MADISON STREAM TEAM WATER QUALITY AND NUTRIENT MONITORING
SAMPLING AND ANALYSIS PLAN

Prepared for the Montana Department of Environmental Quality

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Introduction

This document constitutes the Sampling and Analysis Plan (SAP) for the completion of volunteer water quality sampling for five creeks (Moores Creek, Jack Creek, North Meadow Creek, South Meadow Creek, and Hot Springs Creek) in the Upper Madison TMDL planning area in Madison County Montana (Table 1). Moores Creek, Jack Creek, North Meadow Creek, and South Meadow Creek have been monitored by the Madison Conservation District and Madison Stream Team since 2010. Additionally, monitoring began on Hot Springs Creek in 2016. These waterbodies were selected to either better understand sources of pollutants that led to their impaired status, or to establish long-term trends where anticipated residential growth is expected. These five streams have been prioritized for monitoring due to their high potential for future water quality improvements. The high concentration of residential development, recreation, and agricultural production in these watersheds allow for many opportunities for local conservation organizations to work with landowners and land managers to identify and implement conservation practices that improve or maintain the water quality conditions of these five streams. Additionally, the Madison Stream Team is currently limited to focusing sampling on these waterbodies due to time and budget constraints.

This effort was initiated to increase education and outreach opportunities specific to water quality in the Madison Watershed. The supporting organizations recognize the value of collecting water quality and quantity data on impaired waterways that will add to the information which has already been used by Montana Department of Environmental Quality in making water quality assessment determinations and developing TMDLs. Furthermore, this information will be used in assessing sources of impairments which will lead to identifying potential projects that will make improvements on impaired streams. This SAP outlines general field parameters and sampling for lab analysis that will take place in 2019.

Project Objectives

The goals of the project are:

- To increase community engagement around water resources, and to collect data that enhances the understanding of conditions on local waterways.
- To create an awareness of non-point source pollution sources, and inform citizens of improvement opportunities that exist through watershed restoration efforts.
- Identify potential sources of water quality pollutants on North Meadow Creek, South Meadow Creek, Moores Creek, Hot Springs Creek, and Jack Creek.
- To increase communication between data collectors and land managers.

Through the collection of water quality data, the project will provide the following products or opportunities:

- Annual report containing data from current year with comparisons to data collected in previous years. Baseline conditions will be established by noting any extremes or incidences of exceedances of state standards. Annual report will be made available to the public at the Madison Conservation District website.
- Summary of preliminary findings of the Madison Stream Team project will be presented to the general public and other pertinent audiences following the field season.

Sampling Design

The list of streams on the 2018 303d list in the Madison TMDL planning area (Table 1: Causes of impairment for streams monitored in 2019.

WATERBODY NAME / LOCATION	PROBABLE CAUSE OF IMPAIRMENT
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Iron
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Lead
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Nitrogen, Total
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Phosphorus, Total
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Sedimentation/Siltation
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Arsenic
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Escherichia coli (E. Coli)
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Nitrogen, Total
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Phosphorus, Total
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Sedimentation/Siltation
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Temperature
NORTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Sedimentation/Siltation
SOUTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Copper
SOUTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Nitrogen, Total
SOUTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Phosphorus, Total
SOUTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Sedimentation/Siltation

1) was evaluated along with additional information from the recent water quality assessments by DEQ to come up with the streams and monitoring locations for the 2019 monitoring. Since 2010, 7 of the 17 impaired waterbodies in the Madison have undergone additional monitoring by the Madison Stream Team. Sample sites for 2019 were selected based on data collected in previous years in conjunction with the TMDL planning that is currently taking place. The sampling schedule is focused between July and September, and is largely influenced by the availability of volunteers, many of whom reside in the watershed only during the summer months.

Table 1: Causes of impairment for streams monitored in 2019.

WATERBODY NAME / LOCATION	PROBABLE CAUSE OF IMPAIRMENT
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Iron
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Lead
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Nitrogen, Total
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Phosphorus, Total
HOT SPRINGS CREEK, headwaters to mouth (Madison River)	Sedimentation/Siltation
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Arsenic
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Escherichia coli (E. Coli)
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Nitrogen, Total
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Phosphorus, Total
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Sedimentation/Siltation
MOORE CREEK, springs to mouth (Fletcher Channel), T5S R1W S15	Temperature
NORTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Sedimentation/Siltation

SOUTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Copper
SOUTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Nitrogen, Total
SOUTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Phosphorus, Total
SOUTH MEADOW CREEK, headwaters to mouth (Ennis Lake)	Sedimentation/Siltation

Sites where monitoring and sampling will occur are outlined in Table 3. Data collection activities to be conducted at each site are listed in Table 2.

A full water quality sampling will occur on South Meadow Creek, Moores Creek, Hot Springs Creek, and Jack Creek. On each site visit for each stream, collection will include: data from YSI 556 meter (air and water temperature, pH, specific conductance, and dissolved oxygen), discharge, photo point monitoring, and turbidity. Chemical analysis will also be performed at all primary sampling events from July through September, and nuisance algae photos will be taken at all sites once during the year.

Lab analysis in 2019 will include; total persulfate nitrogen, total phosphorus, and nitrate plus nitrite. Quality assurance and quality control samples (blank and duplicate samples) will be collected during the July sampling events. A detailed outline of the parameters which are to be analyzed at each site is presented in Table 2.

In addition to the full sampling suite described above, turbidity samples will be collected by volunteers at a higher frequency on Moores Creek, Jack Creek, North Meadow Creek, and South Meadow creek. This additional turbidity monitoring is centered around spring and early summer snow melt, as well as spring, summer, and fall precipitation events (May through October). Samples collected exclusively for turbidity do not coincide with the schedule outlined in Table 2, but are collected during optimal conditions when volunteers are available. Sites selected for turbidity monitoring may vary from regular monitoring sites in an effort to incorporate more data points that may lead to identifying possible sources of sediment. These additional turbidity monitoring sites are outlined in a separate section within Table 3. Additional information regarding turbidity sampling sites and protocol is included in "Madison Stream Team Turbidity Guidance Document".

Table 2: Parameters to be assessed by Madison Stream Team volunteers in 2019.

