:

$$\%Difference = \frac{|I - S|}{I} \times 100$$

Where I = initial sample result

S = serial dilution result

Since SD samples assess matrix interference, field blank samples should not be used for the initial sample. Additionally, as with LDS, MS, and PDS samples, sample similarity should be considered when assessing SD results; and since field blank samples are of a differing matrix, they are not qualified for SD samples which do not meet criteria. Serial dilution results are reported only in L+ and Full packages. Table 23 specifies analyses for which SD samples are applicable, and acceptance criteria; while, Table 24 presents actions for non-compliant SD results. The code "SD" should be used for samples qualified for serial dilution results which do not meet criteria.

Table 23 – Serial Dilution Criteria

Laboratory QC[1,2]	Analysis	Method	Frequency	Control Limits
Serial Dilution (SD)	Metals	SW846 6020 SW846 6020A SW846 6020B	One in every batch of 20 or fewer samples	6020/6020A - 1:5 dilution 20% difference of original result when original sample is ≥ 50X the MDL 6020B - 20% difference of 1:5 dilution of MS or samples with concentration 25X the lower limit of quantification in parent sample
Serial Dilution (SD)	Metals	SW846 6010B SW846 6010C SW846 6010D	One in every batch of 20 or fewer samples	6010B, 6010C - 20% difference of original result when original sample is > 10X the RL. 6010D - 20% difference of 1:5 dilution of MS or samples with concentration 25X the lower limit of quantification in parent sample EPA 200.7 - 20% difference for original samples ≥ 50X the MDL

[1]Reported in Limited Plus and Full packages
[2]Serial dilutions are not required for EPA 200.8, but if performed control limits for 6020/6020A apply

Table 24 – Serial Dilution Action

SD Result[1]	Applicable Method	Original Sample Concentration	Action for Samples	Qualifier Code
SD not performed at required frequency	One per batch of 20 or fewer samples	NA	Use professional judgement. Investigate why MS was not performed. At a minimum, qualify detects as estimated (J) and non-detects as estimated (UJ)	SD
SD %Difference (%D) > 20%	SW846 6020 SW846 6020A EPS 200.8 SW846 6010B SW846 6010C EPA 200.7	≥ 50X MDL	Qualify results that are ≥ MDL as estimated **(J)** Qualify non-detects as estimated non-detect (UJ)	SD
SD %D > 20%	SW8466020 SW846 6020A EPA 200.8 SW846 6010B SW846 6010C EPA 200.7	< 50X MDL	No Qualification	
SD %D > 20%	SW846 6020B SW846 6010D	> 25X lower limit of quantification or 1:5 dilution of MS	Qualify results that are ≥ MDL as estimated (J) Qualify non-detects as estimated non-detect (UJ)	SD
SD %D > 20%	SW846 6020B SW846 6010D	< 25X lower limit of quantification	No Qualification	

[1]Serial dilution results are reported in Limited Plus and Full packages

3.5 Data Validation Process for Analytical Parameters

This section outlines validation steps by analytical parameter (mercury, metals, alkalinity, etc.). Since laboratory packages present calibration and QC results by parameter, the most efficient way to assess data is by parameter, rather than by QC sample. That is, assess all mercury calibration and QC sample results, next assess all ICP calibration and QC sample results, and so on, rather than assessing blank results for all analyses, assess LCS results for all analyses, etcetera. In assessing laboratory data for each parameter, use the limits and corrective actions provided in Section 3.3.

3.5.1 Mercury Assessment

Mercury analyses are assessed for the calibration and QC samples found in Table 25.

3.5.2 Metals Assessment

Metals analyses are assessed for the calibration and QC samples found in Table 26.

3.5.3 Alkalinity Assessment

Alkalinity analyses are assessed for the calibration and QC samples found in Table 27

3.5.4 Solids (TDS/TSS) Assessment

Solids (TSS, TDS, etc.) analyses are assessed for the calibration and QC samples found in Table 38.

3.5.5 Nitrate +Nitrite Assessment

Nitrate + nitrite analyses are assessed for the calibration and QC samples found in Table 29

3.5.6 Ammonia Assessment

Ammonia analyses are assessed for the calibration and QC samples found in Table 30.

3.5.7 Total Kjeldahl Nitrogen (TKN) Assessment

TKN analyses are assessed for the calibration and QC samples found in Table 31.

3.5.8 Dissolved/Total Organic Carbon (DOC/TOC) Assessment

DOC and TOC analyses are assessed for the calibration and QC samples found in Table 32. The analytical method for DOC and TOC is identical, the difference is that a sample to be analyzed for DOC is field filtered.

3.5.9 Sulfate Analysis by ASTMD 516-90 Assessment

Sulfate analyses by ASTMD 516-90 are assessed for the calibration and QC samples found in Table 33.

3.5.10 Total Phosphorus Assessment

Total phosphorus analyses are assessed for the calibration and QC samples found in Table 34

3.5.11 Chloride Analysis by SM4500-Cl E Assessment

Chloride analyses by SM4500-CL E are assessed for the calibration and QC samples found in Table 35.

3.5.12 Anion Analysis (Bromide, Chloride, Fluoride, and Sulfate) by EPA 300 Assessment

Anion analyses (bromide, chloride, fluoride, and sulfate) by EPA Method 300 are assessed for the calibration and QC samples found in Table 36.

3.5.13 Fluoride Assessment

Fluoride analyses by SM4500-F-C analyses are assessed for the calibration and QC samples found in Table 37.

3.5.14 Sulfide Assessment

Sulfide analyses are assessed for the calibration and QC samples found in Table 38.

3.5.15 Chemical Oxygen Demand (COD) Assessment

Chemical oxygen demand (COD) analyses are assessed for the calibration and QC samples found in Table 39**.**

3.5.16 Orthophosphate Assessment

Orthophosphate analyses are assessed for the calibration and QC samples found in Table 40.

Table 25 - Mercury Calibration and Laboratory QC Sample Requirements

Laboratory Calibration/ QC Sample	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	SW846 7470 SW846 7470A EPA 245.1	Once in 24 hours or each time the instrument is set up	r ≥ 0.995	Table 7	No	Yes	Yes
ICV	SW846 7470 SW846 7470A EPA 245.1	Immediately after instrument calibration and after a continuing calibration failure	90-110% of true value EPA 245.1 - 95-105%R	Table 7	No	Yes	Yes
CCV	SW846 7470 SW846 7470A EPA 245.1	1 in 10 samples, and after the last analytical sample	90-110% of true value	Table 7	No	Yes	Yes
CCRL	SW846 7470 SW846 7470A EPA 245.1	At the beginning of each run.	SW846 7470/7470A 80-120%R 245.1 70-130%R	Table 9	No	Yes	Yes
ICB	SW846 7470 SW846 7470A EPA 245.1	Immediately after instrument calibration, following the ICV	< MDL	Table 8	No	Yes	Yes
CCB	SW846 7470 SW846 7470A EPA 245.1	1 in 10 samples immediately after CCVs and after the last analytical sample	< MDL	Table 8	No	Yes	Yes
MB	SW846 7470 SW846 7470A EPA 245.1	1 per batch of ≤ 20 samples	< MDL	Table 8	Yes	Yes	Yes

Laboratory Calibration/ QC Sample	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
LCS	SW846 7470 SW846 7470A EPA 245.1	1 per batch of ≤ 20 samples	80-120% R EPA 245.1 - 85-115%R	Table 16	Yes	Yes	Yes
LDS (MSD suffices as LDS)	SW846 7470 SW846 7470A EPA 245.1	1 per batch of ≤ 20 samples	≤ 20% RPD	Table 18	Yes	Yes	Yes
MS/MSD	SW846 7470 SW846 7470A EPA 245.1	1 per batch of ≤ 20 Samples EPA 245.1 - 1 per batch & if > 11 samples in a batch, an additional MS is required.	80-120%R EPA 245.1 - 70-130%R ≤ 20% RPD	Table 20	Yes	Yes	Yes

Table 26 – Metals Calibration and Laboratory QC Sample Requirements

Laboratory QC[1]	Method	Frequency[1]	Control Limits[1]	Action Table	L Report	L+ Report	Full Report
Tuning	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	Prior to calibration Tune solution analyzed five times, consecutively	mass calibration within 0.1 amu % RSD of absolute signals < 5%	Table 5	No	Yes	Yes
Calibration Curve Fit	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	Once in 24 hours or each time the instrument is set up	$r \geq 0.998$	Table 7	No	Yes	Yes
Calibration Curve Fit	SW846 6010B SW846 6010C SW846 6010D EPA 200.7	Once in 24 hours or each time the instrument is set up	$r \geq 0.995$	Table 7	No	Yes	Yes
ICV	SW846 6020 SW846 6020A SW846 6020B EPA 200.8 SW846 6010B SW846 6010C SW846 6010D EPA 200.7	Immediately after instrument calibration and after a continuing calibration failure	90-110% R EPA 200.7 - 95-105%R	Table 7	No	Yes	Yes
CCV	SW846 6020 SW846 6020A SW846 6020B EPA 200.8 SW846 6010B SW846 6010C SW846 6010D EPA 200.7	1 in every 10 samples, and after the last analytical sample	90-110% R SW846 6010B - The RSD of the CCV must be < 5%	Table 7	No	Yes	Yes
CCRL	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	At the beginning of each run for every analyte of interest	6020/200.8 - 60-140% R 6020A - 70-130% R 6020B - 80-120% R 6010B – 50-150% R	Table 10	No	Yes	Yes

Laboratory QC[1]	Method	Frequency[1]	Control Limits[1]	Action Table	L Report	L+ Report	Full Report
	SW846 6010B EPA 200.7		200.8 - 60-140% R				
ICB	SW846 6020 SW846 6020A SW846 6020B EPA 200.8 SW846 6010B SW846 6010C SW846 6010D EPA 200.7	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	SW846 6020 SW846 6020A SW846 6020B EPA 200.8 SW846 6010B SW846 6010C SW846 6010D EPA 200.7	1 in every 10 samples, immediately after CCV	< MDL	Table 8	No	Yes	Yes
MB	SW846 6020 SW846 6020A SW846 6020B EPA 200.8 SW846 6010B SW846 6010C SW846 6010D EPA 200.7	1 in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
ICS	SW846 6020 SW846 6020A SW846 6020B EPA 200.8 SW846 6010B SW846 6010C SW846 6010D EPA 200.7	At the beginning of each analytical sequence, or a minimum of twice per 8-hour shift, whichever is more frequent.	80-120% R for analytes included in the ICS, < 2XRL for analytes not included in the ICS	Table 12	No	Yes	Yes

Laboratory QC[1]	Method	Frequency[1]	Control Limits[1]	Action Table	L Report	L+ Report	Full Report
Internal Standard Response	SW846 6020 SW846 6020A SW846 6020B EPA 200.8	Monitor signal intensity throughout the analytical run.	6020A/6020B - 70-130% EPA 200.8 - 60-125%	Table 14			
Internal Standard Response	SW846 6010B SW846 6010C EPA 200.7	Monitor signal intensity throughout the analytical run.	60-125% R	Table 14	No	Yes	Yes
LCS	SW846 6020 SW846 6020A SW846 6020B EPA 200.8 SW846 6010B SW846 6010C SW846 6010D EPA 200.7	1 in every 20 samples	80-120% R EPA 200.8 - 85-115% R EPA 200.7 - 85-115% R	Table 16	Yes	Yes	Yes
LDS	SW846 6020 SW846 6020A SW846 6020B EPA 200.8 SW846 6010B SW846 6010C SW846 6010D EPA 200.7	1 in every 20 samples MSD suffices as LDS	20% RPD	Table 18	Yes	Yes	Yes
MS/MSD	SW846 6020 SW846 6020A SW846 6020B EPA 200.8 SW846 6010B SW846 6010C SW846 6010D EPA 200.7	MS One in every 20 samples EPA 200.7 & 200.8 MS - One in every 10 samples MSD one in every 20 samples	75-125% R EPA 200.7 & 200.8 - 70-130% R ≤ 20% RPD	Table 20	Yes	Yes	Yes
PDS	SW846 6020 SW846 6020A SW846 6020B	1 per QC batch if MS/MSD recovery outside of 75-125%	6020/6020A 80-120% R 6020B 75-125% of true value	Table 22	No	Yes	Yes

Laboratory QC[1]	Method	Frequency[1]	Control Limits[1]	Action Table	L Report	L+ Report	Full Report
PDS	SW846 6010B SW846 6010C SW846 6010D	1 per QC batch if MS/MSD recovery outside of 75-125%	6010B 85-120% R 6010C 80-120% R 6010D 75-125% R	Table 22	No	Yes	Yes
SD	SW846 6020 SW846 6020A SW846 6020B	1 in every 20 samples	6020/6020A/EPA 200.8 - 1:5 dilution 20% D of original result when original sample is ≥ 50X the MDL 6020B - 20% D of 1:5 dilution of MS or samples with concentration 25X the lower limit of quantification in parent sample	Table 24	No	Yes	Yes
SD	SW846 6010B SW846 6010C SW846 6010D EPA 200.7	1 in every 20 samples	6010B, 6010C - 20% D of original result when original sample is > 10X the RL. 6010D - 20% D of 1:5 dilution of MS or samples with concentration 25X the lower limit of quantification in parent sample EPA 200.7 - 20% D for original samples ≥ 50X the MDL	Table 24	No	Yes	Yes

[1]Serial dilutions are not required for EPA 200.8, but if performed control limits for 6020/6020A apply

Table 27 – Alkalinity Calibration and Laboratory QC Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	SM2320B	At the beginning of run	slope 96-106% of true value	Table 7	No	Yes	Yes
pH Calibration Check	SM2320B	Immediately after pH probe calibration	± 0.10 pH units	Table 7	No	Yes	Yes
ICV	SM2320B	Immediately after instrument calibration and after a continuing calibration failure	90-110% R	Table 7	No	Yes	Yes
CCV	SM2320B	1 in every ten samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	SM2320B	Immediately after instrument calibration, following the ICV	< MDL	Table 8	No	Yes	Yes
CCB	SM2320B	One in every 10 samples, immediately after CCVs	< MDL	Table 8	No	Yes	Yes
MB	SM2320B	1 in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	SM2320B	1 in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LCSD	SM2320B	1 in every 20 samples	20% RPD	Table 16	Yes	Yes	Yes
LDS	SM2320B	1 in every 10 samples MSD suffices for LDS	20% RPD	Table 18	Yes	Yes	Yes
MS/MSD	SM2320B	One in every 10 samples	80-120% R 20% RPD	Table 20	Yes	Yes	Yes

Table 28 – TDS/TSS Laboratory QC Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
MB	SM 2540C/D	1 in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	SM 2540C/D	1 in every 20 samples	80-120% R	Table 16	Yes	Yes	Yes
LCSD	SM 2540C/D	1 in every 20 samples (if analyzed)	10% RPD	Table 16	Yes	Yes	Yes
LDS	SM 2540C/D	1 in every 10 samples	10% RPD	Table 18	Yes	Yes	Yes

Table 29 – Nitrate + Nitrite Calibration and Laboratory QC Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	EPA 353.2 SM 4500 NO_3-H	At the beginning of run	$r \geq 0.995$	Table 7	No	Yes	Yes
ICV	EPA 353.2 SM 4500 NO_3-H	Immediately after instrument calibration and after a continuing calibration failure	90-110% R	Table 7	No	Yes	Yes
CCV	EPA 353.2 SM 4500 NO_3-H	One in every ten samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	EPA 353.2 SM 4500 NO_3-H	Immediately after instrument calibration, immediately following ICV	< MDL	Table 8	No	Yes	Yes
CCB	EPA 353.2 SM 4500 NO_3-H	1 in every 10 samples, immediately after CCVs	< MDL	Table 8	No	Yes	Yes
MB	EPA 353.2 SM 4500 NO_3-H	1 in every 20 samples	< MDL	Table 8	Yes	Yes	Yes

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
LCS	EPA 353.2 SM 4500 NO_3-H	1 in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LDS	EPA 353.2 SM 4500 NO_3-H	EPA 353.2: 1 in every 20 samples SM 4500 NO_3-H: 1 in every 10 samples MSD suffices as LDS	≤ 20% RPD	Table 18	Yes	Yes	Yes
MS/MSD	EPA 353.2	1 in every 20 samples	90-110% ≤ 20% RPD	Table 20	Yes	Yes	Yes
MS/MSD	SM 4500 NO_3-H	SM 4500 NO_3-H: 1 in every 10 samples	80-120% R ≤ 20% RPD	Table 20	Yes	Yes	Yes

Table 30 – Ammonia Calibration and Laboratory QC Sample Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	EPA 350.1	At the beginning of run	r ≥ 0.995	Table 7	No	Yes	Yes
ICV	EPA 350.1	Immediately after instrument calibration and after a continuing calibration failure	90-110% R	Table 7	No	Yes	Yes
CCV	EPA 350.1	1 in every ten samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	EPA 350.1	Immediately after instrument calibration, immediately following ICV	< MDL	Table 8	No	Yes	Yes
CCB	EPA 350.1	1 in every ten samples, , immediately after CCVs, and after the last analytical sample	< MDL	Table 8	No	Yes	Yes

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
MB	EPA 350.1	1 in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	EPA 350.1	1 in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LDS	EPA 350.1	1 in every 10 samples MSD suffices as LDS	≤ 20% RPD	Table 18	Yes	Yes	Yes
MS/MSD	EPA 350.1	1 in every 10 samples	90-110% R 20% RPD	Table 20	Yes	Yes	Yes

Table 31 – TKN Calibration and Laboratory QC Samples Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	EPA 351.121	At the beginning of run	r ≥ 0.995	Table 7	No	Yes	Yes
ICV	EPA 351.2	Immediately after instrument calibration and after a continuing calibration failure	90-110% R	Table 7	No	Yes	Yes
CCV	EPA 351.2	1 in every 10 samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	EPA 351.2	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	EPA 351.2	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	< MDL	Table 8	No	Yes	Yes
MB	EPA 351.2	1 in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	EPA 351.2	1 in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LDS	EPA 351.2	1 in every 20 samples (MSD or alternate)	≤ 10% RPD	Table 18	Yes	Yes	Yes

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
MS/MSD	EPA 351.2	MS 1 in every 10 samples MSD 1 in 20	90-110% R	Table 20	Yes	Yes	Yes

Table 32 – DOC/TOC Calibration and Laboratory QC Samples Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	SM 5310C EPA 9060A	At the beginning of run	r ≥ 0.995	Table 7	No	Yes	Yes
ICV	SM 5310C EPA 9060A	Immediately after instrument calibration and after a continuing calibration failure DOC/TOC analysis by SM 5310C calibration frequency is every six months or as needed. Thus, ICV frequency may be six months.	90-110% R	Table 7	No	Yes	Yes
High and Low Standard Check	SM 5310C EPA 9060A	Daily prior to sample analysis unless ICV is run that day		Table 7			
CCV	SM 5310C EPA 9060A	One in every ten samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	SM 5310C EPA 9060A	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	SM 5310C EPA 9060A	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	< MDL	Table 8	No	Yes	Yes
MB	SM 5310C	1 in every 20 samples	< MDL	Table 8	Yes	Yes	Yes

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
	EPA 9060A						
LCS	SM 5310C EPA 9060A	SM5310 C:1 in every 20 samples EPA 9060A: 1 in every 10 samples	80-120% R	Table 16	Yes	Yes	Yes
LDS	SM 5310C EPA 9060A	SM5310 C:1 in every 20 samples EPA 9060A: 1 in every 10 samples	≤ 25% RPD	Table 18	Yes	Yes	Yes
MS	SM 5310C EPA 9060A	SM5310 C:1 in every 20 samples EPA 9060A: 1 in every 10 samples	80-120% R	Table 20	Yes	Yes	Yes

Table 33 – Sulfate by ASTM D516-90 Calibration and Laboratory QC Sample Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	ASTM D516-90	At the beginning of run	r ≥ 0.990	Table 7	No	Yes	Yes
ICV	ASTM D516-90	Immediately after instrument calibration and after a continuing calibration failure	80-120% R	Table 7	No	Yes	Yes
CCV	ASTM D516-90	1 in every 10 samples, and after the last analytical sample	80-120% R	Table 7	No	Yes	Yes
ICB	ASTM D516-90	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	ASTM D516-90	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	< MDL	Table 8	No	Yes	Yes
MB	ASTM D516-90	1 in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	ASTM D516-90	1 in every 20 samples	80-120% R	Table 16	Yes	Yes	Yes

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
LCSD	ASTM D516-90	1 in every 20 samples	≤ 20% RPD	Table 16	Yes	Yes	Yes
LDS	ASTM D516-90	1 in every 10 samples MSD suffices as LDS	≤ 30% RPD	Table 18	Yes	Yes	Yes
MS/MSD	ASTM D516-90	1 in every 10 samples	80-120% R 30% RPD	Table 20	Yes	Yes	Yes

Table 34 - Total Phosphate by SM4500P-E Calibration and Laboratory QC Sample Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	SM4500P-E	At the beginning of run	r ≥ 0.995	Table 7	No	Yes	Yes
ICV	SM4500P-E	Immediately after instrument calibration and after a continuing calibration failure	90-110% R	Table 7	No	Yes	Yes
CCV	SM4500P E	1 in every 10 samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	SM4500P E	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	SM4500P E	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	< MDL	Table 8	No	Yes	Yes
MB	SM4500P E	One in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	SM4500P E	One in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LDS	SM4500P E	One in every 10 samples MSD suffices as LDS	30% RPD	Table 18	Yes	Yes	Yes
MS/MSD	SM4500P E	One in every 10 samples	80-120% R	Table 20	Yes	Yes	Yes

Table 35 – Chloride by SM4500-Cl E Calibration and Laboratory QC Sample Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	SM 4500-Cl E	At the beginning of run	r ≥ 0.995	Table 7	No	Yes	Yes
ICV	SM 4500-Cl E	Immediately after instrument calibration and after a continuing calibration failure	90-110% R	Table 7	No	Yes	Yes
CCV	SM 4500-Cl E	1 in every 10 samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	SM 4500-Cl E	At beginning of analytical run, immediately after ICV	< 1/2 RL	Table 8	No	Yes	Yes
CCB	SM 4500-Cl E	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	< 1/2 RL	Table 8	No	Yes	Yes
MB	SM 4500-Cl E	1 in every 20 samples	< 1/2 RL	Table 8	Yes	Yes	Yes
LCS	SM 4500-Cl E	1 in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LDS	SM 4500-Cl E	1 in every 10 samples MSD suffices as LDS	≤ 20% RPD	Table 18	Yes	Yes	Yes
MS/MSD	SM 4500-Cl E	1 in every 10 samples	80-120% R	Table 20	Yes	Yes	Yes

Table 36 – Anion (Bromide, chloride, fluoride, sulfate) Analysis by EPA 300.0 Calibration and Laboratory QC Sample Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	EPA 300.0	At the beginning of run	r ≥ 0.990	Table 7	No	Yes	Yes
ICV	EPA 300.0	Immediately after instrument calibration and after a continuing calibration failure	90-110% R	Table 7	No	Yes	Yes
CCV	EPA 300.0	1 in every 10 samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	EPA 300.0	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	EPA 300.0	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	< MDL	Table 8	No	Yes	Yes
MB	EPA 300.0	1 in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	EPA 300.0	1 in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LDS	EPA 300.0	1 in every 10 samples MSD suffices as LDS	≤ 20% RPD	Table 18	Yes	Yes	Yes
MS/MSD	EPA 300.0	1 in every 10 samples	80-120% R	Table 20	Yes	Yes	Yes

Table 37 - Fluoride Analysis by SM4500-F-C Calibration and Laboratory QC Sample Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve	SM 4500-F-C	Daily, prior to analysis	Slope=90-110%	Table 7	No	Yes	Yes
ICV	SM 4500-F-C	Immediately after instrument calibration and after a continuing calibration failure Sulfide analysis by SM4500-S^{2-}D calibration frequency is every six months or as needed. Thus, ICV frequency may be six months.	90-110% R	Table 7	No	Yes	Yes
CCV	SM 4500-F-C	1 in every 10 samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	SM 4500-F-C	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	SM 4500-F-C	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	< MDL	Table 8	No	Yes	Yes
MB	SM 4500-F-C	One in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	SM 4500-F-C	One in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LDS	SM 4500-F-C	One in every 10 samples	20% RPD	Table 18	Yes	Yes	Yes
MS/MSD	SM 4500-F-C	One in every 10 samples	80-120% R	Table 20	Yes	Yes	Yes

Table 38 - Sulfide Analysis by SM4500-S^{2}-D Calibration and Laboratory QC Sample Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	SM4500-S^{2-}D	At the beginning of run	r ≥ 0.995	Table 7	No	Yes	Yes
ICV	SM4500-S^{2-}D	Immediately after instrument calibration and after a continuing calibration failure Sulfide analysis by SM4500-S^{2-}D calibration frequency is every six months or as needed. Thus ICV frequency may be six months.	90-110% R	Table 7	No	Yes	Yes
High calibration check	SM4500-S^{2-}D	Daily prior to sample analysis unless ICV is run that day.	90-110% R	Table 7	No	Yes	Yes
Low calibration check	SM4500-S^{2-}D	Daily prior to sample analysis unless ICV is run that day.	90-110% R	Table 7	No	Yes	Yes
CCV	SM4500-S^{2-}D	One in every ten samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	SM4500-S^{2-}D	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	SM4500-S^{2-}D	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	90-110% R	Table 8	No	Yes	Yes
MB	SM4500-S^{2-}D	One in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	SM4500-S^{2-}D	One in every 20 samples	80-120% R	Table 16	Yes	Yes	Yes
LDS	SM4500-S^{2-}D	One in every 20 samples	20% RPD	Table 18	Yes	Yes	Yes
MS	SM4500-S^{2-}D	One in every 20 samples	75-125% of true value	Table 20	Yes	Yes	Yes

Table 39 – COD Analysis by SM5220D and EPA 410.4 Calibration and Laboratory QC Sample Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	SM 5220D EPA 410.4	At the beginning of run	r ≥ 0.995	Table 7	No	Yes	Yes
ICV	SM 5220D EPA 410.4	Immediately after instrument calibration and after a continuing calibration failure	SM5220D - 95-105% EPA 410.4 - 90-10%	Table 7	No	Yes	Yes
CCV	SM 5220D EPA 410.4	One in every ten samples, and after the last analytical sample	SM5220D - 95-105% EPA 410.4 - 90-10%	Table 7	No	Yes	Yes
ICB	SM 5220D EPA 410.4	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	SM 5220D EPA 410.4	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	< MDL	Table 8	No	Yes	Yes
MB	SM 5220D EPA 410.4	One in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	SM 5220D EPA 410.4	One in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LDS	SM 5220D EPA 410.4	One in every 10 samples MSD suffices as LDS	20% RPD	Table 18	Yes	Yes	Yes
MS	SM 5220D EPA 410.4	One in every 10 samples	SM 5220D 80-120% EPA 410.4 90-110%	Table 20	Yes	Yes	Yes

Table 40 – Ortho Phosphate Analysis by SM4500P-G Calibration and Laboratory QC Sample Requirements

Laboratory QC	Method	Frequency	Control Limits	Action Table	L Report	L+ Report	Full Report
Calibration Curve Fit	SM4500P-G	At the beginning of run	r ≥ 0.995	Table 7	No	Yes	Yes
ICV	SM4500P-G	Immediately after instrument calibration and after a continuing calibration failure	90-110% R	Table 7	No	Yes	Yes
CCV	SM4500P-G	1 in every 10 samples, and after the last analytical sample	90-110% R	Table 7	No	Yes	Yes
ICB	SM4500P-G	At beginning of analytical run, immediately after ICV	< MDL	Table 8	No	Yes	Yes
CCB	SM4500P-G	1 in every 10 samples, immediately after CCVs, and after the last analytical sample	< MDL	Table 8	No	Yes	Yes
MB	SM4500P-G	One in every 20 samples	< MDL	Table 8	Yes	Yes	Yes
LCS	SM4500P-G	One in every 20 samples	90-110% R	Table 16	Yes	Yes	Yes
LDS	SM4500P-G	One in every 10 samples MSD suffices as LDS	30% RPD	Table 18	Yes	Yes	Yes
MS/MSD	SM4500P-G	One in every 10 samples	80-120% R	Table 20	Yes	Yes	Yes

3.6 Reported Results Authentication

For Stage 2b, 3, and 4 validation, compare at least 10% of the reported results to the raw data results. When comparing results, correct for sample volumes, dilution factors, and units. The results should be confirmed randomly (i.e. do not pick the first 10% of results reported.) If there is a discrepancy, the laboratory needs to be notified and to submit a report revision with correct results included.

One of the initial steps in Stage 2b data validation is confirming that all laboratory calibration and QC samples, as well as all client samples, appear in the raw data. Reported concentrations can be checked when confirming calibration and sample presence in the raw data. Figure 4 below shows the reported results for a client sample which has been assigned laboratory ID 10455965003. Figure 5 displays the Analysis Run Log. From the log, the analysis time and dilution factor can be determined. Note that sample -003 was run at 1X, 10X, and 100X dilutions and different parameters were reported from each of these analyses. Figure 6 shows the sample -003 raw data for the 1X dilution; while Figure 7 shows the raw data for the 10X and 100X dilutions. Note that in the examples below, results from the raw data are in ppb, while the reported values are in ppm. When corrected for units and dilutions, the raw data agrees with the reported values.

3.6.1 Check Laboratory Reported Sample Concentrations

For metals and mercury analyses in which both total and dissolved analyses have been performed, compare the laboratory reported total concentrations to the dissolved concentrations. For projects which report both total and dissolved concentrations, there is a worksheet which performs this comparison within the DV spreadsheet. The calculation (Total Result – Dissolved Result) is used; thus, the difference should be positive. Check for negative differences. In the case where numerous dissolved concentrations exceed total concentrations for the same sample, a switch (either by the laboratory or sampling team) is likely. Notify the laboratory of the results and ask for a sample confirmation or rerun if possible.

For projects in which total Kjeldahl nitrogen (TKN) and ammonia analyses have been performed, TKN results should always be greater than ammonia results. This check is performed automatically when the EDD is imported to the database. TKN is the sum of organic and ammonia nitrogen; thus, a TKN result significantly lower than an ammonia result is suspect. Discretion should be used in comparing TKN concentrations near the reporting limit.

Figure 4 – Reported Results for Client Sample with Laboratory ID 10455965003

ANALYTICAL RESULTS

Project: Rocker

Pace Project No.: 10455965

Sample: [redacted] **Lab ID:** 10455965003 Collected: 11/15/18 10:26 Received: 11/17/18 10:00 Matrix: Water

Parameters	Results	Units	Report Limit	MDL	DF	Prepared	Analyzed	CAS No.	Qual
200.8 MET ICPMS, Dissolved	Analytical Method: EPA 200.8 Preparation Method: EPA 200.8								
Arsenic, Dissolved	**0.73**	mg/L	0.00050	0.00011	1	11/28/18 08:59	12/06/18 23:22	7440-38-2	
Cadmium, Dissolved	**0.0011**	mg/L	0.000080	0.000027	1	11/28/18 08:59	12/06/18 23:22	7440-43-9	
Calcium, Dissolved	**88.1**	mg/L	0.40	0.14	10	11/28/18 08:59	12/06/18 23:25	7440-70-2	
Copper, Dissolved	**0.0011**	mg/L	0.0010	0.00022	1	11/28/18 08:59	12/06/18 23:22	7440-50-8	
Iron, Dissolved	**0.26**	mg/L	0.050	0.0054	1	11/28/18 08:59	12/06/18 23:22	7439-89-6	
Lead, Dissolved	**0.000067J**	mg/L	0.00010	0.000039	1	11/28/18 08:59	12/06/18 23:22	7439-92-1	
Magnesium, Dissolved	**22.7**	mg/L	0.010	0.0050	1	11/28/18 08:59	12/06/18 23:22	7439-95-4	
Manganese, Dissolved	**27.8**	mg/L	0.050	0.024	100	11/28/18 08:59	12/06/18 23:28	7439-96-5	
Potassium, Dissolved	**4.6**	mg/L	0.10	0.018	1	11/28/18 08:59	12/06/18 23:22	7440-09-7	
Silicon, Dissolved	**19.5**	mg/L	0.50	0.16	10	11/28/18 08:59	12/06/18 23:25	7440-21-3	
Sodium, Dissolved	**29.3**	mg/L	0.050	0.018	1	11/28/18 08:59	12/06/18 23:22	7440-23-5	
Zinc, Dissolved	**0.0033J**	mg/L	0.0050	0.0019	1	11/28/18 08:59	12/06/18 23:22	7440-66-6	
2320B Alkalinity	Analytical Method: SM 2320B								
Alkalinity, Hydroxide (CaCO3)	ND	mg/L	5.0	1.0	1		11/28/18 08:18		
Alkalinity, Total as CaCO3	**226**	mg/L	5.0	1.0	1		11/28/18 08:18		
Alkalinity,Bicarbonate (CaCO3)	**226**	mg/L	5.0	1.0	1		11/28/18 08:18		
Alkalinity,Carbonate (CaCO3)	ND	mg/L	5.0	1.0	1		11/28/18 08:18		
2540C Total Dissolved Solids	Analytical Method: SM 2540C								
Total Dissolved Solids	**514**	mg/L	20.0	10.0	1		11/21/18 10:57		
ASTM D516 Sulfate Water	Analytical Method: ASTM D516								
Sulfate	**182**	mg/L	25.0	12.0	10		11/30/18 12:31	14808-79-8	
SM4500Cl-E Chloride	Analytical Method: SM 4500-Cl E								
Chloride	**20.1**	mg/L	2.0	0.59	1		11/27/18 11:32	16887-00-6	

Figure 5 – Analysis Run Log Showing Sample 10455965003. Log provides analysis time and dilution factors.

