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Bear River Sediment TMDL Implementation Plan

Prepared for

Wyoming Department of Environmental Quality

Prepared by

SWCA Environmental Consultants

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BEAR RIVER SEDIMENT TMDL IMPLEMENTATION PLAN

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CONTENTS

MAPS

FIGURES

TABLES

ABBREVIATIONS

BANCS - bank assessment for non-point source consequences of sediment
BEHI - bank erosion hazard index
BMP - best management practice
BURPs - Beneficial Use Reconnaissance Monitoring and Assessment Reports
cfs - cubic feet per second
EPA - U.S. Environmental Protection Agency
MGD - million gallons per day
mg/L - milligrams per liter
mL - milliliters
NBS - near bank stress
NRCS - Natural Resources Conservation Service
UCCD – Uinta County Conservation District
SWCA - SWCA Environmental Consultants
TMDL - total maximum daily load
TSS - total suspended soils
WDEQ - Wyoming Department of Environmental Quality
WSII - Wyoming Stream Integrity Index

CHAPTER 1. INTRODUCTION

The Bear River implementation plan outlines a strategy for reducing sediment loads to attain water quality standards along the impaired segment of the Bear River from the confluence with Sulphur Creek to Woodruff Narrows Reservoir (Map 1). This implementation plan is supported by the Bear River Sediment total maximum daily load (TMDL) report (hereafter referred to as the TMDL report) completed by the Wyoming Department of Environmental Quality (WDEQ) in 2014 (WDEQ 2014). When combined with existing and recommended management measures, completion of the proposed implementation plan may result in a trend that may lead to full support of the uses designated by the State of Wyoming for the Bear River. The impaired segment is currently not supporting its cold water fishery and aquatic life other than fish designated uses, due to excess sediment, and this segment was added to the 303(d) list in 2002 (WDEQ 2012).

This implementation plan, in conjunction with portions of the TMDL report, includes the nine key elements identified by the EPA that are considered critical for achieving improvements in water quality (EPA 2008). The EPA requires that these nine elements be addressed in watershed plans funded with incremental Clean Water Act Section 319 funds, and strongly recommends that they be included in all watershed plans intended to address water quality impairments. Although there is no formal requirement for the EPA to approve watershed plans, the plans must address the nine elements discussed below if they are developed in support of Section 319-funded projects (EPA 2008). This implementation plan outlines a strategy to attain the load reductions identified in the TMDL report through implementation of best management practices (BMPs) throughout the watershed. The project implementation plan identifies source-specific BMPs, priorities for implementation, a period for implementation, a coordination plan, a monitoring plan, and costs associated with recommended structural BMPs.

The EPA's nine key elements are listed below in the order they appear in the guidelines and in this implementation plan; however, it should be noted that although they are listed as *a* through *i*, they do not necessarily need to be completed sequentially.

a) Identify and quantify causes and sources of the impairment(s).

b) Estimate load reductions needed to meet water quality standards.

c) Identify BMPs needed to achieve load reductions and critical areas where these management measures will be implemented.

d) Estimate needed technical and financial resources.

e) Provide an information, education, and public participation component.

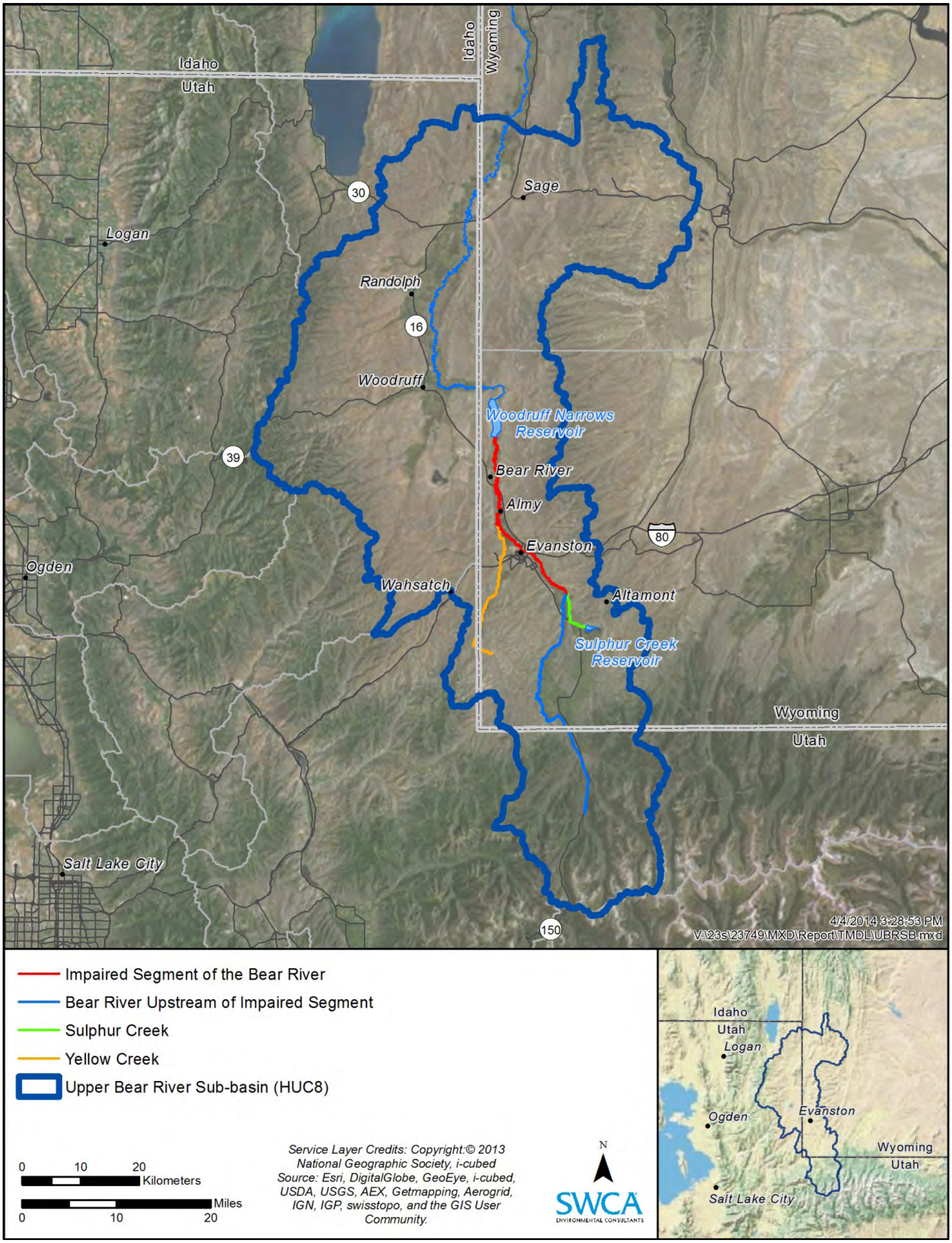
f) Include a schedule for implementing nonpoint source management measures.

g) Identify/describe interim measurable milestones for implementation.

h) Establish criteria to determine if load reductions/targets are being achieved.

i) Provide a monitoring component to evaluate effectiveness of the implementation over time for criteria in h.

For purposes of this implementation plan, the term *segment* applies only to the impaired segment; *reach* applies to the reaches defined within the impaired segment (i.e., Reach 1, Reach 2, and Reach 3), the upstream reach, and reaches of Sulphur and Yellow Creeks; and *section* applies to areas where field surveys (e.g., bank erosion hazard index [BEHI]/near bank stress [NBS]) were conducted.



Map 1. Bear River sediment TMDL study area.

For the purposes of this implementation plan, BMPs refer to any action or measure implemented or maintained in the watershed to control nonpoint sources of sediment to the impaired segment of the Bear River. These include traditional structural and nonstructural BMPs, as defined by the Natural Resources Conservation Service (NRCS), successful management measures implemented in similar watersheds, and actions and measures related to planning by stakeholders and to public information and education. Recommendations for nonpoint source reductions consider all sources and are based on management measures that consider BMPs, effectiveness, attainability, cost, critical areas, and the goal of distributing the responsibility for sediment reduction among all users in the watershed. BMPs should be implemented year-round, although the critical season for sediment loading was found to be during spring snowmelt flows, representing the period of April 1–July 1, as described in the TMDL report.

The implementation strategy for reducing sediment loads is an adaptive process, where data are gathered on an ongoing basis, sources are identified and eliminated if possible, and control measures including BMPs are implemented, assessed, and modified as needed. Measures to abate sediment loads include everything from public education and involvement, to reducing the bank erosion through engineering practices. Implementation of management measures as a suite of BMPs, as described in this plan, ensures that sediment load reductions could be achieved and designated uses may be restored to full support status.

This implementation plan has been developed based on the results presented in the TMDL report. In that report, a 19% reduction in sediment load is required for the impaired segment of the Bear River. Additional information and supporting calculations for the load analysis can be found in the TMDL report.

CHAPTER 2. KEY ELEMENTS OF THE IMPLEMENTATION PLAN

2.1 Identify and Quantify Causes and Sources of the Impairment (element *a*)

Identification of the causes and sources of excess sediment resulting in the impairment of the Bear River requires characterization and understanding of the geology, hydrology, land cover, and land uses in the study area. The TMDL report defines the study area for this characterization (see Map 1) that includes areas that contribute excess sediment to the impaired segment of the Bear River. The study area is described as follows: the main stem of the Bear River between Woodruff Narrows Reservoir and the headwaters of the Bear River, along Sulphur Creek below Sulphur Creek Reservoir, and along Yellow Creek.

The geology in the study area consists of fine-grained erodible formations that create highly erodible soils. The channel of the Bear River is situated in alluvium and colluvium derived from geologic formations that consist of mudstones, siltstones, sandstones, and shales. Hence, the Bear River is classified as an *alluvial river*, that is, a river in which the bed and banks are made up of mobile sediment and/or soil (Leopold et al. 1964). An alluvial river is continually changing its position and shape as a consequence of the hydraulic forces acting on its bed and banks. In the study area, these changes in channel configuration are evidenced by abandoned channels, meander cutoffs, and vegetation growth patterns observed on aerial/satellite photographs and identified during field surveys along the Bear River.

In the study area, the Bear River is a snow melt–dominated river. The headwaters of the Bear River are located in the Uinta Mountains of Utah and Wyoming where elevations range up to 13,000 feet and receive up to 40 inches of precipitation a year. Most of this precipitation falls predominantly as snow, where it is stored until the spring melt. Years with high snow packs and warm spring weather can release large amounts of water to the Bear River, resulting in floods. Spring peak flows average 1,914 cubic feet per second (cfs), with 100-year and 50-year recurrence interval flows of 4,248 and 3,803 cfs, respectively. The last floods occurred in the spring seasons of 2010 and 2011 when flows measured 3,240 and 3,390 cfs, respectively. Flooding is and always has been a natural characteristic of the Bear River, causing it to continuously shift its course and channel pattern throughout history.

