

Deep Creek Watershed Sampling and Analysis Plan

2015



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Introduction and Background

Project Scope

This document constitutes the **Sampling and Analysis Plan (SAP)** that will guide future monitoring efforts for the Deep Creek watershed restoration project in Broadwater County, MT. For several decades, Deep Creek has been influenced by sedimentation, high water temperatures, and low-flow impairments brought on by resource use both in and around the creek. The reoccurrence of these issues and negative impacts they pose on landowner interests prompted the creation of a lengthy restoration project for the watershed, which is outlined in the Deep Creek Watershed Restoration Plan (WRP).

This SAP will provide a concrete framework for the water quality and quantity sampling and inventory efforts to occur in the Deep Creek watershed over the next 10 years*. The data collected by this monitoring plan will serve two purposes. First, it will provide information necessary to evaluate whether the targets outlined in Deep Creek's WRP are achieved in the following years. Second, it will allow project partners to gauge the effectiveness of restoration and projects land-use management changes implemented throughout the watershed.

The primary goals of the monitoring efforts outlined in this document are threefold: 1) to determine whether WRP projects are effectively improving aquatic ecosystem health and function, 2) to ascertain whether Deep Creek's connectivity to its floodplain is improving overtime and 3) to provide acquired data to DEQ, in hope that this supplemental information will provide additional justification to have Deep Creek removed from the impaired waters list. In addition to this environmental assessment, the human element of this project will also be evaluated via surveys to landowners involved with WRP projects. This effort will help determine whether these landowners' operations were positively impacted by WRP projects.

Monitoring and inventory efforts will include:

- Stream flow
- Stream temperature
- Macroinvertebrate sampling
- Permanent photopoints
- Fish counts and beaver dam assessments
- Cross-section monitoring
- Riparian re-vegetation assessments
- Sediment load reduction estimates

The effort to develop this SAP was initiated by Broadwater Conservation District (BCD) and Montana Fish, Wildlife and Parks (FWP), with technical assistance from MSU Extension Water Quality, Natural Resource Conservation Service (NRCS), and the Department of Environmental Quality (DEQ). The project is funded by a Montana DEQ Clean Water Act Section 319 Nonpoint Source (NPS) grant (DEQ Contract #214008), DNRC, and NRCS (NWQI).

*Modest modifications will be made each year with potential for more comprehensive edits/revisions under new contracts

Project Area

The Deep Creek watershed is located in central Montana in the heart of Broadwater County. The creek originates in the Big Belt Mountains, about 20 miles east of Townsend, MT, where it flows for roughly 30 river miles west to its confluence with the Missouri River. The 88 square mile drainage area has two distinct upper and lower watershed zones, separated by the US Forest Service western boundary (see Figure 1). From this point Deep Creek flows approximately 20.7 river miles to the Missouri River. This lower half of the watershed contains the WRP “Project Reach” where all of the restoration work and the majority of monitoring will take place.

The lower watershed is predominantly privately owned land used for cultivated agriculture, irrigated pasture, grazing, and residential development. In the upper watershed, Deep Creek runs through steep canyons adjacent Highway 12 before it opens up to the wider, flatter portion of the lower watershed. Land use in the upper watershed is sparse, but includes logging, grazing, residential development and several active forest roads.

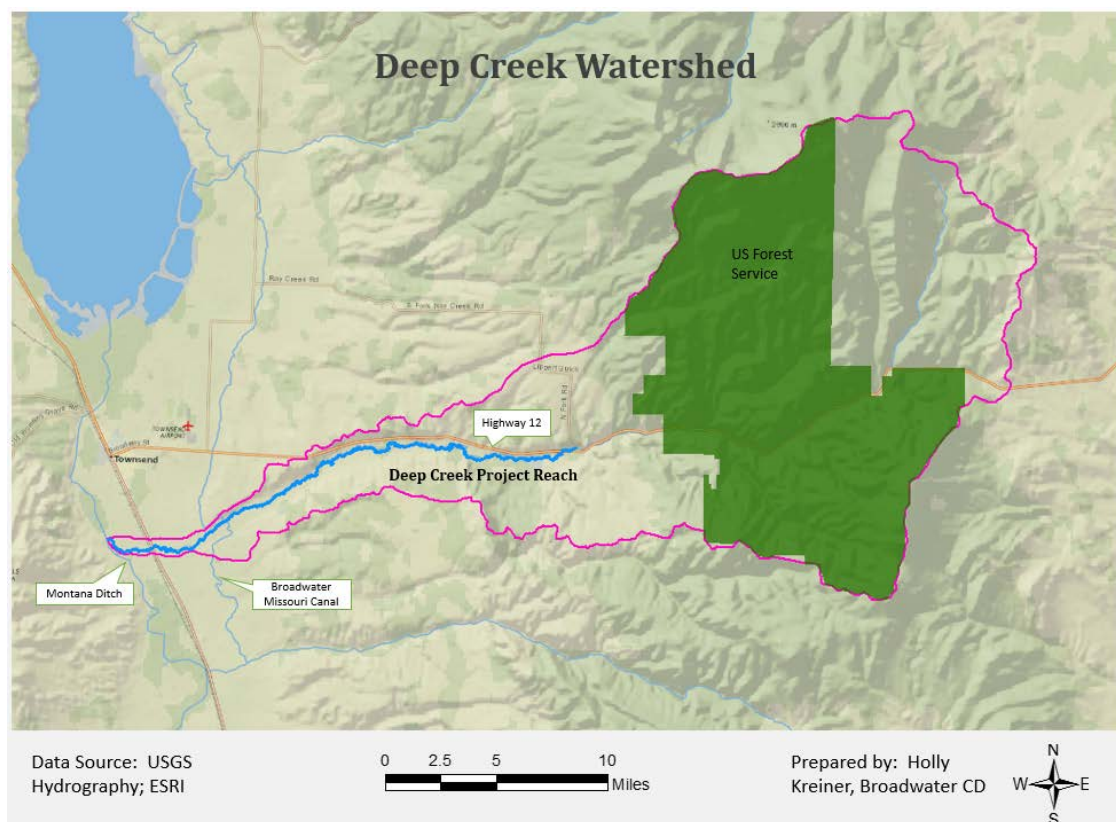


Figure 1: Deep Creek Watershed Map

Site History

For the last century land use around many of Montana’s rivers and streams, like Deep Creek, have greatly altered the natural function of stream corridor zones. The relative flat and fertile nature of these riparian areas make them ideal sites for development and, following settlement in Montana, much of this habitat was replaced by roads, logging operations, grazing pasture, agricultural fields, and residential areas. In order protect these newly developed lands, beaver

eradication, vegetation removal, and channel confinement became common practice, and in many places this management continues today. The riparian loss and channelization on Deep Creek created an extensive system of down-cut, continuously eroding stream banks and a subsequent sediment impairment in the stream.

In 1996, the Montana Department of Environmental Quality (DEQ) created a Total Max Daily Load (TMDL) to address the high sediment-loading concern in Deep Creek. At this time efforts to reduce sediment-loading and erosion generally involved intensive channel treatments and bank stabilization efforts. In an attempt to achieve TMDL targets, over 100,000 square feet of eroding stream bank were stabilized using relatively soft practices and several miles of riparian fence were installed from 1997-2003. Although much of these implementation efforts were successful, a significant flood event swept through the Deep Creek watershed in 2011, damaging many bank stabilization structures and undermining riparian fencing.

