

Clark Fork River Water Quality Monitoring Program – Upper and Middle Clark Fork

Sampling and Analysis Plan (SAP) JUNE 2025

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Year	Page	Section	Description of Changes
2021	All	All	For 2021, the entire SAP was reformatted in accordance with new DEQ guidelines including the inclusion of this table.
	6	Table 1	Station IDs were update from CFR to CFRPO to better match DEQ's water quality database.
	14	Table 4	In accordance with corrective actions from the QA/QC report for 2020, the project reporting limit for TPN was changed from 50 to 40 ug/l and the holding time for frozen SRP samples was changed from 28 to 45 days.
	9	4.2	Station names were changed from CFC-## to CFRPO-## to match the guidance in the QAPP and for consistency with DEQ database management requirements
2022	All	All	Updated DEQ staff
	5	1.2	Updated Figure 1 with site CFRPO-22b
	7	2.3	Updated Table 1 with site CFRPO-22b
	9	3	Updated Section 3.0 paragraph and Table 3 with responsibility of CFC to coordinate with DEQ to create the QC report
2023	All	All	CFC is no longer involved in this project. Dr. Vicki Watson (UM) will collect nutrient and algae samples. This SAP now includes both water chemistry sampling and benthic algae sampling.
	5	1.2	Updated Figure 1 caption with "Site CFRPO-22b will no longer be used going forward"
	7	2.3	Updated Table 1 with site CFRPO-22
2024	All	All	Missoula County Water Quality District (MCWQD) will collect water quality samples and Dr. Vicki Watson (UM) will collect algae samples. This SAP includes work for both entities.
	11-12	4.2	Updated language to include how to fill out DEQ Site Visit Forms with Site Visit Codes.
	17	4.2	Updated analytical table hold times. TN & TP are 28 days. NH3+4, NO2+3, and SRP are 45 days

2025	All	All	Updated Program Manager to Clark Fork Coalition
	10-11	4.2	Updated language to a more simplified version of collecting samples not using DEQ Site Visit Codes
	19	Appendix B	Updated sample field form and COC

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ACRONYMS LIST

Acronym	Definition
°C	degrees Celsius
CFC	Clark Fork Coalition
CFRWQMC	Clark Fork River Water Quality Monitoring Committee
COC	chain of custody
DEQ	Montana Department of Environmental Quality
DO	dissolved oxygen
DQI	data quality indicators
EDD	electronic data deliverables
EPA	U.S. Environmental Protection Agency
g/m ²	grams per square meter
HDPE	high-density polyethylene
µm	micrometer
µs/cm	microsiemens per centimeter
mg/L	milligrams per liter
mg/m ²	milligrams per square meter
mL	milliliter
mm	millimeter
mv	millivolts
NTU	nephelometric turbidity unit
NO ₂ +NO ₃ -N	dissolved nitrate+nitrite-nitrogen
NH ₃ +NH ₄ -N	dissolved ammonia-nitrogen
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
QC	quality control
SAP	sampling and analysis plan
SRP	soluble reactive phosphorus
SVF	site visit form
TDS	total dissolved solids
TP	total phosphorus
TPN	total persulfate nitrogen
TSWQC	Tri-State Water Quality Council
UM	University of Montana
WQPB	Water Quality Planning Bureau



Suggested Citation:

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1.0 INTRODUCTION

This section provides background information and context to clarify the motivations for the project and explains the problem statement or need that the monitoring described throughout this sampling and analysis plan (SAP) will support.

This SAP covers nutrient water quality monitoring activities in the upper and middle Clark Fork River. Monitoring activities are sponsored and completed by Montana Department of Environmental Quality (DEQ), in cooperation with Clark Fork Coalition and the University of Montana (UM). The monitoring covered by this SAP is part of a larger coordinated effort to assess water quality status and trends of the Clark Fork River and meet objectives established under the Voluntary Nutrient Reduction Program.

1.1 PROBLEM DEFINITION AND PROJECT BACKGROUND

Nutrient ambient water quality monitoring in the Clark Fork River is one component of the overall Clark Fork River Water Quality Monitoring program (program) managed by the Clark Fork River Water Quality Monitoring Committee (CFRWQMC). The CFRWQMC is comprised of DEQ, Avista, Clark Fork Coalition, and UM. Originally organized as the Tri-State Water Quality Council (TSWQC), the Committee has been conducting nutrient water quality monitoring activities since 1998. The Clark Fork River Water Quality Monitoring program was critical in assessing implementation of the Voluntary Nutrient Reduction Program in which nutrient contributors in the Clark Fork River basin, including industry and municipalities, voluntarily implemented changes/practices to reduce nutrient inputs to the river. Monitoring efforts are broken into five-year periods with annual reporting followed by a comprehensive five-year water quality trends analysis report. Previous five-year monitoring periods include: 1998–2002, 2003–2007, 2008–2012, 2013–2017, and 2018–2022. Each five-year period builds on itself and provides the basis for a statistical analysis of water quality time trends for the Clark Fork River. The TSWQC was a partnership of government and private entities in the Clark Fork-Pend Oreille Basin in Montana, Idaho, and Washington. In 2012 the TSWQC folded and with it the overall scope of the basin-wide monitoring program. The focus of the CFRWQMC program is on assessing activities affecting water quality of the Clark Fork River in Montana. The current five-year monitoring program is inclusive of the years 2023–2027.

This SAP provides the necessary details required for Clark Fork Coalition to complete their water quality monitoring and UM to complete their algae monitoring in the upper and middle Clark Fork River, which is part of the CFRWQMC's larger Clark Fork River Water Quality Monitoring Program (program). Avista conducts monitoring in the lower Clark Fork River under a separate SAP. The overall program and this SAP are directed by the program's overarching Quality Assurance Project Plan (QAPP) (DEQ 2023). If any discrepancy exists between the QAPP and the SAP, the QAPP takes precedence. Prior to sampling, field personnel must also review and become familiar with all pertinent portions of the QAPP.

1.2 PROJECT AREA

The project area is the Clark Fork River from its origin below Warm Springs Ponds to its confluence with the Flathead River. Lower Silver Bow Creek and the Flathead River just above its confluence with the Clark Fork near Paradise, Montana are also included. Monitoring locations are shown in **Figure 1** and presented in more detail in **Section 2.3**.

