



**APPENDIX F**

**RESTORATION EFFECTIVENESS MONITORING PROTOCOL FOR  
THE BLACKFOOT WATERSHED**



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# RESTORATION EFFECTIVENESS MONITORING PROTOCOL FOR THE BLACKFOOT WATERSHED

## 1.0 INTRODUCTION

The Blackfoot River watershed has been the focus of extensive stream restoration activities over the past several years, with the scope of restoration activities increasing in recent years. Restoration activities undertaken by various entities, including but not limited to, Montana Department of Fish Wildlife and Parks (FWP), the Blackfoot Challenge, and the Big Blackfoot Chapter of Trout Unlimited (BBCTU) have focused on fisheries restoration, water conservation, and mitigation of impaired streams as identified on the State of Montana 303(d) list. Due to the increasing scope of restoration activities in the watershed, and specific needs tied to certain restoration project funding sources, the restoration partners have identified a growing need for an established restoration monitoring program and protocol designed to document the effectiveness of restoration activities in the watershed in terms of immediate and long-term attainment of restoration goals.

This document presents a conceptual plan for restoration effectiveness monitoring in the Blackfoot Watershed. The purpose of this Restoration Effectiveness Monitoring Plan is to provide a common reference for restoration planners to determine appropriate monitoring parameters/activities and protocol to utilize on a given restoration project. Specific objectives of this document include:

- Promoting inclusion of appropriate pre- and post-restoration monitoring in ALL stream and riparian area restoration projects within the watershed;
- Establishing monitoring protocol and procedures to be employed for restoration monitoring to ensure consistency in data collection efforts between projects and between various organizations/agencies involved with stream and riparian area restoration; and
- Providing a tool for use in the planning and design phase of restoration projects throughout the watershed.

Attainment of these objectives will not only assist project planners in the design and implementation of appropriate restoration effectiveness monitoring on their projects, but should also result in a greater degree of consistency in the scope of monitoring, and monitoring methodologies employed, both from project to project and through time. This in turn will lead to development of a comprehensive database of restoration-related data and information collected under consistent methods, thus facilitating informational sharing among projects and, potentially, reduced monitoring costs in the long-term.

This Restoration Effectiveness Monitoring Plan is intended to serve as a guide to restoration project monitoring. The plan outlines various monitoring activities that should be considered for inclusion on restoration projects, depending on the restoration project objectives and/or

impairment conditions associated with the project. The specific scope of monitoring to be applied for a given project should be determined by the individuals and agencies involved in the project, with the scope of monitoring dependent on specific project needs as well as possible budget constraints. However, it is hoped that through consultation of this plan, all restoration projects will be monitored to the extent necessary to allow determination of the effectiveness of the restoration action, with a level of consistency in monitoring methodology so that data may be used by other restoration and land use planners in the watershed.

This document is designed to be a quick reference for restoration planners evaluating potential monitoring needs for their projects. Section 2 outlines monitoring parameters/activities, such as stream substrate characterization or water temperature monitoring, that may be applicable to restoration projects based on project objectives and goals, and stream impairment conditions. Section 3 summarizes actual protocol, or methodologies, to be employed for specific parameter measurement (i.e., streamflow measurement by USGS protocol).

## 2.0 RESTORATION EFFECTIVENESS MONITORING METRICS

Appropriate measures of restoration effectiveness will vary depending on the particular goals and objectives of the restoration project, be they restoration of aquatic habitat, maintenance of in-stream flow, or irrigation efficiency improvements. The various types of metrics used to assess the status of a water body generally include biological, physical, and chemical measurements. Table 2-1 shows suggested metrics to be used for restoration projects depending on the restoration goals and/or the particular water body impairment.

Biological metrics are particularly appropriate for many types of restoration effectiveness monitoring, due to their capacity to provide information on overall stream health by integrating the effects of many potential sources of impairment. For example, fish populations and macroinvertebrate community structure and abundance both will respond favorably to improvements in aquatic habitat and riparian conditions, as well as reductions in loads of specific pollutants such as nutrients or metals. Measurements of pollutant concentrations through water quality sampling should, if possible, be supplemented by one or more biological metrics to provide a more comprehensive representation of stream status and response to restoration activities. Note that biological metrics are typically more labor-intensive and expensive to conduct than water quality sampling; therefore, careful planning is important for conducting biological surveys.

As shown in Table 2-1, each restoration project category has multiple monitoring metrics identified as potentially applicable with some categories, such as “Excess Siltation in Stream Substrate”, showing the majority of metrics as applicable. This does not mean that all of the identified monitoring metrics need be, or should be, included. Instead, a suitable suite of parameters should be selected by project planners based on the specific project scope and needs, as well as availability of funding. It should also be noted that the list of monitoring metrics in Table 2-1 is by no means exhaustive. For instance, the methods included for quantifying stream substrate composition (percent fine content measurements and McNeil core sampling), represent only two of numerous methods available for stream substrate characterization. Other common methods, such as Wohlman Pebble Counts and Riffle Stability Index, may be equally as applicable. However, the list of metrics included in this document are intended to provide a reasonable spectrum of measurement options, from relatively simple semi-qualitative methods to more intensive methods, to fit most project needs and budgets. The number of methods has intentionally been kept short in order to promote consistency in the data collection methodology throughout the watershed. Specific monitoring protocols are summarized in Section 3.

