SHIELDS RIVER WATERSHED NUTRIENT AND CHLOROPHYLL MONITORING

Sampling and Analysis Plan

Prepared by:

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
Watershed Management Section, Water Quality Planning Bureau
1520 East 6th Avenue
Helena, MT 59620-0901

Approvals **All Signatures on File at MDEQ**

/s/	8-26-10
Christina Staten (TMDL Project Manager)	Date
/s/	8-27-10
Dean Yashan (TMDL Section Supervisor)	Date
/s/	8-27-10
Mindy McCarthy (QA Officer)	Date

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This document constitutes the Sampling and Analysis Plan (SAP) for the completion of a nutrient characterization, source assessment and loading estimate for the identified streams in the Shields River watershed.

1.0 INTRODUCTION AND BACKGROUND

The Shields River watershed is located in south-central Montana mostly within Park County just north of Livingston and 13 miles northeast of Bozeman. The Shields River flows north to south to the confluence of the Yellowstone River, near Livingston. **Figure 1** shows the Shields River watershed boundary and major tributaries.

The watershed is predominately privately owned, with 75% of the area used for farming or ranching. Irrigation of agricultural lands in the Shields River Valley constitutes a primary use of surface water. Multiple large irrigation diversions exist which may provide a potential source of nutrient loading to the Shields River.

Nutrient sampling has been conducted in multiple years past; however, there are no streams within the watershed listed for nutrients on the 2008 303(d) List. This sampling is being conducted in response to the Shields Valley Watershed Group's request for a nutrient source assessment, combined with the availability of 319 money to fund the project. Data collected during this sampling effort will be used in conjunction with prior collected data for water quality impairment assessment and 303(d) listing determinations.

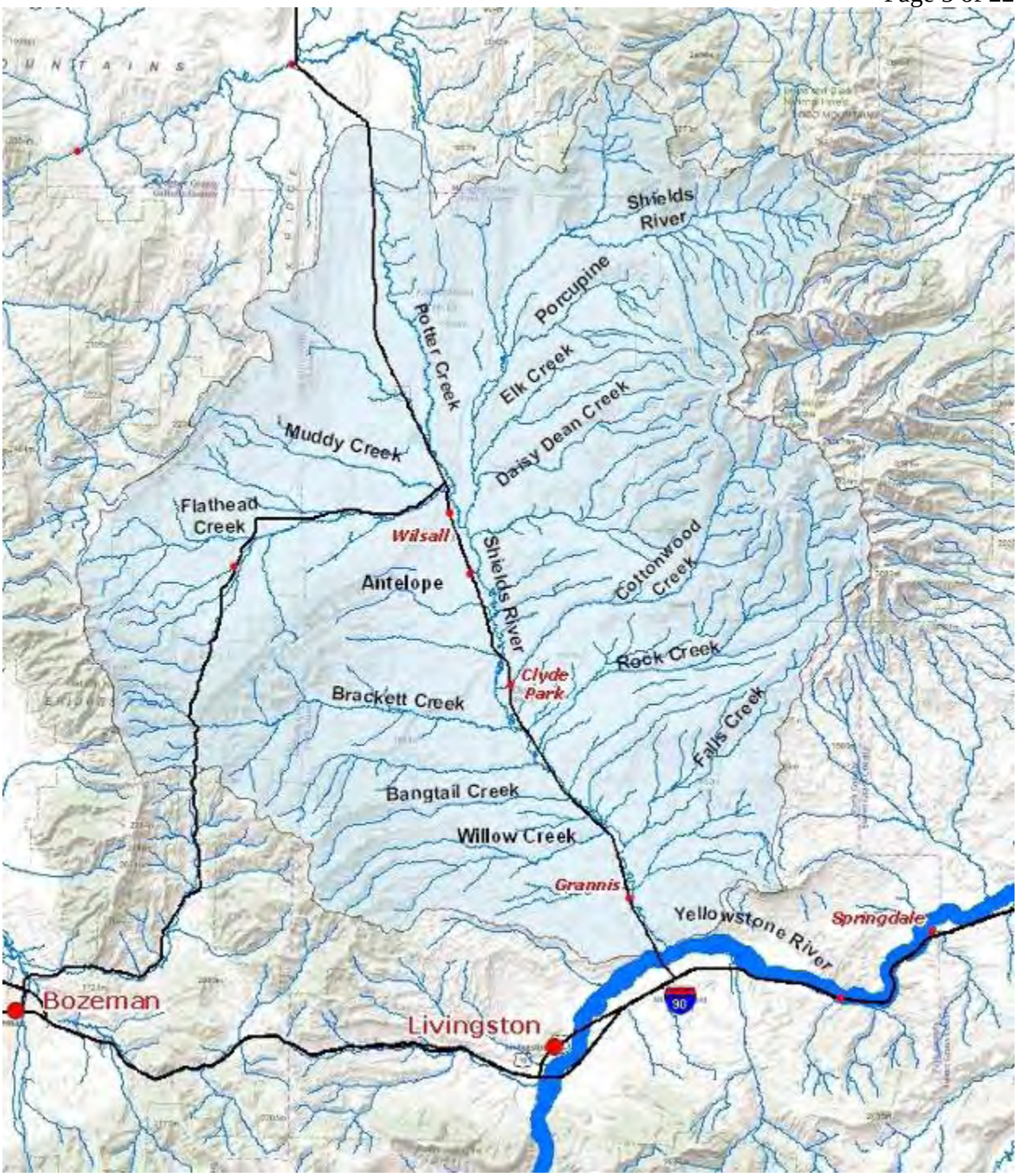

Figure 1: Boundary of the Shields River Watershed

2.0 OBJECTIVES AND DESIGN

The objective of this sampling plan is to collect chemistry and chlorophyll data, in conjunction with field parameters that will be used for the following:

- Identification of possible nutrient sources within the Shields River watershed
- Assessment of water quality to aid in beneficial use determinations specific to nutrient and TSS impairment for sampled stream segments
- Quantification of nutrient and TSS loads associated with specific land use categories in the Shields River watershed to assist with any required future TMDL development

2.1 Study Design

In order to meet the above objectives, nutrient conditions will be determined by extensive water quality sampling in the Shields River and identified tributaries. Specific sample locations were chosen to identify and assess potential nutrient sources to the Shields River, and are further discussed in the Section 2.3. Synoptic surveys for nitrogen and phosphorus compounds in the water column will be performed at each of the selected sample sites during two low-flow sampling events scheduled for late August / early September of 2010 and July of 2011. Chlorophyll *a* sampling with ash-free dry weight (AFDW) analysis will be completed in conjunction with nutrient sampling. Total suspended solids (TSS) will be collected at all sample sites. Physical parameters (i.e. water temperature, dissolved oxygen, pH, and conductivity) will be collected with a field meter at all sites. DEQ will review results of the 2010 sampling and may add or remove sites and parameters for the 2011 sampling event, based on the defined objectives.

