Gallatin River Task Force
Community Water Quality Monitoring Program
Sampling Analysis Plan

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1.0 INTRODUCTION

The Gallatin River Task Force (Task Force) Community Water Quality Monitoring Program (CWQMP), which involves routine monitoring of water quality in the Upper Gallatin Watershed (**Figure 1**) by volunteers, has been in existence since 2000. This program was created to collect a baseline water quality data set to compare to any change in water quality if the Big Sky Water and Sewer District (BSWSD) were to discharge wastewater effluent directly into the Gallatin River.

To date, the BSWSD has let the aforementioned discharge permit expire and does not have any plans to reapply in the near future. For this reason and to address current water quality conditions/threats, the Task Force updated the objectives and design of its CWQMP in the spring of 2015. The updated program is designed to assess water quality issues uncovered by the Upper Gallatin Total Maximum Daily Load (TMDL) assessments (wastewater, road traction sand/salt, and sediment) (Table 1) [MTDEQ, 2010] in the West Fork of the Gallatin ("West Fork") Watershed (**Figure 2**) and to monitor for the successes/failures of future restoration efforts.

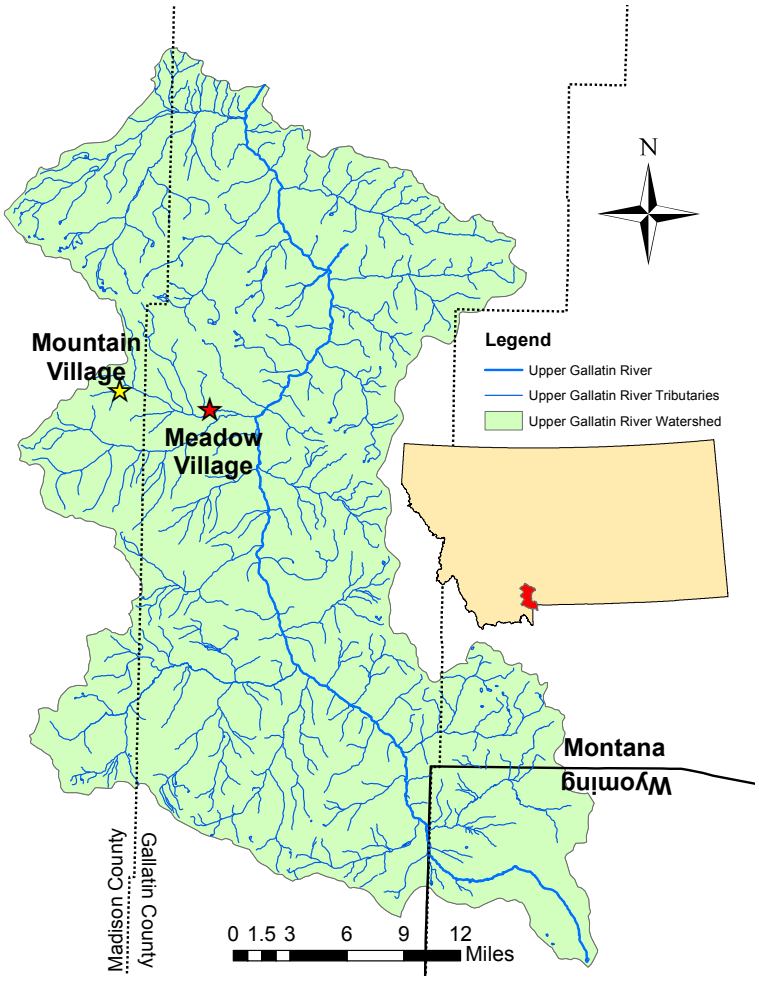

Figure 1: The Upper Gallatin River Watershed

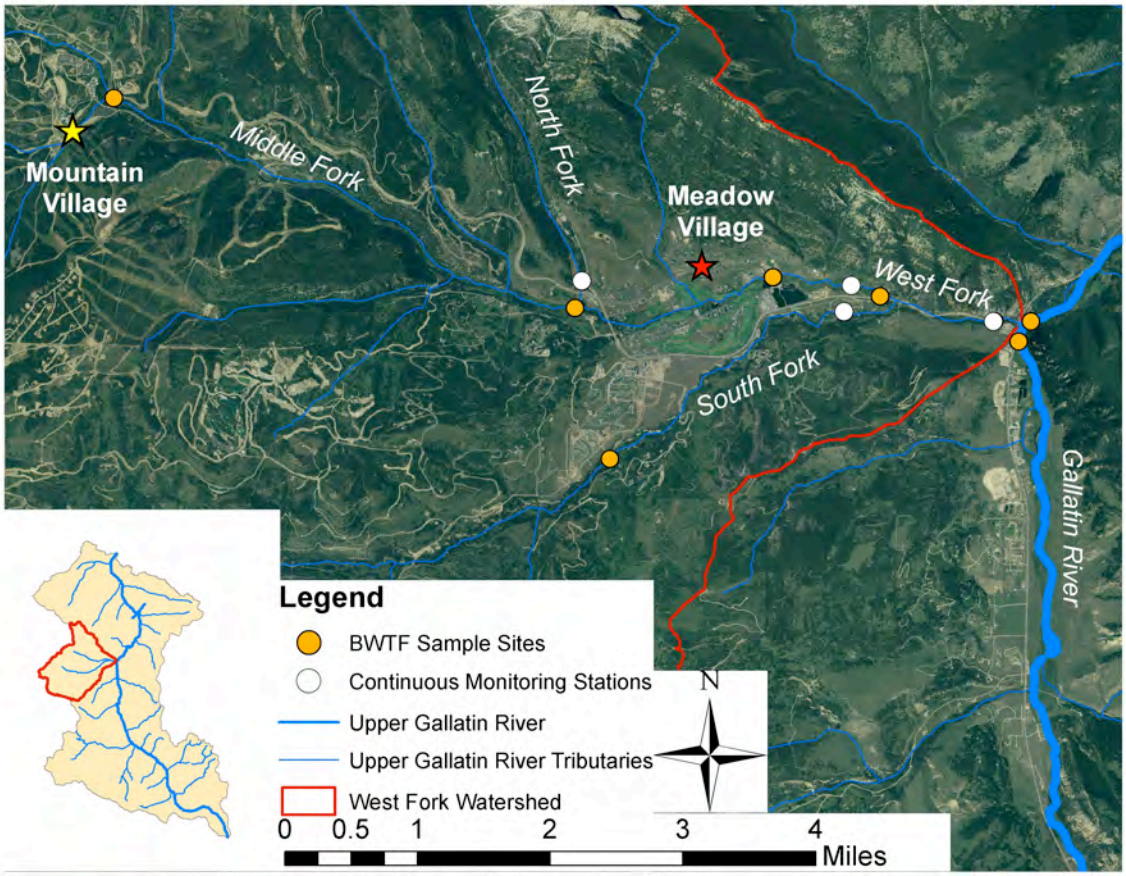

Figure 2: The West Fork of the Gallatin River Watershed and its major tributaries.

2.0 PROJECT OBJECTIVES

The goals of the Task Force CWQMP are:

1. To record baseline water quality and macroinvertebrates data on the Gallatin River to assess for trends and episodic events.
2. To assess the successes/failures of future restoration projects on streams with TMDLs in the Upper Gallatin Watershed (Table 1).