FORM XIII INORGANIC-1
ANALYSIS RUN LOG

Lab: Pace Analytical - Minnesota SDG No. : 10455965 Contract: Rocker

Instrument: 10ICM3 Analysis: EPA 200.8

Start: 12/06/2018 21:42 End Date: 12/07/2018 02:12

Sample Name	Lab Sample ID	D/F	Date	Time	As	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Si	Zn
21235421CAL0	21235421CAL0	1	12/06/2018	21:42	X	X	X	X	X	X	X	X	X	X	X	X
21235422CAL1	21235422CAL1	1	12/06/2018	21:45	X	X	X	X	X	X	X	X	X	X	X	X
21235423CAL4	21235423CAL4	1	12/06/2018	21:48	X	X	X	X	X	X	X	X	X	X	X	X
21235424CAL5	21235424CAL5	1	12/06/2018	21:52	X	X	X	X	X	X	X	X	X	X	X	X
21235425CAL6	21235425CAL6	1	12/06/2018	21:55	X	X	X	X	X	X	X	X	X	X	X	X
21235426CAL2	21235426CAL2	1	12/06/2018	21:58	X	X	X	X	X	X	X	X	X	X	X	X
21235427CAL3	21235427CAL3	1	12/06/2018	22:02	X	X	X	X	X	X	X	X	X	X	X	X
21235428ICV	21235428ICV	1	12/06/2018	22:05	X	X	X	X	X	X	X	X	X	X	X	X
21235429ICB	21235429ICB	1	12/06/2018	22:12	X	X	X	X	X	X	X	X	X	X	X	X
21235430CRDL	21235430CRDL	1	12/06/2018	22:15	X	X	X	X	X	X	X	X	X	X	X	X
21235431ICSA	21235431ICSA	1	12/06/2018	22:19	X	X	X	X	X	X	X	X	X	X	X	X
21235432ICSAB	21235432ICSAB	1	12/06/2018	22:22	X	X	X	X	X	X	X	X	X	X	X	X
21235433CCV	21235433CCV	1	12/06/2018	22:25	X	X	X	X	X	X	X	X	X	X	X	X
21235434CCB	21235434CCB	1	12/06/2018	22:32	X	X	X	X	X	X	X	X	X	X	X	X
3127538BLANK	3127538	1	12/06/2018	22:35	X	X	X	X	X	X	X	X	X	X	X	X
3127539LCS	3127539	1	12/06/2018	22:38	X	X	X	X	X	X	X	X	X	X	X	X
[redacted]	10455965001	1	12/06/2018	22:42	X	X	X	X	X	X	X	X	X	X		X
3139123SD	3139123	5	12/06/2018	22:45	X	X	X	X	X	X	X	X	X	X		X
3127540MS	3127540	1	12/06/2018	22:52	X	X	X	X	X	X	X	X	X	X	X	X
3127541MSD	3127541	1	12/06/2018	22:55	X	X	X	X	X	X	X	X	X	X	X	X
[redacted]	10455965001	10	12/06/2018	22:59											X	
3139123SD	3139123	50	12/06/2018	23:06											X	
21235435CCV	21235435CCV	1	12/06/2018	23:09	X	X	X	X	X	X	X	X	X	X	X	X
21235436CCB	21235436CCB	1	12/06/2018	23:12	X	X	X	X	X	X	X	X	X	X	X	X
[redacted]	10455965002	1	12/06/2018	23:15	X	X	X	X	X	X	X	X	X	X		X
[redacted]	10455965002	10	12/06/2018	23:19											X	
[redacted]	10455965003	1	12/06/2018	23:22	X		X	X	X	X	X		X	X		X
[redacted]	10455965003	10	12/06/2018	23:25		X									X	
[redacted]	10455965003	100	12/06/2018	23:28								X				
[redacted]	10455965008	1	12/06/2018	23:32			X	X	X	X	X	X	X	X		X
[redacted]	10455965008	10	12/06/2018	23:35	X	X									X	

Figure 6 – ICP Raw Data Showing Sample 10455965002 Run at a 1X Dilution

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User Pre-dilution: 1.000

Run	Time	23Na	25Mg	27Al	28Si	31P	34S	35Cl	39K	43Ca	45Sc	47Ti
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		21470.000	9299.000	3.084	M 14860.000	-6.055	-1207.000	-746900.000	3508.000	38180.000	97.006%	0.158
%RSD		3.180	2.360	29.670	M 2.485	7.066	4.936	0.676	1.740	3.060	0.934	109.000
Run	**Time**	**52Cr**	**53Cl O**	**54Fe**	**55Mn**	**59Co**	**60Ni**	**63Cu**	**66Zn**	**72Ge**	**75As**	**78Se**
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		0.260	0.955	76.900	398.100	0.274	0.279	11.820	149.000	97.456%	70.250	0.251
%RSD		24.790	17.870	0.891	2.065	13.070	14.570	2.684	1.292	0.331	1.722	21.470
Run	**Time**	**82Se**	**95Mo**	**107Ag**	**111Cd**	**115In**	**121Sb**	**137Ba**	**159Tb**	**205Tl**	**208Pb**	**232Th**
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		1.576	6.154	0.034	0.418	97.966%	0.695	21.760	101.562%	0.046	0.010	102.047%
%RSD		97.730	4.239	7.232	10.040	0.832	10.650	1.715	0.823	8.151	28.290	1.078
Run	**Time**	**238U**										
		ppb										
x		2.102										
%RSD		2.675										

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User Pre-dilution: 1.000

Run	Time	23Na	25Mg	27Al	28Si	31P	34S	35Cl	39K	43Ca	45Sc	47Ti
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		2132.000	937.800	2.191	1474.000	-1.104	-182.100	-866100.000	348.100	3792.000	98.528%	0.045
%RSD		0.968	4.857	22.620	2.935	19.840	31.250	1.894	2.701	1.291	0.753	143.100
Run	**Time**	**52Cr**	**53Cl O**	**54Fe**	**55Mn**	**59Co**	**60Ni**	**63Cu**	**66Zn**	**72Ge**	**75As**	**78Se**
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		0.033	0.843	8.413	39.780	0.025	0.039	1.183	15.250	100.293%	6.935	0.007
%RSD		31.370	20.090	11.350	0.879	10.870	25.650	1.250	3.667	0.444	2.207	780.500
Run	**Time**	**82Se**	**95Mo**	**107Ag**	**111Cd**	**115In**	**121Sb**	**137Ba**	**159Tb**	**205Tl**	**208Pb**	**232Th**
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		-0.974	0.608	0.022	0.053	99.486%	0.066	2.099	101.162%	0.039	0.004	100.990%
%RSD		11.090	7.943	4.191	12.250	0.552	12.310	3.162	1.184	2.454	92.180	0.422
Run	**Time**	**238U**										
		ppb										
x		0.210										
%RSD		0.807										

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User Pre-dilution: 1.000

Run	Time	23Na	25Mg	27Al	28Si	31P	34S	35Cl	39K	43Ca	45Sc	47Ti
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		29310.000	22660.000	2.845	M 19830.000	-57.000	-3606.000	-869200.000	4565.000	M 89390.000	97.786%	0.343
%RSD		0.708	1.420	7.424	M 1.278	5.308	3.041	1.752	1.162	M 2.158	1.259	38.060
Run	**Time**	**52Cr**	**53Cl O**	**54Fe**	**55Mn**	**59Co**	**60Ni**	**63Cu**	**66Zn**	**72Ge**	**75As**	**78Se**
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		0.219	0.779	263.800	TM 28580.000	1.455	3.533	1.097	3.291	97.430%	729.500	0.071
%RSD		16.600	23.180	1.243	TM 1.278	3.980	8.170	1.839	2.615	1.580	1.663	133.200
Run	**Time**	**82Se**	**95Mo**	**107Ag**	**111Cd**	**115In**	**121Sb**	**137Ba**	**159Tb**	**205Tl**	**208Pb**	**232Th**
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		1.848	64.820	0.006	1.118	98.597%	0.302	67.680	102.319%	0.042	0.067	103.027%
%RSD		41.840	1.513	37.240	2.448	1.645	1.795	1.025	1.964	2.383	2.205	1.503
Run	**Time**	**238U**										
		ppb										
x		5.758										
%RSD		1.825										

Figure 7 – Raw Data Showing Sample 10455965002 Run at a 10X and 100X Dilutions

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User Pre-dilution: 1.000

Run	Time	23Na	25Mg	27Al	28Si	31P	34S	35Cl	39K	43Ca	45Sc	47Ti
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		2856.000	2297.000	2.877	1954.000	-7.694	-401.000	-877400.000	452.000	8807.000	106.424%	0.039
%RSD		0.941	1.864	10.970	3.201	14.190	12.190	1.238	1.837	2.697	0.531	151.600

Run	Time	52Cr	53Cl O	54Fe	55Mn	59Co	60Ni	63Cu	66Zn	72Ge	75As	78Se
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		0.035	0.847	27.020	TM 2834.000	0.132	0.430	0.116	0.622	109.042%	71.730	0.000
%RSD		17.900	11.310	1.610	TM 2.178	10.370	19.940	24.000	5.126	1.100	1.133	128400.000

Run	Time	82Se	95Mo	107Ag	111Cd	115In	121Sb	137Ba	159Tb	205Tl	208Pb	232Th
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		-0.919	6.298	0.004	0.101	107.754%	0.031	6.272	107.888%	0.030	0.006	106.315%
%RSD		33.550	1.653	105.100	6.300	1.188	19.790	2.915	0.386	11.260	44.350	0.138

Run	Time	238U
		ppb
x		0.568
%RSD		1.208

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User Pre-dilution: 1.000

Run	Time	23Na	25Mg	27Al	28Si	31P	34S	35Cl	39K	43Ca	45Sc	47Ti
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		277.000	228.500	2.750	187.300	-1.012	-124.800	-887600.000	44.070	928.100	107.447%	0.005
%RSD		1.305	2.479	21.600	7.870	20.300	10.060	0.297	6.012	6.217	0.326	1233.000

Run	Time	52Cr	53Cl O	54Fe	55Mn	59Co	60Ni	63Cu	66Zn	72Ge	75As	78Se
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		0.006	0.955	3.317	278.100	0.018	0.053	-0.009	0.146	108.736%	7.125	0.021
%RSD		148.000	20.950	23.940	0.567	15.840	14.740	53.940	44.390	1.039	1.260	98.670

Run	Time	82Se	95Mo	107Ag	111Cd	115In	121Sb	137Ba	159Tb	205Tl	208Pb	232Th
		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
x		0.157	0.634	0.001	0.012	107.252%	0.001	0.645	106.031%	0.026	0.004	103.952%
%RSD		468.600	3.194	73.790	82.980	1.153	488.000	3.570	1.002	17.280	45.720	1.151

Run	Time	238U
		ppb
x		0.055
%RSD		1.925

3.7 Data Validation Notes to Remember

In addition to the general guidance and method specific guidance discussed above, the validator should keep the items discussed in Section 3.7 in mind.

3.7.1 Laboratory Qualifiers

Sample results come with laboratory qualifiers. The Laboratory Information Management System (LIMS)) automatically qualifies unrounded results lower than the MDL, "U" or "non-detect". Just like the case narrative, use the laboratory qualifier flags as a tool; do not rely on these flags, as they may be inconsistent with guidance used to assign validation qualifiers.

3.7.2 Laboratory Control Limits

The LIMS may use control limits which differ from those specified in these guidelines, or the project QAPP, and control limits may differ among labs. There may be instances when data are/are not flagged by the laboratory, and these data will not/will warrant a data validation qualifier. When assessing data, the control limits within project QAPPS are the most pertinent reference. The limits tabulated in project QAPPs are the limits laboratories are required to meet; and generally, these limits align with method limits.

3.7.3 Multiple Data Qualifiers and DV Reason Codes

In the data assessment process, a data point may be qualified for more than one QC deficiency. For example, a sample result less than the MB result may receive a UJ qualification. This same data point may be qualified because the laboratory duplicate precision was greater than the acceptable RPD, warranting a J qualification. Each data point is assigned only one qualifier, so an overall qualifier would be applied (see Table 41).

Unlike qualifiers, multiple reason codes may be applied, and these are listed in Table 42 below. If multiple reason codes are used, always list these codes in alphabetical order. For example, if a data point is qualified for matrix spike recovery (MS), laboratory duplicate precision (RPD), and a field blank detection (FB), the codes should be listed as "FB,MS,RPD". All analytical results, data validation qualifiers, and reason codes are stored in a database. A database recognizes "FB,MS,RPD" and "MS,FB,RPD" as two different reason codes. Multiple reason codes must be separated by commas, without any spaces in the text string. Ideally, only one and no more than two reason codes are applied. It is permissible to use more than one reason code; but use discretion in applying codes. For example, if an associated laboratory blank has a detection 10 parts per trillion (ppt) above the MDL and a field blank has a detection 10X the MDL, the FB detection would override the MB detection and only a FB code would be applied.

Table 41 – Multiple Data Qualifiers

Multiple Qualifiers	Overall Qualifier
Data point qualified (UJ) and either (J), (J+), or (J-)	Qualify result as estimated non-detect (UJ)
Data point qualified a combination of (J) and (J+) or (J) and (J-)	Qualify result as estimated high (J+) or estimated low (J-), respectively
Data point qualified as (J+) and (J-)	Qualify result as estimated (J)
Data point qualified (R) and any other qualifier	Qualify result as rejected (R)

Table 42 – Data Validation Reason Codes

Code[1]	Definition
A	Laboratory is not accredited for associated analyses
AB	Did not meet level A/B criteria
CC	Correlation coefficient less than 0.995 for instrument calibration
CCB	Continuing calibration blank contamination
CCV	Continuing calibration verification outside limits
COM	Result is not comparable to historical data
CQ	No calibration performed
CRQL	Contract required quantitation limit (CRDL) standard recovery outside quality control limits
DNR	Do not report. An alternate, acceptable result is available.
EB	Equipment blank contamination
ECR	Reported concentration exceeds instrument calibration range
FB	Field blank contamination
FD	Field duplicate RPD outside limits
HT	Holding time exceeded
ICB	Initial calibration blank contamination
ICS	Interference check standard recovery outside limits
ICV	Initial calibration verification outside limits
IP	Incorrect sample preservation
IS	Internal standard recovery outside limits
J	Result is between MDL and RL
LCS	Lab control spike recovery is outside quality control limits
MB	Method blank contamination
MDL	Non-detect at MDL value
MI	Matrix interference with analyte quantitation
MS	Matrix spike recovery is outside quality control limits
PDS	Post digestion spike recovery is outside control limits
RB	Equipment rinse blank contamination
RPD	Duplicate sample relative percent difference exceeds QC limits
SD	ICP serial dilution percent difference outside QC limits
SUR	Surrogate recovery is outside QC limits
TB	Trip blank contamination
TIC	Compound was tentatively identified by GC/MS search
[1]**Always list reason codes in alphabetical order, separated by commas, no spaces**	

3.7.4 Labeling Errors

Occasionally sample bottles are mislabeled in the field, and this is most likely to happen when the field QC set is being collected. On many projects the entire QC set is collected at a single site, in the order: primary sample, duplicate sample, blank sample. When reviewing results, if the precision between the primary and duplicate sample is very poor for nearly all parameters and the blank sample has a detection for nearly every parameter, it is likely that the bottles were mis-labeled. Use professional judgement in re-assigning sample types. If this occurs, the database manager for instructions on how to remedy the mix-up. Also notify the field team leader and the quality assurance officer. Detail the mistake and resolution within the checklist.

4.0 FIELD DATA VALIDATION

Field data validation includes an assessment of QC samples collected by the sampling team, and a review of sampling documentation and record keeping. Field QC sample assessment is discussed first. Refer to the project QAPP to determine the type and frequency of field QC samples. Some projects require only field duplicates, others require field duplicates and field blanks, and more than one type of field blank may be required. Generally, field QC sample frequency is one field QC sample or sample set (duplicate and blank), per 20 primary samples; however, there may be projects which require one field QC set per day. The project QAPP will provide this information.

Data for the majority of Woodard & Curran CFRSSI projects is managed by the in-house data management team. The team has developed macro-enabled spreadsheets specifically for data validation (referred to as Data Validation Spreadsheet-DVS- below). Spreadsheet format may differ slightly across projects. In the examples within this section, spreadsheets developed for BPSOU are used in examples.

4.1 Data Summary Table Setup

Field QC files have been developed for BPSOU projects, and these can be found in the project specific folders within the data validation folder. Open the field QC template, immediately save it to the appropriate folder with an intuitive file name. Within the files there are worksheets for field blanks and field duplicate sets. Populate these worksheets by copying the appropriate results from the DV spreadsheet. Within the field duplicate worksheet be certain duplicate sets are aligning and analytical parameters are aligning. When copying data into the worksheets, do not paste over columns containing formulas. Once data is pasted into the correct worksheet, use “convert to number” to assure results are expressed as number values, not text values. If results are not expressed as number values, the formulas will not work.

The Blank worksheet checks for field blank results which do not meet criteria, and if criteria are not met (≤ the MDL), the blank result is multiplied by 5. The worksheet titled Dup calculates the RPD for duplicate pairs. The Dup worksheet also checks sample and duplicate results to see if there is > a 20% RPD between results, if results are ≥ 5X the RL, and if not, the spreadsheet checks the difference between the duplicate pair results. All field blank samples will be listed in the Blank worksheet and all field duplicate samples will be listed in the DUP worksheet. Data can be copied directly from the DVS into the QC templates.

To find field QC samples within the DVS, filter the data to isolate field duplicate and field blank samples. In the sample type column, field duplicates will be have a suffix of “-D” (FG-D, IS-D, or AS-D). The primary sample for each duplicate will have suffix of “-N” as in “FG-N”). Field blanks will be sample types such as FB, RB, TB, ECB, CCB, and in the location column any field collected blank will be identified as SWQC or GWQC. In the ensuing discussion, this field QC worksheet will be referred to as the Field QC Summary file (FQC).

4.1.1 Group Samples in Field QC Batches

As previously discussed, the field QC frequency for most projects is one field duplicate and one field blank per 20 primary samples. This is an overall rate; thus, if a project consists of 21-40 primary samples, two of each required QC samples could be collected on a single day. Ideally, field QC samples will be collected at a rate of one duplicate, one blank (as appropriate) within the first 20 primary samples collected. The second duplicate and blank will be collected between primary sample 21 and 40, the third QC sample set will be collected between primary sample 41 and 60, and so on. Results of the first duplicate and field blank will be used to assess primary samples 1-20, results of the second duplicate and field blank will be used to assess primary samples 21-40, etc. The primary sample counts (groups of 20) includes only primary samples; field QC samples are not included in the count.

Often project sampling is not completed in a single day and as an example, field QC samples may have been collected on two days of a three-day sampling event. Try to group primary samples/QC samples by SDG to simplify the validation process. In order to batch field QC samples with laboratory SDGs, it is allowable to group primary samples in groups of up to 22 primary samples (assuming the QC sample rate is 5% of primary samples). If this is done, some groups will have fewer than 20 samples. No matter how samples are batched, the overall field QC rate must have been met.

When validating samples collected in automatic samplers which collect multiple samples, try to avoid breaking up the sampler group. For example, if Samplers A, B, C, D, E, and F each collect four there would be 24 primary samples among the four samplers. If possible don't assign QC set 1 to the samples from samplers A, B, C, D, and two of the samples in Samper E and QC set 2 to the two remaining samples in Sampler E and the four samples from Sampler F. Rather, keep all samples in Sampler E with the same QC set.

4.2 Verify Field QC Parameters

Required field QC sample frequency and sample type is indicated in project QAPPs. Verify that QC sample type and frequency were met. All field QC samples must be analyzed for the same parameters analyzed in primary samples. If field QC sample type, frequency, or analyses did not meet the criteria specified in the project QAPP, this will be indicated on the field checklist, which is discussed in Section 5.1

4.3 Field Blank Results

Field collected blanks may be identified as field blanks, "trip" blanks, rinsate blanks, equipment contamination blanks, or cross contamination blanks. In this discussion, all of these will be referred to as FBs, and ideally all of these should have results less than the MDL. Any BP LaMP approved laboratory should report results to the MDL; thus, results below the detection limit will be reported as "< MDL" "ND" (non-detect), or as a value at the MDL accompanied by a "U" qualifier. If a result is reported at the MDL with no "U" qualifier, then the result was a detection at the MDL. Unless indicated in the project QAPP, laboratories not in the LaMP program may not report to the MDL, but to the reporting limit (RL). If this occurs, field blank results should be < RL.

Field collected blank results may be influenced by laboratory blank results; but, use discretion in qualifying field collected blank results based on laboratory blank detections. While the majority of projects do assess field collected blank results based on laboratory blank results, there are projects which assess the two types of blanks separately. Check with the project manager or quality assurance officer to determine which practice is followed for the analytical results being validated.

If FB results will be assessed against laboratory blanks, determine if it is likely that the FB result was influenced by laboratory contamination. With L+ and Full packages, ICB and CCB detections should be applied to FB results only if the FB was analyzed between out of control ICB/CCB samples. Since MBs apply to entire laboratory QC batches, FB results should be assessed against MB results, assuming the FB was analyzed in the same laboratory QC batch which had MB detections. There will be instances when FB results apply to samples which were analyzed in two or more laboratory QC batches. Table 43 provides guidance on assessing sample results when this occurs. Table 44 provides guidance for qualifying data based on FB detections. Table 43 and Table 44 should be used together. First determine which situation in Table 43 applies, then apply qualifiers as indicated in Table 44. If a data validation qualifier is assigned for the FB detection, add reason code "FB". Refer to Section 3.4.3 Laboratory Blank Data for guidance in qualifying data for laboratory blank detections.

Unlike laboratory blanks, the laboratory instrument value is not used in assessing FB detections. Use the reported result of the FBs and associated samples in assessing FB detections.

Table 43 – Field Blank Assessment in Relation to Laboratory Blanks

FB/MB/Samples all in same lab QC batch			
FB Result	**Lab Blank > MDL**	**FB Qualification**	**Associated Sample Qualification**
FB > MDL	MB > FB	Qualify FB for MB detection	Qualify samples based on MB detection
FB > MDL	FB > MB	Qualify FB for MB detection but use professional judgement. If the FB is >> MB and MB detection is ≤ 2X MDL it is doubtful the MB detection had an impact on the FB result.	Qualify samples based on FB detection

Table 44 – Field Blank Action

Field Blank Result	**Sample Results**	**Action for Samples**
FB < Lab Blank	Any	No action for FB detection. Data assessed based on lab blank results
> MDL	Non-detect (< MDL) > MDL but ≤ 5X blank value > 5X blank value	No action Qualify results as non-detect (U) No action

4.4 Field Duplicate Results

Check the RPDs between primary and duplicate samples and assign data qualifiers as indicated in Table 45. The RPD is determined by:

$$RPD\% = \frac{|S - D|}{\frac{S + D}{2}} \times 100$$

Where S = primary sample

D = duplicate sample

Acceptable RPDs are ≤ 20% for aqueous samples and ≤ 35% for solid samples. The 20%/35% limits are applicable when both the primary and duplicate sample are ≥ 5X the RL. If either the primary or duplicate sample are < 5X the RL, an acceptable RPD is < RL for aqueous samples or < 2X the RL for solid samples. When qualifying data based on field precision, consider matrix similarity in the same manner that it is assessed for laboratory duplicates and laboratory MS/MSD samples and consider the method used to collect the duplicate set. Qualifications based on FD RPDs are not applied to field collected blanks since they are made up of DI water, and the sample matrix differs from that which makes up the primary and duplicate sample.

When assessing RPDs, round to the whole number, with values < 20.5/35.5 rounded down and values ≥ 20.5/35.5 rounded up. Assign code "FD" to results qualified for field precision.

Table 45 – Field Duplicate Action

Duplicate Sample Results	Action for Samples
Both primary and duplicate sample ≥ 5X RL & RPD > 20%/35%	Qualify results ≥ MDL as estimated (J) Qualify non-detects as estimated non-detect (UJ)
Primary or duplicate sample result < 5X RL & absolute difference between sample and duplicate > RL (2X RL for solids)	Qualify results ≥ MDL as estimated (J) Qualify non-detects as estimated non-detect (UJ)
Primary or duplicate sample result < 5X RL & absolute difference between sample and duplicate ≤ RL (2X RL for solids)	No action

5.0 QUALITY DESIGNATION

Data quality is assessed by assigning each data point a quality of Enforcement (E), Screening (S), or Rejected (R). Before assigning quality, the Field Checklist must be completed, and samples must be designated as meeting Level A or Level B criteria. Note that only primary samples are assigned a quality status. A quality status is not applicable to field QC samples.

5.1 Level A/B Assessment

Note that Level A/B applies to entire samples, not individual data points. Figure 8 presents an example Field Checklist. The checklist may differ slightly across projects. The Figure 8 example was developed for Clark Fork River Superfund Site Investigations (CFRSSI) projects; and for those projects, the checklist is often referred to as the Level A/B checklist. The checklist is fairly self-explanatory. The checklist information can be found in field logbooks or on electronic field forms. If this information is not found in the logbooks or forms, within reason, it can be discerned through conversation with the sampling team. However, if conversations are necessary, the sampling team should be instructed to document the missing information for all future field efforts.

Based on the checklist review, all samples (primary samples and field QC samples) are designated as Level A, Level B, or Unusable. If a sample receives Level A or Unusable designation, all results for that sample would receive the reason code AB and be assigned screening quality, but a validation qualifier would not be applied. It is possible for a sample to be designated as Level B, but individual data points for that sample to be qualified as estimated and coded AB. This would only happen if the field QC samples associated with that sample did not undergo the full analysis the sample underwent. For example, if manganese analysis was requested for two primary samples, but the field duplicate did not undergo manganese analysis, the field QC requirements (item III.3 in Figure 8) would not be complete for manganese analysis. In such a case, the sample would be considered Level B, but the manganese results for the two samples would be qualified J, and an AB reason code applied.

A Level A/B checklists is attached as an appendix to these guidelines.

Figure 8 – Example Field Checklist

Level A/B Screening Checklist			
I.	**General Information**		**II. Screening Results**
	Site:	SITE NAME	Data are:
	Project:	SITE NAME/LAB SDG #	1) Unusable ________
	Client:		2) Level A YES or NO
	Sample Matrix:		3) Level B YES or NO
II.	**Level A Screening**		
			Yes/No
1.	Sampling date		
2.	Sample team/or leader		
3.	Physical description of sample location		
4.	Sample depth (soils)		
5.	Sample collection technique		
6.	Field preparation technique		
7.	Sample preservation technique		
8.	Sample shipping records		
III.	**Level B Screening**		
1.	Field instrumentation methods and standardization complete		
2.	Sample container preparation		
3.	Collection of field replicates (insert QAPP requirement)		
4.	Proper and decontaminated sampling equipment		
5.	Field custody documentation		
6.	Shipping custody documentation		
7.	Traceable sample designation number		
8.	Field notebook(s), custody records in secure repository		
9.	Completed field forms		

5.2 Quality Designation

Each primary sample data point is assigned a quality, Enforcement, Screening, or Rejected. Field QC samples do not receive a data quality designation. Enforcement quality data meet all QA/QC and documentation requirements and can be categorized as definitive data with unrestricted use. Screening quality data do not meet the applicable QA/QC requirements and/or documentation requirements and can be categorized as data whose associated numerical values are estimated. Unusable data may result from inappropriate sampling, analysis, or documentation procedures; or from field or laboratory calibration and/or QC sample results which are far outside of acceptable criteria. Unusable data is given a qualifier and a quality of R, rejected and these data cannot be used. Table 46 provides a matrix for determining data quality assignment. Note that the J qualifiers in Table 46 refer to those applied during validation, not J qualifiers applied by the laboratory.

Table 46 – Data Quality Matrix

Data Validation Qualifier	Level A/B Designation		
	Level B	Level A	Rejected
No qualifier, A qualifier or U qualifier	Enforcement (E)	Screening (S)	Unusable (R)
J, J+, J- or UJ	Screening (S)	Screening (S)	Unusable (R)
R	Unusable (R)	Unusable (R)	Unusable (R)

6.0 DATA VALIDATION SUMMARY

6.1 Data Validation Summary

The data validation checklist that is compiled throughout the validation process is one portion of the data validation summary. A second component is a short write-up which summarizes the outcome of data validation. The summary should state the number of primary sample data points, the number (and percentage) of data points which were assessed as enforcement quality, the number (and percentage) of data points assessed as screening quality, and the number (and percentage) that were rejected. The summary should also state the reason data points did not meet enforcement quality. Refer to the checklists in Appendix D for examples of data validation summaries.

6.2 Data Assessment Report (DAR.)

The frequency that data assessment reports (DARs) must be compiled differs among projects. For BPSOU projects, the DAR is compiled annually, and submitted as an appendix to annual Data Summary Reports. Rocker OU DARs are compiled quarterly and submitted as an appendix to quarterly Operations and Monitoring Reports. The details, table formats, and checklists included in DARs differs among projects. Generally, the depth of detail is driven by the project manager in conference with the project quality assurance officer, as well as the Agency reviewer. DARs include a write-up of data validation results of all analytical data for the reporting period, several tables, and checklists.

6.2.1 Review the DV spreadsheet.

Once the data validation spreadsheet, the data validation checklist, and the data validation summary are compiled, a competent person should review the spreadsheet, the checklist, and the summary report. Use the following items as a guide.

1. Ensure that all requested analyses have been reported. This can be done by performing a total count of data points and comparing that to the expected number of data points.
2. Make sure all required fields are populated in the DV file: validator qualifier, qualifier code, quality designation, validator, validation date, validation stage, Level A/B designation (AB designation is on a separate worksheet within the DV file).

3. Perform filter checks within the distribution file to check for the following mistakes:
   a. No Non-Detects were qualified J and No detects were qualified UJ (unless the data point was qualified as "UJ" during laboratory blank or FB assessment.)
   b. No FB samples were qualified due to MS, MSD, LDS, SD, FD, or FB codes unless the FB sample was used as the parent sample for the MS or LDS.
   c. Any result assigned an E quality does not have a corresponding qualifier or code. Any results assigned an S quality has a corresponding qualifier and code. Any result assigned an R quality has a R qualifier.
   d. No FD or FB results have been assigned a quality.
   e. All primary sample results have been assigned a quality.
4. Double check the totals vs dissolved metals concentration comparison. This is performed within the distribution file under the tab "DisTR_DBLinked". If there are numerous dissolved concentrations > total concentrations for a sample, it is likely that the two sample aliquots were mislabeled in the field, or a mix-up occurred at the lab.
5. Ensure that laboratory QC batches have been applied properly within the checklist.
6. Ensure sample and analysis dates are correct within the checklist.
7. Review the checklist and compare qualifications within the checklist to qualifications in the DV file to make sure that they agree.
8. Make sure all results are unfiltered prior to submittal.

