INTERIM COMPREHENSIVE LONG-TERM MONITORING PLAN FOR SILVER BOW CREEK STREAMSIDE TAILINGS OPERABLE UNIT

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INTERIM

COMPREHENSIVE

LONG-TERM MONITORING PLAN

FOR

SILVER BOW CREEK

STREAMSIDE TAILINGS OPERABLE UNIT

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1.0 INTRODUCTION

Silver Bow Creek extends from Butte approximately 23 miles to the Warm Springs Ponds (Figure 1). Since the late 1800s, and as recently as the early 1970s, mill tailings and other mine wastes containing elevated metals concentrations have been discharged to Silver Bow Creek. During periods of high streamflow, these toxic wastes have been transported and deposited throughout the floodplain, severely impacting surface water and groundwater quality, and decimating aquatic life in Silver Bow Creek. Tailings deposited in the floodplain are phytotoxic, resulting in a riparian zone and adjacent floodplain areas largely devoid of vegetation, and with minimal value as wildlife habitat.

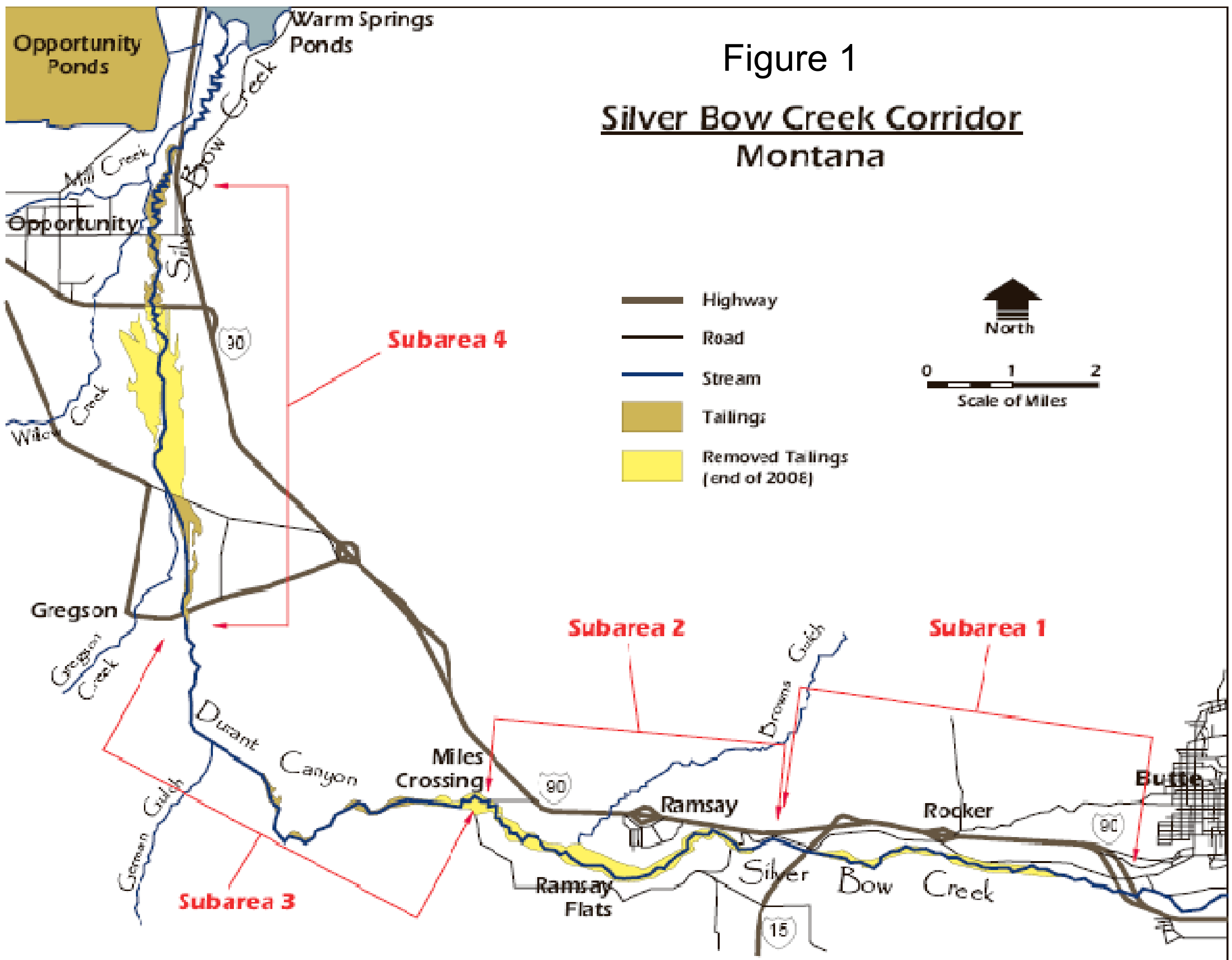

Figure 1: Silver Bow Creek Corridor Montana
(Source: Silver Bow Creek Update Winter 2009, MDEQ/NRDP.)

In November 1995 the Montana Department of Environmental Quality (MDEQ) and the U.S. Environmental Protection Agency (EPA) issued a Record of Decision (ROD) for Silver Bow Creek that identified the final site remedy and the agencies' rationale for selecting that remedy. The major remedial actions that resulted from the ROD include the excavation of tailings and related impacted soils from the floodplain of Silver Bow Creek, and the subsequent reconstruction of the stream channel and floodplain. In a 1999 state, federal and tribal settlement, Atlantic Richfield Company (ARCO) agreed to pay $215 million to the State to resolve certain claims. From the settlement amount, $80 million plus interest was set aside for

MDEQ and EPA to implement the remedy for Silver Bow Creek. Some of the remaining amount is being used to enhance the cleanup of Silver Bow Creek through restoration actions. These restoration actions are in addition to the remedial actions, and are designed to bring Silver Bow Creek to an uncontaminated or “baseline” condition. This is defined as the expected condition of the resource had the release of hazardous substances not occurred. The Natural Resource Damage Program (NRDP) has funded these restoration actions through Greenway and Bighorn Environmental restoration grants. The NRDP administers the Restoration Grant process and annually receives grant applications.

The portion of Silver Bow Creek and its adjacent floodplain undergoing remediation and restoration under settlement with ARCO is designated the Streamside Tailings Operable Unit (SST OU). The SST OU is divided into four subareas based upon geologic and topographic features that control the soil, hydrogeologic, geomorphic, surface water, ecologic, demographic, and land use characteristics of the OU. These are: Subarea 1 – Rocker, Subarea 2 – Ramsay, Subarea 3 – Canyon, and Subarea 4 – Upper Deer Lodge Valley. Subarea boundaries are illustrated in Figure 2, reproduced from the ROD, and are described in the ROD (MDEQ/USEPA 1995, pp. 13-14). For ease of management, each subarea is further divided into reaches, with each reach approximately one mile in length and designated alphabetically upstream to downstream, i.e., Reach A, Reach B, etc.

Two other media are also present throughout the OU but are not necessarily related to the subarea divisions: railroad bed materials and instream sediments. Materials associated with the railroad bed, in addition to native alluvium, rock and imported ballast, include mine waste rock or low grade ore, concentrate spills, impacted materials consisting of non-vegetated soils, and slag. Instream sediments contain contaminants of concern extending throughout the entire length of the SST OU stream channel. Instream sediments consist of tailings, soil and rock particles that have been deposited instream or are carried through the OU as a result of surface water transport (MDEQ/USEPA 1995, pp.14-16).

Remediation actions include excavation of tailings and related impacted soils from the floodplain of Silver Bow Creek, removal to a local repository or by rail to the Opportunity Ponds, replacement of removed tailings with local fill material, native grass seeding, limited willow and shrub plantings, and complete channel reconstruction. Restoration actions involve various habitat improvements that include the addition of organic matter to the borrow soils and additional plant revegetation and aquatic habitat components. Of the 22 miles of Silver Bow Creek within the SST OU, the first 10 miles are completely reconstructed, 3.0 miles in Subarea 4 are partially reconstructed, and 2.5 miles in Subarea 3 are currently under construction (MDEQ/NRDP 2009). Of the 1,400 acres of contaminated tailings and soils alongside the stream, approximately 1140 acres have been remediated and restored, which amounts to almost 4.1 million cubic yards of the estimated 5.0 million cubic yards of tailings present in the floodplain in 1999 at the beginning of the remediation (MDEQ/NRDP 2010).

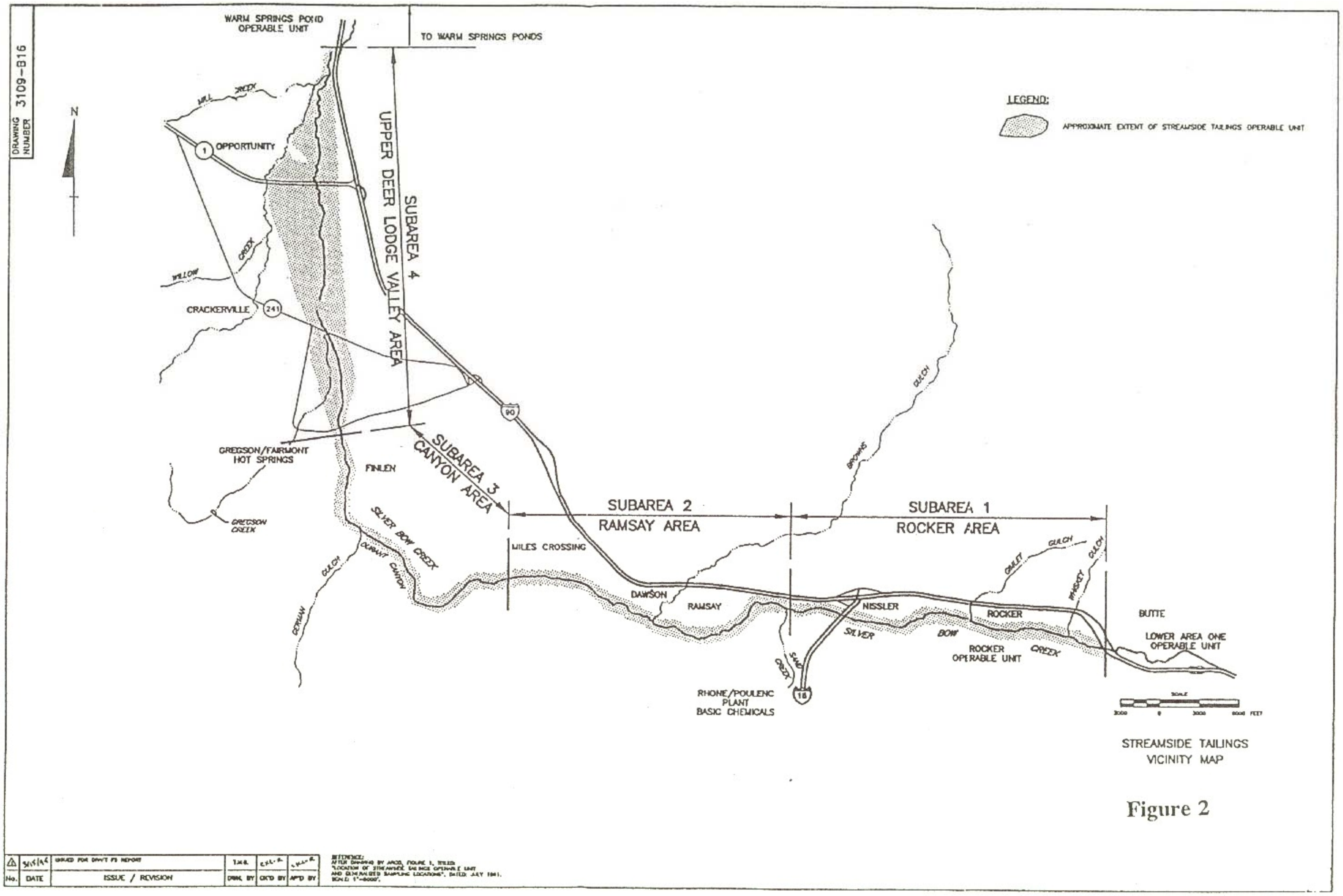

Figure 2: Streamside Tailings Vicinity Map

2.0 PURPOSE

The Comprehensive Long-Term Monitoring Plan for Silver Bow Creek Streamside Tailings Operable Unit is a dynamic document in that it will be reviewed and updated yearly as remediation and restoration progresses downstream. The purpose of the long-term monitoring plan is to set measurable goals that indicate successful remediation and restoration for several media, document monitoring requirements for each medium over time, and identify specific monitoring locations for the reaches that are to be monitored each year. Media covered in this plan are vegetation, instream sediments, surface water, groundwater, vadose water, soil, fish habitat and fluvial geomorphology, as well as aquatic biology, including macroinvertebrates, periphyton, and fish. Also, this monitoring plan sets forth a program for inclusion of each reach as it is completed, monitoring changes as goals are reached, and monitoring flexibility to accommodate variability within reaches, natural environmental events, and public interest.

Monitoring techniques described in this plan are accepted practice at this time; future advancements may lead to changes in monitoring strategies. Unless otherwise noted, if the Clark Fork River Standard Operating Procedures (SOPs) address methods for monitoring a specific medium, the SOPs are followed. Any future changes, additions, or modifications of long-term monitoring or SOPs in the operable unit will be addressed in this document. For example, as new sampling locations are established, they will be added to this plan, or if sampling techniques or methods change, those changes will be documented.

In many cases ecological function cannot be measured directly, so it is inferred from measurable parameters describing the condition of relevant media. Conclusions about the stream are based on values for these media known to exist in functioning streams. Goals and standards in this plan are often based on healthy streams, since achievable levels of remediation and restoration are unknown for a project of this magnitude. While these standards represent a desired condition, the achievement of these standards may not be possible within the first 10 years after construction. Once initiated, the recovery process is expected to continue for decades, during which the similarity to unimpacted aquatic and riparian zones is expected to increase.