3. Determine if road salt and sand from winter maintenance activities has an impact on water quality of the Upper Gallatin River and its tributaries.

Table 1: Streams with TMDLs in the Upper Gallatin Watershed [MTDEQ, 2010].

Waterbody	Waterbody ID	Pollutant	Impaired Uses
Middle Fork of the West Fork of the Gallatin River	MT41H005_050	Sediment Nitrate+Nitrite *E.coli*	Aquatic Life Cold WaterFishery Primary Contact Recreation
South Fork of the West Fork of the Gallatin River	MT41H005_060	Sediment Nitrate+Nitrite	Aquatic Life Cold Water Fishery Primary Contact Recreation
West Fork of the Gallatin River	MT41H005_040	Sediment Nitrate+Nitrite	Aquatic Life Cold Water Fishery, Primary Contact Recreation

3.0 SAMPLING DESIGN

3.1 Parameters and Timing

The following parameters are monitored at each site to address the goals listed in Section 2.0 (**Table** 2): water temperature, conductivity, turbidity, pH, chloride, total nitrogen, nitrate + nitrite, total phosphorus, total dissolved solids, sediment size, total coliform, *E.coli*, and dissolved oxygen. In addition, photo documentation of algae is conducted and macroinvertebrates samples are collected and sent to a lab for analysis.

Field sampling events will occur during four periods of the year to capture the distinct hydrologic (baseflow, pre-snowmelt, and snowmelt) (**Figure** 3) and biologic phases (growing and dormant seasons). The growing season in the Upper Gallatin is generally between June 15 through September 15th. The exact timing of the sampling events will depend on the timing of the hydrograph and can be generalized as summer baseflow (late July/August), winter baseflow (December/January), pre-snowmelt (late April/March), and snowmelt (mid-May/early July).