2.2 Nutrients and Chlorophyll

Nutrient and chlorophyll *a* sampling during low flow in late summer is anticipated to measure nutrient concentrations when they are likely to affect beneficial uses, and measure chlorophyll *a* during peak algal growth. Instantaneous flow will be measured for each site so that nutrient loads can be calculated.

Chlorophyll a sampling with AFDW analysis will occur during both sampling events at each site that is determined to have ‘considerable’ algal growth over the entire site, or sampling unit as defined by the Chlorophyll-a SOP (See Section 3.2). Algae will be collected for chlorophyll a analysis at each site where algal density is visually estimated to be close to or greater than 50 mg/m2. The visual determination of algal growth will be made based on comparison to photos of sites with known concentrations **(Appendix A, Chlorophyll a Photo Packet**). An algal density of 125-150 mg/m2 was determined to negatively affect recreational use but 50 mg/m2 will be used for this study to err on the conservative side during data collection and provide a margin of safety during visual estimations. Ash free dry weight will also be analyzed at the lab for all template and hoop chlorophyll a samples.

2.3 Sampling Sites

Sampling sites (**Table 1 and Figure 2**) were chosen to represent the differing landscape characteristics and land use/ land cover influences existing in the watershed, as well as the contribution of major tributaries. Sampling sites were identified by assessment of aerial images, by reviewing historic sampling locations and their sample results, assessment of the 2009 aerial images to identify current land uses and riparian health, and also through field reconnaissance, to

capture the variability in land use and watershed characteristics potentially contributing to nutrient and TSS concentrations in streams. Monitoring locations are spatially located to aid in determining the location of and contribution of sources.

Table 1: Sample locations for nutrient, chlorophyll, TSS, and flow monitoring in the Shields River Watershed

Water Body	Water Body ID	Station ID	Location	Latitude	Longitude
Shields River	MT43A001_011	SHIELD01	Shields River near the mouth	45.726166	-110.462729
Shields River	MT43A001_011	SHIELD02	Shields River below Grannis	45.749386	-110.488936
Rock Creek	MT43A002_051	ROCK01	Rock Creek at the mouth	45.847424	-110.580682
Shields River	MT43A001_011	SHIELD03	Shields River d/s of Cottonwood Creek & Clyde Park	45.876621	-110.612762
Cottonwood Creek	MT43A002_031	CTNWD01	Cottonwood Creek at the mouth	45.885499	-110.61728
Shields River	MT43A001_012	SHIELD04	Shields River above Cottonwood Creek	45.886227	-110.617384
Shields River	MT43A001_012	SHIELD05	Shields River below Antelope Cr and unnamed trib	45.921692	-110.620102
Antelope Creek	MT43A002_020	ANTLP01	Antelope Creek at the mouth	45.93029	-110.622403
Antelope Creek	MT43A002_020	ANTLP02	Antelope Creek d/s of Shy Creek Road crossing	45.930761	-110.664781
Shields River	MT43A001_012	SHIELD06	Shields River above Antelope Creek	45.929908	-110.620975
Shields Canal		SHLDCANAL01	Shields Canal d/s of Shields Lane road crossing	45.959357	-110.654895
Shields River	MT43A001_012	SHIELD07	Shields River d/s x-trib below Indian Creek Rd	45.954114	-110.633938
Shields River	MT43A001_012	SHIELD08	Shields River below Flathead Creek	45.97359	-110.64138
Shields Canal		SHLDCANAL02	Shields Canal at Rodeo Fairgrounds in Wilsall	45.99264	-110.65446
Flathead Creek	MT43A002_070	FLTHD01	Flathead Creek at Rodeo Fairgrounds in Wilsall	45.99283	-110.653912
Potter Creek	MT43A002_010	PTR01	Potter Creek at the mouth	46.010929	-110.656032
Shields River	MT43A001_012	SHIELD09	Shields River above Flathead Creek	45.98692	-110.646087
Elk Creek	MT43A002_040	ELK01	Elk Creek at the mouth	46.022351	-110.638025
Shields River	MT43A001_012	SHIELD10	Shields River above Elk Creek	46.026072	-110.641088
Porcupine Creek	MT43A002_060	PRCPN01	Porcupine Creek near the mouth	46.087418	-110.61195
Shields River	MT43A001_012	SHIELD11	Shields River below SF Shields River	46.168092	-110.487815