6.3 Submit the Distribution File to the Data Team.

For BPSOU projects, data tracking should be performed within the DV Index Excel sheet on Teams. Completion, reviews, any rejected results or special cases (ie. switched sample results) should be documented in the Notes section of the DV Index file. This will be useful when compiling Data Assessment Reports. Once review and any necessary revisions are made, send the distribution file with the pre-assigned naming convention to: Donna Hawley, Jonathan Longden, and the appropriate project email address:

mailto:jlongden@woodardcurran.com

BPSOU and Rocker data: bpsoudata@woodardcurran.com
Great Falls Data: TrecDataGF@woodardcurran.com

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APPENDICES

Appendix A Measurement Performance Criteria for Data

Measurement performance criteria are established by defining acceptance criteria and quantitative or qualitative goals (e.g., control limits) for accuracy, precision, representativeness, comparability and completeness of measurement data. The definitions of precision, accuracy, representativeness, comparability and completeness are provided below along with the acceptance criteria for data collected. Equations for calculation of precision, accuracy and completeness are provided in Table 1– Holding Times and Preservation Requirements.

Table A1 Precision, Accuracy and Completeness Calculations Equations

Characteristic	Formula	Symbols
Precision (as relative percent difference, RPD)	$RPD = \frac{(x_i - x_j)}{\left(\frac{x_i + x_j}{2}\right)} \times 100$	x_i, x_j: replicate values of x
Precision (as relative standard deviation, RSD, otherwise known as coefficient of variation)	$RSD = \frac{\sigma}{\bar{x}} \times 100$	σ: sample standard deviation $\bar{x}$: sample mean
Accuracy (as percent recovery, R, for samples without a background level of the analyte, such as reference materials, laboratory control samples and performance evaluation samples)	$R = \frac{x}{t} \times 100$	x: sample value t: true or assumed value
Accuracy (as percent recovery, R, for samples with a background level of the analyte, such as matrix spikes)	$R = \frac{SSR - SR}{SA} \times 100$	SSR: spiked sample result SR: sample result SA: spike added
Accuracy (as percent difference, D, for samples > 50X the MDL, which have undergone at least a five-fold dilution, with the result, S, corrected for the dilution)	$D = \frac{\lvert I - S \rvert}{I} \times 100$	I: initial sample result S: serial dilution result
Completeness (as a percentage, C)	$C = \frac{n}{N} \times 100$	n: number of valid data points produced N: total number of samples taken

<u>Precision</u>

Precision is the level of agreement among repeated measurements of the same characteristic. There are two general forms of uncertainty. The first is the random error component of the data collection process. The second is inherent stochastic variability, which cannot be eliminated but can be described.

Data precision is assessed by determining the agreement between replicate measurements of the same sample and/or measurements of duplicate samples. The overall random error component of precision is a function of the sampling. The analytical precision is determined by the analysis of field duplicates by laboratories and by replicate analyses of the same sample. An analytical duplicate is the preferred measure of analytical method precision. When analytes are present in samples at concentrations below or near the quantitation limit, precision may be evaluated using duplicate analyses of laboratory prepared samples such as duplicate laboratory matrix spike samples (MS/MSD), duplicate laboratory control spike samples (LCS/LCSD), and/or laboratory duplicate (LD) samples. Precision can be measured as relative percent difference (RPD) or as relative standard deviation (RSD) (also known as a coefficient of variation). Formulae for both are presented in Table A1.

Accuracy/Bias

Accuracy is the degree of difference between the measured or calculated value and the true value. It is a measure of the bias or systematic error of the entire data collection process. Potential sources of systematic errors include:

- sample collection methods;
- physical or chemical instability of the samples;
- interference effects during sample analysis;
- calibration of the measurement system; and
- contamination.

Field blanks and laboratory method blanks (MB) may be analyzed to assess artifacts introduced during sampling, transport and/or analysis that may affect the accuracy of the data. In addition, initial calibration verifications (ICVs), continuing calibration verifications (CCVs), initial calibration blanks (ICBs), and continuing calibration blanks (CCBs) are used to verify that sample concentrations are accurately measured by the analytical instrument throughout the analytical run. Note that ICV, CCV, ICB, and CCB results are reported only in Level III and IV data packages.

Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point or environmental conditions. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling program. Representativeness of samples shall be achieved through the careful selection of sampling locations and methods. Sample representativeness may also be evaluated using the RPDs for field duplicate results, as well as field blank results. Agreement between duplicate samples is applicable to representativeness of individual sampling points, not the overall sampling program. If agreement between field duplicates is acceptable (≤ 20% RPD for sample concentrations greater than five times the reporting limit, and a delta < the RL for samples less than five times the reporting limit), it can be assured that the reported concentration is a valid representative measure of near-aquifer conditions. If agreement between duplicate samples is not acceptable, the reported concentration must be considered an estimation of conditions.

Comparability

Data comparability is defined as the measure of the confidence with which one data set can be compared to another. Comparability is a qualitative parameter but must be considered in the design of the sampling plan and selection of analytical methods, quality control protocols, and data reporting requirements. Comparability is ensured by analyzing samples obtained in accordance with appropriate SOPs. All analytical data should be calculated and reported in units consistent with standard reporting procedures so that the results of the analyses can be compared with those of other laboratories, if necessary.

Completeness

Completeness refers to the amount of usable data produced during a sampling and analysis program. When determining completeness, also consider the number of samples that were collected in terms of the number of samples that were anticipated to be collected.

Sensitivity

Sensitivity refers to the capability to quantify an analyte at a given concentration, and this parameter is associated with the instrument and method detection limits, and the project reporting limits. The desired analytical sensitivity are typically method detection limits less than the applicable water quality standards specified in Montana Circular DEQ-7, Montana Numeric Water Quality Standards and detection limits that will allow geochemical analysis.

Appendix B Comprehensive Holding Time Table

Table B1 – Expanded List of Holding Times and Preservation Requirements

Analyte	Method	Holding Time	Preservative	BPSOU BF	BPSOU WW	Diagnostic	Expanded	BPSOU GW	Rocker	Great Falls
Alkalinity: Total, Carbonate, Bicarbonate, & Hydroxide	SM 2320B	14 days	Raw 0-6°C	Total only	Total only			x	x	
Anions by Chromatography (bromide, chloride, fluoride, sulfate)	EPA 300.0	28 days	Raw 0-6°C				Cl, F, SO4	Cl, SO4		x
Anions by Chromatography (orthophosphate-P, nitrate, nitrite)	EPA 300.0	48 hours	Raw 0-6°C							
Chloride	SM4500-Cl C	28 days	Raw 0-6°C						X	
Fluoride	SM 4500-F− C	28 days	Raw 0-6°C							
Orthophosphate-P	SM4500-P B/E	48 hours	Raw 0-6°C							
Sulfate	ASTMD 516	28 days	Raw 0-6°C	x	x	x			x	
Dissolved Organic Carbon/Total Organic Carbon (DOC/TOC)	SM 5310 C	28 days	H_2SO_4 < pH 2 0-6°C	DOC	DOC		DOC			

Analyte	Method	Holding Time	Preservative	BPSOU BF	BPSOU WW	Diagnostic	Expanded	BPSOU GW	Rocker	Great Falls
Hardness[1]	SM 2340B	180 days	HNO_3 < pH 2	x	x					
Mercury (aqueous) total and dissolved by CVAA	EPA 245.1, SW846 7470	28 days	HNO_3 < pH 2	245.1	245.1			245.1		
Metals (aqueous) total and dissolved by ICP-AES	EPA 200.7, SW846 6010	180 days	HNO_3 < pH 2				SW846 6010B			
Metals (aqueous) total and dissolved by ICP-MS	EPA 200.8, SW846 6020, 6020A, 6020B,	180 days	HNO_3 < pH 2	200.8	200.8	200.8	SW846 6020A	200.8	200.8	
Metals (aqueous) - Dissolved Exotic by ICP-MS (Cs & Rb)	SW6020A_E	180 days	HNO_3 < pH 2				x			
Nitrogen - Ammonia	**EPA 350.1** SM 4500-NH3 B/C	28 days	H_2SO_4 < pH 2 0-6°C	x	x					
Nitrogen - NO_2/NO_3	**SM 4500-NO3 H** SM 4500-NO3 E SM 4500-NO2 B	28 days	H_2SO_4 < pH 2 0-6°C	x	x					

Analyte	Method	Holding Time	Preservative	BPSOU BF	BPSOU WW	Diagnostic	Expanded	BPSOU GW	Rocker	Great Falls
Nitrogen - Total Kjeldahl Nitrogen	**EPA 351.2** SM 4500-Norg B	28 days	H_2SO_4 < pH 2 0-6°C	x	x					
pH	EPA 150.1	24 hours	Raw 0-6°C				x	x		
Solids - Total Dissolved Solids	SM 2540C	7 days	Raw 0-6°C	x	x			x		
Solids - Total Suspended Solids	SM 2540D	7 days	Raw 0-6°C	x	x	x				
Solids, Total (TS)	SM 2540B	7 days	Raw 0-6°C							
Solids, Volatile (VS)	SM 2540 E / EPA 160.4	7 days	Raw 0-6°C							
Solids, Settleable (SS)	SM 2540 F	48 hours	Raw 0-6°C							
Solids, Volatile Suspended (VSS)	SM 2540 D / EPA 160.4	7 days	Raw 0-6°C							
Specific Conductivity	SM 2510B	28 days	Raw 0-6°C				x	x		

Analyte	**Method**	**Holding Time**	**Preservative**	**BPSOU BF**	**BPSOU WW**	**Diagnostic**	**Expanded**	**BPSOU GW**	**Rocker**	**Great Falls**
Total Metals in Solids by ICP-MS (Sb, As, Ba, Cd, Cr, Cu, Pb, Mn, Mo, Ni, U, & Zn)	SW6020	180 days	None				x			
Phosphorus **- Total**/Dissolved	**SM 4500P-B**/E	28 days	H_2SO_4 < pH 2 0-6°C	x	x					
Biochemical Oxygen Demand (BOD)	SM 5210 B	48 hours	Raw 0-6°C							
Chemical Oxygen Demand (COD)	SM 5220 D	28 days	H_2SO_4 < pH 2 0-6°C							
Sulfide, Soluble	SM 4500-S2− D	15 minutes	Raw 0-6°C							
Sulfide, Total	SM 4500-S2− D	7 days	ZnAc2 & NaOH pH > 9 0-6°C							

Appendix C Level A/B Checklist

Level A/B Screening Checklist

I.	**General Information**	**II. Screening Results**
	Site/BIF: BPSOU Project: Base Flow SW Monitoring Client: Atlantic Richfield Sample Matrix: Water	Data are: 1) Unusable _______ 2) Level A YES 3) Level B YES

II.	**Level A Screening**	**Yes/No**
1.	Sampling date	Yes
2.	Sample team/or leader	Yes
3.	Physical description of sample location	Yes
4.	Sample depth (soils)	N/A
5.	Sample collection technique	Yes
6.	Field preparation technique	Yes
7.	Sample preservation technique	Yes
8.	Sample shipping records	Yes

III.	**Level B Screening**	**Yes/No**
1.	Field instrumentation methods and standardization complete	Yes
2.	Sample container preparation	Yes
3.	Collection of field replicates (1/20 minimum)	Yes
4.	Proper and decontaminated sampling equipment	Yes
5.	Field custody documentation	Yes
6.	Shipping custody documentation	Yes
7.	Traceable sample designation number	Yes
8.	Field notebook(s), custody records in secure repository	Yes
9.	Completed field forms (COC Record)	Yes

Appendix D Example Data Validation Checklists

Example BPSOU GW Stage 2b Checklist

\\woodardcurran.net\shared\Projects\TREC\9208_AR_MT_BPSOU\9208-Butte-ARCO\A\DataValidation\2021\GW\Spring\CompletedReport\Level-IV_DV-Checklist_2021-05_10560318_r0.xlsx

Example BPSOU Normal Flow Stage 2a Checklist

\\woodardcurran.net\shared\Projects\TREC\9208_AR_MT_BPSOU\9208-Butte-ARCO\A\DataValidation\2022\SWBF\CompletedRpts\Level_II_Dv-Checklist_SWBF_10595253_r0.xlsx

Appendix C – MDEQ Sample Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Communities Standard Operating Procedure

Montana Department of
ENVIRONMENTAL QUALITY

Sample Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Communities Standard Operating Procedure

March 15, 2012

Approvals:

Dave Feldman, Biocriteria Specialist, Water Quality Standards — Date

Robert Bukantis, WQ Standards Supervisor, Water Quality Planning Bureau — Date

Mindy McCarthy, QA Officer, Water Quality Planning Bureau — Date

Darrin Kron, Monitoring and Assessment Supervisor, Water Quality Planning Bureau — Date

REVISION HISTORY

Revision No.	Date	Modified By	Sections Modified	Description of Changes
1	10/21/2004	DF, MB, BB	4,5,7, Appendices, Attachment 1	Quality Assurarnce procedures were added. The taxa list (Appendix 3) was updated The site visit field forms (Attachment 1) were updated.
2	09/08/2006	DF, MB, MS, BB	1,2,5,6,7, Appendices	The Montana Observed/Expected (a.k.a. RIVPACS) Model and Multimetric Indices (MMIs) were added. The Appendices were relabeled by letter instead of number. The taxa list (Appendix A) was updated. The Glossary of metrics was updated for the MMIs. Appendix D was added to the SOP.
3	03/15/2012	DF, MM, KM, BB	All	The scope of the SOP was refined to include which river segments were unwadeable and beyond the scope of the sampling protocols. The justification for the index sampling period was slightly modified. The coldwater O/E model and Bray Curtis (BC) Index were added. The MMIs were removed. The rarefaction instructions to prepare the data for the MMIs in Appendix C were removed and replaced with example outputs from both O/E models. The code to calculate the coldwater O/E model and instructions on how to use it was added as Appendix D. The laboratory subsampling procedures were updated to require that the labs submit their SOPs, and use unbiased subsampling procedures.

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ACRONYMS

Acronym	Definition
CW	Cold Water (fisheries)
DEQ	Department of Environmental Quality (Montana)
EDD	Electronic Data Deliverable
EMAP	Environmental Monitoring and Assessment Protocol
EPA	Environmental Protection Agency (US)
ETOH	95% Ethanol
FFP	Frost-Free Period Point
GIS	Geographic Information System
GPS	Global Positioning System
HBI	Hilsenhoff Biotic Index
ITIS	Integrated Taxonomic Information System
MQO	Measurement Quality Objective
NRCS	National Resources Conservation Service
O/E	Observed/Expected
OTU	Operational Taxonomic Units
PTD	Percent Taxonomic Disagreement
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RPD	Relative Percent Difference
RPDE	Relative Percent Difference in Enumeration
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
USU	Utah State University
WQX	EPA's Water Quality Exchange System

1.1 Scope and Applicability

The methods described herein are used for collecting and analyzing macroinvertebrate data from wadeable streams (1st order or higher) by or for the Montana Department of Environmental Quality (DEQ). Benthic macroinvertebrate data collected on large rivers is beyond the scope of this method. **Table 1-1** lists those large river segments.

Table 1-1. Non-wadeable river segments within the state of Montana

River Name	Segment Description
Big Horn River	Yellowtail Dam to mouth
Clark Fork River	Bitterroot River to state-line
Flathead River	Origin to mouth
Kootenai River	Libby Dam to state-line
Madison River	Ennis Lake to mouth
Missouri River	Origin to state-line
South Fork Flathead River	Hungry Horse Dam to mouth
Yellowstone River	State-line to state-line

1.1 General Considerations

Prior to conductiong a benthic macroinvertebrate survey, determine the specific data quality objectives (DQOs) and the information sought. DQOs can be qualitative or quantitative statements developed to specify the quality of data needed to support specific decisions and conclusions about the information sought. The DQOs should be documented in a Sampling and Analysis Plan or Quality Assurance Project Plan.

1.1.1 Index Period

The index period is the period of time that samples should be collected to minimize seasonal variation.

- The index period for Montana is generally the summer (June 21 to October 1), following runoff loeb (Richards D.C., 1996; Loeb and Spacie, 1994). Eastern Montana streams may be sampled May 1 to October 1.
- Sampling may occur outside of the index period, however this may reduce certainty that the data are comparable to historical data, reference conditions or indices (see discussion below).

The index period noted above was the temporal basis for reference conditions used in the development of the Observed/Expected (O/E) model. However, even within this index period, extreme runoff or summer drought conditions could affect these periods; professional judgment must be used when considering sampling schedules. Sampling macroinvertebrates during high flows, besides being potentially unsafe, is likely to increase sampling variance due to the difficulties associated with sampling these waters using the methods described herein.

When monitoring for trends at a particular site, minimize seasonal variation by sampling as close as possible to the same date each year.

1.1.2 Site Selection

Sampling requirements including the total number of sampling sites their location in the study area, and the spatial and temporal independence are outlined in each DEQ pollutant-specific assessment method. Some of the assessment methods do not require any biological samples to be collected for assessment decisions. Refer to the assessment method when determining the sampling design in order to achieve an appropriate assessment of the stream. Always consider potential constraints to collecting representative samples such as site access when selecting sites. Document any necessary changes due to site access restrictions.

The study design should specify requisite site specifications for the study. For example, many study designs use the riffle environment as the specific point of comparison between streams. A *rationale* described in the Sampling and Analysis Plan (SAP) for determining representative riffles for the anticipated stream types would be a *site selection specification*.

Although riffle areas with cobble substrates are generally the most diverse and productive habitat type, these may not be representative of the predominant type of habitat in the stream. If so, the study design should describe the variety of habitats, the rationale for representative sampling, and the various appropriate sampling techniques for the study.

There is ample evidence that the presence of lakes, impoundments, bridges, road crossings, and bedrock or large-boulder dominated substrates affect benthic invertebrate community composition; therefore, sampling sites should be located as far from these as is practical, *unless the objective of the study is to measure their localized influence*.

Always sample sufficiently upstream from the confluence of major tributaries or receiving waterbodies to minimize their influence on study sites. Otherwise, consider the mixing zone of the two waterbodies and select sites downstream of the confluence that are well mixed, and represent both the biological community and water quality conditions.

1.1.3 Sample Collection Methods

DEQ employs a semi-quantitative Environmental Monitoring and Assessment Protocol (EMAP) reach wide sampling technique to collect samples in a known area allowing the estimation of population density, in addition to diversity and abundance.

1.1.4 Checklist of Recommended Field Supplies

- ❑ Field Meter (pH, Spec. Conductance, DO)
- ❑ Macroinvertebrate sample bottles (1 liter wide mouth poly)
- ❑ Lab markers, external labels, clear tape, Parafilm-M
- ❑ Internal labels (paper)
- ❑ Sampler (D-frame net)
- ❑ Field notebook
- ❑ Field data sheets (Site Visit Form, Photo Documentation Form, Site Map Form)
- ❑ Camera
- ❑ GPS unit
- ❑ 95% Ethanol preservative
- ❑ 500 um sieve for washing and sorting out large objects
- ❑ Pencils

- ❑ Clipboard
- ❑ De-Ionized Water
- ❑ Hip boots or waders
- ❑ Maps
- ❑ Dishwashing brush
- ❑ Hard or soft-sided Coolers to store samples
- ❑ Small soft-sided coolers to transport samples

2.0 SAMPLE COLLECTION PROCEDURES

The following section discusses sample collection procedures used to sample macroinvertebrates in streams and wadeable rivers not listed in **Table 1-1**.

2.1 PRECAUTIONS

Care must be taken when looking for suitable sampling sites not to disturb the substrate or habitat in areas where samples might be collected. A sample collected where the substrate has been disturbed by walking may not be representative of the community.

Be sure to transfer the entire sample to the bottles. Only fill each bottle one-half to three-quarters full with sample to leave room for preservative. Capture all bugs by thoroughly cleaning off all large rocks and sticks. Excluding large rocks prevents grinding damage to bugs during transport. Discard cleaned rocks and sticks.

Pack and store collection bottles carefully and securely in order to protect the sample jars and prevent the loss of contents during transport or shipment.

2.2 SAMPLE LABELING

Accurate labeling of sample bottles is important to preserve critical information. Attach a preprinted label to the jar clearly identifying the sample (location, date, number of bottles, method of collection and sample number). Use pre-printed, fill-in-the-blank labels to help ensure that the sample information is complete.

2.2.1 Sample Containers and Preservation

Collection jars: 1-liter wide-mouth polyethylene bottle. (Note: It may be necessary to use more than one 1-liter polyethylene bottle.)

Use 95% ethanol (ETOH) to preserve the macroinvertebrate samples. . Please remember that ETOH is flammable! The drawback of using ethanol is that the fluid composition of the sample needs to be dominated by ethanol to properly preserve the sample. Because of this, try to keep as much water out of the sample jar as possible, and fill the sample bottle only one half with sample and the remainder with ETOH to fill the bottle completely. Split the sample using an additional bottle(s) if necessary, and be sure to correctly label the bottles using a numeric sequence (i.e. 1 of 3, 2 of 3, 3 of 3).

2.2.2 Sampling Quality Control

2.2.2.1 Field Replicates

Field replicates are collected to measure total method error and should always be included in the sampling design at a predetermined frequency (usually 10%).

Field replicates are two or more samples, collected side-by-side or consecutively, at the sampling site. Replicate samples should be taken at places that are very similar in terms of depth, substrate, composition, and slope. ***Always collect samples from downstream to upstream to avoid sample contamination***. Replicates are processed in the laboratory as discrete samples. They are compared directly to the original samples. Any difference represents total method error (e.g., heterogeneity of site, reproducibility of sampling technique, sorting error, and identification error).

Relative Percent Difference (RPD) is used to evaluate results differences between two replicate samples.

$$RPD = \frac{(result1 - result2)}{(result1 + result2)/2} \times 100$$

The results of replicated samples (i.e. O/E model results) should be < 20% RPD, however, each project must state its required replicate precision criteria based on project DQO's.

2.2.3 Benthic macroinvertebrate sampling methods and protocols

A variety of other sampling methods are available from EPA, USGS, and other organizations. It is beyond the scope of this SOP to discuss all available sampling methods, or the applicability of sampling design for determining the health of benthic macroinvertebrate communities using the Data Analysis and Interpretation tools presented in Section 5 of this SOP.

When sampling methods other than those listed in this SOP are used for water quality assessments by or for DEQ, the SOP(s) for the alternate methods must be attached or cited in the project's Quality Assurance Project Plan (QAPP) or Sampling and Analysis Plan (SAP). Any known (documented) or assumed comparability to the methods in this SOP should be cited or documented in these Quality Assurance (QA) documents.

2.2.3.1 Environmental Monitoring and Assessment Protocol (EMAP)

Currently, the DEQ Reference Project uses EMAP sampling protocols to identify and assess reference sites (Peck, 2006). These data were included in the compiled reference data collection used for the O/E models. Therefore, EMAP methods are considered valid sampling techniques for use with the tools presented in Section 5 of this SOP.

2.2.3.1.1 Reachwide Sample

The EMAP sampling protocol requires that a kick sample be collected at each of 11 transects (A though K), sampling from downstram to upstream along the reach; these kick samples are composited to obtain a sample that is representative of the entire reach. Collect each kick sample at each transect (A through K) at the assigned sampling point (left, center, or Right). Position a 500um D-frame kick net within a representative portion of the designated channel location and hold the net vertically upright with the base of the frame in contact with the substrate and the open portion of the net facing into the flow. See **Figure 2-1** for a conceptual diagram of the EMAP reach, and where to collect each macroinvertebrate kick sample. Note: if a sampling location that is unsafe to wade to is encountered, try to find a safer location either up or downstream approximately 1 meter of that location. Switch to another position (i.e., R.L,C) on the same transect if moving up or downstream to collect the sample isn't possible. Return to the initial sampling pattern at the next transect after the kick is collected. Here are some important points to consider when collecting macroinvertebrate samples:

- *Thoroughly* inspect and clean (with stream water) the net after each sampling event to ensure that all organisms have been removed to prevent contamination between sites. Consider the following procedures to ensure that all organisms are removed from the net and placed in the jars:
  - Rinse large rocks, sticks, and other debris into the net and thoroughly inspect them prior to discarding.
  - Use a small plastic spoon to scoop the sample into the sample jar.
  - Inspect the entire inner surface of the net and use clean forceps to carefully remove any organisms clinging to the net and place them into the sample jar.
  - Dump the contents of the net into a 500 um sieve, rinse stream water through the sieve to clean the sample of fine sediment and transfer the sample into the jar.
  - Elutriate each kick sample to separate the organic and inorganic portions before you transfer it into sample jars; this should help protect the soft-bodied macroinvertebrates from damage caused by inorganic material in the sample jar during sample transport and storage. Elutriate by submerging portions of the sample in a 5 gallon bucket containing some water, vigorously swirl the sample in the water to separate the organic and inorganic portions of the sample, then decant the floating material into the 500 micron sieve and transfer from the sieve into the sample jar. Repeat this process several times until almost the entire organic portion of the sample has been removed. Then transfer the inorganic portion to different sample jars and submit these along with the organic portions to the analytical laboratory.
  - When sampling a pool with little to no flow, follow the same procedure except use your hands or feet to push the sample into the net. If encountering a slackwater area choked with vegetation, sweep the net through the vegetation for 30 seconds over the $0.09m^2$ sampling location.
  - Add enough ETOH to submerge the debris in each sample jar as soon as the material from each kick is added to the jar to prevent damage or loss of some taxa by opportunistic predators.
  - Spray organisms clinging to the net with a dilute (10%) ammonia or (95%) EtOH solution to detach them from the net. Partially immerse the net in the stream to concentrate the detached organisms at the base of the net and/or use forceps to transfer organisms directly into the jar.
  - To collect replicate samples using the reachwide approach, simply collect replicate kicks at each transect at another location on the same transect. For example, if the regular sample is collected following the Right, Left, Center pattern, the replicate sample could either be collected following the Left, Center, Right or Center, Right, Left pattern.
  - Always check all of the sampling gear between sampling events to make certain all organisms were removed. This prevents sample contamination between sites and prevents biased biological assessments

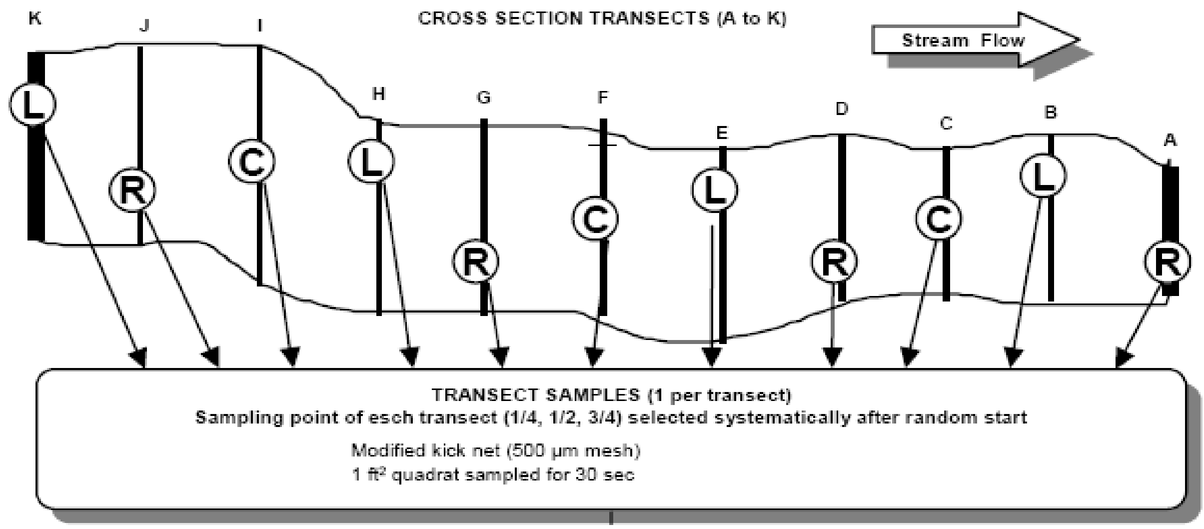

Figure 2-1. Sampling locations for the reachwide benthic macroinvertebrate sample within the sampling reach (adopted from Peck et al. 2006).

2.3 SUPPORTING FIELD DATA

Macroinvertebrate sample sites are described by metadata recorded at the time of sampling as well as any field observations taken at the time of sampling. Use the Site Visit Form (**Attachment 1**) to record metadata (GPS lat/long in decimal degrees, NAD 83) for the sampling site and record sample identifiers.

Digital photographs should be taken of the sampling site (upstream, downstream, and the site itself) and of the substrate sampled. Record metadata for the photos on the Photo Point Form (**Attachment 2**). As a back-up to digital photos, a sketch of the sampling site is recommended, along with an indication where the sample was taken at the site. A Site Sketch Form is included in this SOP (**Attachment 3**).

3.0 SUBSAMPLING & SORTING

Subsampling is using a representative portion of the field-collected sample for analysis. Sorting is the physical separation, counting, and grouping of organisms from the debris collected in the sample. All macroinvertebrate samples collected by and for DEQ should follow an unbiased subsampling procedure to achieve a target subsample count of 500 + 10% organisms.

It is important to understand the objectives of the project when selecting subsampling techniques. If the intention of the study is to measure population density (i.e., quantitative sampling), sort the entire sample. Full sample sorts can be used for samples collected by semi-quantitative collection methods if the study requires that all organisms are identified. However, full sample sorts are more time consuming for the taxonomist, adding additional expense to each sample.

3.1 PRE-SUBSAMPLING METHODS

To get a relatively even distribution of organisms prior to subsampling or sorting, remove large debris from the sample. There are two approaches to this sample clean up. The debris can be removed from the sample (picking) or the sample can be removed from the debris (elutriation).

3.1.1 Picking detritus

Picking the debris from the sample involves rinsing out fine material, removing large rocks, woody debris and setting them aside. Picking and rinsing should be performed in a 500 um sieve with a gentle stream of water to prevent splattering. Large rocks and sticks must be thoroughly scraped, rinsed and examined prior to setting them aside. The remaining sample is placed in an appropriate sized Caton tray for subsampling and sorting.

3.1.1.1 Elutriation

Elutriation is basically an extraction of the organisms from the substrate remaining in the sample. This technique works best when the substrate is inorganic material such as sand, pebbles, and rocks. Samples with a large amount of organic material are not amenable to this extraction. Field elutriations can be performed to reduce the number of jars a field crew transports to the macroinvertebrate laboratory or to separate soft-bodied macroinvertebrates from the course material in a sample.

Dump the sample into a 5-gallon bucket and fill the tray with water. Swish the sample around in the tray to liberate organic material and bugs from the substrate. The organic material and organisms should float in the water. Pour the water and all floating material and organisms into a 500um sieve. Add more water and repeat the process until no more organic material remains in the tray. Note: A 10% magnesium sulfate solution can be used instead of just water to increase the efficiency of the elutriation.

Once the sample is separated, use a magnifying lamp to check the inorganic portion of the sample for snails, clams, stone cased organisms, or any other organism too heavy to have floated. Have a fellow technician take a second look to verify that all organisms were removed. Any organisms found in the inorganic fraction must be added to the organisms in the sieve so they may be included in the sort. If a large number of organisms are found remaining in the inorganic fraction, the elutriation technique is not appropriate and the sample fraction in the sieve must be recombined with the inorganic fraction and sorted as a whole.

3.2 SUB-SAMPLING AND SORTING

The techniques for subsampling and sorting vary slightly between the contractors used by DEQ. Rather than describing (in detail) each contractor's specific method, DEQ requires that each contractor documents their procedure in a SOP, which includes the following components:

- Magnifying glass or microscope used for subsample and sort. (Specify power)
- Standardized sorting bench sheets
- Random selection of cells
- Last cell chosen
- Quality Controls to determine sorting efficiency or precision

SOPs must be submitted to DEQ as part of the contractor qualification process.