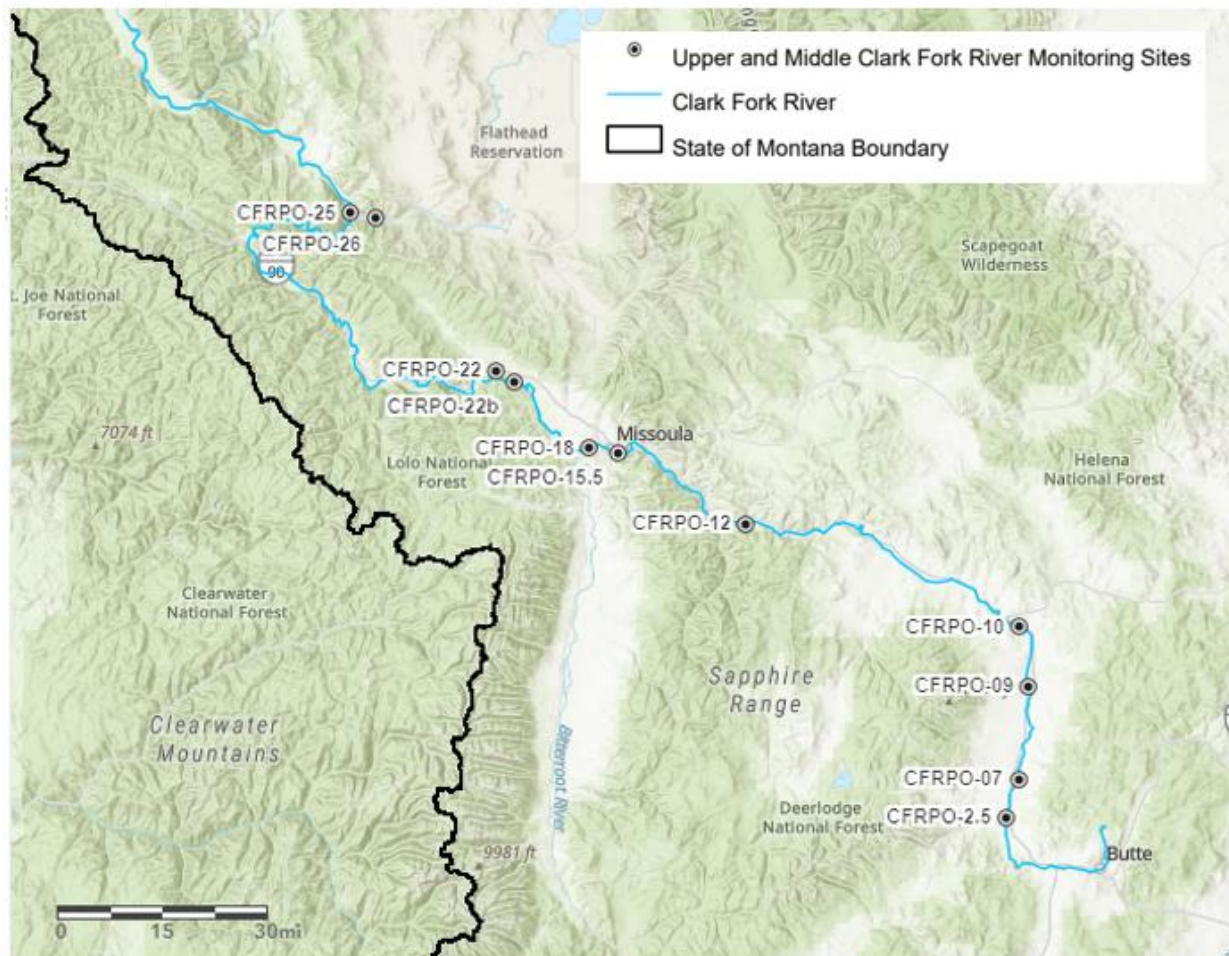


Figure 1. Location map for Clark Fork River water quality monitoring sites on the middle and upper Clark Fork River. Site CFRPO-22b will no longer be used going forward.

2.0 OBJECTIVES AND SAMPLING DESIGN

This section states the project's objectives, describes key elements of the sampling design such as monitoring locations and the timing of monitoring events, and outlines information about each parameter that will be monitored.

2.1 MONITORING OBJECTIVES

This SAP is part of a larger coordinated effort to assess the nutrient water quality status and trends of the Clark Fork River, which includes water quality monitoring with distributed spatial coverage for evaluating the effects of point and nonpoint pollution sources, influences of major population centers, and effects of major tributaries within the Clark Fork River. This design provides for a cost-effective and reasonably sensitive assessment of nutrient inputs throughout the basin.

The primary objective of this monitoring effort reflects a sampling strategy designed to detect long-term trends in nutrient water quality in the Clark Fork River and to meet the following specific monitoring objectives originally established by the TSWQC and adopted by the CFRWQMC:

- Evaluate time trends in nutrient concentrations in the mainstem Clark Fork River and selected tributaries.
- Evaluate time trends for benthic algae chlorophyll in the upper and middle Clark Fork River.
- Monitor compliance with established summer nutrient and benthic algae chlorophyll target levels in the upper and middle Clark Fork River.
- Estimate nutrient loading rates to Lake Pend Oreille from the Clark Fork River.

More detail about the objectives and design of this project can be found within the program's QAPP (DEQ 2023).

The specific monitoring objectives for Clark Fork Coalition in this SAP are as follows:

1. Measure physical field parameters (water temperature ($^{\circ}\text{C}$), dissolved oxygen (DO) (mg/L), pH (standard units), specific conductance ($\mu\text{S}/\text{cm}$), total dissolved solids (TDS) (mg/L), and turbidity (NTU)) *in situ* at all sites indicated in this SAP.
2. Collect nutrient samples: total phosphorus (TP), total persulfate nitrogen (TPN), dissolved nitrate + nitrite nitrogen ($\text{NO}_2+\text{NO}_3\text{-N}$), dissolved ammonia nitrogen ($\text{NH}_3+\text{NH}_4\text{-N}$), and soluble reactive phosphorus (SRP) at all sites indicated in this SAP.

The specific monitoring objectives for UM in this SAP are as follows:

1. Collect and analyze benthic algae biomass samples: Chlorophyll-*a* (mg/m²) and ash free dry weight (g/m²) at seven monitoring stations indicated in **Table 1**.

2.2 SAMPLING DESIGN

The sampling design for the project provides consistency with long-term monitoring sites and collection of field and nutrient parameters. Consistency with historical sampling practices is critical in allowing the CFRWQMC to achieve its monitoring objectives. In general, the sampling design is intended to evaluate cumulative nutrient impacts to the Clark Fork River in Montana, and to Lake Pend Oreille in Idaho.

Specifically, this SAP is designed to support four primary objectives for the program in the Clark Fork River:

- 1) Evaluate time trends in nutrient concentrations through the collection of field parameter and a suite of nutrient parameters at ten sample sites twice monthly July through September.
- 2) Evaluate time trends for benthic algae chlorophyll-*a* in the upper and middle Clark Fork River.

- 3) Monitor compliance with established summer nutrient and benthic algae chlorophyll target levels in the upper and middle Clark Fork River.
- 4) Estimate nutrient loading rates to Lake Pend Oreille from the Clark Fork River.

Loading estimates to Lake Pend Oreille are evaluated with data collected by Avista under guidance from the CFRWQMC and covered under a separate SAP.

2.3 MONITORING LOCATIONS

Upper and middle Clark Fork water quality monitoring is conducted at the ten monitoring stations located on the Clark Fork River, Silver Bow Creek, and the Flathead River identified in **Table 1**.

Table 1. Monitoring Locations

Monitoring Station	Site Description	Latitude	Longitude	Parameters Collected
CFR Station 2.5 (CFRPO-2.5)	Silver Bow Creek at Opportunity	46.1076	-112.8052	Nutrients, in situ measurements
CFR Station 07 (CFRPO-07)	Clark Fork below Warm Springs Creek	46.1879	-112.7678	Nutrients, in situ measurements
CFR Station 09 (CFRPO-09)	Clark Fork at Deer Lodge	46.38`	-112.7390	Nutrients, in situ measurements, Algae
CFR Station 10 (CFRPO-10)	Clark Fork above Little Blackfoot Creek	46.4977	-112.7411	Nutrients, in situ measurements, Algae
CFR Station 12 (CFRPO-12)	Clark Fork at Bonita (Beavertail Hill)	46.7219	-113.5725	Nutrients, in situ measurements, Algae
CFR Station 15.5 (CFRPO-15.5)	Clark Fork above Missoula	46.8644	-113.9761	Nutrients, in situ measurements, Algae
CFR Station 18 (CFRPO-18)	Clark Fork below Missoula (Tower Street Conservation Area)	46.8726	-114.0599	Nutrients, in situ measurements, Algae
CFR Station 22 (CFRPO-22)	Clark Fork at Huson	47.0108	-114.2883	Nutrients, in situ measurements, Algae
CFR Station 25 (CFRPO-25)	Clark Fork above Flathead	47.3561	-114.7828	Nutrients, in situ measurements, Algae
CFR Station 26 (CFRPO-26)	Flathead River near the Mouth	47.3444	-114.7080	Nutrients, in situ measurements

2.4 MONITORING TIMEFRAME AND SCHEDULE

The Clark Fork Coalition will measure physical parameters and collect nutrient samples from ten monitoring stations as indicated in **Table 1**. Site visits for sampling these monitoring stations will occur six times (twice in July, August, and September). An approximate schedule is provided in **Table 2**. The University of Montana will conduct benthic algae chlorophyll sampling and this will occur two times (once in August and once in September) at 7 monitoring stations indicated in **Table 2**. Benthic algae chlorophyll sampling may also occur in July at 5 monitoring stations to capture peak algal biomass. Due to consistently low algae levels at Site 26 in the Flathead River, benthic algae sampling was discontinued at this site in 2018; however nutrient monitoring will continue as in previous years.