**TABLE 2-1. RESTORATION EFFECTIVENESS MONITORING METRICS APPLICABLE TO VARIOUS RESTORATION OBJECTIVES/IMPAIRMENT SOURCES**

| METRICS                             | RESTORATION PROJECT OBJECTIVES/IMPAIRMENT CAUSES |                     |                            |                             |                  |                           |                        |                           |
|-------------------------------------|--------------------------------------------------|---------------------|----------------------------|-----------------------------|------------------|---------------------------|------------------------|---------------------------|
|                                     | In-Stream Flow Maintenance                       | Habitat Restoration | Reduce Substrate Siltation | Reduce Thermal Modification | Reduce Ag Runoff | Riparian Area Restoration | Reduce Elevated Metals | Reduce Elevated Nutrients |
| <b>BIOLOGICAL METRICS</b>           |                                                  |                     |                            |                             |                  |                           |                        |                           |
| Fish Population Surveys             | X                                                | <b>X</b>            | X                          | X                           | X                | X                         |                        |                           |
| Redd Counts                         | X                                                | <b>X</b>            | X                          | X                           | X                | X                         |                        |                           |
| Macroinvertebrate Sampling          | X                                                | X                   | X                          | X                           | X                | X                         | X                      | X                         |
| Periphyton Sampling                 | X                                                | X                   | X                          | X                           | <b>X</b>         |                           |                        | X                         |
| Chlorophyll-a                       |                                                  |                     |                            |                             | <b>X</b>         |                           |                        | X                         |
| <b>PHYSICAL PARAMETERS</b>          |                                                  |                     |                            |                             |                  |                           |                        |                           |
| Habitat Assessments                 | X                                                | X                   |                            |                             |                  | <b>X</b>                  |                        |                           |
| Riparian Assessment                 |                                                  | X                   | X                          | X                           | X                | <b>X</b>                  |                        |                           |
| Water Temperature                   | X                                                | X                   | X                          | <b>X</b>                    | X                | <b>X</b>                  |                        |                           |
| Flow Monitoring                     | <b>X</b>                                         |                     |                            | X                           |                  |                           | <b>X</b>               | <b>X</b>                  |
| Photo Points                        | <b>X</b>                                         | <b>X</b>            | <b>X</b>                   | <b>X</b>                    | <b>X</b>         | <b>X</b>                  | <b>X</b>               | <b>X</b>                  |
| <b>WATER CHEMISTRY</b>              |                                                  |                     |                            |                             |                  |                           |                        |                           |
| TSS Samples                         |                                                  |                     | <b>X</b>                   |                             | <b>X</b>         |                           | X                      | X                         |
| Nutrient Sampling                   |                                                  |                     |                            |                             | <b>X</b>         |                           |                        | <b>X</b>                  |
| Metals Sampling                     |                                                  |                     |                            |                             |                  |                           | <b>X</b>               |                           |
| <b>STREAM SUBSTRATE COMPOSITION</b> |                                                  |                     |                            |                             |                  |                           |                        |                           |
| McNeil Core Samples                 |                                                  | X                   | <b>X</b>                   |                             |                  | X                         |                        |                           |
| Percent Fine Sediment Content       |                                                  | X                   | <b>X</b>                   |                             |                  | X                         |                        |                           |

X – Metrics marked in bold should be given primary consideration for monitoring

TSS- Total Suspended Sediment

## **3.0 RESTORATION MONITORING PROTOCOL**

The following monitoring protocols represent methodologies and practices generally accepted and commonly used for biological, physical and chemical characterization of aquatic and riparian systems. These protocols have been compiled by the Blackfoot Challenge, with input from various restoration partners. For instance, the Department of Fish, Wildlife and Parks provided methodologies for fish population surveys, redd counts, habitat assessments, and water temperature monitoring. FWP has been the primary entity performing these monitoring activities in the past, and should be consulted when these monitoring activities are being considered for restoration projects.

### **3.1 BIOLOGICAL MONITORING**

#### **3.1.1 Fish Population Surveys**

Depending on the survey objectives, fish population surveys take many different forms. Methods generally involve fish collections using traps, seines, electrofishing or other methods. In some cases, population surveys may involve direct observations of fish (eg. Snorkeling) or of spawning activity (redds). Restoration-related fish population surveys often involve electrofishing means. These methods usually involve some quantification of densities or biomass using single-pass, mark-recapture, or multiple pass-depletion methods. Other information typically collected includes age/length structure, species identification

#### **3.1.2 Redd Counts**

Counting spawning sites (redds) is a standard method of assessing the numbers of adult spawning fish within a spawning area or for a given population. Redd counts are not considered a useful method for certain spring spawning fish in environments where high water and turbidity confounds the identification of redds. Redd counts work best for fall spawning fish (brown trout and bull trout) or in spring creeks. Counts were made by walking the spawning areas shortly after the spawning period. Redd areas were identified by a cleaned, oval shape (pit), and a mound of unconsolidated gravel (tailspill) left by the females digging activities. Only redds where a definite pit and tailspill were discernable are counted. Redd counts are often made in index reaches where surveys are completed annually in order to assess population trends.