Land cover in the study area varies based on the elevation, precipitation, and human activities. At the headwaters of the Bear River, the land cover is dominated by evergreen and mixed aspen and conifer forests that have been altered by silviculture (logging), recreational development, oil and gas production, mining, and utility development. At lower elevations along the main stem of the Bear River, Sulphur Creek, and lower Yellow Creek, most of the natural riparian areas and wood wetlands have been altered by clear cutting, vegetation treatments, and grazing. The land cover in these areas now consists of shrub/scrub and irrigated pasture and hay meadows. The conversion of riparian and upland vegetation to urban development occurs around the City of Evanston. At even lower elevations along the main stem of the Bear River, the land cover consists of emergent herbaceous wetlands that have been altered by rural development.

In summary, the seemingly endless source of fine-grained erodible sediments, combined with the continually changing morphology of the Bear River channel, natural flood events, and human activities have caused excess sediment to be eroded, transported, and deposited along the Bear River. These sediment sources and causes have resulted in a habitat modification, which does not support the impaired segment's designated uses for cold water fishery and aquatic life other than fish.

The remainder of this section identifies and quantifies the point and nonpoint sediment sources and loads associated with the impaired segment of the Bear River.

2.1.1 Point Sources

The Town of Bear River wastewater treatment facility is the only point source identified that discharges sediment-containing water directly to the Bear River. There are other point sources that indirectly discharge to the Bear River (via Yellow Creek), and these include the City of Evanston wastewater treatment facility and the Flying J commercial wastewater treatment system. No other point sources are known to contribute sediment to the Bear River. Average discharges, total suspended solid (TSS) concentrations, and sediment loads for these point sources are summarized in Table 1. Point sources represent 0.07% of the total sediment load to the impaired segment of the Bear River.

Table 1. Point Source Loads to the Bear River

Permit Holder/ Permit Number	Receiving Waterbody	Monthly Average Discharge (MGD)	Monthly Average TSS (mg/L)	Current Sediment Load (tons/day)
Town of Bear River/ WY0031712	Bear River	0.25	20.8	0.021
City of Evanston/ WY0020095	Yellow Creek	1.41	2.3	0.014
Flying J, Inc./ WY0035700	Yellow Creek	0.10	25.5	0.011
Total				**0.046**

MGD = million gallons per day; mg/L = milligrams per liter.

2.1.2 Nonpoint Sources

Nonpoint sources of sediment include watershed erosion, stream bank and channel erosion, and urban stormwater runoff. These nonpoint sediment sources are discussed further below.

2.1.2.1 Watershed Erosion

As defined in the TMDL report, watershed erosion is considered to be all erosion that occurs on the soil surface during rainfall events and transports sediment to the Bear River and tributaries as overland sheet flow. However, as discussed in the TMDL report, watershed erosion was determined to be of negligible importance for sediment transport in the study area. Therefore, management measures related to watershed erosion are not considered a high priority and are not addressed in this implementation plan.

2.1.2.2 Stream Bank and Channel Erosion

In the study area, stream bank and channel erosion occurs along the entire length of the Bear River and along the main tributaries (Sulphur Creek and Yellow Creek), but to varying degrees. Despite the natural factors that lend to stream bank and channel erosion along the Bear River, human activities have also had an influence on the occurrence and rate of this sediment source.

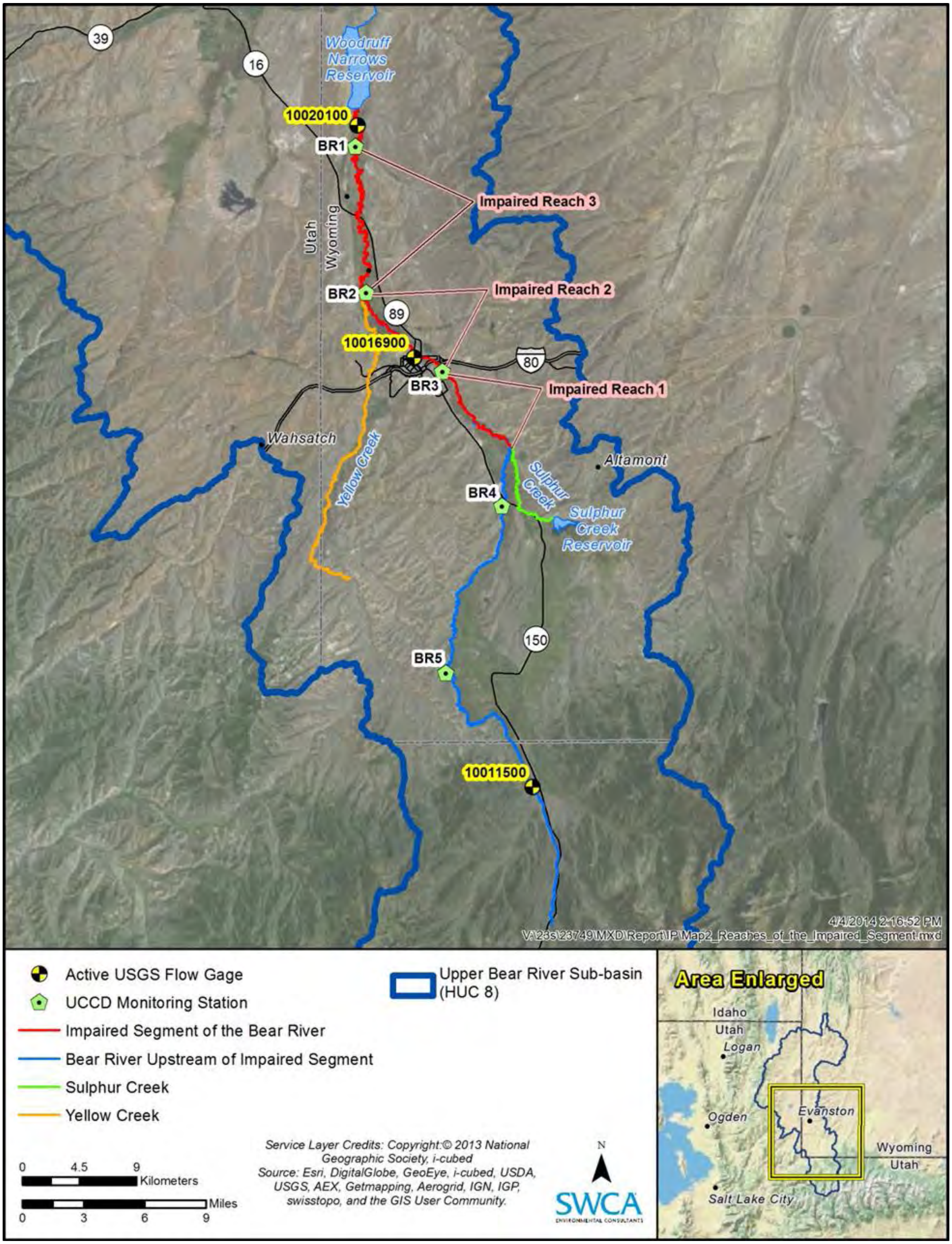
These influences include land use changes such as agricultural expansion into riparian buffer zones; construction of seasonal “push-up” dams for irrigation; removal of wooded wetlands and riparian vegetation; high-pulse short-term releases of water from Sulphur Creek Reservoir; bridge, road, and railroad building in riparian zones; haphazard placement of concrete blocks along stream banks; and channelization of the Bear River through the City of Evanston. All of these factors have contributed to increased stream bank erosion above what would be considered “background” levels.

As demonstrated in the TMDL report, stream bank and channel erosion represents the most significant nonpoint sediment source and load to the impaired segment of the Bear River. Stream bank erosion was estimated for the Bear River and tributaries by conducting BEHI/NBS surveys and subsequent BANCS[1] analysis (see the TMDL Report for details). The results of these surveys and analyses were used to calculate the sediment loads from stream bank erosion, delineate and map the bank erosion risk categories, and identify critical areas for implementation of management measures.

Most (99%) sediment loads from stream bank erosion are associated with spring snowmelt flows, representing the period of approximately April 1–July 1, the critical season for sediment loading to the Bear River and its tributaries. Sediment loads were estimated from TSS concentrations and flow data provided by Uinta County Conservation District (UCCD), as well as the BANCS analysis (see Appendix A in the TMDL document).

Quantification of the nonpoint source sediment loads from stream bank and channel erosion is addressed separately below for the Bear River upstream of the impaired segment, Sulphur Creek, and the impaired segment of the Bear River. The impaired segment of the Bear River is further divided into reaches based on monitoring locations established by the UCCD. Reach 1 begins at the top of the impaired segment and extends downstream to monitoring station BR3, Reach 2 extends from BR3 to BR2, and Reach 3 extends from BR2 to BR1 (Map 2). These monitoring stations are conveniently placed at locations where changes in land use and land cover occur. Therefore, these reaches provide a good division of the impaired segment for identifying the causes of stream bank erosion and evaluating the appropriate management measures.

[1] BANCS = bank assessment for nonpoint source consequences of sediment



Map 2. Reaches defined for the impaired segment of the Bear River.

Stream bank erosion along the impaired segment of the Bear River is significant, but variable. Stream bank erosion rates calculated using the BANCS model indicate that the area with the highest erosion rate is along impaired Reach 1 (from the Sulphur Creek confluence to Bear River State Park), which is roughly twice as large as the other two segments (Table 2). However, it is important to recognize that these results represent average conditions throughout each segment, and there can be a large amount of fine-scale spatial variability in stream bank erosion within each segment. There is also large-scale spatial variability in stream bank erosion along the impaired segment due to changes in the geology. The impaired segment of the Bear River is mostly situated in alluvium and colluvium; however, in Reach 1 the Bear River flows along the highly erodible cliffs of the Wasatch Formation that consists of mudstones, sandstones, siltstones, and claystones.

Table 2. Summary of Current Bank Erosion Rates and Associated Sediment Loads Along the Impaired Segment of the Bear River

Reach of the Impaired Segment	Length of Stream (feet)	Erosion Rate (tons/year/feet)	Stream Bank Erosion Sediment Load (tons/day)
Reach 1: Sulphur Creek Confluence to Bear River State Park	20,446	0.215	12.0
Reach 2: Bear River State Park to Yellow Creek	60,118	0.085	14.0
Reach 3: Yellow Creek to Woodruff Narrows Reservoir	111,464	0.096	29.5
Total	**192,028**	**Not applicable**	**55.5**

2.1.2.3 Upstream Sediment Loads

The upstream sediment load to the impaired segment of the Bear River was calculated using TSS and flow data collected by UCCD at the BR4 monitoring station. The BR4 station is on the Bear River approximately 4.4 miles upstream of the Sulphur Creek confluence. As shown in Table 3, the upstream sediment load was estimated from the average flows and average TSS measurements collected during the high, medium, and low flow regimes. A weighted sediment load was then calculated based on the frequency of flows in each flow regime (i.e., from the flow duration curve: high flow frequency = 20%, medium flow frequency = 60%, and low flow frequency = 20%). The resulting average upstream sediment load is 10.2 tons/day.