Table 2. Upper and Middle Clark Fork River General Water Quality Monitoring Schedule

MONTH	DATE*	SITES
JULY	7 – 11	2.5, 07, 09, 10, 12, 15.5, 18, 22, 25, 26
JULY	21 – 25	2.5, 07, 09 [^] , 10 [^] , 12 [^] , 15.5 [^] , 18 [^] , 22, 25, 26
AUG	4 – 8	2.5, 07, 09 [^] , 10 [^] , 12 [^] , 15.5 [^] , 18 [^] , 22 [^] , 25 [^] , 26
AUG	18 – 22	2.5, 07, 09, 10, 12, 15.5, 18, 22, 25, 26
SEP	8– 12	2.5, 07, 09 [^] , 10 [^] , 12 [^] , 15.5 [^] , 18 [^] , 22 [^] , 25 [^] , 26
SEP	22 – 26	2.5, 07, 09, 10, 12, 15.5, 18, 22, 25, 26

* Exact dates to be determined during the field season but sampling will occur approximately every 2 weeks.

[^] Denotes algae sample site

2.5 PARAMETERS

Clark Fork Coalition will collect all field parameters (*in situ* measurements). During each water quality sampling event, at each sampling site, the following field parameters will be collected:

1. water temperature (°C)
2. air temperature (°C)
3. dissolved oxygen (DO) (mg/l)
4. pH (standard units)
5. barometric pressure (mm/Hg)
6. redox potential (mv)
7. specific conductance (µs/cm)
8. turbidity (NTU) (if supplies are available)

Clark Fork Coalition will also collect all nutrient water quality samples. During each water quality sampling event, at each sampling site, the following nutrient water quality samples (nutrient suite) will be collected:

1. total persulfate nitrogen (TPN)
2. total phosphorus (TP)
3. low level dissolved nitrate + nitrite-nitrogen (NO₂+NO₃-N)
4. dissolved ammonia-nitrogen (NH₃+NH₄-N)
5. soluble reactive phosphorus (SRP)



UM will collect benthic algae samples as a measure of chlorophyll-*a* concentrations and ash-free dry weight at sites CFRPO- 09, 10, 12, 15.5, 18, 22, and 25.

3.0 PROJECT TEAM AND RESPONSIBILITIES

The Clark Fork Coalition will implement this SAP and is responsible for training, quality control (QC), and field data entry into the EQUIS Water Quality Exchange database (MT-eWQX) for submittal to DEQ at the end of the year. Clark Fork Coalition is the field project manager for the nutrient water quality sample collection and is responsible for the implementation of this SAP and will collect nutrient water quality samples and data in the field. Vicki Watson (UM) is the field project manager for benthic algae collection and is responsible for the overall implementation of this SAP and will collect samples and data in the field. Energy Laboratories will analyze the nutrient samples and provide electronic deliveries of these data to DEQ. UM will analyze benthic algae samples for chlorophyll-*a* and ash-free dry weight concentrations. DEQ will conduct a quality assurance (QA) review and validation and upload data in MT-eWQX. The CFRWQMC will review this SAP annually and update as needed. The SAP must be in place prior to the first sampling event. Project team roles and responsibilities are summarized in **Table 3**.

Table 3. Project Team Roles and Responsibilities

Individual	Affiliation	Roles	Responsibilities
Gabrielle Metzner	MT DEQ	CFRWQMC member	DEQ Program coordination, Sample delivery to lab, EDD upload to MT-eWQX database
Brian Chaffin	Clark Fork Coalition	CFRWQMC member	Oversees SAP implementation and field personnel. Collects nutrient water quality data at all locations.
Vicki Watson	University of Montana	CFRWQMC member	Oversees SAP implementation and field personnel. Collects benthic chlorophyll- <i>a</i> data at several locations. Conduct analyses for benthic algae chlorophyll- <i>a</i> and ash-free dry weight concentrations.
Energy Laboratories	Private Laboratory	Laboratory	Analyze and report water quality samples

4.0 FIELD PROCEDURES

This section cites or describes each field procedure that will be applied while collecting data during this project and references the field forms that will be used to record data and sample collection activities.



4.1 ORDER OF OPERATIONS

A flow diagram that explains the order of operations for sample collection, data analysis, data management, QA, and reporting is provided in **Appendix A**. In general, in-situ field parameters will be collected first followed by water quality sample collection. See methods described in **Section 4.3**.

4.2 NUTRIENT WATER QUALITY FIELD FORMS AND SAMPLE LABELS – CLARK FORK COALITION

Sampling personnel will complete the “water sampling and monitoring record” site visit form (field form or site visit form) for each of the sample collection dates and when quality control samples are collected. The site visit form includes space to document sample collection date and time, sampler’s name, description of water conditions, and observations or notes of circumstances that may have occurred during sampling (**Appendix B**). Use standard nomenclature at the top of the site visit form in documenting the station name. Consistency in documenting station name and sample collection date is vital to the success of the monitoring program. The form must be completed in the field during monitoring. It is also used to verify that all samples have been collected and processed correctly. Field parameters and associated units measured by the field meters are recorded on the site visit form. All field forms must be reviewed by the field crew prior to departure from each site to verify completeness and accuracy.

All field forms should be printed on water resistant all-weather paper and filled out using pencil (preferable) or permanent fine-line marker. A completed example field form is included in **Appendix B**.

The laboratory Chain of Custody (COC) form must be completed when relinquishing control of sample sets. The COC is provided by the laboratory and should be completed for each sample set on the day the samples were collected at the completion of monitoring. The original COC must be transmitted along with the samples. A copy of the COC should be maintained by the sampler. Example COCs are provided in **Appendix B**.

Prior to collecting samples at each site, all sample containers will be labeled with information required by the laboratory including waterbody name, sample site code, time/date, filtered/not filtered, preserved, and personnel performing the sampling, as well as any other information requested on the label. Labels will be filled out with pencil or permanent fine-point marker, affixed to the sample container and covered completely with clear plastic tape to protect the label from being damaged during storage.