Table 2: Timing and purpose of the sampling for each parameter

Parameter	Sampling Occurrence	Sites	Goal Addressed (Section 2.0)
pH	Winter Baseflow (WB), Pre-Snowmelt (PS), Snowmelt (S), and Summer Baseflow (SB)	All	1, 2 & 3
Temperature	WB, PS, S, SB	All	1,
Dissolved Oxygen	WB, PS, S, SB	All	1,
Conductivity	WB, PS, S, SB	All	1 & 3
Turbidity	WB, PS, S, SB	All	1 & 3
Total Dissolved Solids	WB, PS, S, SB	All	1 & 3
Chloride Ion	WB, PS, S, SB	All	1, 2 & 3
Nitrate plus Nitrite	WB, PS, S, SB	All	1 & 2
Total Nitrogen	SB	All	1 & 2
Total Phosphorous	SB	All	1
E. coli/	WB, PS, S, SB	All	1 & 2

Total Coliform			
Macroinvertebrate	SB	Four rotating	1 & 2
Discharge	Six times varying streamflow	West, North, South, and Community	1, 2, & 3
Pebble Count	SB	All	1, 2, &3
Algae	SB	All	1 & 2

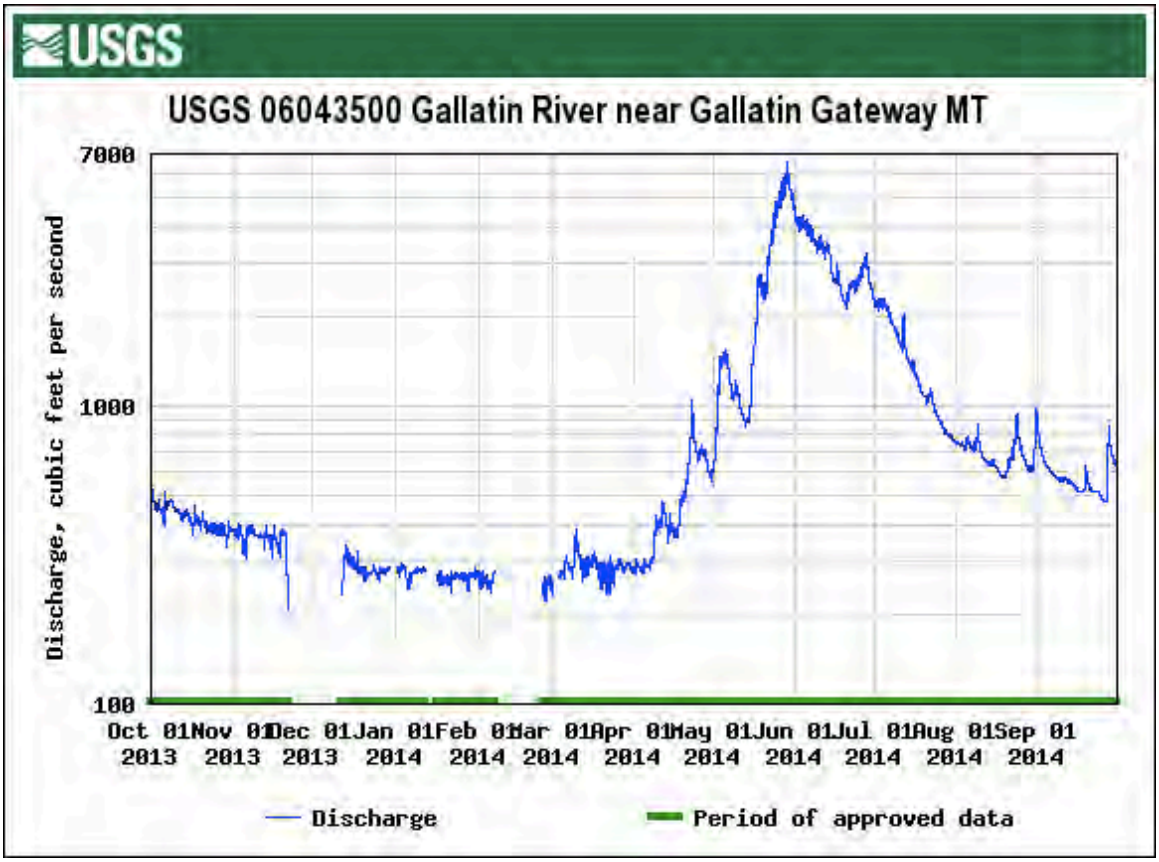

Figure 3: A typical hydrograph in the Upper Gallatin Watershed from the US Geological Survey (USGS) gage on the Gallatin River at Gallatin Gateway.

3.2 Study Design

Seven sites on the mainstem Gallatin River, one site on the Taylor Fork, and eight sites in the West Fork Watershed are monitored for water quality (**Figures** 4 and 5, **Tables** 3 and 4**).**

Table 3: Monitoring site ID's, names, location, and descriptions.