As also shown in Table 3, most (97.7%) of the sediment load delivered to the impaired segment of the Bear River from upstream sources occurs during periods of high flow. This is consistent with widely accepted hydrologic theories that most sediment transport occurs during high flows. “High flows” are defined in the TMDL report using a flow duration approach recommended by EPA. For the Bear River TMDL, flow regimes are defined by the following flow duration intervals: 0–20% (high flow), 20%–80% (medium flow), and 80%–100% (low flow).

Table 3. Upstream Sediment Loads to the Impaired Segment of the Bear River

Flow Regime	Average Flow (cfs)	Average TSS (mg/L)	Average TSS (tons/day)	Weighted Average TSS Load (tons/day)	Percentage of Total Load
High	434	32	49.7	9.9	97.7%
Medium	54	3	0.3	0.2	2.0%
Low	24	2	0.1	0.03	0.3%
Total	**–**	**–**	**–**	**10.2**	**100%**

2.1.2.4 Tributary Sediment Loads

There are two main tributaries to the Bear River in the study area: Sulphur Creek and Yellow Creek. Flows to the Bear River from Sulphur Creek have been altered by the construction of Sulphur Creek Reservoir. This reservoir is used to store irrigation water that typically spills in the spring. It has non-irrigation releases of 10 to 50 cfs that occasionally exceed 200 cfs from spilling before irrigators request releases. Releases for irrigation are less than 102 cfs and average 80 cfs (personal communication Dennis Cornelison, Chairman UCCD, to John Christensen, SWCA, May 14, 2014). In addition, since construction of the dam, the timing of peak flows in Sulphur Creek has changed. Before construction, flows peaked in Sulphur Creek on average near the middle of April, whereas post-construction flows are now peaking on average near the middle of May. Historically, flows in Sulphur Creek peaked about a month and a half before flows in the Bear River above the confluence of Sulphur Creek peaked (data from USGS gage 10014000 indicate that flows peaked around May 31). Now, Sulphur Creek peaks at about the same time as the peak in Bear River.

The sediment load from Sulphur Creek to the impaired segment of the Bear River was calculated using TSS and flow data collected by UCCD at the SC1 monitoring station. The SC1 station is on Sulphur Creek approximately 6 miles upstream of its confluence with the Bear River. Using the same approach to calculate upstream loads, the resulting average upstream sediment load from Sulphur Creek is 2.1 tons/day (Table 4). As also shown in Table 5, most (86%) of the sediment load delivered to the impaired segment of the Bear River from Sulphur Creek occurs during periods of high flow.

Table 4. Sulphur Creek Sediment Loads to the Impaired Segment of the Bear River

Flow Regime	Average Flows (cfs)	Average TSS (mg/L)	Average TSS Load (tons/day)	Weighted Average TSS Load (tons/day)	Percentage of Total Load
High	96	37.5	9.0	1.8	86.3%
Medium	22	7	0.4	0.3	12.9%
Low	7	6	0.09	0.02	0.8%
Total	–	–	–	**2.3**	**100%**

Little is known about the flows in Yellow Creek. There was a U.S. Geological Survey flow gage (10017000) on Yellow Creek, near the Wyoming-Utah state line that operated from 1943 to 1978. However, it is located above most major irrigation diversions and does not represent flows at the mouth of Yellow Creek. No TSS monitoring activities could be identified on Yellow Creek. A bank erosion survey conducted by SWCA in 2013 indicated that the bank erosion risk is extreme[2]; however, the presence of flows needed to transport these sediments to the Bear River is unknown. Flows are low at the mouth of Yellow Creek (i.e., less than 5 cfs) for most of the year, but during spring snowmelt, flows generally range from 20 to 30 cfs, and can peak as high as 100 cfs (personal communication Donald Shoemaker, Water Commissioner for District IV, to John Christensen, SWCA, November 20, 2013). Sediment loads from Yellow Creek were estimated using an assumed average high flow regime flow of 25 cfs. TSS was estimated at the mouth of Yellow Creek from the only identified measurement, taken during a beneficial use reconnaissance project (BURP) report when the flow was reported as 0.058 cfs. These calculations yielded a TSS load of 3.9 tons/day, resulting in a weighted high flow average TSS load of 0.8 tons/day from Yellow Creek to the impaired segment.

[2] The survey methods and results from this survey are presented in the TMDL report (WDEQ 2014).

2.1.2.5 City of Evanston Stormwater

Stormwater flows from urban areas consist of episodic flows that accumulate from streets, parking areas, rooftops, and other impervious surfaces. Constituents transported during storm events can include oil and grease from vehicles, sediment, nutrients, and organic matter such as litter, yard clippings, and pet wastes. Thus stormwater runoff may have a disproportionate influence on habitat.

The stormwater system in the City of Evanston is currently unregulated and does not require a permit (personal communication, Barb Sahl, March 12, 2013). Therefore, the city stormwater system is considered a nonpoint source.

Stormwater in the City of Evanston is collected in numerous basins and discharged to 103 outfalls. Eight of these outfalls discharge directly to the Bear River. The current stormwater sediment load to the Bear River was calculated by estimating the collection basin areas associated with each of these eight outfalls, and multiplying the modeled runoff from each stormwater basin by the area-weighted TSS concentrations for each basin (see TMDL report). The modeled runoff from each stormwater basin was determined using the average annual rainfall in Evanston (11.71 inches) that is based on rainfall data from 1990 to 2013. This resulted in an average sediment load to the Bear River of 0.21 ton/day. Stormwater sediment represents 0.3% of the total sediment load to the impaired segment of the Bear River.

2.1.3 Natural Background

Considering that human influence has been a significant factor in the development and channel evolution of the Bear River over the past century, it is difficult to establish what would have been a pre-development background sediment load. However, EPA (2000) provides reference values for background turbidity concentrations for the xeric west ecoregion. Turbidity was correlated with TSS for the UCCD monitoring station upstream of the impaired segment (BR4), and this relationship was used to estimate a background upstream TSS concentration for the Bear River (8.1 mg/L). This concentration was then multiplied by measured high flows measured at BR4 to arrive at an average background load of 9.5 tons/day. By applying a high flow frequency of 20%, the weighted average high flow upstream background TSS load is equal to 1.9 tons/day. Similar calculations were made to estimate the natural background concentrations for Yellow Creek and Sulphur Creek (Table 5.)

Table 5. Summary of Natural Background Sediment Loads in the Study Area

Reach	Natural Background Sediment Load (tons/day)
Upstream (BR4)	1.9
Yellow Creek (BR2 TSS assumed)	0.1
Sulphur Creek (SC1)	0.5

2.1.4 Summary of Causes, Sources, and Sediment Loads

Sediment loads to the impaired segment of the Bear River are dominated by instream channel and bank erosion. Although the Bear River has experienced a significant amount of channel migration and erosion in the past, anthropogenic influences have amplified these effects to a point where the current channel configuration and flow regime cannot adequately transport sediment loads to meet Wyoming water quality standards.

The total current sediment load to the impaired segment of the Bear River is 68.1 tons/day including natural background. Point sources contribute very little sediment load (0.046 ton/day) to the current load. Natural background from all sources equals 5.2 tons/day, leaving 62.8 tons/day from all nonpoint sources (Table 6). Stream bank and channel erosion along the impaired segment accounts for most (77%) of the total sediment load, where upstream loads (12%) and natural background loads (10%) make up most of the remaining sediment load (Figure 1).

Table 6. Current Load Summary

Sediment Source	Sediment Load (tons/day)	Natural Background Load (tons/day)	Sediment Load Adjusted for Natural Background (tons/day)
Bear River upstream of the impaired segment	9.9	1.9	8.0
Sulphur Creek	1.8	0.5	1.3
Stream bank and channel erosion of the impaired segment	55.5	2.7	52.8
City of Evanston stormwater	0.02	0	0.02
Yellow Creek	0.8	0.1	0.7
Point sources	0.046	0	0.046
Total	**68.1**	**5.2**	**62.8**

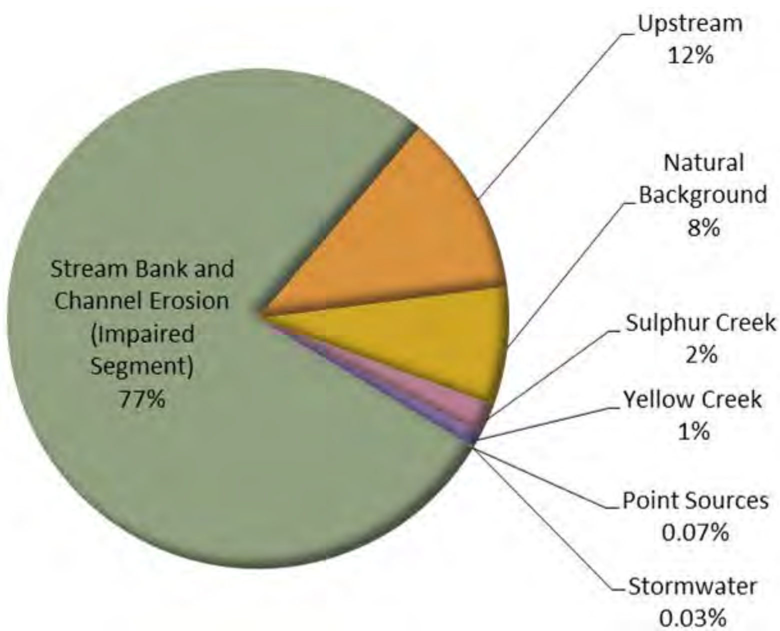


Figure 1. Sediment sources and percentages of load to the impaired segment of the Bear River.

2.2 Estimate Load Reductions Needed to Meet Water Quality Standards (element *b*)

2.2.1 Waste Load Reductions

A summary of waste load allocations for point sources that discharge to the impaired segment of the Bear River and Yellow Creek is presented in Table 7. Waste load allocation calculations are based on the permitted monthly average discharge and permitted monthly average TSS (see TMDL report).

Table 7. Point Source Waste Load Allocations

Permit Holder	Permitted Monthly Average Discharge (MGD)	Permitted Monthly Average TSS (mg/L)	Waste Load Allocations (tons/day)	Current Sediment Load (tons/day)
Town of Bear River	0.18	100	0.073	0.021
City of Evanston	2.90	30	0.363	0.014
Flying J, Inc.	0.10	30	0.012	0.011
Total			**0.448**	**0.046**

MGD = million gallons per day; mg/L = milligrams per liter.

The total sediment waste load allocation for the three point sources is 0.448 tons/day. This represents 0.07% of the total load to the impaired segment of the Bear River. The current point source sediment loads are at or below their respective waste load allocations, and no further action or sediment load reduction is necessary.

2.2.2 Load Reductions

Nonpoint sources account for 99.9% of the sediment load to the impaired segment of the Bear River. Stream bank and channel erosion along the impaired segment, upstream of the impaired segment, and on Sulphur and Yellow Creeks accounts for 99.6% of this load; and stormwater from the City of Evanston accounts for 0.3%. Therefore, nonpoint source load reductions focus on stream bank and channel erosion. However, management measures to ensure control of stormwater sediment sources are provided in section 2.3.2.

