Montana Department of Environmental Quality

Little Blackfoot River Watershed TMDLs and Framework Water Quality Improvement Plan – Metals Addendum

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ARM	Administrative Rules of Montana	16
BLM	Bureau of Land Management (Federal)	25
CWA	Clean Water Act	60
DEQ	Department of Environmental Quality (Montana)	1
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ICIS	Integrated Compliance Information System	13
LA	Load Allocation	22
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DOCUMENT SUMMARY

This addendum presents total maximum daily loads (TMDLs) for impaired streams in the Little Blackfoot watershed, including Dog Creek, Monarch Creek, Ontario Creek, Telegraph Creek, Un-named Creek and the Little Blackfoot River.

The Montana Department of Environmental Quality (DEQ) develops TMDLs and submits them to the U.S. Environmental Protection Agency (EPA) for approval. Both the Montana Water Quality Act and the Federal Clean Water Act require DEQ to develop TMDLs for streams and lakes that do not meet, or are not expected to meet, Montana water quality standards. A TMDL is the maximum amount of a pollutant a waterbody can receive and still meet water quality standards. TMDLs provide an approach to improve water quality so that streams and lakes can support and maintain their designated beneficial uses.

The Little Blackfoot watershed is located in the west-central Montana. The drainage area encompasses 413 square miles and includes the towns of Avon and Elliston. The majority of the watershed is within Powell County, with a small northern portion in Lewis and Clark County. All surface water flows into the Clark Fork River near Garrison, MT.

In 2011, EPA established TMDLs for multiple streams in Little Blackfoot watershed addressing 64 waterbody-pollutant combinations in the document titled *Little Blackfoot River Watershed TMDLs and Framework Water Quality Improvement Plan* (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). In 2013, after the document was finalized, DEQ completed a reassessment of existing metals data, which indicated that ten additional waterbody-pollutant combinations warranted listing on Montana’s 303(d) list. The purpose of this addendum is to complete TMDLs for these ten new listings. No new surface water monitoring was completed for this project. With the approval of this document, all currently identified impairments in the Little Blackfoot watershed will be addressed.

1.0 SUPPORTING INFORMATION

This addendum builds off information presented in the Little Blackfoot Watershed TMDL document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011) and therefore contains only the fundamental information necessary to understand the TMDL process. To learn more about the process in detail, please refer to the 2011 document. The addendum begins with a discussion on how metals affect beneficial uses and a general description of the applicable streams and pollutant sources. The next section describes water quality standards and how impairment determinations are made. This is followed by a section that explains how TMDLs are calculated and allocated, and continues on to sections devoted to identifying sources, evaluating data and establishing TMDLs for each stream segment individually. Finally, the addendum touches on a restoration strategy and provides a documentation of public comments and responses from DEQ.

1.1 EFFECTS OF METALS ON DESIGNATED BENEFICIAL USES

Metal concentrations exceeding aquatic life and/or human health criteria can impair support of numerous beneficial uses including: aquatic life, primary contact recreation, drinking water, and agriculture. Within aquatic ecosystems, metals can have a toxic, carcinogenic, or bioconcentrating effect on biota. Likewise, humans and wildlife can suffer acute and chronic effects from consuming water or fish with elevated metals concentrations. Because elevated metals concentrations can be toxic to plants and animals, high metals concentrations in irrigation or stock water may affect agricultural uses.

1.2 STREAM SEGMENTS OF CONCERN

Following DEQ's 2013 reassessment, nine waterbody segments in the Little Blackfoot watershed were newly identified as impaired by metals. All of these streams had TMDLs developed for other metals in 2011, but require additional TMDLs that are included in this addendum. **Table 1-1** indicates which TMDLs are established in this addendum and which have been established previously.

Table 1-1. TMDLs established within this addendum and the 2011 Little Blackfoot Watershed TMDL document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011)

Waterbody & Location Description	Waterbody ID	TMDLs Established in This Addendum	TMDLs Established in 2011 Little Blackfoot TMDL Document
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	Aluminum	Arsenic, Cadmium, Copper, Lead, Sediment, Zinc
DOG CREEK, Meadow Creek to mouth (Little Blackfoot River)	MT76G004_072	Aluminum	Copper, Lead, Sediment, Total Phosphorus
LITTLE BLACKFOOT RIVER, headwaters to Dog Creek	MT76G004_020	Aluminum	Arsenic, Cyanide, Cadmium, Copper, Lead, Sediment
LITTLE BLACKFOOT RIVER, Dog Creek to mouth (Clark Fork River)	MT76G004_010	Aluminum	Arsenic, Lead, Sediment, Total Phosphorus
MONARCH CREEK, headwaters to mouth (Ontario Creek)	MT76G004_060	Aluminum	Copper, Lead, Mercury, pH*
ONTARIO CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_130	Aluminum	Cadmium, Copper, Lead
		Zinc	

Table 1-1. TMDLs established within this addendum and the 2011 Little Blackfoot Watershed TMDL document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011)

Waterbody & Location Description	Waterbody ID	TMDLs Established in This Addendum	TMDLs Established in 2011 Little Blackfoot TMDL Document
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	Aluminum	Arsenic, Beryllium, Cadmium, Copper, Lead, Sediment, Zinc
TELEGRAPH CREEK, Hahn Creek to mouth (Little Blackfoot River)	MT76G004_052	Aluminum	Cadmium, Copper, Lead, Mercury, Zinc
UN-NAMED CREEK, headwaters to mouth (Ontario Creek)	MT76G006_010	Aluminum	Arsenic, Cadmium, Copper, Iron, Lead, Mercury, pH*, Zinc

*pH impairments were addressed through surrogate metals TMDLs

1.3 Sources of Metals

Metals sources may be both naturally occurring and anthropogenic (i.e., human-caused). TMDLs are developed for waterbodies that do not meet standards, at least in part, due to anthropogenic sources. Therefore identifying and characterizing the loading contribution from each source category is an important step in the TMDL process. Many trace metals occur naturally in the environment and their abundance is largely controlled by the weathering of geologic parent material. This is especially true for aluminum which is the second most abundant metallic element in the Earth's crust. Human activities can accelerate the process by exposing bedrock to surface weathering and mobilizing aluminum through increasing the acidity of soils and surface water (Driscoll and Postek, 1995). Mining is one such activity as it can leave waste rock and tailing piles on the landscape and release acidic water and material into the environment.

The Little Blackfoot watershed was mined extensively and as a result, abandoned mines are a significant source of metals pollution today. Much of the mining began in the 1860s with gold-bearing placers. Later, lode deposits of lead, zinc, gold, silver, and copper came into production and many sites established milling operations. The project area encompasses the Ophir, Elliston, Garrison and Emery Mining Districts. Mining was widespread but activity was most concentrated in the Elliston District, which is near the Little Blackfoot headwaters, with smaller clusters of mines in Carpenter and Dog Creek drainages. The Montana Bureau of Mines and Geology (MBMG) completed an environmental survey of 468 abandoned mine sites in the Helena National Forest in the 1990s (Hargrave et al., 1998). Twenty sites in the watershed were determined to have the potential to adversely affect soil or water on United States Forest Service (USFS) land. Around the same time, DEQ's Abandoned Mine Lands Program (AML) investigated mines on both private and public lands across the state in order to assess potential human health and environmental threats and to help prioritize site cleanup (Pioneer Technical Services, Inc., 1995)[1].Through this process, fifteen sites in the project area were listed as high priority abandoned mines. Some degree of reclamation work has taken place at six of these sites. There are no active mines in the watershed.

As of November 2013, there are three existing point sources in the Little Blackfoot watershed permitted through the Montana Pollutant Discharge Elimination System (MPDES). Two of these are general permits for construction stormwater discharges (MTR105127 and MTR104828) and according to EPA's

[1] Sites in Powell County through Yellowstone Counties

Integrated Compliance Information System (ICIS), construction activities were predicted to be complete at the time this addendum was written. Therefore they are not considered active point sources for purposes of this TMDL addendum nor is the nature of these activities a likely source of metal loading. The third permit is for a suction dredge operation (MTG370318) located in the headwaters region of Carpenter Creek, a tributary to the lower segment of the Little Blackfoot River. This general permit requires the operator to minimize harm caused by elevated suspended sediment concentrations by not disturbing streambanks, dredging only within the wetted channel, not driving wheeled equipment in the stream while dredging, and not dredging in areas where silt and clay are concentrated. Additionally, no visual increase in turbidity is allowed at the end of the mixing zone (i.e., 10 stream widths downstream), and the permittee must keep a daily log to demonstrate compliance with this condition. Furthermore, the operation can only be active from May 16th through August 31st to protect fish life stages during other times of the year. The permit does not include loading limits for metals. However, the suction dredging operation is not expected to contribute metals water quality exceedances to Carpenter Creek or the Little Blackfoot River based on the type of activity, requirements contained in the permit, and observed concentrations of metals in streambed sediments.

When possible, natural background loading is accounted for separately from human-caused sources. However, because mining has affected all of the streams that are listed for metals impairment to some extent, the natural background loading may not be expressed separately from other loading.
It is assumed that natural background concentrations alone do not exceed instream water quality standards. If future monitoring indicates otherwise, adaptive management will be required, including the possibility of revising allocations to natural background. A more detailed source assessment is provided for each stream segment later in this addendum.

1.4 Data and Information Sources

Metals concentrations in the water column and streambed sediments are the primary data used in this addendum; the majority of these data were collected by DEQ's Water Quality Planning Bureau in 2008 and 2009 for use in the 2011 Little Blackfoot Watershed TMDL document. That dataset supplemented information the Bureau collected at a much reduced number of sites in 2004 and 2005. Additionally, the United States Forest Service (USFS) established one site on Ontario Creek where zinc and dissolved aluminum samples were collected in 2008 and 2010. All data used for analysis throughout this addendum is provided in **Section 16**. That section contains data collected by DEQ's Abandoned Mine Lands Program (AML) and the United States Geological Survey (USGS). Metals data collected by these organizations were used to establish TMDLs in the 2011 Little Blackfoot Watershed TMDL document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011), but were not directly applicable to this addendum (i.e., stream segment not subject to this addendum or dissolved aluminum samples not collected).

In accordance with DEQ's data quality guidance, only data collected in the last 10 years are used for impairment assessment and target evaluation. Older data are considered descriptive and may be used for source characterization, loading analysis and trend evaluation. Where possible, data were refined to information collected after abandoned mine reclamation activities were complete in order to characterize existing conditions. However, because cleanup work at the Bald Butte Mine was just recently finalized in 2012, the only monitoring data available on Dog Creek was collected prior to reclamation. An adaptive management approach is recommended for Dog Creek if future monitoring indicates conditions have changed as a result of the Bald Butte cleanup and impairment determinations require revisions. Data for all other stream segments can be reasonably assumed to represent existing conditions.