In response to this flood, landowners and agency professionals partnered together to create a watershed restoration plan for Deep Creek that struck the balance between protecting watershed health and landowner interests. Within this plan, Deep Creek partners recognized the need to allow the creek to naturally migrate within its floodplain through the protection and restoration of riparian habitat whenever possible. Partners also recognized current and historical irrigation management concerns and conceived ways to address the periodic de-watering of Deep Creek in this new plan. The end result was the formulation of a watershed restoration project that simultaneously assists landowners with various improvement projects that benefit both their operations and the health of the stream. In order to monitor the effectiveness of these projects and health of Deep Creek, project partners have collaborated to tackle a long-term monitoring program on Deep Creek; which is outlined in this document.

Current Stream Condition

Deep Creek is currently listed on Montana's 303(d) impaired waters list for high sediment-loading and low flow alterations. Although not recognized as a definitive impairment due to lack of long-term data, elevated water temperature is recognized as an additional concern for the creek. Sediment loading is primarily the result of extensive stream bank erosion, but is also sourced by surface runoff. Lower late season flows in Deep Creek are believed to primarily be the result of irrigation management concerns, but could also stem from loss of floodplain storage recharge from bank incision. Elevated water temperatures are likely the result of a combination of factors including increased sedimentation, loss of canopy cover, and lower flows through the creek.

Deep Creek is an extensively entrenched system with bank heights reaching 50 feet high in some places (average eroding stream bank height is 10 ft.; Skidmore 2013). In such systems, streams become disconnected from their floodplain and when high flow events arise streams are unable to dissipate their flow onto their banks. The result is that stream flow power becomes concentrated within the inset channel, leading to increased bank erosion and susceptibility to extreme channel migration and property loss. Additionally, down-cut systems can lead to a loss of floodplain water storage, resulting in reduced late season flows and increased late season temperatures.

Past Studies

Since the 2011 flood event, two studies were completed in the lower Deep Creek watershed. Peter Skidmore completed a geomorphic stream assessment in 2012 and the USDA Natural Resource Conservation Service (NRCS) completed a riparian assessment in 2013. Both assessments provided various general and specific restoration recommendations that were used during the development of the Deep Creek Watershed Restoration Plan. From 1997 to 2003, Hydrotech Water Resource Consultants conducted monitoring of Deep Creek in an effort to evaluate the effectiveness of TMDL projects and their outcomes. The results of this monitoring provided valuable data about the persistent impairments of Deep Creek and was instrumental in the development of this novel monitoring plan. In 2014, DEQ completed nutrient, macroinvertebrate sampling, temperature and sediment assessments of Deep Creek, which may be completed again in 2019 and 2024. These assessments will provide baseline data that could justify a beneficial use assessment of Deep Creek and potentially lead to the removal of the stream from the 303d list, if improvements are achieved.

Project Goals and Objectives

The overarching goal of the watershed restoration project is to implement projects that enhance the ecosystem function of Deep Creek while simultaneously improving landowner operations and interests. The monitoring goals and objectives outlined below will provide the necessary data to evaluate whether this goal is achieved at the end of the monitoring program.

Goal 1: Evaluate whether riparian and flow enhancement efforts in the Deep Creek watershed are effectively improving watershed function both instream and in the surrounding riparian zone

Objective a) - To determine whether cumulative project activities (improved irrigation systems, water right exchanges, and enhanced riparian canopy cover) are increasing instream flows and if minimum flow thresholds are being attained

Objective b) - To determine whether cumulative project activities (increased flows, enhanced riparian shading, and improved channel form) are reducing instream water temperature in Deep Creek (related to objective 1a)

Objective c) - To assess the physical changes of the stream and document the pre and post condition of riparian enhancement projects and channel restoration work

Objective d) - To evaluate changes in floodplain connectivity at established cross-section locations

Objective f) - To monitor fishery response to riparian and flow enhancement projects

Objective e) - To determine changes in the distribution of beaver dams and number of brown trout spawning beds in response to riparian and flow enhancement projects.

Objective g) - To monitor macroinvertebrate populations in the creek as an indicator of aquatic health

Objective h) - To determine the establishment and survival of revegetation projects

Goal 2: To determine whether sediment loads in Deep Creek are being reduced post-project implementation

Objective a) - To determine the approximate amount of sediment stored in-channel by implementing grade controls along the creek at the reach 8 channel restoration site (between river mile 9-10)

Objective b) - To determine the sediment load reductions as a result of implementing riparian restoration projects around the creek

Goal 3: To increase public engagement in water resource management and foster stewardship in both youth and adults

Objective a) To track involvement and raise awareness about watershed health (through the development of a long-term monitoring program and outreach/educational events)

Goal 4: To collect information on the successes and challenges associated with the Deep Creek project to both inform future management decisions in the watershed and to guide future projects in other watersheds in the county

Objective a) To evaluate the overall success of the Deep Creek WRP (related to goals 1 and 2)

Objective b) To determine whether landowners directly involved with WRP projects had a positive experience (see Appendix 8)

Sampling Design

Sampling Sites

A total of 25 locations have been selected as established monitoring sites along Deep Creek and its tributaries. Table 1 lists all of these sites and includes the parameters to be measured at each. For a detailed description of each location including geographical location, directions, and site pictures see the Standard Operating Procedures (Appendix 1). Figure 2 provides a visual of the flow monitoring site locations throughout the watershed.

Table 1: Monitoring locations for on-going data collection

Site ID; Site Name	Latitude	Longitude	Monitoring Parameter
DC- U; <i>Upper Deep Creek</i>	46.34894	-111.13592	Flow, Photopoint
DC-SB; <i>Sulphur Bar</i>	46.33049	-111.20977	Flow, Photopoint
DC-CG; <i>Cabin Gulch</i>	46.33501	-111.220828	Flow, Photopoint
DC-HP; <i>Horse Pasture</i>	46.33297	-111.26112	Flow, Temperature, Photopoint
DC-NF; <i>North Fork</i>	46.32752	-111.28308	Flow, Photopoint
DC-CL; <i>Clopton Lane</i>	46.32681	-111.36844	Flow, Temperature, Photopoint
DC-S; <i>Stock's Bridge</i>	46.31509	-111.41744	Flow, Photopoint
DC-BM; <i>Above Broadwater Missouri Canal</i>	46.29708	-111.46201	Flow, Temperature, Photopoint
DC-HR; <i>Hahn's Ranch</i>	46.28514	-111.50617	Flow, Temperature, Photopoint
DC-XS-1	TBD	TBD	Cross-section, Photopoint
DC-XS-2	TBD	TBD	Cross-section, Photopoint
DC-X -3	TBD	TBD	Cross-section, Photopoint
DC-XS-4	TBD	TBD	Cross-section, Photopoint
DC-XS-5	TBD	TBD	Cross-section, Photopoint
DC-XS-6	TBD	TBD	Cross-section, Photopoint
DC-XS-7	TBD	TBD	Cross-section, Photopoint
DC-XS-9	TBD	TBD	Cross-section, Photopoint
DC -XS -10	TBD	TBD	Cross-section, Photopoint
DC-M01 <i>Hahn's</i>	46.28570007	-111.508318833	Macroinvertebrate sampling
DC-M02 <i>Stocks</i>	46.29730082	-111.461952954	Macroinvertebrate sampling
DC-M03 <i>Lippert Gulch</i>	46.32232877	-111.329767980	Macroinvertebrate sampling
DC-CL-HWY12; <i>Redd/Beaver reach</i>	46.32669 -111.36868 to 46.32465 -111.29332		Redd/Beaver dam count
DC-HR-FISH; <i>Above Montana Ditch</i>	46.28479	-111.51181	Juvenile, Out-migrant trout count
DC-R-FISH; <i>Reiders</i>	46.30334	-111.44510	Resident trout count