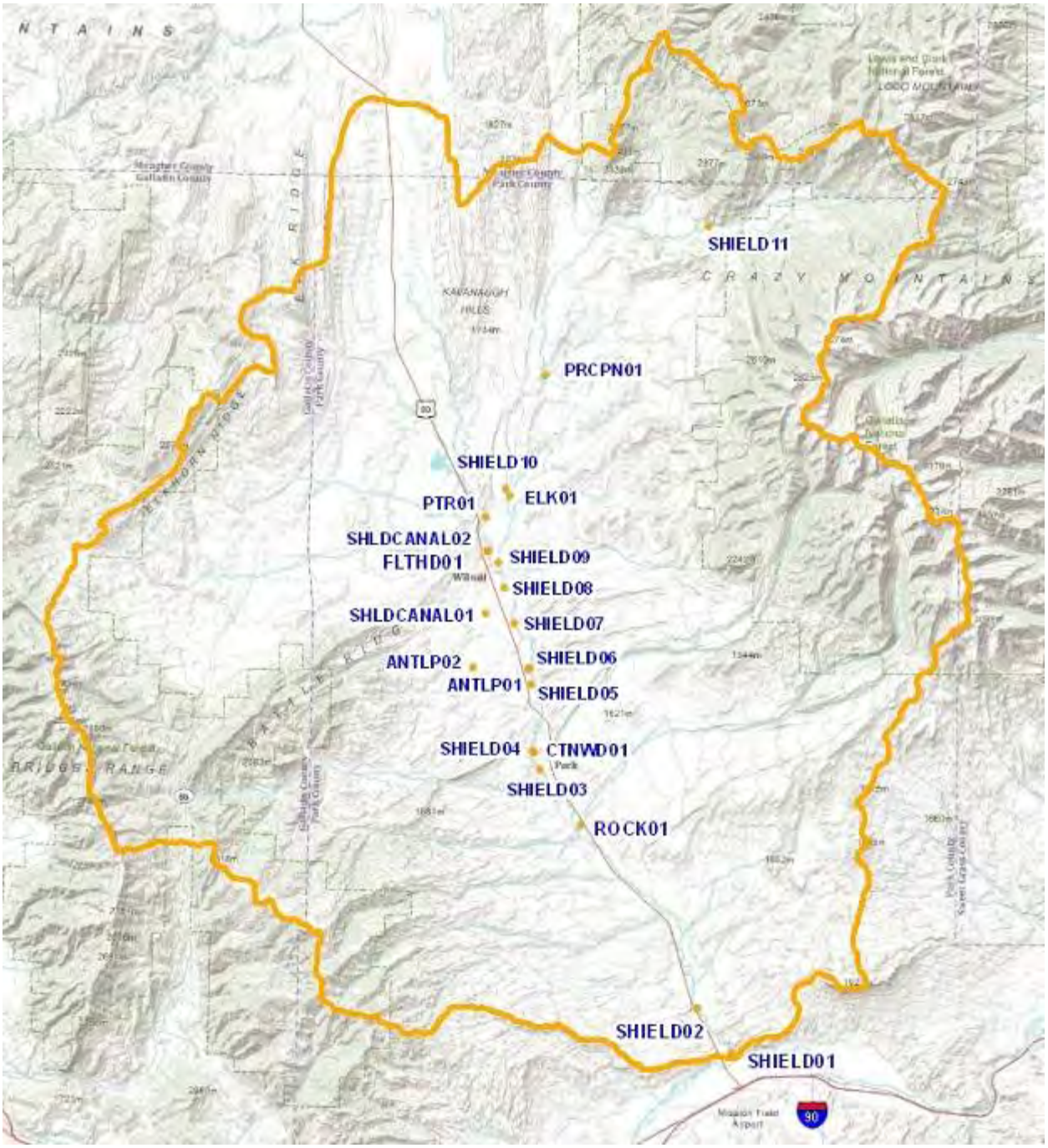

Figure 2: Sample site locations for 2010 and 2011 nutrient, chlorophyll, TSS, and flow monitoring in the Shields River Watershed

Table 2: Parameters for 2010 and 2011 nutrient, chlorophyll, TSS, and flow monitoring in the Shields River Watershed

Station ID	Location	Nutrients	NH_{3+4}	Diss PO4	Chlorophyll	TSS	Flow
SHIELD01	Shields River near the mouth	X			X	X	X
SHIELD02	Shields River below Grannis	X			X	X	X
ROCK01	Rock Creek at the mouth	X			X	X	X
SHIELD03	Shields River d/s of Cottonwood Creek & Clyde Park	X			X	X	X
CTNWD01	Cottonwood Creek at the mouth	X			X	X	X
SHIELD04	Shields River above Cottonwood Creek	X	X		X	X	X
SHIELD05	Shields River below Antelope Cr and unnamed trib	X		X	X	X	X
ANTLP01	Antelope Creek at the mouth	X		X	X	X	X
ANTLP02	Antelope Creek d/s of Shy Creek Road crossing	X				X	X
SHIELD06	Shields River above Antelope Creek	X	X		X	X	X
SHIELD07	Shields River d/s unnamed trib below Indian Creek Rd	X			X	X	X
SHLDCANAL01	Shields Canal d/s of Shields Lane road crossing	X		X		X	X
SHIELD08	Shields River below Flathead Creek	X			X	X	X
SHLDCANAL02	Shields Canal at Rodeo Fairgrounds in Wilsall	X		X		X	X
FLTHD01	Flathead Creek at Rodeo Fairgrounds in Wilsall	X		X	X	X	X
PTR01	Potter Creek at the mouth	X			X	X	X
SHIELD09	Shields River above Flathead Creek	X			X	X	X
ELK01	Elk Creek at the mouth	X			X	X	X
SHIELD10	Shields River above Elk Creek	X			X	X	X
PRCPN01	Porcupine Creek near the mouth	X			X	X	X
SHIELD11	Shields River below SF Shields River	X			X	X	X

3.0 FIELD SAMPLING METHODS

Monitoring will be done in accordance with the MDEQ's Field Procedures Manual which is available on the internet at: http://deq.mt.gov/wqinfo/QAProgram/PDF/SOP%20WQPBWQM-020.pdf (DEQ, 2005a). Grab samples will be collected and analyzed for nutrients as identified in **Tables 2 and 3**. Water samples will be collected directly in the required bottle (See **Appendix B**, Analyte Checklist for this information). Bottles shall be rinsed three times with native water prior to sampling. Samples will be collected in a well-mixed portion of each stream, or, if the stream has ceased flowing (intermittent), the sample will be collected at the surface in a pool without disturbing the sediments. During sampling, the sample bottle opening should face upstream and should be drawn through the water column once, carefully avoiding disturbance of bottom sediments.

Table 3: Analyte suite for nutrients

Nutrients	Other
Total N (TN as N)	TSS
Nitrate + Nitrite (NO_{2+3} as N)	
Ammonia (NH_{3+4} as N)	
Total P (TP as P)	
Dissolved Orthophosphate as P	

3.1 Nutrients

Table 3 shows the suite of nutrients that will be measured for each sampling event and site. Four bottles will be required for the identified nutrient analytes:

TP, NO_{2+3}, NH_{3+4}: preserved with sulfuric acid; $\leq 6^oC$
TN: no preservative; $\leq 6^oC$
TSS: no preservative; $\leq 6^oC$
Dissolved Orthophosphate: field filter 100 ml through .45 µm; no preservative; frozen with dry ice (only fill bottle ¾ full to prevent bursting when frozen)

Total phosphorus, ammonia, and NO_{2+3} samples will be acidified to a pH of less than 2 by adding concentrated 1+1 sulfuric acid (H_2SO_4); 4 ml/L. Water for dissolved orthophosphate will be filtered in the field through a 0.45 µm syringe into clean polyethylene bottles. Dissolved orthophosphate samples are not preserved with acid.

All samples will be properly labeled, stored in coolers and chilled to 6°C or less for transport to the lab, with the exception of dissolved orthophosphate samples which will be frozen with dry ice. Additional details regarding the analytes, collection bottles, and preservation methods are contained in **Appendix B, Analyte Checklist**. The site names on the sample labels must correspond to the site names provided in this SAP (**Tables 1 & 2**).