Water quality samples will be labeled according to the following protocol, where XX is the station number:

- CFRPO-XX-MMDDYY-S (for samples)
- CFRPO-XX-MMDDYY-QC-FB (for QC field blank samples)
- CFRPO-XX-MMDDYY-QC-FD (for field duplicate samples)

4.3 DATA COLLECTION PROCEDURES – CLARK FORK COALITION

Consistency in data collection is key to maintaining data quality for the program. Clark Fork Coalition will collect nutrient water quality samples. Water quality grab samples should be collected at the same

location in the stream, about the same time of each month, and at about the same time of day. At each site, one set of water samples will be collected at a location where:

- The sampler can safely wade into and stand in the stream or stand securely on the streambank and access the sampling location with the sample bottle fixed to a sampling pole.
- The water column is well-mixed (water is flowing steadily, is not stagnant or an eddy).
- The water is deep enough so water sample bottles can be fully submerged below the water surface and so the mouth of the bottle is elevated away from the river bottom.
- Upstream from any disturbances (e.g., areas where people or dogs have disturbed the streambed or water).

To collect grab samples:

1. Collect water samples in laboratory-provided containers.
2. Carry the bottles and wade into the stream to a preferred sampling location.
3. Collect samples upstream from where you are standing.
4. Submerge the bottle (for unfiltered samples) or syringe (for filtered samples) below the water surface to avoid collecting surface scum, but so the mouth of the bottle is elevated away from the river bottom to avoid collecting sediments from the stream bottom. Water for soluble samples can be collected directly from the river with the syringe or in the 250 ml TPN bottle for safer onshore filtration.
5. Follow either unfiltered or filtered grab sampling procedures described below, as applicable, for each sample.
6. Record the sample on the routine SVF.

All samples will be collected in high-density polyethylene (HDPE) bottles provided by the lab:

- TPN: 250 ml square bottle with white lid
- TP: 500 ml bottle
- SRP, soluble nitrate + nitrite, and soluble ammonia: 250 ml square bottle with white lid

A summary of the nutrient suite required analytical methods and limits, and preservation requirements is provided in **Table 4**. A list of equipment and supplies needed to conduct all data collection activities associated with this SAP is provided in **Appendix D**.

4.3.1 In-Situ Field Parameters – Clark Fork Coalition

In-situ field parameter measurements must be taken prior to collecting water quality samples or other physical disturbances to the water column and substrate. The following methods for collecting field parameters will be used:

- The field meter should be placed in a safe location in the shade, with the storage cap unscrewed a few threads to allow ventilation to the atmosphere and allowed to sit undisturbed for approximately 10-to-15 minutes. This allows the barometric pressure to stabilize in the meter in preparation for DO readings at each site. After barometric pressure stabilization, remove storage cap and screw on probe guard before taking field measurements. Use the field meter carrying case or a backpack to create shade if the site does not have suitable shaded trees or shrubs.
- Field measurements should be taken at a location that is well-mixed, has steady flow, is not excessively turbulent, stagnant or in an eddy, is free of upstream obstructions (for example, not

directly downstream from a bridge, boulder, tree, people, dogs), and deep enough so the sensor can be entirely submerged.

- The results of the field measurements will be recorded on routine SVFs for each monitoring station.

4.3.2 Unfiltered Grab Samples – Clark Fork Coalition

The following samples will be collected using unfiltered grab sampling techniques:

- TPN: 250 ml square bottle with white lid
- TP: 500 ml bottle

NOTE: Collecting samples directly from the waterbody into the laboratory-provided sample bottle is strongly encouraged. However, field crews that intend to use the 250 ml TPN bottle as a transfer bottle for filtering the soluble samples and/or field blanks should do that prior to collecting the unfiltered grab samples (see below).

1. Triple-rinse the bottles and lids: facing upstream into the direction of the flow, collect a small amount of water in the bottle, replace the lid, and shake gently. Discard this rinse water behind you. Repeat this process three times to triple-rinse each bottle.
2. Collect the samples: Submerge the sample bottles deep enough so that the mouth of the bottle is below the water surface but not so deep that you scoop river bottom sediments. Fill the bottle up to the shoulder, leaving a small amount of “head space,” and securely tighten the lid.
3. Add the vial of sulfuric acid preservative to the TP sample (no preservative to the TPN bottle): carefully unscrew the lid of the TP sample bottle and dump the entire contents of the acid vial into the TP sample bottle, securely tighten the lid on the sample bottle, discard the empty vial, and gently invert the sample bottle three times to mix the preservative into the sample.

4.3.3 Filtered Grab Samples – Clark Fork Coalition

The following samples will be collected using filtered grab sampling techniques: SRP, nitrate + nitrite, and ammonia:

1. Use 250 ml square bottles with white cap.
2. Open the new 60 cc syringe package, remove the syringe, and discard the packaging. Triple-rinse the syringe by drawing stream water into the syringe, gently shaking, and compressing the syringe to force the water out three times.
3. Fill the syringe with stream water.
4. Open a new 0.45 μ m filter package by gripping the blue ring and peeling the cover open. Screw the filter onto the syringe and discard the packaging. Pass a small amount of water through the filter to “prime” it.

Note: Avoid contaminating the filter before and during sample collection by not touching the filter tip anywhere besides the blue ring.

5. Triple-rinse the sample bottle with filtered water. Draw water into the syringe from below the water surface or from the transfer bottle. Plunge a small amount of water (approximately 10–20 ml) from the syringe through the filter into the sample bottle. Replace the lid and shake gently. Discard this

rinse water behind you. Repeat this process three times to triple-rinse the bottle with filtered water. When finished rinsing, unscrew and discard the filter used for rinsing.

6. Refill the syringe with ambient stream and pass a small amount of water through the filter to “prime” it. Replace the filter as needed as it becomes clogged and prime the new filter.
7. Once the bottle has been rinsed, fill the bottle with filtered water. When the syringe is empty, grip the filter’s blue ring, unscrew the filter, and refill the syringe, taking care not to contaminate the filter. If the filter is not clogged, screw the filter back onto the syringe and continue filtering until the bottle is sufficiently full. If the filter clogs mid-way throughout filtering, unscrew and discard the clogged filter, refill the syringe, screw on a new filter, pass a small amount of water through the new filter, and continue filtering. Repeat this process until the sample bottle is full.

Note: Be sure to leave enough headspace in this sample bottle so it can expand when frozen without breaking, about ¼” below the shoulder of the bottle.

4.3.4 Benthic Algae Collection - UM

The University of Montana uses two methods of sampling benthic biomass on the Clark Fork River depending on the dominant algae type at the sampling site (DEQ 2021, Watson 2018). These methods include template samples (a rock scraping method) and hoop samples (a bulk sampling method). At river sites where microalgae films (diatom algae) dominate, the template method is used. At river sites dominated by heavy growths of filamentous green algae, samples are collected using the hoop method.

To quantify biomass for long-term trend analysis, sampling occurs only in an indicator zone & time (rocks 30 +/-5 cm deep, 10-20 cm in longest dimension: 1st weeks of August & September). This is the time & place where heavy growths are most likely to interfere with beneficial uses. Limiting sampling to this depth and substrate type and to these dates reduces variability & makes it easier to note trends.

Ten to twenty replicate samples are collected over a reach that is 100 m long at a minimum where the desired depths and substrate type are dominant. At each site, 3 sub-sites are used that are 10-20 stream widths apart. Approximate 1/3 of the samples are collected at each sub-site.

Where microalgae films dominate the site, 20 rocks are sampled randomly by zigzagging across the indicator zone, walking upstream, and periodically stopping without looking, then taking the closest rock to the sampler’s foot that meets the requirements for depth (30 cm +/-5) and size (10-20 cm in longest dimension). Rocks are collected in a plastic basin and carried to shore where they are kept in the shade until sampled within minutes of removing from the water. Algal material is collected by scraping a 2inx2in area on the surface of the rock. Single edge razor blades and flexible templates with a 2x2 square hole assist with this.