Site ID	Site Name	Latitude	Longitude	Description
TASK FORCE-GL-BH	Bighorn	44.921405	-111.202598	Gallatin River in Yellowstone National Park
TASK FORCE-GL-PR	Park	45.054390	-111.156101	Gallatin River at the Yellowstone National Park boundary

TASK FORCE-GL-TY	Taylor	45.078513	-111.206468	Gallatin River downstream from the Taylor Fork confluence
TASK FORCE-TF-TF	TF	44.921405	-111.036533	Taylor Fork upstream from the confluence with the Gallatin River
TASK FORCE-GL-BK	Bucks	45.201159	-111.238891	Gallatin River across from Bucks trailhead access road
TASK FORCE-GL-UP	Up	45.263678	-111.252998	Gallatin River above the confluence with the West Fork
TASK FORCE-GL-D1	Down 1	45.265900	-111.251200	Gallatin River downstream of the confluence with the West Fork
TASK FORCE-GL-D2	Down 2	45.277749	-111.229526	Gallatin River above Jack Smith bridge
TASK FORCE-WF-BR	West Fork	45.266000	-111.257000	West Fork above Highway 64 bridge
TASK FORCE-WF-CN	WF above SF	45.268273	-111.274582	West Fork above the confluence with the South Fork
TASK FORCE-WF-CP	Community	45.270062	-111.29110	West Fork at the Big Sky Community Park
TASK FORCE-SF-EH	South Fork	45.268273	-111.280076	South Fork above the confluence with the West Fork
TASK FORCE-SF-OU	Ousel	45.24187	-111.3349	South Fork on Ousel Falls trail above first bridge
TASK FORCE-MF-CN	Lower Middle	45.266273	-111.321682	Middle Fork above the confluence with the North Fork
TASK FORCE-MF-LL	Below Lake	45.287934	-111.393682	Middle Fork below Lake Levinsky
TASK FORCE-NF-LM	North Fork	45.269162	-111.320707	North Fork at Lone Mountain Ranch

Table 4: Sample site rationale

Site ID	Site Name	Sample Site Rationale
TASK FORCE-GL-BH	Bighorn	Reference site on mainstem Gallatin in Yellowstone National Park
TASK FORCE-GL-PR	Park	Site on the Gallatin upstream of any potential influence from housing/ranching developments but influenced by Highway 191.
TASK FORCE-GL-TY	Taylor	Site on the Gallatin downstream from the confluence with the Taylor Fork, which contributes fine sediment during storm events.
TASK FORCE-TF-TF	TF	The Taylor Fork site was recently added to assess fine sediment, turbidity, and nutrient concentrations.
TASK FORCE-GL-BK	Bucks	Site on the Gallatin upstream of high-density housing developments
TASK FORCE-GL-UP	Up	Site on the Gallatin above the confluence with the West Fork, which drains Big Sky Resort and associated development
TASK FORCE-GL-D1	Down 1	Site on the Gallatin downstream of the confluence with the West Fork, which drains Big Sky Resort and associated development
TASK FORCE-GL-D2	Down 2	Site on the Gallatin, 2.3 km downstream of the West Fork confluence, to assess for length of influence of the West Fork
TASK FORCE-WF-BR	West Fork	Site on the West Fork, which drains Big Sky Resort and associated development, and has TMDLs for nutrients, sediment, and E.coli.. This site assesses for changes after the South Fork confluence
TASK FORCE-WF-CN	WF above SF	This site assesses the West Fork after the river travels past the wastewater storage ponds and before influence by the South Fork
TASK FORCE-WF-CP	Community	This site on the West Fork assesses water quality after the river travels through the Big Sky Golf Course and before traveling past the wastewater storage ponds
TASK FORCE-SF-EH	South Fork	This site is at the mouth of the South Fork before it joins the West Fork. The South Fork has TMDLs for nutrients and sediment
TASK FORCE-SF-OU	Ousel	This site on the South Fork is located before it travels through high-density development in Meadow Village
TASK FORCE-MF-CN	Lower Middle	This site on the Middle Fork is above the confluence with the North Fork. The Middle Fork is listed for nutrients, sediment, and E.coli
TASK FORCE-MF-LL	Below Lake	This site on the Middle Fork is below Lake Levinsky after draining Lone Peak and associated development in Meadow Village
TASK FORCE-NF-LM	North Fork	This site on the North Fork is downstream of Lone Mountain Ranch before the creek joins the Middle Fork to form the West Fork