In addition to on-going monitoring efforts, specific channel and riparian restoration sites will be monitored a single time to analyze and document the condition of these projects. Table 2 lists all of the WRP projects that will undergo some form of assessment. Many of these riparian restoration locations are still TBD and will be implemented throughout the duration of the WRP contract period. A summary and conceptual diagram of WRP projects can be found at the end of this document.

Table 2- Singular monitoring efforts at WRP project locations

WRP projects	Monitoring parameter
Reach 8 Channel Restoration	Sediment load reduction estimate, Photo documentation
Off-site water tank placement	Sediment load reduction estimate, Photo documentation
Riparian fencing placement	Sediment load reduction estimate, Photo documentation
Revegetation implementation and assessment	Sediment load reduction estimate, Photo documentation, Stem counts
Diversion consolidation, improvements, relocations	Photo documentation

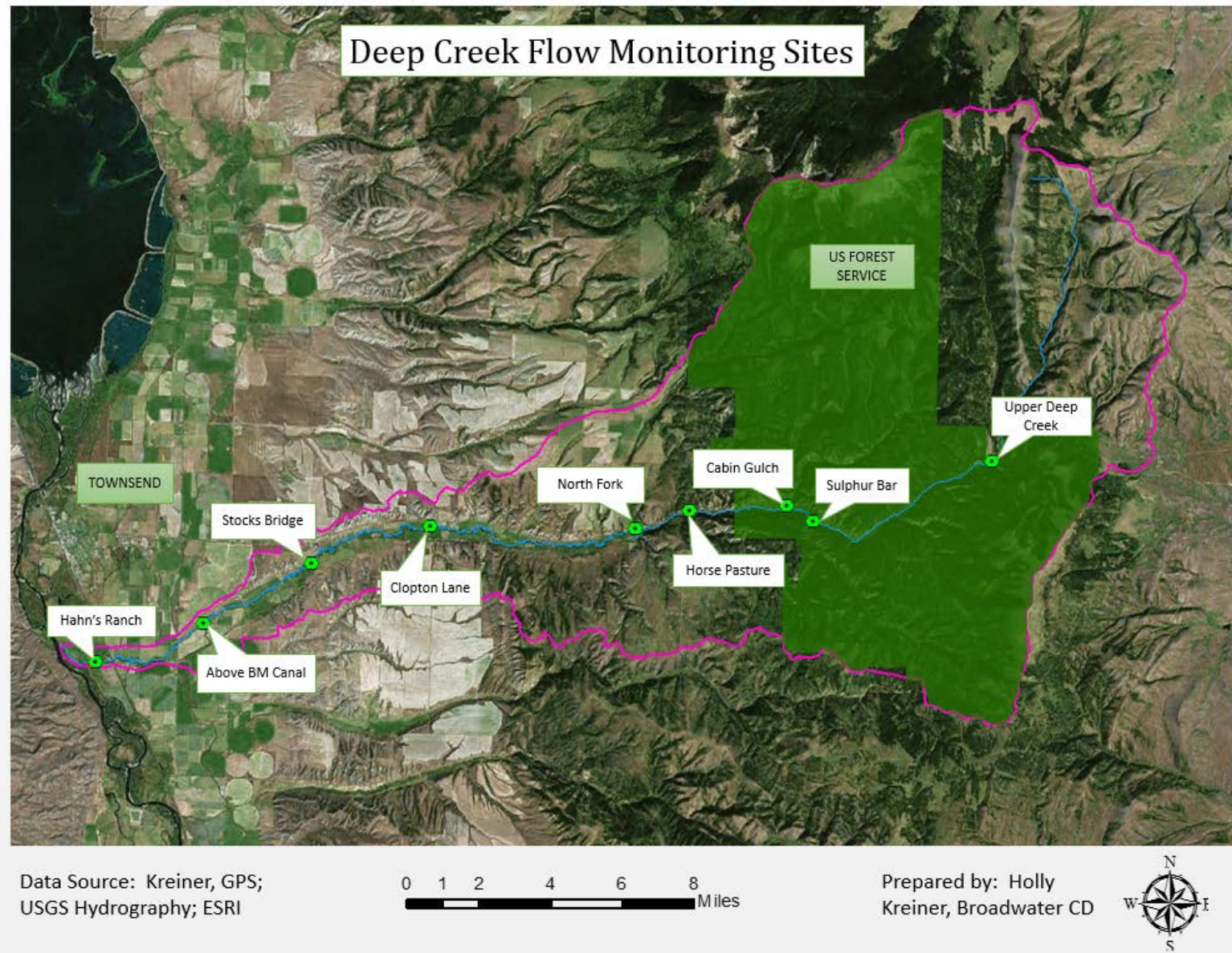


Figure 2: Deep Creek Flow Monitoring Sites

Sampling Site Justification

Table 3: Justification for Sampling Locations

Site Name	Justification for Selection
Upper Deep Creek	This site provides a snapshot of Deep Creek's condition near its headwaters and the landowner has given permission to access this site.
Sulphur Bar	This site is on US Forest Service property, just upstream from the road closure gate. Its purpose is to document the hydrology of a smaller tributary of Deep Creek from a north facing drainage.
Cabin Gulch	This site is a former US Forest Service measuring location. Its purpose is to document the hydrology of a smaller tributary of Deep Creek from a south facing drainage.
Horse Pasture	This US Forest Service site serves as the control site for analyzing flow and temperature at lower sites and drawing comparisons. It also provides important information about the characteristics of the stream in response to upper watershed land use and disturbance in addition to being a historical and current Forest Service monitoring site.
North Fork	This gauge allows for a determination of how much flow is being contributed to Deep Creek from this large tributary.
Clopton Lane	This site serves as additional control site for monitoring project effectiveness, as it lies below all but a few irrigation diversions and project sites on Deep Creek. A staff gauge had been mounted on a wall of the Clopton Lane Bridge by FWP several years ago and some periodic measurements had been made here.
Stock's Bridge	This site is just downstream from a major diversion from Deep Creek and below the future channel restoration project site. It's located on private property with landowner support and easy stream access.
Above Broadwater Missouri Canal	This gauge is above several irrigation diversions from lower Deep Creek and lies at the intersection of Deep Creek with Broadwater Missouri Canal. A staff gauge had been mounted on a wall of the Lower Deep Creek Road Bridge by DFWP several years ago and some periodic measurements had been made there.
Hahn Ranch	A gauge was located here to measure the water of Deep Creek just before it flows into the Missouri River. This site lies below all of the WRP projects and provides a snapshot of Deep Creek's condition in response to land use in the watershed.
Cross-section sites	These sites will provide the best possible representation of the channel geomorphology of Deep Creek through the project reach (sites TBD)
Macroinvertebrate sampling sites	Hydrotech completed macroinvertebrate sampling at these 3 locations in 91', 92', and 96'. New sampling at these sites will allow for comparison and the ability to monitor trends overtime
Beaver/Redd reach	FWP has monitored redds/beaver dams counts along this reach annually for the last decade. This assessment will allow for continual evaluation of trends overtime.
Above Montana Ditch (at Hahn's)	Hydrotech and FWP completed past fish counts at these locations. New counts at these sites will allow for comparison and the ability to monitor trends overtime.