2.0 Water Quality Standards and Impairment Determinations

Water quality standards provide the means to determine whether or not a waterbody is impaired. Standards include three main parts: stream classifications and designated beneficial uses, water quality criteria, and nondegradation provisions. Streams are classified based on their beneficial uses. All stream segments assessed as part of this project are classified by the state of Montana as B-1, which specifies that the water must be maintained suitable to support drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; the growth and propagation of salmonids fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply. Water quality must still be maintained suitable for all designated beneficial uses whether or not the waterbody is currently being used for that particular beneficial use. All waterbodies not fully supporting a designated beneficial use due to a pollutant are considered impaired and require a TMDL. A more detailed description of Montana's surface water classifications is provided in Montana Administrative Rules ARM 17.30.623.

The second component of water quality standards is water quality criteria, which describe conditions necessary to protect designated uses. Criteria can be numeric and expressed as a pollutant specific maximum concentration, level or magnitude for a specified frequency and recurrence interval; or they can be narrative descriptions of allowable or desired conditions. The third aspect of water quality standards, nondegradation, is not applicable to the TMDLs developed within this addendum because the streams presented herein are already considered impaired. A more detailed description of Montana's water quality standards may be found in the Montana Water Quality Act (75-5-301,302 MCA) and Circular DEQ-7 (Montana Department of Environmental Quality, 2012).

The process used to determine which waterbodies require TMDLs follows two steps:

1. Identify targets
   TMDLs must include targets that represent a condition that meets Montana's ambient water quality standards. All metals in this addendum have established numeric water quality criteria. These numeric water quality criteria are used directly as the primary TMDL targets and are presented in more detail below.

2. Determine Impairment
   DEQ compares recent monitoring data to water quality targets to determine whether a waterbody is impaired by a pollutant and thus requires a TMDL. In cases where one or more targets are not met, a TMDL is developed. If data demonstrate that a previously identified impairment is no longer verified, the waterbody-pollutant combination is recommended for removal from the 303(d) list. The impairment determination process is presented below in further detail.

2.1 Metals Targets

Targets for metals-related impairments in the Little Blackfoot watershed include both water column targets and streambed sediment targets. The water column targets are based on numeric human health criteria and aquatic life criteria as defined in DEQ Circular DEQ-7 (Montana Department of Environmental Quality, 2012). Sediment chemistry targets are adopted from numeric screening values for metals in freshwater sediment established by the National Oceanographic and Atmospheric Administration (NOAA) (Buchman, 2008).

Water Chemistry Targets

All metals pollutants applicable to the project have numeric water quality criteria defined in Circular DEQ-7 (Montana Department of Environmental Quality, 2012). These criteria include values for protecting both human health and aquatic life. Aquatic life criteria are split into acute and chronic categories. Chronic criteria prevent long-term, low level exposure to pollutants while acute criteria protect against short-term exposure. Acute and chronic aquatic life criteria are intended to protect aquatic life beneficial uses; human health criteria are intended to protect drinking water beneficial uses. For any given pollutant, the most stringent of these criteria is adopted as the water quality target in order to protect all beneficial uses.

The aquatic life criteria for zinc are dependent upon water hardness: the criteria increase (i.e., becomes less stringent) as the hardness increases. Aquatic life criteria for aluminum are not hardness dependent. Water quality criteria for aluminum and zinc at water hardness values of 25 mg/L and 400 mg/L are shown in **Table 2-1**. The targets are expressed in micrograms per liter, equivalent to parts per billion. Note that the chronic and acute aquatic life criteria for zinc are equivalent and no human health criterion has been developed for aluminum.

Table 2-1. Numeric water quality targets for metals

Metal of Concern	Aquatic Life Criteria (µg/L) at 25 mg/L Hardness		Aquatic Life Criteria (µg/L) at 400 mg/L Hardness		Human Health Criteria
	Acute	Chronic	Acute	Chronic	
Aluminum, dissolved	750	87	750	87	-
Zinc, total recoverable	37.02	37.02	387.83	387.83	2,000

Montana's numeric aluminum criteria only apply within a pH range of 6.5-9 standard units. Many aluminum samples used in this TMDL analysis were collected from acidic waters below pH 6.5. While this precludes use of the numeric criteria, general prohibitions within Montana's narrative standards still apply. Specifically, Administrative Rules of Montana (ARM) 17.30.637 states that "…waters must be free from substances…that will: create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life…"

Published literature confirms that aluminum is lethal to fish when pH is less than 6.5 (Baker and Schofield, 1982; Buckler et al., 1987; Cleveland et al., 1986; Hunn et al., 1987). Many studies have also shown increased aluminum toxicity as acidity increases (Baker and Schofield, 1982; Buckler et al., 1987). Increased toxicity at low pH is common for all metals, not just aluminum. However, pH is particularly important with aluminum due to the increase in bioavailability that results from pH-induced changes in aluminum speciation (Buckler et al., 1987). Often the end result is a coagulation of aluminum hydroxides on gill surfaces leading to death of the individual fish (Cleveland et al., 1986).

Given the documented toxic effects in low pH situations, the chronic aquatic life criterion (87 µg/L) will be applied as the aluminum threshold for impairment determinations regardless of pH. In other words, the narrative statement contained in ARM 17.60.637 is translated to 87 µg/L. EPA has approved aluminum TMDLs in the past which have followed a similar rationale (Montana Department of Environmental Quality, 2011). Due to the extent of historic mining in the study area, there is a high degree of confidence that the low pH values and high aluminum concentrations can be attributed to a common cause: acid mine drainage. Thus these aluminum issues are human-caused impairments that must be addressed through TMDL development opposed to a natural phenomenon.

Sediment Chemistry Targets

While Montana does not currently have numeric criteria for metals in stream sediment, the same general water quality prohibitions mentioned above apply to streams sediments. Once again, ARM 17.30.637 states "…waters must be free from substances…that will: create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life…" Stream sediment metal concentrations must not be toxic and the concentrations of these sediments can be used as supplemental indicators of waterbody impairment. In addition to directly impairing aquatic life in contact with stream sediments, high metals in sediment commonly correspond to elevated concentrations of metals in the water column during high flow conditions when the sediment is re-suspended. Where instream water quality data exceed water quality targets, sediment data provide supporting information, but are not necessary to verify impairment.

In the absence of numeric criteria for metals in stream sediment, DEQ bases sediment quality targets on values established by the National Oceanic and Atmospheric Administration (NOAA). NOAA has developed concentration guidelines for metals in freshwater sediments. These criteria come from numerous toxicity studies and investigations, and are expressed in Probable Effects Levels (PELs). PELs represent the sediment concentration above which toxic effects to aquatic life frequently occur, and are calculated as the geometric mean of the 50th percentile concentration of the toxic effects dataset and the 85th percentile of the no-effect dataset (Buchman, 2008). **Table 2-2** contains the PEL value for zinc. The PEL value is expressed in milligrams per kilogram, equivalent to parts per million. Aluminum does not have an established PEL value.

Table 2-2. Secondary targets for metals in stream sediments

Metal of Concern	PEL (mg/kg)
Aluminum	NA
Zinc	315

The zinc PEL value is used as a supplemental target to evaluate whether streams are meeting Montana's narrative criteria outlined in ARM 17.30.637. If water quality targets are met but sediment concentrations are more than double the PEL (100% exceedance magnitude), the sediment data can be used as an indication of a metals water quality problem. While a TMDL is typically not developed based solely on sediment metals data, it can help identify where additional sampling may be necessary to fully evaluate target compliance.

2.2 Impairment Determination

The evaluation process used to determine the impairment status of each stream is derived from DEQ's guidance for metals assessment methods (Drygas, 2012). A waterbody is considered impaired by a pollutant if at least one of the following scenarios is met:

- A single sample exceeds the human health target
- A single sample exceeds the acute aquatic life target by a factor of two or more
- More than 10% of the samples exceed the chronic or acute aquatic life target

Eight independent samples are regarded as the minimum dataset, although either of the first two bullets can be met with less than eight samples. Additionally for the third bullet, a waterbody may be deemed impaired if the dataset has fewer than eight samples but contains at least two aquatic life exceedances. For a pollutant currently listed as impaired with a dataset not falling into any of the three scenarios listed above but having fewer than eight samples, the status will remain impaired because the dataset is insufficient to prove water quality standards are met. All other scenarios result in a non-impaired status determination. Following these steps, DEQ determined ten pollutants on nine stream segments in the watershed are impaired and require TMDLs. Impairment determination summaries for these nine impaired stream segments are documented individually in this addendum starting with **Table 4-1**.

3.0 Calculating TMDLs and Allocations

Total maximum daily loads are provided in this addendum for all waterbody-pollutant combinations indicated in **Table 1-1**.

3.1 Calculating TMDLs

TMDLs are based on the most stringent water quality target, the water hardness (applicable only to zinc), and streamflow. Using the most stringent target ensures the TMDLs are protective of all designated beneficial uses. These TMDLs apply to any point along the waterbody and therefore protect beneficial uses along the entire stream. Because streamflow and hardness vary seasonally, TMDLs within this addendum are not expressed as a static value, but as an equation of the appropriate target multiplied by flow using the following formula:

Equation 1:
TMDL = (X) (Y) (k)

TMDL = Total Maximum Daily Load in lbs/day
X = lowest applicable metals water quality target in µg/L
Y = streamflow in cubic feet per second (cfs)
k = conversion factor of 0.0054

Example TMDLs are developed for high and low flow conditions in order to address seasonality. Seasonality is important because metals loading pathways and water hardness change as flow conditions change. During high flows, loading associated with overland flow and erosion of metals-contaminated sediment and mine wastes tend to be the major cause of elevated metal concentrations. Contributions switch during low flow, as groundwater transport and adit discharges often become the largest source of metals pollution. Hardness tends to be lower during high flow conditions, which leads to more stringent water quality standards for hardness-dependent metals during the runoff season.

Table 3-1 provides example TMDLs and the total load reductions necessary to meet each TMDL. Example TMDLs are calculated by replacing the “X” and “Y” variables in **Equation 1** with the measured flow and appropriate target value based upon water hardness also measured in the field. The field data used to calculate example TMDLs correspond to the monitoring site and date that had the most metals target exceedances, in accordance with the procedure followed for the 2011 TMDLs. Existing loads are calculated using the same flow values but changing the “X” variable to the observed metal concentration at the same site, which was not always the highest aluminum or zinc concentration on record. Existing loads are shown in the stream segment-specific sections below. The required percent reduction in total loading is calculated by subtracting the TMDL from the existing load, and dividing the difference by the existing load. In cases where streams appear to be meeting the TMDL for a certain time period based on the current dataset, the percent reduction is reported as 0%.