Consistent trends toward the established goals and standards that demonstrate the restoration of functionality of Silver Bow Creek and the adjacent floodplain is more important than meeting any given standard. Data will be evaluated yearly to determine if trends towards the goals exist. If a medium is not showing trends towards the goals, remediation and restoration methods will be evaluated and may be adjusted downstream to increase success. Additional remediation and restoration may be implemented to achieve our goals by year 10 post-remediation. Finally, since many of the goals have not been tested on a project of this scope, the data will be evaluated yearly to determine whether the goals are achievable within 10 years. Changes to remedial and restorative design and implementation are expected. Modifications to the goals set forth in this document may also occur as empirical data is gathered on the project. If, after 10 years post-remediation, despite additional remediation and restoration, the media is not moving towards the goals, data will be evaluated to determine whether further action is needed. Monitoring will continue until the goals are met.

Minimum post-remedy monitoring requirements are identified in the Streamside Tailings Operable Unit Record of Decision (ROD), Table 18 (MDEQ/USEPA 1995, p. 111) and are reproduced in Table 1 of this document. As described in the sections that follow, the monitoring plan has expanded beyond the minimum requirements summarized in Table 1.

Table 1. Minimum Post-Remedy Monitoring Requirements[1] (Table 18, MDEQ/USEPA 1995, p. 111)		
Media	**Locations/Physical**	**Analytical Parameters**
Surface Water	SS-07, SS-10, SS-13, SS-14, SS-15, SS-16, SS-17, SS-19	Metals: Total recoverable and dissolved: As, Cd, Cu, Pb, Hg, Zn Commons: Ca, Mg, Na, K, Cl^-, SO_4^{2-} Nutrients: Nitrate + Nitrite Nitrogen, Phosphorous Physical: Temperature, pH, Eh, conductance, dissolved O_2
Instream Sediments, Geomorphology, Aquatic Biologic Resources	Surface water locations and at each depositional area. Physical stream parameters such as geomorphologic stability (erosion rates and locations) and bedform morphologic features. Macroinvertebrate diversity, abundance and aquatic health.	Metals: Total As, Cd, Cu, Pb, Hg, Zn. To be analyzed in three size fractions: 1 mm and greater, between 1mm and 63 µm, and less than 63 µm.
Groundwater	Upstream end near Colorado Tailings, Rocker, Silver Bow, Nissler, Ramsay Flats, Miles Crossing, Fairmont, Crackerville, Stuart, Opportunity, STARS in-situ treatment areas and every repository location.	Metals: Dissolved: As, Cd, Cu, Pb, Hg, Zn Commons: Ca, Mg, Na, K, Cl^-, SO_4^{2-} Physical: Temperature, pH, Eh, conductance, dissolved O_2
Soil	Minimum one (1) sample per 10 acres and three (3) sample per repository	Neutralization potential, sulfur fractionation, conductance, pH
Vegetation	In conjunction with soil sample locations	Percent cover (total and by species), production (total and by species)
Vadose Zone	In conjunction with groundwater sampling locations; three (3) per repository location	Metals: Dissolved: As, Cd, Cu, Pb, Hg, Zn Commons: Ca, Mg, Na, K, Cl^-, SO_4^{2-} Physical: Temperature, pH, Eh, conductance

[1] – Monitoring will focus on principal contaminants of concern: As, Cd, Cu, Pb, and Zn including mercury (Hg), but analyzing other contaminants, if any, that are not principal contaminants of concern and are determined to be occurring at levels exceeding performance standards. The level of monitoring effort described in this table should be considered as minimal requirements. The necessity to meet remediation goals, cleanup/performance standards, and points of compliance might dictate a more substantial effort. The agencies will determine the final level of monitoring which includes sampling locations, frequency and duration, as well as statistical methods for evaluating the data, as needed, during remedial design.

In the 2005 monitoring plan, station SS-08, Silver Bow Creek at Rocker, was added to the sampling sites. Station SS-10, Silver Bow Creek at Sand Creek, was replaced with SS-10A and SS-10B above and below the confluence, respectively, to capture the influence of Sand Creek. Similarly, station SS-13 at Browns Gulch was replaced by SS-11C and SS-11D, above and below the confluence, respectively, to capture the influence of Browns Gulch. Manganese and bicarbonate was added to the list of analytical parameters for water throughout the document, and ammonia was added to surface water monitoring. In addition, to reflect new methods and technology, modifications from the original ROD specifications were made in the soils, aquatic biology, and vegetation sections.

In 2006, station SS-06G was added above the Butte Wastewater Treatment Plant (WWTP) outfall to bracket this significant point source of nutrients to Silver Bow Creek. The impacts of the WWTP discharge are particularly apparent at site SS-07, just downstream of outfall at the upper end of the SST OU, and remain relatively pronounced at the lower end of the SST OU.

Three sites were added in 2007 in the unremediated reach through Durant Canyon: stations SS-15A and SS-15 B on Silver Bow Creek above and below the confluence of German Gulch, and station SS-15G on German Gulch at the mouth. The intent was to investigate effects of the higher-quality German Gulch water on Silver Bow Creek.

In 2008 sample sites were unchanged from those monitored the previous year.

In 2009 three new sediment and surface water monitoring stations were added on Silver Bow Creek in the vicinities of Father Sheehan Park (SS-01, labeled SS-05A in the 2009 Monitoring Plan) and the Butte Reduction Works (SS-06A), both to better understand contributions to the

SST OU from upstream sources, and in Reach J of Subarea 2 (Ramsey Flats/Miles Crossing Area, SS-14), where channel remediation work recently had been completed.

For the 2010 monitoring, sediment and surface water locations will be unchanged from 2009, with sampling to be conducted at thirteen Silver Bow Creek sites and one tributary site. In 2010, the plan includes field filtering rather than lab filtering dissolved constituents, a change from past practices.

3.0 VEGETATION

3.1 Revegetation Goals

The remediation goal for revegetation is to protect the remedy and restore remediated areas to a permanent productive condition; it must be self-sustaining and self-repairing. It must protect the streambanks and adjacent floodplain from erosion that would impair the remedy.

The main goal of restorative revegetation is to quicken the return of the stream and floodplain to a baseline condition. Streambank and near-stream vegetation should interact with the stream and other site factors to provide good trout habitat. This interaction is monitored in accordance with the Fluvial Geomorphology section of this plan. In addition, throughout the floodplain, restoration seeks to increase structural diversity (i.e., growth-form diversity) and establish a mix of physiognomic types (community structure or growth form of the dominant layers). This restores wildlife habitat for a variety of animal species. Restoration may also provide a greater array of adapted native species than remediation.

In addition to measuring compliance with these objectives, revegetation monitoring indicates how well revegetation prescriptions, methods, and materials worked. Monitoring results from different fields of the same revegetation habitat type can be combined to evaluate how different aspects of revegetation prescriptions performed, and indicate whether they should be modified for future uses. Revegetation monitoring may incorporate soil sampling if edaphic conditions are suspected of limiting revegetation success.

3.1.1 Remediation Measures

Monitoring of canopy cover by species (Daubenmire 1959) quantifies total plant cover and species composition. These data are used to evaluate whether species are withstanding climatic variation, wildlife foraging, and other natural influences and re-establishing following disturbances such as occasional flooding. The amount of total plant cover determines if effective erosion control is provided. Recording litter, rock, and bare ground cover further substantiates erosion protection capabilities on site.

Monitoring of canopy cover by species and photomonitoring at observed disturbances determines whether the vegetation is self-repairing.

Remediation goals are fulfilled if the canopy coverage equals or exceeds the goals set forth in Table 2, 10 years after germination of the last seeding. Normally distributed sample means will be compared to performance standards using the statistic (described by Neter, et al., 1985) with 0.1 Type I error and 90% of the performance standard.

Table 2. Minimum Canopy Coverage Approximately 10 Years after Seeding		
Hydrologic Zone	**Average Canopy Coverage***	**Transects Meeting Cover**
Uplands, Subirrigated	60%	65%
Streambanks, Transition Zone	80%	95%
Wetlands (not open water)	95%	65%
*Noxious weeds and non-native annual species are not factored into total canopy coverage.		

3.1.2 Restoration Measures:
In addition to the information gathered by remediation, woody plant density and structural diversity are monitored to determine whether restoration efforts successfully return woody vegetation to the area, and if wildlife habitat (security cover, forage/browse, perches, etc.) is enhanced. The restoration goals are met if the data supports the existence and persistence of a variety of native species of different growth forms and multiple physiognomic types 10 years after germination.

Monitoring also provides a basis for evaluating development of vegetation, e.g., structural diversity trends and recovery from fluvial disturbances, among others. Measurement of vegetation cover and density quantifies plant abundance and species composition, provides a basis to evaluate temporal developments, and indicates whether plants are persisting and/or reproducing, or unseeded plants are establishing. Analysis of the data collected for both remediation and restoration monitoring determines the effectiveness of revegetation prescriptions, methods, and materials. It may also indicate areas requiring additional revegetation measures.

3.2 Initial Monitoring Requirements

3.2.1 Sampling Protocols
Vegetation monitoring during sampling years occurs at or near peak annual accumulated growth. Plot and transect locations are placed to represent the major vegetation types. Locations are confirmed using GPS (Global Positioning System) instruments and are depicted on maps in monitoring reports along with UTM (Universal Transverse Mercator) coordinates. Only revegetation units large enough to accommodate plots/transects are sampled.

The basic unit for revegetation monitoring is a field. A field is a contiguous unit of a single hydrologic regime and similar coversoil that receives essentially the same revegetation materials and treatments. Fields are delineated on permanent maps, and corresponding treatment records are kept throughout the monitoring period. These records include not only the original treatments, but also subsequent fertilization, weed control measures, mowing, etc.

Not every field is formally monitored. As a practical measure, monitoring focuses on at least three representative stands of each important revegetation habitat type/revegetation prescription seeded at one time. Typically one or two reaches are seeded at a time. A hydrologic zone (wetland, transition zone, subirrigated, or upland) in conjunction with a class of coversoil constitutes a revegetation habitat type. If there is more than one seeding, as sometimes occurs in uplands, each is sampled. Revegetation habitat types of limited aerial extent may be sampled with fewer than three transects, or, for very small units, formal sampling may be unnecessary.

3.2.2 Monitoring Schedule

The revegetation process is usually in a state of flux for several years, during which time the relative abundance of species can shift. Long-term monitoring begins the third year following germination of the last major seeding. Monitoring again at year six indicates temporal dynamics as plant species composition equilibrates with more enduring site conditions, simultaneously providing data to evaluate the effectiveness of revegetation strategies. After approximately a decade, the rate of change slows notably. By this time, plants, soil organisms, and climate modify soils. At this time, long-term monitoring indicates whether revegetation meets performance standards.

So, unless disturbances or replanting require modifications, monitoring measurements are taken when the field reaches 3, 6, and 10 years of age. Field age begins with germination of the original seeding, or the last major seeding if the field is reseeded later. Year one is defined as one year after germination. For example, if a site was seeded in late fall of year 2000 and most germination occurs in spring 2001, the field is one year old in spring 2002. Depending on establishment and development of the vegetation, including interseeding, long-term monitoring would begin in 2003 or 2004, and could end in 2011. By this time, the course of early vegetation development will be known, and reclamation success will be evaluated relative to performance standards, if climatic conditions are not aberrant. The final measurement, generally in year 10, will not be taken in a year of aberrant precipitation, defined subsequently in Section 3.4.1, Incorporating Precipitation Effects.

3.2.3 Locations

Three transects per vegetation type and soil material are established in a reach to make conclusions about a treatment. If two reaches are seeded at the same time with the same seed mixes in the same borrow material or similar in situ material, three transects per revegetation habitat type are sufficient. Locations of transects are not determined until construction is complete and the vegetation monitoring contractor evaluates the site and provides recommendations.

Locations are confirmed using GPS (Global Position System) instruments and depicted on maps in monitoring reports in state plane, North American Datum 1983 (NAD 83), along with UTM coordinates.

Vegetation surveys completed in 2009 included Reaches D and E, the gravel pit area north of Highway 1, Phase 3 areas previously planted in rye and permanently seeded in 2008, Phase 2 addition, and cover-board sampling SA 1 and SA 2.

Scheduled for vegetation surveys in 2010 are Reaches B, C, H and I; for seedling density Reaches J and upper K; and SA 4 Phase 2, excluding transects sampled in 2009 (R. Prodgers, pers. comm.).

3.2.4 Parameters and Methods

3.2.4.1 Cover

Plant cover is the amount of ground covered by plants expressed as a percentage. Two aspects of plant community performance are revealed by cover sampling. First, total plant cover indicates whether the desired amount of plant cover is present to stabilize the site. Second, cover by species demonstrates how species composition begins and changes through time, and quantifies the abundance of undesirable species.

Of the several ways to measure plant cover, Daubenmire's canopy-coverage method (1959) is selected for this project because it is efficient and can be measured regardless of wind conditions. Canopy coverage is based on ocular estimates for each vascular species within frames of a typical area between 0.1 m^2 and 0.5 m^2. The percentage of litter, bare soil, and coarse fragments (>2mm) are also estimated within each frame. Rather than use Daubenmire's cover classes (ranges of cover values), canopy coverage is estimated to the nearest percent. Data are reported in tables with columns that identify taxa, average cover, relative cover, and frequency.

Wherever possible, plots are arranged along transects. To assure comparable frequencies for the duration of monitoring, the following factors remain constant throughout the monitoring period: location, plot size and configuration (0.5 x 1.0 meters), transect length (100 meters wherever field size and configuration allow), and number of samples per transect (20).