Using the results from the BANCS analysis, the sediment load capacity for the Bear River and its tributaries is based on reduced bank erosion rating categories. Bank erosion rating categories are qualitative measures of the sediment supply loaded into a river, and they are delineated from the total distribution of erosion rates (in tons per year per foot of bank) (Table 8). The distribution of erosion rates from the BANCS model implied the following categories, which correlate to the 10th, 25th, 50th, 75th, and 90th quartiles of the distribution.

Table 8. Erosion Rating Categories

Category	Range of Erosion Rates (tons/year/feet)
Very low	0.000–0.050
Low	0.051–0.100
Moderate	0.101–0.200
High	0.201–0.500

Very high	0.501–1.000
Extreme	>1.000

Based on the results of BEHI/NBS surveys conducted on the unimpaired upstream reach of the Bear River (i.e., the Bear River above the confluence with Sulphur Creek), the highest measured erosion risk category was moderate (see Map 3 in section 2.3.1.3). Therefore, an erosion risk category of moderate or lower was used for estimating nonpoint source load capacities and reductions for tributaries to the impaired segment and the impaired segment proper. Thus, each reach of the impaired segment that had an erosion risk category of high or greater was reduced to moderate (0.101 tons per year per foot of bank) to estimate the sediment load capacities and reductions required (Table 9).

Table 9. Sediment Load Capacity Based on BANCS and Reductions Required

Reach or Tributary	Current Load (tons/day)	Load Capacity (tons/day)	Reduction Required (tons/day)	Percentage Reduction Required	Reduction Required (tons/day/mile)
Reach 1: Sulphur Creek confluence to Bear River State Park (7.5 miles)	12.0	5.5	6.5	54.2%	0.9
Reach 2: Bear River State Park to Yellow Creek (8.2 miles)	14.0	14.0	0	0.0%	0.0
Reach 3: Yellow Creek to Woodruff Narrows Reservoir (16.4 miles)	29.5	25.3	4.2	14.0%	0.3
Total	55.5	44.8	10.7	19%	0.3

2.3 Identify BMPs Needed to Achieve Load Reductions and Critical Areas Where These Management Measures will be Implemented (element *c*)

Excess sediment contributions from natural processes and human activities are often difficult to segregate and measure; however, human activities also need to consider the dynamic and sensitive landscape of the Bear River. It is the goal of this implementation plan to maintain the land uses that are critical to the health and livelihood of the landowners and stakeholders, while finding solutions to reduce sediment and restore the Bear River to full support of its designated uses. This goal can be achieved through the implementation of the management measures recommended in this section, which requires a concerted effort among landowners, stakeholders, and the general public.

As discussed above, stream bank erosion is the largest source of sediment to the impaired segment of the Bear River and, due to its varying causes and degree of impact throughout the study area, represents a significant challenge in achieving the required load reductions. Therefore, management measures that focus on load reductions from stream bank and channel erosion are emphasized. However, management measures to ensure control of stormwater sediment sources are also discussed.

2.3.1 Stream Bank and Channel Erosion

Excess stream bank erosion is a result of both land management practices and stream channel health, and therefore requires a variety of measures to address its associated sediment loading. In summary, most human impacts can be mitigated through a suite of management measures that include BMPs such as re-design of irrigation diversion structures, channel stabilization, and management of reservoir releases.

2.3.1.1 Existing Management Measures in Watershed

The Upper Bear River Water Quality Steering Committee, in cooperation with the Wyoming Association of Conservation Districts, the UCCD, the NRCS, and the Wyoming Department of Agriculture, created the *Upper Bear River Watershed Management Plan* in 2005 to address water quality and trans-boundary regulatory issues affecting the health of the Bear River (UCCD 2005). The watershed plan identifies BMPs to address stream bank and channel erosion.

The watershed management plan also outlines potential sources of funding for these BMPs, including incentives through the Farm Bill, Wyoming Department of Water Quality, and government assistance programs, as well as cost-share opportunities provided by UCCD and NRCS. It is clear that a great deal of time and effort went into the planning of this watershed management plan, and the recommended management measures presented in Section 2.3.1.2 below include some of the BMPs from that plan.

There have been several bank stabilization projects completed in the impaired segment of the Bear River over the past 30 years. In their geomorphic and hydraulic assessment of the Bear River near Evanston, Smith and Maderak (1993) note that much of the channel from Bear River State Park through the town of Evanston had been stabilized in the early 1980s (Figure 2). They also note that many of these stabilization measures were inadequate and cite the deposition of dislodged riprap material (cement bags, concrete slabs, boulders, and tires) downstream from placement sites, indicating that riprap stabilization is only a temporary stabilization measure.

Figure 2. Riprap bank stabilization on the Bear River near Evanston in 1983. Photograph courtesy of Smith and Maderak (1993).

In the past 15 years, more concentrated efforts from the State of Utah, Uinta County, Wyoming Department of Transportation, and others have increased channel stability throughout the impaired segment of the Bear River. In 2013, Uinta County Road and Bridge completed a project on the Saxton property through an U.S. Army Corps of Engineers bank stabilization permit, which placed rocks and boulders along the river banks to mitigate erosion risk to a county road and regional water service line (Figure 3).

Figure 3. Before (left) and after (right) photographs of Saxton property bank stabilization. Photograph courtesy of Gary Welling, GIS Coordinator, Uinta County, Wyoming.

Additionally, the Town of Bear River is working with the National Park Service to develop five separate parcels of land (ranging from 5 to 17 acres) into a park and trail system. The National Park Service is currently creating a bank stabilization BMP plan for the Town of Bear River to address the issue of bank erosion near the proposed trail and expects for the plan to be complete by the summer of 2014 (personal communication, Kenneth Richley, National Park Service, to Jake Diamond, SWCA, January 21, 2014). In 2007, the UCCD and NRCS worked with the Town of Bear River and local volunteers to slope and revegetate a bank on the town's park easements (Figure 4). Prior to this, the Town of Bear River has also performed some revetment and willow planting along its banks, but these stabilization measures were washed away in a heavy runoff year.

Figure 4. Substitute teacher Rose Hurdsman gets direction from NRCS conservationist Jeff Lewis on tying willow bundles. Photograph from *Herald Journal News* 2007.

The State of Utah and Wyoming Department of Transportation recently completed a concrete riprap stabilization project in winter 2013 where U.S. Route 89 crosses the Bear River, and in 2011, stabilization and stream restoration work was completed in Bear River State Park (Figure 5). Most recently, a request for proposals was advertised by the UCCD for a planned Yellow Creek stream stabilization and restoration project for 6,300 stream feet located 5.3 miles southwest of Evanston. The goal of the project is to benefit the northern leatherside chub and other aquatic fish and wildlife species. The project is assumed to be completed in 2014.

Figure 5. Boulder placement and channel stabilization - City of Evanston Greenway.

2.3.1.2 Recommended Management Measures for Future Implementation

To address sediment loading and deposition into the Bear River, several actionable management measures and BMPs have been identified for future implementation, in addition to those that have already been implemented or planned. Table 10 lists the recommended management measures and BMPs for reducing sediment loads from stream bank and channel erosion.

Table 10. Recommended Management Measures and BMPs for Reducing Sediment Loads from Stream Bank and Channel Erosion (Adapted from EPA 2004)

Management Measure	BMP	Description
Hard bank stabilization	Boulder revetments	Place boulders in varying configurations along a bank. Effective stabilization method when cause of failure is toe erosion, bank scouring, or urban stream enlargement.
	Rootwad revetments	Lower trunk and root fan of tree (this is best for smaller streams without channel incision).
	A-jacks	Use star-like concrete structures for toe protection. Best for stream banks with cohesive soils and must be combined with other stream bank protection measures to stabilize upper and middle stream bank.
	Live cribwalls	Use timber frame retaining wall with vegetation to enhance in-stream habitat. Used along eroding stream banks with steep slopes.
Soft bank stabilization	Stream bank shaping	Change contours of stream bank without changing the toe.
	Coir fiber logs	Use biodegradable cylinders of coconut fiber (used in low-gradient small streams).

Table 10. Recommended Management Measures and BMPs for Reducing Sediment Loads from Stream Bank and Channel Erosion (Adapted from EPA 2004)

Management Measure	BMP	Description
	Erosion control fabrics and revetments	Use netting or mat on gentle slopes. Suitable for upland slopes and floodplains or stream bank slopes of 2:1 or gentler.
	Soil lifts	Use terraces of soil wrapped in soil erosion control fabric. Can be used on slopes as steep as 1:1 and banks as tall as 30 feet.
	Live stakes	Install dormant, unrooted cuttings of riparian trees into stream banks. Can be used for shallow streams with low to moderate toe erosion and poor bank vegetation.
	Live fascines	Use bundled dormant cuttings of willow bound with wire for toe protection. Can be used as toe protection along low gradient streams when erosion potential is low.
	Brush mattress	Place a layer of dormant cuttings on stream bank and secure with stakes .Ideal bank slope is 3:1 and cohesive soils with adequate moisture.
	Vegetation establishment	Plant native vegetation (this is critical to stream bank stabilization)
Flow deflection techniques	Wing deflectors	Use low-profile triangular structures that extend out from stream banks. Best for streams with extensive channel widening and shallow, poorly defined baseflow channels.
	Log, rock, and "J" vanes	Use linear rock or log structure extending out from stream bank, points upstream. Used in urban streams where toe erosion and scour are dominant erosion processes. Not recommended in streams that are actively degrading or incising.
Grade control	Rock vortex weirs	Use instream structure that creates diversity of flow velocities. Appropriate in cobble/gravel streams with gradients less than 3% and moderate bedload transport.
	Rock cross vanes	Similar to rock vortex weirs, but with lower profile Appropriate in low to moderate gradient cobble/gravel bed streams.
	Step pools	Use a series of low-elevation weirs and pools that dissipate stream energy. Used to reconnect urban stream reaches separated by large drops in channel elevation.
	V-log drops	Use two logs joined at an angle with apex pointing upstream. Each log should be long enough so that 1/3 of its total length is anchored in the streambed.
Instream habitat enhancement (also help to reduce flow velocities causing erosion)	Lunkers	Install wooden, crib-like structures below water surface. Located below low flow water surface on outside of meander bends. Not suitable for straight reaches or the inside of meander bends.
	Large woody debris	Install large tree limbs, trunks, and root wads in channel. Debris needs to be sized correctly for channel size.
	Boulder clusters	Install large rocks near the stream center. Should only be applied in streams that are stable in grade and plan form. Should be avoided in braided and sand bed streams.
	Baseflow enhancement	Install a series of BMPs to direct flows to stream center. Effective for medium to large urban streams with mobile cobble/gravel substrates.
Comprehensive restoration	Channel re-design	Alter dimensions, pattern, and profile of unstable channel.