#### **3.1.3 Macroinvertebrate Sampling**

In instances where restoration project objectives include fisheries restoration, pre- and post-restoration macroinvertebrate sampling should be considered. Besides serving as an indicator for general water quality and substrate conditions, macroinvertebrate populations represent an integral component of a functioning biological system and will therefore help in determining restoration project success and/or beneficial use support associated with aquatic life. Careful consideration should be given to the need for and utility of macroinvertebrate sampling due to the considerable expense.

### **Procedure:**

When conducting macroinvertebrate sampling, two general methods can be used; the quantitative and qualitative methods. The quantitative sampling method uses a Hess or Surber sampler, and is the preferred sampling method. When sampling by the quantitative method, sampling should include collection of multiple samples (replicates) at each site to allow for statistical analysis of the data. Typically, between 3 and 8 replicate samples are recommended depending on the suspected site variability, level of analysis required, and budgetary constraints. In most cases, 4 replicate samples per site should suffice for evaluating restoration effectiveness. The qualitative method uses a kick net for sample collection. The qualitative method is quicker and generally less expensive than the quantitative method, but yields less reliable results.

Macroinvertebrate sampling should be performed by experienced personnel following MDEQ's Rapid Bioassessment Protocols, Standard Operating Procedures 12.1.3.1 (Quantitative Method) or 12.3.1.2 (Qualitative Method). The MDEQ protocols are available upon request from the Blackfoot Challenge, or at:

<http://www.deq.state.mt.us/wqinfo/monitoring/SOP/pdf/12-1-3.pdf>

If preferred, comparable procedures, such as the EPA Rapid Bioassessment Protocol, can be used provided they are consistent with substantive portions of the MDEQ protocol. When quantitative macroinvertebrate sampling is performed, it should also be performed in a manner consistent with the Status and Trends macroinvertebrate sampling to allow for comparison to the basin-wide Status and Trends data.

### **Monitoring Sites/Schedule:**

Due to the considerable cost associated with macroinvertebrate sample analyses, careful consideration should be afforded to selection of sampling locations and schedules. Ideally, a minimum of two sampling sites should be established within and/or downstream of the restored stream segment. However, if budget constraints dictate, one sampling site properly located within the restored segment may suffice (see MDEQ SOPs for sample site selection). Once established, sampling sites should be photographed, and described using the Rapid Bioassessment Protocol Physical Evaluation Form and Contractor Evaluation Form provided with the MDEQ SOPs.

Macroinvertebrate sampling should occur at least once prior to and once after restoration. Sampling should occur after runoff, preferably in August/September, although samples can be collected later in the year if necessary. Sampling should not be conducted immediately after large storm-related runoff events.

#### **3.1.4 Periphyton/Chlorophyll a Sampling**

Periphyton refers to the assemblage of algae living attached to or in close proximity to the stream substrate. These assemblages represent the principle source of primary productivity in most Montana streams. In general, excessive crops of periphyton are indicators of poor

water quality, particularly elevated nutrient concentrations. In addition, species composition, diversity and abundance can be used as a measure of overall stream ecological health, since different species show variable sensitivity to potential impairment causes such as temperature, nutrients, and toxic constituents. Periphyton analyses may include quantification of chlorophyll a, and/or taxonomic identification to varying levels of precision. The methods chosen will depend on the specific project objectives.

**Procedure:**

MDEQ protocol divides periphyton sampling into three tasks of increasing complexity:

- Field observations;
- Standing crop/chlorophyll a sampling; and
- Community composition and structure sampling.

Field observations include completion of an Aquatic Plant Field Sheet, which records information on general composition, amount, color, and condition of aquatic plants and is equivalent to a Level I Rapid Bioassessment Protocol for plants (similar to the RBP for macroinvertebrates). Semi-quantitative assessments of biomass and taxonomy may also be conducted using a field-based rapid periphyton survey technique, which involves use of a gridded viewing bucket and a biomass scoring system.

Collection of samples for chlorophyll a analysis can include targeted sampling (sampling of heaviest accumulations of attached algae in a sampling transect), or more random sampling and direct extraction of chlorophyll a from streambed rocks. In both cases an estimate of amount of chlorophyll a per unit area of streambed is generated. Finally, collection of samples for laboratory identification of community composition and structure basically involves scraping rock surfaces, lifting algal film from nearshore sediments, and scraping several submerged branches.

Standard Operating Procedures for periphyton and chlorophyll a sampling have been developed by MDEQ, and are available at the following web address (comparable procedures may also be used):

<http://www.deq.state.mt.us/wqinfo/monitoring/SOP/pdf/12-1-2-0.pdf>

**Monitoring Sites/Schedule:**

Similar to macroinvertebrate analysis, periphyton analysis (identification of community structure and composition) is a time-consuming, labor-intensive, and thus relatively expensive endeavor. Thus, the objectives of sampling and the potential data uses should be thoroughly assessed prior to collecting samples for periphyton. Ideally, a reference site should be established to evaluate baseline conditions, in addition to 1 or 2 monitoring locations within and/or downstream of the restored stream section. For high-gradient streams, one periphyton sampling site should cover a single riffle, while in low-gradient streams, the sampling site should consist of at least one meander length (about 20 bankful channel widths).