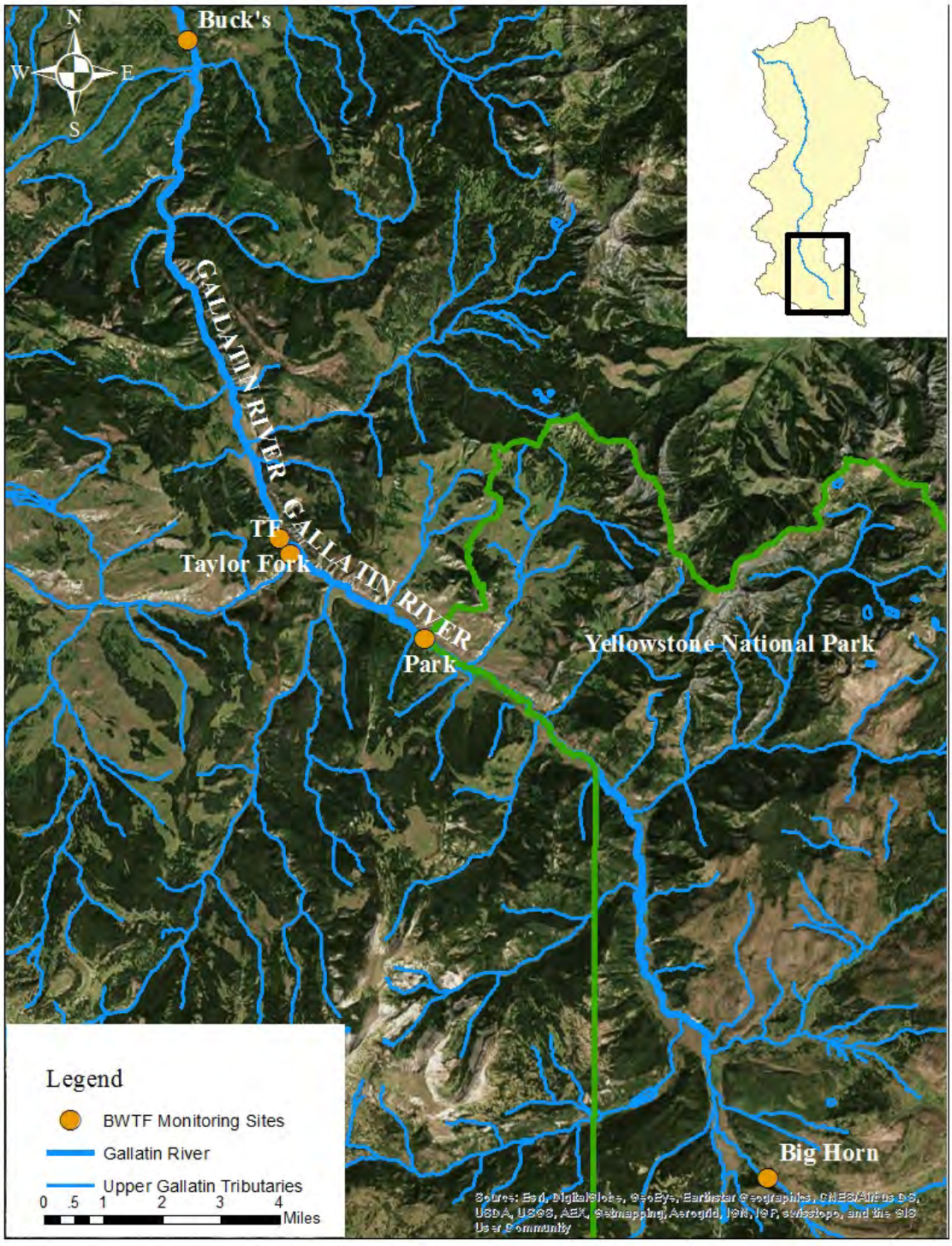

Figure 4: Monitoring sites in the Upper Gallatin mainstem upstream of the West Fork.