Table 3-1. Inputs for example TMDLs in the Little Blackfoot watershed

Stream Segment	Station	Discharge (cfs)		Hardness (mg/L)		Metal	Target Conc. (µg/L)		TMDL (lbs/day)		% Total Reduction	
		High Flow	Low Flow	High Flow	Low Flow		High Flow	Low Flow	High Flow	Low Flow	High Flow	Low Flow
DOG CREEK, upper segment	NA*	26.65	1.80	99	156.5	Aluminum	87	87	12.520	0.846	38%	0%
DOG CREEK, lower segment	DOG-8	247.60	12.17	49	134	Aluminum	87	87	116.323	5.718	33%	0%
LITTLE BLACKFOOT RIVER, upper segment	LBF-5	908.13	35.90	33	65	Aluminum	87	87	426.640	16.866	3%	0%
LITTLE BLACKFOOT RIVER, lower segment	LBF-10	1555.50	58.20	67	138	Aluminum	87	87	730.774	27.342	21%	0%
MONARCH CREEK	MCH-2	13.79	1.49	9	15	Aluminum	87	87	6.479	0.700	33%	0%
ONTARIO CREEK	ONT-2	238.09	5.39	9	15	Aluminum	87	87	111.855	2.532	33%	0%
						Zinc	37.02	37.02	47.5896	1.078	0%	72%
TELEGRAPH CREEK, upper segment	TGH-3A	90.16	1.91	13	38	Aluminum	87	87	42.357	0.897	49%	0%
TELEGRAPH CREEK, lower segment	TGH-4	93.38	4.36	16	42	Aluminum	87	87	43.926	2.048	46%	0%
UN-NAMED CREEK	ONT-1	NA	0.07	NA	43	Aluminum	NA	87	NA	0.033	NA	76%

*TMDL calculated for hypothetical monitoring station below the confluence of Dog Creek and American Gulch Creek as explained in **Section 4.3**

3.2 Calculating Allocations

Once a TMDL is calculated, the total load must be allocated to all contributing sources. A TMDL is generally broken into one or more wasteload allocations (WLA), load allocations (LA), and a margin of safety (MOS). WLAs are allowable pollutant loads that are assigned to permitted and non-permitted point sources. Mining-related waste sources (e.g., adit discharges, tailings accumulations, and waste rock deposits) are considered non-permitted point sources subject to WLAs. LAs are allowable pollutant loads assigned to nonpoint sources and may include the pollutant load from naturally occurring sources, as well as human-caused nonpoint loading. TMDLs must also take into account uncertainties inherent to environmental analyses such as these in a margin of safety. These elements are combined in the following equation:

Equation 2:

TMDL = ∑WLA + ∑LA + MOS

WLA = Wasteload allocation or the portion of the TMDL allocated to point sources

LA = Load allocation or the portion of the TMDL allocated to nonpoint sources and naturally occurring background

MOS = Margin of safety or an accounting of uncertainty about the relationship between metals loads and receiving water quality

Many metals sources in this addendum are given a composite wasteload allocation due to uncertainties involved with allocating loads to specific mines and data lacking from reference sites not impacted by mining which would allow for natural background loads to be identified separately. In these cases, future targeted monitoring could help refine composite WLAs. Adaptive management policies and conceptual implementation strategies for TMDLs developed within this addendum follow those contained in 2011 Little Blackfoot Watershed TMDL document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). An implicit margin of safety (i.e., MOS = 0) is applied to all TMDLs in this addendum through use of conservative assumptions throughout the TMDL development process as summarized below:

- Although a 10% exceedance rate is allowed for chronic and acute aquatic life targets, the TMDLs are set so the lowest applicable target is satisfied 100% of the time. This focuses remediation and restoration efforts toward 100% compliance with all targets, thereby providing a margin of safety for the majority of conditions where the most protective (lowest) target value is linked to the numeric aquatic life criteria.
- The monitoring results used to estimate existing water quality conditions and daily loads are instantaneous measurements, whereas chronic aquatic life criteria are based on average conditions over a 96-hour period. This provides a margin of safety since a four-day loading limit could potentially allow higher daily loads in practice.
- The lowest, most stringent numeric water quality criterion is used as the TMDL target in impairment determinations for all waterbody-pollutant combinations. This ensures protection of all designated beneficial uses.
- Sediment metals concentration criteria were used as a supplemental indicator target. This helps ensure that episodic loading events were not missed as part of the sampling and assessment activity.
- The TMDLs are based on numeric water quality criteria developed at the national level via EPA and incorporate a margin of safety necessary for the protection of human health and aquatic life.

- Target attainment, allocations refinement, impairment determinations and TMDL-development decisions are all based on an adaptive management approach that relies on future monitoring and assessment for updating planning and implementation efforts.

As an example, the steps taken to establish the high flow aluminum TMDL and allocation scheme on Monarch Creek is provided below.

Establish example TMDL (see Equation 1)
(87 µg/L) x (13.79 cfs) x (0.0054) = 6.479 lbs/day

Calculate existing load
(130 µg/L) x (13.79 cfs) x (0.0054) = 9.680 lbs/day

Calculate total percent reduction required to meet TMDL
(9.680 lbs/day – 6.479 lbs/day) ÷ 9.680 lbs/day = 0.33 = 33%

Allocate TMDL to sources (see Equation 2)
$LA_{NatBack}$ = (70 µg/L) x (13.79 cfs) x (0.0054) = 5.213 lbs/day
WLA_{Mines} = TMDL - $LA_{NatBack}$ = 6.479 lbs/day – 5.213 lbs/day = 1.266 lbs/day

The following nine sections are organized alphabetically by waterbody and provide a stream segment-specific description of metals sources, target evaluations, TMDL calculations and allocations.

4.0 Dog Creek, Upper Segment (MT76G004_071)

Dog Creek, from the headwaters to Meadow Creek (4.3 miles), previously had TMDLs developed for arsenic, cadmium, copper, lead, sediment and zinc (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). DEQ reassessed the waterbody in 2013 and added aluminum to the list of pollutants impairing aquatic life beneficial uses. This addendum addresses the aluminum impairment by establishing an aluminum TMDL for Dog Creek's upper segment.

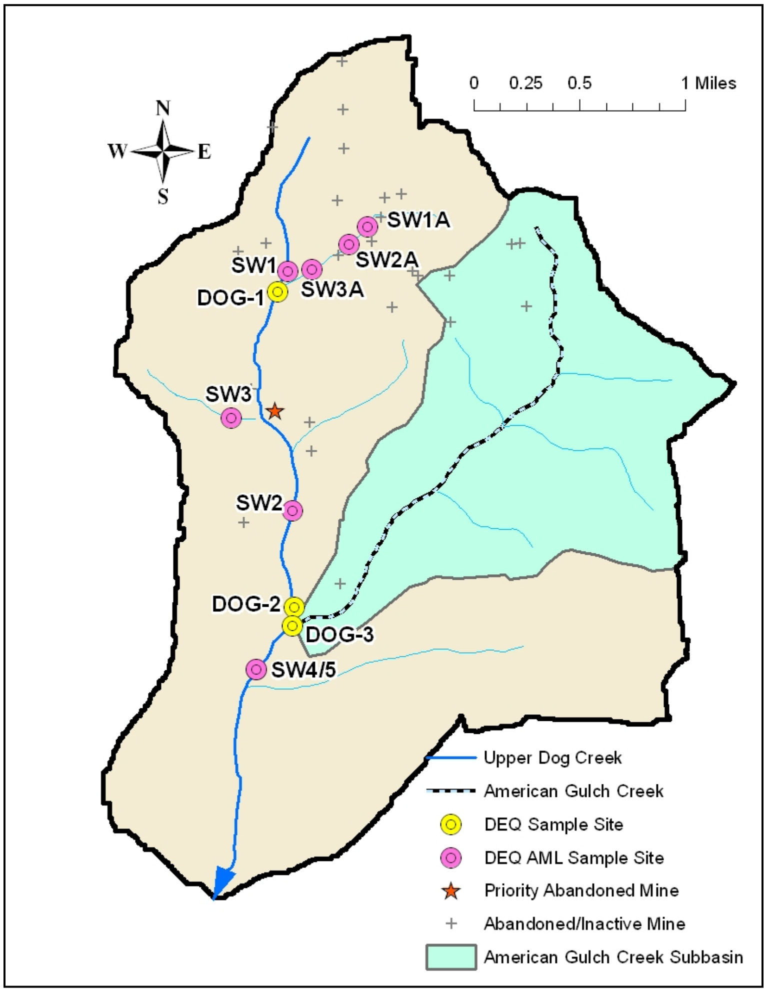

Figure 4-1. Upper Dog Creek Monitoring Sites

4.1 Sources of Aluminum

According to DEQ and MBMG databases the upper Dog Creek basin contains approximately 25 abandoned mines. These same records indicate at least seven mines (Bald Butte, Black Hawk Janette, Black Douglas, Kenawa, Larson, Rose Bud, and Rose Densmore) have waste rock piles or flooded mine shafts potentially impacting water quality. One site, the Bald Butte Mine and Millsite, is identified by the state as a high priority abandoned mine. In 2012, DEQ's Abandoned Mine Lands Program (AML) concluded a three year reclamation project that removed mine wastes from the Dog Creek floodplain originating primarily from the Bald Butte Mine and Millsite, reconstructed nearly a mile of stream channel, closed six hazardous mine openings, and revegetated 55 acres of disturbed area (Montana Department of Environmental Quality, Abandoned Mine Lands Bureau and U.S. Department of the Interior, Bureau of Land Management, 2013). Return visits the following summer indicated the new stream channel was performing properly and the riparian willow plantings had a high survival rate (Williams, David, personal communication 2013). Mine waste from Bald Butte was combined with contaminated material from three other mines in the vicinity (Devon/Sterling, Albion and Great Divide) for a total of 250,000 cubic yards of material. This material was placed in a secure repository constructed with an impervious liner and leachate collection/evaporation ponds on Bureau of Land Management (BLM) property in the headwaters of Dog Creek (Olympus Technical Services, Inc., 2004; Koerth, John, personal communication 2013). The repository experienced a large rainstorm event in June 2013 before seeded vegetation could adequately establish which lead to erosion issues. These erosion failures were corrected using heavy machinery in October 2013 (Williams, David, personal communication 2013). While the Bald Butte reclamation work addressed four mines, numerous other abandoned mines in the area are known to discharge metal-laden water into nearby streams either directly or through groundwater flow and need to be addressed to improve water quality in Dog Creek (Pioneer Technical Services, Inc., 1995; Hargrave et al., 1998). There are no permitted point sources in the basin. A more comprehensive description of abandoned mines found in this watershed is located in **Appendix F** of the 2011 Little Blackfoot Watershed TMDL Document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

4.2 Existing Data and Comparison to Water Quality Targets

The current aluminum dataset consists of eight samples collected at two sites by DEQ's Water Quality Protection Bureau in 2008 and 2009 (see **Figure 4-1**). A third site, DOG-3, appears in the figure to be located on Dog Creek but is actually on American Gulch Creek. DEQ's AML Program collected numerous surface water and sediment samples throughout the basin in 2003 to categorize conditions before reclamation work began at the Bald Butte Mine however the samples were not analyzed for dissolved aluminum. Three of the eight aluminum samples exceeded the chronic aquatic life target indicating the waterbody is impaired. Exceedances occurred at both sites but only during high flow conditions. The greatest aluminum concentration observed in Dog Creek was 170 µg/L, or nearly twice the 87 µg/L target. **Table 4-1** compares existing aluminum data to the targets described in **Section 2.1**. Note that all Dog Creek data used in this addendum were collected before the start of reclamation work at the Bald Butte Mine. Existing water quality conditions may have changed from what is presented in this document as a result. If that is the case, an adaptive management approach is recommended for listing determinations and required load reductions.