Stream	***July***	***August***	***September***
South Meadow Creek	*Discharge, Field meter, Turbidity meter, Nutrients (TN, N+N, TP at 5 sites)*	*Discharge, Field meter, Turbidity Meter, Rock Chlorophyll photo, Nutrients (TN, N+N, TP at 5 sites)*	*Discharge, Field meter, Turbidity Meter, Nutrients (TN, N+N, TP at 5 sites),* ***One Field Blank and Two Duplicate QAQC samples***
Moores Creek	*Discharge, Field meter, Turbidity Meter, Nutrients (TN, N+N, TP at 6 sites),* ***One Field Blank and Two Duplicate QAQC samples***	*Discharge, Field meter, Turbidity Meter, Rock Chlorophyll photo, Nutrients (TN, N+N, TP at 6 sites)*	*Discharge, Field meter, Turbidity Meter, Nutrients (TN, N+N, TP at 6 sites)*
Jack Creek	*Discharge, Field meter, Turbidity Meter, Nutrients (TN, N+N, TP at 3 sites)*	*Discharge, Field meter, Turbidity Meter, Rock Chlorophyll photo, Nutrients (TN, N+N, TP at 3 sites),* ***One***	*Discharge, Field meter, Turbidity Meter, Nutrients (TN, N+N, TP at 3 sites)*

		Field Blank and Two Duplicate QAQC samples	
Hot Springs Creek	*Discharge, Field meter, Turbidity Meter, Nutrients (TN, N+N, TP at 5 sites)*	*Discharge, Field meter, Turbidity Meter, Rock Chlorophyll photo, Nutrients (TN, N+N, TP at 5 sites)*	*Discharge, Field meter, Turbidity Meter, Nutrients (TN, N+N, TP at 5 sites)*

Table 3: Sample site IDs, names, coordinates and descriptions.

Sites for Full Monitoring Suite (field sampling, discharge, turbidity, chlorophyll photo, and nutrients)				
Stream	**Site ID**	**Lat.**	**Long.**	**Site Description**
South Meadow	SM-WEIR	45.44941	-111.82273	In front of Weir
	SM-NMCR	45.447230	-111.760708	N. Meadow Cr. Road
	SM-EDC	45.451069	-111.746997	Endecott Ranch
	SM-HWY	45.448672	-111.731720	Highway 287
	SM-CR	45.444182	-111.718796	Crumley Ranch
Moores Creek	MC-STATE	45.351846	-111.801426	State Land
	MC-POND	45.335653	-111.767877	Pond Outlet
	MC-MCR	45.195858	-111.445201	Moores Creek Road
	MC-BRK	45.338411	-111.737349	Bricker's House
	MC-HOME	45.349427	-111.730100	Ennis Homestead
	MC-RST	45.361555	-111.728229	Downstream of Restoration
Hot Springs Creek	HS-STER	45.56491	-111.75407	Near historic town of Sterling
	HS-ROAD	45.57351	-111.72485	State lands stream crossing
	HS-NOR	45.573888	-111.683538	Norris Hot Springs
	HS-BRAD	45.58698	-111.64814	Bradley Creek Road
	HS-CNF	45.58592	-111.59382	Warms Springs FAS
Jack Creek (*no nutrient samples collected at sites JC-CG and JC-CY)	JC-SSR	45.33051	-111.47585	South Side Road
	JC-SJ	45.326003	-111.495317	South Jack Creek
	*JC-CG	45.34662	-111.5295	Old Campground
	*JC-CY	45.356403	-111.585992	Canyon Entrance
	JC-JCR	45.375816	-111.693702	Jack Creek Ranch
Sites for additional Turbidity Sampling				
Stream	**Site ID**	**Lat.**	**Long.**	**Site Description**
North Meadow Creek	NM-FSCG	45.52977	-111.85362	USFS Campground
	NM-BAR	45.513884	-111.821992	Washington Bar
	NM-INT	45.494555	-111.793672	Near Road Intersection
	NM-ROAD	45.480709	-111.776516	Near NM Creek Road
	NM-HAM	45.470710	-111.772283	Hamilton Ranch
	NM-HWY	45.456537	-111.731132	Highway 287
	NM-MLL	45.445448	-111.713847	Meadow Lake Lodge
Jack Creek	JC-CMP	45.34662	-111.5295	OLD CAMPGROUND
	JC-MILL	45.352837	-111.543571	MILL CREEK TRAILHEAD
	JC-BRIDGE	45.355423	-111.570877	JACK CREEK ROAD BRIDGE
	JC-CY	45.356403	-111.585992	CANYON ENTRANCE
	JC-ROAD	45.379002	-111.674889	JACK CREEK ROAD
	JC-JCR	45.37519	-111.69392	JACK CREEK RANCH

Moores Creek	MC-MCR	45.333269	-111.748198	Moores Creek Road
	MC-HWY	45.336855	-111.741031	Highway 287
	MC-BRK	45.338411	-111.737349	Bricker's House
	MC-ARM	45.344000	-111.731511	Armitage Street
	MC-STF	45.347840	-111.730591	Steffens Street
	MC-HOME	45.349427	-111.730100	Ennis Homestead
South Meadow Creek	SM-WEIR	45.45085	-111.82071	Weir
	SM-EDC	45.45094	-111.74782	Endicott
	SM-HWY	45.44799	-111.73182	Highway 287
	SM-LKRD	45.44372	-111.71871	Lake Road

Table 4: Sample site selection rational

Site ID	Site Name	Rational for site selection
SM-WEIR	Weir	Below USFS boundary, and above residential development and livestock grazing. Site provides natural flow conditions above several irrigation diversions.
SM-NMCR	North Meadow Cr. Rd.	Downstream of residential developments, and upstream of 2012 restoration project
SM-EDC	Endecott	Location of 2012 restoration project, and upstream of portions of the creek that have significant groundwater upwelling.
SM-HWY	Highway 287	Middle channel of South Meadow Creek at HWY 287 crossing, and likely the result of groundwater upwelling.
SM-CR	Crumley Ranch	Captures all upstream uses just before South Meadow Creek enters Ennis Lake.
MC-STATE	State Land	Downstream of large equine facility, and upstream of other major human influences.
MC-POND	Below Pond	Below impoundment on Moores Creek.
MC-MCR	Moores Creek Rd.	Above 2017 restoration project.
MC-BRK	Bricker's House	Upstream end of Ennis city limits, and above most urban development.
MC-HOME	Ennis Homestead	Below residential development in Ennis city limits.
MC-RST	Restoration	Below ½ mile riparian fencing project implemented in 2016.
HS-STER	Sterling	Below public grazing allotments and historic mining.
HS-ROAD	Sterling Road	Above cropland and residential development near town of Norris.
HS-NOR	Norris Hot Springs	Below residential development near Norris.
HS-BRAD	Bradley Creek Rd.	Below State grazing lands, and above straightened channelized stream segments along HWY 84.
HS-CNF	Confluence	Just above confluence with the Madison River.
JC-SSR	South Side Road	Site encompasses all Moonlight Basin resort development and recreation facilities.
JC-SJ	South Jack Creek	Reference site with headwaters in Lee Metcalf Wilderness area. No existing development, but proposed future development just above monitoring site.