Where heavy filamentous growths cover the bottom, many rocks are actually bare even though the heavy filaments obscure the entire stream bottom. Under these conditions, random sampling of rocks would likely underestimate actual benthic biomass levels. At such sites, samples are collected by tossing a 30 cm diameter hoop (heavy gauge copper wire works well) at random points in the 30 cm depth zone and collecting all the algae inside the hoop (any filaments extending beyond the hoop are cut off). The substrate found at the site should be noted since not all the rocks in the hoop may be 10-20 cm in size. Usually only 10 hoop samples are collected at a site if all are hoop samples.



Use a Benthic Algae SVF for each site visited (**Appendix C**). Record the number of template samples and hoop samples collected from each of the three subsites on the Benthic Algae SVF.

Algae photos

At each sub-site, take at least one each of the following photo types:

- (1) the surrounding landscape to document the sub-site's location,
- (2) of the substrate within the indicator zone, and
- (3) photos of substrate pieces used for sampling if water is too turbid for benthic photo.

For each photo, record the photo number, photo type, and pertinent sub-site information on the Benthic Algae SVF. An example Benthic Algae SVF is included in **Appendix C**.

4.4 CHANGES TO THE FIELD SAMPLING PLAN

As conditions in the field may vary, it may become necessary to implement minor modifications to sampling as presented in this plan. Field personnel will clearly document any modifications made to the approved plan and will communicate these modifications, preferably before or as soon as possible after, with the project leader. If, for any reason, field staff feel that conditions are unsafe for collecting samples (e.g., swift waters, weather or ice conditions, other site hazards) they are not to collect the samples. Field personnel will make reasonable effort to reschedule any missed sampling events in consultation with the project leader, or to replace samples that are lost or broken during the sampling event. If field personnel suspect that an instrument is malfunctioning or giving inaccurate readings, they will add a comment to the SVF explaining the issue and will communicate the issue to the project leader and equipment technician. Project leaders will acknowledge modifications in year-end project reports. Modifications to the approved plan will be documented in the sampling project report or QA/QC report at the end of each field season.

4.5 FIELD HEALTH AND SAFETY PROCEDURES

Field personnel will carry first aid kits with them during each sampling trip. Field personnel will wear personal protective equipment as appropriate, including but not limited to nitrile gloves, eye protection, wading belts, and personal floatation devices. First aid and CPR training is recommended for all field personnel. Chemical safety precautions will be taken in accordance with chemical safety data sheets. Field personnel will be required to adhere to all safety precautions related to driving, including following traffic regulations, avoiding driving while tired, and selecting appropriate vehicles for anticipated driving conditions. Safety measures will be taken when working in and around water, including wearing wading belts and using approved alternate sampling techniques during excessive flow conditions.

5.0 SAMPLE HANDLING AND LABORATORY ANALYSIS

This section contains information pertaining to sample handling, chain-of-custody, and laboratory analysis.

5.1 SAMPLE HANDLING AND DELIVERY

In the field, Clark Fork Coalition will store nutrient water chemistry samples according to the preservation requirements shown in **Table 4**. All samples will be placed immediately on ice following sampling collection. The SRP, nitrate + nitrite, and ammonia sample will be frozen solid as soon as possible after collection and before shipping. Care will be taken to maintain appropriate temperatures (e.g., adequate air circulation or ice supply), and coolers will be drained frequently to avoid contamination from melted ice. Storage time between sample collection and delivery to the lab will be minimized and samples will be received by the lab within the holding times specified in **Table 4**.

Algae samples will be kept in the dark, on ice, until they reach the UM lab where they will be stored frozen at -20°C until thawed for analysis.

Clark Fork Coalition will store water chemistry samples and periodically deliver the samples and field forms the lab. This delivery shall occur at least once a month. Dissolved samples (SRP, nitrate + nitrite, and ammonia) will be frozen to extend their holding time, and measures will be taken while packing samples for delivery to ensure samples are frozen solid and are surrounded by sufficient ice to keep the samples frozen until arrival at the lab. Whenever samples are transferred, the "relinquished by" portion of the COC/SVF will be completed.

5.2 CHAIN OF CUSTODY

A record of COC will be maintained for each sample collected during this project so that physical possession is tracked at all points from sample collection through laboratory analysis. The COC section of each SVF will be used to record signatures, dates, and times when samples are relinquished and received during transfers among people including laboratory staff. If samples are shipped, custody seals will be used on the shipping container to ensure that custody is maintained and that samples are not tampered with while in transit. Upon analysis of the samples, Energy Labs will send the Lab Report (as a .pdf) and Lab Results (as a spreadsheet) to both Sam Carlson at the Clark Fork Coalition and Deanna Tarum at DEQ. At the end of the season, the Clark Fork Coalition will submit the completed EDD with all sample results and field parameter data to DEQ.

5.3 LABORATORY ANALYTICAL REQUIREMENTS

Table 4 summarizes, per analyte, the analytical methods, and detection/reporting limits, holding times, and sample collection and preservation requirements to be used for this project.

Table 4. Nutrient Parameter Suite, Analytical Methods, Sampling Volumes, Containers, Preservation, and Holding Times

Analytes	Method	Required Quantification Limit	Filtered?	Sample Volume	Container	Preservation and Storage	Holding Time
Total Persulfate Nitrogen	A4500 N-C	40 ug/l	N	250 ml	Acid-washed HDPE	Cool on ice in field	28 days
Total Phosphorus	EPA 365.1	2 ug/l	N	500 ml		H ₂ SO ₄ , Cool to ≤ 4°C (on ice) in field	

Low level dissolved nitrate + nitrite-nitrogen (NO ₂ +NO ₃ -N)	EPA 353.2	2 ug/l	Y	250 ml		Filter, cool on ice in field, then freeze solid	45 days
Dissolved ammonia-nitrogen (NH ₃ +NH ₄ -N)	EPA 350.1	10 ug/l	Y				
Soluble reactive phosphorus	EPA 365.1	2 ug/l	Y				
Chlorophyll- <i>a</i>	A 10200H	Template: 4 mg/m ² Hoop: 0.1 mg/m ²	N	NA	47 mm petri dish OR zip lock bag	Prevent light exposure, cool on ice in field, freeze in lab	90 days
Ash free dry weight	A 10300 C (5)	Template: 4 g/m ²	N	NA	47 mm petri dish OR zip lock bag	Cool on ice in field, freeze in lab	120 days

The reporting limits shown in Table 4 have been selected intentionally to maintain consistency with past years' RRLs for statistical trend analysis purposes. The project laboratory has confirmed that they can achieve these RRLs.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

This section describes the QA/QC elements applicable to this project.

6.1 TRAINING AND QUALIFICATIONS

All field personnel implementing this SAP are adequately trained and are qualified for the work. Training and qualifications of field personnel include:

- Multiple years of experience working in the field and implementing this SAP.
- Annual review of the SAP.
- Initial training conducted by an experienced professional.

6.2 INSTRUMENT CALIBRATION AND MAINTENANCE

Field meters currently used to implement this SAP include a YSI water quality probe and a Hach turbidimeter, provided by DEQ to Clark Fork Coalition, if needed and if available. Instructions and guidance on instrument calibration follow:

1. Field personnel will calibrate the meters according to instructions in the user manuals.
2. The water quality probe will be calibrated at least once per month immediately prior to sampling activities during the field season.
3. The turbidimeter will be calibrated once per season or as recommended by the manufacturer.
4. All instrument calibration shall be conducted in the office and recorded in a logbook. Notations for calibration logbook include:

- a. Date, time, and personnel performing the calibration
 - b. Parameter calibrated
 - c. Calibration standard value and temperature corrected value if applicable
 - d. Calibration standard expiration date
 - e. Meter measurement of standard prior to calibrating
 - f. Meter measurement of standard after calibrating
5. Calibration of DO will be completed in the field at least one time per day during sampling activities.
6. Calibration standards must not be expired.
7. Refer to field meter manual specifications in **Appendix E**.