Table 4-1. Upper Dog Creek data summary and target exceedances

Parameter	Aluminum
Number of samples	8
Date of samples	2008-2009
% of samples considered high flow	50%
Chronic AL criteria exceedance rate > 10%?	Yes
> 2x acute AL criteria exceeded?	No
Human health criteria exceeded?	NA
NOAA PEL exceeded?	NA
Human caused sources present?	Yes
Impairment Determination	Impaired

4.3 Upper Dog Creek TMDLs

Previously established TMDLs for metals on upper Dog Creek were broken into a wasteload allocation to mining sources in the upper Dog Creek watershed (**WLA_{UpDog}**), a composite wasteload allocation for the contribution from American Gulch Creek's mining and naturally occurring sources (**$WLA_{American}$**), and a load allocation to natural background sources in the upper Dog Creek watershed (**LA_{Nat}**) excluding the background load already factored into **$WLA_{American}$**, as expressed by the following formula:

$TMDL_{UpDog} = WLA_{UpDog} + WLA_{American} + LA_{Nat}$

A different allocation scheme was chosen for aluminum because aluminum samples exceeded targets at the Hope Creek site (DOG-5) used to estimate naturally occurring metal concentrations for the 2011 TMDLs. Therefore due to uncertainties in defining background concentrations of aluminum, the aluminum TMDL in this addendum is presented as a composite wasteload allocation to all sources both naturally occurring and mining-related, as expressed by the following formula:

$TMDL_{UpDog} = WLA_{Composite}$

There is no monitoring site in the upper Dog Creek watershed below the confluence of American Gulch Creek, a tributary that doubles the discharge of Dog Creek. There is a monitoring site on Dog Creek (DOG-2) and one on American Gulch Creek (DOG-3) just upstream of their confluence. Flow and hardness values measured at these sites were combined to estimate conditions in Dog Creek below the confluence. For example, during high flow conditions on May 22, 2009 at Dog Creek site DOG-2, the flow was 13.28 cfs and water hardness was 99 mg/L. That same day at American Gulch Creek site DOG-3 the flow was 13.37 cfs and the water hardness was 99 mg/L. The flows from these sites were summed (13.28 + 13.37 = 26.65 cfs) and the hardness values were averaged ([99 + 99] / 2 = 99 mg/L) for use in calculating loads as shown in **Table 3-1**. The same process was followed to estimate low flow conditions below the confluence of American Gulch Creek. Existing loads were calculated using aluminum concentrations observed at the DOG-2 site on May 28, 2008 and July 24, 2008 and the calculated flows previously described. **Table 4-2** provides example TMDLs, allocations and necessary percent reductions; however because TMDLs are flow dependent, actual TMDLs will not always match **Table 4-2**.

Table 4-2. Upper Dog Creek example aluminum TMDLs and allocations

Flow	$TMDL_{UpDog}$	$WLA_{Composite}$	Existing Load	% Reduction
High flow	12.520	12.520	20.147	38%
Low flow	0.846	0.846	0.146	0%

All units are lbs/day

The current dataset suggests that the aluminum TMDL is met during low flow conditions but that a 38% reduction in aluminum loading is required during high flow time periods. However because existing loads were calculated using data from before reclamation work at the Bald Butte Mine, the reductions required might be less than what is present here. **Table 3-1** lists the inputs used to calculate upper Dog Creek's example TMDLs.

5.0 Dog Creek, Lower Segment (MT76G004_072)

Dog Creek, from Meadow Creek to the mouth at the Little Blackfoot River (13.6 miles), previously had TMDLs developed for copper, lead, sediment and total phosphorus (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). DEQ reassessed the waterbody in 2013 and added aluminum to the list of pollutants impairing aquatic life beneficial uses. This addendum addresses the aluminum impairment by establishing an aluminum TMDL for Dog Creek's lower segment.

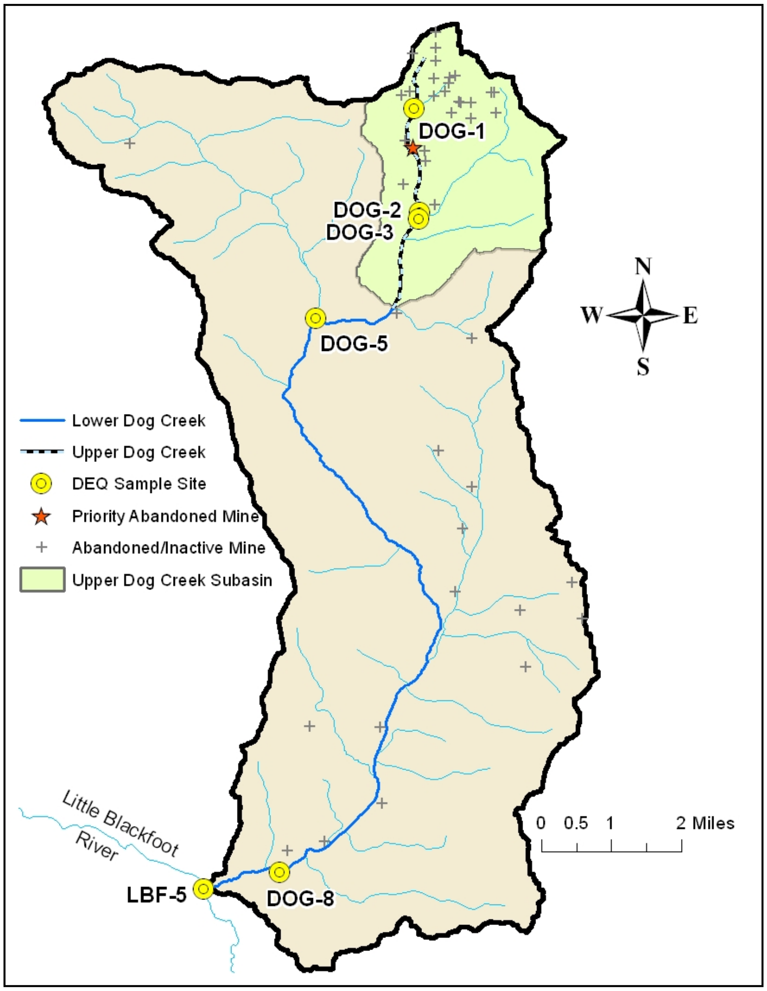

Figure 5-1. Lower Dog Creek Monitoring Sites

5.1 Sources of Aluminum

According to DEQ and MBMG databases the Dog Creek basin contains approximately 40 abandoned mines, 25 of which are located in the upper Dog Creek basin. The 15 mines restricted to the lower Dog Creek basin lack detailed descriptions in abandoned mine databases besides listing copper, gold and silver as the type of commodity produced (Hargrave et al., 1998). Investigations by MBMG and DEQ's AML Program failed to visit mines in the lower Dog Creek drainage. The Bald Butte Mine, discussed in the **Section 4.0**, is the only mine in the greater Dog Creek watershed listed by the state as a high priority abandoned mine. It's also the only mine in the Dog Creek watershed to be reclaimed. Like the upper basin, there are no point sources in the lower Dog Creek basin. A more comprehensive description of abandoned mines found in this watershed is located in **Appendix F** of the 2011 Little Blackfoot Watershed TMDL Document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

5.2 Existing Data and Comparison to Water Quality Targets

The current aluminum dataset consists of four samples collected at one site by DEQ's Water Quality Protection Bureau in 2008 and 2009 (see **Figure 5-1**). A second site, DOG-5, appears in the figure to be located on Dog Creek but is actually on Hope Creek. Two of the four aluminum samples exceeded the chronic aquatic life target indicating the waterbody is impaired. Both of these samples were collected during high flow conditions. The highest measured concentration, 340 µg/L, is nearly four times the chronic aquatic life target. Aluminum loads at DOG-8 were always greater than loads seen on the upper Dog Creek segment. Synoptic sampling also revealed concentrations were always equal to or greater than what was measure on the upper section. This indicates a source of aluminum exists within the lower section's drainage. **Table 5-1** compares existing aluminum data to the targets described in **Section 2.1**.

Table 5-1. Lower Dog Creek data summary and target exceedances

Parameter	Aluminum
Number of samples	4
Date of samples	2008-2009
% of samples considered high flow	50%
Chronic AL criteria exceedance rate > 10%?	Yes
> 2x acute AL criteria exceeded?	No
Human health criteria exceeded?	NA
NOAA PEL exceeded?	NA
Human caused sources present?	Yes
Impairment Determination	Impaired

5.3 Lower Dog Creek TMDLs

Previously established TMDLs for metals on lower Dog Creek were broken into a wasteload allocation to mining sources in the lower Dog Creek watershed ($\mathbf{WLA}_{LwrDog}$), a composite wasteload allocation for the contribution from upper Dog Creek's mining and naturally occurring sources ($\mathbf{WLA}_{UpDog}$), and a load allocation to natural background sources in the lower Dog Creek watershed ($\mathbf{LA}_{Nat}$) excluding the background load already factored into $\mathbf{WLA}_{UpDog}$, as expressed by the following formula:

$$TMDL_{LwrDog} = WLA_{LwrDog} + WLA_{UpDog} + LA_{Nat}$$

A different allocation scheme was chosen for aluminum because aluminum samples exceeded targets at the Hope Creek site (DOG-5) used to estimate naturally occurring metal concentrations for the 2011 TMDLs. Therefore, due to uncertainties in defining background concentrations of aluminum, the aluminum TMDL in this addendum is presented as a composite wasteload allocation to all sources both naturally occurring and mining-related, as expressed by the following formula:

$$TMDL_{LwrDog} = WLA_{Composite}$$

TMDLs were calculated using the appropriate target concentration and the streamflow values observed at site DOG-8 in May and August 2009. Existing loads were calculated using the same inputs as the TMDLs but using aluminum concentrations observed at DOG-8 in May and August 2009 instead of the target concentrations. **Table 5-2** provides example TMDLs, allocations and necessary percent reductions; however because TMDLs are flow dependent, actual TMDLs will not always match **Table 5-2**.

Table 5-2. Lower Dog Creek example aluminum TMDLs and allocations

Metal	Flow	$TMDL_{LwrDog}$	$WLA_{Composite}$	Existing Load	% Reduction
Aluminum	High flow	116.323	116.323	173.815	33%
	Low flow	5.718	5.718	1.972	0%

All units are lbs/day

The current dataset suggests that the aluminum TMDL is met during low flow conditions but that a 33% reduction in loading is required during high flow time periods. **Table 3-1** lists the inputs used to calculate lower Dog Creek's example TMDLs.