3.2.1 Sorting Quality Control (QC)

3.2.1.1 Relative Percent Difference in Enumeration (RPDE)

DEQ evaluates the precision of sample counts taken for the subsamples by calculating the relative percent difference of enumeration (RPDE). The RPDE is the standard formula used to evaluate how well a laboratory performs by comparing a sample result versus the result generated by a second laboratory evaluating the same sample (American Public Health Association, et al., 1998). Calculate the RPDE by comparing results from two independent laboratories or taxonomists using the formula:

$$\text{RPDE} = \frac{\left|\text{Sample Result}_1 - \text{Sample Result}_2\right|}{(\text{Sample Result}_1 + \text{Sample Result}_2)/2}$$

where *sample result$_1$* is the number of organisms in a sample counted by the first laboratory, and *duplicate result$_2$* is the recount by the second taxonomist or laboratory (adapted from Standard Methods 20th Ed. - 1020 B (American Public Health Association, et al., 1998)). The purpose of this calculation is to highlight those samples where counts differ substantially and to focus attention on obtaining better consistency.

The measurement quality objective (MQO) for RPDE is 10%. Values for individual sample comparisons exceeding the MQO (> 10%) require an examination to determine causes of the difference. Upon completion of this investigation, DEQ will communicate when and if the RPDE exceeds 10% to the taxonomic contractor and QC taxonomist(s). This will occur as a conference call and/or e-mail correspondence with the contractor(s).

4.0 TAXONOMY

4.1 TAXONOMIC IDENTIFICATION

Consistency in macroinvertebrate taxonomy is critical for final site assessments and interpretation. It is the responsibility of the taxonomist to communicate the composition of samples to those personnel performing data entry, and to be able to defend taxonomic results to the ultimate data analysts. DEQ encourages taxonomists to identify specimens to the *lowest practical taxonomic level*. However, DEQ also understands that specimen condition (damage, early instar, poor slide mounts) may force the taxonomist into an unavoidable situation of having to leave identification at more coarse levels (e. g., family instead of genus). With the limitation of organism condition in mind, DEQ will judge consistency of data based on historical hierarchical levels that have been achieved, resulting in the Montana Master Taxa list (**Appendix A**).

Count vs. non-count specimens. In general, all specimens in the subsample should be identified and counted by the taxonomist, including pupae. However, there are several exceptions known as <u>non-counts</u>, which include:

- Empty mollusk shells (lacking soft tissue)
- Worm fragments lacking the anterior (head) end
- Body parts NOT INCLUDING at least the head and thorax
- Surface dwellers such as Collembola, Gerridae, and Veliidae

- Incidentally-collected terrestrial specimens

Some hierarchical inconsistency in taxonomic data is dealt with during coding and analysis (see **Section 5.2**). During development of the Observed/Expected (O/E) models (**Section 5.5**), operational taxonomic units (OTUs) are specified to reduce the influence of ambiguous taxonomy. The complete Montana taxa list with OTUs and other attributes is available from DEQ as a table within the DEQ macroinvertebrate database and as **Appendix A**. A template for tracking identification and enumerations is provided as **Appendix B**.

4.2 Quality Control for Taxonomy

All QC activities, including specification and response to corrective actions, should be completed *prior* to initiation of data reduction (metric calculation and indicator analysis). The aspects relevant to taxonomic data quality are: accuracy and precision (Stribling, et al., 2003).

4.2.1 Accuracy

Accuracy is defined as the nearness of a measurement to a specified analytical truth. For taxonomy, there are several options that can be used as the analytical truth, including:

- Museum-based type material (holotype, paratype, or other; the original specimen or series of specimens on which the original description of a species is based),
- The most current and accepted taxonomic literature (dichotomous keys with illustrated, diagnostic morphological characters), or
- A reference collection, verified by an independent taxonomic specialist.

Type material is usually found in museums, and direct interaction with museum curators is required to use it for comparisons. Thus, it is often not feasible, or even necessary, for routine monitoring and assessment programs or projects (Stribling et al. 2003). Contractors must provide at least one reference collection per year that can be verified by a qualified, independent macroinvertebrate taxonomist. Depending on the magnitude of an individual project, a project-specific reference collection may be requested by DEQ; what the reference collection is intended to represent will be determined by DEQ. Whether the reference collection is annual or project-based, specimens included in it are intended to represent the original taxonomist's concept of the morphological basis of each taxon. Verification of the reference collection, by DEQ staff or independent laboratories or taxonomists, documents the morphological and nomenclatural understanding of the original taxonomist. This will provide DEQ with some assurance of the contract taxonomist's use of up-to-date nomenclature (with the Integrated Taxonomic Information System [ITIS] as the standard), as well as verifying their understanding of the morphological bases of taxonomic groupings.

4.2.2 Precision

Precision is defined as nearness of different measures of the same property. Simply stated, it is a measure of consistency and repeatability; for production taxonomy (Stribling et al. 2003), quantification of taxonomic precision provides the ability to document and communicate the quality of taxonomic data within a project, or within a laboratory over time. Taxonomic precision is evaluated by direct comparison of the results (list of taxa and number of individuals of each) of a randomly-selected sample that is processed by 2 taxonomists or laboratories. Once a sample is identified by the primary taxonomist (T1), it is sent to an outside, independent taxonomist (T2), who re-identifies the entire (sub)sample. The sample should be sent to T2 blind, that is, without any identification labels associated with the material. Each taxonomist will be provided with a hierarchical target list (standard level of effort for each taxon) and “counting rules” (need to be included as attachments). The total set of randomly-selected subsamples is a subset of the total number of samples collected for:

- A single project,
- Multiple projects within a sampling year, or
- >1 projects over several sampling years.

If multiple taxonomists within a project or laboratory have each identified enough samples, the subset can be stratified among the taxonomists so that specific checks can be made on individual taxonomists. Generally, and as a rule-of-thumb, the subset of samples can be approximately 10% of the total sample lot. For example, if a project has a total of 30 samples, there should be 3 samples randomly selected that will be re-identified by an outside/independent taxonomist. It is recommended that there be at least 3 samples selected and re-identified for sample lots of ≤ 30. For large programs or projects, say > 500 samples, it may be unnecessary to have 50 samples re-identified, but that decision will be made by DEQ.

Using the final results by the taxonomists, precision is quantified for both specimen enumeration and taxonomic identifications for each of the QC or re-id samples.

4.2.2.1 Percent Taxonomic Disagreement (PTD)

Use the formula below for determining Percent Taxonomic Disagreement (PTD):

$$PTD = \left[1 - \left(\frac{comp_{pos}}{N}\right)\right] \times 100$$

Where: $comp_{pos}$ is the number of agreements, and N is the total number of organisms in the larger of the two counts (Stribling et al. 2003).

Three types of taxonomic errors are illuminated by this comparison process: 1) straight disagreements, 2) hierarchical differences, and 3) missing specimens. Effort will be made during the side by side comparison of individual samples to specify the types of differences that are observed, and which types predominate in each sample. The lower the PTD value, the greater is the overall taxonomic precision, indicating relative consistency in sample treatment. For the 2006 field season and beyond, an MQO for PTD ≤ 15% is established. Values for individual sample comparisons exceeding the MQO (> 15%) will prompt a more detailed examination of those individual samples to determine the cause or causes of the difference in counts. PTD results as well as parsing of the difference types will be used by DEQ to develop corrective actions. Corrective actions related to taxonomic disagreement will be forwarded in writing to the taxonomy laboratory responsible for the primary identifications. The corrective actions will require that the contractor(s) correct the entire sample lot, or only the 10% subset that were the QC samples.

4.2.2.1.1 Bias

Bias is defined as statistical or method error caused by systematically favoring some outcomes over others and can be characterized as the degree of departure from a true value. Taxonomic bias exists if there are consistent misinterpretations of dichotomous keys or morphological features, poor processing of samples (e.g., poor slide-mounting techniques), or inadequate optical equipment. There is no specific

MQO established for bias but it may be a factor in the review of accuracy, which is described as low bias (directional error) and high precision.

4.2.3 Corrections to database

Any corrections to DEQ databases will be handled by the DEQ QA Officer, who will work directly with the DEQ MT-eWQX Coordinator and the DEQ macroinvertebrate specialist, who are responsible for the MT-eWQX and EDAS databases, respectively.

5.0 DATA ANALYSIS AND INTERPRETATION

Data analysis and assessment of biological integrity should be performed following the six steps listed here and described in **Sections 5.1** – **5.6**.

1. Transfer sample data from laboratory output to a reliable database
2. Reduce sample data
   a) condense to proper OTUs
   b) exclude taxa marked
   c) artificially reduce large samples
3. Compile site information (predictor variables) and identify site classes
4. Calculate the Montana-specific version of the Hilsenhoff Biotic Index (HBI)
5. Calculate a Observed/Expected(O/E) Model Result
6. Assess site biological integrity through interpretation of index results

Most of these steps are considerably simplified by using EDAS (Tetra Tech and Montana Department of Environmental Quality, 2006), which can be obtained from DEQ along with its User's Manual (Tetra Tech, 2006). Compiling site information (step 3), calculating the O/E model (step 4), and the interpreting the results (step 5) are accomplished using other technologies and procedures described below.

5.1 TRANSFER SAMPLE DATA

Benthic macroinvertebrate taxa lists with individual counts should be transferred into EDAS (Tetra Tech 2006a) or another database in which taxa can be associated with the taxonomic attributes used in calculating metrics and predictive models. EDAS includes a function that automates import of taxonomic data after the data are properly formatted in a spreadsheet. With any data transfer procedure, the accuracy of the transfer should be checked to assure 100% accuracy.

5.2 REDUCE SAMPLE DATA

5.2.1 Operational Taxonomic Units (OTUs)

For each taxon in a sample taxa list, the OTU must be determined. OTUs are identified in the Benthic Master Taxa table of EDAS. This is the level of identification at which taxonomic counts are condensed for calculations, for O/E (predictive model) calculations[1]. For instance, midges (Diptera: Chironomidae) have OTUs at the subfamily level because this is the level at which all agencies in Montana reliably

[1] Note: OTUs are not considered taxonomic target levels. Future DEQ macroinvertebrate tools may require different taxonomic requirements. Therefore, macroinvertebrate taxonomy should include identifications at the lowest practical taxonomic level, as stated in **Section 4-1**.

identify them. Numbers of individuals in multiple taxa identified at a more detailed level are summed within a sample if the OTU is at a more coarse level. OTUs for metric calculations include family and order level identifications. OTUs for predictive models exclude family and more coarse identifications for some taxa groups.

5.2.2 Excluded Taxa

In calculations of metrics that are counts of taxa (richness metrics), only those taxa that are unique within each sample should be counted. Ambiguous taxa are excluded from taxa counts. Such taxa include family level identifications within a sample that also includes genus level identifications from the same family. Likewise, order or coarser identifications may be ambiguously unique and should be excluded. Such exclusions should be made after converting taxa and individual counts at the appropriate OTU level. In EDAS, 'Excluded Taxa' are automatically marked as they are imported. Excluded taxa can also be marked manually. Within each sample, every OTU taxon that defines a group that is also represented by another OTU taxon identified at a more detailed taxonomic level should be marked for exclusion from metrics that count unique taxa.

5.2.3 Re-Sampling

Random re-sampling is the process by which samples larger than the target subsample size are reduced to the exact target subsample size. Random re-sampling generates a list of taxa and their abundances that would occur if the original sample had identified only the target number of individuals. Such a list is necessary for the predictive model, in which presence and absence of taxa for a standard sample size is required. It contrasts from rarefaction, which gives a probability for every taxon, but does not reduce the list of individuals or taxa.

In EDAS, random re-sampling is accomplished by assigning a random number to each individual in an oversized sample, ordering the list by the random numbers, and selecting the top 300 individuals to represent the new sample. By this method, some individuals and perhaps some uncommon taxa are eliminated from the list. Because it uses random number generators in determining the final list of taxa, random re-sampling can result in different taxa lists every time it is executed.

5.3 IDENTIFY SITE CLASSES

5.3.1 Predictor Variables

Site classes for the predictive model (O/E) are not distinct, but are calculated as probabilities within the model. Both indices require predictor variables for site classification (**Table 5-1**). These variables can be derived by associating geographically referenced data with the coordinates and delineated watersheds of each site. While it is possible to derive predictor values through map analysis, watershed delineation and spatial analyses are best performed with a Geographic Information System (GIS), such as ArcGIS 9.x or 10.x. The GIS analysis is outlined in Chinnayakanahalli et al. (2006). The basic GIS analytical procedures include the ***association*** of Station IDs with waterbody names with ***geographic*** coordinates, loading the spatially referenced stations into the GIS program, verifying station locations, delineating catchments using Digital Elevation Models (DEMs), and intersecting station points and catchments with the appropriate predictor data layers.

Table 5-1. Predictive variables associated with each sampling station.

Variable (EDAS name)	Description	Model	Data Source
Latitude (GIS_LAT)	Latitude (decimal), confirmed during delineation	O/E 2005; 2011	GIS or map
Longitude(GIS_LONG)	Longitude (decimal), confirmed during delineation	O/E 2005	GIS or map
Area (SQ_KM)	Catchment area (km^2)	O/E 2005; 2011	GIS or map
Basin (Columbia River Basin)	Within the Columbia River Basin (1 = yes, 0 = no)	O/E 2005	GIS or map
Air Temperature (TMAX_PT)	Annual mean of daily maximum temperatures at the site between 1971-2000 (C x 10, e.g., 14.4 degrees C = 144)	O/E 2005	PRISM database[a]
Standard Deviation of the elevation within the watershed (ELEVsd_WS)	The standard deviation of the digital elevation model data within the watershed	O/E 2011	GIS
Air Temperature (TMAX_PT_2011)	Annual mean of daily maximum temperatures at the site between 1961-1990 (C x 10, e.g., 14.4 degrees C = 144)	O/E 2011	PRISM database[a]
Julian Day (DAY)	Numeric Day of the year (1-365)	O/E 2011	Calendar
Mountains (Mtn1)	Classified as a coldwater stream (1 = yes, 0 = no)	O/E 2011	ARM[b]

[a]PRISM: Parameter-elevation Regressions on Independent Slopes Model (Daly, et al., 2004), URL: http://www.ocs.orst.edu/prism/
[b]Administrative Rules of Montana

5.4 Calculate Macroinvertebrate Indicator Results

5.4.1 Calculate the Montana-specific Hilsenhoff Biotic Index (HBI)

The HBI metric represents the relative sensitivity of the sample to nutrient perturbation. It is calculated as the average tolerance value of all individuals in the sample (excluding those without tolerance values). The range of the Biotic Index values is 0-10, 0 being sensitive and 10 being pollution tolerant. The biotic index values are listed in the "TolVal" column in the Master Taxa List in **Appendix A**. The HBI results are calculated using a weighted average:

$$HBI = \sum (ni \; x \; ai)/N$$

Where:
"n" is the number of individuals in a taxon, "i";
"a" is the index value assigned to that taxon;
N is the number of individuals in the sample with a Biotic Index value.

5.4.2 Calculate Observed/Expected

The O/E models are calculated as the ratio of the number of taxa observed (O) in the collected sample to the number expected (E) in that site type (Feldman and Jessup, 2012). The O/E ratio is calculated from sample taxa lists and predictive variables that are either uploaded to a website that runs the model or via the coldwater O/E model built using the R statistical language. The website is maintained by the Utah

State University's (USU) Western Center for Monitoring and Assessment of Freshwater Ecosystems (http://www.cnr.usu.edu/wmc/). The R code for the coldwater O/E model is detailed in **Appendix D**. Details for generating uploadable files from EDAS and running either of the models are available in the EDAS User's Manual (Tetra Tech 2010) and on the website. An explanation of the theory and processes of the model is included in Feldman and Jessup (2012).

5.5 Validating Model Outputs

Output from either O/E model provides information to determine the validity of the values (see **Appendix C**). Validity is dependent on having a minimum sample size after data reduction and, for the O/E, on model recognition of the combination of predictor variables. Sample sizes for the O/E may be different for the same sample because the O/E discounts some coarse taxa identifications (see **Section 5.2**). To determine whether the O/E could recognize the combination of predictor variables, refer to the website results labeled 'outlier'. An outlier O/E test result indicates a site that is outside of the experience of the model and the O/E value may be unreliable.

5.6 Interpret the Observed/Expected Index

The interpretation of benthic macroinvertebrate data is a component within the broader Water Quality Assessment Method (Montana Department of Environmental Quality, 2011). Depending on the availability and rigor of other biological data, benthic macroinvertebrate data *may not,* be used exclusively for aquatic life and fisheries beneficial use support determinations. With this in mind, this section of the SOP uses the terms: "pass", or "fail" in relation to the biological model test in the context of the biological component within an established water quality assessment method (**Appendix D**).

The O/E model is used with established assessment methods to determine the integrity of the macroinvertebrate community. The O/E models are used to test how far a given macroinvertebrate community deviates from those sampled at reference sites.

O/E values in **Table 5-4** indicate when a macroinvertebrate sample either passes or fails the biological model test. Note: some DEQ stressor-specific assessment methods apply different O/E thresholds in a different manner than those presented in **Table 5-4** (see Suplee and Sada de Suplee, 2011). Follow the guidelines in those assessment methods when using the biological indicators for stressor-specific assessments. Otherwise use the thresholds in **Table 5-4**.

Table 5-4. Biological test thresholds based on O/E results.

O/E Model	Region (stream setting)	Pass	Fail
2005	Eastern MT (plains)	≥ 0.80	< 0.80
2011	Western MT (mountain/transitional)	≥ 0.90	< 0.90

5.6.1 Bray-Curtis Index

A supplemental measure to the O/E model is the Bray-Curtis Index (BC) (Van Sickle, 2008). The BC index is derived from some of the same information used to calculate the O/E score. It can be a useful tool for discerning counterintuitive O/E results. The BC Index is most helpful whenever a high (i.e. good) O/E score results from a sample collected from a known stressed stream. Occasionally this occurs when certain stressors (e.g. excess nutrients) cause some taxa to be **replaced** by other taxa that are more tolerant of the stressors, resulting in a high O/E score in a stream with high stressors. The BC Index shows when new taxa have replaced others taxa above and beyond what the O/E model expected to measure in a given stream.

The formula for the BC Index is the sum of the absolute differences in the number of presence/absence (1,0) of observed taxa (O) minus their associated probabilities of capture (P) divided by the total sum of the O + P values:

$$BC = \frac{\sum|O - P|}{\sum(O + P)}$$

Note that the O is the formula above is not the raw count of individuals from a taxa group (e.g., 15 *Tricorythodes sp.* out of 100 total individual insects counted in a sample). Rather, it is a dummy variable indicating whether or not even a single individual of the taxa in question was observed in the sample (o no, 1 yes). The BC Index is scaled in the opposite direction than the O/E model. The BC scores will range between 0 and 1; a score of 0 means that no taxa replacement has occurred, and 1 means that all of the taxa have been replaced with other taxa**.** Use the BC Index ***only*** to help guideyour assessment decisions when you believe you are getting an incorrect O/E score. It is not meant to trump or replace the O/E score, just to clarify it. Van Sickle (2008) reported that the BC Index was more sensitive to several stressor gradients based upon nationwide datasets. You can use it to show when a community is shifting before the O/E model will react to the stressor.

5.6.1.1 How the BC Index Can Be Helpful

Table 5-6 shows a hypothetical macroinvertebrate sample collected from a stream with a high measured stressor (e.g., a fine sediment source) upstream of the sampling location. For demonstration purposes, this is an extremely small sample (five taxa). Remember that the “E” in the O/E formula is the sum of the probability of capture values for all of the taxa in a sample.

Table 5-6. A hypothetical example that demonstrates the O/E calculation, the absolute difference for the hypothetical observed (O) and expected (P) taxa, and sum of O and P for 5 taxa (adopted from Van Sickle 2008).

Taxon	O	P	|O - P|	(O + P)
1	1	0.1	0.9	1.1
2	1	0.3	0.7	1.3
3	1	0.8	0.2	1.8
4	0	0.9	0.9	0.9
5	0	0.9	0.9	0.9
	O = sum =3	E= sum = 3	Mean = 0.72; sum = 3.6	sum = 6

In this scenario, taxa 4 and 5 were expected by the model to be in the sample (i.e., probability of capture = 0.9; however, they were not collected, therefore O = 0 for both taxa. Taxa 1 and 2 were very unlikely to be collected, yet they were collected (O = 1 for each taxon). The probability of capture rates for taxa 1 and 2 was 0.1 and 0.3, respectively. The O/E score in this scenario = (3/3) = 1, and at first blush, this could be interpreted as a reference quality stream supporting a healthy macroinvertebrate community. In the example, however, recent habitat observations of high fine sediment deposition suggested an impairment really is occurring at the stream but it was not detected by O/E. The BC Index = 0.6 (3.6/6.0). This means that 40% of the taxa in this sample were replaced by rare, potentially tolerant, taxa. With this combination of O/E and BC scores, you can say that the macroinvertebrate community was in the process of adjusting to the instream changes in stressor levels.

5.7 Reporting Results

Reports written for the DEQ following the methods described herein require:

- The EDAS output and a concise one paragraph ecological interpretation. The ecological interpretation includes a description of the invertebrates found in the sample and what their presence represents in terms of water quality.
- Taxonomic lists of macroinvertebrates, including tolerance values and functional feeding group designations used for each taxon. Taxa lists should include class, order, family, genus, and species designations where possible. Taxa lists should follow the taxonomic classification scheme shown in **Appendix A** to facilitate DEQ quality assurance activities.
- Copies of taxonomic bench sheets should be included (Taxa List Template example provided in **Appendix B**.)
- Number pages on all reports, including appendices.
- A clear and concise summary of findings and conclusions.
- Clearly document the dates samples were collected in any written report.
- If an internal reference is developed for the analysis, describe the internal reference used.
- Clear documentation of the proportion of sample subsampled.
- Submit data both in hard copy and in electronic form (EQUiS/WQX Compatible).
- If any further analysis is needed in which the O/E models cannot be used, contact David Feldman; Water Quality Standards Section; Montana Department of Environmental Quality, PO Box 200901, Helena MT 59620- 0901 (406)-444-6764, dfeldman@mt.gov or the current biocriteria specialist for the state of Montana.

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APPENDIX A - MONTANA MACROINVERTEBRATE TAXA LIST

Phyla	Class	Order	Family	FinalID	TolVal	OTU_2005	OTU_2011
Arthropoda	Insecta	Diptera	Chironomidae	Ablabesmyia	8	Tanypodinae	Ablabesmyia
Arthropoda	Insecta	Diptera	Chironomidae	Acalcarella	8	Chironominae	NA
Arthropoda	Arachnida	Acarina	Acarina	Acarina	5	Acarina	Acari
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acentrella	4	Acentrella	Acentrella
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acentrella insignificans	4	Acentrella	Acentrella
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acentrella turbida	4	Acentrella	Acentrella
Arthropoda	Insecta	Lepidoptera	Pyralidae	Acentria		Lepidoptera	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acerpenna		Acerpenna	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acerpenna pygmaea		Acerpenna	NA
Arthropoda	Insecta	Diptera	Chironomidae	Acricotopus	6	Orthocladiinae	NA
Arthropoda	Insecta	Plecoptera	Perlidae	Acroneuria	0	Acroneuria	Perlidae
Arthropoda	Insecta	Plecoptera	Perlidae	Acroneuria abnormis	2	Acroneuria	Perlidae
Arthropoda	Insecta	Diptera	Culicidae	Aedes	7	Culicidae	NA
Arthropoda	Insecta	Odonata	Aeshnidae	Aeshna		Aeshna	NA
Arthropoda	Insecta	Odonata	Aeshnidae	Aeshnidae	5	Aeshnidae	NA
Arthropoda	Insecta	Coleoptera	Dytiscidae	Agabinus		Agabinus	Dytiscidae
Arthropoda	Insecta	Coleoptera	Dytiscidae	Agabus	5	Agabus	Dytiscidae
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Agapetus	0	Agapetus	Glossosomatidae
Arthropoda	Insecta	Diptera	Blephariceridae	Agathon	0	Blephariceridae	NA
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Agraylea	8	Agraylea	Hydroptilidae
Arthropoda	Insecta	Hemiptera	Naucoridae	Ambrysus	3	Naucoridae	Other_Hemiptera
Arthropoda	Insecta	Hemiptera	Naucoridae	Ambrysus mormon	3	Naucoridae	Other_Hemiptera
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	0	Ameletus	Ameletidae
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Ametor		Ametor	Hydrophilidae
Arthropoda	Insecta	Ephemeroptera	Ametropodidae	Ametropus		Ametropus	NA
Arthropoda	Insecta	Trichoptera	Brachycentridae	Amiocentrus	3	Amiocentrus	Amiocentrus
Arthropoda	Insecta	Trichoptera	Brachycentridae	Amiocentrus aspilus	3	Amiocentrus	Amiocentrus
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	Amnicola		Hydrobiidae	NA
Arthropoda	Insecta	Odonata	Coenagrionidae	Amphiagrion	7	Amphiagrion	Zygoptera
Arthropoda	Insecta	Trichoptera	Limnephilidae	Amphicosmoecus canax		Amphicosmoecus	Limnephilidae
Arthropoda	Insecta	Plecoptera	Nemouridae	Amphinemura	2	Amphinemura	NA
Arthropoda	Insecta	Plecoptera	Nemouridae	Amphinemura banksi	2	Amphinemura	NA
Crustacea	Malacostraca	Amphipoda	.	Amphipoda		Amphipoda	Amphipoda
Arthropoda	Insecta	Coleoptera	Amphizoidae	Amphizoa		Amphizoa	NA
Arthropoda	Insecta	Trichoptera	Limnephilidae	Anabolia		Anabolia	Limnephilidae

Phyla	Class	Order	Family	FinalID	TolVal	OTU_2005	OTU_2011
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Anacaena	5	ANACAENA	Hydrophilidae
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Anagapetus	0	Anagapetus	Glossosomatidae
Arthropoda	Insecta	Ephemeroptera	Acanthametropodidae	Analetris eximia		Analetris	NA
Arthropoda	Insecta	Odonata	Aeshnidae	Anax	5	Anax	NA
Arthropoda	Insecta	Odonata	Aeshnidae	Anax junius		Anax	NA
Annelida	Annelida	Annelida	Annelida	Annelida		Annelida	NA
Arthropoda	Insecta	Diptera	Culicidae	Anopheles	10	Culicidae	NA
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	3	Antocha	Antocha
Arthropoda	Insecta	Trichoptera	Apataniidae	Apatania	3	Apatania	Apataniidae
Arthropoda	Insecta	Diptera	Chironomidae	Apedilum		Chironominae	NA
Mollusca	Gastropoda	Basommatophora	Physidae	Aplexa		Aplexa	Physidae
Arthropoda	Insecta	Diptera	Chironomidae	Apsectrotanypus	8	Tanypodinae	Macropelopiini
Arthropoda	Insecta	Odonata	Lestidae	Archilestes	9	Archilestes	Zygoptera
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	2	Arctopsyche	Arctopsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche grandis	2	Arctopsyche	Arctopsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsychinae		Arctopsychinae	NA
Arthropoda	Insecta	Odonata	Coenagrionidae	Argia	7	Argia	Zygoptera
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Asioplax		Asioplax	NA
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Asioplax edmundsi		Asioplax	NA
Arthropoda	Insecta	Diptera	Athericidae	Athericidae	2	Atherix	NA
Arthropoda	Insecta	Diptera	Athericidae	Atherix	5	Atherix	NA
Arthropoda	Insecta	Diptera	Athericidae	Atherix pachypus	4	Atherix	NA
Arthropoda	Insecta	Diptera	Ceratopogonidae	Atrichopogon		Forcipomyiinae	Ceratopogonidae
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	3	Attenella	NA
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella delantala		Attenella	NA
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella margarita	3	Attenella	NA
Annelida	Oligochaeta	Haplotaxida	Tubificidae	Aulodrilus	10	Oligochaeta	Tubificidae
Arthropoda	Insecta	Diptera	Chironomidae	Axarus		Chironominae	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	4	Baetidae	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	5	Baetis	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis alius	1	Baetis	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis bicaudatus	2	Baetis	Baetis_bicaudatus
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis flavistriga	5	Baetis	Baetis_flavistriga
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis intercalaris		Baetis	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis propinquus	6	Baetis	NA

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Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis punctiventris		Baetis	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis tricaudatus	4	Baetis	Baetis_tricaudatus
Arthropoda	Insecta	Ephemeroptera	Baetiscidae	Baetisca		Baetisca	NA
Arthropoda	Insecta	Hemiptera	Belostomatidae	Belostomatidae	10	Belostomatidae	Other_Hemiptera
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Berosus	5	Berosus	Hydrophilidae
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia		Ceratopogoninae	Ceratopogonidae
Arthropoda	Insecta	Diptera	Blephariceridae	Bibiocephala	0	Blephariceridae	NA
Arthropoda	Insecta	Diptera	Blephariceridae	Bibiocephala grandis	0	Blephariceridae	NA
Arthropoda	Insecta	Diptera	Blephariceridae	Blephariceridae	0	Blephariceridae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Boreochlus	1	Podonominae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Boreoheptagyia		Diamesinae	NA
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentridae	1	Brachycentridae	NA
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	1	Brachycentrus	Brachycentrus
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus americanus	1	Brachycentrus	Brachycentrus
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus occidentalis	2	Brachycentrus	Brachycentrus
Arthropoda	Insecta	Ephemeroptera	Caenidae	Brachycercus	3	Brachycercus	Caenidae
Annelida	Hirudinea	Branchiobdellida	.	Branchiobdellida		Branchiobdellida	NA
Arthropoda	Insecta	Diptera	Chironomidae	Brillia	4	Orthocladiinae	Brillia
Arthropoda	Insecta	Diptera	Chironomidae	Brundiniella	3	Tanypodinae	Macropelopiini
Arthropoda	Insecta	Coleoptera	Haliplidae	Brychius	5	Brychius	Haliplidae
Bryozoa	Tubellaria	.	.	Bryozoa		Bryozoa	NA
Arthropoda	Insecta	Hemiptera	Notonectidae	Buenoa		Notonectidae	Other_Hemiptera
Crustacea	Malacostraca	Isopoda	Asellidae	Caecidotea	8	Asellidae	NA
Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenidae	8	Caenidae	Caenidae
Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenis	8	Caenis	Caenidae
Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenis latipennis	7	Caenis	Caenidae
Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenis youngi	8	Caenis	Caenidae
Arthropoda	Copepoda	Calanoida	.	Calanoida		Calanoida	NA
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria californica	2	Calineuria	Perlidae
Arthropoda	Insecta	Ephemeroptera	Baetidae	Callibaetis	9	Callibaetis	Callibaetis
Arthropoda	Insecta	Hemiptera	Corixidae	Callicorixa		Corixidae	Corixidae
Arthropoda	Insecta	Diptera	Stratiomyidae	Caloparyphus	7	CALOPARYPHUS/EUPARYPHUS	Stratiomyidae
Crustacea	Malacostraca	Decapoda	Cambaridae	Cambaridae		Cambaridae	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Camelobaetidius	4	Camelobaetidius	NA
Arthropoda	Insecta	Diptera	Chironomidae	Camptocladius	6	Orthocladiinae	NA