3.2 Chlorophyll

Chlorophyll *a* will be collected via the *Sample Collection and Laboratory Analysis of Chlorophyll-a SOP* (available at

http://deq.mt.gov/wqinfo/QAProgram/PDF/SOP%20WQPBWQM-011v4_final.pdf). Review the SOP directions on how to set up the sampling reach; the methods for template, core, and hoop sampling techniques; sample preservation; site visit form completion; COC submittal; and calculation of reach weighted averages. Ash-free dry weight will be included with the chlorophyll a laboratory analysis.

The chlorophyll-a section of the site visit form must be filled out in its entirety. For any transects that are not sampled, an "N" will be put on the site visit form. "Composite" must be specified on the chain of custody forms so the laboratory will properly process the samples. Samples will not be composited in the field. Chlorophyll a samples collected during the 2011 sampling event will be collected at the same transects established for each site during the 2010 monitoring; new reach lengths and transect distances will not be calculated.

Chlorophyll a Photographs

For sample sites requiring determination of chlorophyll-a collection (see **Table 2**), photographs will be taken regardless of whether or not the site is determined to have considerable algal growth. The photos will later be used to compare and evaluate the congruency of the apparent visual algal growth condition in the stream to the laboratory analytical result. For sites that are not sampled, the photographs will be used to document low algal growth conditions.

All photographs will be recorded in a photo log and will include:

- Picture #
- Site ID
- Date and time
- Transect letter for substrate photos or transect boundaries for reach photos
- Visual growth estimates for substrate photos.

Photos will be taken in the same manner as those contained in **Appendix A, Chlorophyll a Photo Packet**. A polarized lens will be used where necessary to reduce glare; glary photos are of limited use. Factors reducing substrate visibility, such as turbidity, should be noted in the photo log and on the site visit form.

Photographs for both Sampled and Non-Sampled Sites (Reach Photos)

Reach photos will be taken for both sites that are sampled and those that are not. A minimum of three reach photos will be taken to provide an overview of chlorophyll growth within the sampling frame. The substrate condition should be clearly visible in the foreground of the picture. Photos must mimic those in **Appendix A**. Preferably, the minimum three photos will be taken between transects A&D, E&G, and H&K. For large rivers requiring 11 samples across 1 transect, a substrate photo will be taken at each end of the transect, and an upstream and downstream reach photo will be taken.

Photographs for Sites Determined not to have Considerable Algal Growth (Substrate Photos)

Substrate photos will be taken with reach photos, at the same locations (i.e. a minimum of three photos). If substrate is poorly visible in the picture, collect five representative rocks from the site and photograph at close range if the substrate permits (i.e. cobble or large gravel).

Photographs for Sites Determined to Have Considerable Algal Growth
A substrate photo will be taken at each transect sample location (the 1m x 1m area from which the sample is collected) prior to collection of the sample. If substrate is poorly visible in the picture, collect five representative rocks from the site and photograph at close range if the substrate permits (i.e. cobble).

Each individual collected sample will also be photographed:

- Template: Scraped rocks may be collected and photographed together
- Hoop: Both the hoop and collected algae must be present in the photo
- Core: No photograph necessary. Substrate pictures of core sample locations will suffice

Visual estimates of all individual samples, including core samples, will be recorded in the photo log.

3.3 Discharge

Stream discharge data will be collected at all water quality monitoring sites using a *Marsh McBirney Flo-Mate 2000*™ current velocity meter in accordance with MDEQ's Field Procedures Manual (DEQ, 2005a). Extreme low flow sampling (<1.5" deep channel) may necessitate the use of estimating flow using a float method. This method must be indicated on both the site form and the discharge field form, and documented with a photograph of the measurement location.

Discharge via the Float Method
Find a reach of stream that is linear/straight, as well as uniform in width and depth; a glide is preferred. This will assure that laminar flow is achieved to the greatest extent possible. Determine mean wetted width by measurement of three transects. Measure or pace off the distance twice the mean wetted width (in feet) along the bank and mark each end. If a length twice the wetted width cannot be achieved, mark the distance of the mean wetted width instead. Record the measured distance on the discharge form.

Toss an item heavy enough to stay in and move consistently with the main current, and also harmless to wildlife and water quality, into the middle of the stream above the upstream marker of the measured reach. Begin timing when the item passes the upstream marker. Count (with a watch or stopwatch) the seconds it takes the item to reach the downstream marker. The item must stay in the main current. If it does not, repeat the measurement. Complete three measurable floats. Record the data on the site visit form and the discharge form.

Width and depth will be measured at one or two representative transects within the marked distance using the same method employed to measure discharge with a Marsh McBirney meter, by setting up a cross section. Record this information on the discharge form.

Calculations:
Mean width x mean depth = cross-sectional area (ft^2)
Convert stick float time to ft/second (i.e., 26 ft/15 sec = 1.7 ft/sec)
Determine CFS (a x b)

Measurement and Estimation of Small Discharge Volumes
Volumetric measurements (bucket and stopwatch) should be used if possible where discharges come from a pipe and no other way of metering will succeed. If bucket counts are not feasible for pipes, the pipe diameter, depth of water to bottom of pipe and estimated velocity of discharge will be recorded and discharge will be calculated from this information. Visual discharge estimates in natural channels can be provided if field measures are not feasible via any other method. Justification for using the visual estimate must be clearly articulated in field notes. Visually estimated discharge must be based upon documented average width, depth, and velocity. Estimated average width, depth, and velocity MUST be documented in field notes.

3.4 Other Data

A DEQ Site Visit Form will be completed for each site. Observations (e.g. beaver dams, cattle, irrigation influences, or excessive macrophyte growth) will be recorded on a separate form or in a field book. Separate site visit forms will be completed for each set of duplicate and blank samples with “Duplicate Samples” or “Field Blanks” recorded in the Site Visit Notes. Sample labels must indicate the sample is either a duplicate or a blank.

Physical parameters (i.e. water temperature, dissolved oxygen, pH, and conductivity) will be collected in the field with a YSI 85 or equivalent meter in accordance with MDEQ’s Field Procedures Manual (DEQ, 2005a). The field meter and velocity meter will be calibrated prior to use at each site according to their respective operation manuals. The GPS coordinate system datum will be NAD 1983 State Plane Montana, in decimal degrees to at least the fourth decimal. All data and information for this project must meet other data reporting requirements identified in the Contract for work. Data formats identified in the contract will be used for TMDL related data analysis.