The recommended time for periphyton sampling is summer (late June through September). During this period, stream flow is relatively stable, and most streams exhibit peaks of both periphyton standing crop (biomass) and community diversity. If temporal trends are to be assessed by repeated sampling over a number of years, the time of sampling should remain consistent from year to year to minimize seasonal variance.

## **3.2 PHYSICAL PARAMETERS**

### **3.2.1 Habitat Assessments**

Methods of assessing aquatic habitat vary greatly depending on the scale of the project and the specific survey objectives. An excellent reference for determining scale and objectives is found in *Aquatic Habitat Assessment: common methods* (Bain and Stevenson, 1999). At a restoration project level, habitat survey methods should focus on survey precision and repeatability necessary for post-project evaluation. Habitat surveys almost always involve a longitudinal and areal description of channel bed forms including pools, riffles and channel complexity. Habitat survey methods often involve geomorphic assessments, stream bank condition and riparian health, measurements of flow, water temperature and water quality, substrate compositions and instream wood counts.

### **3.2.2 Riparian Assessment**

Assessment and monitoring of riparian areas is a critical step in assessing riparian system health. Initial stream reach inventories can be used as indicators of problem areas and identification of potential solutions to unstable stream situations. These same assessment techniques can also be used to observe changes over time, especially to gauge progress in restoring health and vigor to riparian systems functioning at levels below their potential.

Vegetation in stream zones is the best terrestrial indicator of stream health and function. Healthy vegetation within the watershed, especially within the riparian corridor, is the best indicator of a proper functioning stream system from a biological and hydrological perspective. Vegetation is also the component of a watershed over which a land manager has the most influence.

Consequently, when riparian vegetation is not in a healthy state, management changes may be warranted. Riparian areas are complex systems and thus present numerous options to the land manager to make positive changes in management, especially when dealing with grazing animals. If management of these areas is part of an unhealthy stream system, management changes must then be part of any solution to enhance riparian health. Downward trends in vegetation health can be reversed relatively quickly with positive changes in management of grazing animals.

Physical and biological processes occurring in riparian areas are sustainable in a healthy stream system. These processes are complex but need to be in balance to maintain a proper functioning, stable system. Inventory, assessment techniques used to gauge the health of these systems therefore need to account for this complexity.

Two riparian assessment techniques are recommended for use in the Blackfoot Watershed, as described below. Both techniques account for the complexity of riparian systems, yet are relatively user friendly to those familiar with inventory techniques, and also provide repeatable, quantifiable data. Whatever process is used for an initial inventory of the riparian system, it should quantify current condition, assess problems, and be repeatable. The first method was developed by the NRCS and is a relatively quick means of assessing riparian conditions. The second method is the USFS Green Line method, which is slightly more complex, yet should be readily implementable on most restoration projects. The appropriate method to use for specific restoration projects should be based on the project scope and budget, and importance of riparian conditions to the project goals and objectives.

The first riparian evaluation recommended for use in the Blackfoot Watershed is the Riparian Assessment procedure and field form developed by the USDA NRCS (USDA, 2004). This evaluation gives the user a good overview of a particular stream reaches status of the ecological and physical processes interacting at a site. This assessment will indicate problem areas within a stream system and yields a numeric rating which can be used to indicate trends through time. This evaluation technique is a relatively quick method for trained observers to utilize and will indicate specific physical or biological problems for more detailed inventory/analysis. The NRCS protocol document and filed forms are available at the following website, or from the Blackfoot Challenge upon request:

<http://www.mt.nrcs.usda.gov/technical/>

The stream reach evaluated should be well identified and documented (e.g. gps points, aerial photography, photo points) so that future evaluators can locate the same site. All pertinent observations should be recorded on the enclosed forms to enable future reference. The more notes/observations recorded during an assessment, the easier it will be for future evaluators to visualize the current conditions.

The second riparian evaluation method recommended for use is Monitoring the Vegetation Resources in Riparian Areas, USDA Forest Service, Technical Report RMRS-GTR-47 (USDA, 2000). Since vegetation is a key component in evaluating riparian health, this method zeroes in on one of the key monitoring tools for streams. This monitoring technique does require some technical knowledge of riparian vegetation, and thus should only be used when a more quantitative analysis of the riparian situation is desired. For example, when a grazing management problem is identified, a more detailed evaluation of the current vegetation condition may be warranted to enhance management changes. This monitoring technique also provides a more quantitative measure of vegetation trends through time. Sites where this technique is employed should again be accurately documented to ensure that assessment reaches can be relocated in the future.

The publication RMRS-GTR-47 is available from the Blackfoot Challenge upon request. The document can also be ordered from the USDA Forest Service Rocky Mountain Research Station at phone number (970) 498-1392, or downloaded from:

<http://www.fs.fed.us/rm>

### 3.2.3 Water Temperature

Water temperature measures now include programmable miniature temperature loggers. These loggers collect time and temperatures at user-defined intervals. Loggers can be record for several years if needed. Loggers can be downloaded in a manner that provide maximum, min and mean temperature values or as continuous data. Data can be easily manipulated in computer programs like EXCEL or can be statistically manipulated.

### 3.2.4 Flow Monitoring

Streamflow measurements should be recorded anywhere that restoration goals include maintenance of in-stream flow. In addition, accurate flow measurements are necessary for calculating loads of chemical constituents (e.g., nutrients, metals) within a water body. Streamflow measurements should be collected using one of three general methods, depending on the channel geometry and stream or seep discharge rate:

- Velocity-area method;
- Portable trapezoidal flume; or
- Volumetric method.