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Arthropoda	Insecta	Plecoptera	Capniidae	Capniidae	1	Capniidae	Capniidae
Arthropoda	Insecta	Diptera	Chironomidae	Cardiocladius	5	Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Cardiocladius albiplumus	5	Orthocladiinae	NA
Arthropoda	Insecta	Plecoptera	Perlodidae	Cascadoperla trictura	2	Cascadoperla	Perlodidae
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	0	Caudatella	Caudatella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella cascadia		Caudatella	Caudatella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella edmundsi	0	Caudatella	Caudatella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella heterocaudata	0	Caudatella	Caudatella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella hystrix	0	Caudatella	Caudatella
Arthropoda	Insecta	Hemiptera	Corixidae	Cenocorixa		Corixidae	Corixidae
Arthropoda	Insecta	Ephemeroptera	Baetidae	Centroptilum	2	Centroptilum	NA
Arthropoda	Insecta	Trichoptera	Leptoceridae	Ceraclea	3	Ceraclea	Leptoceridae
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogonidae	6	Ceratopogonidae	Ceratopogonidae
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	6	Ceratopogoninae	Ceratopogonidae
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Ceratopsyche	5	Hydropsyche_Ceratopsyche	NA
Arthropoda	Insecta	Ephemeroptera	Caenidae	Cercobrachys		Cercobrachys	Caenidae
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Cercyon		Cercyon	Hydrophilidae
Arthropoda	Insecta	Diptera	Chironomidae	Chaetocladius	6	Orthocladiinae	Chaetocladius
Annelida	Oligochaeta	Haplotaxida	Naididae	Chaetogaster		Oligochaeta	Naididae
Annelida	Oligochaeta	Haplotaxida	Naididae	Chaetogaster diaphanus	6	Oligochaeta	Naididae
Annelida	Oligochaeta	Haplotaxida	Naididae	Chaetogaster limnaei	6	Oligochaeta	Naididae
Arthropoda	Insecta	Diptera	Chaoboridae	Chaoboridae	8	Chaoboridae	Chaoboridae
Arthropoda	Insecta	Diptera	Chaoboridae	Chaoborus		Chaoborus	Chaoboridae
Arthropoda	Insecta	Diptera	Empididae	Chelifera	5	Chelifera_Metachela_Neoplasta	Empididae
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	5	Cheumatopsyche	Cheumatopsyche
Arthropoda	Insecta	Trichoptera	Philopotamidae	Chimarra utahensis	4	Chimarra	Philopotamidae
Arthropoda	Insecta	Diptera	Chironomidae	Chironomidae	10	Chironomidae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	7	Chironominae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Chironomini	6	Chironominae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Chironomus	10	Chironominae	Chironomus
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Chloroperlidae	1	Chloroperlidae	NA
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Chloroperlinae		Chloroperlidae	NA
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Choroterpes	2	Choroterpes	Leptophlebiidae
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Choroterpes albiannulata	2	Choroterpes	Leptophlebiidae
Arthropoda	Insecta	Diptera	Tabanidae	Chrysops	10	Tabanidae	Tabanidae

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Arthropoda	Insecta	Trichoptera	Limnephilidae	Chyrandra	2	Chyrandra	Limnephilidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Chyrandra centralis	2	Chyrandra	Limnephilidae
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygma	0	Cinygma	NA
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	0	Cinygmula	Cinygmula
Arthropoda	Insecta	Plecoptera	Perlidae	Claassenia	2	Claassenia sabulosa	Perlidae
Arthropoda	Insecta	Plecoptera	Perlidae	Claassenia sabulosa	3	Claassenia sabulosa	Perlidae
Arthropoda	Branchiopoda	Diplostraca	.	Cladocera		Cladocera	Cladocera
Arthropoda	Insecta	Diptera	Chironomidae	Cladopelma		Chironominae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Cladotanytarsus	7	Chironominae	Cladotanytarsus
Arthropoda	Insecta	Coleoptera	Elmidae	Cleptelmis	4	Cleptelmis	Cleptelmis
Arthropoda	Insecta	Coleoptera	Elmidae	Cleptelmis addenda		Cleptelmis	Cleptelmis
Arthropoda	Insecta	Coleoptera	Elmidae	Cleptelmis ornata	4	Cleptelmis	Cleptelmis
Arthropoda	Insecta	Diptera	Empididae	Clinocera	5	Clinocera	Empididae
Arthropoda	Insecta	Odonata	Coenagrionidae	Coenagrion		Coenagrionidae	Zygoptera
Arthropoda	Insecta	Odonata	Coenagrionidae	Coenagrionidae	7	Coenagrionidae	Zygoptera
Arthropoda	Insecta	Coleoptera	Dytiscidae	Colymbetes		Colymbetes	Dytiscidae
Arthropoda	Insecta	Diptera	Chironomidae	Conchapelopia	6	Tanypodinae	Other_Tanypodinae
Arthropoda	Insecta	Diptera	Chironomidae	Constempellina	8	Chironominae	NA
Arthropoda	Copepoda	Copepoda	Copepoda	Copepoda		Copepoda	Copepoda
Arthropoda	Insecta	Coleoptera	Dytiscidae	Coptotomus	5	Coptotomus	Dytiscidae
Mollusca	Bivalvia	Corbiculacea	Corbiculidae	Corbicula		Corbicula	NA
Arthropoda	Insecta	Odonata	Cordulegastridae	Cordulegaster		Cordulegaster	NA
Arthropoda	Insecta	Odonata	Cordulegastridae	Cordulegastridae		Cordulegastridae	NA
Arthropoda	Insecta	Odonata	Corduliidae	Corduliidae		Corduliidae	NA
Arthropoda	Insecta	Hemiptera	Corixidae	Corisella		Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Corisella tarsalis		Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Corixidae	9	Corixidae	Corixidae
Arthropoda	Insecta	Diptera	Chironomidae	Corynoneura	7	Orthocladiinae	Corynoneura
Crustacea	Malacostraca	Amphipoda	Crangonyctidae	Crangonyx		Crangonyx	Amphipoda
Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus	8	Orthocladiinae	Cricotopus
Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus (Cricotopus)	8	Orthocladiinae	Cricotopus
Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus (Isocladius)	8	Orthocladiinae	Cricotopus
Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus (Nostococladius)	8	Orthocladiinae	Cricotopus
Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus bicinctus	9	Orthocladiinae	Cricotopus
Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus tremulus	8	Orthocladiinae	Cricotopus

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Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus trifascia	8	Orthocladiinae	Cricotopus
Arthropoda	Insecta	Diptera	Chironomidae	Cricotopus trifasciatus	8	Orthocladiinae	Cricotopus
Arthropoda	Insecta	Trichoptera	Limnephilidae	Cryptochia	3	Cryptochia	Limnephilidae
Arthropoda	Insecta	Diptera	Chironomidae	Cryptochironomus	8	Chironominae	Cryptochironomus
Arthropoda	Insecta	Diptera	Tipulidae	Cryptolabis		Cryptolabis	Other_Tipulidae
Arthropoda	Insecta	Diptera	Chironomidae	Cryptotendipes	6	Chironominae	Cryptotendipes
Arthropoda	Insecta	Diptera	Culicidae	Culex	10	Culicidae	NA
Arthropoda	Insecta	Diptera	Culicidae	Culicidae	10	Culicidae	NA
Arthropoda	Insecta	Diptera	Ceratopogonidae	Culicoides	10	Ceratopogoninae	Ceratopogonidae
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Culoptila	2	Culoptila	Glossosomatidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Cultus	2	Cultus	Perlodidae
Arthropoda	Insecta	Coleoptera	Curculionidae	Curculionidae		Curculionidae	NA
Arthropoda	Copepoda	Cyclopoida	.	Cyclopoida	8	COPEPODA	NA
Arthropoda	Branchiopoda	Diplostraca	Daphniidae	Daphniidae		Cladocera	Cladocera
Crustacea	Malacostraca	Decapoda	.	Decapoda	6	Decapoda	NA
Arthropoda	Insecta	Diptera	Chironomidae	Demicryptochironomus	8	Chironominae	NA
Annelida	Oligochaeta	Haplotaxida	Naididae	Dero digitata		Oligochaeta	Naididae
Arthropoda	Insecta	Coleoptera	Dytiscidae	Deronectes	5	Deronectes	Dytiscidae
Arthropoda	Insecta	Coleoptera	Dytiscidae	Desmopachria		Desmopachria	Dytiscidae
Arthropoda	Insecta	Plecoptera	Leuctridae	Despaxia	2	Leuctridae	Leuctridae
Arthropoda	Insecta	Plecoptera	Leuctridae	Despaxia augusta	2	Leuctridae	Leuctridae
Arthropoda	Insecta	Diptera	Deuterophlebiidae	Deuterophlebia	0	Deuterophlebia	NA
Arthropoda	Insecta	Diptera	Chironomidae	Diamesa	5	Diamesinae	Diamesa
Arthropoda	Insecta	Diptera	Chironomidae	Diamesinae	4	Diamesinae	NA
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	2	Dicosmoecus	Limnephilidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus atripes	2	Dicosmoecus	Limnephilidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus gilvipes		Dicosmoecus	Limnephilidae
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	0	Dicranota	Dicranota
Arthropoda	Insecta	Diptera	Chironomidae	Dicrotendipes	8	Chironominae	Dicrotendipes
Arthropoda	Insecta	Ephemeroptera	Baetidae	Diphetor hageni	5	Diphetor	Diphetor
Arthropoda	Insecta	Diptera	Chironomidae	Diplocladius	5	Orthocladiinae	NA
Arthropoda	Insecta	Diptera	.	Diptera		Diptera	NA
Arthropoda	Insecta	Plecoptera	Perlodidae	Diura	2	Diura	Perlodidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Diura knowltoni	2	Diura	Perlodidae
Arthropoda	Insecta	Diptera	Dixidae	Dixa	4	Dixa	Dixidae

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Arthropoda	Insecta	Diptera	Dixidae	Dixella		Dixella	Dixidae
Arthropoda	Insecta	Diptera	Dixidae	Dixidae	4	Dixidae	Dixidae
Arthropoda	Insecta	Diptera	Dolichopodidae	Dolichopodidae	4	Dolichopodidae	NA
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes	0	Dolophilodes	Philopotamidae
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	0	Doroneuria	Perlidae
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria theodora	0	Doroneuria	Perlidae
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	1	Drunella	NA
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella coloradensis	0	Drunella coloradensis/flavilinea	Drunella_coloradensis/ flavilinea
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella doddsi	1	Drunella doddsi	Drunella_doddsi
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella flavilinea	2	Drunella coloradensis/flavilinea	Drunella_coloradensis/ flavilinea
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella grandis	2	Drunella grandis	Drunella_grandis
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella spinifera	0	Drunella spinifera	Drunella_spinifera
Arthropoda	Insecta	Coleoptera	Dryopidae	Dryopidae		Dryopidae	NA
Arthropoda	Insecta	Coleoptera	Elmidae	Dubiraphia	6	Dubiraphia	Dubiraphia
Platyhelminthes	Tubellaria	Tricladida	Planariidae	Dugesia		Turbellaria	Turbellaria
Arthropoda	Insecta	Coleoptera	Dytiscidae	Dytiscidae	5	Dytiscidae	Dytiscidae
Arthropoda	Insecta	Coleoptera	Dytiscidae	Dytiscus	5	Dytiscus	Dytiscidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Ecclisocosmoecus		Ecclisocosmoecus	Limnephilidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Ecclisomyia	4	Ecclisomyia	Limnephilidae
Annelida	Oligochaeta	Lumbriculida	Lumbriculidae	Eclipidrilus	4	Oligochaeta	Eclipidrilus
Arthropoda	Insecta	Diptera	Simuliidae	Ectemnia		Simuliidae	Simuliidae
Arthropoda	Insecta	Diptera	Chironomidae	Einfeldia	8	Chironominae	NA
Arthropoda	Insecta	Coleoptera	Elmidae	Elmidae	4	Elmidae	NA
Arthropoda	Insecta	Diptera	Empididae	Empididae	6	Empididae	Empididae
Arthropoda	Insecta	Odonata	Coenagrionidae	Enallagma	7	Coenagrionidae	Zygoptera
Annelida	Oligochaeta	Haplotaxida	Enchytraeidae	Enchytraeidae	4	Oligochaeta	NA
Arthropoda	Insecta	Diptera	Chironomidae	Endochironomus	10	Chironominae	Endochironomus
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Enochrus	5	Enochrus	Hydrophilidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Eocosmoecus		Eocosmoecus	Limnephilidae
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	2	Epeorus	Epeorus
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus albertae	2	Epeorus	Epeorus
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus deceptivus	0	Epeorus	Epeorus
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus grandis	0	Epeorus	Epeorus
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus longimanus	1	Epeorus	Epeorus
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Ephemera	2	Ephemera	NA

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Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Ephemera simulans	1	Ephemera	NA
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	2	Ephemerella	Ephemerella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella aurivillii	0	Ephemerella aurivillii	Ephemerella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella inermis	4	Ephemerella	Ephemerella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella infrequens	2	Ephemerella	Ephemerella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerellidae	1	Ephemerellidae	NA
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Ephemeridae	4	Ephemeridae	NA
Arthropoda	Insecta	Ephemeroptera	.	Ephemeroptera		Ephemeroptera	NA
Arthropoda	Insecta	Ephemeroptera	Polymitarcyidae	Ephoron	2	Ephoron	NA
Arthropoda	Insecta	Ephemeroptera	Polymitarcyidae	Ephoron album	2	Ephoron	NA
Arthropoda	Insecta	Diptera	Ephydridae	Ephydridae	6	Ephydridae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Epoicocladius		Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Tipulidae	Erioptera	7	Erioptera	Other_Tipulidae
Arthropoda	Insecta	Odonata	Gomphidae	Erpetogomphus	3	Gomphidae	Gomphidae
Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	Erpobdella		Erpobdellidae	Hirudinea
Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	Erpobdellidae	8	Erpobdellidae	Hirudinea
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella	4	Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella brehmi	2	Orthocladiinae	Eukiefferiella_Brehmi_Gr
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella claripennis	5	Orthocladiinae	Eukiefferiella_Claripennis_Gr
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella coerulescens	4	Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella devonica	4	Orthocladiinae	Eukiefferiella_Devonica_Gr
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella gracei	4	Orthocladiinae	Eukiefferiella_Gracei_Gr
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella pseudomontana		Orthocladiinae	Eukiefferiella_Pseudomontana_Gr
Arthropoda	Insecta	Diptera	Chironomidae	Eukiefferiella similis		Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Stratiomyidae	Euparyphus	7	CALOPARYPHUS/EUPARYPHUS	Stratiomyidae
Arthropoda	Insecta	Ephemeroptera	Baetidae	Fallceon quilleri	5	Fallceon	NA
Mollusca	Gastropoda	Basommatophora	Ancylidae	Ferrissia	6	Ferrissia	NA
Mollusca	Gastropoda	Basommatophora	Ancylidae	Ferrissia parallelus	6	Ferrissia	NA
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	Fluminicola		Hydrobiidae	NA
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyiinae	6	Forcipomyiinae	Ceratopogonidae
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Fossaria	6	Lymnaeidae	Lymnaeidae
Crustacea	Malacostraca	Amphipoda	Gammaridae	Gammaridae	4	Gammaridae	Amphipoda
Crustacea	Malacostraca	Amphipoda	Gammaridae	Gammarus	4	Gammarus	Amphipoda
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Glossiphonia		Glossiphoniidae	Hirudinea
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	9	Glossiphoniidae	Hirudinea

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Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Glossiphoniidae	9	Glossiphoniidae	Hirudinea
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	0	Glossosoma	Glossosomatidae
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma traviatum	0	Glossosoma	Glossosomatidae
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma velona	0	Glossosoma	Glossosomatidae
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosomatidae	0	Glossosomatidae	Glossosomatidae
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops	1	Pelecorhynchidae	Glutops
Arthropoda	Insecta	Trichoptera	Limnephilidae	Glyphopsyche	1	Glyphopsyche	Limnephilidae
Arthropoda	Insecta	Diptera	Chironomidae	Glyptotendipes	10	Chironominae	NA
Arthropoda	Insecta	Trichoptera	Goeridae	Goeracea		Goeridae	NA
Arthropoda	Insecta	Odonata	Gomphidae	Gomphidae	2	Gomphidae	Gomphidae
Arthropoda	Insecta	Odonata	Gomphidae	Gomphus		Gomphidae	Gomphidae
Arthropoda	Insecta	Coleoptera	Hydraenidae	Gymnochthebius		Gymnochthebius	NA
Mollusca	Gastropoda	Basommatophora	Planorbidae	Gyraulus	8	Planorbidae	Planorbidae
Arthropoda	Insecta	Coleoptera	Gyrinidae	Gyrinus	5	GYRINUS	NA
Arthropoda	Insecta	Coleoptera	Haliplidae	Haliplidae	8	Haliplidae	Haliplidae
Arthropoda	Insecta	Coleoptera	Haliplidae	Haliplus	8	Haliplus	Haliplidae
Annelida	Oligochaeta	Haplotaxida	Haplotaxidae	Haplotaxidae		Oligochaeta	NA
Annelida	Oligochaeta	Haplotaxida	Haplotaxidae	Haplotaxis		Oligochaeta	NA
Arthropoda	Insecta	Diptera	Chironomidae	Harnischia		Chironominae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Heleniella	6	Orthocladiinae	Heleniella
Arthropoda	Insecta	Coleoptera	Dryopidae	Helichus	5	Helichus	NA
Arthropoda	Insecta	Coleoptera	Dryopidae	Helichus striatus	5	Helichus	NA
Arthropoda	Insecta	Trichoptera	Helicopsychidae	Helicopsyche	3	Helicopsyche	NA
Arthropoda	Insecta	Trichoptera	Helicopsychidae	Helicopsyche borealis	3	Helicopsyche	NA
Arthropoda	Insecta	Trichoptera	Helicopsychidae	Helicopsychidae	3	Helicopsychidae	NA
Mollusca	Gastropoda	Basommatophora	Planorbidae	Helisoma	6	Planorbidae	Planorbidae
Mollusca	Gastropoda	Basommatophora	Planorbidae	Helisoma anceps	7	Planorbidae	Planorbidae
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Helobdella	10	Glossiphoniidae	Hirudinea
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	10	Glossiphoniidae	Hirudinea
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Helophorus	5	Helophorus	NA
Arthropoda	Insecta	Diptera	Empididae	Hemerodromia	6	Hemerodromia	Empididae
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptagenia	4	Heptagenia	NA
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	2	Heptageniidae	NA
Arthropoda	Insecta	Diptera	Tipulidae	Hesperoconopa	1	Hesperoconopa	Other_Tipulidae
Arthropoda	Insecta	Hemiptera	Corixidae	Hesperocorixa		Corixidae	Corixidae

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Arthropoda	Insecta	Hemiptera	Corixidae	Hesperocorixa laevigata	9	Corixidae	Corixidae
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla pacifica	1	Hesperoperla	Perlidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Hesperophylax	3	Hesperophylax	Limnephilidae
Arthropoda	Insecta	Odonata	Calopterygidae	Hetaerina americana		Calopterygidae	Zygoptera
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius	3	Heterlimnius	Heterlimnius
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius corpulentus	3	Heterlimnius	Heterlimnius
Arthropoda	Insecta	Coleoptera	Heteroceridae	Heteroceridae		Heteroceridae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Heterotrissocladius	0	Orthocladiinae	Heterotrissocladius
Arthropoda	Insecta	Diptera	Chironomidae	Heterotrissocladius marcidus		Orthocladiinae	Heterotrissocladius
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Hexagenia	6	Hexagenia	NA
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Hexagenia limbata	6	Hexagenia	NA
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	2	Hexatoma	Hexatoma
Annelida	Hirudinea	.	.	Hirudinea	9	Hirudinea	Hirudinea
Arthropoda	Insecta	Trichoptera	Limnephilidae	Homophylax	2	Homophylax	Limnephilidae
Crustacea	Malacostraca	Amphipoda	Talitridae	Hyalella	8	Hyalella	Amphipoda
Crustacea	Malacostraca	Amphipoda	Hyalellidae	Hyalella azteca	8	Hyalella	Amphipoda
Crustacea	Malacostraca	Amphipoda	Hyalellidae	Hyalellidae	8	Hyalellidae	Amphipoda
Coelenterata	Hydrozoa	Hydroida	Hydridae	Hydra	5	Hydridae	NA
Arthropoda	Insecta	Coleoptera	Hydraenidae	Hydraena		Hydraena	NA
Arthropoda	Insecta	Diptera	Chironomidae	Hydrobaenus	8	Orthocladiinae	Hydrobaenus
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	Hydrobiidae		Hydrobiidae	NA
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Hydrobius		Hydrobius	Hydrophilidae
Arthropoda	Insecta	Coleoptera	Hydrochidae	Hydrochus	7	Hydrochus	NA
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Hydrophilidae	5	Hydrophilidae	Hydrophilidae
Arthropoda	Insecta	Coleoptera	Dytiscidae	Hydroporus		Hydroporus	Dytiscidae
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	5	Hydropsyche_Ceratopsyche	Hydropsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche bronta	5	Hydropsyche_Ceratopsyche	Hydropsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche cockerelli	4	Hydropsyche_Ceratopsyche	Hydropsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche morosa	6	Hydropsyche_Ceratopsyche	Hydropsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche occidentalis	5	Hydropsyche_Ceratopsyche	Hydropsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche oslari	4	Hydropsyche_Ceratopsyche	Hydropsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche simulans		Hydropsyche_Ceratopsyche	Hydropsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche slossonae	4	Hydropsyche_Ceratopsyche	Hydropsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	4	Hydropsychidae	NA
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae		HYDROPSYCHINAE	NA

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Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila	6	Hydroptila	Hydroptilidae
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptilidae	4	Hydroptilidae	Hydroptilidae
Coelenterata	Hydrozoa	.	.	Hydrozoa	5	Hydrozoa	NA
Arthropoda	Insecta	Coleoptera	Dytiscidae	Hygrotus		Hygrotus	Dytiscidae
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Ironodes	0	Ironodes	NA
Arthropoda	Insecta	Odonata	Coenagrionidae	Ischnura	7	Coenagrionidae	Zygoptera
Arthropoda	Insecta	Plecoptera	Perlodidae	Isogenoides	3	Isogenoides	Perlodidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Isogenoides elongatus	3	Isogenoides	Perlodidae
Arthropoda	Insecta	Ephemeroptera	Isonychiidae	Isonychia	2	Isonychia	NA
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla	2	Isoperla	Perlodidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla fulva	3	Isoperla	Perlodidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla sobria	2	Isoperla	Perlodidae
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Ithytrichia	4	Ithytrichia	Hydroptilidae
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Kathroperla	1	Kathroperla	NA
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Kathroperla perdita	1	Kathroperla	NA
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	1	Kogotus	Perlodidae
Arthropoda	Insecta	Diptera	Chironomidae	Krenosmittia	1	Orthocladiinae	Krenosmittia
Arthropoda	Insecta	Ephemeroptera	Baetidae	Labiobaetis		Labiobaetis	NA
Arthropoda	Insecta	Diptera	Chironomidae	Labrundinia	7	Tanypodinae	Labrundinia
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Laccobius		Laccobius	Hydrophilidae
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus	5	Laccophilus	Dytiscidae
Arthropoda	Insecta	Ephemeroptera	Oligoneuriidae	Lachlania		Oligoneuriidae	NA
Arthropoda	Insecta	Coleoptera	Lampyridae	Lampyridae		Lampyridae	NA
Arthropoda	Insecta	Coleoptera	Elmidae	Lara	1	Lara	Lara
Arthropoda	Insecta	Coleoptera	Elmidae	Lara avara	1	Lara	Lara
Arthropoda	Insecta	Diptera	Chironomidae	Larsia	6	Tanypodinae	Larsia
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	1	Lepidostoma	Lepidostomatidae
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma cascadense		Lepidostoma	Lepidostomatidae
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma pluviale		Lepidostoma	Lepidostomatidae
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostomatidae	1	Lepidostomatidae	Lepidostomatidae
Arthropoda	Insecta	Trichoptera	Leptoceridae	Leptoceridae	4	Leptoceridae	Leptoceridae
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebia	3	Leptophlebia	Leptophlebiidae
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebiidae	2	Leptophlebiidae	Leptophlebiidae
Arthropoda	Insecta	Odonata	Lestidae	Lestes	9	Lestes	Zygoptera
Arthropoda	Insecta	Hemiptera	Belostomatidae	Lethocerus	10	Belostomatidae	Other_Hemiptera

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Arthropoda	Insecta	Odonata	Libellulidae	Leucorrhinia		Libellulidae	Libellulidae
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Leucotrichia	2	Leucotrichia	Hydroptilidae
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Leucotrichia pictipes	2	Leucotrichia	Hydroptilidae
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Leucrocuta	1	Leucrocuta	NA
Arthropoda	Insecta	Plecoptera	Leuctridae	Leuctridae	1	Leuctridae	Leuctridae
Arthropoda	Insecta	Odonata	Libellulidae	Libellula	9	Libellulidae	Libellulidae
Arthropoda	Insecta	Odonata	Libellulidae	Libellulidae	9	Libellulidae	Libellulidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Limnephilidae	3	Limnephilidae	Limnephilidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Limnephilus	3	Limnephilus	Limnephilidae
Annelida	Oligochaeta	Haplotaxida	Tubificidae	Limnodrilus	10	Oligochaeta	Tubificidae
Annelida	Oligochaeta	Haplotaxida	Tubificidae	Limnodrilus hoffmeisteri	10	Oligochaeta	Tubificidae
Arthropoda	Insecta	Diptera	Tipulidae	Limnophila	3	Limnophila	Limnophila
Arthropoda	Insecta	Diptera	Muscidae	Limnophora	7	Muscidae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Limnophyes	6	Orthocladiinae	Limnophyes
Arthropoda	Insecta	Diptera	Tipulidae	Limonia		Limonia	Other_Tipulidae
Arthropoda	Insecta	Coleoptera	Dytiscidae	Liodessus		Liodessus	Dytiscidae
Arthropoda	Insecta	Diptera	Chironomidae	Lopescladius	2	Orthocladiinae	NA
Annelida	Oligochaeta	Haplotaxida	Lumbricidae	Lumbricidae	4	Oligochaeta	NA
Annelida	Oligochaeta	Haplotaxida	Lumbricidae	Lumbricina	4	Oligochaeta	NA
Annelida	Oligochaeta	Lumbriculida	Lumbriculidae	Lumbriculidae	4	Oligochaeta	NA
Annelida	Oligochaeta	Lumbriculida	Lumbriculidae	Lumbriculus		Oligochaeta	NA
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Lymnaeidae	6	Lymnaeidae	Lymnaeidae
Arthropoda	Insecta	Diptera	Chironomidae	Macropelopia	6	Tanypodinae	Macropelopiini
Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka	1	Malenka	Malenka
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Mayatrichia	1	Mayatrichia	Hydroptilidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Megarcys	1	Megarcys	Perlodidae
Mollusca	Gastropoda	Basommatophora	Planorbidae	Menetus		Planorbidae	Planorbidae
Arthropoda	Insecta	Diptera	Dixidae	Meringodixa		Meringodixa	Dixidae
Nematoda	Polychaeta	Mermithida	Mermithidae	Mermithidae	5	Nematoda	NA
Arthropoda	Insecta	Diptera	Chironomidae	Mesosmittia		Orthocladiinae	NA
Arthropoda	Insecta	Hemiptera	Mesoveliidae	Mesovelia			Other_Hemiptera
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Metrichia		Metrichia	Hydroptilidae
Arthropoda	Insecta	Diptera	Chironomidae	Metriocnemus		Orthocladiinae	NA
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	1	Micrasema	Micrasema
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema bactro	1	Micrasema	Micrasema

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Arthropoda	Insecta	Coleoptera	Elmidae	Microcylloepus	5	Microcylloepus	NA
Arthropoda	Insecta	Coleoptera	Elmidae	Microcylloepus pusillus	5	Microcylloepus	NA
Arthropoda	Insecta	Diptera	Chironomidae	Micropsectra	4	Chironominae	Micropsectra
Arthropoda	Insecta	Diptera	Chironomidae	Microtendipes	6	Chironominae	Microtendipes
Arthropoda	Insecta	Trichoptera	Molannidae	Molanna	6	Molanna	NA
Mollusca	Ostracoda	.	.	Mollusca		Mollusca	NA
Arthropoda	Insecta	Diptera	Tipulidae	Molophilus		Molophilus	Other_Tipulidae
Arthropoda	Insecta	Diptera	Chironomidae	Monodiamesa	7	Prodiamesinae	NA
Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	Mooreobdella	10	Erpobdellidae	Hirudinea
Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	Mooreobdella melanostoma		Erpobdellidae	Hirudinea
Arthropoda	Insecta	Plecoptera	Leuctridae	Moselia infuscata		Leuctridae	Leuctridae
Arthropoda	Insecta	Diptera	Muscidae	Muscidae	9	Muscidae	NA
Arthropoda	Insecta	Trichoptera	Leptoceridae	Mystacides	4	Mystacides	Leptoceridae
Annelida	Oligochaeta	Haplotaxida	Naididae	Naididae	8	Oligochaeta	Naididae
Annelida	Oligochaeta	Haplotaxida	Naididae	Nais	9	Oligochaeta	Naididae
Annelida	Oligochaeta	Haplotaxida	Naididae	Nais behningi	8	Oligochaeta	Naididae
Annelida	Oligochaeta	Haplotaxida	Naididae	Nais bretscheri		Oligochaeta	Naididae
Annelida	Oligochaeta	Haplotaxida	Naididae	Nais simplex		Oligochaeta	Naididae
Annelida	Oligochaeta	Haplotaxida	Naididae	Nais variabilis	10	Oligochaeta	Naididae
Arthropoda	Insecta	Diptera	Chironomidae	Nanocladius	3	Orthocladiinae	Nanocladius
Arthropoda	Insecta	Coleoptera	Elmidae	Narpus	2	Narpus	Narpus
Arthropoda	Insecta	Coleoptera	Elmidae	Narpus concolor	2	Narpus	Narpus
Arthropoda	Insecta	Diptera	Chironomidae	Natarsia		Tanypodinae	Other_Tanypodinae
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Neaviperla	1	Chloroperlidae	NA
Arthropoda	Insecta	Trichoptera	Leptoceridae	Nectopsyche	2	Nectopsyche	Leptoceridae
Nematoda	Polychaeta	.	.	Nematoda	5	Nematoda	Nematoda
Nematomorpha	Polychaeta	.	.	Nematomorpha		Nematomorpha	NA
Arthropoda	Insecta	Trichoptera	Limnephilidae	Nemotaulius	3	Nemotaulius	Limnephilidae
Arthropoda	Insecta	Diptera	Stratiomyidae	Nemotelus	7	Nemotelus	Stratiomyidae
Arthropoda	Insecta	Plecoptera	Nemouridae	Nemouridae	2	Nemouridae	NA
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Neochoroterpes	2	Neochoroterpes	Leptophlebiidae
Arthropoda	Insecta	Coleoptera	Dytiscidae	Neoclypeodytes		Neoclypeodytes	Dytiscidae
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax	3	Neophylax	Uenoidae
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax occidentis		Neophylax	Uenoidae
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax rickeri	3	Neophylax	Uenoidae