Pictures will be taken at each sampling location during the first sampling event in summer 2010 to document the general sample location. Pictures that document the sample site location do not need to be retaken for the 2011 sampling event, unless the sample location changes or an additional site is added. All pictures will be documented on field forms with the following information recorded:

Picture number
Date and time
Waterbody
Station ID
Directional reference (facing upstream or downstream and N, S, E, W)

4.0 SAMPLE HANDLING AND LABORATORY ANALYTICAL PROCEDURES

Immediately following grab-sample collection, samples will be put on ice, with the exception of dissolved orthophosphate samples which will be frozen with dry ice. Sample handling procedures will follow DEQ standard operating procedures as defined in DEQ guidance, *Sampling and Water Quality Assessment of Streams and Rivers in Montana, 2005: Quality Assurance Project Plan (QAPP)* (DEQ, 2005b). See **Appendix B, Analyte Checklist**, for chlorophyll a samples preservation methods. Algal samples from each transect should be stored

in separate containers but grouped together by site for shipping. Caution should be used with algal samples during shipping. Refer to the DEQ *Sample Collection and Laboratory Analysis of Chlorophyll-a SOP* (DEQ, 2008) for specific guidance. **Chlorophyll a samples from waters with a pH less than 7 require faster processing than other samples to prevent degradation. If the sample water has a pH less than 7, this should be indicated on the Chain of Custody form so the lab will expedite sample processing**. Standard DEQ Water Quality Planning Bureau site visit/chain of custody forms will be used to document and track all samples collected in the project. Samples will be delivered to Energy Labs for analysis. **Appendix B, Analyte Checklist**, contains a table with the collection container, preservative, analytical method, required reporting limit, and holding time for each analyte. The lab must use "J value" reporting for results between the RL and the MDL.

5.0 QUALITY ASSURANCE AND QUALITY CONTROL REQUIREMENTS

During each sampling trip, field duplicates will be collected randomly for 10% of all samples and field blanks (not trip blanks) will be prepared for 10% of all samples. Filter blanks will be completed for 10% of filtered samples to address bias due to filter contamination. This equates to two field duplicates and two field blanks for this project. Note that as stated in the Chlorophyll-a SOP, field QC samples do not apply to chlorophyll-a samples.

Data quality objectives (DQOs) are the quantitative and qualitative criteria established for a sampling design in order to meet the project's objectives. Data quality indicators (DQIs) are quantitative criteria established for the data acquired within this design to assure it is of sufficient quality for its intended use. Descriptions of data qualifiers and common QC terms and acronyms are included in **Appendix C, QA/QC Checklist**.

5.1 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 rationale:

Spatial representation:

> Sampling sites were chosen to represent the potential of landscape characteristics and land use/land cover influences existing in the watershed to influence the nutrient concentrations in the listed waters, as well as the contribution of major tributaries. Sampling sites were identified by both assessment of aerial images and prior sampling locations to capture the variability in land use and watershed characteristics potentially contributing to pollutant concentrations in streams including: land use/land cover (e.g. forest, grass, riparian area, geology, and soils), watershed residence times, and stream order.

Temporal representation:

> One time period is used to represent the potential for low flow nutrient conditions for the selected streams. This data will be added on to previously collected data for data analysis.

5.2 Comparability

Comparability is the ability to compare historic data sets to current, or new, data. Comparability can be determined through review and comparison of field sampling methods, analytical methods, and rigor and use of quality assurance and control protocols.

5.3 Completeness

Completeness is a measure of the amount of data prescribed for assessment activities and the usable data actually collected, expressed as a percentage.

Completeness as % = (No. Valid Data Points or Samples / Total # Data Points or Samples) x 100

The overall project goal is 95% completeness. Sites lost due to inaccessibility will reduce the total number of sites in the equation but not the completeness goal. Although, alternative sites will be considered if original site access can not be obtained. Data results qualified with H flags will count against completeness. Data with B and J flags will not affect completeness. If flagged data is not fully useful to the project and the flag was caused by field or laboratory error which could have been prevented by following standard procedures, it will be counted against completeness. If any stream has less than 50% of its planned sites sampled due to accessibility issues, the project summary will note this fact.

5.4 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). Laboratories must determine their MDL's annually and routinely check each method's ability to achieve this level of sensitivity using negative controls (e.g., Method Blanks, Continuing Calibration Blanks, and Laboratory Reagent Blanks).

Sensitivity quality controls for all laboratory methods will follow the frequency and criteria specified in the analytical method or as described in the Laboratory's Quality Assurance Plan (LQAP). The criteria used to assess field method sensitivity for water and sediment samples shall be:

Field method controls (Field Blank) < Reporting Limit in Appendix B

Corrective Action: If analytical method controls fail the specified limit, check with the laboratory to see how they addressed the non-conformance and qualify data as necessary. If Field Blanks fail, qualify all associated project data < 10x the detected value with B flags.

5.5 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).

$$\text{RPD as \%} = ((D1 - D2)/((D1 + D2)/2)) \times 100$$

Where:

D1 is first replicate result
D2 is second replicate result

Lab precision (laboratory duplicates)
Precision quality control for all laboratory methods will follow the frequency specified in the analytical method or as described in the LQAP. The criteria used to assess analytical method precision shall be:

Water samples: 20 % RPD for duplicate results > 5 times the reporting limit

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

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

Corrective Action: If laboratory duplicates fail this limit, check with the laboratory to see how they addressed or qualified the data and add additional qualifiers and notes as needed. If the field duplicates fail this limit, qualify all associated with a "J".

5.6 Bias and Accuracy

Bias is systematic nonrandom 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, Laboratory Fortified Blank, Standard Reference Material) and the analytical batch controls (i.e. Matrix Spike and Matrix Spike Duplicate). The criteria used for this assessment will be the limits that the laboratory has developed through control charting of each method's performance or based on individual method requirements. Method QC descriptions are contained in **Table C-2 in Appendix C, QA/QC Checklist**.

Corrective Action: For any QC value outside of the recovery range, check with the laboratory to see how they addressed the non-conformance and qualify data as necessary.

6.0 DATA ANALYSIS, RECORD KEEPING, AND REPORTING REQUIREMENTS

6.1 QC Review and Documentation

A review of field and analytical data will be conducted following receipt of the laboratory data package[1] that includes all items on the QC Checklist in **Appendix C**. All water quality data collected as part of this SAP will be evaluated against the criteria listed in Section 5.0. Data

[1] A data package includes all hardcopy results from the lab (including QC summary and completed chain of custody), and the electronic data deliverable (EDD in MT eWQX compliant format).

qualifiers provided in **Appendix C (Table C-1)** will be assigned to data that does not meet these target quality control criteria. Qualifiers will be included in both the hardcopy and electronic forms of the data.