Site ID	Site Name	Rational for site selection
SM-WEIR	Weir	Below USFS boundary, and above residential development and livestock grazing. Site provides natural flow conditions above several irrigation diversions.
SM-NMCR	North Meadow Cr. Rd.	Downstream of residential developments, and upstream of 2012 restoration project
SM-EDC	Endecott	Location of 2012 restoration project, and upstream of portions of the creek that have significant groundwater upwelling.
JC-CG	Old Campground	Above 3 mile section of Jack Creek that parallels a heavily used dirt road, and above several residential developments near the stream.
JC-CY	Canyon Entrance	Downstream of 3 mile section of road that parallels the stream, and site of historic USGS gaging station.
JC-JCR	Jack Creek Ranch	Captures all upstream uses before Jack Creek enters the Madison River, and below wetland and riparian restoration project.

Instantaneous discharge (flow) will be measured at each site on each visit, if conditions allow for the safe measurement. TruTrack capacitance rods that measure hourly water height (mm), water temperature (C), and air temperature (C), will be deployed at: SM-WEIR, SM-EDC, SM-HWY, MC-STATE, MC-MCR, MC-BRK, NM-FSCG, and JC-JCR. Additionally, permanently mounted stream gaging stations at JC-SSR and JC-CY measure continuous water height, water and air temperature, and continuous specific conductivity. Discharge measurements at these sites will be paired with stage data to develop rating curves that produce daily streamflow values.

Measurement of field parameters is a basic operating procedure when other water quality data is collected and will provide context for interpreting basic stream conditions and other data. Samples collected for nutrients will be handled according to SOPs and shipped to the DEQ contracted laboratory (Energy Laboratories) for analysis. Nutrient concentration data will be compared to MT DEQ nutrient standards. Nutrient data will also be supplemented by photographing rocks collected during the growing season for a qualitative assessment of algae/chlorophyll presence. Additionally, bottles will be filled at each site for analysis with a Hach 2100Q Portable Turbidimeter in order to assist in locating possible sources of sediment into each stream.

Project Team Responsibilities

The project manager will be the Conservation Programs Manager, Ethan Kunard. Responsibilities of the project manager include pre-season meeting, volunteer coordination, storage/maintenance of equipment, data management, data analysis, report composition, and reporting to project partners. The project manager will also join the volunteers on each site visit to ensure monitoring protocols are followed properly and to capture photo and video of the volunteer efforts. The project administration will be completed by the Madison Conservation District, which will include the accounting and financial management of the project. The project team responsibilities are provided in Table 5.

Table 5: Project team members and responsibilities

Name/Title	Project Responsibilities	Contact information
Ethan Kunard, Program Manager and Brieana Shook, Big Sky Watershed Corps Member	Data Collection, coordination of educational events, equipment maintenance, volunteer recruitment and training, data analysis and reporting.	PO Box 606 Ennis, MT 59729 406.682.7289; ethan@madisoncd.org

Name/Title	Project Responsibilities	Contact information
Emily Osborn; Madison Conservation District Administrator	Financial Management	PO Box 606 Ennis, MT 59729 406.682.7289; emily@madisoncd.org
Adam Sigler; MSUEWQ Water Quality Specialist	Technical assistance as needed for equipment and data.	Sigler Lab, MSU, PO Box 173120, Bozeman, MT, 59717-3120 406.994.7381; asigler@montana.edu

Sampling Methods

Sampling will be conducted according to the standard operating procedures (SOP) outlined in the Madison Stream Team 2019 SOP. A Site Visit Form will be completed for each site visit and will include all field data collected and an inventory of samples collected for analysis at the DEQ contracted laboratory. Site locations will be corroborated using this document and/or a GPS and the method will be specified on the site visit form. The GPS coordinate system datum will be NAD 1983 State Plane Montana, in decimal degrees to at least the fourth decimal. Photographs will be taken using a digital camera at each site to verify site location, and document site conditions.

Field methods

Field parameter data will be collected with an YSI 556 meter, and turbidity samples will be analyzed with a Hach 2100Q Portable Turbidimeter. The meters will be calibrated according to manufacturer instructions on the same day prior to sampling, and calibration logs will be kept for each meter.

Table 6: Field instruments and performance characteristics.

Parameter	Meter	Measurement Range	Resolution	Accuracy
Temperature	YSI 556	-5 to 45° C	0.01° C	±0.15° C
pH	YSI 556	0.0 to 14.00 units	0.01 units	±0.2 units
SC	YSI 556	0 to 200 mS/cm	0.001 mS/cm to 0.1 mS/cm	±0.5% of reading or 0.001 mS/cm
DO	YSI 556	0 to 50 mg/L	0.01 mg/L	±2% of the reading or 0.2 mg/L
Turbidity	Hach 2100Q	0-1000 NTU	.01 NTU	±2% of the reading

Flow (Discharge) Measurement

Stream discharge data will be collected at all water quality monitoring sites using the Marsh-McBirney Model 2000 Flo-Mate. The Flo-mate is a portable flow meter that uses an electromagnetic sensor to measure velocity. As conditions allow, TruTrack capacitance rods will be installed from April to October and programmed to record hourly water height (mm), water temperature (C), and air temperature (C). Upon each subsequent site visit, data will be downloaded to a laptop computer equipped with Omnilog Software and saved as a Microsoft Excel file with site name, date, and time of download. Measured flow and recorded height will be used to create a stage/discharge relationship for each year data is collected. As suggested by DEQ staff, stage data for periods with air temperatures below freezing will be evaluated and data may be qualified based on observations that stage data accuracy decreases within this temperature range.

Photo Point Monitoring

The conditions of each site will be documented by capturing photos in a repeatable format. Photo points are taken from the same position and oriented in the same direction with the same vertical angle. This

is done with a goal of recreating the same frame within the picture so that minor and major changes in riparian condition can be documented. Camera operators must take extra precaution when taking photo points to ensure they are in the correct location and orientation, and to record the necessary photograph metadata.