6.0 Little Blackfoot River, Upper Segment (MT76G004_020)

The Little Blackfoot River, from the headwaters to Dog Creek (22.5 miles), previously had TMDLs developed for arsenic, cyanide, cadmium, copper, lead, and sediment (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). DEQ reassessed the waterbody in 2013 and added aluminum to the list of pollutants impairing aquatic life beneficial uses. This addendum addresses the aluminum impairment by establishing an aluminum TMDL for the Little Blackfoot River's upper segment.

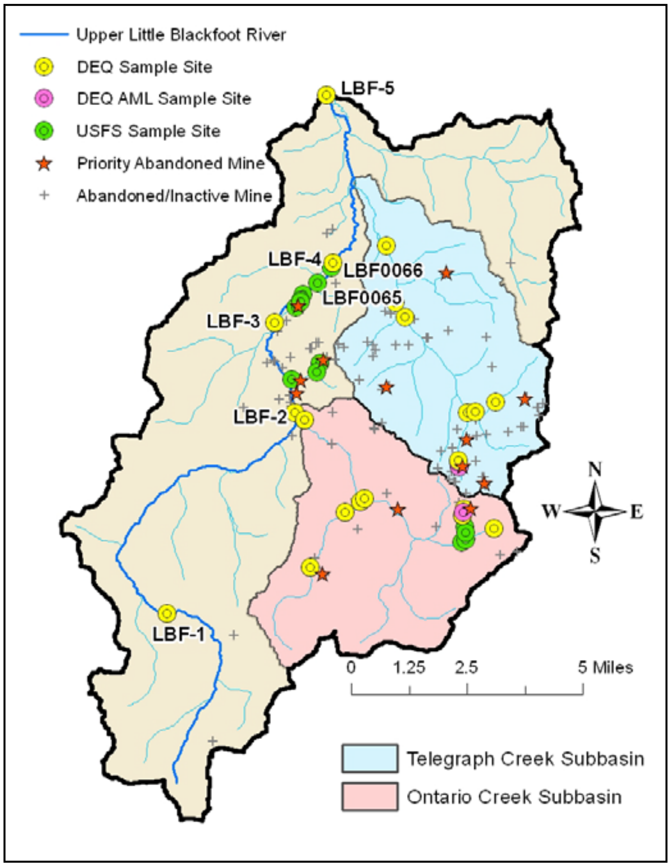

Figure 6-1. Upper Little Blackfoot River Monitoring Sites

6.1 Sources of Aluminum

According to DEQ and MBMG databases the upper Little Blackfoot River basin contains an estimated 110 abandoned mines, approximately 70 of which are located in the tributary basins of Ontario and Telegraph Creek. Metals sources in these basins will be discussed separately in **Sections 9.1** and **11.1** to follow. Excluding the Ontario and Telegraph Creek watersheds, four sites are identified by the state as high priority abandoned mines: Charter Oak, Kimball, Mountain View, and Golden Anchor Mine. The Charter Oak Mine was reclaimed by the USFS in the late 1990s and is now listed on the National Register of Historic Places and open for interpretative tours. In 2009 and 2010, the USFS collected surface water, groundwater, and adit samples near the Charter Oak Mine. Samples collected from the Little Blackfoot River at that time were not analyzed for aluminum however the highest groundwater measurement of dissolved aluminum was 193,000 µg/L and a beaver pond adjacent the river measured 4,110 µg/L total aluminum. These elevated results suggest that the Charter Oak Mine continues to introduce aluminum into the Little Blackfoot River.

The other three high priority abandoned mines, the Kimball, Mountain View, and Golden Anchor, have mine wastes documented near surface waters. In November 2008, the formerly plugged Golden Anchor Mine adit blew-out sending a large volume of orange-colored water into Tramway Creek, a tributary to the Little Blackfoot River (Byron, 12/4/2008). For three months following the blow-out, the USFS collected water quality data and witnessed total aluminum concentrations in Tramway Creek reach 1,000 µg/L however all dissolved aluminum samples were below the 30 µg/L detection limit. No fish-kills were attributed to the incident (Byron, 1/17/2009). A review of abandoned mine records housed at DEQ identified five additional mines in the upper Little Blackfoot basin with discharging adits (Negroes, NE NW Section 12, SE NW Section 12, SW NE Section 12, and SW SE Section 1). There are no permitted point sources in the basin. A more comprehensive description of abandoned mines found in this watershed is located in **Appendix F** of the 2011 Little Blackfoot Watershed TMDL Document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

6.2 Existing Data and Comparison to Water Quality Targets

The current aluminum dataset consists of 18 samples collected at five sites by DEQ's Water Quality Protection Bureau in 2008 and 2009 (see **Figure 6-1**). Note data collected by the USFS immediately following the Golden Anchor Mine blowout were not used for TMDL calculations because monitoring results indicated the effects to water quality were short-lived and the blowout timeframe is not representative of current conditions. Six of the eighteen aluminum samples exceeded the chronic aquatic life target indicating the waterbody is impaired. One of these exceedances had pH concentrations of less than 6.5, however as discussed previously in the metals target section (**Section 2.1**) it was still included in the assessment based on an interpretation of the narrative standard. All samples with exceedances were collected during high flow conditions and exceedances were observed at every site. The highest measured concentration was 150 µg/L. Synoptic sampling revealed that aluminum concentrations always increased between sites LBF-2 and LBF-3, always decreased or remained constant between LBF-3 and LBF-4, and then always increased again or remained constant between LBF-4 and LBF-5. Comparing results from LBF-3 to LBF-4 indicates that mines in the Ontario Creek basin and those surrounding the Little Blackfoot River like the Kimball, Golden Anchor and Mountain View mines would be effective areas to concentrate reclamation efforts. Similarly, mines in the Telegraph Creek basin are largely responsible for the pattern observed in monitoring data between sites LBF-4 and LBF-5 and this source area also needs to be addressed. **Table 6-1** compares existing aluminum data to the targets described in **Section 2.1**.

Table 6-1. Upper Little Blackfoot River data summary and target exceedances

Parameter	Aluminum
Number of samples	18
Date of samples	2008-2009
% of samples considered high flow	50%
Chronic AL criteria exceedance rate > 10%?	Yes
> 2x acute AL criteria exceeded?	No
Human health criteria exceeded?	NA
NOAA PEL exceeded?	NA
Human caused sources present?	Yes
Impairment Determination	Impaired

6.3 UPPER LITTLE BLACKFOOT RIVER TMDLS

Previously established TMDLs for metals on the Little Blackfoot River's upper segment were broken into composite wasteload allocations representing the contribution from mining and naturally occurring sources in the Ontario Creek ($\mathbf{WLA}_{Ontario}$) and Telegraph Creek ($\mathbf{WLA}_{Tele}$) watersheds, a wasteload allocation to mining sources in the upper Little Blackfoot watershed ($\mathbf{WLA}_{UpLBF}$), and a load allocation to natural background sources in the upper Little Blackfoot watershed ($\mathbf{LA}_{Nat}$) excluding the background load already factored into $\mathbf{WLA}_{Ontario}$ and $\mathbf{WLA}_{Tele}$, as expressed by the following formula:

$$TMDL_{UpLBF} = WLA_{Ontario} + WLA_{Tele} + WLA_{UpLBF} + LA_{Nat}$$

A different allocation scheme was chosen for aluminum because aluminum samples exceeded targets at the Little Blackfoot River site (LBF-1) used to estimate naturally occurring metal concentrations for the 2011 TMDLs. Therefore, due to uncertainties in defining background concentrations, the aluminum TMDL in this addendum is presented as a composite wasteload allocation to all sources both naturally occurring and mining-related, as expressed by the following formula:

$$TMDL_{UpLBF} = WLA_{Composite}$$

TMDLs were calculated using the appropriate target concentration and the streamflow values observed at site LBF-5 in May and August 2009. Existing loads were calculated using the same inputs as the TMDLs but using aluminum concentrations observed at LBF-5 in May and August 2009 instead of the target concentrations. **Table 6-2** provides example TMDLs, allocations, and necessary percent reductions; however because TMDLs are flow dependent, actual TMDLs will not always match **Table 6-2**.

Table 6-2. Upper Little Blackfoot River example aluminum TMDLs and allocations

Metal	Flow	$TMDL_{UpLBF}$	$WLA_{Composite}$	Existing Load	% Reduction
Aluminum	High flow	426.640	426.640	441.351	3%
	Low flow	16.866	16.866	5.816	0%

All units are lbs/day

The current dataset suggests that the aluminum TMDL is met during low flow conditions but that a slight reduction in loading (3%) is required during high flow time periods. However, a larger high flow percent reduction may be required. For example, if the aluminum concentration from LBF-3 observed in May 2008 (150 µg/L) were used to estimate the existing load instead of using LBF-5 to maintain consistency with the 2011 TMDLs, a 42% reduction would be estimated instead of 3%. **Table 3-1** lists the inputs used to calculate the Little Blackfoot River's upper segment example TMDLs.

7.0 Little Blackfoot River, Lower Segment (MT76G004_010)

The Little Blackfoot River, from Dog Creek to the mouth at the Clark Fork River (26.5 miles), previously had TMDLs developed for arsenic, lead, sediment, and total phosphorus (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). DEQ reassessed the waterbody in 2013 and added aluminum to the list of pollutants impairing aquatic life beneficial uses. This addendum addresses the aluminum impairment by establishing an aluminum TMDL for the Little Blackfoot River's lower segment.