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Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax splendens		Neophylax	Uenoidae
Arthropoda	Insecta	Diptera	Empididae	Neoplasta	6	Chelifera_Metachela_Neoplasta	Empididae
Arthropoda	Insecta	Hemiptera	Pleidae	Neoplea		Pleidae	Other_Hemiptera
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma	1	Neothremma	Uenoidae
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Neotrichia	2	Neotrichia	Hydroptilidae
Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	Nephelopsis		Erpobdellidae	Hirudinea
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Neureclipsis	6	Polycentropodidae	NA
Arthropoda	Insecta	Odonata	Corduliidae	Neurocordulia		Corduliidae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Nilotanypus	7	Tanypodinae	Other_Tanypodinae
Arthropoda	Insecta	Hemiptera	Notonectidae	Notonecta	5	Notonectidae	Other_Hemiptera
Arthropoda	Insecta	Hemiptera	Notonectidae	Notonectidae	7	Notonectidae	Other_Hemiptera
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Nyctiophylax	5	Polycentropodidae	NA
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Ochrotrichia	4	Ochrotrichia	Hydroptilidae
Arthropoda	Insecta	Coleoptera	Hydraenidae	Ochthebius		Ochthebius	NA
Arthropoda	Insecta	Odonata	Gomphidae	Octogomphus		Gomphidae	Gomphidae
Arthropoda	Insecta	Diptera	Chironomidae	Odontomesa	4	Prodiamesinae	Odontomesa
Arthropoda	Insecta	Diptera	Stratiomyidae	Odontomyia		Hedriodiscus/Odontomyia	Stratiomyidae
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis	8	Oecetis	Leptoceridae
Annelida	Oligochaeta	.	.	Oligochaeta	8	Oligochaeta	NA
Arthropoda	Insecta	Trichoptera	Uenoidae	Oligophlebodes	3	Oligophlebodes	Uenoidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Onocosmoecus	3	Onocosmoecus	Limnephilidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Onocosmoecus unicolor	3	Onocosmoecus	Limnephilidae
Annelida	Oligochaeta	Haplotaxida	Naididae	Ophidonais	6	Oligochaeta	Naididae
Annelida	Oligochaeta	Haplotaxida	Naididae	Ophidonais serpentina	6	Oligochaeta	Naididae
Arthropoda	Insecta	Odonata	Gomphidae	Ophiogomphus	5	Gomphidae	Gomphidae
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	5	Optioservus	Optioservus
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus seriatus	4	Optioservus	Optioservus
Crustacea	Malacostraca	Decapoda	Cambaridae	Orconectes		Cambaridae	NA
Arthropoda	Insecta	Coleoptera	Elmidae	Ordobrevia	5	Ordobrevia	NA
Arthropoda	Insecta	Coleoptera	Elmidae	Ordobrevia nubifera	5	Ordobrevia	NA
Arthropoda	Insecta	Coleoptera	Dytiscidae	Oreodytes	5	Oreodytes	Dytiscidae
Arthropoda	Insecta	Diptera	Empididae	Oreogeton	4	Oreogeton	Empididae
Arthropoda	Insecta	Diptera	Tipulidae	Ormosia	6	Ormosia	Other_Tipulidae
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladius	7	Orthocladiinae	Orthocladius

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Arthropoda	Insecta	Diptera	Chironomidae	Orthocladius annectens		Orthocladiinae	Orthocladius
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladius rivulorum		Orthocladiinae	Orthocladius
Crustacea	Ostracoda	.	.	Ostracoda		Ostracoda	Ostracoda
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Oxyethira	3	Oxyethira	Hydroptilidae
Crustacea	Malacostraca	Decapoda	Astacidae	Pacifastacus	6	Astacidae	NA
Crustacea	Malacostraca	Decapoda	Astacidae	Pacifastacus leniusculus		Astacidae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Pagastia	1	Diamesinae	Pagastia
Arthropoda	Insecta	Hemiptera	Corixidae	Palmacorixa	9	Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Palmacorixa buenoi	9	Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Palmacorixa gillettei	9	Corixidae	Corixidae
Arthropoda	Insecta	Diptera	Chironomidae	Parachaetocladius		Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Parachironomus	10	Chironominae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Paracladius	8	Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Paracladopelma	7	Chironominae	Paracladopelma
Arthropoda	Insecta	Ephemeroptera	Baetidae	Paracloeodes		Paracloeodes	NA
Arthropoda	Insecta	Diptera	Chironomidae	Paracricotopus		Orthocladiinae	NA
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Paracymus		Paracymus	Hydrophilidae
Arthropoda	Insecta	Diptera	Chironomidae	Parakiefferiella	6	Orthocladiinae	Parakiefferiella
Arthropoda	Insecta	Diptera	Chironomidae	Paralauterborniella	8	Chironominae	Paralauterborniella
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	1	Paraleptophlebia	Leptophlebiidae
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia bicornuta	2	Paraleptophlebia	Leptophlebiidae
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia debilis	1	Paraleptophlebia	Leptophlebiidae
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia heteronea	1	Paraleptophlebia	Leptophlebiidae
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia temporalis	1	Paraleptophlebia	Leptophlebiidae
Arthropoda	Insecta	Plecoptera	Leuctridae	Paraleuctra	2	Leuctridae	Leuctridae
Arthropoda	Insecta	Diptera	Chironomidae	Paramerina		Tanypodinae	Paramerina/Zavrelimyia
Arthropoda	Insecta	Diptera	Chironomidae	Parametriocnemus	5	Orthocladiinae	Parametriocnemus
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Paraperla	1	Paraperla	NA
Arthropoda	Insecta	Diptera	Chironomidae	Paraphaenocladius	4	Orthocladiinae	NA
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	0	Parapsyche	Parapsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche almota		Parapsyche	Parapsyche
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche elsis	1	Parapsyche	Parapsyche
Arthropoda	Insecta	Diptera	Chironomidae	Paratanytarsus	6	Chironominae	Paratanytarsus
Arthropoda	Insecta	Diptera	Chironomidae	Paratendipes	10	Chironominae	Paratendipes
Arthropoda	Insecta	Diptera	Chironomidae	Parochlus	1	Podonominae	NA

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Arthropoda	Insecta	Diptera	Chironomidae	Parorthocladius	6	Orthocladiinae	Parorthocladius
Arthropoda	Insecta	Diptera	Tipulidae	Pedicia	6	Pedicia	Other_Tipulidae
Arthropoda	Insecta	Coleoptera	Haliplidae	Peltodytes	8	Peltodytes	Haliplidae
Arthropoda	Insecta	Diptera	Chironomidae	Pentaneura	6	Tanypodinae	Other_Tanypodinae
Arthropoda	Insecta	Diptera	Chironomidae	Pentaneurini	6	Tanypodinae	Other_Tanypodinae
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	4	Pericoma/Telmatoscopus	Psychodidae
Arthropoda	Insecta	Odonata	Libellulidae	Perithemis		Libellulidae	Libellulidae
Arthropoda	Insecta	Plecoptera	Perlidae	Perlidae	2	Perlidae	Perlidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	1	Perlinodes	Perlodidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes aurea	1	Perlinodes	Perlodidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlodidae	2	Perlodidae	Perlodidae
Arthropoda	Insecta	Plecoptera	Leuctridae	Perlomyia		Leuctridae	Leuctridae
Arthropoda	Insecta	Lepidoptera	Pyralidae	Petrophila	5	Lepidoptera	NA
Arthropoda	Insecta	Diptera	Chironomidae	Phaenopsectra	7	Chironominae	Phaenopsectra
Arthropoda	Insecta	Trichoptera	Limnephilidae	Philarctus quaeris		Philarctus	Limnephilidae
Arthropoda	Insecta	Trichoptera	Philopotamidae	Philopotamidae	3	Philopotamidae	Philopotamidae
Arthropoda	Insecta	Diptera	Blephariceridae	Philorus		Blephariceridae	NA
Arthropoda	Insecta	Trichoptera	Phryganeidae	Phryganea		Phryganeidae	NA
Arthropoda	Insecta	Trichoptera	Phryganeidae	Phryganeidae	4	Phryganeidae	NA
Mollusca	Gastropoda	Basommatophora	Physidae	Physa		Physa_Physella	Physidae
Mollusca	Gastropoda	Basommatophora	Physidae	Physella	8	Physa_Physella	Physidae
Mollusca	Gastropoda	Basommatophora	Physidae	Physidae	8	Physidae	Physidae
Arthropoda	Insecta	Diptera	Tipulidae	Pilaria	7	Pilaria	Other_Tipulidae
Annelida	Hirudinea	Rhynchobdellida	Piscicolidae	Piscicolidae		Piscicolidae	Hirudinea
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidiidae	8	Pisidiidae	Pisidiidae
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	8	Pisidiidae	Pisidiidae
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium milium	8	Pisidiidae	Pisidiidae
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Placobdella		Glossiphoniidae	Hirudinea
Platyhelminthes	Tubellaria	Tricladida	Planariidae	Planariidae		Turbellaria	Turbellaria
Mollusca	Gastropoda	Basommatophora	Planorbidae	Planorbella		Planorbidae	Planorbidae
Mollusca	Gastropoda	Basommatophora	Planorbidae	Planorbidae	6	Planorbidae	Planorbidae
Mollusca	Gastropoda	Basommatophora	Planorbidae	Planorbula		Planorbidae	Planorbidae
Arthropoda	Insecta	Ephemeroptera	Baetidae	Plauditus	5	Plauditus	NA
Arthropoda	Insecta	Ephemeroptera	Baetidae	Plauditus punctiventris	5	Plauditus	NA
Arthropoda	Insecta	Plecoptera	Nemouridae	Podmosta	2	Podmosta	NA

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Platyhelminthes	Tubellaria	.	.	Polycelis coronata	4	Turbellaria	Turbellaria
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropodidae	6	Polycentropodidae	NA
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus	6	Polycentropus	NA
Arthropoda	Insecta	Diptera	Chironomidae	Polypedilum	6	Chironominae	Polypedilum
Porifera	Hydrozoa	.	.	Porifera		Porifera	NA
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	Potamopyrgus antipodarum		Potamopyrgus	NA
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Potamyia	4	Potamyia	NA
Arthropoda	Insecta	Diptera	Chironomidae	Potthastia	2	Diamesinae	Potthastia
Arthropoda	Insecta	Diptera	Chironomidae	Potthastia gaedii	3	Diamesinae	Potthastia
Arthropoda	Insecta	Diptera	Chironomidae	Potthastia longimana	4	Diamesinae	Potthastia
Annelida	Oligochaeta	Haplotaxida	Naididae	Pristina	10	Oligochaeta	Naididae
Arthropoda	Insecta	Diptera	Chironomidae	Procladius	9	Tanypodinae	Procladius
Arthropoda	Insecta	Ephemeroptera	Baetidae	Procloeon	7	Procloeon	NA
Arthropoda	Insecta	Diptera	Chironomidae	Prodiamesa	3	Prodiamesinae	Prodiamesa
Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium	3	Simuliidae	Simuliidae
Arthropoda	Insecta	Plecoptera	Nemouridae	Prostoia besametsa	3	Prostoia	NA
Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae	Prostoma		Nemertea	NA
Arthropoda	Insecta	Diptera	Tanyderidae	Protanyderus	5	Tanyderidae	NA
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Protoptila	1	Protoptila	Glossosomatidae
Arthropoda	Insecta	Diptera	Chironomidae	Psectrocladius	8	Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Psectrotanypus	10	Tanypodinae	Macropelopiini
Arthropoda	Insecta	Diptera	Chironomidae	Pseudochironomus	5	Chironominae	Pseudochironomus
Arthropoda	Insecta	Ephemeroptera	Baetidae	Pseudocloeon	4	Pseudocloeon	NA
Arthropoda	Insecta	Diptera	Chironomidae	Pseudodiamesa	2	Diamesinae	Pseudodiamesa
Arthropoda	Insecta	Diptera	Chironomidae	Pseudorthocladius	0	Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Pseudosmittia	6	Orthocladiinae	NA
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Pseudosuccinea		Lymnaeidae	Lymnaeidae
Arthropoda	Insecta	Diptera	Psychodidae	Psychoda	4	Psychoda	Psychodidae
Arthropoda	Insecta	Diptera	Psychodidae	Psychodidae	4	Psychodidae	Psychodidae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Psychoglypha	0	Psychoglypha	Limnephilidae
Arthropoda	Insecta	Trichoptera	Psychomyiidae	Psychomyia	2	Psychomyia	NA
Arthropoda	Insecta	Trichoptera	Psychomyiidae	Psychomyia flavida	2	Psychomyia	NA
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcella	4	Pteronarcella	NA
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcella badia	3	Pteronarcella	NA
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcyidae	2	Pteronarcyidae	NA

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Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcys	2	Pteronarcys	NA
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcys californica	2	Pteronarcys	NA
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcys dorsata	2	Pteronarcys	NA
Arthropoda	Insecta	Trichoptera	Phryganeidae	Ptilostomis		Phryganeidae	NA
Arthropoda	Insecta	Diptera	Ptychopteridae	Ptychoptera	7	Ptychopteridae	Ptychopteridae
Arthropoda	Insecta	Trichoptera	Limnephilidae	Pycnopsyche		Pycnopsyche	Limnephilidae
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	Pyrgulopsis		Hydrobiidae	NA
Annelida	Oligochaeta	Haplotaxida	Tubificidae	Quistradrilus multisetosus		Oligochaeta	Tubificidae
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Radix auricularia		Radix auricularia	Lymnaeidae
Arthropoda	Insecta	Hemiptera	Nepidae	Ranatra	7	Ranatra	Other_Hemiptera
Arthropoda	Insecta	Diptera	Tipulidae	Rhabdomastix	1	Rhabdomastix	Rhabdomastix
Arthropoda	Insecta	Coleoptera	Dytiscidae	Rhantus		Rhantus	Dytiscidae
Arthropoda	Insecta	Diptera	Chironomidae	Rheocricotopus	4	Orthocladiinae	Rheocricotopus
Arthropoda	Insecta	Diptera	Chironomidae	Rheosmittia		Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Rheotanytarsus	6	Chironominae	Rheotanytarsus
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	0	Rhithrogena	Rhithrogena
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena robusta	0	Rhithrogena	Rhithrogena
Annelida	Oligochaeta	Haplotaxida	Tubificidae	Rhyacodrilus		Oligochaeta	Tubificidae
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	1	Rhyacophila	NA
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila alberta	0	Rhyacophila alberta gr.	Rhyacophila_alberta_gr
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila angelita	0	Rhyacophila angelita gr.	Rhyacophila_Angelita_Gr
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila arnaudi		Rhyacophila arnaudi	NA
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila betteni	1	Rhyacophila betteni gr.	Rhyacophila_Betteni_Gr
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila blarina		Rhyacophila sibirica gr.	NA
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila brunnea	0	Rhyacophila brunnea/vemna Gr.s	Rhyacophila_Brunnea_Gr
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila coloradensis	0	Rhyacophila coloradensis gr.	NA
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	1	Rhyacophila hyalinata gr.	Rhyacophila_Hyalinata_Gr
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila iranda		Rhyacophila vofixa gr.	NA
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila narvae	0	Rhyacophila sibirica gr.	Rhyacophila_narvae
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila nevadensis		Rhyacophila nevadensis gr.	NA
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila pellisa	0	Rhyacophila sibirica gr.	Rhyacophila_pellisa/valuma
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila rotunda		Rhyacophila rotunda gr.	NA
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila sibirica		Rhyacophila sibirica gr.	NA
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila vagrita	0	Rhyacophila vagrita gr.	NA
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila verrula	0	Rhyacophila verrula gr.	Rhyacophila_Verrula_Gr

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Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila vofixa	0	Rhyacophila vofixa gr.	Rhyacophila_vofixa_Gr
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophilidae	0	Rhyacophilidae	NA
Annelida	Oligochaeta	Lumbriculida	Lumbriculidae	Rhynchelmis		Oligochaeta	Rhynchelmis
Arthropoda	Insecta	Diptera	Chironomidae	Robackia	4	Chironominae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Saetheria	8	Chironominae	NA
Arthropoda	Insecta	Hemiptera	Saldidae	Saldula		Saldula	Other_Hemiptera
Arthropoda	Insecta	Diptera	Sciomyzidae	Sciomyzidae		Sciomyzidae	NA
Arthropoda	Insecta	Trichoptera	Uenoidae	Sericostriata		Sericostriata	Uenoidae
Arthropoda	Insecta	Trichoptera	Uenoidae	Sericostriata surdickae		Sericostriata	Uenoidae
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	2	Serratella	Serratella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella micheneri	0	Serratella	Serratella
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella tibialis	2	Serratella	Serratella
Arthropoda	Insecta	Plecoptera	Perlodidae	Setvena	0	Setvena	Perlodidae
Arthropoda	Insecta	Plecoptera	Perlodidae	Setvena bradleyi	0	Setvena	Perlodidae
Arthropoda	Insecta	Hemiptera	Sialidae	Sialis	4	Sialis	Sialis
Arthropoda	Branchiopoda	Diplostraca	Sididae	Sididae		Cladocera	Cladocera
Arthropoda	Insecta	Hemiptera	Corixidae	Sigara	9	Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Sigara alternata		Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Sigara decorata		Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Sigara decoratella		Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Sigara grossolineata		Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Sigara lineata		Corixidae	Corixidae
Arthropoda	Insecta	Diptera	Simuliidae	Simuliidae	6	Simuliidae	Simuliidae
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	5	Simuliidae	Simuliidae
Arthropoda	Insecta	Ephemeroptera	Siphlonuridae	Siphlonurus	2	Siphlonuridae	NA
Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	3	Skwala	Perlodidae
Mollusca	Bivalvia	Veneroida	Sphaeriidae	Sphaeriidae	8	Pisidiidae	Pisidiidae
Mollusca	Bivalvia	Veneroida	Pisidiidae	Sphaerium	8	Pisidiidae	Pisidiidae
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Stagnicola	6	Lymnaeidae	Lymnaeidae
Arthropoda	Insecta	Diptera	Chironomidae	Stempellina	2	Chironominae	Stempellina
Arthropoda	Insecta	Diptera	Chironomidae	Stempellinella	4	Chironominae	Stempellinella
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Stenacron	4	Stenacron	NA
Arthropoda	Insecta	Coleoptera	Elmidae	Stenelmis	5	Stenelmis	NA
Arthropoda	Insecta	Coleoptera	Elmidae	Stenelmis occidentalis		Stenelmis	NA
Arthropoda	Insecta	Diptera	Chironomidae	Stenochironomus	5	Chironominae	NA

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Arthropoda	Insecta	Diptera	Chironomidae	Stictochironomus	5	Chironominae	Stictochironomus
Arthropoda	Insecta	Coleoptera	Dytiscidae	Stictotarsus		Stictotarsus	Dytiscidae
Arthropoda	Insecta	Diptera	Chironomidae	Stilocladius	6	Orthocladiinae	Stilocladius
Arthropoda	Insecta	Diptera	Stratiomyidae	Stratiomyidae	7	Stratiomyidae	Stratiomyidae
Arthropoda	Insecta	Diptera	Stratiomyidae	Stratiomys		Stratiomys	Stratiomyidae
Arthropoda	Insecta	Odonata	Gomphidae	Stylurus		Gomphidae	Gomphidae
Arthropoda	Insecta	Diptera	Chironomidae	Sublettea	2	Chironominae	NA
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia	1	Chloroperlidae	Suwallia
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	0	Chloroperlidae	Sweltsa
Arthropoda	Insecta	Odonata	Libellulidae	Sympetrum	9	Libellulidae	Libellulidae
Arthropoda	Insecta	Diptera	Chironomidae	Symposiocladius	6	Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Sympotthastia	2	Diamesinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Synendotendipes		Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Synorthocladius	2	Orthocladiinae	NA
Arthropoda	Insecta	Diptera	Tabanidae	Tabanidae	10	Tabanidae	Tabanidae
Arthropoda	Insecta	Diptera	Tabanidae	Tabanus	10	Tabanidae	Tabanidae
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema	2	Taeniopterygidae	Taeniopterygidae
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taeniopterygidae	2	Taeniopterygidae	Taeniopterygidae
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		Tanypodinae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Tanypus	10	Tanypodinae	Tanypus
Arthropoda	Insecta	Diptera	Chironomidae	Tanytarsini	6	Chironominae	NA
Arthropoda	Insecta	Diptera	Chironomidae	Tanytarsus	6	Chironominae	Tanytarsus
Arthropoda	Insecta	Diptera	Thaumaleidae	Thaumalea		Thaumaleidae	NA
Arthropoda	Insecta	Diptera	Thaumaleidae	Thaumaleidae		Thaumaleidae	NA
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Theromyzon		Glossiphoniidae	Hirudinea
Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniella	6	Orthocladiinae	Thienemanniella
Arthropoda	Insecta	Diptera	Chironomidae	Thienemannimyia		Tanypodinae	Thienemannimyia_Gr
Arthropoda	Insecta	Diptera	Chironomidae	Thienemanniola		Chironominae	NA
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Timpanoga	2	Timpanoga	NA
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Timpanoga hecuba	2	Timpanoga	NA
Arthropoda	Insecta	Diptera	Tipulidae	Tipula	4	Tipula	Tipula
Arthropoda	Insecta	Diptera	Tipulidae	Tipulidae	3	Tipulidae	Other_Tipulidae
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Traverella	2	Traverella	Leptophlebiidae
Arthropoda	Insecta	Trichoptera	Leptoceridae	Triaenodes	6	Triaenodes	Leptoceridae
Arthropoda	Insecta	Diptera	Chironomidae	Tribelos		Chironominae	NA

Phyla	Class	Order	Family	FinalID	TolVal	OTU_2005	OTU_2011
Arthropoda	Insecta	Diptera	Empididae	Trichoclinocera		Trichoclinocera	Empididae
Arthropoda	Insecta	Hemiptera	Corixidae	Trichocorixa	9	Corixidae	Corixidae
Arthropoda	Insecta	Hemiptera	Corixidae	Trichocorixa borealis	9	Corixidae	Corixidae
Arthropoda	Insecta	Trichoptera	.	Trichoptera		Trichoptera	NA
Platyhelminthes	Tubellaria	Tricladida	.	Tricladida	4	Turbellaria	Turbellaria
Arthropoda	Insecta	Ephemeroptera	Tricorythidae	Tricorythidae	4	Tricorythidae	NA
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	4	Tricorythodes	Tricorythodes
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes minutus	4	Tricorythodes	Tricorythodes
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Triznaka		Chloroperlidae	NA
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Tropisternus		Tropisternus	Hydrophilidae
Annelida	Oligochaeta	Haplotaxida	Tubificidae	Tubifex		Oligochaeta	Tubificidae
Annelida	Oligochaeta	Haplotaxida	Tubificidae	Tubifex tubifex	10	Oligochaeta	Tubificidae
Annelida	Oligochaeta	Haplotaxida	Tubificidae	Tubificidae	10	Oligochaeta	Tubificidae
Platyhelminthes	Tubellaria	.	.	Turbellaria	4	Turbellaria	Turbellaria
Arthropoda	Insecta	Diptera	Chironomidae	Tvetenia	5	Orthocladiinae	Tvetenia
Arthropoda	Insecta	Diptera	Chironomidae	Tvetenia bavarica		Orthocladiinae	Tvetenia
Arthropoda	Insecta	Diptera	Chironomidae	Tvetenia discoloripes		Orthocladiinae	Tvetenia
Arthropoda	Insecta	Diptera	Chironomidae	Tvetenia vitracies		Orthocladiinae	Tvetenia
Arthropoda	Insecta	Diptera	Simuliidae	Twinnia	7	Simuliidae	Simuliidae
Arthropoda	Insecta	Trichoptera	Uenoidae	Uenoidae	2	Uenoidae	Uenoidae
Mollusca	Bivalvia	Unionida	Unionidae	Unionidae		Unionidae	NA
Mollusca	Gastropoda	Heterostropha	Valvatidae	Valvata	3	Valvata	NA
Mollusca	Gastropoda	Heterostropha	Valvatidae	Valvatidae	3	Valvatidae	NA
Arthropoda	Insecta	Plecoptera	Nemouridae	Visoka cataractae	0	Visoka	Visoka
Arthropoda	Insecta	Diptera	Empididae	Wiedemannia		Wiedemannia	Empididae
Arthropoda	Insecta	Trichoptera	Philopotamidae	Wormaldia	0	Wormaldia	Philopotamidae
Arthropoda	Insecta	Diptera	Chironomidae	Xenochironomus	4	Chironominae	NA
Arthropoda	Insecta	Trichoptera	Leptoceridae	Ylodes		Ylodes	Leptoceridae
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla	0	Yoraperla	Peltoperlidae
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla brevis		Yoraperla	Peltoperlidae
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia	5	Zaitzevia	Zaitzevia
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia parvulus		Zaitzevia	Zaitzevia
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	2	Zapada	NA
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada cinctipes	3	Zapada	Zapada_cinctipes
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada columbiana	2	Zapada	Zapada_columbiana

Phyla	Class	Order	Family	FinalID	TolVal	OTU_2005	OTU_2011
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada frigida	1	Zapada	NA
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada Oregonensis		Zapada	Zapada_oregonensis_gr
Arthropoda	Insecta	Diptera	Chironomidae	Zavrelimyia	8	Tanypodinae	Paramerina/Zavrelimyia
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Zumatrichia	3	Zumatrichia	Hydroptilidae
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Zumatrichia notosa	3	Zumatrichia	Hydroptilidae

APPENDIX B - AN EXAMPLE TAXA LIST TEMPLATE

Site ID:			**TAXA LIST TEMPLATE**			
Sample Date:						
Taxonimist(s):						
ITIS Code	**Class**	**Order**	**Family**	**Genus/Species**	**Funtional Feeding Group (cite literature)**	**Count**
					Total for this Page:	

Site ID:			TAXA LIST TEMPLATE			
Sample Date:						
Taxonimist(s):						
ITIS Code	**Class**	**Order**	**Family**	**Genus/Species**	**Funtional Feeding Group (cite literature)**	**Count**
					Total for This Page:	

Page 1 Total:

Page 2 Total:

Total # of Organisms ID'd:

APPENDIX C - EXAMPLE OUTPUT FOR THE OBSERVED/EXPECTED MODELS

The following page shows an example output table from EDAS (Tetra Tech 2006a). These are used to illustrate index results for samples. The EDAS output result comes as a direct output saved as an MS Excel (2003) spreadsheet (**Table C-1**). The spreadsheet contains all of the relevant sampling location information and O/E values. EDAS can also generate Multimetric Index values if a project requires them (not shown in the example).

Table C-1. EDAS output table example.

Station ID	Waterbody Name	Lat_Dec	Long_Dec	Cld Wrm Type	SiteClass	Four Code HUC	TMDL Planning Area	Reference	ActivityID	CollDate	CollMeth	Ben Samp ID	Rep Num	OE model test	Total OE Bugs	O/E_ 2005	BC_2005	CW_ OE_ 2011	CW_outlier 05_2011	CW_BC_ pc>half_2011
C04FIREC01	Fire Creek	46.8884031	-114.804544	Cold	Mountains	17010204	MIDDLE CLARK FORK	Reference	2523-MAC-R	13-Jun-06	MAC-R-500	17087	0	P	300	0.80	0.62	0.64	1	0.43
C04FIREC01	Fire Creek	46.8884031	-114.804544	Cold	Mountains	17010204	MIDDLE CLARK FORK	Reference	2705-MAC-R	08-Sep-06	MAC-R-500	17089	0	P	300	0.80	0.14	0.94	0	0.25

APPENDIX D - MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY BENTHIC MACROINVERTEBRATE OBSERVED/EXPECTED MANUAL

D1.0 Introduction

D1.1 Background

This manual is intended to guide users in creating and applying predictive models of observed and expected (O/E) benthic macroinvertebrate taxa in samples from streams in Montana. O/E models have been developed in 2005 and 2011 by consultants to the Montana Department of Environmental Quality (DEQ). With this guidance and associated software, development of new models and application of existing models should be possible for DEQ staff.

The O/E model is an assessment tool that can be used to determine the degree to which a sample contains the number and type of taxa expected after considering relevant characteristics of each site's environmental setting. Literature on the O/E predictive models is abundant, and the theories behind the responsiveness of the models to stress can be reviewed in those articles (Clarke et al. 1996, Clarke et al. 2002, Clarke et al. 2003, Hawkins and Carlisle 2001, Hawkins et al. 2000, Hawkins and Norris 2000, Hawkins et al. 2009, Hubler 2008, Van Sickle et al. 2005, Van Sickle et al. 2006, and Van Sickle et al. 2007). The Bray-Curtis (BC) index is used as a secondary indicator and its development and application are also presented in this document. It is developed using theories similar to the O/E index (Van Sickle 2008).

D1.2 Purpose and Goals

This document is intended as a guide for developing, interpreting, and applying O/E and BC indices. It is especially tailored to the needs of DEQ in assessing benthic macroinvertebrate conditions in streams of Montana. Following the steps of this manual should allow DEQ staff to calibrate new predictive models, interpret the model output, and apply developed models for assessment purposes.

D1.3 Data organization and software

Data for analyses must conform to DEQ standards for sample collection for taxa and other data standards for reference designations and predictor data. The necessary information for development and application of the O/E and BC indices include two types: One of taxonomic composition in samples and another of site and sample characteristics (predictors) for the sampling locations. DEQ uses the Ecological Data Analysis System (EDAS) for generating macroinvertebrate indicator of water quality results. EDAS is also used to generate taxonomic and predictor data in formats that can be used for model development and application. Some formats require further manipulation after export from EDAS. In this manual, we assume that the analyst is familiar with EDAS and its functions. Specific format for analyses will be described in following sections.

The instructions include references to existing software. While some details on the use of the software are provided, analysts are expected to have basic knowledge of the software and can investigate software application issues through other manuals specific to those programs. The software referenced most often includes Excel (Microsoft Corporation), PC-ORD (McCune and Mefford 2006), R (http://www.r-project.org), Statistica (StatSoft, Inc.), and "SubSample.exe" (a DOS program). Alternative software could be used for some steps of the analyses.

D2.0 Applying an Observed/Expected model

Once the O/E and BC models are built on calibration data and saved, they can be applied to test data. Test data are samples from any site that was not used as a reference sample in the model calibration. This could include samples from reference-quality sites sampled in years following the calibration effort or from sites that have some know degree of disturbance.

D2.1 Required files and scripts

The files required to calculate O/E scores from an established model include 2 data files and multiple R scripts. The taxa and predictor matrix should have the same format described for model building. Taxa identifiers should be the 8-character OTUs, predictors must include all predictors used in the models, and records for the taxa and predictor files must have the same sample identifiers in the same order. The same predictor file used for model building can be used for model application, where the 'RefCalVal' field includes 'test' designations. Only the sample identifiers and the model predictors are required in the test predictor file, but the other fields can be included as well.

The model can be applied either at the end of the 'model.build.V4.1.R' script or from the 'model.apply.V4.1.R' script. During its execution, the script calls on other files, including 'model.predict.v4.1.r', 'MyModel.Version1.Rdata', and 'assess.one.sample.4.1.r'. If new data are prepared for calculation of O/E and BC scores, first create the taxon and predictor files as described above. Then run the 'model.apply.V4.1.R' script as described below.

The required fields in the predictor files are as follow. All spellings and cases must be exact.

SampID	Also called BenSamp-Rep (rename to SampID)
RefCalVal	With allowed values 'Calib', 'Valid', or 'test' (case sensitive) (optional field)
ELVsd_WS	Standard deviation of Elevation in the watershed
GIS_LAT	Latitude
JulianDay	Sequential day of the year (cold only)
log_sqkm	logarithm of watershed square kilometers (also called 'log_km2' [rename])
Mtns1	Designation of the mountains ecoregions (1), or not (0)
Tmax_PT	Maximum monthly average temperature at the point (also TMAX_PT_2011)
FFP_PT	Frost-Free Period Point (For Warm-Water model only)
WDmin_PT	Minimum number of wet days (For Warm-Water model only)

There are alternate names for two variables because these were also used in the 2005 O/E model. In the case of Tmax_PT, the value is calculated differently among models, so that in EDAS the value is labeled Tmax_PT_2011, but it is recognized in the model as 'Tmax_PT'.

D2.2 Running model application R code

The model application R code is named 'model.apply.V4.1.R'. The code is run in sections so that errors can be corrected sequentially (and to avoid wasting time running subsequent erred sections). In the next report section, the code for the cold-water model is contained in text boxes. It is recommended that the code be run in the blocks between bullets as shown below. All model development files should be kept in one file folder (or "directory"). Retaining distinct runs in separate directories is a good idea when experimenting and interpreting.