The velocity-area method is used to measure streamflow in larger, wadeable streams. Measurement of streamflow is performed in accordance with the area-velocity method developed by the USGS (USGS, 1977). In general, the entire stream width is divided into subsections and the stream velocity measured at the midpoint of each subsection and at a depth equivalent to six-tenths of the total subsection depth. The velocity in each subsection is then multiplied by the cross-sectional area to obtain the flow volume through each subsection. The subsection flows are then summed to obtain the total streamflow rate. Streamflow measurements are typically collected in a stream reach as straight and free of obstructions as possible, to minimize potential measurement error introduced by converging or turbulent flow paths. Streamflow measurement data should be recorded on specially prepared forms available from the Blackfoot Challenge.

Streamflow measurements on smaller streams or seeps are obtained using a portable flume such as a 90° v-notch cutthroat flume. This flow measurement method is based on equations developed by Skogerboe et al (1967). To measure streamflow, the flume is placed and leveled in the streambed, and the full streamflow directed through the flume throat. Water depth or head measurements are then collected at specified locations in the upstream ( $H_a$ ) and downstream ( $H_b$ ) sections of the flume. The head measurements are used to verify proper functioning of the flume and to calculate streamflow based on the water depth.

Collection of volumetric flow measurements consists of directing the flow into a container of known volume (such as a five-gallon bucket), and recording the time required to fill the known volume. Volumetric flow measurements are typically limited to monitoring points with small seepage flows (which can be diverted into a container) and discrete discharge points such as culverts and pipes.

### **3.2.5 Photo Point Monitoring**

Photo points should be established for all restoration projects to assure collection of adequate pre- and post-restoration photographs. Pre- and post-restoration photos are invaluable for visually portraying large scale changes in response to restoration activities and in presenting such information to the general public. Following are a few simple rules that should be applied when establishing photo points to ensure that Pre- and post- project photos capture the level of information desired.

- Photo points should be selected and established in the earliest stages of the project. This will allow pre-restoration photos to be taken for all seasons.
- Photo points should be permanently marked to facilitate future relocation and identification. Once selected, photo points should be marked in the field with a steel or wood stake and GPS coordinates recorded. Photo points should be assigned a unique site code name and the marker stake inscribed with the site code.
- Long view photos representative of the entire or large portion of the project area should have a distinct permanent landmark in the background such as a mountain peak, rock outcrop, etc. Other considerations when choosing photo point locations include:
  - Locations should be easily relocatable and accessible;
  - Make sure that future plant growth will not obscure view; and
  - Select sites that will portray the level and depth of information applicable to the project.
- Information on project photos should be recorded on special project photo forms for systematic documentation into a project photolog. Forms should include information such as: Project name and location; Photo point number and location; Direction of photo; Photograph date, time, and weather conditions; Photographers name; Dates of previous photos, if known; and any comments/notes by the photographer.

## **3.3 WATER QUALITY MONITORING**

Water quality monitoring needs for specific projects will depend on the restoration project objectives and the specific causes of impairment. In most cases, water quality monitoring needs will include nutrients, sediment, and/or metals. Monitoring for each of these general parameter groups is described below.

### **3.3.1 General Water Sampling Procedures**

#### **Procedure**

The USGS has published water quality monitoring protocol for sampling of metals, nutrient, and suspended sediment concentrations. These methods are widely accepted and used for water quality monitoring across Montana. Restoration effectiveness water quality monitoring conducted within the Blackfoot River drainage should be completed in

accordance with USGS protocol, or in accordance with comparable methods such as MDEQ protocol. USGS procedures are available at the following web address:

<http://water.usgs.gov/owq/FieldManual/>

Current MDEQ procedures are available at:

<http://www.deq.state.mt.us/wqinfo/monitoring/SOP/sop.asp>

Streamflow rates should be measured in conjunction with all water quality monitoring events to allow parameter loads (mass/time) to be calculated from parameter concentrations (mass/volume) determined through sampling. Comparison of parameter loads at multiple locations along a stream can be used to determine where load increases occur, and thus where sources of contaminant loading are located. Streamflow measurement should be performed as described in Section 3.2.

### **Monitoring Sites and Schedule**

When water quality sampling is performed to assess restoration effectiveness, samples should be collected upstream of the restoration area in addition to sampling within and downstream of the restored stream reach. Sampling upstream of the restoration project will document the quality of surface water entering the restoration stream reach, allowing variations in upstream water quality to be taken into account when evaluating restoration project effectiveness. For restoration projects encompassing relatively short segments of stream (1,000 feet or less), one monitoring site near the upstream boundary and a second site near the downstream boundary will generally be sufficient. For stream restoration projects encompassing longer stream segments, one or more internal monitoring sites should be added to document water quality trends through the project area.