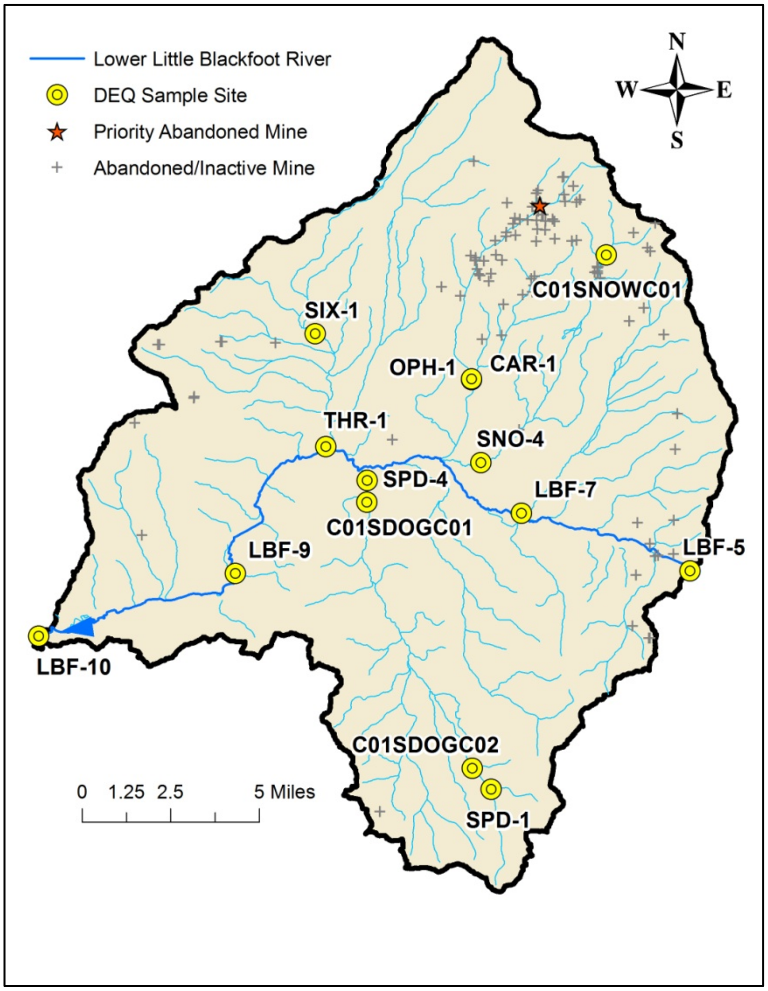

Figure 7-1. Lower Little Blackfoot River Monitoring Sites

7.1 Sources of Aluminum

According to DEQ and MBMG databases lower Little Blackfoot River basin contains an estimated 100 abandoned mines. This number does not include the additional 110 mines located in the upper basin potentially influencing the water quality of the lower segment. A description of metal sources for the Little Blackfoot River's upper segment is provided in **Section 6.1**. One site within the lower basin, the Victory/Evening Star Mine, is identified by the state as a high priority abandoned mine. Like most mining in the lower Little Blackfoot River basin, the Victory/Evening Star Mine is located in the Ophir Creek drainage. When MBMG visited the mine site in 1995 there were tailings in the Ophir Creek floodplain but they did not appear to be actively eroding (Hargrave et al., 1998). A review of abandoned mine land records housed at DEQ identified nine additional non-priority mines (Blue Speckled Adit, Cow Spring Cabin, Esmeralda Hill, Gimlet, NE NE Section 19, NE NW Section 29, Ophir Cabin, SE NW Section 20, and Upsetti) in the basin with waste rock piles or standing water in mine shafts with the potential to impact water quality in the Little Blackfoot River. A more comprehensive description of abandoned mines found in this watershed is located in **Appendix F** of the 2011 Little Blackfoot Watershed TMDL Document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

As of November 2013, there was one active MPDES permit in the lower Little Blackfoot basin for a suction dredge operation (MTG370318) located in the headwaters region of Carpenter Creek. The general permit requires the operator to minimize harm caused by elevated suspended sediment concentrations and can only be active from May 16th through August 31st to protect fish life stages during other times of the year. The general permit does not include loading limits for metals. Although there is no PEL established for aluminum, DEQ sampled streambed sediments in Carpenter Creek in 2008 and found all other metal concentrations to be below targets (see data tables in **Section 16.0**). The suction dredging operation is not expected to contribute to aluminum water quality exceedances in the Little Blackfoot River based on the type of activity, requirements contained in the permit that limit suspended sediment, and observed concentrations of metals in streambed sediments.

7.2 Existing Data and Comparison to Water Quality Targets

The current aluminum dataset consists of 12 samples collected at three sites by DEQ's Water Quality Protection Bureau in 2008 and 2009 (see **Figure 7-1**). LBF-5 is included in **Figure 7-1** to show its relative location however the site is located on the upper segment of the river. The USFS and USGS have established other sites on the Little Blackfoot River to sample surface water but their analyses did not include dissolved aluminum so the results cannot be compared to TMDL targets. Three of the twelve aluminum samples exceeded the chronic aquatic life target indicating the waterbody is impaired. The highest measured concentration was 170 µg/L. Exceedances occurred at all three sites during high flow conditions in 2008. No exceedances occurred during spring runoff the following year or during low flow time periods. **Table 7-1** compares existing aluminum data to the targets described in **Section 2.1**.

Table 7-1. Lower Little Blackfoot River data summary and target exceedances

Parameter	Aluminum
Number of samples	12
Date of samples	2008-2009
% of samples considered high flow	50%
Chronic AL criteria exceedance rate > 10%?	Yes
> 2x acute AL criteria exceeded?	No
Human health criteria exceeded?	No
NOAA PEL exceeded?	NA
Human caused sources present?	Yes
Impairment Determination	Impaired

7.3 Lower Little Blackfoot River TMDLs

Previously established TMDLs for metals on the Little Blackfoot River's lower segment were broken into a wasteload allocation representing the total contribution from the upper segment of the Little Blackfoot River (**WLA_{UpLBF}**), another addressing the suction dredge permit on Carpenter Creek (**$WLA_{Suction}$**), and a third wasteload allocation for abandoned mines within the lower watershed (**WLA_{LwLBF}**). Additionally, a load allocation to natural background sources (**LA_{Nat}**) was isolated to represent the nonpoint source load contributed within the lower Little Blackfoot watershed. These four TMDL components came together in the following formula:

$$TMDL_{LwrLBF} = WLA_{UpLBF} + WLA_{Suction} + WLA_{LwrLBF} + LA_{Nat}$$

The same allocation scheme was chosen for aluminum. Metals concentrations from SPD-1, at site on the tributary stream Spotted Dog Creek and located upstream of mining activity, were used to calculate the natural background load allocation (**LA_{Nat}**). TMDLs were calculated using the appropriate target concentration and the streamflow values observed at site LBF-10 in May and September 2009. Existing loads were calculated using the same inputs as the TMDLs but using aluminum concentrations observed at LBF-10 in May and July 2008 instead of the target concentrations. If the suction dredge operation adheres to the requirements of its general permit, no aluminum loading is expected to occur and the source is assigned a load of zero in this addendum. The **WLA_{UpLBF}** is equivalent to the TMDL calculated for the Little Blackfoot River's upper segment in **Section 6.3** and the **WLA_{LwrLBF}** is identified as the difference between the TMDL and the other three allocations. **Table 7-2** provides example TMDLs, allocations and necessary percent reductions; however because TMDLs are flow dependent, actual TMDLs will not always match **Table 7-2**.

Table 7-2. Lower Little Blackfoot River example aluminum TMDLs and allocations

Metal	Flow	$TMDL_{LwrLBF}$	WLA_{UpLBF}	$WLA_{Suction}$	WLA_{LwrLBF}	LA_{Nat}	Existing Load	% Reduction
Aluminum	High flow	730.774	426.640	0.0	24.470	279.664	923.967	21%
	Low flow	27.342	16.866	0.0	6.864	3.613	9.428	0%

All units are lbs/day

The current dataset suggests that the aluminum TMDL is met during low flow conditions but that a 21% reduction in loading is required during high flow time periods. **Table 3-1** lists the inputs used to calculate the Little Blackfoot River's lower segment example TMDLs.

8.0 Monarch Creek (MT76G004_060)

Monarch Creek, from the headwaters to the mouth at Ontario Creek (4.7 miles), previously had TMDLs developed for copper, lead, mercury, and pH (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). DEQ reassessed the waterbody in 2013 and added aluminum to the list of pollutants impairing aquatic life beneficial uses. This addendum addresses the aluminum impairment by establishing an aluminum TMDL for Monarch Creek.

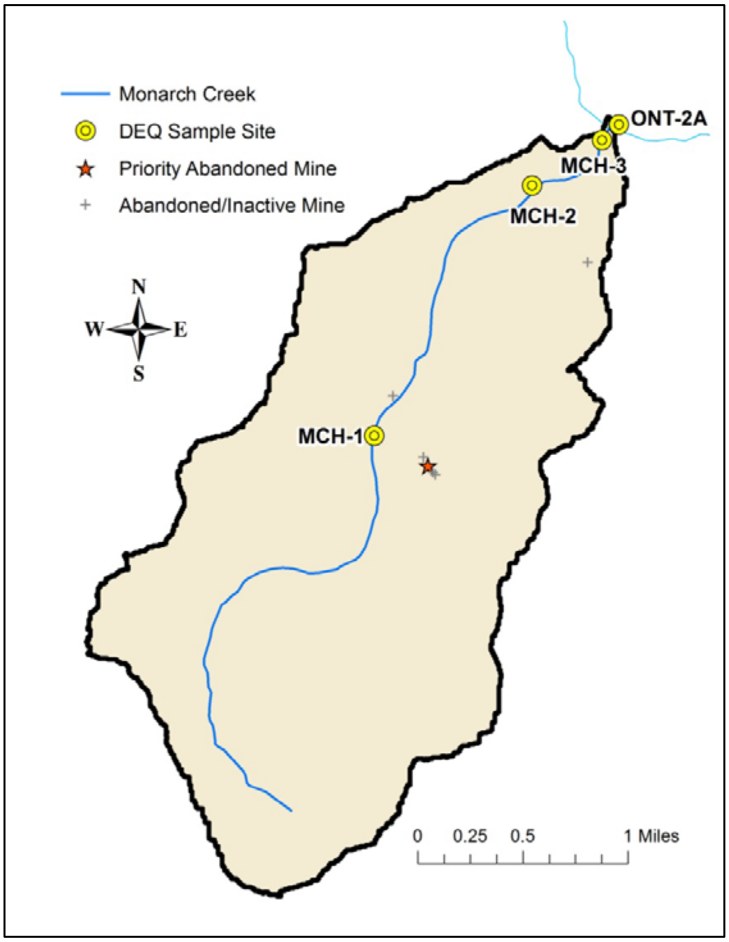

Figure 8-1. Monarch Creek Monitoring Sites

8.1 Sources of Aluminum

The Monarch Creek basin contains a handful of prospect mines but only one abandoned hardrock mine according to DEQ and MBMG databases. The Monarch Mine is identified by the state as a high priority abandoned mine. The mine was most active at the turn of the 20th century although sporadic mining activity occurred as recently 1995 (Hargrave et al., 1998). The Monarch Mine is the most probable source of metals impairment in Monarch Creek as the mine site consists of discharging adits, tailing piles in the floodplain, and ferric-hydroxide-stained pools between the mill and creek (Hargrave et al., 1998). There are no permitted point sources in the basin. A more comprehensive description of the Monarch Mine is located in **Appendix F** of the 2011 Little Blackfoot Watershed TMDL document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

8.2 Existing Data and Comparison to Water Quality Targets

The current aluminum dataset contains seven samples collected at three sites by DEQ's Water Quality Protection Bureau in 2008 and 2009 (see **Figure 8-1**). DEQ collected an additional sample in 2004 but the detection limit used to analyze the sample was insufficient to compare against targets and thus could not be included in this assessment. Of the seven acceptable samples, two exceeded the chronic aquatic life criteria target but had pH concentrations less than 6.5. As discussed previously in the metals target section (**Section 2.1**), based on an interpretation of the narrative standard the assessment concludes aluminum is impairing aquatic life beneficial uses in Monarch Creek. Exceedances occurred at the two sites lowest in the basin and both occurred during high flow conditions. The highest measured concentration was 130 µg/L. **Table 8-1** compares existing aluminum data to the targets described in **Section 2.1**.