3.2.4.2 Woody Plant Density

Along streambanks, i.e., within two meters of the water's edge during average flow, woody plant density is measured and computed as the number of stems per linear foot of streambank. Stems rather than individual plants are monitored because one species of willow that propagates from rootstocks is planted along the banks.

Beyond the two-meter streambank zone, one-meter-wide belt transects centering on standard revegetation transects are used to measure the density of woody plants. Since transects must conform to the configuration of the revegetation unit, very narrow, elongated plots are chosen in these areas. The location of transects can have a big influence on monitoring results depending on whether they include pods (designated units of dense woody transplants). Where pods are planted, macro plots of area >10 m^2 and ≤50 m^2 are used to sample density within the pod. In measuring density, plants (often stem clusters) are counted for species whose growth-form allows easy identification of individual plants. Examples are sagebrush, rabbitbrush, and Geyer, Bebb, and Booth willow. For colonial species such as slenderleaf willow, snowberry, rose, and aspen, stems are the basis for counting. Monitoring reports include an unequivocal description of density-measuring methods, including a practical definition of how one individual "plant" is defined, if counting is based on plants, and where the base of a plant is a stem cluster, a rule for deciding when it is "in" or "out" of the sample.

Plants are tallied by height classes:

0-25cm	1-1.5 m
26-50 cm	1.5-2 m
51-75 cm	2-3 m
76-100 cm	>3 m

and the actual height of taller plants.

3.2.4.3 Diversity

Diversity is an ARAR (Applicable or Relevant and Appropriate Requirement) and structural diversity is a restoration objective. There is no performance standard for species diversity because most strategies that favor numerous species also provide an opening for weeds to establish. While not a direct measure of revegetation success, diversity monitoring provides feedback on revegetation strategies and identifies trends.

Diversity in revegetation is calculated from canopy-coverage data in two ways:

1) Richness: the number of species as determined from a standard number of individual samples or standard size sample area. Where sample size is unequal, dividing the number of species by the log of sample area or number of samples transforms the sample size to the standard. Family richness is also computed.
2) A measure of proportional species abundance: such as Simpson's Index or the Shannon Index, calculated from cover data. This is a data analysis procedure using canopy-coverage data.

Structural diversity can be partially described using canopy-coverage data by applying a proportional abundance index to the amount of relative cover within growth-forms or life-forms. To evaluate the extent of structural diversity at the landscape scale, as opposed to within communities, the relative area (percent) of different physiognomic types identified by the uppermost strata (e.g., trees, tall shrubs, midsized shrubs, and herbs) within a subarea are calculated from an accurate vegetation map.

Wildlife habitat cover is measured by the visual obstruction caused by vegetation at permanent reference points at specified heights. The cover-board method is used to measure security habitat provided by structural diversity.

3.2.4.4 Photomonitoring

Another form of descriptive monitoring useful for public presentations and nontechnical reviewers is photomonitoring. There is no performance standard for this type of monitoring. At the landscape scale, photomonitoring indicates the development of vegetation at a scale to which laypersons can relate. At the micro scale, photomonitoring documents changes within individual frames along permanent transects. Used in conjunction with cover summaries, photomonitoring aids evaluation of plant regeneration and successional trends, if any. The spots chosen for photomonitoring should include “fully stocked” and partially open micro sites.

At the landscape scale, photographs are taken from the same location, in the same direction, and during the same season using a camera lens of approximately the same focal length. Four photographs per reach is the minimum. Locations (UTM/NAD83) are recorded and plotted in revegetation monitoring reports. Photographs of sample transects taken at the time of sampling may serve for landscape photomonitoring.

At the micro scale, photographs are taken from directly above frames used for canopy coverage. The maximum frame size suitable for a 35 mm format is about 0.5 m x 1.0 m. A slightly wide-angle lens (e.g. 35-40 mm) allows location of the camera at a practical height above the ground. Photo points are permanently marked, e.g., with steel fence posts, and the exact locations monitored through time. In order to minimize distortion, the camera is oriented with the film plane parallel to the ground surface, and the entire plot frame is visible in the picture for reference. Canopy-coverage estimates (Daubenmire 1959) should accompany each photograph (each frame). The date of photography should be relatively consistent among years. By examining color enlargements, the establishment, growth, and senescence of individual plants is tracked. At minimum, several photo plots are monitored in conjunction with remediation and restoration monitoring for each revegetation type.

3.3 Monitoring Requirements as Goals Are Attained

In the tenth year, formal monitoring concludes for revegetation habitat types in each reach when standards are met. If transects exceed goals prior to year 10, measurement of the parameters exceeding the goals may be discontinued. However, photomonitoring will be utilized to document changes until year 10. Formal monitoring will be reinstituted if declining trends are noted in the photomonitoring. In addition to providing data that determines whether performance standards are met, analysis of long-term monitoring data should answer these questions:

- How has species composition shifted through time, and what lessons does this hold for future revegetation?
- Are weeds effectively controlled?
- What special measures can be employed on sites where revegetation efforts have proven ineffective or unsatisfactory?

3.4 Monitoring Flexibility

A walk-through of reconstructed reaches along Silver Bow Creek may lead to the discovery of disturbed areas that need specific monitoring. Monitoring strategies (timing, methods, etc.) will be determined at the time of the discovery. If problems are observed, suggested remedies will be evaluated and additional monitoring may be implemented.

Vegetation monitoring results may indicate the need for soils monitoring. This is further discussed under SOIL section 8.0 of this plan.

3.4.1 Incorporating Precipitation Effects
The annual and cumulative dynamic in precipitation is directly related to plant production (hence cover) in uplands and indirectly related via groundwater elevations in wetlands and the transition zone. Groundwater elevations in conjunction with capillary rise influences transplant mortality as well as establishment from seed and production in the wetter zones. Riparian plant cover can vary twofold over a decade (Prodgers 2002).

By the fall of 2003, groundwater elevations in Subarea 1 ranged three feet as a series of wet years in the late 1990s was followed by a series of dry years. The delineation of hydrologic zones, therefore, is not static. In uplands in a semiarid environment, seasonal precipitation and plant abundance are sometimes directly linked, but the relationship is different for different plant communities (Prodgers 1988). To evaluate revegetation success in year 10, a means of evaluating the influence of moisture availability on cover is necessary to avoid concluding that revegetation is satisfactory because unusually high precipitation increased plant cover that year, or rating a field as unsatisfactory because it was sampled when annual plant growth was below-average in a drought year.

In a semiarid climatic zone such as the Upper Clark Fork Valley, the simplest and surest way to evaluate revegetation performance is to measure it only in years of relatively normal precipitation. At Butte, the long-term average annual precipitation is 12.6 inches, and the standard deviation is 3.0 inches. One interpretation is that annual precipitation is between 9.6 and 15.6 inches in two out of three years.

Table 3. Precipitation at Butte, Montana (inches)		
Year	**Annual Precipitation**	**May + June**
1964-2009	12.5	4.3
1999-2004	10.6	3.7
2005	13.4	5.2
2006	12.5	4.2
2007	12.6	4.9
2008	10.2*	4.1
2009	12.5	3.5
1999-2009	11.3	4.0
* Probably higher, the airport seemingly missed some spring rain, on the order of two inches.		

For revegetation using cool-season grasses, May plus June precipitation is more influential than annual precipitation, although antecedent conditions are also influential, and the duration and intensity of rainfall can be as important as the quantity. The average May plus June precipitation in Butte is 4.3 inches with a standard deviation of 1.9 inches. A range of 2.4-6.2 inches of May plus June precipitation allows for too much variation in cover since each inch of spring precipitation is correlated with about 4% canopy coverage (Prodgers 1992). Therefore, revegetation is measured only when May plus June precipitation is between 3.0 and 5.6 inches. Within that range, if measurements are taken in a wetter year, an adjustment to the amount of cover required of satisfactory revegetation is made based on the previously cited relationship of cover to spring precipitation (Prodgers 1992). However, if measurements are taken in a drier year and the standards are met, revegetation success is demonstrated. A way of incorporating antecedent conditions, e.g. prolonged series of wet or dry years, may have to be found if precipitation levels fall outside the target range for several years when an evaluation is due.

4.0 INSTREAM SEDIMENTS

4.1 Goal

From a regulatory standpoint, stream sediments are unlike surface water in that numeric standards have not been developed for metals contamination. Prior to 2009, the Silver Bow Creek remediation goals for instream sediments matched the cleanup standards for tailings and impacted soils throughout the floodplain. These standards were determined to be too high to be protective of the stream resource and more stringent standards were adopted in 2009. The new standards are based on the threshold effects concentrations (TEC) values developed by freshwater ecologists (MacDonald et al. 2000). The TECs are intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms were not expected. In addition to identifying TEC concentrations, probable effect concentrations (PEC) are included here, which are intended to identify the contaminant concentrations above which harmful effects on sediment-dwelling organisms are expected to occur frequently (MacDonald et al. 1996; Swartz 1999). Both standards provide a basis for predicting negative effects of metals concentration on aquatic life. TECs are concentrations below which no effect on sediment dwelling organisms are expected, whereas PECs are the concentrations at which negative effects on sediment dwelling organisms are judged more likely than not. Table 4 presents the potential metal and metalloid contaminants on Silver Bow Creek, along with the relevant standards.

Table 4. Contaminants of Concern and Applicable Sediment Quality Standards

Parameter	Primary Contaminant	Standards		
		TEC[1]	PEC[2]	Prior SBC Goal[3]
Aluminum		---	---	---
Antimony		---	---	---
Arsenic	X	9.79	33.0	200
Barium		---	---	---
Beryllium		---	---	---
Boron		---	---	---
Cadmium	X	0.99	4.98	20
Chromium		43.4	111	---
Cobalt		---	---	---
Copper	X	31.6	149	1000
Iron		---	---	---
Lead	X	35.8	128	1000
Manganese		---	---	---
Mercury	X	0.18	1.06	10
Molybdenum		---	---	---
Nickel		22.7	48.6	---
Selenium		---	---	---
Silver		---	---	---
Uranium		---	---	---
Vanadium		---	---	---
Zinc	X	---	---	1000

[1] Threshold Effect Concentration per MacDonald et al 2000

[2] Probable Effect Concentration per MacDonald et al 2000

[3] Silver Bow Creek Remediation Goal
All standard concentrations presented in mg/kg dry weight basis

From a management standpoint, stream sediments are unlike surface water in that they typically have longer residence time. Water moves into and out of the remediation reach of Silver Bow Creek fairly rapidly. This can cause wide variation in water quality over short time periods. Sediment moves much more slowly, and contamination in sediment can have lasting effects on water quality and aquatic life.

Instream sediment samples are collected and analyzed with the goal of preventing exposure of humans and aquatic species to sediments having concentrations of contaminants in excess of published (in peer reviewed journals) risk-based concentrations (MDEQ/USEPA 1995, p. 104). Meeting the limits established for in-stream sediments is expected to improve the quality of Silver Bow Creek sediments so that Silver Bow Creek could support the growth and propagation of fishes and associated aquatic life.

While there is no mandated contaminant concentration goal for instream sediments, the remediation and restoration goal is considered met if all analytes monitored at a site are below limits in Table 4 or near background concentrations for at least three consecutive years, and all upstream sites are also below limits or near background levels for at least three consecutive years. Establishing realistic timeframes for success is not feasible at this time. On a project of this magnitude, contaminated areas outside the SST OU potentially impact sediment loading.

While clean up has taken place in the Lower Area One Operable Unit (LAO OU), immediately upstream of the SST OU, a number of the monitoring sites included within this plan are designed to measure any continued impacts from the LAO OU. Background instream sediment sampling was conducted in 2004 on Blacktail Creek near Thompson Park, Silver Bow and Yankee Doodle Creeks above the Yankee Doodle Tailings Pond, and the Browns Gulch tributary, streams relatively unaffected by mining that drain granitic rocks of the Boulder Batholith.

4.1.1 Measures

Sediment samples will be collected and analyzed for concentration of contaminants of concern; specifically, arsenic, cadmium, copper, lead, mercury, manganese, and zinc. These metals and metalloids are the primary causes of pre-remedy contamination. Reduction of these contaminants in the instream sediments is expected post-remedy.

4.2 Monitoring Requirements

4.2.1 Sampling Protocols

Instream sediment sampling follows the protocols defined in the Clark Fork River Standard Operating Procedures (SOPs) SS-3, G-6, and G-8 (ARCO 1992). Disposable sampling devices may be utilized in lieu of the decontamination procedures described in G-8. Instream sediments are analyzed in three size fractions: 1mm and greater, between 1mm and 63 μm, and less than 63 μm (MDEQ/USEPA 1995, p. 111).

4.2.2 Monitoring Schedule

Instream sediments will be collected quarterly on Silver Bow Creek according to the schedule in Table 5, including during approximate high and low flow conditions during calendar year 2010.

4.2.3 Locations

Sediment sampling locations are placed in the remediated channel as close as reasonably possible to the pre-remediation site locations, and as remediation progresses downstream final site locations are approved by MDEQ. Instream sediments will be collected in 2010 at the locations specified in Table 5. Fall sampling must coincide with surface water and biological monitoring. Sediment monitoring locations for 2010 are illustrated in Figure 3.