- Introduction and set-up.

```
# R code modified to allow application only (cut out much of the building steps)

# Ben Jessup and Dave Feldman modified original code by John Van Sickle, US Environmental
Protection Agency;
#Version 3: For application of an existing model (established through the model.build.v4.1 script)

###################################################;

## First clear the workspace
rm(list=ls())

#load required packages;
library(gtools); library(MASS);
library(cluster); library(Hmisc);
require(scatterplot3d)
require(maps)

# change directory based on where have script and data files (EWL)
#  but to keep code the same subsititute with "getwd"
# change the working directory to the correct one using "setdir". Notice that the filepath uses "/"
setdir ("C:/working directory")
 myDir <- getwd()
```

- Load the predictor file and display example data, which should be in the same directory as the script.

```
# STEP 1 -- INITIAL SETUP -- Input and organize the bug and predictor data;
# The exact code for this step is very particular for each data set, ;
# but similar operations will need to be done on every data set;
# Data setup below is an example which contains both reference and nonreference sites;

################################;
# Input data are predictor data and a (site x taxa) matrix of abundance for all bugs;
# Predictor data file must include a column to identify the calibration, validation and test sites;

# Step 1a - Read and organize predictor data;
# Input the predictor data, tab delimited. Use the sample/site ID as the row name;

# Import Data
myFile = "data.cold.preds.tst.tab"
predall=read.delim(myFile,row.names=1)

head(predall); #look at 1st 5 rows, all columns;
dim(predall); # number of rows and columns;
```

- Load the bug file and display dimensions of the file (# rows and # columns)

```
## Step 1b - Input the assemblage data (bug data), as a site-by-taxa matrix;
# The bug matrix is the result of fixed-count subsampling and matrify or cross-tab functions;

bugall<-read.table(paste(myDir,"data.cold.bugs.tst.tab",sep="/"),row.names="SampID",
        header=T,sep="\t");
dim(bugall)
```

- Make sure that the predictor and bug files have records in the same order, with the same identifiers.
- If records are aligned, “true” will appear for every record.

```
## Step 1c - Align bug and predictor data, by site/sample;
#check sample(row) alignment of bug and predictor data;
row.names(bugall)==row.names(predall);
# If samples are not aligned, fix by aligning bugs data to predictor data;
bugall<-bugall[row.names(predall),];
#check alignment again -- alignment OK;
row.names(bugall)==row.names(predall);
```

- Change taxa abundance to presence/absence.

```
#Create a Presence/absence (1/0) matrix (site by taxa) for the bugs;
bugall.pa<-bugall;
bugall.pa[bugall.pa>0]<-1;
```

- The following lines are mostly informative.
- The source and load lines call on scripts and files that should be in the same directory as the script.
- The last line displays taxa names.

```
# Step 7 (continuation of steps in model.build.v4.1) - Making predictions for new (test) data.
# first, source the prediction script and also load the desired model;
 source("model.predict.v4.1.r");
 load('MyModel.Version1.Rdata');

 # User must supply a sample-by-taxa matrix of taxa abundance or else presence/absence
        #(coded as 1 or 0), for all new samples;
 # User must also supply a corresponding file of predictor data for those same samples;
 # These 2 files should have similar formats as the original taxa and predictor data sets;
 # Notes on file formats --
 #  A) The sample ID column in both files should be read into R as a row name (see Step 1 examples).
 #  B) Predictor data set -- Must include columns with the same names, units, etc.,
 #   as the model's predictor variables. All other columns will be ignored;
 #   Column order does not matter;
 #   Predictions and calculations of O/E will be made only for those samples that have;
 #   complete data for all model predictors.;
 #  C) Sample-by-taxa matrix. Can contain abundance or presence/absence (1 or 0).
 #              Missing or empty cells now allowed;
 #   Sample ID's (row names) must match those of predictor data.
 #   Any names for new taxa (column names) are acceptable, in any order;
 #   HOWEVER - Only those new-data taxa names that match the names in the
 #     calibration data can be used to calculate observed richness;
 #     All other taxa (columns) in the new-data bug matrix are ignored;
 #   To see a list of the calibration-taxa names, do:
   names(bugcal.pa)[colSums(bugcal.pa)>0];
```

- Define subset of data if desired
- Limit analysis to sites with complete data

```
# Example predictions: non-reference sites are labeled "test" (see Step 1);

pred.test<-predall; #predictor data - ALL sites;
bug.test.pa<-bugall.pa; #Bug presence/absence matrix, ALL sites;

#To limit to test sites only, use this code;
#pred.test<-predall[as.character(predall[,'RefCalVal'])=='test',];
#bug.test.pa<-bugall.pa[as.character(predall[,'RefCalVal'])=='test',];

#Drop all samples/sites that do not have complete data for the model predictors;
pred.test<-pred.test[complete.cases(pred.test[,preds.final]),];
bug.test.pa<-bug.test.pa[row.names(pred.test),];
```

- Calculate and display O/E, BC, and outlier status
- Results are not automatically saved and should be copied from the R console

- Looking at capture probabilities and predicted group occurrences is optional

```
#makes predictions for test data; *** Check PC at end of line, modify if needed
            #(may want to run BC at PC=1.e-14) **
OE.assess.test<-model.predict.v4.1(bugcal.pa,grps.final,preds.final,
grpmns,covpinv,prednew=pred.test,bugnew=bug.test.pa,Pc=0.5);

# Look at O/E and BC scores of test-data samples;
 OE.assess.test$OE.scores;
##### COPY these from the R console to a spreadsheet

# Look at predicted capture probabilties (1st 5 rows) for all calibration taxa, for test data;
 Head (OE.assess.test$Capture.Probs);
# Look at predicted group occurrence probabilties, for all test samples;
 OE.assess.test$Group.Occurrence.Probs;
```

- Calculate increaser/decreaser statistics
- Results are not automatically saved and should be copied from the R console
- For each of taxon, we list the 'Sensitivity Index'. The index is calculated from the average predicted probability of detection (assuming sites were under reference condition), the number of test sites at which taxa were predicted to occur, the number of test sites at which taxa were observed, and the ratio of observed sites to expected sites for each taxon (the 'Sensitivity Index'). We interpret it as a measure of sensitivity of a taxon to whatever stressors are influencing a taxon within the set of test sites submitted for assessment. A ratio > 1 indicates the taxon was found at more sites than expected and was thus an 'increaser' or tolerant taxon. A ratio < 1 indicates the taxon was found at fewer sites than expected and was thus a 'decreaser' or intolerant taxon.

```
# Increaser/Decreaser taxa
## use the output from this (in test sites) to find increasers and decreasers
## also called the sensitivity index
## Increaser values will be >1 (or >2 for certain increasers)
## Decreaser values will be <1 (or <0.5 for certain decreasers)

# limit above to test sites only
 taxa.pc<-OE.assess.test$Capture.Probs[as.character(predall[,'RefCalVal'])=='test',];
 bug.test.pa<-bugall.pa[as.character(predall[,'RefCalVal'])=='test',]; #Bug presence/absence matrix,
test sites;
# calculate observed occurences in all test sites over predicted occurences in all test sites
 Inc.dec.taxa<-apply(bug.test.pa,2,sum) / apply(taxa.pc,2,sum);
 Inc.dec.taxa
```

- Calculating O/E for an individual sample
- This gives more detailed results than the routine above, especially for individual taxa
- First identify the script and load the data
- Other lines are informative

```
## Assessing an individual sample or site;
	source("assess.one.sample.4.1.r")
	bug.test.pa<-bugall.pa
#This function assesses a single site or sample from a new (test) data set to which
# model.predict.v4.1() has already been applied.
# assess.one.sample() compares observed occurrences with the model-predicted
# probabilities of occurrence for all taxa;

# Input parameters are:
# case -- A selected sample ID, for which a prediction has already been made ;
	# The selected case must be among those assessed above;
# result.prd -- Output from O/E calculation above.
# bugnew -- Sample-by-taxa matrix of new samples.
# Pc -- Cutoff for capture probabilties for inclusion of taxa in O/E;
```

- Enter the name of the sample between quotes after *case=*

```
# The function produces a data frame with one row per taxon, and the following columns:
# observed presence(1) or absence(0);
# predicted capture probability;
# Big.diff = "Yes", if there is a big difference (>=0.5) between observed and predicted;
# In.OtoE = "Yes" if the taxon would be included in the O/E calculation for this sample,
	# given the stated value of Pc;

#By default, the function displays the results with its rows (taxa) sorted by
	# the magnitude of (observed-predicted),
	# as suggested in Van Sickle, J. (2008), JNABS 27:227-235;

site1.result<-assess.one.sample.4.1(case="11591_0",result.prd=OE.assess.test, bugnew=bug.test.pa,
Pc=0.5);

# See below for other sorting possibilities;
# Alternative display is to sort the taxa by their predicted occurrence probabilities;
 site1.result[order(site1.result$predicted,decreasing=TRUE),];
# Another alternative is to sort alphabetically by taxon name;
 site1.result[order(row.names(site1.result)),];
```

- End of script

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ATTACHMENT 1 – SITE VISIT FORM

Place Site Visit Label Here

Site Visit Form

(One Station per page)

Project ID:______________________

Date: ____________ **Time:** ____________ **Personnel:** ______________________________
Waterbody: ______________________________ Location: ______________________________
Station ID: ______________ Visit #: ________ HUC: ______________ County: ____________________
Latitude: __ __ . __ __ __ __ . Longitude __ __ __ . __ __ __ __. Lat/Long Verified? ☐ By:
Elevation: ____________ ft m Geo Method: **GPS** Other: Datum: NAD27 **NAD83** WGS84

Samples Collected:		**Sample ID:**	**Sample Collection Information/Preservation:**
Water	☐		GRAB EWI
Analysis:			Preserved: HNO_3 H_2SO_4 H_3PO_4 HCL Ice Frozen None
Analysis:			Preserved: HNO_3 H_2SO_4 H_3PO_4 HCL Ice Frozen None
Analysis:			Preserved: HNO_3 H_2SO_4 H_3PO_4 HCL Ice Frozen None
Analysis:			Preserved: HNO_3 H_2SO_4 H_3PO_4 HCL Ice Frozen None
Analysis:			Preserved: HNO_3 H_2SO_4 H_3PO_4 HCL Ice Frozen None
Analysis:			Preserved: HNO_3 H_2SO_4 H_3PO_4 HCL Ice Frozen None
Analysis:			Preserved: HNO_3 H_2SO_4 H_3PO_4 HCL Ice Frozen None
Analysis:			Preserved: HNO_3 H_2SO_4 H_3PO_4 HCL Ice Frozen None
Sediment	☐		SED-1
Analysis:			Preserved: None Other:
Benthic Chl-a	☐		Sample Method: C=Core H=Hoop T=Template N=None
Composite at Lab ☐ Ash-Free Dry Weight ☐			Sample Location: R=Right C=Center L=Left
Transect: A___-___ B___-___ C___-___ D___-___ E___-___ F___-___ G___-___ H___-___ I___-___ J___-___ K______-			
Phytoplankton Chl-a	☐		D1 Filtered:_________mL D2 Filtered:_________mL
Phytoplankton CNP	☐		D1 Filtered:_________mL D2 Filtered:_________mL
Algae	☐		PERI-1-MOD PERI-1 OTHER:
Macroinvertebrates	☐		MAC-R-500 HESS OTHER:
Collection Reach Length (m):			# of Jars: | Mesh Size: 500 OTHER:

Field Measurements:		Time: am pm	**Field Assessments:**
Water Temp: °C °F		Air Temp: °C °F	Field Forms: Fish Cover Form ☐ Photographs ☐
Bar. Pressure: mm/Hg		SC: umho/cm	Aquatic Plant Tracking Form ☐ Rosgen Form ☐
pH:	DO: mg/L	Flow: cfs	NRCS Form ☐ MAP Forms ☐ Summary Form ☐
Flow Comments: Dry Bed ☐ No Measurable Flow ☐			Channel Cross-Section ☐ Other:______.
Flow Method: Meter ☐ Float ☐ Gage ☐ Visual Est. ☐			Data Loggers: Temperature ☐ YSI ☐ TruTrack ☐
Turbidity: Clear ☐ Slight ☐ Turbid ☐ Opaque ☐			AquaRods ☐ Weather Station ☐ Surveyor ☐

Comments	Only Transect F ☐ Total Site Length_____m Average Wetted Width____m Transect Length____m

Chemistry Lab Information:		
Lab Samples Submitted to:	Account #:	Term Contract Number:
Contact Name & Phone:		EDD ☒ Format: MT-eWQX Compatible
1) Relinquished By & Date/Time:	1) Shipped By: Hand ☐ FedEx/UPS ☐ USPS ☐	1) Received By & Date/Time:
2) Relinquished By & Date/Time:	2) Shipped By: Hand ☐ FedEx/UPS ☐ USPS ☐	2) Received By & Date/Time:

Lab Use Only - Delivery Temperature: Wet Ice_______°C Dry Ice_______°C

Rev. 3/18/2011

Site Visit Form Instructions

Place a Site Visit Code label in the upper left corner (ONLY 1 SITE VISIT CODE PER FORM).
Place a Trip Label in the upper right corner. (Covering Project ID and Trip ID with label is alright.)

1. **Project ID**: If you do not have a Trip Label, enter the Project ID assigned by Data Management. If Project ID is not assigned, leave blank for Water Quality Database Manager.
2. **Trip ID:** If you do not have a Trip Label, enter the Trip ID assigned by Data Management. If Trip ID is not assigned, leave blank for Water Quality Database Manager.
3. **Date/Time**: Enter the date and time of the station visit.
4. **Personnel**: Enter the first and last name(s) of the personnel conducting field activities.
5. **Waterbody**: Enter the name of the waterbody such as "Missouri River".
6. **Location**: Description of sample location such as "upstream from bridge on Forest Service road 100". For confidentiality please <u>DO NOT</u> use proper names of people in the location field.
7. **Station ID**: If you have a Trip Label, enter the established ID. If there is no ID on the Trip Label, leave the field blank and Data Management will generate a Station ID when the Site Visit Form is submitted.
8. **Visit #**: Enter "1" if this is a new station. Leave blank if visit number is unknown.
9. **HUC**: If you do not have a Trip Label, enter the fourth code (8 digit) HUC the station falls within.
10. **County**: If you do not have a Trip Label, enter the county in which the station falls within.
11. **Lat/Long**: Latitude and Longitudes should be obtained in decimal degrees using a GPS unit reading **NAD83** whenever possible. If a lat/long is obtained by another method, the datum and method must be recorded in the Site Visit Comments.
12. **Lat/Long Verified**: Latitudes and Longitudes should be verified <u>immediately</u> upon return from the field. Verify by plotting on a paper map or using a mapping website. Once the lat/long has been verified check the Verified box and enter initials after "By". Do not make minor adjustments to measured values during verification; they are assumed to be correct within the limitations of the measurement system. Gross errors should be corrected as follows: 1) Draw a single line through the erroneous value(s) and initial. Do not erase the original reading. 2) Write the corrected value in the comment field along with the method and datum used to derive the corrected value.
13. **Elevation:** Record elevation collected by GPS and circle the GPS datum used. If elevation is obtained by another method, the datum and method must be recorded in the Site Visit Comments.
14. **Samples Collected**: Check the box next to each activity that is collected during the station visit.
15. **Sample ID**: Write the Sample ID (Site Visit Code-sample identifier) for all of the samples collected.
16. **Sample Collection Procedure**: Circle the appropriate Sample Collection Procedure ID.
    For each Chlorophyll-*a* transect, record the sample collection method in the first space provided and the sample location in the second space provided (example: A:<u> T - R </u>).
    For Phytoplankton, record the volume filtered for each sample collected.
17. **Analysis Requested**: Record the requested laboratory analysis for each chemistry sample and circle the preservative used.
18. **Field Measurements**: Record your field measurements in the spaces provided.
19. **Field Assessments**: Check the boxes next to each type of field assessment completed.
20. **Site Visit Comments**: Record general comments about the station visit, samples, and field measurements.
21. **Chemistry Lab Information**: If chemistry lab samples were taken, complete this section.
    Lab Samples Submitted to: Enter name of laboratory where samples will be sent.
    Account #: Enter account number at laboratory where samples will be sent.
    Date Submitted: Record date the samples were received by the laboratory.
    Sign and date the form each time the samples change possession.

ATTACHMENT 2 – PHOTOGRAPH LOCATIONS AND DESCRIPTIONS OF REACH AND/OR SITES

PHOTOGRAPH LOCATIONS AND DESCRIPTIONS OF REACH AND/OR SITES

Date:		**Site Visit Code(s):**	

Photo No: ________ **Lat** ________ **Long** ________
Description:

Photo No: ________ **Lat** ________ **Long** ________
Description:

Photo No: ________ **Lat** ________ **Long** ________
Description:

Photo No: ________ **Lat** ________ **Long** ________
Description:

Photo No: ___ **Lat** ________ **Long** ___
Description:

PHOTOGRAPH LOCATIONS AND DESCRIPTIONS-CONTINUED

Photo No: ______________ **Lat** ______________ **Long** ______________
Description:

Photo No: ______________ **Lat** ______________ **Long** ______________
Description:

Photo No: ______________ **Lat** ______________ **Long** ______________
Description:

Photo No: ______________ **Lat** ______________ **Long** ______________
Description:

Photo No: ______________ **Lat** ______________ **Long** ______________

Photo No:		**Lat**		**Long**	
Description:					

ATTACHMENT 3 – SITE SKETCH FORM

Date:_______________________________________ **Site Visit Code:**__________________________

Waterbody: ____

Personnel: ____

Appendix D – Environmental Monitoring and Assessment Program Forms

Rapid Bioassessment Protocol (RBP) Forms

Reviewed by (initial): ______

RAPID HABITAT ASSESSMENT FORM: RIFFLE/RUN PREVALENCE - STREAMS

SITE NAME: DATE: / / 97 VISIT: G1 G2 ___

SITE ID: M A I A 9 7 - __ __ __ __ __ TEAM ID (X): G1 G2 G3 G4 G5 G6 G7 G8

TOTAL SCORE	CATEGORY			
HABITAT PARAMETER	OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
1. INSTREAM COVER (FISH)	Greater than 50% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat.	30 to 50% mix of boulder, cobble, or other stable habitat; adequate habitat.	10 to 30% mix of boulder, cobble, or other stable habitat; habitat availability is less than desirable.	Less than 10% of boulder, cobble, or other stable habitat; lack of habitat is obvious.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. EPIFAUNAL SUBSTRATE	Well-developed riffle and run; riffle is as wide as stream and its length extends two times the width of stream; abundance of cobble.	Riffle is as wide as stream, but is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; reduced riffle area that does not extend across entire cross section and is less than two times the width; gravel or large boulders and bedrock prevalent; cobble present.	Riffles or run virtually non-existent; gravel or large boulders and bedrock prevalent; cobble lacking.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. EMBEDDEDNESS	Gravel, cobble, and boulder particles are between 0 and 25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are between 25 and 50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are between 50 and 75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are over 75% surrounded by fine sediment.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. VELOCITY/DEPTH REGIMES	All four velocity regimes are present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only three of the four habitat types are present (if fast-shallow is missing, score lower than if other regimes are missing).	Only two of the four habitat types are present (if fast-shallow or slow-shallow are missing, score low).	Dominated by one velocity/depth regime (usually slow-deep).
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. CHANNEL ALTERATION	No channelization of dredging present..	Some channelization is present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging (greater than past 20 yr) may be present, but recent channelization is not present.	New embankments are present on both banks; and 40 to 80% of the stream reach is channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach is channelized and disrupted.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. SEDIMENT DEPOSITION	Little or no enlargement of islands or point bars and less than 5% of the bottom is affected by sediment deposition.	Some new increase in bar formation, mostly from coarse gravel; 5 to 30% of the bottom is affected; slight deposition in pools.	Moderate deposition of new gravel or coarse sand on old and new bars; 30 to 50% of the bottom is affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material; increased bar development; more than 50% of the bottom is changing frequently; pools almost absent due to substantial sediment deposition.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Reviewed by (initial): ______

RAPID HABITAT ASSESSMENT FORM: RIFFLE/RUN - STREAMS (continued)

SITE NAME:	DATE: / / VISIT: G1 G2 ___
SITE ID: ___ ___ ___ ___ ___ ___ - ___ ___ ___ ___ ___	TEAM ID (X): G1 G2 G3 G4 G5 G6 G7 G8

HABITAT PARAMETER	CATEGORY			
	OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
7. FREQUENCY OF RIFFLES	Occurrence of riffles is relatively frequent; the distance between riffles divided by the width of the stream equals 5 to 7; variety of habitat.	Occurrence of riffles is infrequent; distance between riffles divided by the width of the stream equals 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is greater than 25.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. CHANNEL FLOW STATUS	Water reaches the base of both banks and a minimal area of channel substrate is exposed.	Water fills more than 75% of the available channel; or less than 25% of the channel substrate is exposed.	Water fill 25 to 75% of the available channel; and/or riffle substrates are mostly exposed.	Very little water in channel, and mostly present as standing pools.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. CONDITION OF BANKS	Banks stable; no evidence of erosion or bank failure.	Banks moderately stable; infrequent, small areas of erosion mostly healed over.	Moderately unstable; up to 60% of banks in reach have areas of erosion.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; on side slopes, 60 to 100% of bank has erosional scars.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
10. BANK VEGETATIVE PROTECTION	More than 90% of the stream bank surfaces are covered by vegetation.	70 to 90% of the stream bank surfaces are covered by vegetation.	50 to 70% of the stream bank surfaces are covered by vegetation.	Less than 50% of the stream bank surfaces are covered by vegetation.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
11. GRAZING OR OTHER DISRUPTIVE PRESSURE	Vegetative disruption, through grazing or mowing is minimal or not evident; almost all plants are allowed to grow naturally.	Disruption is evident but is not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	Disruption is obvious; patches of bare soil or closely cropped vegetation are common; less than one-half of the potential plant stubble height remaining.	Disruption of stream bank vegetation is very high; vegetation has been removed to 2 inches or less in average stubble height.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
12. RIPARIAN VEGETATION ZONE WIDTH (LEAST BUFFERED SIDE)	Width of riparian zone is greater than 18 m; human activities (i.e.; parking lots, roadbeds, clearcuts, lawns, or crops) have not impacted this zone.	Zone width is between 12 and 18 m; human activities have only minimally impacted this zone.	Zone width is between 6 and 12 m; human activities have impacted the zone a great deal.	Width of zone is less than 6 m; little or no riparian vegetation due to man-induced activities.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Reviewed by (initial): ______

RAPID HABITAT ASSESSMENT FORM: GLIDE/POOL PREVALENCE - STREAMS

SITE NAME:	DATE: / / VISIT: G1 G2 ___
SITE ID: ___ ___ ___ ___ ___ ___ - ___ ___ ___ ___ ___	TEAM ID (X): G1 G2 G3 G4 G5 G6 G7

TOTAL		CATEGORY			
HABITAT PARAMETER		OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
1. INSTREAM COVER		Greater than 50% mix of snags, submerged logs, undercut banks, or other stable habitat; rubble or gravel may be present.	30 to 50% mix of stable habitat; adequate habitat for maintenance of populations.	10 to 30% mix of stable habitat; habitat availability is less than desirable.	Less than 10% stable habitat; lack of habitat is obvious.
SCORE:		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. EPIFAUNAL SUBSTRATE		Preferred benthic substrate (to be sampled) is abundant throughout stream site and at a stage to allow for full colonization potential (i.e.; logs and snags that are not new fall and not transient.	Substrate is common but is not prevalent nor well-suited for full colonization potential.	Substrate frequently disturbed or removed.	Substrate is unstable or lacking.
SCORE:		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. POOL SUBSTRATE CHARACTERIZATION		Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation are common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation are present	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE:		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. POOL VARIABILITY		Even mix of large-shallow, large-deep, small-shallow, and small-deep pools are present.	The majority of pools are large and deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools are small-shallow or pools are absent.
SCORE:		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. CHANNEL ALTERATION		No channelization of dredging present.	Some channelization is present, usually in areas of bridge abutments; evidence of past channelization, i.e.; dredging (greater than past	New embankments are present on both banks; channelization may be extensive, usually in urban areas or drainage areas of	Extensive channelization; banks shored with gabion or cement; heavily urbanized areas; instream habitat greatly altered or removed
SCORE:		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. SEDIMENT DEPOSITION		Less than 20% of the bottom is affected; minor accumulation of fine and coarse material at snags and submerged	20 to 50% affected; moderate accumulation; substantial sediment movement only during major storm events; some new increase in bar	50 to 80% affected; major deposition; pools shallow and heavily silted; embankments may be present on both banks;	Channelized; mud, silt, and/or sand in braided or non-braided channels; pools almost absent due to deposition.
SCORE:		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Reviewed by (initial): ______

RAPID HABITAT ASSESSMENT FORM: GLIDE/POOL- STREAMS (continued)

SITE NAME:	DATE: / /	VISIT: G1 G2 ___	
SITE ID: ___ ___ ___ ___ ___ ___ - ___ ___ ___ ___ ___	TEAM ID (X): G1 G2 G3 G4 G5 G6 G7		

HABITAT PARAMETER	CATEGORY			
	OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
7. CHANNEL SINUOSITY	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length between 1 and 2 times longer than if it was in a straight line.	Channel is straight; waterway has been channelized for a long distance.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. CHANNEL FLOW STATUS	Water reaches the base of both lower banks and a minimal amount of channel substrate is exposed.	Water fills more than 75% of the available channel; or less than 25% of the channel substrate is exposed.	Water fills 25 to 75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel, and mostly present as standing pools.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. CONDITION OF BANKS	Banks stable; no evidence of erosion or bank failure.	Banks moderately stable; infrequent, small areas of erosion mostly healed over.	Moderately unstable; up to 60% of banks in reach have areas of erosion.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; side slopes 60 to 100% of bank has erosional
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
10. BANK VEGETATIVE PROTECTION	Over 90% of the stream bank surfaces is covered by vegetation.	70 to 90% of the stream bank surfaces is covered by vegetation.	50 to 70% of the stream bank surfaces is covered by vegetation.	Less than 50% of the stream bank surfaces are covered by vegetation.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
11. GRAZING OR OTHER DISRUPTIVE PRESSURE	Vegetative disruption minimal or not evident; almost all plants are allowed to grow naturally.	Disruption is evident but is not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	Disruption is obvious; patches of bare soil or closely cropped vegetation are common; less than one-half of the potential plant stubble height remaining.	Disruption of stream bank vegetation is very high; vegetation has been removed to 2 inches or less in average stubble height.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
12. RIPARIAN VEGETATIOUN ZONE WIDTH (LEAST BUFFERED SIDE)	Width of riparian zone is greater than 18 meters; human activities (i.e.; parking lots, roadbeds, clearcuts, lawns, or crops) have not impacted this zone.	Width of riparian zone is between 12 and 18 meters; human activities have only minimally impacted this zone.	Width of riparian zone is between 6 and 12 meters; human activities have impacted the zone a great deal.	Width of riparian zone is less than 6 meters; little or no riparian vegetation due to human activities.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Reviewed by (initial): ______

ASSESSMENT FORM - STREAMS/RIVERS

SITE NAME: DATE: / / VISIT: G1 G2 ___

SITE ID: ___ ___ ___ ___ ___ ___ - ___ ___ ___ ___ ___ TEAM ID (X): G1 G2 G3 G4 G5 G6 G7 G8

WATERSHED ACTIVITIES AND DISTURBANCES OBSERVED (INTENSITY: BLANK=NOT OBSERVED, L=LOW, M=MODERATE, H=HEAVY)

L	M	H	RESIDENTIAL	L	M	H	RECREATIONAL	L	M	H	AGRICULTURAL	L	M	H	INDUSTRIAL	L	M	H	STREAM MANAGEMENT
			RESIDENCES				PARKS, CAMPGROUNDS				CROPLAND				INDUSTRIAL				LIMING
			MAINTAINED LAWNS				PRIMITIVE PARKS, CAMPING				PASTURE				MINES/QUARRIES				DRINKING WATER TREATMENT
			CONSTRUCTION				TRASH/LITTER				LIVESTOCK USE				OIL/GAS WELLS				ANGLING PRESSURE
			PIPES, DRAINS				SURFACE FILMS, SCUMS, OR SLICKS				ORCHARDS				POWER PLANTS				DREDGING
			DUMPING								POULTRY				LOGGING				CHANNELIZATION
			ROADS								IRRIGATION PUMPS				EVIDENCE OF FIRE				WATER LEVEL FLUCTUATIONS
			BRIDGE/CULVERTS												ODORS				FISH STOCKING
															COMMERCIAL				DAMS

REACH CHARACTERISTICS (percent of reach)

FOREST	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
SHRUB	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
GRASS	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
WETLAND	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
BARE GROUND	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
MACROPHYTES	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
AGRICULTURE - ROW CROP	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
AGRICULTURE - GRAZING	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
LOGGING	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
DEVELOPMENT (RESIDENTIAL & URBAN)	G RARE (< 5%)	G SPARSE (5 TO 25%)	G MODERATE (25 TO 75%)	G EXTENSIVE (> 75%)
WATER CLARITY	G CLEAR	G MURKY	G HIGHLY TURBID	G STORM INFLUENCED

WATERBODY CHARACTER (X ONE)

PRISTINE	G 5	G 4	G 3	G 2	G 1	HIGHLY
APPEALING	G 5	G 4	G 3	G 2	G 1	UNAPPEALING

GENERAL ASSESSMENT (wildlife, vegetation diversity, forest age class (0-25 yrs, 25-75 yrs, >75)

LOCAL ANECDOTAL INFORMATION:

Environmental Monitoring and Assessment Program (EMAP) Physical Habitat Characterization (EPA, 1998) Components

Thalweg Profile

The thalweg profile is a longitudinal survey of depth, habitat class, and presence of soft/small sediment at equally spaced intervals along the centerline between lower and upper ends of the sampling reach. Intervals for taking thalweg profile measurements are determined as a function of channel width as detailed in Table 1.

Table 1 - Thalweg Measurement Intervals Based on Channel Width

Channel Width	Thalweg Measurement Interval
< 2.5 m	1 m
2.5-3.5 m	1.5 m
> 3.5 m	0.01 × reach length (m)

Beginning from the downstream end of the sampling reach, maximum depth, habitat classes, and presence of soft sediment are measured at 10 or 15 equally spaced intervals between each of the 11 cross-section transects (100 or 150 measurements along the entire reach). One team member is in the channel measuring stream width and depth, and determining whether soft/small sediment is present. A second team member records those measurements, classifies the channel habitat, and tallies large woody debris (LWD).

In streams with average widths less than 2.5 m, thalweg measurements will be taken at 1 m intervals. Because the minimum sampling reach length is set at 150 m, there will be 15 total measurements between each cross-section. In streams with average widths greater than 2.5 m, measurement intervals are determined from Table 1 and a total of 10 measurements are taken between each cross-section. Inset C of **Error! Reference source not found.** provides examples of these layouts. These measurement interval locations between each cross-section are hereafter referred to as thalweg stations for the purpose of measurement procedures.

Wetted widths are measured at thalweg stations 0, station 5 (if the stream width defining the reach length is > 2.5 m) or station 7 (if the stream width defining the reach length is < 2.5 m). Widths are recorded on the *Channel/Riparian Cross-Section and Thalweg Profile Form*.

At each thalweg profile station, a surveyor's rod is used to locate and measure the deepest point (the "thalweg"). At this location, the biologist also observes whether small, loose, or soft sediments are present directly beneath the surveying rod. The second biologist determines the channel unit code (i.e., stream microhabitat feature), whether the station cross-section intersects a mid-channel bar, and the presence/absence of a side channel at the station's cross-section. All measurements and observations are conducted at the 10 or 15 thalweg stations between cross-sectional transects and are recorded on a field data form. Once the next transect is reached, a new *Channel/Riparian Cross-Section and Thalweg Profile Form* is prepared and the above steps are repeated until the field crew reaches the upstream end of the sampling reach.

Large Woody Debris Tally

Large woody debris is defined as large woody material with a small end diameter of at least 10 cm and a length of at least 1.5 m. The LWD tally includes all pieces of LWD that are at least partially in the base flow channel, the active channel (flood channel up to bank-full stage) or spanning above the active channel.

For each LWD piece, length and diameter are visually estimated in order to place it in diameter and length categories provided on the field data form. As in the thalweg profile, LWD measurements are recorded at each station (10 to 15) between transects on a total of 10 field forms for the entire sampling reach. The presence of LWD is tallied by length and diameter for pieces entirely or partially within the bank-full channel (zones 1-2) and pieces that span, or bridge, the bank-full channel (zone 3).

Large woody debris estimates are recorded on the LWD section of the *Thalweg Profile & Woody Debris Form.*

Slope and Bearing

Stream slope (water-surface slope) is measured by two people "backsighting" between transects (e.g., transect "B" to "A", "C" to "B", etc). One person reads slope (%) via a clinometer on a second person flagged at the eye level of the first person. Alternatively, slope can be measured if each person has a rod or pole marked at the same height from which a clinometer is read.