6.3 DATA QUALITY INDICATORS

Data quality indicators (DQIs) are attributes of samples that allow data users to assess data quality. The CFRWQMC has developed DQIs for precision, bias, accuracy, representativeness, comparability, completeness, and sensitivity for use in the program. A description of the programs DQIs are provided in the programs QAPP (DEQ 2023).

Program QA/QC requires field duplicate and field blank samples collected at a rate of ten percent of the total samples collected per analyte (QA/QC sample set). For this SAP, one QA/QC sample set is collected as part of each monthly monitoring event.

6.4 LABORATORY QUALITY CONTROL

Laboratory QC procedures have been established by the CFRWQMC as described in the program's QAPP (DEQ 2023).

7.0 DATA MANAGEMENT AND RECORD KEEPING

This section describes the process for managing data and maintaining records associated with this monitoring project.

7.1 DATA REVIEW AND VALIDATION

Nutrient water quality data collected from the Clark Fork River under this SAP is submitted annually to the Montana DEQ's MT-eWQX database and used for a five-year trend report for the Clark Fork River. A flow diagram that explains the order of operations for sample collection, data analysis, data management, QA, and reporting is provided in **Appendix A**.

Data review and validation procedures for this SAP follow direction in the program's QAPP (DEQ 2023). There are several specific data review and validation activities that take place in relation to this SAP. These activities and responsibilities are described below:

Clark Fork Coalition

- Review field meter calibration logs, note discrepancies, and submit annually to DEQ.
- Review site visit field forms after each sampling event and submit annually to DEQ.



- Inspect sample labels for correctness and cooler temperatures prior to DEQ delivery.
- Review COCs for completeness prior to sample pick up by DEQ.
- Review field sheets and enter and compile field electronic data deliverable (EDD) in MT-eWQX format.
- Perform basic data validation of each laboratory report and provide follow-up email to members.
- Receive and review laboratory analytical reports, distribute to members.
- Compile Program-wide laboratory EDD in MT-eWQX format, submit to DEQ annually.
- Prepare annual Program-wide data report.
- Coordinate and host annual CFRWQMC meeting to discuss previous year's data, data quality issues, corrective actions, and schedule for upcoming year.
- Initiate annual review of Program QAPP and SAPs. Provide summary of field sampling activities to DEQ annually.

University of Montana:

- Review site visit field forms after each sampling event and submit annually to DEQ.
- Inspect sample labels for correctness and proper sample preservation.
- Provide summary of field sampling activities to DEQ annually.
- Review field sheets and send information to DEQ.
- Analyze benthic algae samples and submit data to DEQ.
- Review program QAPP and SAPs, as needed.

DEQ:

- Review COCs for completeness prior to sample pick up from Clark Fork Coalition, and delivery to lab.
- Compile and review field forms, field meter calibration logs, COCs, and laboratory reports.
- Review field sheets and enter and compile field electronic data deliverable (EDD) in MT-eWQX format.
- Receive and review laboratory analytical reports.
- Perform basic data validation of each laboratory report.
- Conduct Program-wide data quality review and data validation in accordance with program QAPP for field and laboratory data.
- Prepare annual program-wide data quality report.
- Upload validated data to MT-eWQX database.
- Review and update program QAPP and SAPs.

7.2 DATA MANAGEMENT

All site information, field measurements and analytical results from laboratories for this project will be uploaded into DEQ's MT-eWQX. Data uploaded to MT-eWQX is submitted to EPA's National WQX Warehouse and accessible via the Water Quality Portal. All data submitted to DEQ for this project from analytical laboratories and others must adhere to the most current EDD and submittal requirements



published in the MT-eWQX EDD Guidance available on the Water Quality Planning Bureau's (WQPB) WQX webpage: <https://deq.mt.gov/water/Programs/sw>.

All raw electronic files, including EDDs, data logger files, and any other types, will be retained indefinitely on DEQ's server within the WQPB field season data archive and on the annual WQPB field season archive DVDs. SVFs and other field forms used to document field activities, measurements and site information will be scanned and retained indefinitely in the WQPB data archive and field season archive DVDs.

8.0 DATA ANALYSIS AND REPORTING

This section describes the intended data analyses to be performed using data produced by this project.

8.1 DATA ANALYSIS

Data collected under this SAP provides one part of multiple components of the CFRWQMC program. The program's QAPP fully describes the specific data analysis activities that take place.

8.2 REPORTING

Data reporting is fully described in the program's QAPP (DEQ 2023). In general, reporting includes:

- 1) Annual data summary report
- 2) Annual nutrient loading memo prepared by Avista's technical consultant, and
- 3) A five-year nutrient water quality time trends analysis prepared by a consultant under contract with DEQ and Avista.

Reports are published and available to the public via DEQ's website.