Upon arrival a monitoring site, samplers will refer to the Photo Point Instruction Guide for that site. This will provide instructions on the specific photo points that are to be taken, including helpful notes and reference photographs that can be used to ensure photo uniformity from visit to visit.

Water Sample Collection and Handling for Laboratory Analysis

Grab samples will be collected for delivery to the DEQ contracted lab for chemistry analysis using acid washed, polyethylene bottles provided by the testing laboratory. Table 7 details the analytical methods and handling procedures for each parameter. Table 2 lists parameters to be analyzed by stream, and a detailed parameter list for each stream is included in the SOP.

Bottles shall be rinsed three times with stream water prior to sampling. Samples will be collected in a well-mixed portion of each stream. During sampling, the sample bottle opening should face upstream and should be drawn through the water column once, carefully avoiding disturbance of bottom sediments. Samples will be preserved in the field and stored on ice until shipment to the lab.

Table 7: Lab parameter analytical methods, reporting limits, hold times, and preservatives.

Parameter	Preferred Method	Alternate Method	Req. Report Limit mg/L	Holding Time Days	Bottle	Preservative	Lid Color
Total Persulfate Nitrogen (TPN)	A 4500-N C	A4500-N B	0.04	28	250 ml HDPE	NA	White
Nitrate-Nitrite as N	EPA 353.2	A4500-NO3 F	0.01	28	250 ml HDPE	H_2SO_4, ≤6°C	Yellow
Total Phosphorus as P	EPA 365.1	A4500-P F	0.003	28	250 ml HDPE	H_2SO_4, ≤6°C	Yellow

One set of field blanks will be prepared during each of the three sampling events for each parameter that is being analyzed by the lab. Two sets of duplicates will be prepared during each sampling event (6 total throughout the season) to total 10% of all samples collected from July through September) The location and visit for QC sampling is indicated in the parameter tables in the SOPs. Field blanks will be prepared by volunteers or Madison Conservation District staff and labeled according to the labeling methods. A duplicate sample is a second stream sample collected at the same time in the same way that the regular stream sample is collected. Duplicate and blank samples are labeled according to the labeling protocol below which does not identify which sample is which to the lab. Blank and duplicate samples are handled and delivered to the lab in the same manner that regular samples are handled.

Sample labels should be filled out with the date, time, and sample ID. The sample ID is very important and includes the year, the month, the day, the site ID and a letter indicating they type of sample (regular, blank or duplicate).

Sample ID = YearMonthDay-SiteID-Parameter ID-Sample Type Letter

- Sample Type Letter

  R = Regular sample

  D = Duplicate sample

  B = Blank sample

Sample ID Examples:

A **regular sample** collected at the Moore Creek Bricker site on August 15th, 2014 for Total Persulfate Nitrogen would be labeled:

- 20190815-MCBRK -R

A **duplicate** at the same place and time as above:

- 20190815-MCBRK- D

A **blank** at the same place and time as above:

- 20190815-MCBRK- B

Immediately following grab-sample collection, samples will be put on ice. The MT DEQ contract analytical lab chain of custody forms will be used to document and track all samples collected during the project. Chain of custody forms will be completed for each set of samples submitted to the laboratory.

Quality Assurance and Quality Control Requirements

For water quality data to be useful, it needs to be an accurate representation of conditions in the water body at the time the samples were collected. This requires proper sample handling and processing and then assessment of data to ensure quality. Data quality objectives (DQOs) state the required quality of data for the intended use and data quality indicators (DQIs) are the specific criteria that data are assessed by to determine quality. Definitions and a list of DQIs are included in the glossary. These indicators are assessed by collecting quality control (QC) samples and then performing quality assurance (QA) checks on those samples.

QC samples are blank, duplicate and spike samples collected or created in the lab and/or the field for evaluation of quality indicators. Once the lab results are returned for the QC samples, QA is the process of assessing the data through use of indicators to determine data quality.

Data Quality Objectives

Efforts have been made to produce a spatially representative dataset by selecting at least three monitoring sites on each stream over the length of the waterbody. See Table 4 for a description of the rational for site selection. Efforts will be made to collect streamflow in June to produce high flow data, but the monitoring schedule is constrained by the availability of the volunteers and safety of conditions. The bulk of monitoring will occur from July through September.

Provisions are in place to ensure sensitivity of data collected to differences in stream water quality and comparability of data collected to other datasets. These provisions include the collection of grab samples and field QC for submission to a certified laboratory and assessment of QC data relative to data quality indicators. Data that does not meet quality criteria will be qualified appropriately in the annual report and during the MT EQUIS submission process.

To ensure the highest degree of data completeness possible, the team leaders will fill out datasheets and review them before leaving a site. Ethan Kunard and/or Brieana Shook will review datasheets for completeness and will follow-up with volunteers if fields are not completed. Volunteers and/or staff are expected to complete scheduled events as long as no complications arise from possible weather, access, and volunteer availability challenges.

Data Quality Indicators

Quality assurance and quality control (QAQC) can be broken down into a field and a laboratory component. The field component consists of collection of blank and duplicate samples and comparison of data to criteria. The laboratory component consists of assessment of data for blanks as well as a variety of duplicate and spiked samples analyzed by the lab. Blank samples should ideally yield results indicating "no detection" of the analyte in question. Duplicate samples should ideally produce identical results and analysis of spiked samples should recover exactly the amount of analyte added. Methods are not perfect however, so the criteria outlined in the following two sections are used to assess if data is of acceptable quality.

Quality Assurance for Field Quality Control Samples

In 2019, QC samples will be collected for 10% of all samples collected on a stream. Each set of field QC samples will include a blank and a duplicate for each analyte being sampled for. Accuracy for field QC samples will be assessed by ensuring that blank samples return values less than the data quality indicator criteria specified in Table 8. If a blank sample returns a result greater than the threshold, all data for that parameter from that batch of samples may need to be qualified. The exception is that data with a value greater than 10 times the detected value in the blank does not need to be qualified. Precision for field QC samples will be assessed by ensuring that relative percent difference (RPD) between duplicates is less than 25%. RPD is calculated using the equation below. In addition to these accuracy/precision checks, it will be necessary to check that all samples were processed within their specified hold times.

RPD as % = ((D1 – D2)/((D1 + D2)/2)) x 100

Where: D1 is regular sample result, D2 is duplicate sample result

Table 8: Data quality indicator criteria for field QC samples.