For the bearing measurements, the person reading slope sites back from the middle of the channel with a compass to the middle of the channel at the downstream transect and records the bearing in degrees on the field data form. If there is not a direct line-of-site between transects, intermediate points are set up for slope and bearing measurements and these are also recorded on the field data form.

Slope and bearing measurements are recorded on the *Slope and Bearing Form*.

Substrate Size and Channel Dimensions

Substrate size and embeddedness (the degree to which larger particles are covered with finer particles) are evaluated at each of the 11 cross-section transects. Substrate sampling points are measured along the cross-section at 0, 25, 50, 75, and 100% of the measured wetted width. A particle is selected at each point directly beneath the rod and classified into one of the size classes listed on the field data form based on the middle dimension of its length, width, and depth. The average percent embeddedness within a 10 cm circle around the measuring rod is then estimated and recorded on the field form.

Substrate and channel measurements are recorded in the *Substrate Cross-Sectional Information* section of the *Channel/Riparian Cross-Section and Thalweg Profile Form*.

Bank Characteristics

Bank and channel measurements include bank angle, undercutting distance (if present), channel incision, size of mid-channel sand/gravel bars, and height of bankfull flow above the present water level. All measurements are taken from within the stream channel using a surveyor's rod and clinometer (used for bank angle only).

Bank measurements are recorded in the *Bank Measurements* section of the *Channel/Riparian Cross-Section and Thalweg Profile Form*.

Canopy Cover Measurements

Canopy cover over the stream is measured at each of the 11 cross-section transects using a modified convex spherical densiometer (model B type). To avoid interference from overlap of the canopy area read, a portion of the densiometer is taped so the exposed surface produces a "V" shape with 17 square grid intersections. This provides a range of densiometer readings from 0 (no canopy cover) to 17 (maximum canopy cover).. Six canopy cover measurements are taken at each cross-section transect: four measurements in four directions at mid-channel and one at each bank.

Canopy cover measurements are recorded on the *Canopy Cover Measurements* section of the *Channel/Riparian Cross-Section and Thalweg Profile Form*.

Riparian Vegetative Structure

Riparian vegetation is semi-quantitatively evaluated along the stream corridor at each of the 11 cross-section transects. A 10 by 10 m riparian plot is estimated (not measured) on both the right banks and left banks at each cross-section (5 m upstream, 5 m downstream, and 10 m back from the edge of both banks). Within each plot, riparian vegetation is conceptually divided into three layers: a canopy layer (> 5 m high), an understory layer (0.5 to 5 m high), and a ground cover layer (< 0.5 m high). The type of vegetation is recorded in the two upper layers and the areal cover (%) is estimated in each of the three vegetation layers.

Riparian vegetation estimates are recorded in the *Visual Riparian Estimates* section of the *Channel/Riparian Cross-Section and Thalweg Profile Form*.

Instream Cover

Instream cover (filamentous algae, woody debris/brush, overhanging vegetation, undercut banks, boulders, and artificial substrates) is visually estimated from mid-channel at each cross-section transect at a 5 m distance upstream and downstream. The areal cover for each cover type is estimated and recorded on the *Fish/Cover Other* section of the *Channel/Riparian Cross-Section and Thalweg Profile Form.*

Human Influence

At each of the 11 cross-sections, the presence/absence and proximity of 11 categories of human influence are recorded based on their proximity to the stream channel. Four proximity classes are used: in the stream or on the bank within 5 m upstream or downstream of the cross-section transect, present within the 10 m by 10 m riparian plot (but not in the stream or on the bank), present outside of the riparian plot, and absent. Presence or absence of human-influenced features are recorded on the Human Influence section of the *Channel/Riparian Cross-Section and Thalweg Profile Form.*

EMAP Forms

THALWEG PROFILE & WOODY DEBRIS FORM

STREAM NAME:	DATE:
SITE ID:	TEAM MEMBERS:

TRANSECT:	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K

THALWEG PROFILE							INCREMENT (m):		
STATION	THALWEG DEPTH (m)	WETTED WIDTH (m)	BAR WIDTH[1]		SOFT/ SMALL SEDIMENT X for YES	CHANNEL UNIT CODE	POOL FORM CODE	SIDE CHANNEL X for YES	COMMENTS
			X	(m)					
0									
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									

[1] Measure bar width at station 0 and mid-station (5 or 7).

LARGE WOODY DEBRIS (≥ 10 cm small end diameter; ≥ 1.5 m length) -Tally Each Piece-						
DIAMETER LARGE END	PIECES ALL/PART IN BANKFULL CHANNEL			PIECES SPANNING BANKFULL CHANNEL		
	Length 1.5 - 5m	5 - 15 m	> 15 m	Length 1.5 - 5m	5 - 15 m	> 15 m
0.1 to <0.3m						
0.3 - 0.6 m						
0.6 - 0.8 m						
> 0.8 m						

POOL FORM CODES	
N	Not a pool
W	Large Woody Debris
R	Rootwad
B	Boulder or Bedrock
U	Unknown, fluvial
O	Other (see comments)

CHANNEL UNIT CODES	
PP	Pool, Plunge
PT	Pool, Trench
PL	Pool, Lateral Scour
PB	Pool, Backwater
OD	Pool, Impoundment
GL	Glide
RI	Riffle
RA	Rapid
CA	Casade
FA	Falls
DR	Dry Channel

COMMENTS

Reviewed by (initials): ____________

CHANNEL / RIPARIAN CROSS-SECTION 7 THALWEG PROFILE FORM

STREAM NAME:	SITE ID:	TEAM MEMBERS:
DATE:	TRANSECT:	A B C D E F G H I J K

I. SUBSTRATE CROSS-SECTIONAL INFORMATION

LOCATION	DISTANCE FROM LB (m)	DEPTH (m)	SIZE CLASS CODE	EMBED. 0-100%
LEFT				
LEFT-CENTER				
CENTER				
RIGHT-CENTER				
RIGHT				

SUBSTRATE SIZE CLASS CODES

RS = BEDROCK (SMOOTH, LARGER THAN A CAR)
RR = BEDROCK (ROUGH, LARGER THAN A CAR)
BL = BOULDER (250 - 4,000 MM, BASKETBALL TO CAR)
CB = COBBLE (64 - 250 MM, TENNIS BALL TO BASKETBALL)
GC = COARSE GRAVEL (16 - 64 MM, MARBLE TO TENNIS BALL)
GF = FINE GRAVEL (2 - 16 MM, LADYBUG TO MARBLE)
SA = SAND (0.06 - 2 MM, GRITTY - UP TO LADYBUG SIZE)
FN = SILT/CLAY/MUCK, NOT GRITTY)
HP = HARDPAN (FIRM, CONSOLIDATED FINE SUBSTRATE)
WD = WOOD (ANY SIZE)
OT = OTHER (COMMENT)

II. BANK MEASUREMENTS

LOCATION	BANK ANGLE 0 - 360 °	UNDERCUT DISTANCE (m)
LEFT		
RIGHT		
WETTED WIDTH:		
BAR WIDTH:		
BANKFULL WIDTH:		
BANKFULL HEIGHT:		
INCISED HEIGHT:		

III. FISH COVER/ OTHER

COVER IN-CHANNEL
0 = ABSENT (0%)
1 = SPARSE (<10%)
2 = MODERATE (10 - 40%)
3 = HEAVY (40 - 75%)
4 = VERY HEAVY (>75%)

(X ONE)	0	1	2	3	4
FILEMENTOUS ALGAE					
MACROPHYTES					
WOODY DEBRIS > 0.3 m (BIG)					
WOODY DEBRIS < 0.3 m (SMALL)					
OVERHANGING VEG. ≤ 1 m OF SURFACE					
UNDERCUT BANKS					
BOULDERS					
ARTIFICAL STRUCTURES					

IV. CANOPY COVER MEASUREMENTS

DENSIOMETER (0 TO 17 MAX)

CENTER UP		CENTER RIGHT	
CENTER LEFT		LEFT	
CENTER DOWN		RIGHT	

V. VISUAL RIPARIAN ESTIMATES

RIPARIAN VEGETATION COVER
0 = ABSENT (0%); 1 = SPARSE (<10%); 2 = MODERATE (10-40%); 3 = HEAVY (40-75%); 4 = VERY HEAVY (>75%)
D = DECIDUOUS; C = CONIFEROUS; E = BROADLEAF EVG.; M = MIXED; N = NONE

	LEFT BANK					RIGHT BANK				
CANOPY (> 5 M HIGH)	D	C	E	M	N	D	C	E	M	N
VEGETATION TYPE (D, C, M, OR N)										
	0	1	2	3	4	0	1	2	3	4
BIG TREES (TRUNK > 0.3 m DBH)										
SMALL TREES (TRUNK < 0.3 m DBH)										
UNDERSTORY (0.5 TO 5 m HIGH)	D	C	E	M	N	D	C	E	M	N
VEGETATION TYPE (D, C, M, OR N)										
	0	1	2	3	4	0	1	2	3	4
WOODY SHRUBS & SAPLINGS										
NON-WOODY HERBS, GRASSES & FORBS										
GROUND COVER (< 0.5 m HIGH)	0	1	2	3	4	0	1	2	3	4
WOODY SHRUBS & SEEDLINGS										
NON-WOODY HERBS, GRASSES & FORBS										
BARREN, BARE DIRT										

HUMAN INFLUENCE
0 = NOT PRESENT, P = PRESENT > 10 m AWAY
C = PRESENT WITHIN 10 m, B = PRESENT ON BANK

	0	P	C	B	0	P	C	B
WALL/DIKE/REVETMENT/RIP RAP/DAM								
BUILDINGS								
PAVEMENT								
ROAD/RAILROAD								
PIPES (INLET/OUTLET)								
LANDFILL/TRASH								
PARK/LAWN								
ROW CROPS								
PASTURE/RANGE/HAY FIELD								
LOGGING OPERATIONS								
MINING ACTIVITY								

Reviewed by (initials): ____________

Appendix E – Example Chain of Custody

Laboratory Management Program (LaMP) Chain of Custody Record
Soil, Sediment and Groundwater Samples

Page ___ of ___

BP Site Node Path: ______________________ **Req Due Date (mm/dd/yy):** ______________ Rush TAT Yes _____ No _____

BP/RM Facility No: ______________________ **Lab Work Order Number:** ______________________

Lab Name:	BP/ARC Facility Address:	Consultant/Contractor:
Lab Address:	City, State, ZIP Code:	Consultant/Contractor Project No:
Lab PM:	Lead Regulatory Agency:	Address:
Lab Phone:	California Global ID No.:	Consultant/Contractor PM:
Lab Shipping Accnt:	Enfos Proposal No:	Phone: Email:
Lab Bottle Order No:	Accounting Mode: Provision ____ OOC-BU _____ OOC-RM _____	Send/Submit EDD to:
Other Info:	Stage Activity	Invoice To: BP-RM ____ BP-Other ________

BP/RM PM:	**Sample Details**	**Requested Analyses**	**Report Type & QC Level**
		Filt	Limited (Standard) Package ____
PM Phone:		Pres	Limited Plus Package ____
PM Email:			Full Package ____

Lab No.	**Sample Description**	**Date**	**Time**	Field Matrix	Start Depth	End Depth	Depth Unit	Grab (G) or Composite (C)	Total Number of Containers	Analysis														**Comments**

	Relinquished By / Affiliation	**Date**	**Time**	**Accepted By / Affiliation**	**Date**	**Time**
Sampler's Name:						
Sampler's Company:						
Ship Method:						
Shipment Tracking No:						

Special Instructions:

THIS LINE - LAB USE ONLY: Custody Seals In Place: Yes / No | Temp Blank: Yes / No | Cooler Temp on Receipt: _________°F/C | Trip Blank: Yes / No | MS/MSD Sample Submitted: Yes / No

BP LaMP Soil/H2O COC July 2018

Appendix F – Example Corrective Action Report

Corrective Action Report/ Corrective Action Plan

Project ID	Project Name	Document ID

Preparer's Signature/Submit Date	Submitted to:

Description of the requirement or specification	
Reason for the Corrective Action	
Location, affected sample, affected equipment, etc. requiring corrective action	
Suggested Corrective Action	
Corrective Action Plan	Approval of corrective actions required by EPA? Yes No EPA approval name/date:_______________ Corrective actions completed name/date:_______________
Preventative Action Plan	See the Corrective Action Plan Preventative actions completed name/date:_

Appendix G – Components of Limited Analytical Laboratory Package

Limited (Level 2a validation) Data Package Deliverables

A Level 2 data package will include data for analyses of all samples in one Sample Delivery Group (SDG), including field samples, re-analyses, secondary dilutions, blanks, laboratory control samples (LCS), laboratory control sample duplicates (LCSD), matrix spikes (MSs), matrix spike duplicates (MSDs), and/or laboratory duplicates. The laboratory will report one single set of data representing the best of the results for each sample.

SDG General Information

Cover letter signed by Technical Project Manager or designee
Title page
Table of Contents
SDG narrative
References to preparation and analytical methods performed and applicable project documents
Field and Internal laboratory chain-of-custody records
Sample receipt information
Project correspondence

Metals Fraction (ICP, ICP/.MS, CVAA)

Analytical results summaries for samples
Analytical results summaries for preparation (method) blanks
Analytical results summaries for MS/MSD samples
Analytical results summaries for LCSs/LCSDs samples
Preparation (method) blank summaries
MS/MSD recovery and precision summaries
Post-digestion (when applicable) recovery summaries
Laboratory duplicate precision summaries
LCS/LCSD recovery and precision summaries
Sample preparation logs

General Chemistry

Analytical results summaries for samples
Analytical results summaries for preparation (method) blanks
Analytical results summaries for MS/MSD samples
Analytical results summaries for LCSs/LCSDs samples
Preparation (method) blank summaries
MS/MSD recovery and precision summaries
Laboratory duplicate precision summaries
LCS/LCSD recovery and precision summaries
Sample preparation logs

Radiological

Analytical results summaries for samples
Analytical results summaries for preparation (method) blanks
Analytical results summaries for MS/MSD samples
Analytical results summaries for LCS samples
Preparation (method) blank summaries
MS/MSD recovery and precision summaries
Laboratory duplicate precision summaries
LCS recovery and precision summaries
Chemical yield (tracer/carrier) recovery summaries
Sample preparation logs

Appendix H – Data Validation Checklists

Exhibit 1 – Stage 2a Analytical Checklist

Exhibit 2 – Analytical Field Checklist

Exhibit 3 – Analytical Level A/B Checklist

Exhibit 4 – Laboratory and Data Validation Qualifier and Code Definitions

Exhibit 1 – Stage 2a Analytical Checklist

ICP-MS Checklist

Validation Criteria: CFRSSI Data Management/Data Validation Plan and Addendum (ARCO 1992 and ARCO 2000, respectively); Data Validation Guidelines for Inorganic Chemistry (Woodard & Curran Butte, MT, 2021); National Functional Guidelines for Inorganic Superfund Methods Data Review (USEPA, November 2020)			
Approved Project QAPP: Silver Bow Creek/Butte Area NPL Site 2022 Final Butte Priority Soils Operable Unit Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan (QAPP), (Atlantic Richfield, February 2022)			
Site:	Butte Priority Soils Operable Unit	**Project:**	BPSOU SW Monitoring - 0231347
Laboratory:	Pace Analytical Services (Minneapolis, MN)	**Case Number:**	
Matrix:	Aqueous	**Analysis:**	Dissolved: Al, As, Ca, Cd, Cu, Fe, Pb, Mg, Mo, Ag, Zn, Hardness Total: Al, As, Cd, Cu, Fe, Pb, Mo, Ag, Zn
Sample Date(s):		**Analysis Date(s):**	
Data Validator:		**Validation Date:**	

Sample Delivery Group

Field Sample ID	Lab Sample ID	Lab QC Batch	Sample Type	Associated Fld QC	Abbreviated Field ID
Dissolved Metals					
Total Metals					

1. Holding Times

Analyte	Matrix	Method	Collection Date	Analysis Date(s)	Affected data flagged
Dissolved: Al, As, Ca, Cd, Cu, Fe, Pb, Mg, Mo, Ag, Zn, Hardness	Aqueous	EPA 200.8			
Total: Al, As, Cd, Cu, Fe, Pb, Mo, Ag, Zn	Aqueous	EPA 200.8			

Describe corrective actions taken because of holding time problems.

2. Blanks

Were method blanks (MB) analyzed at the frequency of 1/20 samples? Y___ N___
Were MB results non-detects? Y___ N___
Were any data flagged because of blank problems? Y___ N___
Describe corrective actions taken because of blank problems.

3. Laboratory Control Sample (LCS)

Was LCS analyzed at the frequency of 1/20 samples? Y___ N___
Was LCS within control window of 85-115% recovery? Y___ N___
Were any data flagged because of LCS problems? Y___ N___
Describe corrective actions taken because of ICS problems.

4. Matrix Spike (MS) and Matrix Spike Duplicate (MSD)

Was MS sample analyzed at the frequency of 1/10 samples? Y___ N___
Were the MS/MSD results within control window of 70-130% for samples in which the parent sample concentration was ≤ 4X the spike concentration? Y___ N___
Was the MSD sample analyzed at the frequency of 1/20 samples? Y___ N___
If MS & MSD results > 5 times the RL, were results of the MSD ≤ 20% relative percent difference (RPD)? If MS or MSD values < 5 times the RL, was the absolute difference between MS and MSD ≤ the RL? Y___ N___
Were any data flagged because of MS/MSD recovery problems? Y___ N___
Were any data flagged because of MS/MSD RPD problems? Y___ N___
Describe corrective actions taken because of MS problems.

Are there any additional analytical limitations that users should be aware of? Y___ N___

Exhibit 2 – Analytical Field Checklist

Field Checklist

Validation Criteria: CFRSSI Data Management/Data Validation Plan and Addendum (ARCO 1992 and ARCO 2000, respectively); Data Validation Guidelines for Inorganic Chemistry (Woodard & Curran Butte, MT, 2021); National Functional Guidelines for Inorganic Superfund Methods Data Review (USEPA, November 2020)				
Approved Project QAPP: Silver Bow Creek/Butte Area NPL Site 2022 Final Butte Priority Soils Operable Unit Interim Site-Wide Surface Water Monitoring Quality Assurance Project Plan (QAPP), (Atlantic Richfield, February 2022)				
Site:	Butte Priority Soils Operable Unit		**Project:**	BPSOU SW Monitoring - 0231347
Laboratory:	Pace Analytical Services (Minneapolis, MN)		**Case Number:**	
Matrix:	Aqueous		**Analysis:**	Dissolved Hg; Total Hg; Dissolved: Al, As, Ca, Cd, Cu, Fe, Pb, Mg, Mo, Ag, Zn, Hardness; Total: Al, As, Cd, Cu, Fe, Pb, Mo, Ag, Zn; Total Dissolved Solids (TDS); Total Suspended Solids (TSS); Nitrate/Nitrate (NO2/NO3); Ammonia (NH3); Total Kjedahl Nitrogen (TKN); Dissolved Organic Carbon (DOC); Sulfate (SO4)
Sample Date(s):				
Data Validator:			**Validation Date:**	
Sample Delivery Group				
Field Sample ID	**Lab Sample ID**	**Sample Type**	**Associated Fld QC**	**Abbreviated Field ID**

Analyte	Matrix	Method	Collection Date	Analysis Date
Dissolved Hg	Aqueous	EPA 245.1		
Total Hg	Aqueous	EPA 245.1		
Dissolved: Al, As, Ca, Cd, Cu, Fe, Pb, Mg, Mo, Ag, Zn, Hardness	Aqueous	EPA 200.8		
Total: Al, As, Cd, Cu, Fe, Pb, Mo, Ag, Zn	Aqueous	EPA 200.8		
Alkalinity: Total as CaCO3	Aqueous	SM 2320B		
Total Dissolved Solids (TDS)	Aqueous	SM 2540C		
Total Suspended Solids (TSS)	Aqueous	SM2540D		
Nitrate/Nitrate (NO2/NO3)	Aqueous	EPA 353.2		
Ammonia (NH3)	Aqueous	EPA 350.1		
Total Kjedahl Nitrogen (TKN)	Aqueous	EPA 351.2		
Dissolved Organic Carbon (DOC)	Aqueous	SM 5310C		
Total Phosphorus (P)	Aqueous	SM4500P-F		
Sulfate (SO4)	Aqueous	EPA 300.0		

Field QC Samples

Field Blanks FB)

Were FBs sumbitted as specified in the BPSOU SW QAPP (1 in 20)? Y___ N___

Were results for FBs within the target control limits in the BPSOU SW QAPP (< MDL)? Y___ N___

Were any data qualified because of FB problems? Y___ N___

Field Replicates

Were field duplicates (FD) submitted as specified in the BPSOU SW QAPP (1 in 20)? Y___ N___

Were results for FDs within the target control limits in the BPSOU SW QAPP (< 20% RPD or Δ ≤ RL as applicable)? Y___ N___

Were any data qualified because of FD results? Y___ N___

Additional Comments

Exhibit 3 – Analytical Level A/B Checklist

Level A/B Screening Checklist

I.	General Information		II. Screening Results
	Site:	BPSOU/	Data are:
	Project:	BPSOU SW Monitoring - 0231347	1) Unusable ________
	Client:	Atlantic Richfield	2) Level A ________
	Sample Matrix:	Water	3) Level B ___ ___

II. Level A Screening

		Yes/No
1.	Sampling date	
2.	Sample team/or leader	
3.	Physical description of sample location	
4.	Sample depth (soils)	
5.	Sample collection technique	
6.	Field preparation technique	
7.	Sample preservation technique	
8.	Sample shipping records	

III. Level B Screening

		Yes/No
1.	Field instrumentation methods and standardization complete	
2.	Sample container preparation	
3.	Collection of field replicates (1/20 minimum)	
4.	Proper and decontaminated sampling equipment	
5.	Field custody documentation	
6.	Shipping custody documentation	
7.	Traceable sample designation number	
8.	Field notebook(s), custody records in secure repository	
9.	Completed field forms (COC Record)	

Exhibit 4 – Laboratory and Data Validation Qualifier and Code Definitions

Exhibit 5. Data Flags, Data Qualifiers and Descriptors

	Laboratory Flags[a]
1M	A matrix spike/matrix spike duplicate was not performed for this batch due to insufficient sample volume.
AB	Analyte was detected in an associated instrument blank.
AD	Analyte was detected in the method blank at a concentration greater than 2.2 times the MDL.
B	Analyte was detected in the associated method blank.
B0	Analyte was detected in an associated blank at a concentration greater than the MDL.
BC	The same analyte was detected in an associated blank at a concentration above 1/2 the reporting limit but below the laboratory reporting limit.
BH	Analyte was detected in an instrument blank. The result may be biased high.
BL	Analyte was detected in an instrument blank at a negative value. The result may be biased low.
C0	Result confirmed by second analysis.
C1	Result could not be confirmed by second analysis.
C7	Analyte is a possible laboratory contaminant (not present in method blank).
C8	Result may be biased high due to carryover from previously analyzed sample.
C9	Common Laboratory Contaminant.
CC	The continuing calibration for this compound is outside of Pace Analytical acceptance limits. The result may be biased.
CH	The continuing calibration for this compound is outside of Pace Analytical acceptance limits. The results may be biased high.
CL	The continuing calibration for this compound is outside of Pace Analytical acceptance limits. The results may be biased low.
CR	The dissolved metal result was greater than the total metal result for this element. Results were confirmed by reanalysis.
CU	The continuing calibration for this analyte is above Pace Analytical acceptance limits. Analyte was not detected above the reporting limit in any of the associated samples.
D3	Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference.
D4	Sample was diluted due to the presence of high levels of target analytes.
D6	The relative percent difference (RPD) between the sample and sample duplicate exceeded laboratory control limits.
D7	The sample and/or duplicate results for this parameter are less than the reporting limit, calculations are based on estimated values and may be statistically unreliable
D8	The sample and duplicate results for this parameter are less than 5 times the reporting limit, the RPD may not be statistically valid.
D9	Dissolved result is greater than the total. Data is within laboratory control limits.
E	Analyte concentration exceeded the calibration range. The reported result is estimated.
F5	The recovery of the analyte in the CRDL standard (also known as the reporting limit verification) did not meet the acceptance criteria.
FS	The sample was filtered in the laboratory prior to analysis.
H1	Analysis conducted outside the recognized method holding time.
H2	Extraction or preparation was conducted outside of the recognized method holding time.
H3	Sample was received or analysis requested beyond the recognized method holding time.
H4	Sample re-extracted and analyzed outside of EPA method holding time.
H5	Reanalysis conducted in excess of EPA method holding time. Results confirm original analysis performed in hold time.
H7	Re-extraction or re-analysis could not be performed within method holding time.
IC	The initial calibration for this compound was outside of method control limits. The result is estimated.
IH	This analyte exceeded secondary source verification criteria high for the initial calibration. The reported results should be considered an estimated value.
IL	This analyte exceeded secondary source verification criteria low for the initial calibration. The reported results should be considered an estimated value.
IO	The internal standard response was outside the laboratory acceptance limits confirmed by reanalysis. The results reported are from the most QC compliant analysis.
IR	The internal standard recovery associated with this result exceeds the upper control limit. The reported result should be considered an estimated value.
IS	The internal standard response is below criteria. Results may be biased high.
IU	The internal standard recoveries associated with this sample exceed the upper control limit. The reported results should be considered estimated values.
J	Analyte detected below reporting limit, therefore result is an estimate
L0	Analyte recovery in the laboratory control sample (LCS) was outside QC limits.
L1	Analyte recovery in the laboratory control sample (LCS) was above QC limits. Results may be biased high.
L2	Analyte recovery in the laboratory control sample (LCS) was below QC limits. Results may be biased low.
L3	Analyte recovery in the laboratory control sample (LCS) exceeded QC limits. Analyte presence below reporting limits in associated samples. Results unaffected by high bias.
L5	LCS recovery exceeded QC limits. Batch accepted based on matrix spike recovery within LCS limits.
LS	Analyte recovery in the laboratory control sample (LCS) was outside QC limits for one or more of the constituent analytes used in the calculated result.
M0	Matrix spike recovery and/or matrix spike duplicate recovery was outside laboratory control limits.
M1	Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.
M2	Matrix spike recovery was below QC limits due to sample dilution. Data acceptance based on laboratory control sample (LCS) recovery.
M3	Matrix spike recovery was outside laboratory control limits due to matrix interferences.
M4	A matrix spike/matrix spike duplicate was not performed for this batch due to sample dilution.
M6	Matrix spike and Matrix spike duplicate recovery not evaluated against control limits due to sample dilution.
MA	Result determined by method of standard addition.
MD	The analyte was not detected at or above the Method Detection Limit.
MH	Matrix spike recovery and/or matrix spike duplicate recovery was above laboratory control limits. Result may be biased high.

Exhibit 5. Data Flags, Data Qualifiers and Descriptors

ML	Matrix spike recovery and/or matrix spike duplicate recovery was below laboratory control limits. Result may be biased low.
MS	Analyte recovery in the matrix spike was outside QC limits for one or more of the constituent analytes used in the calculated result.
N	Tentatively identified compound (TIC) based on mass spectral library search
P4	Sample field preservation does not meet EPA or method recommendations for this analysis.
P5	The EPA or method required sample preservation degrades this compound, therefore acceptable recoveries may not be achieved in sample matrix spikes.
P6	Matrix spike recovery was outside laboratory control limits due to a parent sample concentration notably higher than the spike level.
P7	This spike was performed as a post digestion spike.
P8	Analyte was detected in the method blank. All associated samples had concentrations of at least ten times greater than the blank or were below the reporting limit.
PI	The precision between the sample and the duplicate sample exceeded laboratory control limits.
R1	RPD value was outside control limits.
R2	RPD value was outside control limits due to matrix interference
R3	RPD value was outside control limits due to uncertainty of values at or near the PRL.
RS	The RPD value in one of the constituent analytes was outside the control limits.
SD	The serial dilution and the original analysis did not agree within ±10%. The concentration is estimated due to a suspected chemical or physical interference.
TP	The samples were received outside of required temperature range. Analysis was completed upon client approval.
TV	Analysis conducted outside EPA method holding time. Results may be biased low.
TW	Dissolved result is greater than the total. Data is within laboratory control limits, however the RPD between the total and dissolved result is >20%.
W	Non-detect results are reported on a wet weight basis.
Z2	Analyte present in the associated method blank above the detection limit.
REV_X	Revision X - This report replaces the Month, DD, YYYY report. This project was revised on Month, DD, YYYY <REASON>. (Lab city, State)
SubCert	This report contains data that were produced by a subcontracted laboratory certified for the fields of testing performed.
TO	Samples requiring thermal preservation were received outside of recommended temperature limits of 0-6 degrees Celsius.
TP	Samples were received outside of required temperature range. Analysis was completed upon client approval.
TQ	Samples were received outside of required temperature range of 0-6 degrees Celsius. The samples were received from the field on ice.
C0	Results confirmed by second analysis.
IQ	The internal standard recoveries associated with this sample exceed the lower control limit. The reported results should be considered estimated values.
IU	The internal standard recoveries associated with this sample exceed the upper control limit. The reported results should be considered estimated values.
sb	Client sample ID on container did not match COC; client was notified.
sd	date - Added 3ml HNO3 to Metals bottle prior to analysis. pH <2.
se	Sample collection dates and times were not present on the sample containers.
sf	Sample collection dates and times were not listed on the COC.
sg	Sample collection time on containers does not match COC; client was notified.
sh	The sampler's name and signature were not listed on the COC.
sl	Sample was received outside the recognized method holding time; client notified and approved.
sm	A Chain of Custody was not received with samples; client was contacted.
	Data Validation Qualifiers[b]
U	The analyte was analyzed for, but was not detected above the level of the reported sample quantitation limit.
UJ	The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting Quality Control (QC) criteria. The analyte may or may not be present in the sample.
	Data Validation Descriptors[c]
AB	Did not meet level A/B criteria
CC	Correlation coefficient less than 0.995 for instrument calibration
CCV	Continuing calibration verification outside limits
CCB	Continuing calibration blank contamination
COM	Not comparable to historical data
CQ	No calibration performed
CRQL	Contract required quantitation limit standard recovery outside quality control limits
DNR	Do not report. An alternate, acceptable result is available.
ECR	Reported concentration exceeds instrument calibration range
FB	Field blank contamination
FD	Field duplicate RPD outside limits
HT	Holding time exceeded
ICB	Initial calibration blank contamination
ICS	Interference check standard recovery outside limits
ICV	Initial calibration verification outside limits
IP	Incorrect sample preservation
IS	Internal standard recovery outside limits

Exhibit 5. Data Flags, Data Qualifiers and Descriptors

LCS	Lab control spike recovery is outside quality control limits
MB	Method blank contamination
MI	Matrix interference with analyte quantitation
MDL	Non-detect at MDL value
MS	Matrix spike recovery is outside quality control limits
RB	Equipment rinse blank contamination
RL	Laboratory detected result below reporting limit
RPD	Duplicate sample relative percent difference exceeds QC limits
SD	ICP serial dilution percent difference outside QC limits
SIC	Sample integrity compromised
SUR	Surrogate recovery is outside QC limits
TB	Trip blank contamination
TIC	Compound was tentatively identified by GC/MS search
	CFRSSI Status[d]
E	Enforcement quality data are data with unrestricted use, meet Level A/B criteria, and are NOT qualified during the data validation process
S	Screening quality data are data whose associated values are estimated or meet only Level A criteria
R	Unusable data are data whose associated numerical values are so questionable it is recommended that they not be used
	Level A/B Screening Results[d]
A	Meets only Level A Screening criteria, but does not meet Level B Screening criteria, including proper techniques
B	Meets both Level A and Level B criteria, including field replicates and proper documentation

[a] Assigned by Pace Analytical Services, Inc.

[b] Adapted from US EPA 2017. Laboratory Data Validation National Functional Guidelines for Inorganic Data Review; EPA, January, 2017)

[c] Assigned by TREC, Inc. during data validation

[d] Defined in Clark Fork River Superfund Site Investigations Data Management/Data Validation Plan; ARCO, May 1992)