A written summary of data quality will be prepared following review of field documentation and receipt of data from the laboratory. The data quality analysis will summarize the QA/QC information from the field event and laboratory analysis (including QC sample results), audit information, corrective actions taken, and the overall results of sampling and analytical activities with respect to compliance with the provisions of this SAP. The primary focus of the data quality analysis will be to assess the effects any deviations from approved procedures may have on the project objectives and credibility of this data for decision making purposes.

6.2 Data Management

Data generated during this project will be stored on field forms, in laboratory reports obtained from Energy Labs, DEQ's MT-eWQX database, and EPA's Water Quality Exchange data system. Site Visit/Chain of Custody forms will be properly completed for all samples. Blank forms can be found on DEQ's Data Management website at: http://www.deq.mt.gov/wqinfo/datamgmt/MTEWQX.mcpx under "Additional Information" in the right-hand side bar. Written field notes, field forms, and digital photos will be processed by field staff following QA/QC procedures and the requirements set forth in the project's Scope of Work. All project forms and reports will be submitted to the DEQ Project Manager upon the completion of this project, following the Scope of Work deliverable dates.

Electronic versions of chlorophyll a photos will be named using the following formats:

- Reach photos: [Station ID]_[date in mmddyy format]_Reach[lower transect letter]_[upper transect letter]
- Substrate photos: [Station ID]_[date in mmddyy format]_[transect letter]
- Collected samples: [Station ID]_[date in mmddyy format]_[transect letter][sample method (i.e. C, H, or T)]

For example, if a hoop sample was collected at transect A on August 24, 2010 at Station SHIELD01, the photo name would be "SHIELD01_082410_AH." A reach photo taken between transects A and D for the same site would be named "SHIELD01_082410_ReachA_D." Sample site location photos should use a similar format including the Station ID and date.

Field data collected and data received from the water quality laboratory will be managed in spreadsheets or database tables compatible with the MT-eWQX database. Data tables will be maintained and managed in record format retaining the unaltered results and meta data recorded in the field or received in a laboratory's electronic data deliverable (EDD). After DEQ approval of the data quality summary, data from all sampling events will be entered into MT-eWQX compatible templates and provided to the DEQ Project Manager for review. Upon approval, data will be loaded into the Environmental Data Processor (EDP) for database QC review prior to data submittal to the MT-eWQX system. Data management tools (including the EDP application) and instructions for submittal to the MT-eWQX system can be found on DEQ's Data Management website noted above. If new stations need to be established, Station IDs will

follow the same format shown in **Table 1**. Data entry will follow the requirements of **Appendix A, MT-eWQX Valid Values for MTWTRSHD_WQX**, of the MT-eWQX Guidance Manual also found on the Data Management website. Verification of successful data upload (i.e., copy of the MT-eWQX system generated email) will be submitted to DEQ.

The following information and the information provided in **Table 4** will be used for completion of the WQX EDD templates:

Project ID:	SHIELDS-NUTS
Project Name:	Shields River Watershed Nutrient & Chlorophyll Monitoring
Project Description:	Collection of chemistry and chlorophyll data, in conjunction with physical parameters, for identification of possible nutrient sources in the Shields River Watershed
Format for Activity IDs:	[Station ID]-[Activity Start Date (m/dd/yy)]-[Activity Type]

Table 4: Station Information for WQX EDD templates

Station ID	Station Name	Station Description	Alternate Station ID	Alternate Station Source
ANTLP01	Antelope Creek at the mouth	Antelope Creek at the mouth	Y02ANTPC01	MDEQ_WQ_WQX
ANTLP02	Antelope Creek d/s Shy Creek Road crossing	Antelope Creek d/s Shy Creek Road crossing		
CTNWD01	Cottonwood Creek at the mouth	Cottonwood Creek at the mouth near Brackett Creek road Shields River crossing		
ELK01	Elk Creek at the mouth	Elk Creek downstream of Elk Creek Road		
FLTHD01	Flathead Creek at the Wilsall Rodeo Fairgrounds	Flathead Creek at the Wilsall Rodeo Fairgrounds		
PRCPN01	Porcupine Creek near the mouth	Porcupine Creek near the mouth	Y02PORPC50	MDEQ_WQ_WQX
PTR01	Potter Creek at the mouth	Potter Creek upstream of Potter Creek Road		
ROCK01	Rock Creek at the mouth	Rock Creek at the mouth	Y02ROCKC95	MDEQ_WQ_WQX
SHIELD01	Shields River near the mouth	Shields River at Old Convict Grade road crossing	Y02SHLDR50	MDEQ_WQ_WQX
SHIELD02	Shields River below Grannis	Shields River below the town of Grannis		
SHIELD03	Shields River below Cottonwood Cr & Clyde Park	Shields River below Cottonwood Creek & Clyde Park		
SHIELD04	Shields River above Cottonwood Creek	Shields River above Cottonwood Creek at Brackett Creek Road crossing		
SHIELD05	Shields River below Antelope Creek & unnamed trib	Shields River below Antelope Creek & unnamed trib		
SHIELD06	Shields River above Antelope Creek	Shields River above Antelope Creek		
SHIELD07	Shields River below unnamed trib	Shields River below Indian Creek Road	Y02SHLR02	MDEQ_WQ_WQX
SHIELD08	Shields River below Flathead Creek	Shields River below Flathead Creek		
SHIELD09	Shields River above Flathead Creek	Shields River upstream of Flathead Creek below Horse Creek Road		
SHIELD10	Shields River above Elk Creek	Shields River above Elk Creek upstream of Elk Creek Road	Y02SHLDR24	MDEQ_WQ_WQX

Table 4: Station Information for WQX EDD templates

Station ID	Station Name	Station Description	Alternate Station ID	Alternate Station Source
SHIELD11	Shields River below South Fork Shields River	Shields River below South Fork Shields River	3345SH01	MONT_DEQ_WQX
SHLDCANAL01	Shields Canal d/s of Shields Lane road crossing	Shields Canal downstream of Shields Lane road crossing		
SHLDCANAL02	Shields Canal at the Wilsall Rodeo Fairgrounds	Shields Canal at the Wilsall Rodeo Fairgrounds		

7.0 SCHEDULE FOR COMPLETION

This monitoring will be completed during August or September of 2010 and July of 2011. Reporting will be fully completed by January of the following year for each event (i.e. Jan, 2011 and Jan, 2012).