Parameter	Field Blank Threshold mg/L	Field Duplicate RPD
Total Persulfate Nitrogen	0.04	< 25% RPD
Nitrate-Nitrite as N	0.01	< 25% RPD
Total Phosphorus as P	0.003	< 25% RPD

Quality Assurance for Lab Quality Control Samples

Certified laboratories run QC samples for at least 10% of their sample volume. Integrity of laboratory data will be determined by comparing results for laboratory QC samples to the data quality indicator criteria in Table 9. Reports with lab QC results and data quality indicator calculations should be provided by the lab with each set of sample results. Each of the quality indicator criteria in Table 9 must be checked for each analyte for each batch of samples submitted to the lab. This process is easier if a matrix is used to systematically check the numbers. An example of a completed matrix is provided on page24 of this document.

Table 9: Data quality indicator criteria for lab QC samples.

Parameter	Method	Method Blanks mg/L	Lab Duplicates (RPD)	Lab Control LCS/LFB (percent recovery)	Matrix Spike/ Matrix Spike Dup (percent recovery)
Total Persulfate Nitrogen	A4500-N C or A4500-N B	0.04	< 10% RPD	90%-110%	90%-110%
Nitrate-Nitrite as N	A353.2 or A4500-NO3 F	0.01	< 10% RPD	90%-110%	90%-110%
Total Phosphorus as P	EPA 365.1 or 4500-P F	0.003	< 10% RPD	90%-110%	90%-110%

Qualifying Data that fails data quality criteria

If any of the data quality objectives for field or laboratory QC samples fail the criteria above, all data for that analyte for that sample batch must be qualified accordingly. Note that a blank which exceeds the threshold does not automatically mean all data for that sample batch must be qualified. Sample results with values greater than 10 times the detected value in the blank do not need to be qualified. A narrative in the annual sampling report should outline what data was qualified and for what reason. The data will also need to be qualified during the process of uploading to MT EQUIS using the appropriate qualifier codes. A list of data qualifier codes is provided in the back of this document.

Training

A volunteer training day for 2019 is planned for early June. The classroom portion will cover watershed and water quality basics and a review of results from 2018. The classroom portion will also include information on aquatic invasive species and methods volunteers can adopt to reduce the risk of transport of these species during field work.

During the field portion of the training, volunteers will learn proper use of the YSI meter and GPS unit, measurement of discharge using the Marsh-McBirney FloMeter, collection of rocks to photograph for nuisance algae assessment, photo documentation, collection of water quality samples for submission to a lab, collection of turbidity samples, and completion of field visit sheets.

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. If for any reason field staff collecting a sample feel conditions are unsafe—e.g., high or swift waters, weather conditions, ice conditions, etc.—they are not to collect the sample(s). Modifications to the approved plan will be documented.

Field Health And Safety Procedures

Data Analysis, Record Keeping & Reporting Requirements

Copies of laboratory analytical reports and electronic data deliverable spreadsheets will be provided by the DEQ contracted analytical lab to both the Project Manager and to DEQ. Analytical laboratories shall

prepare and analyze the samples in accordance with the chain-of-custody forms and the methods requested in Table 9. These standard operating procedures (SOPs) must be controlled under a Laboratory Quality Assurance Program (LQAP) with sufficient rigor. Results from laboratory QC samples are submitted with the laboratory data report.

The Project Manager and Project Assistant will review the laboratory data to ensure lab results are within reporting limits (including the laboratory QA/QC samples) prior to data entry into MT EQUIS. A review of field and analytical data will be conducted following receipt of the laboratory data package that includes all items on the QC Checklist on page 18. Data qualifiers provided on page 23 will be assigned to data in both hardcopy and electronic form that does not meet these target quality control criteria. A brief synopsis of any SAP methodology derivations that occurred will also be drafted.

Data generated during this project will be stored on field forms and in laboratory reports obtained from the laboratories. Electronic copies of field photographs will also be taken. Site Visit and Chain of Custody forms will be properly completed for all samples. Written field notes, field forms, and digital photos will be processed by field staff following QA/QC procedures to screen for data entry errors. Data from all sampling events will be entered into the Montana Water Quality Exchange (EQUIS) database. Records of miles driven per volunteer monitor or monitoring crew will be kept to reimburse volunteers. Records of number of hours worked by volunteer monitoring crews will also be tracked for purposes of budget tracking.

Data (temperature, turbidity, dissolved oxygen, specific conductivity, pH, Nitrate+Nitrite, Total Nitrogen, Total Phosphorus) will be summarized in graphs to facilitate easy comparison to applicable (aquatic life) standards presented in Circular DEQ-7, ARM 17.30.623 and MT DEQ nutrient criteria (Circular DEQ-12A). This information will be used to develop an annual report that will be stored on the Madison Conservation District's website. Additionally, data collected during the 2019 season will be uploaded to the Montana State University Extension Water Quality Data Hub. Here, the information will be publicly available in a user-friendly format where members of the public can access data on streams in the Madison dating back to 2012.