Table 8-1. Monarch Creek data summary and target exceedances

Parameter	Aluminum
Number of samples	7
Date of samples	2004-2009
% of samples considered high flow	43%
Chronic AL criteria exceedance rate > 10%?	Yes
> 2x acute AL criteria exceeded?	No
Human health criteria exceeded?	NA
NOAA PEL exceeded?	NA
Human caused sources present?	Yes
Impairment Determination	Impaired

8.3 Monarch Creek TMDLs

Previously established TMDLs for metals on Monarch Creek were broken into a wasteload allocation to the Monarch Mine (**$WLA_{Monarch}$**) and a load allocation to natural background sources in the Monarch Creek watershed (**LA_{Nat}**) as expressed by the following formula:

$$TMDL_{Monarch} = WLA_{Monarch} + LA_{Nat}$$

The same allocation scheme was chosen for aluminum. Metals concentrations found at MCH-1, a site located upstream of mining activity, were used to calculate the natural background load allocation (**LA_{Nat}**). TMDLs were calculated using the appropriate target concentration and the streamflow values observed at site MCH-2 in May and July 2008. Existing loads were calculated using the same inputs as the TMDLs but using aluminum concentrations observed at MCH-2 in May and July 2008 instead of the target concentrations. **Table 8-2** provides example TMDLs, allocations, and necessary percent reductions; however because TMDLs are flow dependent, actual TMDLs will not always match **Table 8-2**.

Table 8-2. Monarch Creek example aluminum TMDLs and allocations

Metal	Flow	$TMDL_{Monarch}$	$WLA_{Monarch}$	LA_{Nat}	Existing Load	% Reduction
Aluminum	High flow	6.479	1.266	5.213	9.681	33%
	Low flow	0.700	0.459	0.241	0.322	0%

All units are lbs/day

The current dataset suggests that the aluminum TMDL is met during low flow conditions but that a 33% reduction in aluminum loading is required during high flow time periods. **Table 3-1** lists the inputs used to calculate Monarch Creek's example TMDL.

9.0 Ontario Creek (MT76G004_130)

Ontario Creek, from the headwaters to the mouth at the Little Blackfoot River (6.4 miles), previously had TMDLs developed for cadmium, copper, and lead (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). DEQ reassessed the waterbody in 2013 and added aluminum and zinc to the list of pollutants impairing aquatic life beneficial uses. This addendum addresses the new impairments by establishing an aluminum and zinc TMDL for Ontario Creek.

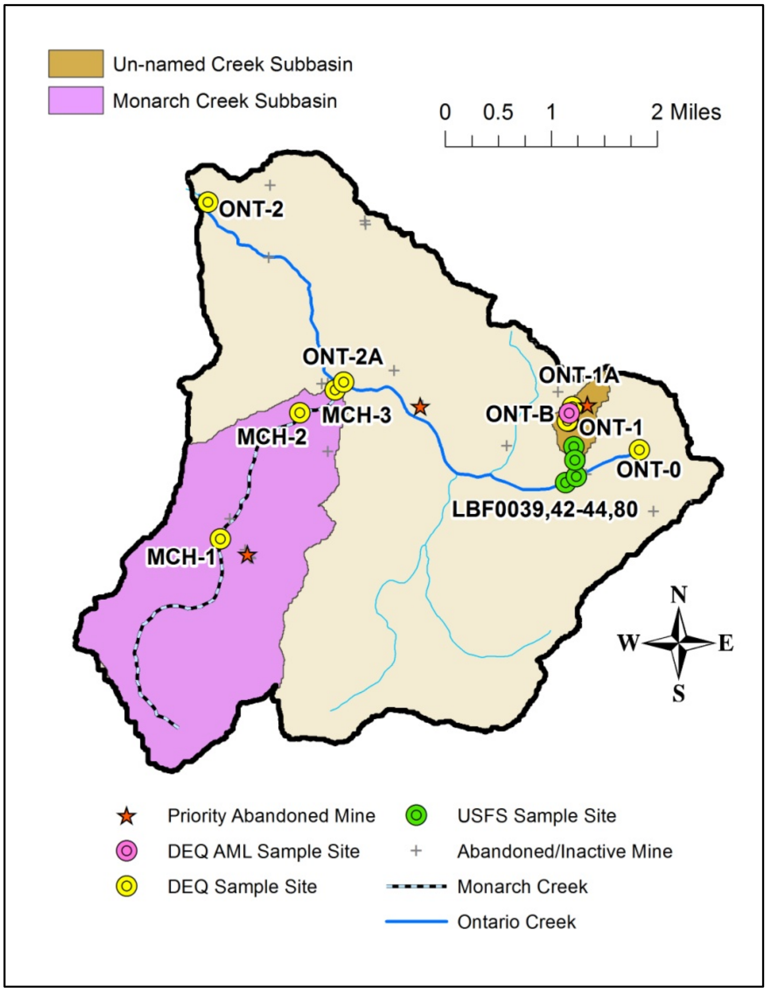

Figure 9-1. Ontario Creek Monitoring Sites

9.1 Sources of Aluminum and Zinc

According to DEQ and MBMG databases the Ontario Creek basin contains approximately 20 abandoned mines including three that the state has identified as high priority abandoned mines: the Hard Luck, Monarch, and Ontario mines. Descriptions of metal sources for two tributary basins, Monarch Creek and Un-named Creek, are provided in **Sections 8.1** and **12.1**. There you will find information on the Monarch and Ontario mines. An additional metals source to Ontario Creek outside these basins is the Hard Luck

Mine. This priority abandoned mine is located within 1,000 feet of Ontario Creek and is comprised of three waste rock piles and two discharging adits (Pioneer Technical Services, Inc., 1995)[2]. When visited in 1993, the adit discharge was being piped around the waste rock dump but no surface water samples were collected. A review of abandoned mine land records housed at DEQ identified three additional non-priority mines (SW NW Section 20, SW NW Section 26 and West Ontario) where water had been observed flowing out of mine adits. There are no permitted point sources in the basin. A more comprehensive description of abandoned mines found in this watershed is located in **Appendix F** of the 2011 Little Blackfoot Watershed TMDL Document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

9.2 Existing Data and Comparison to Water Quality Targets

The current surface water dataset consists of eight aluminum samples and nine zinc samples. The majority of these samples were collected by DEQ's Water Quality Protection Bureau in 2008 and 2009 from three sites (see **Figure 9-1**). DEQ also analyzed streambed sediments for metals at each of their established sites for three total sediment samples. Most recently, the USFS collected surface water data at one site in 2008 and 2010.

Of the eight aluminum samples, four exceeded the chronic aquatic life criteria target but had pH concentrations less than 6.5. As discussed previously in the metals target section (**Section 2.1**), based on an interpretation of the narrative standard the assessment concludes aluminum is impairing aquatic life beneficial uses in Ontario Creek. Every high flow aluminum sample exceeded the chronic aquatic life target, as well as one low flow aluminum sample collected in October. A similar impairment determination is concluded for zinc, after two of nine samples exceeded the chronic aquatic life target and were more than twice the acute aquatic life target. Additionally, streambed sediment samples exceeded the supplementary PEL target. The only site that exceeded zinc surface water targets was the USFS site LBF0044, located some 600 feet downstream of the Un-named Creek confluence. Other sites as far downstream as ONT-2 exceed sediment targets but not surface water targets. **Table 9-1** compares existing aluminum and zinc data to the targets described in **Section 2.1**.

Table 9-1. Ontario Creek data summary and target exceedances

Parameter	Aluminum	Zinc
Number of samples	8	9
Date of samples	2008-2009	2008-2010
% of samples considered high flow	38%	22%
Chronic AL criteria exceedance rate > 10%?	Yes	Yes
> 2x acute AL criteria exceeded?	No	Yes
Human health criteria exceeded?	NA	No
NOAA PEL exceeded?	NA	Yes
Human caused sources present?	Yes	Yes
Impairment Determination	Impaired	Impaired

9.3 Ontario Creek TMDLs

Previously established TMDLs for metals on Ontario Creek were broken into composite wasteload allocations representing the contribution from sources in the Un-named Creek ($\mathbf{WLA}_{\text{Un-named}}$) and

[2] Sites in Powell County through Yellowstone Counties

Monarch Creek watersheds (**WLA**$_{Monarch}$). A third wasteload allocation was assigned to abandoned mines in the Ontario Creek watershed (**WLA**$_{Ontario}$). Lastly, a load allocation to natural background sources in the Ontario Creek watershed, excluding the background loads already factored into **WLA**$_{Un\text{-}named}$ and **WLA**$_{Monarch}$, was identified separately (**LA**$_{Nat}$). Metals concentrations found at ONT-0, a site on Ontario Creek upstream of mining sources, were used to calculate the natural background load allocation (**LA**$_{Nat}$). However, because ONT-0 was only sampled during low flow conditions, metal concentrations observed at LBF-1, a site on the upper Little Blackfoot River also upstream of mining sources, were used to estimate natural background concentrations of metals during high flow conditions. These four TMDL components came together in the following formula:

$$TMDL_{Ontario} = WLA_{Un\text{-}named} + WLA_{Monarch} + WLA_{Ontario} + LA_{Nat}$$

The same allocation scheme was chosen for aluminum during low flow conditions and zinc during both flow conditions. A different allocation scheme was chosen for aluminum during high flow conditions because aluminum samples exceeded targets at the Little Blackfoot River site (LBF-1) used to estimate naturally occurring metal concentrations for the 2011 TMDLs. Therefore, due to uncertainties in defining background concentrations, the high flow aluminum TMDL in this addendum is presented as a composite wasteload allocation to all sources both naturally occurring and mining-related, as expressed by the following formula:

$$TMDL_{Ontario} = WLA_{Composite}$$

TMDLs were calculated using the appropriate target concentrations, and the streamflow and water hardness values observed at site ONT-2 in May and August 2009. Existing loads were calculated using the same inputs as the TMDLs but using the metal concentrations observed at ONT-2 in May and August 2009 instead of the target concentrations. Because ONT-2 did not capture a zinc standard exceedance on those dates, the zinc concentration observed at site LBF0044 in October 2008 was used to calculate the low flow zinc existing load. **Table 9-2** provides example TMDLs, allocations and necessary percent reductions; however because TMDLs are flow and hardness dependent, actual TMDLs will not always match **Table 9-2**.

Table 9-2. Ontario Creek example TMDLs and allocations

Metal	Flow	TMDL$_{Ontario}$	WLA$_{Un\text{-}named}$	WLA$_{Monarch}$	WLA$_{Ontario}$	LA$_{Nat}$	Existing Load	% Reduction
Aluminum	High flow	111.855	WLA$_{Composite}$ = 111.855				167.139	33%
	Low flow	2.532	0.033	0.700	0.864	0.935	0.873	0%
Zinc	High flow	47.596	0.014	2.757	34.030	10.796	25.714	0%
	Low flow	1.078	0.014	0.298	0.532	0.234	3.784	72%

All units are lbs/day

The current dataset suggests a 33% reduction in aluminum loading during high flow conditions and a 72% reduction in zinc loading during low flow conditions is required. The pollutants appear to be meeting TMDLs during the other time periods. **Table 3-1** lists the inputs used to calculate Ontario Creek's example TMDL.