8.0 PROJECT TEAM AND RESPONSIBILITIES

Sampling under this SAP will be split between two external contracts: one for the 2010 event and one for 2011 event. The 2010 contractor is PBS&J. Team members and their responsibilities for the 2010 sampling event are detailed below. Project personnel for the 2011 sampling event will not be determined until a second contract is awarded in 2011, but will most likely include the same members.

Team Member	Affiliation	Responsibilities
Christina Staten	DEQ	DEQ Project Manager, QA oversight during sampling activities
Gary Ingman	PBS&J	PBS&J Project Manager
Jeff Dunn	PBS&J	Field lead and management of field data
Erich Weber	PBS&J	Assistance with data collection, management of laboratory data, and EQuIS upload
Energy Laboratories	Lab	Analytical services
Chris Shirley	DEQ	DEQ Quality Control Coordinator; will provide QA of field and laboratory data
Jolene McQuillan	DEQ	Final WQX approval and upload
Mindy McCarthy	DEQ	DEQ Quality Assurance Officer; overall project QA oversight

9.0 REFERENCES

DEQ 2005a. Water Quality Planning Bureau Field Procedures Manual for Water Quality Assessment Monitoring. Montana Dept. of Environmental Quality, WQPBWQM-020, revision 2. April 21, 2005. *Available at http://deq.mt.gov/wqinfo/QAProgram/PDF/SOP%20WQPBWQM-020.pdf*

DEQ. 2005b. Quality Assurance Project Plan (QAPP) Sampling and Water Quality Assessment of Streams and Rivers in Montana, 2005. *Available at* http://deq.mt.gov/wqinfo/QAProgram/default.mcpx

DEQ. 2008. Sample Collection and Laboratory Analysis of Chlorophyll-a Standard Operating Procedure. Montana Dept. of Environmental Quality, WQPBWQM-011, revision 4. June 5, 2008. *Available at* http://deq.mt.gov/wqinfo/QAProgram/PDF/SOP%20WQPBWQM-011v4_final.pdf

APPENDIX A – CHLOROPHYLL A PHOTO PACKET

REACH PHOTO: 10 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

REACH PHOTO: 38 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

REACH PHOTO: 44 mg/m2

REACH PHOTO: 96 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

REACH PHOTO: 106 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

REACH PHOTO: 152 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

REACH PHOTO: 154 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

REACH PHOTO: 202 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

REACH PHOTO: 235 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

SUBSTRATE PHOTO: 15mg/m2

SUBSTRATE PHOTO: 23mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

SUBSTRATE PHOTO: 23mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

SUBSTRATE PHOTO: 44 mg/m2

SUBSTRATE PHOTO: 60 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

SUBSTRATE PHOTO: 106 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

SUBSTRATE PHOTO: 137 mg/m2

Collect chlorophyll at sites where growth is estimated to be >50 mg/m2. If in doubt, collect a sample

Appendix B

Shields River Watershed Nutrient and Chlorophyll Monitoring
SAP ID: Y02TMDL02SAP-01

Analyte Checklist with Analytical Method, Required Reporting Limit, Collection Container, Preservation Method, and Holding Time

Analysis	Parameter	Preferred Method	Alternate Method	Req. Report Limit ug/L	Holding Time Days	Bottle	Preservative
	Water Sample - Common Ions and Physical Parameters						
☒	Total Suspended Solids (TSS)	A 2540D	EPA 160.2	4000	7	1L HDPE	$\leq 6^{o}C$
	Water Sample - Nutrients						
☒	Total Persulfate Nitrogen (TPN)	A 4500-N C	A 4500-N-B	50	30	250ml HDPE	$\leq 6^{o}C$
☒	Dissolved Orthophosphate as P	EPA 365.1	A4500-P F	1	2	250ml HDPE	Filt. 0.45 um, frozen
☒	Total Phosphorus as P	EPA 365.1	A 4500-P F	5	28	250ml HDPE	H_2SO_4, $\leq 6^{o}C$
☒	Nitrate-Nitrite as N	EPA 353.2	A4500-NO3 F	10			
☒	Total Ammonia as N	EPA 350.1	A4500-NH3 B,C,D,E, or G	50			
	Chlorophyll-a						
☒	Chlorophyll-a (in water)	A 10200 H			21 (pH $\geq$ 7) ASAP (ph $\leq$7) [1]	Variable	Frozen [2]
☒	Ash Free Dry Weight (For template and hoop samples only)	SM 10300C-5					

Note 1: Solid/filter samples taken from water having a pH 7 or higher will be placed in airtight plastic freezer bags and stored frozen for not more than 21 days. Samples from acidic water must be processed promptly to prevent chlorophyll-a degradation.
Note 2: Freeze samples only if filtered or hoop sample. Samples requiring filtration will not be frozen until filtered.

Adapted from Title 40 Code of Federal Regulations, Parts 136-149. 2007 ed.

Appendix C

Shields River Watershed Nutrient and Chlorophyll Monitoring QA/QC Checklist and Data Qualifiers

SAP ID: Y02TMDL02SAP-01

QUALITY CONTROL CHECKLIST

Site Visit Field Forms

__ All sample sites match locations specified in SAP. If not, provide reasoning.

__ All field forms complete. If incomplete areas cannot be completed, document the issue.

__ Reviewed site visit notes and field logs. Documented:

- __ Failures to calibrate and check field instruments as required in SAP
- __ Field equiment problems or failures
- __ Variations from field protocols described in the SAP (e.g. sampling equipment, sampling methods, preservation methods, photo documentation)

__ Completed cursory review of physical parameter readings and documented inconsitencies

__ Field duplicates collected at the proper frequency (specified in SAP)

__ Field blanks collected at the proper frequency (specified in SAP)

Chains of Custody, Laboratory Forms, and Analytical Results

__ Reviewed Chains of Custody and condition of samples upon receipt:

- __ Cooler/sample temperature
- __ Proper collection containers
- __ All containers intact
- __ Sample pH of acidified samples <2

__ Holding times met

__ All sample IDs match those provided in the SAP. Field duplicates are clearly marked on samples and noted as such in lab results

__ Analytical analyses carried out using analytical methods defined in the SAP

__ 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. (The DEQ PM will set the criteria for determining associated data. Contact the DEQ PM to discuss blank results prior to flagging data)

__ Laboratory blanks/duplicates/matrix spikes/lab control samples were analyzed at a 10% frequency

__ Laboratory blanks/duplicates/matrix spikes/lab control samples were all within the required control limits defined within the SAP

__ Field blanks and duplicates were all within the required control limits specified in the SAP

__ Completed cursory review of chlorophyll a photos. Photo visual estimates appear to be consistent with laboratory values.