A minimum of one pre-restoration and one post-restoration monitoring event is required to assess restoration effectiveness from a water quality improvement perspective. However, due to intrinsic variability in surface water quality due to streamflow and climatic conditions, multiple pre- and post-restoration monitoring events should be conducted over a number of years. Ideally, water quality data should be collected from various portions of the streamflow hydrograph, with the specific sampling schedule dependent on the water quality parameters of interest. For instance, sampling for metals concentrations should be performed during the rising limb and falling limb of the spring runoff peak and during baseflow conditions since different metals loading sources will predominate under differing flow conditions (see discussion below). Conversely, nutrient sampling should focus on summer and early fall baseflow conditions when nutrient-related water quality problems are generally most severe. Pre- and post-restoration data used for evaluating restoration effectiveness should be collected under similar climatic conditions since runoff from heavy precipitation events can greatly affect short-term water quality. In general, a minimum of three pre- and post-restoration monitoring events should be performed under appropriate flow and climatic conditions to allow restoration effectiveness to be evaluated with a reasonable level of

confidence. Following is additional detail on monitoring protocol for specific water quality parameters.

### **3.3.2 Nutrient Sampling**

Although nutrient pollution can result from a wide variety of sources, nutrient-related impacts to streams in the Blackfoot watershed will most likely be associated with agricultural runoff. Therefore, water quality monitoring for nutrients should be conducted for restoration projects associated with agricultural sources, and/or where the stream has been identified as impaired due to nutrients. In these cases, pre- and post-restoration water samples should be collected at the upstream and the downstream ends of the restoration project.

Table 3-1 includes a list of typical nutrient parameters for restoration projects, including total phosphorus, orthophosphate, nitrate plus nitrite (as nitrogen), ammonia (as nitrogen) and total kjeldahl nitrogen. This list will allow discrimination of the primary organic and inorganic forms of nitrogen and phosphorus. Samples for all parameters (except total phosphorus) should be filtered through a 0.45-micrometer filter in the field prior to placement in the sample container to remove particulate matter from the water sample that could affect analytical results.

When conducting nutrient sampling, the pre- and post-restoration sampling should be conducted during the same time of the year to prevent seasonal variations in nutrient concentrations from affecting the pre- and post-restoration comparison. Nutrient sampling should be performed during the summer months when water quality impacts from nutrients are expected to be greatest. Precipitation trends during and prior to sampling should be noted since runoff from intense precipitation events can greatly affect nutrient concentrations in streams through agricultural runoff.

**TABLE 3-1. ANALYTICAL PARAMETERS, SAMPLE REQUIREMENTS  
FOR NUTRIENT SAMPLING**

| <b>Parameter</b>              | <b>Detection Limit</b> | <b>Container</b>    | <b>Preservation</b>                                                            | <b>Holding Time</b> |
|-------------------------------|------------------------|---------------------|--------------------------------------------------------------------------------|---------------------|
| Total Phosphorus              | 0.01 mg/l              | 250 ml polyethylene | Add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C                        | 28 days             |
| Orthophosphate                | 0.01 mg/L              | 250 ml polyethylene | Filter to 0.45 micron, add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C | 28 days             |
| Nitrate+Nitrite as N          | 0.05 mg/L              | 50 ml polyethylene  | Filter to 0.45 micron, add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C | 28 days             |
| Ammonia as N                  | 0.1 mg/L               | 50 ml polyethylene  | Filter to 0.45 micron, add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C | 28 days             |
| Total Kjeldahl Nitrogen (TKN) | 0.5 mg/L               | 500 ml polyethylene | Filter to 0.45 micron, add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C | 28 days             |

### 3.3.3 Suspended Sediment Sampling

Total suspended sediment (TSS) monitoring will serve as the primary indicator of the effectiveness of restoration projects on water column sediment concentrations. Although other measures of water column sediment conditions (such as turbidity) are available, TSS monitoring represents the most direct measure of sediment levels within the water column available. Table 3-2 includes details on sample collection and handling for TSS.

Suspended sediment (or water column sediment) sampling will be applicable to many projects in the Blackfoot watershed due to the widespread nature of sediment-related impairment in the drainage. Excessive suspended sediment is not only detrimental to fish and other aquatic life, but also interferes with other beneficial uses such as irrigation water and drinking water supplies. Elevated suspended sediment concentrations also are indicative of or related to a myriad of other water quality problems and impairment causes, such as riparian degradation, agricultural runoff, substrate siltation, and elevated metals and nutrient concentrations. Therefore, documenting changes in suspended sediment concentrations through proper monitoring will be applicable to the majority of restoration projects in the Blackfoot watershed.

Pre- and post-restoration sampling for TSS must be performed under similar conditions to reduce the effects of natural variability in TSS concentrations. For instance, pre- and post-restoration samples should be collected from similar points on the annual hydrograph (rising limb, falling limb, baseflow) and during similar climatic conditions (extended dry periods, during or shortly after significant precipitation events), to exclude flow and weather-induced variations in TSS concentrations from the restoration effectiveness assessment. A minimum of three pre- and post-restoration TSS monitoring events should be performed under various

hydrologic and climatic conditions to adequately document restoration success. Monitoring should occur at the upstream and downstream boundary for smaller restoration projects (on the order of 1,000 feet in length), with one or more internal sites added for longer restoration projects.