Sampling Frequency

The WRP contains a proposed short-term and long-term monitoring schedule (Appendix 4), which was used to formulate duration goals for this monitoring plan. Table 4 below lists these duration goals as well as the sampling frequency for each parameter. Data collection will begin in the 2015. Some parameters will cease to be monitored in 2020, but flow and temperature will be collected until 2025 at designated priority sites.

Table 4: List of the sampling frequency and duration goal for each monitoring parameter

Monitoring Parameter	Sampling Frequency and Duration
Flow	Weather permitting, current meter discharge measurements will be made once a month and on an annual basis from April through November. Continuous stage recorders will be activated in April. Duration goal: Discharge data will be collected for the next 10 years, at a minimum of 3 priority sampling sites (Hahns, Above BM, Clopton)
Temperature	Hobo data loggers will be activated annually between April-June, when conditions allow. Duration goal: Temperature data will be collected for the next 10 years, at a minimum of 3 sampling sites (Hahns, Above BM, Clopton)
Cross-sections	Once annually and/or on a rotating basis where sites are revisited every few years. Duration goal: Conducted annually for the next 5-10 years; minimum of 5 years
Photopoints	Established photopoints will be documented once annually in conjunction with flow and cross-section monitoring Duration goal: Conducted annually for the next 5-10 years; minimum of 5 years
Fish counts	Each of the 3 fish counts (redds, juvenile, out-migrant, resident trout) will be completed at least 2x over the span of 5 years Duration goal: Conducted periodically over the next 5 years
Redd/Beaver dam counts	This assessment will be conducted annually in November Duration goal: Conducted annually over the next 5 years
Macroinvertebrate sampling	At least one macroinvertebrate assessment will be conducted, in conjunction with 2019 DEQ assessment. Duration goal: Conducted once in the next 5 years

Sampling Methods

The WRP proposes the use of several monitoring parameters to evaluate the success of this project and determine if targets are being achieved (Appendix 4). Both this guidance and past monitoring efforts were used to determine the monitoring goals and methods described in this SAP. Note: not all of the parameters suggested in Element 9 (Appendix 4) will be monitored in this study, as the project team has determined that they would not provide relevant data for addressing the goals and objectives of this plan.

The methods for collecting data on each parameter are briefly described below. Refer to the SOP for in-depth guidance and direction for data collection methods of each.

Flow - Each of the nine flow monitoring sites have established bank pins that serve as the permanent location for current meter flow measurements. Manual flow measurements will be collected at these sites once a month during the field season. Continuous staff gauge recorders will be activated in April. A stage discharge rating curve will be created using continuous staff gauge measurements and flow data to obtain an estimation of overall flow at these sites.

Temperature – Hobo continuous temperature recorders will be installed and activated every year after high flow season. These will allow temperatures to be captured at these sites during lower flows in summer and fall. The loggers will be set to collect data every half hour during the deployment so they are likely to represent maximum and minimum daily temperatures accurately.

Cross-sections – Cross-section measurements will generally follow Montana DEQ Water Quality Planning Bureau's sediment monitoring field SOP guidance at a minimum but may be more rigorous when needed for channel restoration projects. Calculations/analysis that will be useful include: width: depth, entrenchment, streambed elevation, channel migration rates.

Photopoints – Photographs at both flow and cross-section sites will be taken once a year in late summer/early fall. Shots will include upstream, downstream, and cross-sections views.

Fish counts – A 5-foot diameter rotary screw trap will be installed at the Hahn's Overflow site to capture an out-migrant trout estimate in Deep Creek. An electrofishing backpack unit will be used to complete both the juvenile and resident trout population estimate fish counts. See appendix 5 for a thorough explanation of the methods that will be used to complete these fish counts and a justification for their use.

Macroinvertebrate sampling – MDEQ will conduct macroinvertebrate data collection in 2019 following accepted agency methodology for beneficial use assessment. BCD and/or FWP partners will conduct an EPA Rapid Bioassessment Protocol (RBP) following methodology used in the 1997 and 2003 macroinvertebrate assessments on Deep Creek (Hydrotech, 2004). This rapid assessment will be done at the same time and place as the MDEQ data collection to serve two purposes: comparison to past data and comparison to future data. RBP will allow for interpretation of 2019 conditions in the context of 1997 and 2003 conditions but also to acknowledge that the more rigorous DEQ methods will likely be collected more consistently

moving forward. Overlap in data collection at the same place and time will allow for qualitative comparison of the results from the two methods.

Beaver dam and redd counts – The number of beaver dams and redds will be assessed from Clopton lane bridge to Highway 12 bridge annually in November. This will be done by simply walking the stream and recording the numbers observed.

Riparian revegetation assessment – Immediately following revegetation projects, the exact area will be recorded using a GPS unit, pictures will be taken, and the number of stems will be counted. At the end of the contract period, these sites will be revisited and a quantitative assessment will be conducted via another stem count. A qualitative assessment of percent survival will also be conducted by comparing new photographs to those taken post-implementation. Another assessment may be conducted after the contract period.

Sediment reduction estimation methods – The amount of sediment prevented from moving downstream will be estimated at specific WRP project locations. This includes the reach 8 channel restoration project, riparian fencing, off-site water tank placement, and revegetation projects. An explanation of how sediment load reduction will be estimated for the reach 8 channel restoration project is provided in the appendix section (Appendix 6). The amount of sediment saved from implementing the latter three riparian-specific projects will be estimated using NRCS RUSLE2 modeling.

MDEQ Sediment reductions estimates – Language articulating future assessments to be performed by DEQ can be added here if DEQ so desires.

Sampling Equipment

For a complete list of all materials and equipment to be used in this study, refer to Sampling Methods sections SOP. Table 5 provides a list of technical equipment that will be used to carry out monitoring.

Table 5: List of technical equipment

Monitoring Parameter	Technical Equipment
Flow	Flow meters: MarshMcBirney Flo-mate 2000 and Hach FH950
	Continuous flow recorders: Float chart recorder (2), Bubbler chart recorder (1), True-Track water level recorder (5)
Temperature	Hobo data loggers
Fish counts	5-meter rotary screw trap and Smith-Root Backpack Electrofishing unit
Photopoints	GPS enabled camera (model TBD; still needs to be purchased)

Sampling Field Sheets

Refer to the Sampling Field Sheets section in the SOP.