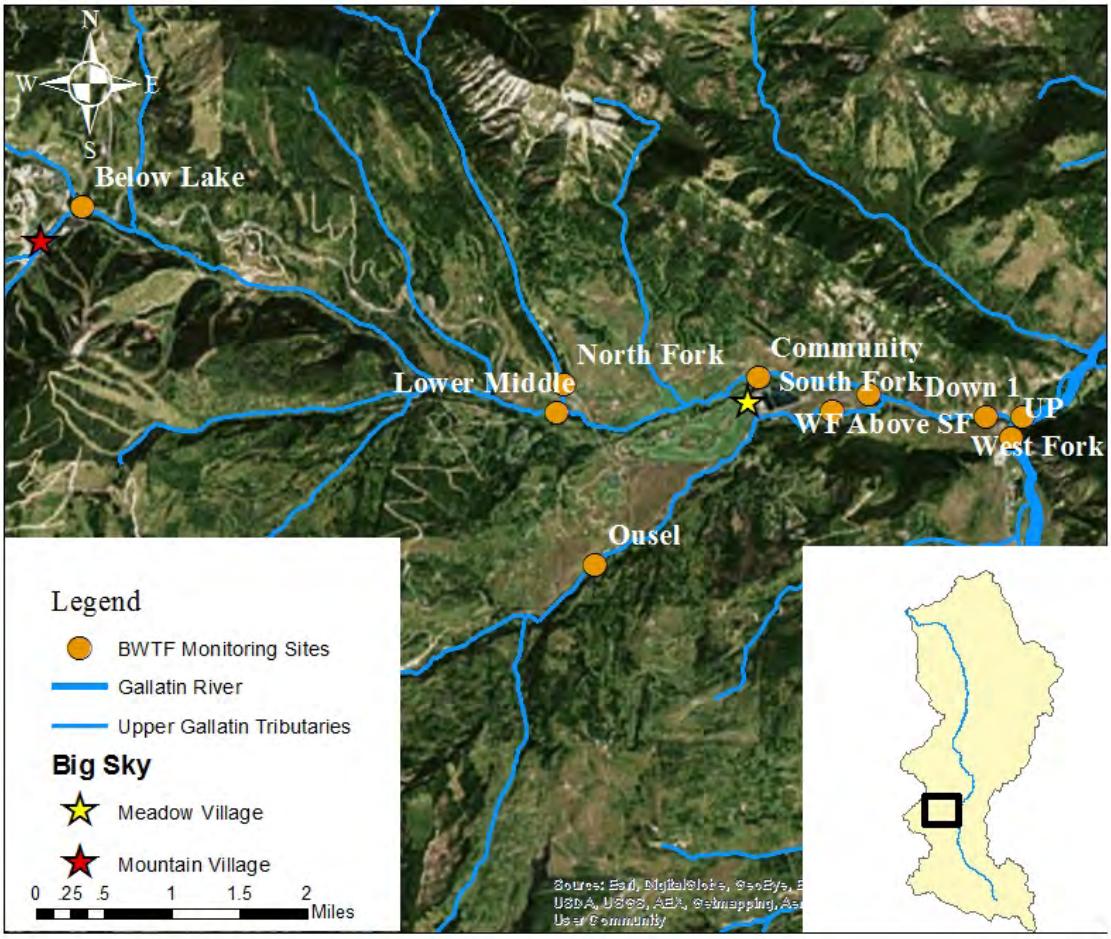

Figure 5: Monitoring sites in lower section of the Upper Gallatin and the West Fork Watershed.

3.3 Project Team

The project manager is Task Force Executive Director, Kristin Gardner. Responsibilities of the project manager will include scheduling events, volunteer generation and training, equipment maintenance and storage, report composition, coordinating educational events, data analysis, and managing fieldwork and laboratory analysis.

During each sampling event a "field leader" will be assigned. The field leader will be responsible for ensuring the following: 1) the safety of all volunteer monitors, 2) the proper use of all equipment, 3) that scheduled measurements are taken and, 4) that all quality assurance and quality control measures are followed. For most sampling events, the field leader will be the Task Force Executive Director, Kristin Gardner; however, in the event that Kristin is not present, a field leader will be chosen who has attended a Task Force training event and has demonstrated proficiency and knowledge of all required tasks. In this case, the field leader will be required to check out all field and laboratory equipment and required documentation with Kristin before the sampling event takes place and check in the equipment in after the monitoring/lab analyses are complete.

4.0 FIELD SAMPLING METHODS

Temperature, pH, dissolved oxygen, conductivity, total dissolved solids, turbidity, chloride, and nitrate will be measured in at all four events. Total nitrogen, algae, total phosphorous, and macroinvertebrate data will be collected during the summer baseflow event. Pebble counts be after runoff has occurred. Streamflow will be measured six times – once during each water quality sampling event and two additional times to capture the variability in streamflow across the year. See **Table** 2 for more details.

4.1 Field Measurements

Temperature, conductivity, pH, turbidity, total dissolved solids, and chloride are to be measured instantaneously at each site using a Horiba W-23XD multi-parameter water quality monitoring probe (**Table** 5). Dissolved oxygen is to be measured with a YSI ProODO Handheld unit. The meters will be calibrated according manufacturer instructions the day of a sampling event [Horiba, 2008; Gardner and O'Hare, 2013.]. A site visit form will be completed for each site visited during a sampling event and will include all field data collected and an inventory of the grab samples collected for analysis at the BSWSD laboratory (Section 4.2.1).

Table 5: Performance of the Horiba W-23XD multi-parameter monitoring probe.

Parameter	Method	Measurement Range	Resolution	Accuracy
pH	Glass electrode	pH 0-14	0.01 pH	±0.1pH
Dissolved Oxygen	Luminescence technology	0-50 mg/L	0.01-0.1 mg/L	±1%
Conductivity	4 AC electrode	0-9.99 S/m	0.1% F.S	±0.3%
Total Dissolved Solids	Conductivity Conversion	0-100 g/L	0.1% F.S	±5 g/L
Temperature	Thermistor	0-55^{o}C	0.01^{o}C	±1.0^{o}C
Turbidity	Penetration and Scattering	0-800 NTU	0.1 NTU	±5%
Chloride Ion	Ion electrode	0.4-35,000 mg/L (pH 3-11)	0.1% F.S	±10%

4.1.1 Pebble Count

During summer baseflow, sediment analysis will be conducted using the Wolman Pebble Count Method as described in Kusnierz et al., [2013]. This method collects at least 100 particles from four riffles at each site for a total of at least 400 pebbles counted.

4.1.2 Algae Documentation

During summer baseflow, photos and notes of algae present at each site will be taken using a digital camera with a polarized lens. At least three photos will be taken and are outlined in the TASK FORCE Standard Operation Procedures (SOP) [Gardner and O'Hare, 2013].