QC Summary

__ Project Data Quality Objectives (DQOs) and Data Quality Indicators (DQIs) were met (as described in SAP)

__ Data completeness requirements were met (specified in SAP). If not, explain why and provide a completeness assessment table like the example shown in Table C-3.

__ Completed draft summary of QC analysis results, including summary of flagged results, issues encountered, and how issues were addressed (corrective action)

MT-eWQX Electronic Data Deliverable (EDD) Completion

Completed QA review of populated MT-eWQX EDD templates prior to submittal to DEQ Project Manager. Reviewed for:

__ Transcription errors

__ Completeness (all sites and parameters entered)

__ SAP specified data and formats

- __ Project Name, Description, and ID match those provided
- __ Station IDs, Names, Descriptions, and Alternate Station IDs are entered correctly
- __ Activity IDs follow stipulated format

Table C-1. 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.

Laboratory flags will be entered in the Result Qualifier field in the WQX templates. Refer to the SAP for more information on how to qualify associated data.

Table C-2. Quality control terminology and descriptions

FIELD QC		
Term	**Description**	**Purpose/Usage**
Trip Blanks	Used only for VOC (Volatile Organic Chemicals). Alias VOA (volatile organic analysis)	To determine if cross contamination occurs between samples.
Field Blank	Reagent water exposed to field sampling conditions	Monitors contamination resulting from field activities and or ambient levels of analytes present at time of sampling.
Field Duplicate	Two independent samples taken under the same conditions. For solids; two samples which are co-located (taken side by side.) Water samples would be two independent samples taken at the same location at the same time.	To determine the homogeneity of the samples collected.
Field Replicate	A single sample is obtained, homogenized, then slit into multiple samples	Monitors laboratory precision independent of laboratory operations.
LABORATORY BATCH QC		
Acronym	**Description**	**Definition**
LRB/Method Blank	Laboratory Reagent Blank	An aliquot of reagent water or other blank matrices that are treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, and internal standards that are used with other samples. The LRB is used to determine if method analytes or other interferences are present.

LFB/LCS	Laboratory Fortified Blank; Laboratory Control Sample	Reagent water spiked with a known amount of analyte. Ideally treated exactly like a MS/LFM. Control used to determine bias in sample spikes.
MS/LFM	Matrix Spike/Laboratory Fortified Matrix .	An aliquot of an environmental sample to which known quantities of the method analytes are added in the laboratory. The LFM is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate aliquot and the measured values in the LFM corrected for background concentrations
MSD/LFMD	Matrix Spike Duplicate/Laboratory Fortified Matrix Duplicate	Determine method precision in sample concentrations are < 5X the RL.
DUP	Duplicate	Determine method precision in sample concentrations are > 5X the RL.
QCS	Quality Control Sample	A solution of method analytes of known concentrations which is used to fortify an aliquot of reagent water or sample matrix. The QCS is obtained from a source external to the laboratory and different from the source of calibration standards. It is used to check either laboratory or instrument performance
SRM	Standard Reference Material	Primarily used as a QCS to verify instrument calibration.
LABORATORY ANALYSIS QC		
Acronym	**Description**	**Definition**
ICB	Initial Calibration Blank	Monitors instrument drift at low end of cal curve.
CCB	Continuing Calibration Blank	Monitors instrument drift at low end of cal curve.
ICV	Initial Calibration Blank	Monitors instrument drift at a defined concentration near the mid range of cal curve.
CCV	Continuing Calibration Blank	Monitors instrument drift at a defined concentration near the mid range of cal curve.
IPC	Instrument Performance Check	Monitors instrument drift at a defined concentration near the mid range of cal curve.
MS/LFM	Matrix Spike/Laboratory Fortified Matrix .	An aliquot of an environmental sample to which known quantities of the method analytes are added in the laboratory. The LFM is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate aliquot and the measured values in the LFM corrected for background concentrations
MSD/LFMD	Matrix Spike Duplicate/Laboratory Fortified Matrix Duplicate	Determine method precision in sample concentrations are < 5X the RL.
DUP	Duplicate	Determine method precision in sample concentrations are > 5X the RL.

QCS	Quality Control Sample	A solution of method analytes of known concentrations which is used to fortify an aliquot of reagent water or sample matrix. The QCS is obtained from a source external to the laboratory and different from the source of calibration standards. It is used to check either laboratory or instrument performance
SRM	Standard Reference Material	Primarily used as a QCS to verify instrument calibration.
IDL	Instrument detection limit	Signal just above baseline. 3-5x the STD DEV of 7 replicates of a blank. Not used for quantification.
MDL	Method detection limit	Statistical determination of the lowest concentration of an analyte with 95% certainty the analyte is present.
PQL	Practical Quantitation Limit	3-5x the MDL. Lowest level that quantification is determined
RL	Reporting Limit	Value a Laboratory reports results. Usually the PQL.

Table C-3: Example Completeness Evaluation Table

	TSS	**TP**	**NH3**	**NO2+ NO3**	**TPN**	**SRP**	**Hard**	**Metals** in combination	**Field measures** in combination	**Field notes** complete	**Discharge**, measured	**Discharge**, estimated		Total #	Total %
Total # of Analytical Tests Requested in SAP	**42**	**33**	**8**	**33**	**33**	**8**	**53**	**389**	**234**	**62**	**58**	**19**		**953**	**100%**
Total # of Analytical Tests Reported	36	29	4	29	29	5	48	346	214	55	39	16		834	88%*
Tests not performed	6	4	4	4	4	3	5	43	20	7	19	3		119	12%*
Total # of Tests H Flagged (counted against completeness)	11	0	0	0	0	0	0	0	0	0	0	0		11	1%**
Total # of Tests J Flagged (not counted against completeness)	5	0	0	0	0	0	0	88	0	0	0	0		93	11%**
Total # of Tests B Flagged (not counted against completeness)	0	0	0	0	0	0	0	0	0	0	0	0		0	0%**
Total # of Tests Useful	25	29	4	29	29	5	48	346	214	55	39	16		834	100%**
Overall Completeness	60%	88%	50%	88%	88%	63%	91%	89%	91%	89%	67%	84%		86%	