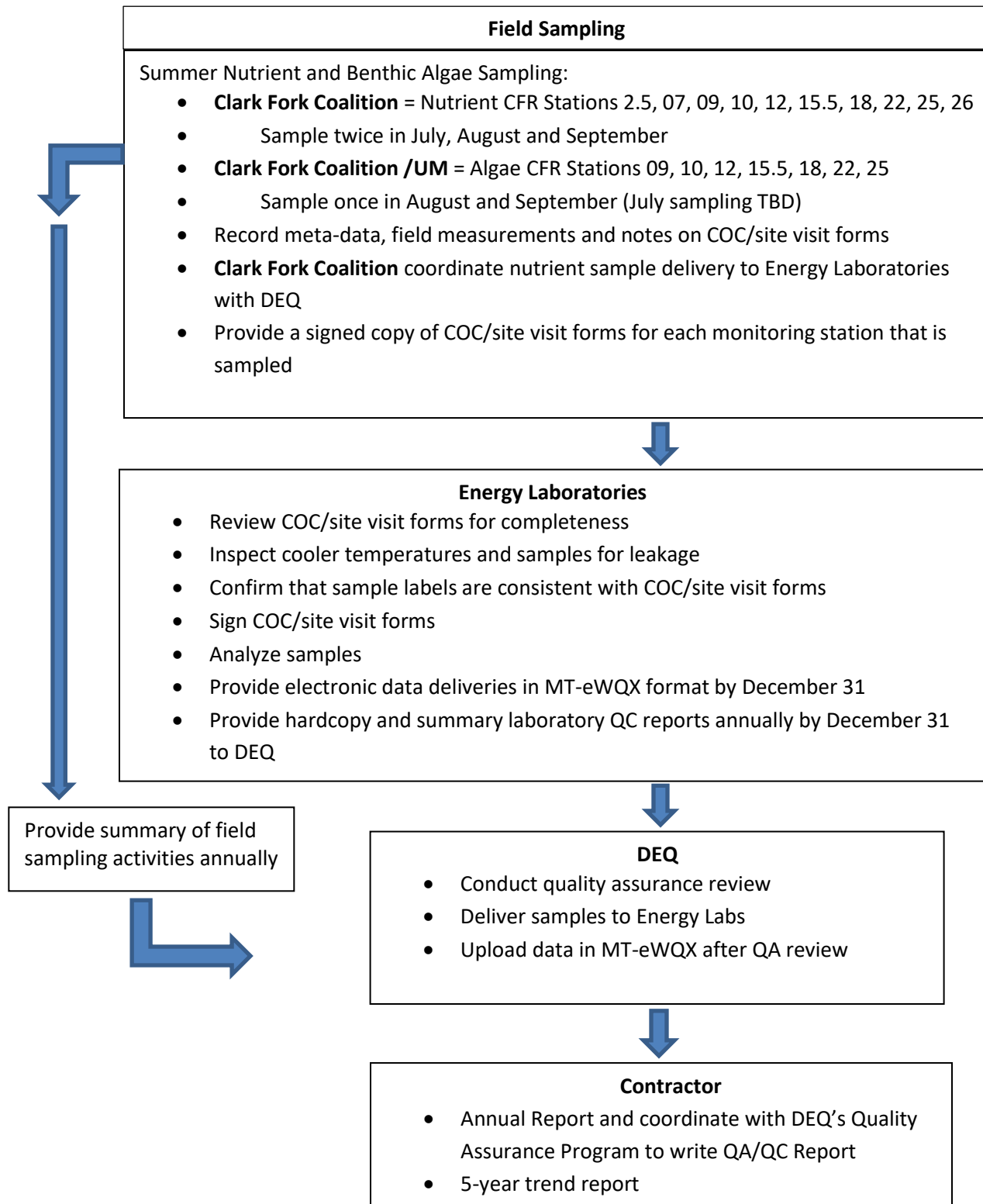
9.0 REFERENCES

Montana Department of Environmental Quality (DEQ). 2021. Sample Collection and Laboratory Analysis of Chlorophyll *a* Standard Operating Procedure. Prepared by Suplee, M., July 2019. Document No. WQPBWQM-011, Version 8.

Montana Department of Environmental Quality (DEQ). 2023. Clark Fork River Watershed Water Quality Monitoring Program from Headwaters to Below Cabinet Gorge Dam - Quality Assurance Project Plan (QAPP). Helena, MT: Montana Department of Environmental Quality, Water Quality Planning Bureau.

Watson, V. 2018. Field Methods of the UM Watershed Health Clinic. Missoula, MT: University of Montana.

APPENDIX A -UPPER AND MIDDLE CLARK FORK RIVER WATER QUALITY DATA COLLECTION FLOW DIAGRAM



APPENDIX B – NUTRIENT WATER SAMPLE FIELD FORM & COC EXAMPLES

Site Visit Form/Field Form

Site Visit Form				Project ID: <u>CFR-BASIN</u>	
Date: <u>9/6/20</u>		Time: <u>14:15</u>		Personnel: <u>John Mann</u>	
Waterbody: <u>Silver Bow Creek</u>		Location: <u>At Opportunity</u>			
Station ID: <u>CFRPO-2.5</u>		HUC: <u>17010201</u>		County: <u>Deer Lodge</u>	
Latitude: <u>46.1082</u>		Longitude: <u>-112.8050</u>		Elevation: <u>4310</u> ft m	
☐ Field Duplicate to _____		☐ Field Blank			
Samples Collected	Sample ID	Sample Collection Information/Preservation			
Water	☒ <u>CFRPO-2.5-090620-S</u>	<u>GRAB</u>			
Analysis: TP		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL <u>Ice</u> Frozen			
Analysis: TN		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL <u>Ice</u> Frozen			
Analysis: SRP, NO ₃ -, Ammonia		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL <u>Ice</u> Frozen			
Field Measurements		Time: <u>14:15</u> (24 hr)			
Water Temp: <u>18</u>	<u>°C</u> °F	Air Temp: <u>81</u>	<u>°C</u> °F		
Bar. Pressure: <u>640.7</u>	mm/Hg	SC: <u>691.0</u>	<u>µS/cm</u>		
pH: <u>8.51</u>	DO: <u>9.90</u> mg/L	Turbidity: <u>3.10</u>	NTU		
Turbidity: ☐ Clear ☒ Slight ☐ Turbid ☐ Opaque					
Field Meter Information					
Multiparameter Meter:	Manufacturer & Model: <u>YSI Pro Plus</u>				
	Date of <u>SpC</u> Calibration: <u>9/6/20</u>		☒ DO calibrated at site visit		
	Date of pH Calibration: <u>9/6/20</u>				
Photos	# <u>104-1234 = looking u/s</u>		#		
	# <u>104-1235 = looking d/s</u>		#		
	# <u>104-1236 = looking across</u>		#		
Site Visit Comments					
Chemistry Lab Information					
Lab Samples Submitted to: _____		Account #: _____		Term Contract Number: _____	
Invoice Contact: _____					
Contact Name & Phone: _____				EDD ☒ Format: MT-eWQX Compatible	
1) Relinquished By & Date/Time: _____		1) Shipped By: ☐ USPS ☐ Hand ☐ FedEx/UPS		1) Received By & Date/Time: _____	
2) Relinquished By & Date/Time: _____		2) Shipped By: ☐ USPS ☐ Hand ☐ FedEx/UPS		2) Received By & Date/Time: _____	
Lab Use Only - Delivery Temperature: Wet Ice _____ °C Dry Ice _____ °C					



Chain of Custody & Analytical Request Record

www.energylab.com

Page of

Account Information (Billing information)				Report Information (if different than Account Information)				Comments				
Company Name Clark Fork Coalition				Company Name Montana Department of Environmental Quality								
Contact Sam Carlson				Contact Deanna Tarum								
Phone (406) 599-8711				Phone								
Mailing Address PO Box 7593				Mailing Address								
City, State, Zip Missoula, MT, 59807				City, State, Zip								
Email scarlson@clarkfork.org				Email dtarum@mt.gov								
Receive Invoice ☐ Hard Copy ☒ Email Receive Report ☐ Hard Copy ☒ Email				Receive Report ☐ Hard Copy ☒ Email								
Purchase Order				Quote H18322				Bottle Order				
Special Reports/Formats: ☐ LEVEL IV ☐ NELAC ☐ EDD/EDT (contact laboratory) ☐ Other _____												
Project Information				Matrix Codes		Analysis Requested						See Attached
Project Name, PWSID, Permit, etc. CFR-Basin				A - Air		Nitrogen, Total Persulfate (A4500 N-C) Ammonia (E350.1) Nitrate + Nitrite (E353.2) Phosphorus, Total (E365.1) Phosphorus, (Ortho as P) (E385.1)						
Sampler Name Clark Fork Coalition Sampler Phone (406) 599-5871				W - Water								
Sample Origin State MT EPA/State Compliance ☐ Yes ☒ No				S - Solids/Solids								
URANIUM MINING CLIENTS MUST indicate sample type ☐ Unprocessed Ore ☐ Processed Ore (Ground or Refined) **CALL BEFORE SENDING ☒ 11(e)2 Byproduct Material (Can ONLY be Submitted to ELI Casper Location)				V - Vegetation								
				B - Biosay								
				O - Oil								
				DW - Drinking Water								
Sample Identification (Name, Location, Interval, etc.)		Collection		Number of Containers		Matrix (See codes Above)						
		Date	Time									
1					W	✓						
2					W	✓						
3					W	✓						
4					W	✓						
5					W	✓						
6					W	✓						
7					W	✓						
8					W	✓						
9					W	✓						
ELI is REQUIRED to provide preservative traceability. If the preservatives supplied with the bottle order were NOT used, please attach your preservative information with this COC.												
Custody Record MUST be signed	Reinquished by (print)	Date/Time	Signature		Received by (print)		Date/Time	Signature				
	Reinquished by (print)	Date/Time	Signature		Received by Laboratory (print)		Date/Time	Signature				
LABORATORY USE ONLY												
Shipped By	Cooler ID(s)	Custody Seals Y N C B	Intact Y N	Receipt Temp °C	Temp Blank Y N	On Ice Y N	CC	Payment Type Cash Check	Amount \$	Receipt Number (cash/check only)		

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All subcontracted data will be clearly notated on your analytical report.