Table 10. Recommended Management Measures and BMPs for Reducing Sediment Loads from Stream Bank and Channel Erosion (Adapted from EPA 2004)

Management Measure	BMP	Description
	De-channelization	Return stream to as natural a condition as possible.
Livestock management	Riparian fencing	Fence riparian areas to allow for the establishment of native vegetation.
Irrigation management	Permanent diversion structures (e.g., lay-flat stanchion dams)	Replace seasonal "push-up" dams, which contribute to sediment loads.
Agricultural management	Riparian buffer	Use a buffer between managed land and riparian banks to prevent bank erosion.

To determine which BMPs will be the most effective in a given location, it is imperative that pre-construction studies be performed to assess channel hydrology and geomorphology.

Examples of some of the BMP listed in Table 10 above are shown in the following photographs (Figures 6–11).

Figure 6. Cross-vane BMP. Photograph courtesy of Wildland Hydrology.

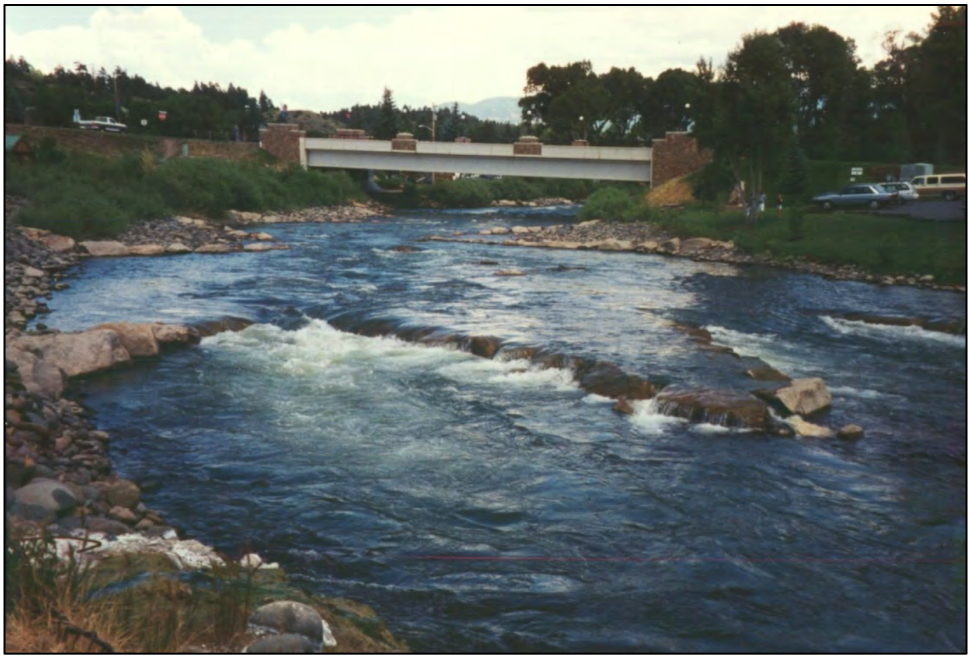


Figure 7. W-weir BMP. Photograph courtesy of Wildland Hydrology.

Figure 8. J-hook BMP. Photograph courtesy of Wildland Hydrology.

Figure 9. Rootwad and log vane combo BMP. Photograph courtesy of Stantec Engineering.

Figure 10. Woody debris and toe sod mat combo BMP. Photograph courtesy of Stantec Engineering.

Figure 11. Before (left) and 3 days after construction (right) for a stream bank shaping and stabilization project in Dry Creek, Oklahoma. Photograph courtesy of Stantec Engineering.

In addition to the management measures and BMPs listed above, efforts should be made to address temporary diversion dams used for irrigation. Temporary diversion dams, also referred to as “push-up” dams or “seasonal” dams, are present on the Bear River and tributaries throughout the study area. A “push-up” dam is a water-diversion structure reconstructed from river gravel and cobbles each spring. Using heavy machinery, river rock is pushed up to raise the river level enough to divert irrigation water into a ditch. The repeated construction of these temporary diversion dams in and along rivers can damage the rivers’ channels and banks and can increase downstream sediment loads during construction and washout. Installation of permanent diversion dams, such as lay-flat stanchion dams or weirs, divert river water for irrigation without degrading the river channel or banks, or affecting downstream water quality.

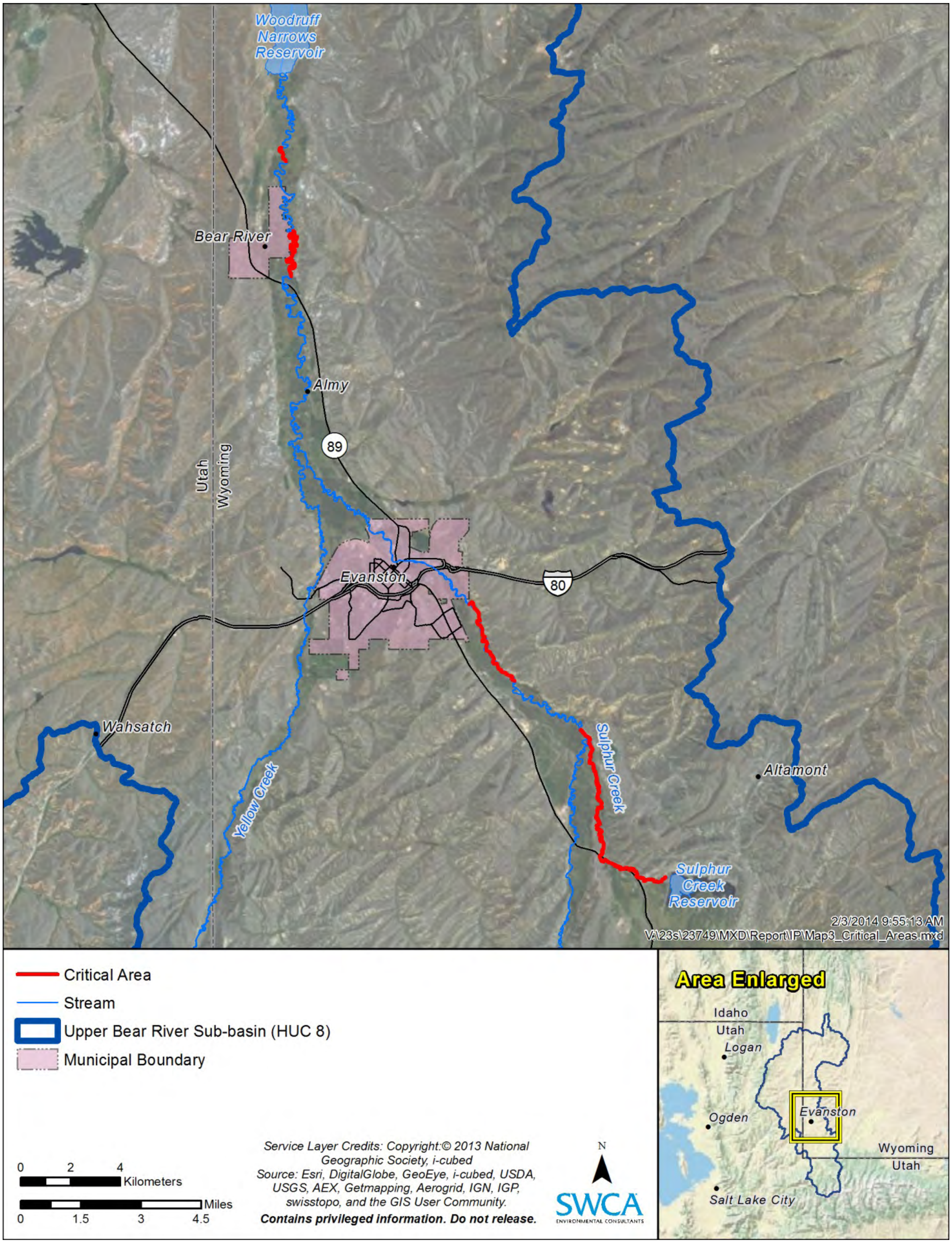
Although the location and number of these temporary diversion dams has not been surveyed or quantified, review of aerial photographs show that these diversion dams appear to be concentrated along the upstream reach, Yellow Creek, and to a lesser degree along the lower reach (Reach 3 on Map 2) of the impaired segment. Most of these diversion dams are installed in the spring and removed in the fall, or left in place to wash out (personal communication, Donald Shoemaker, Water Commissioner for District IV, to John Christensen, SWCA, November 20, 2013). A thorough survey of temporary diversion dam locations and construction methods should be conducted to evaluate the critical areas and appropriate BMPs to address this potential sediment source.

Managing flows released from Sulphur Creek Reservoir to establish a more historical flow regime is also recommended as a BMP to reduce loads from Sulphur Creek. It is recognized that water rights in this region are very complicated and rely on timing of releases from Sulphur Creek Reservoir. Therefore, this recommendation is tempered by the irrigation water requirements of the watershed residents.

2.3.1.3 Critical Areas

Critical areas for implementation were identified through the BANCS analysis of the Bear River and its major tributaries, Sulphur and Yellow Creeks. River reaches with high, very high, or extreme erosion ratings are the most critical areas for targeted implementation efforts (Map 3). Sulphur Creek below the reservoir and the segment between its confluence with the Bear River and the state park are critical areas for implementation of management measures. Although Yellow Creek was identified as a critical area for sediment supply, it is likely that most of the sediment produced in this tributary does not make it to the Bear River due to its low flows and subsequent low stream power. Therefore, Yellow Creek is not as high of a priority as Sulphur Creek and the beginning of the impaired segment.

Although the BANCS analysis has identified reaches and areas that are the highest sources of sediment, there is still a great deal of variability within these reaches. Therefore, the critical areas map (Map 3) should be used as a general way to identify critical areas. From there, local knowledge and additional field surveys should be used to identify more specific reaches for project implementation. However, based on the size and flows of the Bear River, it is clear that large-scale restoration efforts are necessary to create a stable geomorphology and channel structure.



Map 3. Stream bank erosion critical areas.

2.3.2 City of Evanston Stormwater

When compared to stream bank and channel erosion, stormwater is not a significant source of sediment to the impaired segment of the Bear River. However, this implementation plan uses a watershed approach that requires a coordinated effort between all stakeholders to address all sediment sources. Moreover, harboring a local understanding of the relationship between stormwater, watershed processes, river flow, and sediment loads is central to the success of this implementation plan.

2.3.2.1 Existing Management Measures in Watershed

The watershed management plan identifies management measures for stormwater- and stream bank erosion–related sediment loads (UCCD 2005). Similar to the BMPs identified for bank erosion, many of these measures include BMPs that are recommended below for future implementation.

2.3.2.2 Recommended Management Measures for Future Implementation

The management measures outlined in the watershed management plan for reducing stormwater- and watershed-derived sediment loads represent a strong suite of BMPs that are also recommended in this implementation plan. Therefore, it is recommended that the watershed management plan be revisited by stakeholders and associated agencies. Table 11 summarizes some of the management measures and BMPs listed in the watershed management plan, and additional BMPs that are recommended for reducing sediment loads from stormwater and watershed erosion.