**TABLE 3-2. ANALYTICAL PARAMETERS AND SAMPLE REQUIREMENTS FOR TOTAL SUSPENDED SOLIDS SAMPLING**

| <b>Parameter</b>       | <b>Detection Limit</b> | <b>Container</b>         | <b>Preservation</b> | <b>Holding Time</b> |
|------------------------|------------------------|--------------------------|---------------------|---------------------|
| Total Suspended Solids | 10 mg/L                | 1000 ml glass or plastic | Cool to 4°C         | 7 days              |

### 3.3.4 Metals Sampling

Monitoring of metals concentrations in surface water should be performed on all restoration/reclamation projects designed to reduce metals loading to surface waters. This may include abandoned mine reclamation projects or mitigation of other metals loading sources. When monitoring metals concentrations in stream restoration projects, the objectives are to determine how restoration activities affect in-stream metals concentrations, and to determine how post-restoration concentrations compare to applicable water quality standards presented in Circular WQB-7, the official list of Montana Numeric Water Quality Standards published by MDEQ.

Table 3-3 includes sample collection and handling requirements for metals analyses. Typically, metals of interest in assessing surface water quality may include aluminum, arsenic, cadmium, copper, iron, lead, manganese, zinc, or numerous other metals. Actual metals to be analyzed for a project should be based on specific metals impairments or loading sources. On projects where information on specific metals of concern is lacking, the above list of metals should be sufficient for documentation of metals impairment and restoration effectiveness.

With the exception of aluminum, all metals should be analyzed for total recoverable concentrations for comparability to the water quality standards. If applicable, aluminum should be tested for dissolved concentrations (sample should be filtered through 0.45 micron filter prior to acidification) since the aluminum standard is based on the dissolve concentration. Although not typically considered a pollutant, the metals calcium and magnesium should be included in metals sample analyses to determine the water hardness. Because water quality standards for certain metals are dependent on the water hardness,

calcium and magnesium concentrations should be used to determine the water hardness by the following equation:

$$H = [Ca^{2+} \times 2.497] + [Mg^{2+} \times 4.117]$$

Where: H= water hardness (as CaCO<sub>3</sub>) in mg/L  
 Ca<sup>2+</sup> = dissolved calcium concentration  
 Mg<sup>2+</sup>=dissolved magnesium concentration.

Similar to other water sampling protocol, pre- and post-restoration sampling for metals should be performed during similar hydrologic and climatic conditions to reduce the effects of natural variability in metals concentrations. A minimum of two pre- and post-restoration metals monitoring events should be performed under various hydrologic and climatic conditions to adequately document restoration success. Monitoring should occur at the upstream and downstream boundary for smaller restoration projects (on the order of 1,000 feet in length), with one or more internal sites added for longer restoration projects.

**TABLE 3-3. ANALYTICAL PARAMETERS AND SAMPLE REQUIREMENTS FOR METALS SAMPLING**

| Parameter                          | Detection Limit | Container           | Preservation                                                     | Holding Time |
|------------------------------------|-----------------|---------------------|------------------------------------------------------------------|--------------|
| TRC Metals                         | *               | 250 ml polyethylene | Add HNO <sub>3</sub> to pH<2, cool to 4°C                        | 6 mos        |
| Dissolved Calcium, Magnesium       | 1.0 mg/L        | 50 ml polyethylene  | Filter to 0.45 micron, add HNO <sub>3</sub> to pH<2, cool to 4°C | 6 mos        |
| Dissolved Aluminum (if applicable) | 0.05 mg/L       | 50 ml polyethylene  | Filter to 0.45 micron, add HNO <sub>3</sub> to pH<2, cool to 4°C | 6 mos        |

TRC-total recoverable. Specific list of metals to be analyzed dependent on project needs but may include arsenic, copper, cadmium, iron, lead, manganese, zinc, or other metals of interest.

\*Varies with metal. Detection limits for individual metals should be less than applicable water quality standard in WQB-7.

### 3.4 STREAM SUBSTRATE COMPOSITION

Stream substrate composition, or the distribution of sediment particle sizes in streambed sediments, can be an important measure of success and effectiveness for many stream restoration projects. Excessive fine sediment content, typically taken to be any sediment particles less than approximately 6 mm in size, can be detrimental to aquatic life and other beneficial uses. Changes in the fine sediment content of the stream substrate are also a useful measure of the effectiveness of specific restoration measures and objectives, such as reducing sediment runoff from roads or unstable streambanks. Following are two methods for documenting stream substrate composition before and after restoration actions. The Percent Fines Content method is a relatively simple measurement yielding semi-quantitative information on substrate composition, while the McNeil Core Sampling method provides more quantitative information. The specific method used on a project should depend on the scope of the project, importance of streambed siltation to the stream health and project objectives, and available funding. Other methods, such as Wohlman pebble counts, riffle

stability index, etc., may also be considered as long as standard methodologies are employed. Whichever method is chosen, the same method must be applied for the pre- and post-restoration monitoring to allow for direct comparison of the results.