4.1.3 Discharge Methods

Stream velocity will be measured at four sites in the West Fork Watershed with a continuous stage recorder ("West Fork", "South Fork", "North Fork", and just downstream of "Community" – **Figure** 2) with a Marsh McBirney Flo-Mate 2000™ current velocity meter (**Table** 6). Stream discharge will be calculated from the velocity measurements at these sites using the standard USGS area-velocity method (Levesque and Oberg, 2012). Discharge will be determined six times between high flow and ice formation and represent a range of discharge values. Stream rating curves will be determined by plotting measured discharge and corresponding stream stage.

Table 6: Performance and characteristics of the Marsh-McBirney Flo-mate Model 2000 (Marsh-McBirney, 1990)

Method	Range	Resolution	Per Reading Accuracy	Overall Accuracy*
Electromagnetic	-0.5 to 19.99 ft/s	0.01 ft/s	± 2%	± 20%

*(Soupir *et al*, 2009).

4.2 Sample Collection

4.2.1 Stream water

Sample collection will be conducted according to the TASK FORCE SOPs [Gardner and O'Hare, 2013]. Samples will be collected four times a year and analyzed for total nitrogen, total phosphorus, nitrate plus nitrite, and *E.coli*, although not all parameters will be analyzed for all sampling events, see Table 2. Sulfuric acid (H_2SO_4) preservative will be added to the nitrate plus nitrite and total phosphorous samples (Table 10).

4.2.2 Benthic Macroinvertebrates

Macroinvertebrates will be collected during summer baseflow at four sites. The methods for macroinvertebrate collection are outlined in Gardner and O'Hare, 2013. The samples are stored in lab grade ethanol and sent to Rhithron Associates for analysis. Replicates will be collected at each site to gain understanding of the site variability (Bollman, personal communication). Sites will be alternated each year until all fourteen sites (Table 3) have been sampled and then sites will be repeated. The SOPs

5.0 LABORATORY METHODS

Collected samples (Section 4.2.1) will be stored in a designated refrigerator at the BSWSD until analysis [Gardner and O'Hare, 2013 except for those samples to be shipped to Energy Laboratories (Section 5.2).

5.1 *E.coli*/Total Coliform

The *E. coli* tests will be performed with Coliscan® EasyGel® (www.micrologylabs.com) [Gardner and O'Hare, 2013] (**Table** 8).

Table 7: Preservation, holding times, laboratory methods and detection limits for total nitrate + nitrite.

	Bottle Size	Preservation	Holding Times	Analytical Method	Reporting/ Detection Limit
Nitrate + Nitrite	250mL	< 4°C	0 days	HACH Method 8192	0.004 mg/L
E.Coli	250 mL	< 4°C,	0	Coliscan® EasyGel®	33 cfu/100mL

5.2 Total Nitrogen, Nitrate + Nitrite, and Total Phosphorus

Total nitrogen, nitrate + nitrite and total phosphorus samples collected during summer baseflow will be sent to Energy Laboratories, Inc. in Billings for analysis (Table 10). In addition, separate samples will be analyzed for nitrate + nitrite in house using cadmium reduction and spectrophotometry using a Hach DR/2500 spectrophotometer and Hach NitraVer 6 and NitraVer 3 pillows [Hach Company, 2012] [Gardner and O'Hare, 2013] (**Tables** 7 and 8). A standard curve will be created using known concentrations of nitrate for each sampling event. The equation for the curve is then applied to each sample to calculate the true concentration of the sample.

Table 8: Preservation, holding times, laboratory methods and detection limits for total nitrogen, nitrate + nitrite, and phosphorus samples analyzed by Energy Laboratories.

	Bottle Size	Preservation	Holding Times	Analytical Method	Reporting/ Detection Limit
Total Nitrogen	250mL	< 4°C	28 days	A 4500-N C	0.04 mg/L
Nitrate + Nitrite	250mL	< 4°C, H_2SO_4	28 days	EPA 353.2	0.01 mg/L
Total Phosphorus	250mL	< 4°C, H_2SO_4	28 days	EPA 365.1	0.003 mg/L

6.0 QUALITY CONTROL REQUIREMENTS

6.1 Representativeness

Representativeness refers to the extent to which measurements represent an environmental condition in time and space. This is a judgmental sampling design using the following rational:

6.1.1 Spatial Representation:

Sampling sites were chosen to represent the potential of landscape characteristics and land use/land cover to influence water quality. Limitations do exist as a result of site access and landowner permission.

6.1.2 Temporal representation:

Four time periods will be used to represent the variability in streamflow and in potential hydrologic connectivity with the landscape. These time periods will be spring pre-runoff, spring runoff, summer baseflow and winter baseflow.

6.2 Comparability

Comparability expresses the confidence with which one data set can be compared to another. To achieve a comparable result, both the field collection method and the analytical method must be comparable. This is achieved through the use of Standard Operating Procedures (SOPs – DEQ or USGS) for field collection and the *use* of the same analytical methods published by the EPA, APHA - Standard Methods, or USGS in the laboratory.