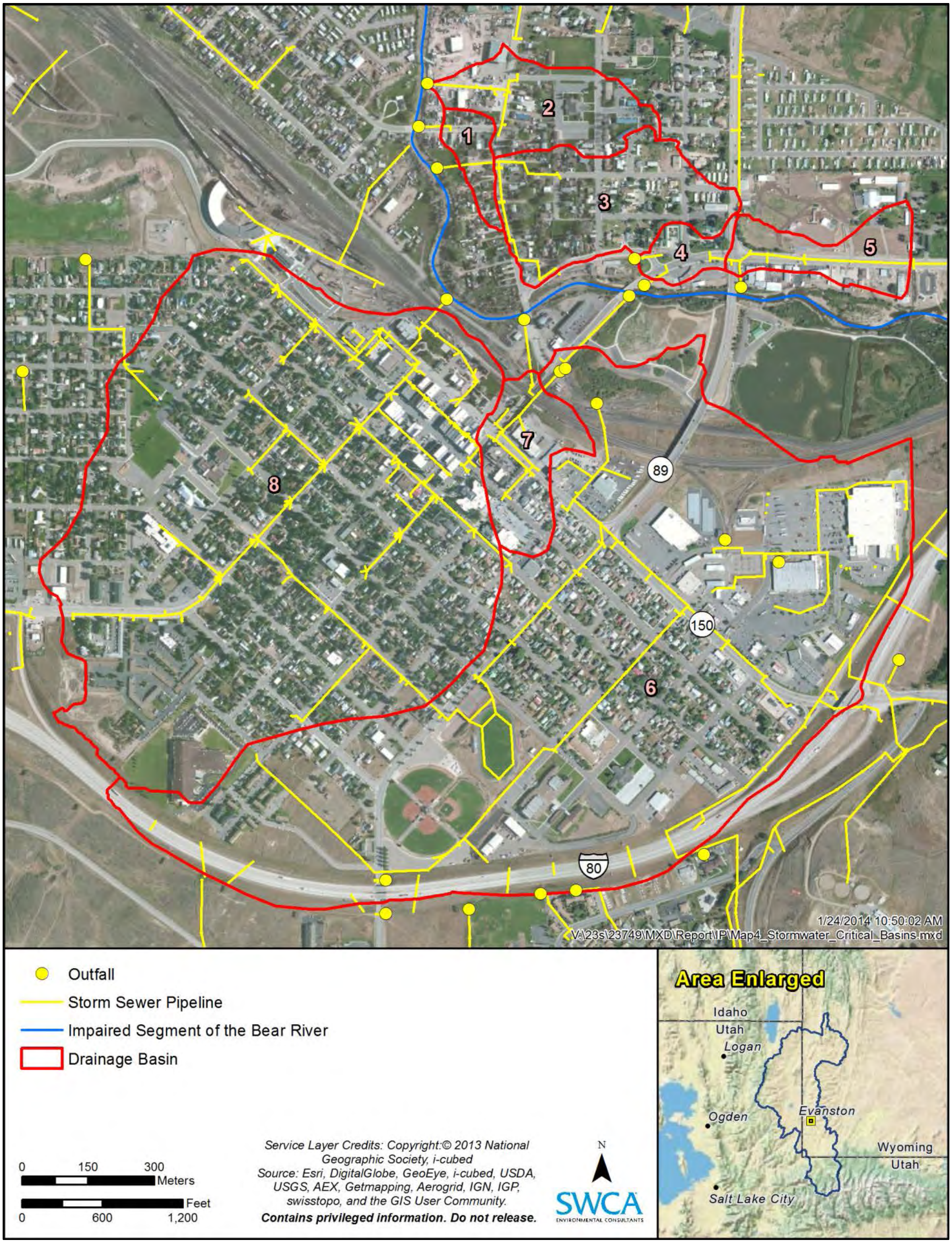
Table 11. Recommended BMPs for Reducing Sediment Loads from Stormwater

Management Measure	BMP	Description
Stormwater retrofits	Inlet protection device	Install flow-through structure with settling unit that removes sediment
	Sand filter	Install to remove sediment from stormwater
	Sediment trap	Install to remove sediment
Discharge prevention	Stormwater planter	Plant tree or shrubs in urban areas to capture stormwater.
	Tree box filter	Install tree box filters in urban areas to capture stormwater.
	Vegetated filter strip	Install vegetated surfaces that are designed to treat sheet flow from adjacent surfaces.
	Vegetated roofs	Plant vegetation on roofs of urban buildings to reduce runoff to impervious areas.
Road stabilization	Rock treatments	Install rocks and ditches

Source: UCCD (2005).

2.3.2.3 Critical Areas

Storm drains concentrate flow and sediment generated from storm events from a particular basin and route it into the Bear River. Critical areas of stormwater runoff are within the eight stormwater basins that collect stormwater that discharges directly to the Bear River (Map 4).



Map 4. Critical areas for stormwater BMPs.

2.4 Estimate Needed Technical and Financial Resources (element *d*)

Successful implementation relies on various technical and financial needs as well as a strong foundation of plan sponsors that will be responsible for actual on-the-ground work. A thorough understanding of these needs is essential for creating a clear path forward that will ensure long-term operation and maintenance of management measures, information and educational activities, and monitoring.

Implementation of the management measures and BMPs necessary to meet the water quality goals outlined in the TMDL will require a significant allocation of financial and technical resources from multiple sources. Cost-benefit studies are recommended as a tool for identifying the most cost-effective strategies to prioritize throughout the watershed. The implementation plan and costs outlined here are a general guide and are not intended to be a comprehensive list of costs associated with all potential BMPs or required resources. Final decisions on project implementation will be made by land managers and owners based on their intricate knowledge of specific areas of the watershed.

2.4.1 Resources

Stakeholders that may be involved in technical assistance and execution of the implementation plan include the following:

- WDEQ
- United States Army Corps of Engineers
- Wyoming Association of Conservation Districts
- UCCD
- NRCS
- Trout Unlimited
- Partners for Fish & Wildlife
- City of Evanston
- Town of Bear River

The needed resources for each recommended BMP are listed in Table 12.

Table 12. Summary of Financial and Technical Needs to Implement BMPs for the Bear River Sediment TMDL

Sediment Source	Management Measure	BMP	Sources of Potential Funding	Technical Needs	Approximate Costs
Bank and Channel Erosion	Hard bank stabilization	Boulder revetments	319(h) funds Cost-shares Trout Unlimited	HE, ENG	$20–$40/linear foot
		Rootwad revetments		HE, ENG	$10–$100/linear foot
		Imbricated riprap		HE, ENG	$60–$90/linear foot
		A-jacks		ENG	$65–$85/linear foot
		Live cribwalls		HE, ENG	$250–$300/linear foot
	Soft bank stabilization	Stream bank shaping		HE, ENG	Varies
		Coir fiber logs		ENG	$8–$30/linear foot
		Erosion control fabrics		ENG	$1–$5/square yard
		Soil lifts		HE, ENG	$12–$30/linear foot per one foot tall lift
		Live stakes		ENG	$1–$3/stake
		Live fascines		ENG	$5–$22/linear foot
		Brush mattress		ENG	$30–$50/linear foot
		Vegetation establishment		ENG	Varies
	Flow deflection techniques	Wing deflectors		HE, ENG	$400–$800 each
		Log, rock, and "J" vanes		HE, ENG	$400–$1,400 each
	Grade control	Rock vortex weirs		HE, ENG	$1,200–$2,100 each
		Rock cross vanes		HE, ENG	$1,200–$1,700 each
		Step pools		HE, ENG	$2,000–$6,000 each
		V-log drops		ENG	$800–$2,600 each
	Instream habitat enhancement	Lunkers		HE, ENG	$45–$60/linear foot
		Large woody debris		HE, ENG	$20–$40/linear foot
		Boulder clusters		HE, ENG	$60–$250 each
		Baseflow enhancement		HE, ENG	Varies
	Comprehensive restoration	Channel re-design		HE, ENG	Varies

Table 12. Summary of Financial and Technical Needs to Implement BMPs for the Bear River Sediment TMDL

Sediment Source	Management Measure	BMP	Sources of Potential Funding	Technical Needs	Approximate Costs
		De-channelization		HE, ENG	Varies
	Livestock management	Livestock fencing		None	$2/linear foot
		Grazing Management		None	Varies
	Irrigation management	Permanent diversion structures		HE, ENG	Varies
	Agricultural management	Riparian buffer		ENG	$400–$5,000/acre
	Land use management	Enforce stream alteration permits		None	Varies
Stormwater	Stormwater retrofits	Inlet protection device	Municipalities	ENG	$50–$150/inlet
		Sand filter		ENG	$3–$10/cubic foot of runoff treated
	Discharge prevention	Stormwater planter		None	Varies
		Tree box filter		None	Varies
		Vegetated filter strip		ENG	$13,000–$30,000/acre
	Road stabilization	Rock treatments	Uinta County	ENG	Varies
Watershed Erosion	Riparian reforestation	Bank revegetation	319(h) funds Cost-shares Trout Unlimited	ENG	Varies
	Runoff prevention	Silt Fence		ENG	$8–$10/linear foot
		Fiber Rolls		ENG	$8–$10/linear foot

HE = heavy equipment; ENG = engineering

Cost data from EPA (2004).

Using a general range of costs ($100–$300/linear foot of bank) for bank stabilization (personal communication, Nathan Jean, Stantec Engineering, to John Christensen, SWCA, January 6, 2014), and the total linear feet of bank that need stabilization, estimated costs are summarized in Table 13.

Table 13. Estimated Costs for Stream Bank Stabilization

Reach	Length of Stream (feet)	Stream Bank Length Needing Stabilization (feet)	Range of Costs
Reach 1: Sulphur Creek Confluence to Bear River State Park	20,446	16,809	$1,500,000–$5,000,000
Reach 2: Bear River State Park to Yellow Creek	60,118	0	$0
Reach 3: Yellow Creek to Woodruff Narrows Reservoir	111,464	15,355	$1,500,000–$4,500,000
Yellow Creek	124,041	83,933	$8,500,000–$25,000,000
Sulphur Creek	34,667	34,667	$3,500,000–$10,500,000
Total	**350,739**	**150,765**	**$15,000,000–$45,000,000**

2.5 Provide an Information, Education, and Public Participation Component (element *e*)

The information and education plan described in this section is largely adapted from the plans outlined in the 2005 *Upper Bear River Watershed Management Plan* (UCCD 2005). Some of the outreach activities conducted by UCCD include:

- Watershed education articles in quarterly newsletters, including: "Watershed Planning; Cost Share Assistance Available", "TMDLs to be written by WDEQ", "Boy Scouts Mark Storm Drains".
- UCCD assisted Evanston High School Chemistry Students test the Bear River.
- UCCD attended a Tread Lightly! Trainer course on January 23rd and became Tread Trainers. Tread Lightly! is an organization that provides education about reducing sediment loads through responsible recreation.
- UCCD partnered with the City of Evanston and Scout Troop 52 to mark 45 storm drains in the City of Evanston. UCCD also assisted Wyatt Feuz with his Eagle Scout project where he marked 55 additional storm drains in Evanston. Storm drain decal read “No Dumping, Drains to Bear River”.
- Partnered with UC Weed and Pest and UW Extension to host a Living on a Few Acres Workshop on April 22nd, 2008. Topics included information on UCCD’s watershed planning.
- UCCD continued to collect chemistry and other physical data in the spring and fall of 2008.
- On May 31st, UCCD assisted the B.E.A.R Project Board, INC with the Bear River Fest with educational activities about the watershed.
- Kerri Sabey continues to serve on the B.E.A.R. Project Board and is a co-chair of the education committee.
- On September 10th, Kerri Sabey gave a presentation at the Upper Bear River Trout Unlimited meeting about UCCD’s efforts in watershed planning on the Upper Bear River.
- UCCD partnered with the Town of Bear River in 2007 on a bank stabilization project. The project was washed out by a heavy storm in the fall so UCCD went back in the fall of 2008 to do some

re-seeding on the bare bank to hopefully get some vegetation growing back to prevent further erosion.