Figure 3: Surface Water/Sediment Monitoring 2010 Sample Locations

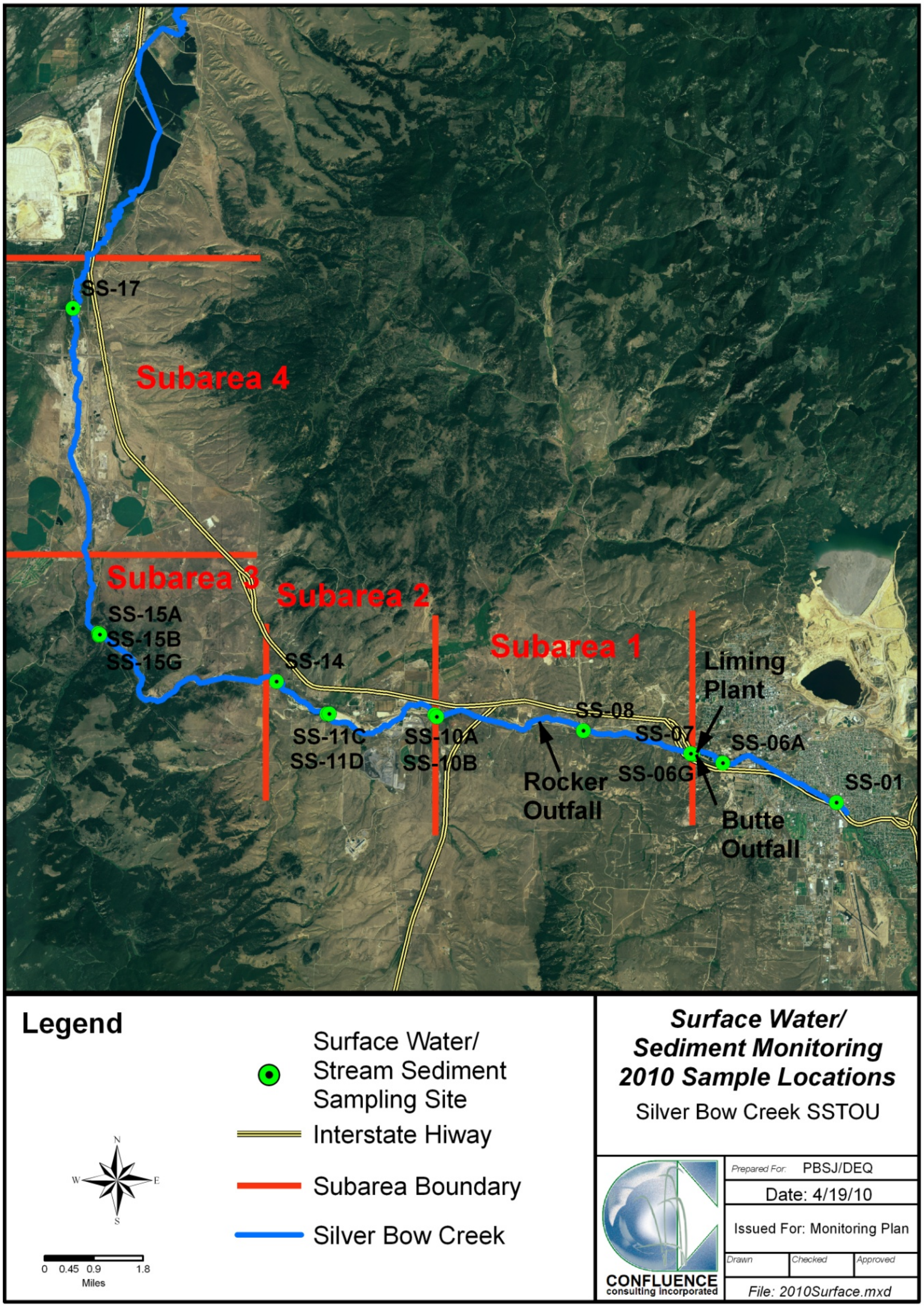

Table 5. Instream Sediment[1] and Surface Water Monitoring Sites and Monitoring Schedule, SST OU 2010						
	GPS Coordinates NAD 83					
Site	**latitude**	**longitude**	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**
SS-01 Father Sheehan Park	45.985231187 (digitized)	-112.507716476 (digitized)	X	High water (2)	Low water (3)	X
SS-06A Butte Reduction Works	45.994580115 (digitized)	-112.551460893 (digitized)	X	High water (2)	Low water (3)	X
SS-06G above Butte WWTP	45.996503889	-112.563000833	X	High water (2)	Low water (3)	X
SS-07 below Butte WWTP	45.996658611	-112.563812222	X	High water (2)	Low water (3)	X
SS-08 Rocker	46.001666667	-112.604901389	X	High water (2)	Low water (3)	X
SS-10A above Sand Creek	46.003749722	-122.660839444	X	High water (2)	Low water (3)	X
SS-10B below Sand Creek	46.004289167	-112.661603056	X	High water (2)	Low water (3)	X
SS-11C above Brown's Gulch	46.003362500	-112.701718333	X	High water (2)	Low water (3)	X
SS-11D below Browns Gulch	46.003419167	-112.702524167	X	High water (2)	Low water (3)	X
SS-14 Miles Crossing	46.011434094 (digitized)	-112.722288611 (digitized)	X	High water (2)	Low water (3)	X
SS-15G German Gulch	46.021703889	-112.790291111	X	High water (2)	Low water (3)	X
SS-15A above German Gulch	46.021872778	-112.790044167	X	High water (2)	Low water (3)	X
SS-15B below German Gulch	46.022162222	-112.790644722	X	High water (2)	Low water (3)	X
SS-17D below Stewart Street, Opportunity	46.107873333	-112.805527778	X	High water (2)	Low water (3)	X

(1) Sediment sample form each site will be analyzed by size fractions mandated in the Record of Decision and in Section 4.2.1.
(2) High water may be 1st or 2nd quarter.
(3) Low water may be 3rd or 4th quarter and must be coordinated with surface water and aquatic biology.

4.2.4 Parameters and Methods

Instream sediment samples consist of a composite of the fine-grained or mobile sediments from the full width of the active channel. Analytes include contaminants of concern listed in Table 6. Analysis of the initial sample collected at a site includes the additional analytes listed in Table 7; analytes in this table exhibiting concentrations above background levels are included in subsequent monitoring.

Table 6. Instream Sediment Sampling Parameters, Limits, and Methods
Arsenic, As
Cadmium, Cd
Copper, Cu
Lead, Pb
Mercury, Hg
Zinc, Zn
Digestion: 3050A Analysis: 200.8/6020CLPM

Table 7. Additional Analytes for Initial Sediment, Surface Water and Groundwater Sampling

Silver, Ag	Cobalt, Co	Antimony, Sb
Aluminum, Al	Chromium, Cr	Selenium, Se
Boron, B	Iron, Fe	Uranium, U
Barium, Ba	Molybdenum, Mo	Vanadium, Va
Beryllium, Be	Nickel, Ni	Manganese, Mn
Digestion for solids: 3050A; Digestion for unfiltered liquids: 3010A; Analysis: Method 200.8/6020-CLPM		

4.3 Monitoring Requirements as Goals Are Attained

If, prior to 10 years of monitoring in a reach, analytes fall below limits in Table 4 and then show no significant change or a declining trend for 3 years, those analytes will be monitored once yearly during low water.

If, prior to 10 years of monitoring in a reach, all analytes fall below limits in Table 4 and then show no significant change or a declining trend for 3 years, the number of monitoring sites will be re-evaluated and possibly reduced.

Sampling will discontinue for those analytes in Table 7 that exceed average background concentrations in the initial sampling but subsequently drop to near background levels and then show no change or a declining trend for 3 consecutive years with no significant spikes. Currently, available background samples vary from average levels by up to 200% for any one sample event and up to 150% over two sample events for aluminum, antimony, iron, and nickel. These percentages are derived from analysis of data from 10 background samples collected from Bison Creek (Essig & Moore 1992).

4.4 Monitoring Flexibility

"If recontamination of instream sediments is found to occur, then additional work to address the sources of the recontamination, as well as additional excavation of recontaminated sediments, will be required" (MDEQ/USEPA 1995, p. 104). Suggested remedies will be evaluated and additional monitoring may be implemented if such problems are observed.

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5.0 SURFACE WATER

5.1 Goal

The remediation and restoration goal for surface water quality is for all parameters in Table 8 to meet the more restrictive of the aquatic life or human health standards for surface water identified in MDEQ Circular WQB-7 and contained in Table 9, and for the additional analytes in Table 7 to be at or near background for at least three consecutive years. When remediation goals are met, it is expected that surface water quality of Silver Bow Creek could support the growth and propagation of fishes and associated aquatic life (MDEQ/USEPA 1995, p. 102).

Table 8. Surface Water Sampling Parameters and Methods

Parameters	Method
Metals: Total recoverable and dissolved As, Cd, Cu, Pb, Hg, Zn	Analysis: 200.8; digestion for total recoverable: 3010A
Common ions: Ca, Mg, Na, K, Cl^-, K, SO_4^{2-}, HCO_3^-	Analysis: 200.7
Nutrients: Nitrate+Nitrite Nitrogen, Ammonia, Total Phosphorus,, Total Persulfate Nitrogen	Analysis: 353.2, 350.1, 365.1, SM 4500-N C
Field parameters: Temperature, pH, EC, dissolved O_2, turbidity	CFR SOPs HG-5 and HG-6

Table 9. Applicable Numeric Water Quality Standards (MDEQ Circular WQB-7, updated 2/08)

Parameter	Primary Contaminant	Surface Water Quality Standards (mg/L)		
			Aquatic Life	
		Human Health	Chronic	Acute
Aluminum as Al		---	0.087	0.75
Antimony as Sb		0.0056	---	---
Arsenic as As	X	0.01	0.15	0.34
Barium as Ba		2	---	---
Beryllium as Be		0.004	---	---
Boron as B		---	---	---
Cadmium as Cd	X	0.005	0.00032 [1]	0.0027 [1]
Chromium as Cr		0.1	0.103 [1]	2.165 [1]
Cobalt as Co		---	---	---
Copper as Cu	X	1.3	0.011 [1]	0.017 [1]
Iron as Fe		0.33 [2]	---	---
Lead as Pb	X	0.005	0.004 [1]	0.108 [1]
Manganese as Mn		0.05 [2]	---	---
Mercury as Hg	X	0.00005	0.00091	0.0017
Molybdenum as Mo		---	---	---
Nickel as Ni		0.1	0.06 [1]	0.57 [1]
Selenium as Se		0.05	0.005	0.02
Silver as Ag		0.1	---	0.006 [1]
Uranium as Ur		0.03	---	---
Vanadium as V		---	---	---
Zinc as Zn	X	2	0.144 [1]	0.144 [1]

1 Based on 125 mg/L hardness (typical value for Silver Bow Creek in SSTOU).
2 Secondary maximum contaminant level, based on aesthetic properties (color, taste, odor).

5.2 Initial Monitoring Requirements

5.2.1 Sampling Protocols

Surface water samples are collected according to SST OU Standard Operating Procedures (SOPs) G-6, SW-1, HG-1, HG-2, HG-3, and HG-4 (ARCO 1992) in new, clean bottles, which are triple rinsed at the time of collection with the water to be sampled. For measurement of field parameters, equivalent meters are substituted for meters specified in SOPs HG-5 and HG-6 that are no longer available. Meters are calibrated at least daily according to manufacturers' recommendations. Analysis of the first surface sample from a site includes the additional analytes listed in Table 7; analytes in this table exhibiting concentrations that exceed background levels are included in subsequent monitoring. Streamflow is determined when surface water samples are collected using SOP SW-6 (ARCO 1992).

5.2.2 Monitoring Schedule

Surface water samples will be collected quarterly on Silver Bow Creek according to the schedule in Table 5 (Section 4), including during approximate high and low flow conditions during calendar year 2010. Fall sampling must coincide with the instream sediment sampling and biological monitoring. Additional sampling of significant run off, storm or flood events will occur as approved by MDEQ.

5.2.3 Locations

Surface water monitoring sites include the sites identified in Table 5 (Section 4), derived from the ROD, as well as others deemed necessary to "ascertain possible surface water contaminant loading from onsite/near-site contaminant sources" (MDEQ/USEPA 1995, p. 88). Monitoring locations correspond to previous CFRDMS (Clark Fork River Data Management System) sites where such sites exist, including SS-06G, SS-07, SS-08, SS-10A, SS-10B, SS-11C, SS-11D, SS-14, SS-15A, SS-15B, SS-15G and SS-17. Monitoring begins one year after remediation is completed downstream of the individual sites. New sampling locations at Ramsey Flats/Miles Crossing (SS-14), and in the vicinity of the Butte Reduction Works (SS-06A) and Father Sheehan Park (SS-01) were established for the 2009 monitoring. Surface water monitoring locations for 2010 are unchanged from 2009, and are illustrated in Figure 3.

5.2.4 Parameters and Methods

Surface water samples are analyzed for the parameters specified in the ROD (MDEQ/USEPA 1995, p. 111) and listed in Table 8, using methods compatible with SOP HG-10 (ARCO 1992). Analysis of the initial sample collected at a site also includes the additional analytes listed in Table 7; analytes in this table exhibiting concentrations above background levels are included in subsequent monitoring.

5.3 Monitoring Requirements as Goals Are Attained

Sampling will discontinue for those analytes in Table 7 that exceed average background concentrations in the initial sampling but subsequently drop to near background levels and then show no change or a declining trend for 3 consecutive years with no significant spikes. Currently, available background samples vary from average levels by up to 300% for any one sample and up to 250% over two samples. However, iron exceeded 1100% of average background. These percentages are derived from analysis of data from 6 to 21 background samples (depending on the particular analyte) collected from Blacktail Creek between Grove Gulch and Silver Bow Creek. As additional data becomes available, background levels and the amount of variability exhibited by the analytes in Table 7 will be re-evaluated. Parameters that are below limits and show no change or a declining trend for 3 years prior to 10 years of monitoring will be monitored once per year during low water. If, for an entire reach, all parameters in are below limits and show no change or a declining trend for 3 years prior to 10 years of monitoring, the number of monitoring sites and monitoring frequency will be re-evaluated and possibly reduced.

At the end of 10 years of monitoring at a surface water site, if all parameters, including those in Table 8, monitored at that site and up-gradient sites exhibit level or declining trends and are below the more restrictive of the aquatic life or human health standards for surface water identified in MDEQ Circular WQB-7, the goals for surface water quality are considered to be met and no further samples will be collected at the site.