Sampling Schedule

Table 4 above provides pertinent information in regards to the sampling schedule, including both frequency and the goal for collection duration. Refer to the Sampling Schedule section in the SOP for a timeline and calendar of monitoring to occur in the following 10 years.

Project Team

Table 6: Project Team Responsibilities

Organization	Contacts	Contact Info	Project Responsibilities
Broadwater Conservation District	Jim Beck - BCD Associate Supervisor; Denise Thompson - District Administrator; BSWC member	415 S Front Street Townsend, MT 59644 (406)266-3146 ext 104 denise.thompson@mt.nacdn.net jbeck3026@mt.net holly.kreiner@mt.usda.gov (2015 BSWC member)	Data Collection: Discharge, cross-sections, photopoints Additional contributions: Data analysis, report composition, volunteer coordination and recruitment, equipment maintenance, landowner and volunteer surveys
Fish, Wildlife and Parks – Townsend Office	Ron Spoon - FWP Fisheries Biologist	39 Centerville Road Townsend, MT 59644 (406)266-4237 rspoon@mt.net	Data collection: Water temperature; fish counts, beaver dam and redd counts; macroinvertebrate sampling, cross-sections Additional Contributions: Data analysis
Natural Resource Conservation Service – Townsend Office	Justin Meissner - NRCS District Conservationist	415 S Front Street Townsend, MT 59644 (406) 266-3146 ext 103 justin.meissner@mt.usda.gov	Data collection: Revegetation survival assessments, RUSLE 2 assessments, IWM monitoring Additional contributions: Technical assistance
MT Department of Environmental Quality	Robert Ray - DEQ Project Supervisor	1520 E. 6th Avenue P.O. Box 200901 Helena, MT 59620-0901 rray@mt.gov	Data collection: BEHI assessments, impairment assessments Additional contributions: Technical assistance
Montana State University Extension Water Quality	Adam Sigler - Extension Association Specialist	PO Box 173120 Bozeman, MT 59717 asigler@montana.edu	Data collection: Periodic monitoring assistance Additional contributions: Technical data analysis assistance

* BCD will periodically bring on BSWC members and/or MSU interns to help with data collection and analysis

Data Management

Data Analysis

Each objective and its corresponding monitoring parameter has specific analysis procedures, which are laid out in Deep Creek SAP Goals, Objectives and Methods Summary (Appendix 2). Analysis objectives vary, but collectively the conclusions drawn will provide justification to evaluate 1) whether targets established in the WRP are achieved, 2) if there are improving trends in watershed function, and 3) if WRP projects were implemented and functioning as they were intended.

At the end of every field season, data will be transferred into basic plots in excel for presentation and cursory analysis. All of the data collected from the 2015 field season to the end of the 319 contract period (June 2017) will be compiled into a summary report and presented to DEQ at that time. Several parameters will be monitored and analyzed beyond this point for a more thorough interpretation of the success of this project over time.

Data Storage and Transfer

All site visit field sheets will be delivered to the BCD office and stored in hardcopy format. These forms will be scanned and saved electronically on a “Deep Creek” Google Drive account. Currently, data is stored on computers belonging to the Broadwater CD, NRCS, FWP and Jim Beck, the primary data collector. Initial efforts to transfer data to a Google Drive account are underway to centralize all electronic files. This will allow for all project partners to access data individually.

All data required in Deep Creek 319 contract will be submitted to DEQ in accordance with the most current upload process, as described in the MT-eWQX guidance manual (<http://deq.mt.gov/wqinfo/datamgmt/MTEWQX.mcp>). Data will be delivered annually and a final report will be submitted at the end of the contract period in June 2017.

Quality Assurance and Quality Control

Data Quality Objectives – Accuracy

Accuracy describes how near a measured value is to the true value observed in the field. Collecting accurate data is paramount in order to draw conclusions and analyze goals. In order to produce the most accurate data possible, a number of data quality objectives have been identified for this monitoring plan. All of the objectives discussed below possess some sort of accuracy check. See the SOP for in-depth guidance on calibration and other accuracy checks.

1. Discharge will be measured such that no one section constitutes more than 10% of the flow. Distance intervals have already been established for each flow monitoring site but should be adapted as stream conditions change. See the SOP for the recommended spacing intervals for each monitoring site.
2. Discharge rating curves will be assessed and R squared values less than 0.7 will be qualified.

3. Continuous stream stage recorders will be monitored regularly using a fixed elevation of reference to ensure the stilling well remains a constant level and downstream.
4. Flow meters will be set to a “fixed point average” (FPA) setting of 40 seconds, which provides an average of velocities over that period of time.
5. Staff gauge height will be observed and recorded at every flow site as an accuracy check for the continuous staff gauge recorders (chart recorders and True-Tracks).
6. The MarshMcBirney Flo-mate 2000, Hach FH950 meter, Hobo data loggers, and Smith-Root Backpack Electrofishing unit will be calibrated at the beginning and end of every field season according to manufacturer specifications and procedures, which are outlined in the SOP.

Data Quality Objectives - Representativeness

Representativeness refers to the extent which measurements represent an environmental condition in time and space. In order to make accurate analyses and conclusions, data collection needs to be both spatially and temporally similar between sampling efforts. Below is a list of objectives for collecting spatially and temporally representative data during this study:

1. All data will be collected following established protocols in the SOP to allow for qualitative analysis of each objective outlined in Appendix 3.
2. All data measurements will be made at the exact place and as close to the same time as possible between sampling efforts. See the SOP for guidance on the location and timing for each monitoring parameter.
3. Flow data will be collected using a MarshMcBirney current meter at each site *at least* once a month during the field season, in order to maintain the most accurate rating curve for overall flow calculation as possible.
4. Temperature data is collected via continuous recorders to capture the most temporally representative temperature dataset.
5. Photographs taken at established photopoints will include some kind of on-the-ground reference feature in order to capture the same shot and ensure repeatability. See SOP for guidance.
6. Cross-section sites are intended to provide an overall representation channel geomorphology along the length of the creek and are spatially distributed to achieve this goal.*

*Sites TBD: Karin Boyd (Applied Geomorphology) is currently creating a channel migration zone map for Deep Creek and will be consulted on the selection of these sites.

Appendices

- Appendix 1: Standard Operating Procedures (SOP)
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Appendix 1 – Standard Operating Procedures (see attachment)

SOP

(Included as separate document)

Deep Creek SAP Goals, Objectives, and Methods Summary

Goal 1: Evaluate whether riparian and flow enhancement efforts in the Deep Creek watershed are effectively improving watershed function both instream and in the surrounding physical habitat.

Objective a) – To determine whether cumulative project activities (improved irrigation systems, water right exchanges, and enhanced riparian canopy cover) are increasing in-stream flows and if minimum flow thresholds are being attained.