- Met with the steering committee to inform them of the TMDL's to be written. The committee then invited and met with DEQ to discuss their plan for writing a TMDL on the Upper Bear River.
- On June 12th, UCCD taught over 40 adults about the importance of water quality, the issues facing our rivers and had them participate in World Water Monitoring Day activities. Several groups contacted UCCD to teach their students about water quality and help them participate in World Water Monitoring Day.
- July 29th through August 1st, UCCD had an informational booth at the County Fair that included information about our watersheds, watershed planning and cost share programs to improve water quality.
- December 18th, members of the Upper Bear River Trout Unlimited group came to a UCCD board meeting to give a presentation on their efforts and to find ways to partner with the district on projects on the Bear River.

[the list above is in progress and will be updated]

2.5.1 Purpose and Approach

The purpose of the information and education component is to attain water quality standards through implementation of TMDL target sediment load reductions by educating the public and encouraging participation in the implementation plan. The methodology for this process is built on identifying various stakeholder groups and developing targeted outreach strategies that will be most effective for encouraging groups to participate. Within each target audience, related sources are identified and solicitation strategies such as outreach, training, information, and assistance to specific demographics throughout the Upper Bear River watershed are presented.

2.5.1.1 Private Landowners

Given that bank and channel erosion on private land is a major contributor to sediment loading to the Bear River and its tributaries, successful engagement of private landowners has the potential to significantly reduce sediment loading. The target audience consists of individuals who own land that is used for grazing and/or crop production, particularly those that have land directly adjacent to surface waterways. This could be facilitated by providing information and education of the U.S. Army Corps of Engineers permitting requirements for construction activities in a stream or wetland. The objective of this goal is to educate private landowners on proper land and water stewardship using appropriate BMPs and also on the potential watershed degradation caused by poor land use practices.

Strategies to accomplishing this goal include supporting local conservation districts in their efforts to educate landowners and provide them with suggestions, information and technical assistance for improving land management.

2.5.1.2 Affiliates of the Agricultural Industry

In addition to private agricultural landowners, there is also a need to focus on individuals that have contact or relationships with the greater agricultural community in the watershed (extension agents, Future Farmers of America, county commissioners). Representatives of the agricultural community have the capacity to expand outreach to communities in which they already have established working relationships.

Regional agricultural affiliates should be included on planning and outreach committees to broaden the networking of education and outreach to individual agricultural operators. Developing and delivering an education program to affiliates of the agricultural industry concerning effective local BMPs would go a long way in reaching individual private landowners.

2.5.1.3 Contractors and Builders

Individuals responsible for the day-to-day operation of construction sites or other building projects in the watershed have great potential to affect sediment loading rates from construction stormwater runoff and from near-channel construction projects. The objective here would be to educate these individuals (contractors and builders) about BMPs that minimize the potential sediment impacts during development and construction. In addition, local training sessions should be conducted for contractors and builders on stormwater BMPs. The Wyoming Pollutant Discharge Elimination System (WYPDES) Storm Water Program web site provides information, fact sheets, and describes the permitting process for construction projects associated with stormwater discharges (see deq.state.wy.us/wqd/WYPDES_Permitting/WYPDES_Storm_Water/stormwater.asp).

In addition, the City of Evanston has adopted ordinances for erosion control and stormwater runoff control. These ordinances are provided in the City of Evanston Code, Chapter 7, Parts 6 and 7 (Evanston City Code, 1982).

2.5.1.4 Residential Outreach

Citizens living in suburban and urban areas should also be targeted and educated about nonpoint source pollution, particularly with regard to bank erosion. Focus should be placed on residents managing lands adjacent to stream banks or the stream channel itself, and whose actions or inactions have a direct impact to the water quality of the stream.

Educational seminars and informational brochures emphasizing proper land and water stewardship could be distributed locally. Additionally, park signage in both the state park near Evanston and the proposed parks in the town of Bear River should be used to help residents and recreators identify major problem areas for erosion and things they can do to help.

2.5.1.5 Local School Education Programs

Educating and involving future residents of the Upper Bear River watershed about river health is important for the continued success of implementation efforts. Visiting local schools and presenting data in a fun and creative way can generate excitement and ownership of local water resources. Encouraging the use of online applications such as EPA's "How's My Waterway" would be one method for encouraging watershed education.

2.5.1.6 Tours of Successful Restoration/Enhancement Projects

The target audience for this goal consists of citizens of the watershed who may be interested in volunteering time or property for future restoration projects. The objective of this goal is to increase awareness and benefits of stream restoration projects. When successful BMPs are completed, they could be used as an example of proper land use practice.

2.5.1.7 Local Watershed Groups

Local watershed groups can provide a platform for organizing citizens in the region to conduct implementation and for acting as a centralized housing unit for watershed data specific to the Bear River. Organizing and centralizing information is crucial for conducting a concerted and successful effort. This has already largely been accomplished in the watershed with the UCCD and the Upper Bear River Water Quality Steering Committee. Continuing the tradition of bringing stakeholders together to represent the watershed is recommended.

2.5.2 Create the Message

Although specific targeted messages will be developed for each stakeholder group, there are primary messages that will be distributed across all audiences. The following are the primary messages that will be communicated throughout all information and education plan efforts:

- Excess sediment loading and deposition to the Bear River contribute to fisheries habitat impairments.
- Sediment loading reductions rely largely on coordinated efforts between stakeholders to manage bank and channel erosion.
- A healthy stream/riparian area creates many benefits including flood protection, food production, and drought mitigation.
- Information concerning all watershed activities could be published and made accessible in a centralized online database.

2.5.3 Distribute the Message

A variety of methods is available for successfully distributing messages throughout the watersheds and many of these have already been identified by the watershed management plan (UCCD 2005). Workshops, trainings, informational materials, presentations, and lectures are all ways to engage local stakeholders and successfully deliver both primary and secondary messages related to pollution management. Implementation becomes most effective when stakeholder groups work together to identify and execute practices that are agreeable to all parties. Successful efforts such as those of the UCCD and NRCS in reaching out to private landowners to encourage proper land use are essential for achieving information and education goals.

2.6 Include a Schedule for Implementing Nonpoint Source Management Measures (element *f*)

A schedule for implementing nonpoint source management measures (see section 2.7) is shown in Figure 12. Adherence to this schedule will result in a timely completion of BMPs and achievement of sediment load reductions.

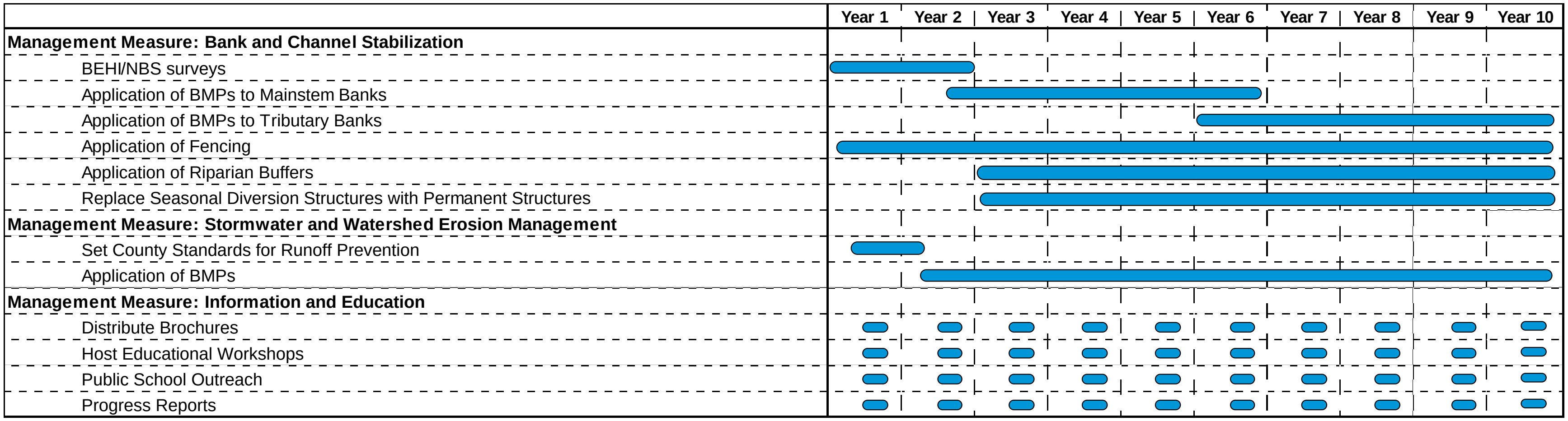


Figure 12. Schedule for implementing voluntary nonpoint source management measures.

2.7 Identify/Describe Interim Measurable Milestones for Implementation (element g)

To attain the targets identified in this implementation plan, a series of milestones and a schedule for their completion are necessary to track progress as implementation continues in the watershed (Table 14). Both BEHI and NBS surveys are recommended before implementing recommended BMPs as they will identify major problem areas and hone efforts.