5.4 Monitoring Flexibility

If problems are observed with analytical parameters within a reach, suggested remedies will be evaluated and additional monitoring may be implemented.

6.0 GROUNDWATER

6.1 Goal

Groundwater contamination is among the environmental concerns within the Silver Bow Creek SST OU and poses a threat to human health and the environment. An objective of removing mine waste from the SSTOU was to reduce loading of contaminants to groundwater, and eventually surface water. "*Removing the source of groundwater contamination by addressing tailings/impacted soils and railroad materials, will allow contaminants in groundwater to attenuate over time through dilution, adsorption, precipitation and dispersion, and should allow eventual attainment of groundwater standards*" (MDEQ/USEPA 1995, pp. 87-88). Remediation and restoration goals for groundwater call for concentrations of contaminants of concern to meet state water quality standards, federal maximum contaminant levels (MCLs), and federal nonzero maximum contaminant level goals (MCLGs) through natural attenuation. All of these standards and levels apply to human health considerations. In addition these goals require that no groundwater discharges occur that would prevent attainment of ambient Circular MDEQ-7 surface water standards in the Silver Bow Creek operable unit or instream sediment remediation goals.

6.2 Initial Monitoring Requirements

6.2.1 Sampling Protocols
Sampling activities conform to the appropriate SOPs including G-6, G-8, HG-7, HG-8, GW-1, GW-5, and GW-9 (ARCO 1992). Dedicated or disposable bailers may be used in low yield wells where installation of a submersible pump is impractical. Disposable cartridge filters may be used in lieu of decontamination of a field filter apparatus.

6.2.2 Monitoring Schedule
Groundwater samples will be collected annually in 2010 during approximate low water level conditions, except at the Mine Waste Relocation Repository (MWRR) where groundwater will be monitored semiannually during approximate high and low water-level conditions. All 2010 groundwater monitoring sites and the monitoring schedule are contained in Table 10. Groundwater monitoring locations for 2010 are illustrated in Figure 4. Analytical parameters and methods are listed in Table 11. Additional analytes are listed in Table 7.

6.2.3 Locations
As remediation progresses downstream, monitoring occurs in clusters of three wells or piezometers near Colorado Tailings, Nissler, Rocker, Silver Bow, Ramsay Flats, Miles Crossing, Fairmont, Crackerville, Stuart, and Opportunity.

The well clusters include one background site, (i.e. outside the influence of the contaminated floodplain), and two sites in the floodplain, one on each side of the creek. Silver Bow Creek typically acts as a groundwater sink, with groundwater flowing toward the creek from both sides (gaining reach), and occasionally as a source with groundwater flowing away on both sides (loosing reach), so wells on either side sample different groundwater flow paths.

Locations of post-remedy groundwater monitoring sites are at pre-remediation locations where practical. Existing wells and piezometers necessary for groundwater monitoring are identified prior to construction and preserved. Permanent groundwater sites selected for long-term monitoring are equipped with locking steel protective covers to protect against damage from flooding, vandalism, etc.

Table 10. Groundwater Monitoring Locations and Monitoring Schedule, SST OU 2010

Site	GPS Coordinates NAD 83 latitude	GPS Coordinates NAD 83 longitude	1st quarter	2nd quarter	3rd quarter	4th quarter
MW-1010R Colorado Tailings	45.999790418	-112.575614927			Low water (2)	
P-06A Colorado Tailings	45.999397900	-112.576222931			Low water (2)	
MW-1052R Colorado Tailings	45.999162424	-112.576235537			Low water (2)	
1GW-1038 Rocker	46.005435665	-112.617493908			Low water (2)	
MW-10 Rocker	46.004471658	-112.617344101			Low water (2)	
MW-6R (3) Rocker	46.004290389	-112.619946310			Low water (2)	
1GW-1003R Nissler	46.004053857	-112.630951661			Low water (2)	
1GW-1004A (3) Nissler	46.003065952	-112.633432908			Low water (2)	
P-58A (3) Nissler	46.002109738	-112.633550474			Low water (2)	
P-39R Nissler	46.004403024	-112.662352058			Low water (2)	
P-37A (3) Silver Bow	46.004487769	-112.661121437			Low water (2)	
P-114 (4) Silver Bow	46.005081917	-112.659413147			Low water (2)	
1GW-1056 MWRR	46.002629781	-112.586153478		High water (1)	Low water (2)	
LYP-07 MWRR	46.002643162	-112.584831642		High water (1)	Low water (2)	
MW2A MWRR	46.003862158	-112.581135576		High water (1)	Low water (2)	
MW2B MWRR	46.002234067	-112.583503698		High water (1)	Low water (2)	
MW2C MWRR	46.002151600	-112.584507380		High water (1)	Low water (2)	
MW2D MWRR	46.002229712	-112.585768032		High water (1)	Low water (2)	
GW-MC-NS	46.013 (digitized)	-112.726 (digitized)			Low water (2)	
GW-MC-SS	46.012 (digitized)	-112.726 (digitized)			Low water (2)	
GW-MC-BG	46.012 (digitized)	-112.721 (digitized)			Low water (2)	

(1) High water may be 1st or 2nd quarter.
(2) Low water may be 3rd or 4th quarter.
(3) Total Number of samples does not include new groundwater monitoring wells in Subarea 2, Reach J.

Table11. Groundwater Monitoring Parameters and Analytical Methods

Parameter	Method
Metals and metalloids: Dissolved As, Cd, Cu, Pb, Hg, Zn	Analysis 200.8
Common ions: Ca, Mg, Na, K, Cl-, SO42-, HCO3-	Analysis 200.7, 300.0
Physical: Temperature, pH, Eh, conductance, dissolved O2	CFR SOPs HG-5 & 6

Groundwater in four wells at the Mine Waste Relocation Repository (MWRR) in Reach A are also monitored. If additional repositories are constructed in the SST OU, monitoring requirements and schedules will be developed prior to construction.

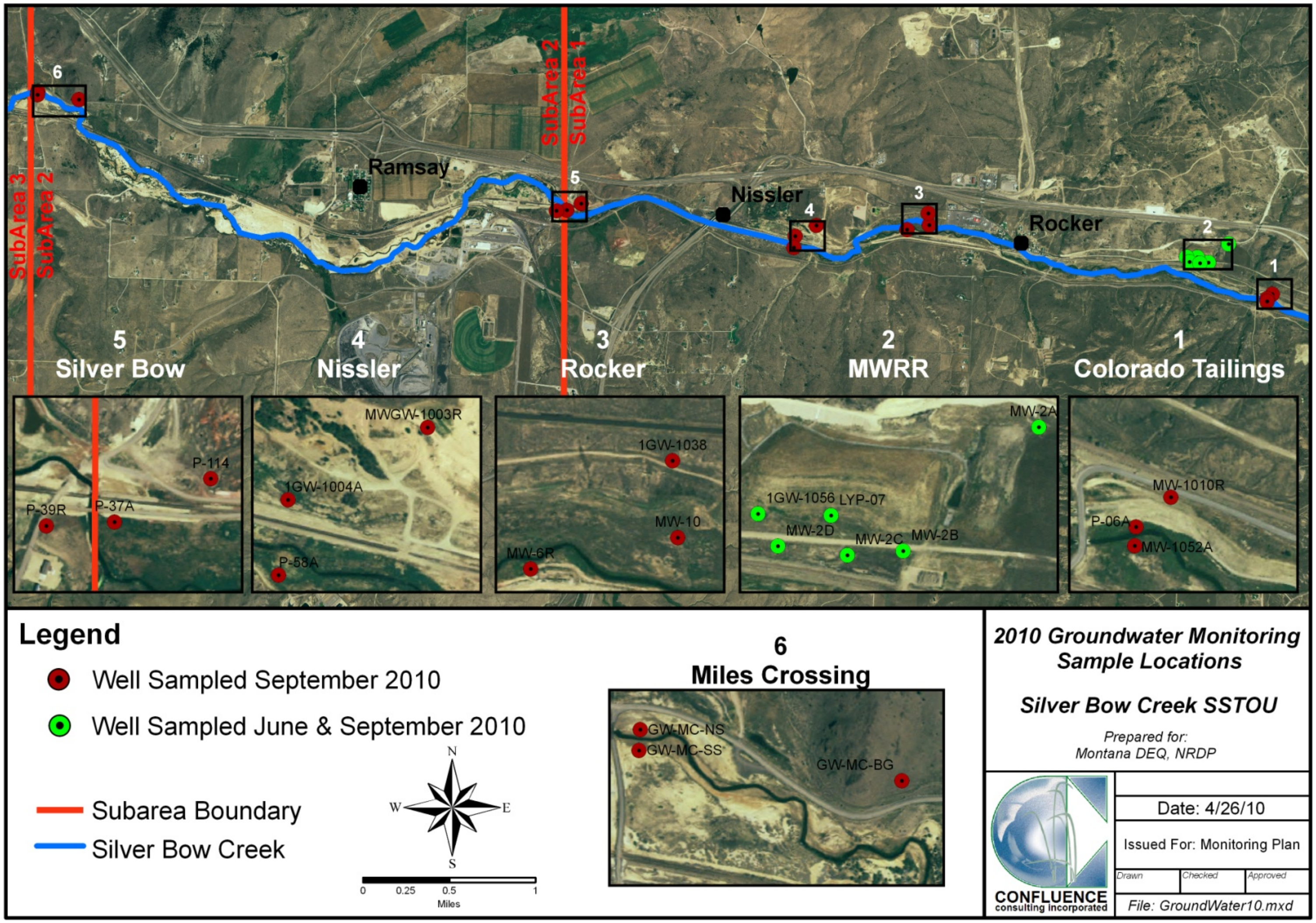

Figure 4: 2010 Groundwater Monitoring Sample Locations

6.2.4 Parameters and Methods
Groundwater is monitored for the parameters listed in Table 11 and the additional analytes listed in Table 7 using analytical methods compatible with SOP HG-10 (ARCO 1992). The first groundwater sample gathered at each site includes the additional analytes listed in Table 7; analytes in this table exceeding background concentrations are included in subsequent monitoring.

6.3 Monitoring Requirements as Goals Are Attained

Sampling will discontinue for those analytes in Table 7 that exceed average background concentrations in the initial sampling, but subsequently drop to near background levels and then show no change or a declining trend for 3 consecutive years with no significant spikes. Currently, available background samples vary from average levels by up to 500% for any one sample and up to 400% over two samples. These percentages are derived from analysis of data from 18 to 39 background samples (depending on the particular analyte) collected from private, business, and monitoring wells in T03N R08W which draw water from the alluvium of Blacktail Creek, Grove Gulch, and the south side of Silver Bow Creek. As additional data becomes available, background levels and the amount of variability exhibited by the analytes in Table 7 will be re-evaluated.

If parameters in Table 11 are below limits, and show no change or declining concentrations for 3 years prior to 10 years of monitoring, they will be monitored every two years during low water.

If, for an entire reach, all parameters in Table 11 are below limits and show no change or a declining trend for 3 years prior to 10 years of monitoring, the number of monitoring sites will be re-evaluated and possibly reduced.

At the end of 10 years of monitoring at a groundwater site, if all parameters monitored at that site and up-gradient sites exhibit level or declining trends and comply with applicable MDEQ Circular WQB-7 standards, federal maximum contaminant levels (MCLs), and federal nonzero maximum contaminant level goals (MCLGs), then the goals for groundwater quality are met and no further samples will be collected at the site.

6.4 Monitoring Flexibility

Increasing contaminant concentrations in the groundwater, persistent exceedances of standards that effect surface water, or problems in establishing vegetation may require re-evaluation of groundwater conditions at a site. Suggested remedies will be evaluated and additional monitoring may be implemented.

7.0 VADOSE ZONE WATER

7.1 Goal

The remediation and restoration goal of vadose zone monitoring is the quantification of analytes listed in Table 12 and additional analytes listed in Table 7 to determine if any are migrating from the mine waste repositories toward the Silver Bow Creek alluvial aquifer, and threatening remediated reaches. Typically, constituent concentrations are higher in vadose zone water than in groundwater. This general increase in concentration within the soil pore water makes existing numeric standards for surface and groundwater inapplicable. As a result, determination of background levels and concentrations is important to evaluate any increase in migrating contaminants within the vadose zone.

7.2 Initial Monitoring Requirements

7.2.1 Sampling Protocols

Lysimeters were installed at the MWRR in Reach A and are sampled following the protocols described in SOP SS-10.

7.2.2 Monitoring Schedule

Water quality parameters listed in Table 12 and the additional analytes in Table 7 are to be monitored semiannually during high water, which more than likely will occur during the second quarter of 2010.

Table 12. Vadose Zone Monitoring Parameters and Methods

Parameter	Method
Metals and metalloids: Dissolved: As, Cd, Cu, Mn, Pb, Hg, Zn	Analysis 200.8
Common ions: Ca, Mg, Na, K, Cl-, SO42-, HCO3-	Analysis 200.7, 300.0
Physical: Temperature, pH, Eh, conductance	CFR SOPs HG-5 & HG-6

7.2.3 Locations

7.2.3.1 Repositories

Lysimeters installed at the MWRR in Reach A (Table 13) allow measurement of levels of analytical parameters in soil water to determine if contaminants might be migrating downward from the MWRR. The lysimeters were placed as close as possible to the repositories without penetrating or compromising the integrity of the cap. The lysimeter locations again slated for vadose zone monitoring in 2010 are illustrated in Figure 5. Problems were identified with at least two of these lysimeters during the 2009 monitoring, which will likely require rehabilitation or re-installation to maintain their function.

If additional repositories are built within the SST OU, monitoring requirements and schedules will be developed prior to construction.