References

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URL confirmed: 5/10/2011

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URL confirmed: 4/27/2015

Madison Stream Team Nutrient and Field Sampling Sites

Figure 1: Map of Madison Stream Team nutrient and field sampling sites

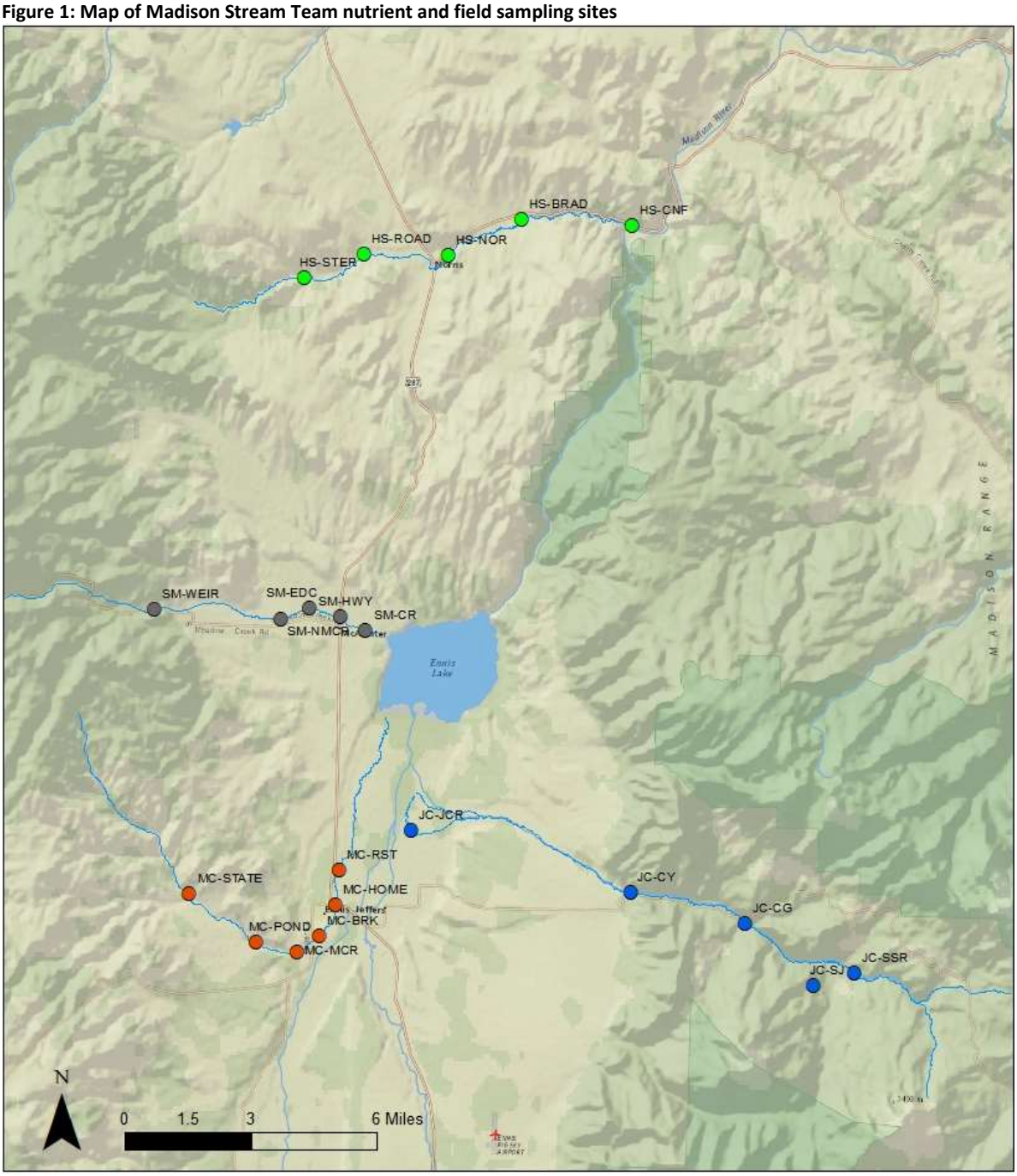
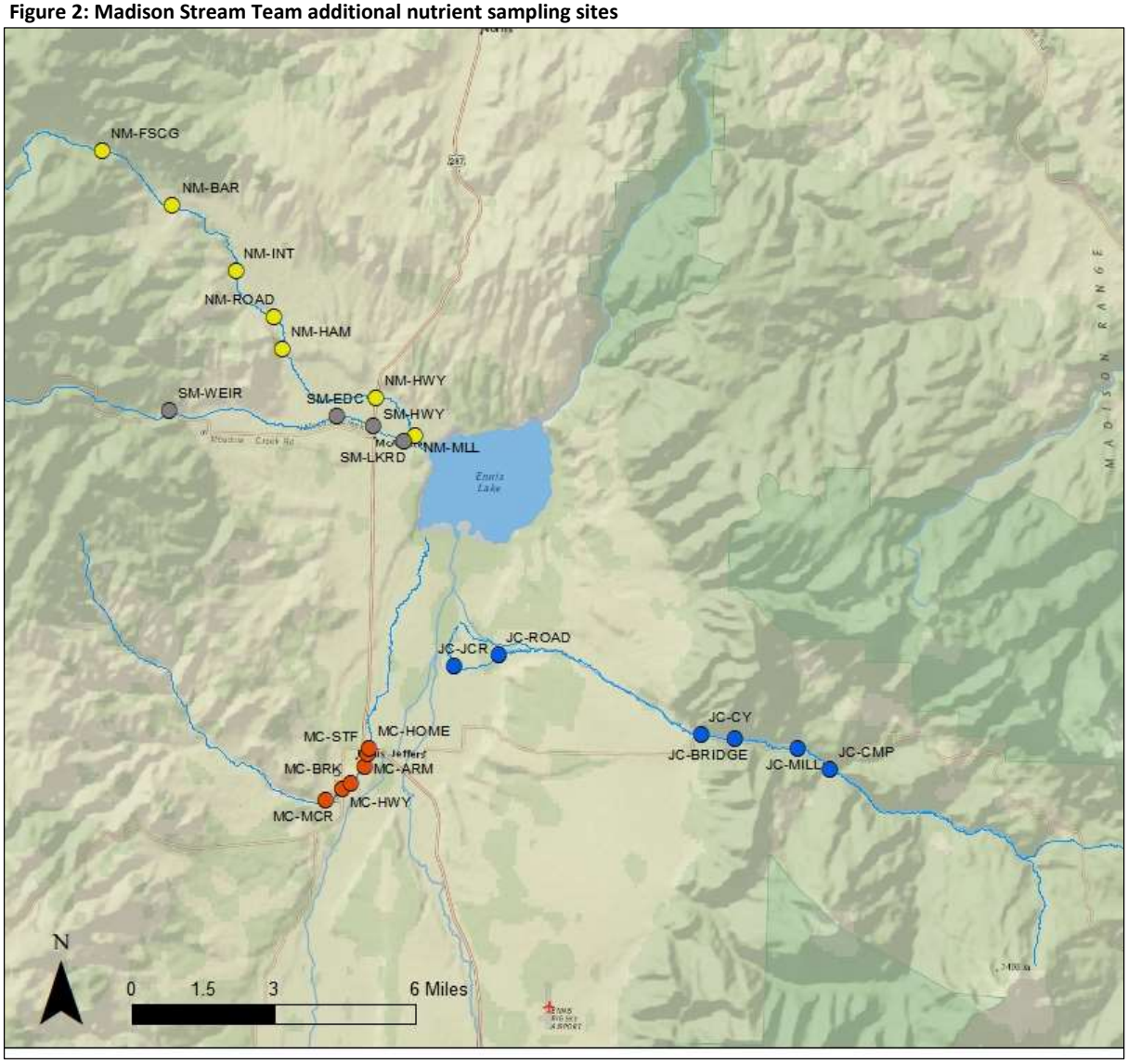