EU-COC-01/21 v.4



UCF COC.pdf

APPENDIX C – BENTHIC ALGAE SAMPLE FIELD FORM EXAMPLE

Clark Fork River Benthic Algae monitoring program

SITE VISIT FORM

Date: 7-24-2020 Personnel: V. Watson
 Waterbody: Clark Fork River Location: CF abv Deer Lodge
 Station ID: CFR-PD-9 HUC: 1701020107 County: Powell

Subsite 1:
 Latitude: 46.3789 Longitude: 112.7367
 Benthic algae samples collected
 # of templates: 7T
 # of hoops: _____
Upper Arrowstone Park

Subsite 2:
 Latitude: 46.3834⁹ Longitude: 112.73190
 Benthic algae samples collected
 # of templates: 6 Bare rocks
 # of hoops: _____
Lower Arrowstone Park

Subsite 3:
 Latitude: 46.3980 Longitude: 112.7428
 Benthic algae samples collected
 # of templates: 7T
 # of hoops: _____
Milwaukee Bridge

COMMENTS:
20 samples including 14 templates + 6 bare rocks

Samples delivered to UM Watershed Health Clinic lab freezer: Date/time: 07/24/2020, 17:00

APPENDIX D – EQUIPMENT AND SUPPLIES

Item	Check
250 ml sampling bottles with white caps for TPN samples (1 for each station per sampling event, field blank, and duplicate)	
500 ml sampling bottles for total phosphorous samples (1 for each station per sampling event, field blank, and duplicate)	
250 ml sampling bottles with white caps for soluble reactive phosphorous, soluble nitrate + nitrite nitrogen, and soluble ammonia samples (1 for each station per sampling event, field blank, and duplicate)	
1-60 cc syringe to collect water for filter (1 per station per sampling event, field blank, and duplicate plus several extras)	
0.45 µm disposable filters (at least 3 for each station per sampling event, field blank, and duplicate, plus several extras)	
Sulfuric acid (H ₂ SO ₄) (1 vial for each station per sampling event, field blank, and duplicate)	
Field meter, turbidimeter, and calibration solutions	
Chain-of-Custody (COC)/SVFs, pencils, sharpies, and waterproof pen	
Cooler and ice, cooler and dry ice	
De-ionized water (2 liters)	
Laboratory will supply bottles with blank labels, de-ionized water, and coolers.	

APPENDIX E – FIELD METER MANUALS AND SPECIFICATIONS

YSI Professional Plus Field Meter Manual. <http://www.ysi.com/media/pdfs/605596-YSI-ProPlus-User-Manual-RevD.pdf>

Hach 2100Q Turbidimeter. <http://www.hach.com/2100q-portable-turbidimeter/product-downloads?id=7640450963>.

Table B-1. Professional Plus System Specifications (Cables & Sensors)

	Sensor Type	Range	Accuracy	Resolution	Units	Calibration
Dissolved Oxygen (%) (temp comp range -5 to 45°C)	Polarographic or Galvanic	0 to 500%	0 to 200% ($\pm 2\%$ of reading or 2% air saturation, whichever is greater) 200% – 500% ($\pm 6\%$ of reading)	1% or 0.1% air saturation (user selectable)	%	1 or 2-points with zero
Dissolved Oxygen (mg/L) (temp comp range -5 to 45°C)	Polarographic or Galvanic	0 to 50 mg/L	0 to 20 mg/L ($\pm 2\%$ of reading or 0.2 mg/L, whichever is greater) 20 – 50 mg/L ($\pm 6\%$ of reading)	0.1 or 0.01 mg/L (user selectable); 0.1% air saturation	mg/L, ppm	1 or 2-points with zero
Temperature (Field rugged cables)		-5 to 70°C	$\pm 0.2^\circ\text{C}$ ($\pm 0.3^\circ\text{C}$ cables over 45-meters)	0.1°C	°C, °F, K	
Temperature (Lab-grade)*		0 to 40°C	$\pm 0.35^\circ\text{C}$	0.1°C	°C, °F, K	
Conductivity**	Four electrode cell	0 to 200 mS/cm (auto range)	$\pm 0.5\%$ of reading or 0.001 mS/cm, whichever is greater (1-, 4-m cable) $\pm 1\%$ of reading or 0.001 mS/cm, whichever is greater (20-m cable)	0 to 0.500 mS/cm = 0.001 0.501 to 50.00 mS/cm = 0.01 50.01 to 200 mS/cm = 0.1 (range dependent)	μS , mS	1 point
Salinity	Calculated from conductivity and temperature	0 to 70 ppt	$\pm 1.0\%$ of reading or 0.1 ppt, whichever is greater	0.01 ppt	ppt, PSU	1 point
pH	Glass Combination Electrode	0 to 14 units	± 0.2 units	0.01 units	mV, pH units	1, 2, 3, 4, 5, or 6 point (user selectable); US, NIST or

Table B-1. Professional Plus System Specifications (Cables & Sensors)

	Sensor Type	Range	Accuracy	Resolution	Units	Calibration
						Custom Buffers
ORP	Platinum button	--1999 to +1999 mV	±20 mV in redox standards	0.1 mV	mV	1 point
Ammonium*** (ammonia with pH sensor)	Ion Selective Electrode	0 to 200 mg/L-N, 0 to 30°C	±10% of reading or 2 mg/L-N, whichever is greater	0.01 mg/L	mg/L-N, mV	1, 2, or 3 point (user selectable)
Nitrate***	Ion Selective Electrode	0 to 200 mg/L-N, 0 to 30°C	±10% of reading or 2 mg/L-N, whichever is greater	0.01 mg/L	mg/L-N, mV	1, 2, or 3 point (user selectable)
Chloride***	Ion Selective Electrode	0 to 1000 mg/L, 0 to 40°C	±15% of reading or 5 mg/L, whichever is greater	0.01 mg/L	mg/L-Cl-, mV	1, 2, or 3 point (user selectable)
Total Dissolved Solids (TDS)	Calculated from conductivity and temperature	0 to 100 g/L TDS constant range 0.30 to 1.00 (0.64 default)		0.001, 0.01, 0.1g/L	kg/L, g/L	
Barometer	Piezoresistive	375 to 825 mmHg	±1.5 mmHg from 0 to 50°C	0.1 mmHg	mmHg, inHg, mbar, psi, kPa, ATM	1 point
Instrument Only Specifications (at Ambient Temperature)						
pH		-2.60 to 16.60	±0.1 mV (0.01 pH units)	0.1 mV (0.01 pH units)		
ORP		-1999 to +1999 mV	±0.5 mV	0.1 mV		
Conductivity		0.0 to 200 mS/cm each range	±0.1% FS ±1 digit for µS/cm to 0.1 mS/cm (range dependent)	0.0001 mS/cm or 0.1		
Dissolved Oxygen		0.00 to 90 mg/L; 0 to 550%	±0.2% FS (550% air saturation) ±1 digit (with 1.25 PE membrane at 10°C)	0.01 mg/L; 0.1% air saturation		
Temperature		-10 to 100.00°C	±0.2% FS ±1 digit	0.1°C	°C, °F, K	

*Lab-grade cables include 605107, -108, -109, 605177, -178, -179

** Derived parameters can include resistivity, salinity, specific conductance, and TDS

***ISE sensors for freshwater only; 17-meter maximum depth



Hach 2100Q Portable Turbidimeter

Accuracy: ± 2 % of reading plus stray light

Measuring Range: 0 - 1000 NTU