Table 13. Vadose Zone Monitoring Schedule, 2010

Site[2]	GPS Coordinates NAD 83		1st quarter	2nd quarter	3rd quarter	4th quarter
	latitude	longitude				
LYS-01	46.002610599	-112.585988221		High water (1)	Low water	
LYS-02	46.002442317	-112.584027876		High water (1)	Low water	
LYS-04	46.002333086	-112.581410970		High water (1)	Low water	
LYS-05	46.002228153	-112.580112367		High water (1)	Low water	
LYS-06	46.002885633	-112.586792373		High water (1)	Low water	
LYS-07	46.002642871	-112.584889226		High water (1)	Low water	

(1) High water may be 1st or 2nd quarter
(2) LYS-03 and LYS-08 are not functioning and are scheduled to be replaced in 2010.

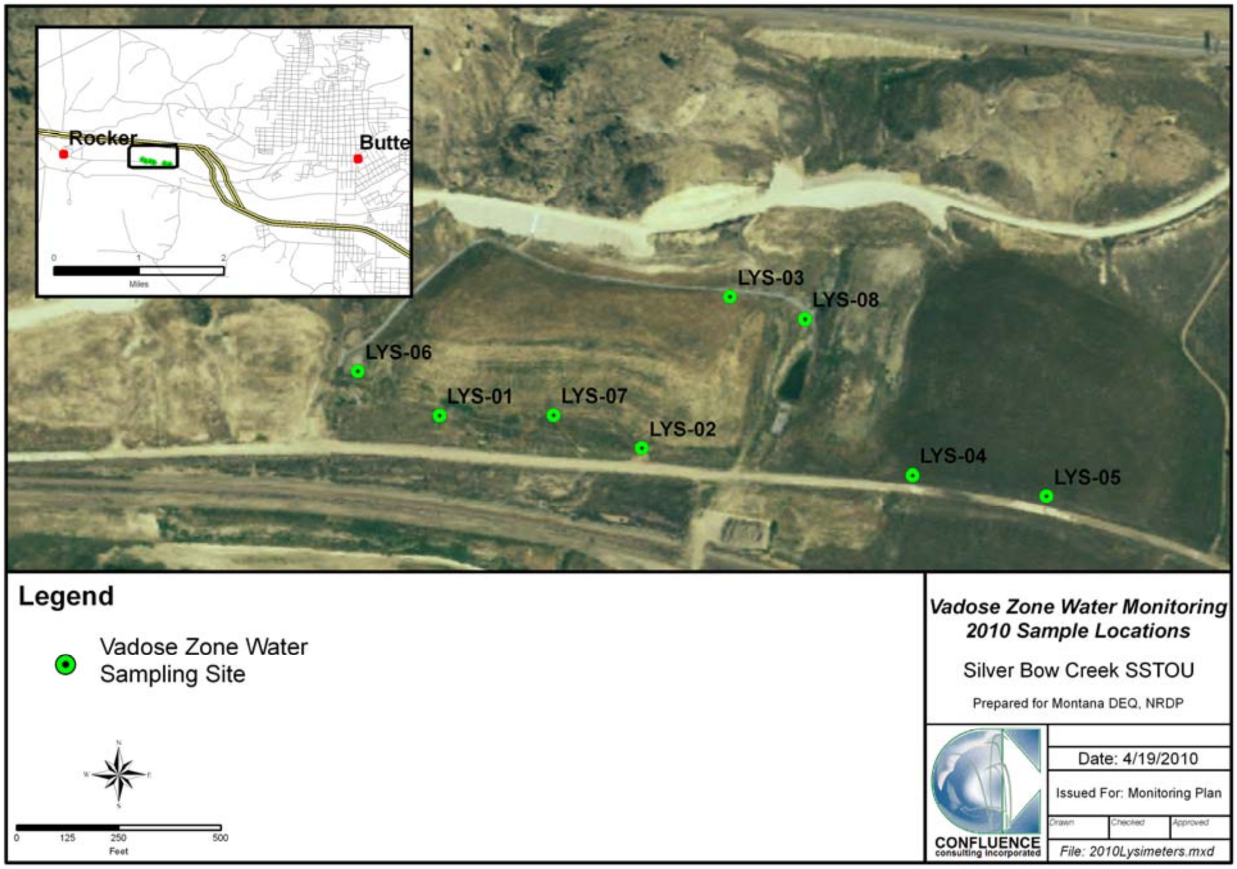

Figure 5: Vadose Zone Water Monitoring 2010 Sample Locations

7.2.4 Parameters and Methods

Lysimeters are currently monitored for the parameters in Table 13 during approximate high water, following SOPs SS-10 and HG-10 (ARCO 1991). The first vadose zone samples gathered at each lysimeter includes the additional analytes listed in Table 7; analytes in this table exceeding background concentrations are included in subsequent monitoring.

7.3 Monitoring Requirements as Goals Are Attained

Sampling will discontinue for those analytes in Table 7 that exceed background concentrations in the initial sampling, but subsequently drop to near background levels and then show no change or a declining trend for 3 consecutive years with no significant spikes.

If water quality parameters in Table 13 are below limits and show no change or a declining trend for 3 years prior to 10 years of monitoring, they will be monitored once per year during high water.

If all parameters in Table 12 are below limits in all wells and show no change or a declining trend for 3 years prior to 10 years of monitoring, the number of monitoring sites will be re-evaluated and possibly reduced.

Continued monitoring of the vadose zone 10 years past construction near the MWRR, or any repository or STARS treated area that may be constructed, will occur as part of the institutional controls, monitoring, and maintenance (ICMM) and operations and maintenance (O&M) plans.

7.4 Monitoring Flexibility

If analytes are identified moving toward the alluvial floodplain from the MWRR, possible remedies will be evaluated and additional monitoring may be implemented.

8.0 SOIL

8.1 Goal

The remediation and restoration goals for soil are to ensure that reconstructed soil is a viable growth medium, contamination levels do not seriously impair revegetation, and processes such as capillary rise of groundwater or downward percolation of run-on from outside the SST OU have not degraded the soil.

8.1.1 Measures

To determine the degree soil goal achievement, soil is sampled every 10 acres and analyzed for the parameters in Table 14, and the level of successful vegetation re-establishment is assessed. The soil parameters measured, in conjunction with the vegetation monitoring, will help guide future remediation and evaluation of sites needing additional work such as soil amendments or reseeding.

8.2 Initial Monitoring Requirements

8.2.1 Sampling Protocols

Soil samples are taken from two depth intervals: 0-6 inches and 6-18 inches using a stainless steel soil auger and adhering to applicable sections of SOPs G-7, G-8, SS-1, and SS-2 (ARCO 1992). Each sample will consist of three subsamples per depth interval, which will be combined into a single sample for analysis.

8.2.2 Monitoring Schedule

A single set of soil samples is collected at least one year but less than four years after the initial revegetation seeding. No routine soil sampling is planned for the 2010 season.

8.2.3 Locations

One set of samples is collected from each 10 acres of remediated floodplain. Sample sites coincide with vegetation transects, areas where salts might be expected to accumulate at the surface, or other areas where vegetation is stressed.

8.2.4 Parameters and Methods

The samples are analyzed for the parameters in Table 14 by the listed or comparable methods.

Table 14. Soil Sampling Parameters and Frequency		
Location	**Parameters**	**Frequency**
Minimum one (1) sample per 10 acres and three (3) samples per repository	SMP buffer test (Extraction & Analysis: ASA Mono. 9, Part 2, Method 12-3.4.4) electrical conductivity (Extraction: ASA Mono 9, Part 1, Method 10-3.2; Analysis: Conductivity meter) paste pH (Extraction: ASA Mono 9, Part 1, Method 10-3.2; Analysis: pH meter) organic carbon & organic matter (Extraction: ASA Mono 9, Part 2, Method 29-3.5.2; Analysis: Spectrophotometer) total Cu, Zn, Mn, and As (Extraction: SW 3050; Analysis: E6010B/E6020) fertility; mineralized N, P, and K (Extraction: ASA Mono 9, Part 2, Methods 38-8.1, 24-5.4, & 13-3.5; Analysis: E353.2, E365.1, & E6010B/6020)	Once, at least one year after and less than four years after seeding.

8.3 Monitoring Requirements as Goals Are Attained

Vegetation success is the primary indicator that soil goals have been met. Where vegetation is successfully established and design criteria are met, soils are considered to meet the remediation and restoration goal. No further soil monitoring is considered necessary.

8.4 Monitoring Flexibility

If problems are observed with vegetation or if analytical parameters exceed removal guidelines, possible remedies will be evaluated and additional monitoring may be implemented. In 2010, a one-time investigation is planned to compare soil microbes in composted and uncomposted, revegetated cover soil 1-year and 10-years-old in Reaches A and K, under Change Order 25 (R. Prodgers, per. com).

9.0 AQUATIC BIOLOGIC RESOURCES/GEOMORPHOLOGY

9.1 Goal

Restoration and remediation goals for Silver Bow Creek include defined objectives for the aquatic biota. For both the macroinvertebrate and periphyton assemblages, the goal is for community composition to reflect a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region (Karr and Dudley 1981). Targets reflecting these goals include progressive increase of biological integrity substantiated by indices developed to rate the health of Montana streams (Bahls 1993, Bollman 1998, Bukantis 1998). For the fish community, the ultimate goal is to improve Silver Bow Creek over time to a condition that supports a self-reproducing fishery for trout species. In addition to evaluating attainment of specified goals for Silver Bow Creek, these assemblages provide useful tools in evaluating environmental conditions such as the presence of toxic chemicals, excess nutrients, and other types of environmental stress. Moreover, these assemblages provide a direct measure of aquatic life, a designated beneficial use of Montana's waters. Together, these applications make biological monitoring a useful tool in evaluating the recovery of Silver Bow Creek following remediation and restoration efforts.

9.1.1 Macroinvertebrates

The remediation and restoration goal for macroinvertebrates in Silver Bow Creek is for the community composition to reflect a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region (Karr and Dudley, 1981). Specific goals for the macroinvertebrate community include the attainment of a total metric score of 75% of the total possible score in the 'Good' category for two consecutive years.

9.1.2 Periphyton

Periphyton is a commonly used assemblage of aquatic life used to evaluate biological integrity and water quality. Periphyton consists of diatoms, a type of golden brown algae with rigid, silica cell walls, and soft-bodied algae. The soft-bodied algae are a diverse group comprised of green algae, blue-green algae (cyanobacteria) and red algae, among others. The remediation and restoration goal for periphyton community composition is the same as for macroinvertebrates; namely, an "integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" (Karr and Dudley 1981). Specific goals for the periphyton community include the attainment of a score within 'Excellent' to 'Good' biological integrity for all metrics for two consecutive years.

9.1.3 Fish

"*Provided that the upstream sources of Silver Bow Creek contaminants are eliminated, [remediation]…should attain the remedial action objective to improve the quality of Silver Bow Creek's surface water and instream sediments to the point that Silver Bow could support the growth and propagation of fishes and associated aquatic life, one of the designated goals for an I-class stream, including a self-sustaining population of trout species*" (MDEQ/USEPA 1995, p 102). The ultimate goal is to improve Silver Bow Creek over time to a condition that supports a self-reproducing fishery for trout species (MDEQ/USEPA 1995, p. 104).

9.1.4 Fish Habitat and Fluvial Geomorphology

The goal of remediation and restoration is to provide suitable habitat to support the healthy fishery described above. Evaluations of habitat and geomorphic characteristics of Divide Creek, a stream sharing many physical similarities with Silver Bow Creek, provide the basis for many of the criteria for successful remediation and restoration (Confluence 2003b). Other criteria are based on additional measures of habitat suitability for cold-water fisheries.

9.1.5 Measures

Biological and habitat parameters provide indicators of the biological, chemical, and physical integrity of Silver Bow Creek. Macroinvertebrate populations provide a means to evaluate the influence of several physiochemical and physical conditions including metals contamination, nutrients, siltation, and riparian condition. Similarly, periphyton associations provide information on the presence of toxic metals, nutrients, and siltation. The composition and abundance of fish populations allows inference on a number of instream conditions including toxic metals and habitat conditions. Finally, geomorphic and habitat parameters are direct measures of physical habitat allowing assessment of attainment of remediation and restoration goals.

9.1.5.1 Macroinvertebrates

Assessment of aquatic macroinvertebrates is a common method of evaluating biological integrity, water quality, and stream health. Macroinvertebrates have a number of advantages as biological indicators. Macroinvertebrates often have limited dispersal and comparatively short life cycles, attributes that make them potentially good indicators of localized and short-term environmental conditions (Barbour et al. 1999). In addition, macroinvertebrates respond more quickly than fish to some perturbations such as sedimentation (Berkman et al. 1986). Other advantages include the abundance, diversity, and relative ease of sampling macroinvertebrates. Moreover, their response to anthropogenic disturbances is relatively easily understood (Karr and Chu 1999). Finally, the State of Montana developed biocriteria for macroinvertebrate communities that provide a robust means of assessing biological integrity using these populations (Bollman 1998, Bukantis 1998).

A series of metrics contained in Tables 15, 16 and 17 provide the basis for evaluating attainment of remediation and restoration goals for macroinvertebrates in Silver Bow Creek. A metric is a quantitative measure of a biological attribute of the assemblage of concern. These metrics reflect community response to a range of both physical and chemical stressors. Criteria for successful remediation and restoration are consistent with macroinvertebrate biocriteria for full support of beneficial uses as developed by Bollman (1998) and Bukantis (1998). To meet the goal of remediation and restoration, macroinvertebrate communities in Silver Bow Creek must score within 75% of the total possible score in the 'Good' category for two consecutive years (Table 18)

Table 15. Macroinvertebrate Community Metrics used in Evaluating the Biological Integrity of Silver Bow Creek (modified from Barbour et al. 1999).