Figure 2: Madison Stream Team additional nutrient sampling sites



Quality Control Checklist

___Condition of samples upon receipt
___Cooler/sample temperature
___Proper collection containers
___All containers intact
___Sample pH of acidified samples <2
___All field documentation complete. If incomplete areas cannot be completed, document the issue.
___Holding times met
___Field duplicates collected at the proper frequency (specified in SAP)
___Field blanks collected at the proper frequency (specified in SAP)

___All sample IDs match those provided in the SAP. Field duplicates are clearly marked on samples and noted as such in lab results.
___Analyses carried out as described within the SAP (e.g. analytical methods, photo documentation, field protocols)
___Reporting detection limit met the project-required detection limit
___All blanks were less than the project-required detection limit
___If any blanks exceeded the project-required detection limit, associated data is flagged
___Laboratory blanks/duplicates/matrix spikes/lab control samples were analyzed at a minimum 10% frequency
___Laboratory blanks/duplicates/matrix spikes/lab control samples were all within the required control limits defined within the SAP
___Project DQOs and DQIs were met (as described in SAP)
___Summary of results of QC analysis, issues encountered, and how issues were addressed (corrective action)
___Completed QC checklist before MT-EQUIS upload

QA/QC Terms

Accuracy. A data quality indicator, accuracy is the extent of agreement between an observed value (sampling result) and the accepted, or true, value of the parameter being measured. High accuracy can be defined as a combination of high precision and low bias.

Analyte. Within a medium, such as water, an analyte is a property or substance to be measured. Examples of analytes would include pH, dissolved oxygen, bacteria, and heavy metals.

Bias. Often used as a data quality indicator, bias is the degree of systematic error present in the assessment or analysis process. When bias is present, the sampling result value will differ from the accepted, or true, value of the parameter being assessed.

Blind sample. A type of sample used for quality control purposes, a blind sample is a sample submitted to an analyst without their knowledge of its identity or composition. Blind samples are used to test the analyst's or laboratory's expertise in performing the sample analysis.

Comparability. A data quality indicator, comparability is the degree to which different methods, data sets, and/or decisions agree or are similar.

Completeness. A data quality indicator that is generally expressed as a percentage, completeness is the amount of valid data obtained compared to the amount of data planned.

Data users. The group(s) that will be applying the data results for some purpose. Data users can include the monitors themselves as well as government agencies, schools, universities, businesses, watershed organizations, and community groups.

Data quality indicators (DQIs). DQIs are attributes of samples that allow for assessment of data quality. These include precision, accuracy, bias, sensitivity, comparability, representativeness and completeness.

Data quality objectives (DQOs). Data quality objectives are quantitative and qualitative statements describing the degree of the data's acceptability or utility to the data user(s). They include data quality indicators (DQIs) such as accuracy, precision, representativeness, comparability, and completeness. DQOs specify the quality of the data needed in order to meet the monitoring project's goals. The planning process for ensuring environmental data are of the type, quality, and quantity needed for decision making is called the ***DQO process*****.**

Detection limit. Applied to both methods and equipment, detection limits are the lowest concentration of a target analyte that a given method or piece of equipment can reliably ascertain and report as greater than zero.

Duplicate sample. Used for quality control purposes, duplicate samples are an additional sample taken at the same time from, and representative of, the same site that are carried through all assessment and analytical procedures in an identical manner. Duplicate samples are used to measure natural variability as well as the precision of a method, monitor, and/or analyst. More than two duplicate samples are referred to as *replicate samples*.

Environmental sample. An environmental sample is a specimen of any material collected from an environmental source, such as water or macroinvertebrates collected from a stream, lake, or estuary.

Field blank. Used for quality control purposes, a field blank is a "clean" sample (e.g., distilled water) that is otherwise treated the same as other samples taken from the field. Field blanks are submitted to the analyst along with all other samples and are used to detect any contaminants that may be introduced during sample collection, storage, analysis, and transport.

Instrument detection limit. The instrument detection limit is the lowest concentration of a given substance or analyte that can be reliably detected by analytical equipment or instruments (see *detection limit*).

Matrix. A matrix is a specific type of medium, such as surface water or sediment, in which the analyte of interest may be contained.

Measurement Range. The measurement range is the extent of reliable readings of an instrument or measuring device, as specified by the manufacturer.

Method detection limit (MDL). The MDL is the lowest concentration of a given substance or analyte that can be reliably detected by an analytical procedure (see *detection limit*).

Precision. A data quality indicator, precision measures the level of agreement or variability among a set of repeated measurements, obtained under similar conditions. Relative percent difference (RPD) is an example of a way to calculate precision by looking at the difference between results for two duplicate samples.

Protocols. Protocols are detailed, written, standardized procedures for field and/or laboratory operations.

Quality assurance (QA). QA is the process of ensuring quality in data collection including: developing a plan, using established procedures, documenting field activities,

implementing planned activities, assessing and improving the data collection process and assessing data quality by evaluating field and lab quality control (QC) samples.

Quality assurance project plan (QAPP). A QAPP is a formal written document describing the detailed *quality control* procedures that will be used to achieve a specific project's data quality requirements. This is an overarching document that might cover a number of smaller projects a group is working on. A QAPP may have a number of sample analysis plans (SAPs) that operate underneath it.

Quality control (QC). QC samples are the blank, duplicate and spike samples that are collected in the field and/or created in the lab for analysis to ensure the integrity of samples and the quality of the data produced by the lab.

Relative percent difference (RPD). RPD is an alternative to *standard deviation*, expressed as a percentage and used to determine precision when only two measurement values are available. Calculated with the following formula:
RPD as % = ((D1 – D2)/((D1 + D2)/2)) x 100

Where:
D1 is first replicate result
D2 is second replicate result

Replicate samples. See duplicate samples.

Representativeness. A data quality indicator, representativeness is the degree to which data accurately and precisely portray the actual or true environmental condition measured.

Sample analysis plan (SAP). A SAP is a document outlining objectives, data collection schedule, methods and data quality assurance measures for a project.

Sensitivity. Related to *detection limits*, sensitivity refers to the capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest. The more sensitive a method is, the better able it is to detect lower concentrations of a variable.

Spiked samples. Used for quality control purposes, a spiked sample is a sample to which a known concentration of the target analyte has been added. When analyzed, the difference between an environmental sample and the analyte's concentration in a spiked sample should be equivalent to the amount added to the spiked sample.