How	Who	Where	When	How Long
Continuous Stage recorder (CSR); Current Meter Measurements (CMM)	BCD (Jim Beck and BSWC member); USFS at Horse Pasture?	CSR and CMM at all 9 sampling sites; *FWP funds set aside for long-term monitoring of one site	CSR – continuous measurements during field season (~Apr–Nov); CMM – monthly measurements	Goal: Discharge data will be collected via these methods for the next 10 years at a minimum of 3 priority sampling sites (Hahns, Above BM, Clopton)*
Analysis • Determine how many days flow at the Clopton Lane site drops below the 9 cfs threshold established in the WRP. • Determine how many days flow at the Hahns site drops below the 6 threshold established in the WRP. • Assess whether the flow from the forest boundary (Horse Pasture site) through the project reach (Clopton, Hahns and Above BM sites) is enhanced after project implementation (i.e. did the project increase flows through the project reach, accounting for natural variation).				

*If data collection at Horse Pasture is abandoned by Forest Service, BCD will revert to this location as a priority site and long-term monitoring efforts at Clopton Lane will cease.

Objective b) - To determine whether cumulative project activities (increased flows, enhanced riparian shading, and improved channel form) are reducing instream water temperature in Deep Creek (related to objective 1a).

How	Who	Where	When	How Long
HOBO data logger (HOBO) Manual thermometer measurements	FWP - HOBO BCD - Thermometer	HOBO – at Hahns, Above BM, Clopton, Horse Pasture, and BM canal sites Thermometer – at all 9 sampling sites	HOBO – continuous measurements during field season (~May– Nov; after high water) Thermometer – monthly measurements	Goal: Temperature data will be collected via these methods for the next 10 years at a minimum of 3 sampling sites (Hahns, Above BM, Clopton)*
Analysis • Determine how many days the daily maximum temperature exceeds 73 F threshold at each site • Compare daily and nightly temperatures of Broadwater Missouri canal and Deep Creek (Above BM) to ascertain the influence of canal return flow temperature on the creek • Assess whether water temperatures at the project reach sites (Clopton, Hahns, and Above BM sites) relative to the temperatures at the forest boundary (Horse Pasture site) are lower after project implementation (i.e. did the project decrease temperatures through the project reach, accounting for natural variation in runoff from the forest and natural variation in temperature across years).				

*If data collection at Horse Pasture is abandoned by Forest Service, BCD will revert to this location as a priority site and long-term monitoring efforts at Clopton Lane will cease.

Objective c) – To assess the physical changes of the stream and document the pre and post condition of riparian enhancement projects and channel restoration work.

How	Who	Where	When	How Long
GPS camera; will follow DEQ “Watershed Restoration Photography Guide” specifications	BCD	Photopoints at cross-section and flow monitoring sites	Annually, after high water; in conjunction with cross-section, flow monitoring	Goal: annually for 5 years and again at year 10
		At channel restoration sites	Channel restoration sites – before and after construction	Once, post project implementation
Analysis				
• Compile photos taken at established photopoints through time for simple visual assessment of site changes for non-technical interpretation • Analyze re-vegetation survival and condition of off-stream water, riparian fencing, and channel restoration projects				

Objective d) - To evaluate changes in floodplain connectivity at established cross-sections locations

How	Who	Where	When	How Long
Collection of width: depth and entrenchment ratios Collection of streambed elevation and channel migration movement using elevation and GPS benchmarks; respectively	BCD and FWP	At ~10 sites along Deep Creek, exact locations TBD	Annually, after high water	Goal: next 5-10 years; minimum of 5 years
Analysis • Determine whether cross-section sites demonstrate improving trends in width:depth ratios and/or entrenchment ratios • Determine how channel has laterally moved using GPS benchmarks adjacent to stream banks • Determine how streambed has vertically moved using elevational benchmarks (an indication that the stream is no longer incising) • Evaluate physical changes using historical aerial imagery (qualitative)				

Objective e) - To monitor fishery response to riparian and flow enhancement projects

How	Who	Where	When	How Long
Juvenile trout abundance counts via electrofishing Out-migrant trout abundance counts via trapping (screw trap) Resident fish population estimate via mark and recapture	FWP	Juvenile trout count at Hahn sampling site Out-migrant trout counts at Hahn sampling site Fish population estimate at reach 5, near Rieder's property	All three counts completed at least twice in the next 5 years	Goal: next 5 years; meet targets in WRP by 2020
Analysis • Determine if juvenile trout abundance exceeds 3 trout/100 seconds of electrofishing • Determine whether out-migrant trout capture exceeds 3,000 trout/year • Assess whether there is an improving trend in juvenile and out-migrant counts by comparing annual data to 1997-2003 data (Hydrotech study) • Determine if resident trout population in previously de-watered reach has improved since 1986-1989 counts (MSU Master's study)				

Objective f) – To determine changes in the number of brown trout spawning beds in response to riparian and flow enhancement projects*

How	Who	Where	When	How Long
Count of beaver dams and spawning beds via walking assessment	FWP	Clopton Lane to Highway 12 bridge	Annually in November	Goal: next 5 years *FWP may continue these assessments beyond 5 years
Analysis • Determine whether < 50 redds are located/mile in each reach • Assess whether there is an improving trend in redd numbers by comparing counts to historical FWP data				

* This assessment will include a survey of present beaver dams in this reach but will not include an analysis regarding beaver dam distribution changes in response to project implementation.

Objective g) – To monitor macroinvertebrate populations in the creek

How	Who	Where	When	How Long
Will be sampling in accordance with EPA RBP – 2003 analysis methods	FWP	At established macroinvertebrate sampling sites: Hahn's, Stocks, Above Lippert Gulch	Sampling to be done in conjunction with DEQ's 2019 EMAP assessment	Goal: next 5 years; meet targets in WRP by 2020
Analysis • Determine whether upper reach (above BM Canal) supports a non-impaired macroinvertebrate community • Determine whether lower reach (below BM Canal) supports a slightly impaired macroinvertebrate community				

Objective h) – To ascertain the establishment and survival of revegetation projects

How	Who	Where	When	How Long
TBD*	NRCS	Sites TBD	One assessment at end of contract period Second assessment - 3-5 years post-planting;	Once at end of contract and a goal to complete a second 3-5 years post planting
Analysis • Compare stem counts from initial planting to numbers observed at the end of the 319 contract • Determine whether revegetation sites maintain a 75% survival rate after a 2-5 period • Evaluate physical changes using photo documentation (qualitative)				

*Will use monitoring recommendations provided by revegetation design contractor (TBD)

Goal 2: To determine whether sediment loads in Deep Creek are being reduced post-project implementation

Objective a) To determine the approximate amount of sediment saved by implementing grade controls along the creek at the reach 8 channel restoration site

How	Who	Where	When	How Long
Estimation of sediment saved by stepping-down the channel gradually (see Appendix 7)	BCD, FWP, NRCS	Reach 8 channel restoration site	Immediately following grade structure implementation	Once, following project implementation
Analysis • Estimate how much sediment is saved by stepping down the stream gradually with grade controls				

Objective b) To determine the approximate amount of sediment saved as a result of implementing riparian restoration projects along the creek

How	Who	Where	When	How Long
RUSLE 2 assessment	NRCS	TBD	Following riparian project implementation	Once, following project implementation
Analysis Estimate the amount of sediment saved from overland flow into Deep Creek due to the implementation of water tanks, riparian fencing, and revegetation projects in areas adjacent to the creek; using RUSLE2 modeling				