Metric	Definition	Description	Response to Environmental Stress
EPT richness	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).	Richness of these organisms reflects diversity of the benthic community. In addition, these tend to be relatively sensitive taxa that are intolerant of a number of stresses such as metals, siltation, and thermal alterations	Decrease
Number of sensitive taxa	Taxa richness of organisms considered to be sensitive to perturbations	Sensitive or intolerant taxa respond to a range of environmental stressors including metals, siltation, thermal alteration, and habitat degradation	Decrease
% Filterers	Percent of organisms that filter fine particulate organic matter from the water column.	Filterers are generalist feeders that consume a wide variety of food sources transported by flow. Preponderance of generalists suggests specialists, which are more sensitive, are limited by environmental stress. Their abundance can be indicative of presence high levels of organic material or nutrient enrichment.	Increase
% tolerant	Percent of organisms considered tolerant to a range of perturbations.	Proportion of tolerant organisms allows inference on overall stress to the aquatic community	Increase
Taxa richness	Number of distinct taxa	This is a measure of the diversity within the sample	Decrease
Hilsenhoff biotic index (HBI)	A weighted measure of percent of organism in the sample within 10 categories of tolerance to organic pollution	The HBI, or biotic index, allows inference on the influence of nutrients on stream health.	Increase
% dominant	Measure of the percent of the sample comprised of the most abundant taxon.	This is another measure of diversity within the sample. Polluted waters promote dominance by one or more tolerant taxon or taxa. Healthy streams have more balance among taxa present.	Increase
% collectors	Percent of sample comprised of organisms that gather fine particulate organic matter from streambed surfaces	These are generalist feeders consuming organic matter from a range of potential sources. Their relative abundance can reflect nutrient pollution, a lack of riparian vegetation to support leaf detritivores, and overall food web imbalance	Increase
% scrapers + shredders	Percent of organisms that graze periphyton (scrapers) or consume leaf litter or other coarse, particulate organic matter.	These groups are trophic specialists, as opposed to the generalists (gatherers and filterers). Usually, specialists are more sensitive to disturbance than generalists. Scrapers are sensitive to pollutants that promote soft-bodied algae over diatoms (nutrients) and siltation. Shredders have multiple sensitivities and require leaf litter contributed from surrounding riparian stands.	Decrease
% Hydropsychidae of Trichoptera	Percent of caddisflies comprised of the sub-family Hydropsychidae	These are pollution tolerant members of the caddisfly order and are indicative of increases in organic pollution or nutrient loading.	Increase

Table 16. Metrics and Scoring Criteria Developed for Western Montana Ecoregions[1] (Bollman 1998).

Metric	Biological Integrity/Score[1]			
	Excellent/3	**Good/2**	**Fair/1**	**Poor/0**
Ephemeroptera taxa richness	> 5	5 – 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 – 2	1	0
Trichoptera taxa richness	> 4	4 – 3	2	< 2
Sensitive taxa richness	> 3	3 – 2	1	0
Total Possible Score	18+	17	8	4
Percent filterers	0 – 5	5.01 – 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 – 10	10.01 – 35	> 35

[1]The overall score is based on percent of possible score of 18 (> 75% = full support, 25% to 75% = partial support, < 25% = nonsupport). Metals tolerance index is scored from 1 (severe impairment) to 5 (no impairment).

Table 17. Biocriteria Developed for Intermountain Valley and Foothills Streams (Bukantis 1998).

Metric	Biological Integrity/Score (see Table 15)			
	Excellent/3	**Good/2**	**Fair/1**	**Poor/0**
Taxa Richness	>28	28-21	21-14	<14
EPT Richness	>14	14-13	12-11	<11
Hilsenhoff Biotic Index	<4	4-5	5-6	>6
% Dominant	<30	30-40	40-50	>50
% collectors (gatherers+filterers)	<60	60-75	75-90	>90
% Scrapers + Shredders	>30	30-20	20-10	<10
% Hydropsychinae of Trichoptera	<75	75-85	85-95	>95
% EPT	>70	70-55	55-40	<40

Table 18. Water Quality Use Support/Standards Thresholds (Bukantis 1998).

Classification	Biological Integrity Score (% of Max)		
	>75	**75-25**	**<25**
Impairment	Slight	Moderate	Severe
Use-support	Full support	Partial support	Non-support

9.1.5.2 Periphyton

There are a number of advantages to using periphyton as biological indicators. These primary producers have short life cycles directly affected by physical and chemical factors; therefore, they are good indicators of short-term effects (Barbour et al. 1999). In addition, the response of these organisms to stressors present in Silver Bow Creek including nutrients and metals is well known.

MDEQ developed biocriteria for determining whether periphyton associations reflect the stated goal for periphyton community composition (Table 19). Both community based metrics and rankings of dominant soft-bodied algae provide the numeric endpoints for periphyton associations. To meet the remediation and restoration goal, the quantitative endpoint or target for diatoms is a score falling within ‘excellent’ or ‘good’ biological integrity for all metrics for two consecutive years.

In addition, *Cladophora* or other soft-bodied algal taxa often associated with sewage inputs can not rank as the dominant soft-bodied algae. This qualifier is important because taxa such as *Cladophora* are so efficient at taking up nutrients that even in highly eutrophic conditions, they may limit nutrients for the diatom community resulting in over-estimation of stream health as reflected by diatom associations. Assessments of periphyton associations on Silver Bow Creek in 2002 provide an example of this phenomenon where diatoms indicated only minor impairment from nutrient enrichment, while dense crops of *Cladophora* and aquatic macrophytes suggested severe impairment from nutrient loading (Confluence 2002a).

Additional metrics have been incorporated as refined indicators of various pollutant impacts on water quality as they have been developed and corroborated. These metrics include percent eutraphentic diatoms and the metals tolerance index. Both metrics have utility for Silver Bow Creek, which receives organic wastes and high levels of nitrogen and phosphorus from the Butte municipal wastewater treatment plant and the surrounding watershed. The metals tolerance index shows promise as an indicator of metals contamination in Silver Bow Creek (Table 20). Other metrics (Table 21) provide a supplemental means to evaluate water quality status of sites on Silver Bow Creek, and include measures of oxygen demand, nitrogen uptake, and saprobity (reliance on decaying organic matter).

Table 19. State of Montana Diatom Association Metrics.

These rate levels of biological integrity, environmental impairment or natural stress, and aquatic life support in wadable mountain streams of Montana (Bahls 1993). The lowest rating for any one metric is the overall rating for the entire study site.

Biological Integrity/ Impairment or Stress/ Use Support	No. of Species Counted[1]	Diversity Index[2] (Shannon)	Pollution Index[3]	Siltation Index[4]	Disturbance Index[5]	% Dominant Species[6]	% Abnormal Cells[7]	Similarity Index[8]
Excellent/None/ Full Support	>29	>2.99	>2.50	<20.0	<25.0	<25.0	0	>59.9
Good/Minor/ Full Support	20-29	2.00-2.99	2.01-2.50	20.0-39.9	25.0-49.9	25.0-49.9	>0.0, <3.0	40.0-59.9
Fair/Moderate/ Partial Support	19-10	1.00-1.99	1.50-2.00	40.0-59.9	50.0-74.9	50.0-74.9	3.0-9.9	20.0-39.9
Poor/Severe/Nonsupport	<10	<1.00	<1.50	>59.9	>74.9	>74.9	>9.9	<20.0
References	Bahls 1979 Bahls 1993	Bahls 1979	Bahls 1993	Bahls 1993	Barbour et al. 1999	Barbour et al. 1999	McFarland et al. 1997	Whittaker 1952
Range of Values	0-100+	0.00-5.00+	1.00-3.00	0.0-90.0+	0.0-100.0	~5.0-100.0	0.0-30.0+	0.0-100.0
Expected Response	**Decrease[9]**	**Decrease[9]**	**Decrease**	**Increase**	**Increase**	**Increase**	**Increase**	**Decrease**

[1]Based on a proportional count of 400 cells (800 valves).

[2]Base 2 [bits]

[3]Composite numeric expression of the pollution tolerances assigned to the common diatom species.

[4]Sum of the percent abundances of all species in the genera *Navicula*, *Nitzschia* and *Surirella.*

[5]Percent abundance of *Achnanthidium minutissimum* (synonym: *Achnanthes minutissima*).

[6]Percent abundance of the species with the largest number of cells in the proportional count.

[7]Cells with an irregular outline or with abnormal ornamentation, or both.

[8]Percent Community Similarity

[9]Species richness and diversity may increase somewhat in mountain streams in response to slight to moderate increases in nutrients or sediment.

Table 20. Metals Tolerant Species	
Species	**Synonyms**
Adlafia minuscula	*Navicula minuscula*
Encyonema minutum	*Cymbella minuta*
Encyonema silesiacum	*Cymbella silesiaca*
Fragilaria capucina	
Fragilaria vaucheriae	*Fragilaria capucina var. vaucheriae*
Gomphonema parvulum	
Mayamaea atomus[1]	*Navicula atomus*[1]
Navicula arvensis	
Navicula minima[1]	*Eolimna minima*[1]
Navicula permitis	*Mayamaea atomus var. permitis*
Navicula seminulum[1]	*Sellaphora seminulum*[1]
Nitzschia palea	
Planothidium dubium	*Achnanthes lanceolata var. dubia*
Planothidium lanceolatum	*Achnanthes lanceolata*
Surirella angusta	
Surirella minuta	*Surirella ovata*
Synedra rumpens	*Fragilaria capucina var. rumpens*
Synedra ulna	*Fragilaria ulna*

[1]All of these species appear to tolerate elevated concentrations of heavy metals.

Table 21. Miscellaneous Diatom Metrics that Provide Inference on Loading of Organic and Inorganic Nutrients	
Metric	**Description**
Low dissolved oxygen	Proportion of diatoms tolerant of low dissolved oxygen, which may reflect biochemical oxygen demand and hypereutrophic waters
Polysaprobous diatoms	Proportion of diatoms relying on decaying organic matter
% Rhopalodiales (formerly % Epithemiaceae	Proportion of diatoms of the family Rhopalodiales, which harbor nitrogen-fixing bacteria. An abundance suggests nitrogen is limiting.
Eutraphentic diatoms	Diatoms with a preference for nutrient-enriched, eutrophic waters; expect an increase in eutraphentic species with increasing nutrient and organic enrichment
Nitrogen heterotrophs	Proportion of species whose growth is enhanced by presence of complex, organic sources of nitrogen.

9.1.5.3 Fish

Fish are monitored in remediated reaches and a select area(s) in unremediated portions of Silver Bow Creek. Professional knowledge of distribution and abundance of fish in healthy Western Montana streams gives a general idea of what might be expected in Silver Bow Creek; however, due to the unique geology at the origin of Silver Bow Creek, establishing specific criteria for remediation success is not practical. In general, remediation is considered successful when surface water and instream sediment quality is sufficient to support fish. Restoration is considered successful when fish numbers and population structure indicate a self-sustaining fishery in the Silver Bow Creek watershed.

From the standpoint of fishery health, several indicators allow evaluation of the success of remediation and restoration activities on Silver Bow Creek. Species composition is a primary indicator. Based on professional knowledge of distribution and abundance of fish in unimpaired Western Montana streams prior to the advent of mining, Silver Bow Creek probably supported three species of salmonid (westslope cutthroat trout [*Oncorhynchus clarki lewisii*], mountain whitefish [*Prosopium williamsoni*], and bull trout [*Salvelinus confluentus*]), two species of sucker (largescale and longnose sucker [*Catostomus macrocheilus* and *C. catostomus*]), and one species of sculpin (slimy sculpin [*Cottus cognatus*]). Several members of the minnow family were likely present as well including peamouth (*Mylocheilus caurinus*), northern pikeminnow (*Ptychocheilus oregonensis*), longnose dace (*Rhinichthys cataractae*), and redside shiner (*Richardsonius balteatus*).

Another component of a healthy fishery is a diverse population structure, which indicates that conditions are suitable in the watershed for reproduction and maintenance of populations over the course of several years. To determine population structure, fish are sorted by species, counted, and their lengths measured. The length distribution of individuals within a fish species is the basis for population structure. While there can be extreme variation in population structure each year, over time there should be a stable relationship between numbers of juvenile and adult fish in a healthy population. There should also be a balance between the numbers of contaminant tolerant species such as suckers, and intolerant taxa such as salmonids. However, due to the variability observed even in healthy streams, establishing a specific target is not feasible.

Ultimately, the fish community in Silver Bow Creek should be trending toward a species composition and population structure similar to healthy streams in the region. However, no timeframe has been established for these objectives, because it is not known what can reasonably be expected in such a large-scale remediation and restoration effort. If improvement continues and trends become apparent, it may be possible to establish appropriate timeframes for the return of healthy fisheries to specific reaches of Silver Bow Creek.

9.1.5.4 Fish Habitat and Fluvial Geomorphology

Remediation of a Silver Bow Creek reach will be considered a success if, 10 years after construction, conditions in the reach fall within the target ranges set in Table 24. An exception is the criterion for woody debris, which will likely take much longer than 10 years to achieve.

Restoration of a Silver Bow Creek reach will be considered a success if post-construction geomorphology falls within the target ranges set in Table 24, the amount of cover provided by undercut banks and vegetation is moving towards the middle of the target ranges, and woody debris is increasing over time.