### **3.4.1 Percent Fine Content**

#### **Procedure**

Percent fines content is calculated using a five-gallon bucket fitted with a clear plastic bottom. The bottom is marked with a grid of one-inch spaced lines, with a 6 mm wide space demarcated at each intersection. The bucket is then placed in the water, and the streambed viewed through the bucket. At each grid intersection (a total of 45), the size of the sediment particle below the intersection (greater than or less than 6 mm), is recorded. The percent fines content is then calculated from the percentage of intersection points with sediment particles less than 6mm. The procedure is described in MDEQ Standard Operating Procedure 11.8.6, Percent Fines Calculation at the following website:

<http://www.deq.state.mt.us/wqinfo/monitoring/SOP/pdf/11-8-6.pdf>

#### **Monitoring Sites/Schedule**

Percent fine sediment measurements should be taken in pool tails and riffles, with the distribution of measurements dependent on the relative abundance of each. For instance, if the reach contains 70% riffles and 30% pools, 70% of the measurements should be taken from riffles and 30% from pools. The total number of measurements to be taken depends of the size and variability of the stream in the restoration area, and importance of stream substrate composition to the project. A sufficient number of measurements should be made to adequately characterize the percent fines content of the stream substrate for the project purposes.

### **3.4.2 McNeil Core Samples**

McNeil core sampling provides more quantitative information on stream substrate composition than does the Percent Fine Content method, but is also more labor and equipment intensive. McNeil core sampling also requires that sediment samples be analyzed for grain size distribution, adding additional costs. However, collection of McNeil core samples should be considered where documentation of the percent fine sediment content in stream substrate before and after restoration is critical to project objectives.

The Helena National Forest has been conducting McNeil core sampling in the Blackfoot watershed for the past several years, resulting in an existing database of McNeil core data from the drainage. In order to ensure comparability of future restoration project sampling results with the existing database, McNeil core sampling performed for restoration projects should be conducted in a manner consistent with the HNF methodology. The following protocol was provided by the Helena National Forest. The general procedure is as follows:

**Required Equipment:**

- GPS Unit
- McNeil core sampler
- 1000 ml Imhoff cone
- 500 ml plastic bottle
- 5 gallon bucket with plastic bag liner

**Field Data to be Recorded:**

- Stream Name /Date /Location
- Observer Name
- Depth of core (6” for bull trout spawning gravel and 4” for cutthroat spawning areas)
- Site # and Core # with a description of the start point and the distance between points.
- Number of redds located at the site.
- GPS location
- Suspended sediment measure (ss) – The measurement of the depth of the water taken within the core sampler after the sample has been pulled into the reservoir, but the sampler is still in the stream.
- Imhoff cone measure (Imh) – Let the sample settle for approximately 20 minutes. If using a 500 ml bottle – double the total sediment reading in the cone (1000 ml) and multiply by 0.4. This will account for how much it would actually settle overnight.

**Field Procedure:**

- Locate a spawning site or a potential spawning site. (All successive sites will be located upstream from the first site.)
- Set up 5-gallon bucket with a plastic bag inside.
- Set up Imhoff cone.
- Write two identification tags on the flagging for each sample using a waterproof marker. One tag is short and will be placed inside the plastic bag with the sample and the other is long and will be used to tie the sample bag when finished. The tags contain the following information: Stream Name, Site #, and Core #.
- Place core sampler next to the existing redd, but not where it would be affected in any way by the coring (remember your feet). If the site is a potential site, place the core sampler where you would expect a redd.
- In a bull trout stream, take 6” of core, or 4” from the top of the inner rim on the McNeil sampler. (The inner cylinder is 10”.)
- In a cutthroat stream take 4” of core, or 6” from the top of the inner rim on the McNeil sampler.
- When drilling the core into streambed, try not to let it walk over the stream bottom. If it hangs up on a large rock go ahead and re-core. If a piece of rubble is too big to fit through the 10” cylinder leave it out of the sample.
- Once the core sampler is down to the appropriate depth, remove the material from the inner 10” cylinder and place into the inner reservoir. You are finished when you feel the top of the teeth at the bottom of the sampler.
- Use the ruler to measure the depth of the water from the bottom of the core sampler.

- Quickly fill the 500 ml bottle to capture the suspended sediments and pour it into the Imhoff cone.
- Slowly pull up the core sampler and place it on the 5 gallon bucket with the bag around the 10” cylinder.
- Empty the sample from the reservoir into the plastic bag through the 10” cylinder. Use extra wash water to carefully wash the extra sediment from inside the core sampler. Pick up the sampler and drain the rest of the water into the bag.
- Remove the bag from the plastic bucket and pour any remaining sediment and water into the bag.
- Place the short tag inside the bag.
- Twist the bag and tie it with many wraps of the long flagging.
- Record the GPS reading, the ss depth in inches and the Imhoff cone reading. Empty the water from the cone using the cap at the bottom and then replace it tightly! (Easy to lose.)

**Sample Analysis:**

- Samples are processed by passing the sample through a set of soil sieves and recording the weight of soil passing through each sieve. The percent passing each sieve is then plotted against the sieve sizes on a semi-log plot to provide the grain size distribution of the sample. Samples should be passed through a stack of sieves consisting of the following sieve sizes:

| <b>Sieve Number</b> | <b>Opening Size (mm)</b> |
|---------------------|--------------------------|
| 200                 | 0.074                    |
| 20                  | 0.85                     |
| 8                   | 2.38                     |
| 4                   | 4.76                     |
| 3                   | 6.3                      |
| 0.5”                | 12.7                     |
| 1.0”                | 25.4                     |
| 2.0”                | 50.8                     |
| 3.0”                | 76.1                     |

From the resulting data, the percent fine sediment can be determined. Other useful metrics, such as the Fredel Index and sorting coefficient, can also be calculated.

#### 4.0 REFERENCES

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