Objective c) To determine if watershed sediment reduction project activities have decreased sediment loads, leading to water quality improvements to the point of supporting beneficial uses

How	Who	Where	When	How Long
DEQ Sediment Assessment Methodology	DEQ	Sites 01, 03 and 05, identified in the DEQ 2014 Deep Creek document	Following project implementation, 2019, 2024	Twice, at five-year intervals
Analysis Repeat Sediment Assessment Methodology documented in DEQ “Deep Creek Monitoring And Assessment Project - 2014: Sediment, Temperature, Nutrients”				

Goal 3: To increase public engagement in water resource management and foster stewardship in both youth and adults

Objective a) To track involvement and raised awareness about watershed health (through the development of a long-term monitoring program and outreach/educational events)

Goal 4: To collect information on the successes and challenges associated with the Deep Creek project to both inform future management decisions in the watershed and to guide future projects in other watersheds in the county

Objective a) To evaluate the overall success of the Deep Creek WRP (see goals 1 and 2)

Objective b) To determine whether landowners directly involved with WRP projects had a positive experience

Appendix 3 - Summary of WRP projects

Summary of Deep Creek WRP Management Activities for 2014-2017

- **15 miles of riparian fencing – locations TBD (319 Contract; Task 5.1)**

Provide wider corridor of undisturbed or periodically disturbed riparian zones by installing fence at agreed upon setbacks from the stream using the Deep Creek Channel Migration Zone Map

- **10 off-site water tanks placements – locations TBD (319 Contract; Task 5.2)**

Minimize the access of livestock to the riparian areas and stream banks to limit erosion and enhance riparian establishment

- **Riparian Revegetation Implementation – locations TBD (319 Contract; Task 5.3)**

Riparian enhancement to reestablish floodplain connectivity, provide shade and cover for aquatic life, and enhance floodplain water storage capacity.

- **Reach 8 Channel Restoration Project (319 Contract; Task 6)**

Select a stable breach location and place grade control structure to reduce impact of impending head-cut.

- **Reach 8 Diversion Relocation (319 Contract; Task 7)**

Eliminate ditch diversion (services two landowners) and move to alternate diversion lower down the creek to encourage floodplain connectivity (related to channel restoration project above) and riparian enhancement.

- **Reach 8 Diversion Consolidation (319 Contract; Task 7)**

Reduce and relocate ditch diversions to reduce riparian disturbance and channelization

- **Reach 4 Diversion Relocation (319 Contract; Task 7)**

Eliminate irrigation diversion on Deep Creek (services three landowners) and move to new point of diversion on Broadwater Missouri Canal to enhance in-stream flow.

- **Reach 4 Diversion Improvement (319 Contract; Task 7)**

Replace and lower Parshall flume at reach 4 ditch diversion to eliminate need to check up Deep Creek to enhance flow passage.

Appendix 4: WRP excerpt – Elements 7, 8, 9

ELEMENT 7. Measurable Milestones for Implementing the NPS Management Measures

Milestones are events we will use to ensure that implementation goals are being met over time. Milestones were broken into short-term (3-7 years) and long-term (10+ years) timeframes (Table 7). (note: CMZ is abbreviation of Channel Migration Zone)

Table 7. Milestones to measure progress in implementing the Deep Creek WRP.

Issue	Milestone
Riparian Habitat and Sediment	By 2017: • Achieve 20% more riparian cover along Deep Creek reaches 5-14 compared to 2013; this milestone will also help improve temperature issues • Install up to 10 off-site watering tanks • Install 30,000' of fencing along CMZ • Completion of 3 channel restoration projects By 2025: • Achieve 30% more native, woody riparian vegetative cover along Deep Creek reaches 5-14 compared to 2013 (based on ground surveys and air photography); this milestone will also help improve temperature issues • Expand weed mapping and implementation of the CWMA within the watershed. • Continue with Cooperative Weed Management Plan and treatment
Sediment	By 2017: • Complete 3 road crossing improvement projects in reaches 1-5 • Restore stable stream function associated with levee in reach 15 • Assist reach 7, 8, and 15 landowners with multi-agency process • Determine baseline sediment loading from upper watershed • Establish 10 miles of CMZ with completed maps and riparian protection
Low Flow Alteration and Temperature	By 2017: • Achieve a minimum flow of 9 cfs at Clopton Lane and 3 cfs at Hahn's Station

Issue	Milestone
	• Achieve < 10 days per year of maximum water temperature > 73°F at Clopton Lane, B-M Canal, and Hahn's monitoring locations • Implement at least 2 water savings projects By 2025: • Achieve a minimum flow of 9 cfs at Clopton Lane and 6 cfs at Hahn's Station • Achieve an overall declining trend in maximum water temperatures over a 5 year period • Establish long term streamflow agreements to protect water savings
Aquatic habitat	By 2020: • Achieve non-impaired macro-invertebrate community in upper reach • Achieve slightly-impaired macro-invertebrate in mid and lower reaches • Achieve increasing trend in juvenile trout abundance (>3.0 per 100 seconds of electrofishing), number of out-migrant trout (>3,000 per year), number of brown trout redds (>50 per mile in each reach); and a decreasing trend in fish loss to canals.
Upper Watershed	By 2017: • Complete a sediment source assessment • Identify 5 road crossing improvements • Flow monitoring at 3 stations • Complete report on hydrology of upper watershed • Work with agencies and landowners to develop a Cooperative Weed Management Plan By 2020: • Development of a detailed map of Upper Watershed • Work with agencies, permittees and landowners on grazing improvements • Work with agencies and landowners to address timber resource concerns • Consolidate and evaluate past Forest Service studies within this watershed and use information for the development of an Upper Watershed Restoration Plan

Issue	Milestone
Education and Outreach	By 2017: • Hold at least three workshops/tours on issues addressed in WRP • Develop and implement a beaver management incentive/ education program • Develop and distribute a semi-annual BCD newsletter • Develop and maintain a BCD website • Give a Deep Creek presentation at a BCD Annual Meeting/Dinner • Host at least one 6th grade conservation event with Deep Creek as focus • Develop a Volunteer Monitoring Program and begin implementation • Develop a Cooperative Weed Management Area to address monitoring, funding, and noxious weed treatment options • Install a project sign within watershed about restoration efforts and projects By 2025: • Continue educational events • Continue with the CWMA • Continue Volunteer Monitoring Program

ELEMENT 8: Criteria to Determine if Pollutant Loading Reductions are Being Achieved

Criteria are water quality indicators BCD and partners can use to determine whether progress toward meeting water quality standards is being made in Deep Creek. These criteria can be direct or indirect indicators of pollutant load reductions and serve as benchmarks to measure against through monitoring. For this WRP, criteria include the following:

- Acreage of riparian vegetation restored or protected
- Acreage of noxious weed infestation
- Decreasing trend in percent of fine surface sediment < 2mm based on pebble counts
- Improving trend in width/depth ratios
- Percent of eroding banks
- Road crossing improvements (culvert upgrades, bridge replacements)
- Decreasing trend in fine sediment in pool tails and riffles
- Increasing trend in stream flow
- Decreasing trend in stream temperature
- Improving trend in macroinvertebrate communities over time
- Improving fish trend monitoring

ELEMENT 9: Monitoring

Monitoring of stream health and water quantity and quality is key to determining whether restoration goals are being met, and for determining how to adjust management in the future. Extensive monitoring occurred on Deep Creek from 1997-2003 to evaluate the early TMDL implementation work completed (Hydrotech, 2004). Past and proposed monitoring sites are displayed in Figure 25. Some of the parameters have proven useful (e.g., bank erosion assessment, macroinvertebrates, temperature, total suspended sediment (TSS), and streamflow) for assessing effective progress whereas others have not (total fish counts that didn't take into account other fish population impacts). TSS monitoring data proved difficult to summarize on a year-by-year basis, but it may provide useful information for long-term trend monitoring.