The ultimate goal of Silver Bow Creek remediation and restoration efforts is the improvement over time of conditions that support a self-sustaining trout fishery in the watershed. The propagation of salmonids is significantly influenced by substrate composition, which is another component of fluvial geomorphology. In order to provide spawning habitat, substrate particles must be small enough to be movable by female salmonids but not so small that they result in smothering or entombment of eggs or alevins. Salmonids can typically move particles up to 10% of their body length (Kondolf 2000); therefore, the median particle size distribution should lie within 10% of the lengths of spawning females. Assuming a population of female salmonids ranging from 8 to 15 inches (200 mm to 381 mm), median particle sizes in pool tails should range between 20 mm and 38 mm in diameter. However, the suitability historically of Silver Bow Creek for fish spawning is unknown. The granitic nature of the geology in the basin's headwaters contributes significant amounts of relatively fine material, especially sand, to Silver Bow Creek. In time, it is likely that recruitment of native materials will result in a streambed dominated by fine-grained materials. Presumably, most trout spawning will occur in tributaries of Silver Bow Creek where suitable-sized particles are more likely to exist.

9.2 Initial Monitoring Requirements

9.2.1 Sampling Protocols

Sampling of macroinvertebrates and periphyton follows standard procedures developed by MDEQ and the EPA. Macroinvertebrate samples are collected and processed using methods described by Bukantis (1996). Calculations follow biocriteria developed by Bollman (1998) and Bukantis (1998). Periphyton samples are collected, processed, and analyzed following procedures described by Bahls (1993). Fish sampling follows standard Fish, Wildlife and Parks monitoring practice. Physical habitat assessments follow methods developed by the EPA (Lazorchak et al. 2001).

9.2.2 Monitoring Schedule

Monitoring of macroinvertebrates and periphyton occurs annually during low water. When possible, this sampling should coincide with the instream sediment and surface water sampling. Fish sampling occurs annually in the fall near Rocker and Ramsey and in the spring and fall near German Gulch, generally during high and low water. Fish habitat and fluvial geomorphology is to be monitored at 5 and 10 years after construction is completed past the proposed sites.

9.2.3 Locations

Monitoring locations and sampling frequency for macroinvertebrates and periphyton are listed in Table 22, and for fish populations, habitat and fluvial geomorphology in Table 23. As discussed earlier, all locations correspond to previous CFRDMS (Clark Fork River Data Management System) sites with modifications to comply with the ROD. With the exception of SS-17, monitoring begun one year after remediation is completed downstream of the individual sites. New macroinvertebrate and periphyton sampling locations established in 2009 included SS-01 (Father Sheehan Park), SS-06A (Butte Reduction Works) and SS-14 (Ramsey Flats/Miles Crossing Area) . Aquatic biology monitoring sites for 2010 are illustrated in Figure 3.

Fish sampling occurs in 1000-foot sections along Silver Bow Creek, beginning at Rocker, Ramsey, and downstream of the confluence of German Gulch. Fish sampling at Father Sheehan Park and at Montana Street (Butte Reduction Works) was first conducted by Montana Fish, Wildlife & Parks in 2005. The sites were added to the formal monitoring in 2006. The section upstream of the Highway 1 crossing near Opportunity was added in 2008.

Table 22. Macroinvertebrate and Periphyton Monitoring Sites and Schedule, SST OU 2010

Site	1st quarter	2nd quarter	3rd quarter	4th quarter
SS-01 Father Sheehan Park			Low water (1)	
SS-06A Butte Reduction Works			Low water (1)	
SS-06G above Butte WWTP			Low water (1)	
SS-07 below Butte WWTP			Low water (1)	
SS-08 Rocker			Low water (1)	
SS-10A above Sand Creek			Low water (1)	
SS-10B below Sand Creek			Low water (1)	
SS-11C above Brown's Gulch			Low water (1)	
SS-11D below Browns Gulch			Low water (1)	
SS-14 Miles Crossing			Low water (1)	
SS-15G German Gulch			Low water (1)	
SS-15A above German Gulch			Low water (1)	
SS-15B below German Gulch			Low water (1)	
SS-17D below Stewart Street, Opportunity			Low water (1)	

(1) Low water may be 3rd or 4th quarter and must be coordinated with instream sediments and surface water monitoring.

Table 23. Aquatic Biologic Resources/Geomorphology Monitoring Parameters and Frequency, SST OU 2010

Location	Parameters	Frequency
SS-01, SS-06A, SS-06G, SS-07, SS-08, SS-10A, SS-10B, SS-11C, SS-11D, SS-14,, SS-15G SS-15A, SS-15B, SS-17D	Macroinvertebrates: ephemeroptera taxa, plecoptera taxa, trichoptera taxa, sensitive taxa	Annually, at low water
	Periphyton: diatom algae, soft-bodied algae	Annually, at low water
Father Sheehan Park, Montana Street, Rocker, Ramsey, Below German Gulch confluence, above Hwy. 1 near Opportunity	Fish: abundance, species composition, and population structure	Annually, at low water

9.2.4 Parameters and Methods

9.2.4.1 Macroinvertebrates

Macroinvertebrate samples are collected at the sites listed in Table 22. Macroinvertebrate samples are collected and processed using methods described by Bukantis (1996). Metric calculations follow biocriteria developed by Bollman (1998) and Bukantis (1998).

9.2.4.2 Periphyton

Periphyton samples are collected at the sites listed in Table 22. Periphyton samples are collected, processed, and analyzed following procedures described by Bahls (1993).

9.2.4.3 Fish

Fish population structure monitoring is conducted at the sites listed in Table 23, and includes counts (abundance) per species (species composition) and population structure of each species. Fish abundance is determined by using single-pass depletion estimate techniques. Multiple-pass depletion techniques were recommended once multiple size and age classes were identified. However, multiple size and age classes are only noticed in long-nosed suckers. At this point, multiple passes are not expected to yield enough data to justify the cost until trout species are seen surviving in Silver Bow Creek.

9.2.4.4 Fish Habitat and Fluvial Geomorphology

Channel cross-sections and streamflow will be measured relative to surveyed points on both banks coordinated with the fall surface water sampling in years 5 and 10 to document changes in channel configuration. Physical habitat assessments follow methods developed by the EPA (Lazorchak et al. 2001). The following fluvial geomorphology parameters will be monitored at Silver Bow Creek sites on required years:

1. Ten (10) sample cross sections, to be assessed for the following parameters, based on EMAP protocols:
    a. Average width to depth ratio,
    b. Average areal cover from overhanging banks,
    c. Average areal cover from overhanging vegetation,
    d. Average percent overstory canopy cover,
    e. Average percent cover provided by woody debris.
2. One (1) 1000-ft channel profile to assess
    a. Run/riffle/pool ratio,
    b. Gross sediment deposition pattern,
    c. Channel planform and gradient.
3. Two (2) stream flow measurements, one each at the most upstream and downstream cross sections,
4. Two (2) pebble counts on riffles to assess bed material gradation.

Fish habitat/fluvial geomorphology monitoring was conducted at SS-10 in 2009. No stations are scheduled for monitoring in 2010.

Using Environmental Monitoring and Assessment Program (EMAP) protocols developed by the EPA (Lazorchak et al., 1998), assessments of physical conditions in Divide Creek provide the basis for several target ranges in Silver Bow Creek (Table 24). Ranges were used because Silver Bow Creek is on average 62% wider than Divide Creek. Therefore, it is reasonable to expect variance between Divide Creek and Silver Bow Creek. Mid-range for these targets is what is inferred from Divide Creek.

Table 24. Criteria for Fish Habitat Features for Silver Bow Creek as Measured using EMAP Protocols

Habitat feature	Criteria – Average within Reach
Percent pools	20-50 %
Average width-to-depth ratio	8-14
Average areal cover from undercut banks	8-20%
Average areal cover from overhanging vegetation	15-35%
Average percent overstory canopy cover (measured at channel margins)	45-65%
Average percent cover provided by woody debris	15-35%

The size, extent, and pattern of native bed material are important considerations from both a geomorphic and fish habitat standpoint. Therefore, monitoring activities will include gradations of recruited bed material, depositional patterns, and the depth of deposition. Information collected on these parameters will be useful in evaluating channel evolution and fine tuning channel morphology requirements with regard to pattern, slope, and dimension to ensure appropriate patterns of sediment deposition and transport. However, there are no specific criteria associated with these parameters.

9.3 Monitoring Requirements as Goals Are Attained

Once monitoring goals are attained, monitoring will no longer be required as part of restoration and remediation activities. Note that as a 303(d) listed stream, MDEQ will continue to monitor Silver Bow Creek every 5 years through the TMDL program. These sampling efforts will likely focus on macroinvertebrate and periphyton community composition and habitat conditions. At this point, the number of sampling stations may be reduced for a focus on long-term monitoring as opposed to effectiveness monitoring to assess restoration and remediation activities. Monitoring frequency for fish populations may likewise be reduced following attainment of goals. The sampling schedule will be contingent on Montana Fish, Wildlife and Parks resource availability and workload.

9.4 Monitoring Flexibility

A number of potential modifications to the monitoring plan may be required in an adaptive management approach to evaluating the effect of restoration and remediation activities. For example, it may be valuable to reassess reference reaches in the event that biological indicators are not improving along with water or sediment chemistry measures. Evaluations in the nearby reference streams may help interpret the impacts of drought or other factors beyond control on biological communities. Similarly, monitoring results from other media may indicate that a change in sampling location or frequency is in order.

10.0 BIRD INVENTORY

10.1 Goal

10.1.1 Measures

In 2007, birds were first monitored in Reaches F, G, and H of Subarea 2 (SA 2), although Reach H was bare dirt in early spring, and Reach G's revegetation was just one year old. The objective was to document bird use including the annual dynamic as revegetation unfolds rather than waiting until the entire subarea is completely vegetated as was done in Subarea 1 (SA 1).

It had been hoped to add Reach I, and possibly J, in 2008. However, construction lagged and the stream channel hadn't been fully located, so the same 12 points in Reaches F, G, and H that were sampled in 2007 were again sampled in 2008.

In 2009, bird monitoring was conducted at 20 stations in Subarea 2.

10.2 Initial Monitoring Requirements

Bird monitoring records temporal changes in wildlife habitat as reflected by avian abundance and species composition at a constant set of sample points. Sample locations tend to center on Silver Bow Creek and constructed ponds both to capture waterfowl and due to increased visibility.

10.2.1 Sampling Protocols

Sampling occurs on a single date in late March, April, and May. Sampling takes less than four hours per session to complete. The sample form was modified (shortened) from a form used for the USDA Forest Service, Region 1. Even the truncated form provides more data than are typically summarized. Sample locations are plotted on the same maps as vegetation-sampling transects.

During the course of sampling, birds often can be seen and heard beyond the confines of remediated areas, but only birds within remediated area are recorded. Flyovers using the habitat were recorded, e.g., flushed waterfowl. Birds apparently merely crossing the area, e.g., crows and ravens drawn to the landfill north of Reach C, were not counted.

Sampling usually proceeds from upper to lower reaches. The order may be reversed for good reason. For example, cliff swallows are relatively late risers. When sampling Reach A after dawn, it became evident that the many swallows there weren't being sampled. Sampling from Reach E to Reach A remedied the undercount.

10.2.2 Monitoring Schedule

Ideally, monitoring begins for a set of reaches or phases soon after the stream is constructed and running, even if vegetation is barely present. Monitoring attempts to sample the early year when vegetation changes occur swiftly until an entire subarea can be sampled in a few hours according to protocol. Subsequently, vegetational changes occur more slowly and bird monitoring occurs every few years, but since data from a single year cannot be assumed to reflect "normal" conditions, it is likely that one subarea will be sampled each year.

10.2.3 Locations

For the 2010 field season, bird monitoring will take place in Subarea 1 (SA 1) and Subarea 4 from Fairmont Road to Crackerville Road (Reaches Q and R).

10.2.4 Parameters and Methods
The following guidelines indicate the sample protocol and proper entries for the form.

Be at the first sample point 15 minutes after sunrise. Don't sample the predawn chorus. Sampling must be completed by 11 a.m., preferably earlier. (Some birds, such as cliff swallows, become more active an hour or two after sunrise, which can greatly affect the number of birds counted per station.)

5.0 minutes of observation at each stop.

Don't sample in continuous rain (more than drizzle) or very strong winds.

Fill in all fields on the sample form.

Top of Form: SSTOU Subarea X (identified).

Observer: First, middle, last initials.

Date: March 18, 2005 = 03/18/05.

Stop: sample location number, 01 to 20.

Time: military hours and minutes, e.g., 0614.

Wind: Beaufort scale 0-5. 0 = calm. 1 = 1-3 mph, barely perceptible breeze. 2 = 4-7 mph, feel breeze on face, vegetation stirs. 3 = 8-12 mph, tall grasses & willows move constantly. 4 = 13-18 mph, dust, paper blow about. 5 = 19-24 mph, trees sway, a stiff wind.

Sky: 0-6. 0 = clear. 1 = <1/2 cloudy. 2 = mostly overcast. 3 = fog or smoke impairs visibility. 4 = light drizzle. 5 = constant snow. 6 = constant rain.

Temperature: estimate deg. F.

Noise: 0-4. 0 = not noticeable. 1 = noise not affecting ability to hear birds. 2 = may be affecting ability to hear birds. 3 = Noise reducing ability to hear birds. 4 = Hard to hear anything at all beyond background noise.

Cues: Aural: 0 = not by sound. S = by song. C = by call. D = by drum.
Visual: 0 = not identified by sight. V = identified by sight.

The following equipment is required for field work: sample forms, tatum, 2 pencils w/ erasers, stopwatch, regular watch, binoculars, 16" rubber boots to cross creek, map of sample locations. Range finder and bird identification book optional depending upon the skill of the observer. In evaluating habitat use, the number of cliff swallows entered is limited numerically to two per station. Otherwise, their abundance greatly skews results.

11.0 YEARLY REPORTING

Following the monitoring year, a report compiling data for each medium will be created. The report will record data collected over time, show trends within each medium, identify whether the medium is moving towards remediation and restoration goals, and draw correlations between media, where relationships exist. The next comprehensive monitoring report will be created from data collected under contract with MDEQ or NRDP, or in conjunction with Fish, Wildlife and Parks during 2009, and is expected in the spring of 2010.

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