Standard operating procedures (SOPs). An SOP is a written document detailing the prescribed and established methods used for performing project operations, analyses, or actions.

Data qualifiers and descriptions

Result Qualifier	Result Qualifier Description
B	Detection in field and/or trip blank
D	Reporting limit (RL) increased due to sample matrix interference (sample dilution)
H	EPA Holding Time Exceeded
J	Estimated: The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample.
R	Rejected: The sample results are unusable due to the quality of the data generated because certain criteria were not met. The analyte may or may not be present in the sample.
U	Not Detected: The analyte was analyzed for, but was not detected at a level greater than or equal to the level of the adjusted Contract Required Quantitation Limit (CRQL) for sample and method.
UJ	Not Detected/Estimated: The analyte was not detected at a level greater than or equal to the adjusted CRQL or the reported adjusted CRQL is approximate and may be inaccurate or imprecise.

Example QAQC matrix

Below is an example of a matrix for use in addressing whether all data quality criteria are met for each analyte for each batch of samples. This table can be created using the thresholds from tables 7 and 8 in this SAP. QC numbers from the lab and calculated from the field are filled in, and compared to thresholds to perform QC checks.

2011-10-25-SMC-LKRD-A,B,C

DQ Indicator	Arsenic		Cadmium		Calcium		Copper		Iron		Lead		Magnesium	
Criteria	Criteria	Value	Criteria	Value	Criteria	Value	Criteria	Value	Criteria	Value	Criteria	Value	Criteria	Value
Method	EPA 200.8	✓	EPA 200.8	✓	EPA 200.7	✓	EPA 200.8	✓	EPA 200.7	✓	EPA 200.8	✓	EPA 200.7	✓
Method Blank	3 µg/L	ND, ND	0.08 µg/L	ND, ND	1000 µg/L	ND, ND	1 µg/L	ND, ND	50 µg/L	ND, 0.7	0.5 µg/L	ND, ND	1000 µg/L	ND, ND
Lab Duplicates (RPD)	< 10% RPD	105, 150	< 10% RPD	150, 1.52	< 10% RPD	0.71, 2.3	< 10% RPD	15, 1.4	< 10% RPD	3.4, 3.8	< 10% RPD	0.9, 0	< 10% RPD	0.7, 2.32
Lab Control LCS/LFB (% rec)	85% - 115%	103/96	85% - 115%	103/96	85% - 115%	104/91	85% - 115%	103/94	85% - 115%	103/90	85% - 115%	104/98	85% - 115%	99/88
Matrix Spike/Matrix Spike Dup (% rec)	70% - 130%	93/99 110/113	70% - 130%	88/90 93/92	70% - 130%	104/104 114/105	70% - 130%	104/100 100/99	70% - 130%	-/- 94/97	70% - 130%	106/106 97/97	70% - 130%	101/100 97/96
Field Blank Threshold	3 µg/L	ND	0.08 µg/L	ND	1000 µg/L	ND	1 µg/L	ND	50 µg/L	ND	0.5 µg/L	ND	1000 µg/L	ND
Field Blank Dup	< 25% RPD	ND ND	< 25% RPD	ND	< 25% RPD	4.35	< 25% RPD	(200)	< 25% RPD	5.13	< 25% RPD	ND	< 25% RPD	0

	Zinc		Hardness as CaCO3		TSS		Total persulfate N		Nitrate-Nitrite as N		Total Phosphorus	
	Criteria	Value	Criteria	Value	Criteria	Value	Criteria	Value	Criteria	Value	Criteria	Value
Method	EPA 200.7	✓	A2340 B		EPA 160.2		A4500-N C or A4500-N B		EPA 200.8		EPA 200.7	
Method Blank	10 µg/L	10, 0.3	See Ca & Mg		4000 mg/L		50 µg/L		0.5 mg/L		1000 µg/L	
Lab Duplicates (RPD)	< 10% RPD	103/94	< 10% RPD		< 10% RPD		< 10% RPD		< 10% RPD		< 10% RPD	
Lab Control LCS/LFB (% rec)	85% - 115%	107/107	See Ca & Mg		70% - 130%		85% - 115%		85% - 115%		85% - 115%	
Matrix Spike/Matrix Spike Dup (% rec)	70% - 130%	103/103 103/100	See Ca & Mg		-		70% - 130%		70% - 130%		70% - 130%	
Field Blank Threshold	10 µg/L	ND	See Ca & Mg		4000 mg/L		50 µg/L		0.5 mg/L		1000 µg/L	
Field Duplicates RPD	< 25% RPD	ND	< 25% RPD		< 25% RPD		< 25% RPD		< 25% RPD		< 25% RPD	

Summary of Lab Analysis Costs and Sampling Schedule

Parameter	Price per Parameter	Number of Sites	Number of visits per site	Number of routine samples (number of sites x number of visits per site)	Number of field blanks (often one per sampling event)	Number of field duplicates (often ~10% of the total number of routine samples)	Total number of samples (routine + duplicates + blanks)	Total Cost (Total number of samples x cost per parameter)
Total Persulfate Nitrogen (TPN)	$15	19	3	57	3	6	66	$990
Total Phosphorus as P	$10	19	3	57	3	6	66	$660
Nitrate-Nitrite as N	$8	19	3	57	3	6	66	$528
Shipping	$12						3	$36

Nutrient Sampling Schedule				
Stream	**Site ID**	**July**	**August**	**September**
South Meadow	SM-WEIR	TN, N+N, TP	TN, N+N, TP, Field Blank & Duplicate	TN, N+N, TP
	SM-NMCR	TN, N+N, TP	TN, N+N, TP, Duplicate	TN, N+N, TP
	SM-EDC	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
	SM-HWY	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
	SM-CR	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
Moores Creek	MC-STATE	TN, N+N, TP, Field Blank & Duplicate	TN, N+N, TP	TN, N+N, TP
	MC-POND	TN, N+N, TP, Duplicate	TN, N+N, TP	TN, N+N, TP
	MC-MCR	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
	MC-BRK	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
	MC-HOME	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
	MC-RST	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
Hot Springs Creek	HS-STER	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
	HS-ROAD	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
	HS-NOR	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
	HS-BRAD	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
	HS-CNF	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP
Jack Creek	JC-SSR	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP, Field Blank & Duplicate
	JC-SJ	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP, Duplicate
	JC-JCR	TN, N+N, TP	TN, N+N, TP	TN, N+N, TP