The following selected monitoring parameters and schedule (Table 8) will be maintained to provide short- and long-term evaluation of restoration projects at Deep Creek.

Short-term (0-5 years):

1. Establishment of long-term photopoints and kite photography sites for stream, weed, and agricultural BMP monitoring
2. Summer streamflow and water temperature at least 3 locations in the upper watershed and three locations within Reaches 1-15 on private land
3. Upper watershed sediment assessments
4. Benthic macroinvertebrate surveys at three locations

5. Fisheries monitoring in selected reaches: redd counts, electrofishing, and trapping
6. Beaver dam count in selected reaches
7. Sediment load reduction estimates, specifically for reaches 7-9
8. Short-term survival and establishment of planted woody riparian species
9. CMZ weed monitoring

Medium to long-term (5-10 years, 10+ years):

10. Bank stability and erosion assessment in Reaches 1 - 15
11. Visual substrate analysis in Reaches 1 – 15
12. Routine photo monitoring (on the ground and aerial) to visually assess riparian and stream changes over time
13. Channel cross-sections in selected reaches
14. Sediment load reductions at the watershed scale
15. CMZ weed monitoring

Appendix 5: Summary of fish monitoring

Deep Creek Fish Monitoring Summary for Deep Creek SAP

Credit: Ron Spoon, MT Fish, Wildlife, and Parks

Fishery response to Deep Creek restoration activities are directed at brown and rainbow trout population monitoring. Trout response to changes in flow, water temperature, and sediment will likely affect both the resident fishery (that live in Deep Creek year-round) and the migratory population (spawning or rearing takes place in Deep Creek and fish migrate out and reside in the Missouri River or Canyon Ferry Reservoir during part of the year).

Four monitoring methods will be used to determine fishery response:

- 1) Juvenile catch-per-effort sampling near the mouth of Deep Creek (Hahn Ranch): one pass electrofishing using a backpack electrofishing unit will determine number of juvenile trout captured per minute of sampling time during the fall. This technique has been used at the Hahn station most years since 1991, and long-term trends of both resident and migratory of trout abundance are determined with this method. Effort: one day with two people.
- 2) Brown trout redd counts (Clopton Lane to Highway 12): provides a long term index of the health of the resident brown trout fishery in the 6-mile reach of Deep Creek upstream of Clopton Lane. Migratory brown trout (from Canyon Ferry or the Missouri River) are relatively rare in this reach of stream. Walking the stream during late November and counting visible spawning beds (redds) during a period of good water clarity provides a reliable index of spawning activity. Effort: 2 days with two people.
- 3) Resident trout population estimates in a 0.87 mile reach on Rieder property: electrofishing during the late 1980's determined abundance of resident trout by conducting mark-recapture estimates during a time when flow depletion affected the fishery. This population estimate will be repeated at least once in 2015 or 2016 to determine the fishery response to improved flow conditions. Effort: 3 days with 3 people.
- 4) Trout emigration (out migration) from Hahn Ranch site to the Canyon Ferry/Missouri River: this complex was assessed for three years (04', 05', 06') using a 5-foot diameter rotary screw trap to capture fish moving out of the stream. This method will be repeated at least one year during the Deep Creek evaluation. Effort: 60 days with one person.

Appendix 6: Summary of sediment load reduction estimation methods

Reach 8 Channel Restoration Project Description and Explanation of Sediment Load Reduction Estimation

Credit: Ron Spoon, MT Fish, Wildlife and Parks

Currently, the reach 8 ditch diversion is elevated above the floodplain and has been historically regulated by constructing dikes. Downstream of this diversion, the streambed has down-cut at least 4 feet in elevation and is entrenched. In the past five years, water users and landowners have repaired holes in the dike at least three times to prevent the elevated channel from finding a new path. Once the this diversion is relocated in 2015/16, water users will no longer need to maintain the dike to perpetuate this unstable condition, and the stream will almost certainly find a new path and create a significant head-cut.

Landowners and agencies have two options for addressing this situation:

- 1) Allow the dike to breach naturally. This will likely mobilize stream sediment and gravel for approximately 0.5 miles and down-cut approximately 2 to 4 feet in elevation. Assuming an active channel width of about 20 feet, an average down-cut of 3.0 ft., and a stream distance of 2640 ft., the quantity of material is estimated to be 158,400 cubic feet.
- 2) Select a stable breach location and place grade control to step-down the channel gradually. Also, during construction excess gravel expected to become mobilized could be removed from the system. This will reduce the length and depth of the head-cut. Approximate quantities of material of the expected head-cut with grade control are: 20 ft. width x 1.5 ft. down-cut x 1500 ft. of channel length. This totals 45,000 cubic feet of material, not count the material actively removed during construction.

The above quantities are estimates prior to conducting a detailed survey, but the gradual, grade control project could reduce mobilized sediment significantly compared to simply allowing the dike to fail and find a stable channel in the future (e.g. 45,000 cubic ft. sediment mobilized with treatment compared to 158,000 cubic feet without treatment).

Appendix 7: Description of flow data collection at Horse Pasture

Flow Data Collection at the Forest Service Horse Pasture Site

For the foreseeable future, Forest Service personnel will continue to collect flow data at their Deep Creek “Horse Pasture” site in the Helena National Forest. Corey Lewellen (Helena National Forest District Ranger, Townsend District), Dave Callery (Forest Service Watershed Program Manager), and Tim Olson (Helena National Forest Hydrologic Technician) have been informed about the Deep Creek monitoring project and there is a collective agreement to foster data exchange from the Horse Pasture site between FS and BCD. A spoken agreement between agency personnel has transpired to the effect that any historical data not yet delivered will be provided and ongoing flow data will be delivered to BCD. In exchange, BCD will keep FS updated on the Deep Creek monitoring project and provide data at their request. In the event that FS abandons data collection at Horse Pasture, BCD personnel will attempt to continue flow monitoring at this site.

Appendix 8: Description of community evaluation project

Community Evaluation of the Deep Creek Monitoring Project

In addition to the environmental assessments that will be carried out by the Deep Creek monitoring project, BCD will endeavor to develop a working partnership with MSU faculty to design a community evaluation of the Deep Creek project (refer to goals 3 and 4). Although still in development phase, this program could include aspects such as surveys and interviews to assess public engagement, evaluations of community perception to the Deep Creek project, and other relevant human element assessments. As this program develops, specific goals and objectives will be refined and the SAP/SOP will be revised to include this additional monitoring piece.