Table 14. Voluntary Interim Milestones for Implementation

Indicator to Measure Progress	Target Value	Interim Targets		
		Short-Term (1–2 years)	**Medium-Term (2–5 years)**	**Long-Term (5–10 years)**
Management Measure: Bank and Channel Stabilization Objective: Reduce Bank and Channel Erosion in the Bear River and its Tributaries				
Percentage of high risk banks with BMPs applied	100% in critical areas	Identify sites with high risk banks (BEHI/NBS surveys).	BMPs applied to 100% of high risk banks on main stem	BMPs applied to 100% of high risk banks on tributaries
Percentage of protected riparian area adjacent to active grazing land	100% in critical areas	33% of riparian area adjacent to grazing land is protected by BMPs that could include seasonal exclusion, off channel watering, grazing management, and management of riparian areas.	67% of riparian area adjacent to grazing land is protected by BMPs that could include seasonal exclusion, off channel watering, grazing management, and management of riparian areas	100% of riparian area adjacent to grazing land is protected by BMPs that could include seasonal exclusion, off channel watering, grazing management, and management of riparian areas
Percentage of riparian area with buffer	100% in critical areas	Identify landowners with land adjacent to the river/tributary and talk with them.	50% of riparian area has buffer between river/tributary and land use.	100% of riparian area has buffer between river/tributary and land use.
Number of seasonal diversion structures	0	Identify locations of all seasonal diversion structures and talk with landowners.	Less than 10 seasonal diversion structures, either removed or converted to permanent	Zero seasonal diversion structures, either removed or converted to permanent
Management Measure: Stormwater Objective: Reduce Sediment Loads associated with Stormwater				
Percentage of stormwater retrofits	100%	33% of stormwater drains retrofitted	66% of stormwater drains retrofitted	100% of stormwater drains retrofitted
Number of discharge prevention structures	10	1 discharge prevention structure as example	5 discharge prevention structures	10 discharge prevention structures
Number of construction projects without runoff prevention	0	Set county standards for runoff prevention and talk with contractors.	No current projects without runoff prevention	No future projects without runoff prevention

Table 14. Voluntary Interim Milestones for Implementation

Management Measure: Information and Education Objective: Inform the Stakeholders of the Issues and Garner Understanding of the Watershed				
Number of bank erosion brochures distributed	1 brochure per property adjacent to river per year	All brochures distributed	–	–
Number of educational workshops	1 per year	1	1	1
Number of progress reports	1 per year	1	1	1
Number of classes taught to schools	1 per school per year	1 per elementary school per year	1 per elementary and middle school per year	1 per all public schools per year
Number of trainings conducted for UCCD personnel	1 training per year	1	1	1

2.8 Establish Criteria to Determine if Load Reductions/Targets are Being Achieved (element *h*)

The sediment criterion required to determine if load reductions are being achieved for the spring snowmelt season (April 1 through July 1) is 30 mg of TSS per 100 mL, measured as an average value per month. This water quality criterion is derived from other state standards, calculations provided in this plan and the TMDL report, and literature values. Achieving a BANCS erosion rating category of moderate for the impaired segment of the Bear River and its tributaries represents an additional criterion for determining if sediment load reductions are being achieved. This is based on reference reach values for the BANCS analysis.

In Wyoming, aquatic life uses are assessed with the use of the Beneficial Use Reconnaissance Monitoring and Assessment Reports (BURPs), which measure many attributes of a given reach to determine if it is meeting its designated uses. Two of the metrics that were below reference values—weighted embeddedness and the Wyoming Stream Integrity Index—are used here for criteria (Table 15). If criteria are not met for the interim targets, a review of current management practices should be performed to determine if stakeholders are following through on implementation of BMPs. If BMPs have been implemented in a timely and appropriate fashion, an update of the loading analyses should be performed to determine if and how sediment supply and transport have changed since the TMDL. This new analyses should define new target values and criteria for load reductions.

Table 15. Criteria to Assure Implementation Plan will Achieve Water Quality Targets

Indicators to Measure Progress	Target Value or Goal	Short-Term (2 years)	Medium-Term (5 years)	Long-Term (10 years)
BANCS erosion ratings	Moderate or lower	Perform BEHI/NBS surveys,	All high risk banks on mainstem reduced	All high risk banks on tributaries reduced
TSS concentration at UCCD monitoring sites	30 mg/L	50 mg/L	40 mg/L	30 mg/L
Weighted embeddedness	< 30	< 60	< 45	< 30
Wyoming Stream Integrity Index	> 70%	> 50%	> 60%	> 70%

2.9 Provide a Monitoring Component to Evaluate Effectiveness of the Implementation Plan Over Time for Criteria in *h* (element *i*)

The monitoring goals of this project are to document progress in achieving improved fisheries habitat conditions in the Bear River as nonpoint source control management strategies are implemented. Specifically, the objectives are as follows:

- Obtain information necessary to ensure that sediment loading and concentration targets for TSS are met.
- Evaluate BMP effectiveness and load reductions that result from implementation efforts.

Successful development and implementation of the monitoring plan will provide flexibility for adapting to new information and changes in the watershed.

To document this progress, a monitoring program is needed to examine and report on the performance of each management strategy. Two types of performance monitoring are proposed in this implementation plan: 1) implementation monitoring and 2) effectiveness monitoring. Implementation monitoring assesses whether the proposed management strategies were implemented and, if they have been implemented, the progress that has been achieved. Effectiveness monitoring is used to check if the selected strategies are effectively reducing sediment loading. The following subsections present implementation and effectiveness monitoring methods proposed for organizations that will be involved in execution of this implementation plan.

2.9.1 Implementation Monitoring

Each organization should monitor implementation of management strategies by tracking the progress and accomplishments of each activity. A centralized database should be used by organizations to monitor implementation of the proposed management strategies. A status column should be added to the database to track actual implementation progress.

One option for monitoring the implementation of management strategies is the Watershed Information System (WIS) developed for the Bear River. As part of a Targeted Watersheds Grant sponsored by the EPA, Utah State University developed the WIS in collaboration with the Bear River Commission, Utah, Idaho, and Wyoming Departments of Environmental Quality, and a number of other interested stakeholders. This website is intended to be a central location where users can get and provided data and information related to water quality and other watershed related issues in the Bear River Basin. The Bear WIS is located at http://bearriverinfo.org.

2.9.2 Effectiveness Monitoring

Effectiveness monitoring is used to check if the selected strategies are reducing pollutant loading. Effectiveness monitoring may be quantitative (e.g., TSS measurements and BURP studies) or qualitative (e.g., visual observation of sediment reduction in the water passing through a fenced riparian area), depending on the BMP implemented and the overall scope of the project. Although quantitative monitoring methods will document progress toward improved conditions, qualitative methods can also provide an effective measurement of implementation progress. Other examples of qualitative effectiveness monitoring include photograph documentation of improvement in stream bank vegetation and cover. Qualitative monitoring could also include documentation of relative sediment volume (i.e., high, medium, or low) collected from detention ponds or filters in stormwater treatment systems. Although these methods do not provide quantitative information on the effectiveness of the projects, they do illustrate progress and can be combined with other monitoring efforts to show success of implementation activities.

Quantitative effectiveness monitoring is required to document actual progress toward improved water quality conditions and can only be achieved through water quality assessments. Therefore, the success in reducing sediment loads will be measured at UCCD monitoring stations and through future BURP and BANCS studies.

Instream monitoring is scheduled to occur periodically throughout the year by UCCD and includes flow and water chemistry measurements. The following subsection outlines the proposed procedures for quantitatively monitoring the effectiveness of the proposed management strategies.

2.9.3 Sampling Design and Parameters

The quantitative monitoring plan requires water quality monitoring of sites throughout the watershed that contribute directly to the annual sediment. To assist in achieving the water quality goals, the monitoring plan should include the following:

- Seasonal monitoring throughout the year at UCCD monitoring stations and tributaries for TSS, turbidity, and discharge.
- Incorporate analysis of suspended sediment concentration (SSC) into the UCCD monitoring plan. When compared to TSS, SSC results are more representative of the actual suspended sediment load because of the analytical method employed. The laboratory procedure for TSS analysis tends to exclude the coarse-grained fraction. Furthermore, SSC results can be compared directly to other agency data (e.g., U.S. Geological Survey) that use SSC exclusively. And, SSC is the preferred suspended load input parameter for most transport models.
- Locate an additional monitoring station at the mouth of Yellow Creek to account for Yellow Creek loads.
- Locate a flow gage at the mouth of Yellow Creek (this will require access and landowner permission as well as a long term agreement for the placement of a flow gage).
- Monitoring streams above and below large BMP installation projects to determine effectiveness of individual projects (will require landowner permission and access).

2.9.4 Other Data Collection Needs

A full geomorphological assessment of the impaired segment and its tributaries would be greatly beneficial to improving habitat and water quality in the Bear River. Understanding how sediment and water were transported through the watershed in the past helps to set goals and benchmarks for future restoration projects and prevents the implementation of projects that cannot succeed due to natural constraints. Information provided by this assessment would include historical flow regimes, equilibrium channel and bank configurations, and hotspot areas for channel erosion. This kind of analysis would be costly in the short term, but likely would be of great benefit to stakeholders in the long term as it can prevent land/construction losses to erosion and provide environmental services and recreation revenue from healthy fisheries.

CHAPTER 3. CONCLUSIONS

This Bear River watershed–based implementation plan outlines a series of management measures that, if implemented, will result in full support of state standards for fisheries habitat. Many of the management measures and BMPs identified in this plan were previously chosen by the committees and organizations that developed the *Upper Bear River Watershed Management Plan*. This document builds on those recommendations and develops a structured approach that will help stakeholders achieve a healthier Bear River. Through quantification of major sources and critical areas, this plan provides stakeholders with a step-by-step plan to have a more targeted and directed effort toward reducing sediment loads to the Bear River. This plan requires effort from all stakeholders and focuses not only on BMPs, but also on education and outreach to guide current and future generations into being good stewards of the land and water.

CHAPTER 4. REFERENCES CITED

Evanston City Code, 1982. The Code of the City of Evanston, Wyoming, 1982 at http://ecode360.com/EV2229. Accessed February 7, 2014.

EPA. 2008. *Handbook for developing watershed plans to restore and protect our waters*. Available at http://www.epa.gov/nps/watershed_handbook. Accessed January 2013.

———. 2000. *Ambient Water Quality Criteria Recommendations: Information Supporting The Development Of State And Tribal Nutrient Criteria For Rivers And Streams In Nutrient Ecoregion III, Xeric West*. Office of Water, USEPA, Washington, DC.

———. 2004. *Urban Stream Repair Practices Version 1.0.* Prepared by Center for Watershed Protection. Office of Water Management, USEPA, Washington, DC.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. *Fluvial Processes in Geomorphology* W.H. Freeman and Co.: San Francisco, California.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. *North Amer. J. Fisheries Manage* 16(4):693–727.

Smith, M.E., and M.L. Maderak. 1993. *Geomorphic and Hydraulic Assessment of the Bear River in and near Evanston, Wyoming.* U.S. Geological Survey Water-Resources Investigations Report 93-4032. U.S. Department of the Interior, U.S. Geological Survey.

UCCD. 2005. *Upper Bear River Watershed Management Plan*. Prepared by the Upper Bear River Water Quality Steering Committee and the Uinta County Conservation District.

WDEQ. 2012. *Wyoming Water Quality Assessment and Impaired Waters List (2012 Integrated 305(b) and 303(d) Report).* Cheyenne, Wyoming: WDEQ, Water Quality Division, Watershed Section.

———. 2013. *Wyoming Pollutant Discharge Elimination System Program*. Information and data provided by WDEQ.

———. 2014. *Bear River Sediment TMDL*. Cheyenne, Wyoming: WDEQ. [insert date when completed]