6.3 Completeness

Completeness is a measure of the amount of data prescribed for assessment activities and the usable data actually collected, expressed as a percentage. Prior to leaving a sampling site the samplers will be required to fill out a data sheet, which will be reviewed and initialed by their field leader on site. These checks will reduce the occurrence of empty data fields. The overall project goal is 95% completeness. Sites lost due to inaccessibility will reduce the total number of sites in the equation above but not the completeness goal.

6.4 Sensitivity

Sensitivity refers to the limit of a measurement to reliably detect a characteristic of a sample. For analytical methods, sensitivity is expressed as the method detection limit (MDL). Sensitivity quality controls for all laboratory methods will follow the frequency and criteria specified in the analytical method. The criteria to assess field method sensitivity for water samples shall be:

Field method controls (field blank) < Reporting limit

6.4.1 Corrective Action

If analytical method controls fail to meet the specified limit, the data will be qualified as necessary. In addition, if appropriate, additional samples will be collected. If field blanks fail, qualify all associated project data with a "B" that is less than 10 times the detected value.

6.5 Precision

Precision refers to the degree of agreement among repeated measurements of the same characteristic. This project will rely on analytical and field duplicates to assess precision based on their relative percent difference (RPD).

$$RPD\ as\ \% = \frac{D_1 - D_2}{\left(\frac{D_1 + D_2}{2}\right)} \times 100$$

where:
D_1= first replicate result
D_2= second replicate result

6.5.1 Laboratory Precision

Precision quality control for all laboratory methods will follow the frequency specified in the associated analytical method. The criteria used to assess analytical method precision shall be:

Water Samples: 20% RPD for duplicate results > 5 times the MDL

6.5.2 Overall Precision

Frequency of field co-located duplicates will be 10% of all samples collected in the field. The criteria used to assess overall precision shall be:

Water samples: 25% RPD for duplicate results > 5 times the MDL

6.5.3 Corrective Action

If laboratory duplicates fail this limit, qualify the data as needed. If the field duplicates fail this limit, qualify all associated results < 5 times the concentration in the duplicates pair's parent sample with a "J".

6.6 Bias and Accuracy

Bias is direction error from the true value. In this context, it is an extension of the representativeness concept applied to an individual sample. Bias can occur either at sample collection or during measurement.

Accuracy is the combination of high precision and low bias. Accuracy of individual measurements will be assessed by reviewing the analytical method controls (i.e. laboratory control sample, continuing calibration verification, standard reference material). The criteria used for this assessment will be the limits that Hach Company and Micrology Labs have developed through control charting of each method's performance or based on individual method requirements.

6.7 Field Measurements

QA/QC procedures from the grab sample field-sampling portion of the TASK FORCE CWQMP will consist of duplicates and blank samples (one blank per sampling event, one duplicate on the Gallatin River and one duplicate in the West Fork Watershed). The field blanks will consist of laboratory-grade deionized (DI) water transported to the field and poured into a prepared sample container. The blank will be prepared at the same time as the sample. The blank sample is used to determine the integrity of the volunteer monitors handling of samples, the condition of the sample containers, and the accuracy of the laboratory methods.

Duplicates consist of two sets of sample containers filled concurrently with stream water from the same sampling site. All duplicate samples will be collected at the same location. Duplicates are used to determine field and laboratory precision. Both duplicates and blank samples are stored and handled following the same procedures as the routine samples being submitted for laboratory analysis.

7.0 DATA ANALYSIS, RECORD KEEPING AND REPORTING

All data will be entered onto TASK FORCE website (bluewatertaskforce.org/test-sites.php) and uploaded into MT-eWQX. Hard copies of the data sheets will be filed in the TASK FORCE office.

8.0 VOLUNTEER TRAINING

The TASK FORCE will hold an informational meeting and training to recruit volunteers for the stream monitoring project once a year in the spring. The Project Manager will lead the training assisted by the TASK FORCE board of directors and the previous year's volunteers.

9.0 REFERENCES

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APPENDIX A

Table A-1: Annual Community Water Quality Monitoring Project Budget

Item	Cost
NitriVer Packets	$70.35
Auto Calibration Solution	$36.00
Chloride Calibration Solution	$28.26
Coliscan Easy Gel Agar and Petri-dishes	$159.32
Reagent Alcohol	$80.00
Miscellaneous Lab and Field Supplies	$50.00
Macroinvertabrate Analysis	$2,700.00
Laboratory Grade Dionized Water	$166.00
Total Phosphorus Analysis - Energy Labs	$380.00
Total Nitrogen Analysis - Energy Labs	$760.00
Nitrate + Nitrite Analysis - Energy Labs	$475.00
Equipment Maintenance	$500.00
Program Management	$2,000.00
Total	**$7,404.93**