10.0 Telegraph Creek, Upper Segment (MT76G004_051)

Telegraph Creek, from the headwaters to Hahn Creek (5.4 miles), previously had TMDLs developed for arsenic, beryllium, cadmium, copper, lead, sediment, and zinc (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). DEQ reassessed the waterbody in 2013 and added aluminum to the list of pollutants impairing aquatic life beneficial uses. This addendum addresses the aluminum impairment by establishing an aluminum TMDL for Telegraph Creek's upper segment.

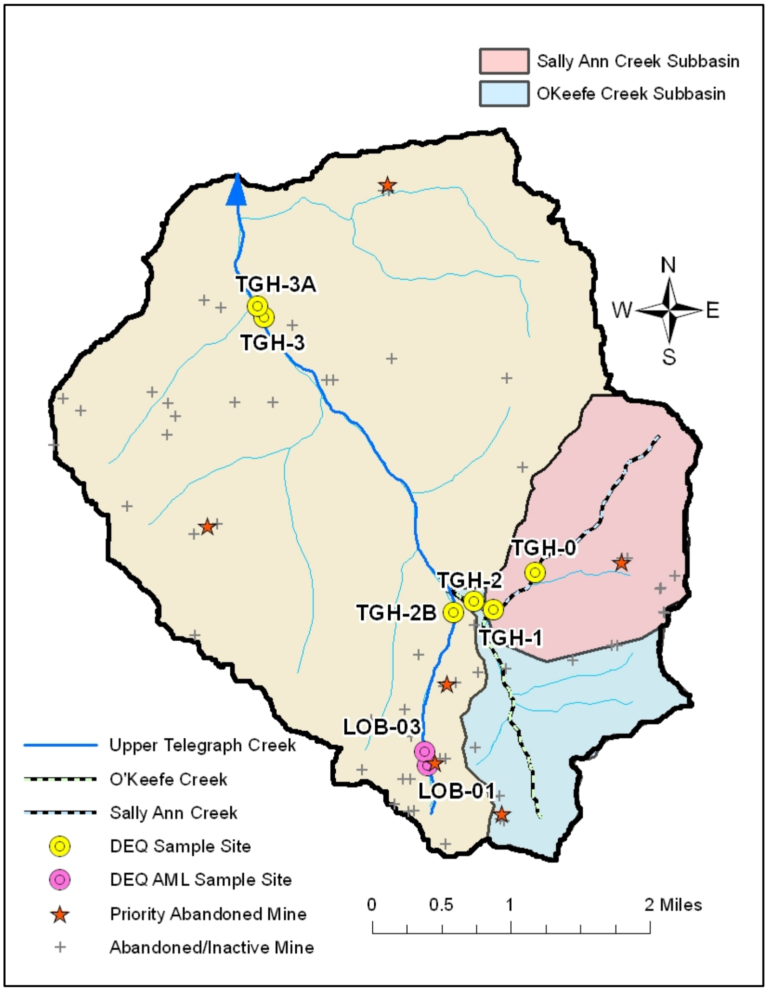

Figure 10-1. Upper Telegraph Creek Monitoring Sites

10.1 Sources of Aluminum

According to DEQ and MBMG databases the upper Telegraph Creek basin contains approximately 50 abandoned mines. Six are identified by the state as high priority abandoned mines: Telegraph, Sure Thing, Lily Orphan Boy, Anna P, Julia, Viking, and Third Term. MBMG investigated the Telegraph Mine, located in the Sally Ann Creek subbasin, in the mid-1990s and noted a discharging adit and water flowing through waste rock and tailings that tested very acidic. All three surface water samples collected near the mine had dissolved aluminum concentrations over 370 µg/L (Hargrave et al., 1998). In 2005 the USFS removed mine waste at the site (Ihle, Beth, personal communication 2008) but the environmental legacy of the mine has not been fully addressed. Similar conditions exist in the O'Keefe Creek subbasin at the Sure Thing Mine, which has an adit discharging very high concentrations of aluminum that flows through tailings and waste rock (Pioneer Technical Services, Inc., 1995; Nordwick, 2008). Starting in 2001, the Sure Thing Mine was the site of an four year field experiment demonstrating the effectiveness of using sulfate-reducing bacteria to mitigate the impacts of acid mine drainage. The study found concentrations of metals, including aluminum, in the adit discharge were reduced and pH increased during treatment, but after the study period ended the system was removed (Nordwick, 2008).

The headwaters region of Telegraph Creek is another critical source area of metals with numerous abandoned mines. This region contains Lily Orphan Boy and Anna P mines along with numerous non-priority mines that have waste rock piles, flooded mine shafts, and aluminum-laden adit discharges (e.g., SW SE Section 10, Champion, Moonlight Cabin, and Hope Mine). The Lily Orphan Boy Mine has discharging adits and waste rock spanning the active channel of Telegraph Creek (Tetra Tech, Inc., 2009). A sulfate-reducing bacteria demonstration occurred at the Lily Orphan Boy site from 1994 to 2004 and the results were similar to those witnessed at the Sure Thing Mine. Likewise, once the demonstration stopped the treatment and improvements in water quality also stopped (Nordwick, 2008). DEQ's AML Program investigated existing conditions at Lily Orphan Boy and detailed the reclamation potential of the site (Tetra Tech, Inc., 2009; Terra Graphic Environmental Engineering, Inc., 2009). While the reports concluded that the single most effective action that could be taken to improve water quality and reduce human and ecologic risks is to remove waste rock in the vicinity of Telegraph Creek, DEQ has no plans to imitate remediation (Koerth, John, personal communication 2013).

There are also numerous mines in the lower portion of Telegraph Creek's upper segment including the Julia, Viking, and Third Term mines. A water sample collected from an adit at the Viking Mine had a dissolved aluminum concentration of 231 µg/L in 1995 (Hargrave et al., 1998). DEQ's AML Program backfilled an adit tunnel and re-sloped land surrounding the Third Term in 1993 (Clark, Pebbles, personal communication 2010). However, within two years the adit subsided and the reclaimed area still lacked soils or vegetation (Hargrave et al., 1998). Third Term was revisited in 2005 along with the Viking, Hub Camp and Hope mines when the USFS removed mine waste from the sites (Ihle, Beth, personal communication 2008).

There are no permitted point sources in the basin. As demonstrated in this brief summary, there are a multitude of abandoned mines that are potential sources of aluminum to Telegraph Creek. A more comprehensive description of abandoned mines found in this watershed is located in **Appendix F** of the 2011 Little Blackfoot Watershed TMDL Document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

10.2 Existing Data and Comparison to Water Quality Targets

The current aluminum dataset consists of six samples collected at three sites by DEQ's Water Quality Protection Bureau in 2008 and 2009 (see **Figure 10-1**). DEQ's AML Program also collected metals surface water data in 2008 near the Lily Orphan Boy Mine but their analysis did not include dissolved aluminum so the results cannot be compared to TMDL targets. Of the six acceptable samples, three exceeded the chronic aquatic life criteria target but had pH concentrations less than 6.5. As discussed previously in the metals target section (**Section 2.1**), based on an interpretation of the narrative standard the assessment concludes aluminum is impairing aquatic life beneficial uses in upper Telegraph Creek. Every sample collected during high flow conditions exceeded aluminum targets while no exceedances were observed outside that time period. Synoptic sampling during both flow conditions revealed generally constant concentrations of aluminum throughout the middle section of the stream from TGH-2B to TGH-3A while streamflow drastically increased, pointing to a large source of aluminum from O'Keefe Creek and further downstream. Other non-synoptic samples from O'Keefe and Sally Ann Creek also implicate these watersheds as aluminum sources. **Table 10-1** compares existing aluminum data to the targets described in **Section 2.1**.

Table 10-1 Upper Telegraph Creek data summary and target exceedances

Parameter	Aluminum
Number of samples	6
Date of samples	2008-2009
% of samples considered high flow	50%
Chronic AL criteria exceedance rate > 10%?	Yes
> 2x acute AL criteria exceeded?	No
Human health criteria exceeded?	No
NOAA PEL exceeded?	NA
Human caused sources present?	Yes
Impairment Determination	Impaired

10.3 Upper Telegraph Creek TMDLs

Previously established TMDLs for metals on upper Telegraph Creek were broken into a wasteload allocation representing the contribution from the Telegraph Creek headwaters region above O'Keefe Creek's confluence (**$WLA_{Headwaters}$**), another capturing the inputs below O'Keefe Creek (**WLA_{Mid}**) and a third representing the total metals load from O'Keefe Creek and Sally Ann Creek (**$WLA_{O'Keefe}$**). Additionally, a load allocation to natural background sources (**LA_{Nat}**) was isolated to represent nonpoint source loading below O'Keefe Creek. These four TMDL components came together in the following formula:

$$TMDL_{UpTele} = WLA_{Headwaters} + WLA_{Mid} + WLA_{O'Keefe} + LA_{Nat}$$

A different allocation scheme was chosen for aluminum because aluminum samples exceeded targets at the Little Blackfoot River site (LBF-1) used to estimate naturally occurring metal concentrations for the 2011 TMDLs. Therefore due to uncertainties in defining background concentrations of aluminum, the aluminum TMDL in this addendum is presented as a composite wasteload allocation to all sources both naturally occurring and mining-related, as expressed by the following formula:

$$TMDL_{UpTele} = WLA_{Composite}$$

TMDLs were calculated using the appropriate target concentration, and the streamflow values observed at site TGH-3A in May and August 2009. Existing loads were calculated using the same inputs as the TMDLs but using the aluminum concentrations observed at TGH-3A in May and August 2009 instead of the target concentrations. **Table 10-2** provides example TMDLs, allocations and necessary percent reductions; however because TMDLs are flow dependent, actual TMDLs will not always match **Table 10-2**.

Table 10-2. Upper Telegraph Creek example aluminum TMDLs and allocations

Metal	Flow	$TMDL_{UpTele}$	$WLA_{Composite}$	Existing Load	% Reduction
Aluminum	High flow	42.357	42.357	82.767	49%
	Low flow	0.897	0.897	0.309	0%

All units are lbs/day

The current dataset suggests that the aluminum TMDL is met during low flow conditions but that a 49% reduction in loading is required during high flow time periods. **Table 3-1** lists the inputs used to calculate upper Telegraph Creek's example TMDL.

11.0 Telegraph Creek, Lower Segment (MT76G004_052)

Telegraph Creek, from Hahn Creek to the mouth at the Little Blackfoot River (2.5 miles), previously had TMDLs developed for cadmium, copper, lead, mercury, and zinc (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). DEQ reassessed the waterbody in 2013 and added aluminum to the list of pollutants impairing aquatic life beneficial uses. This addendum addresses the aluminum impairment by establishing an aluminum TMDL for Telegraph Creek's lower segment.

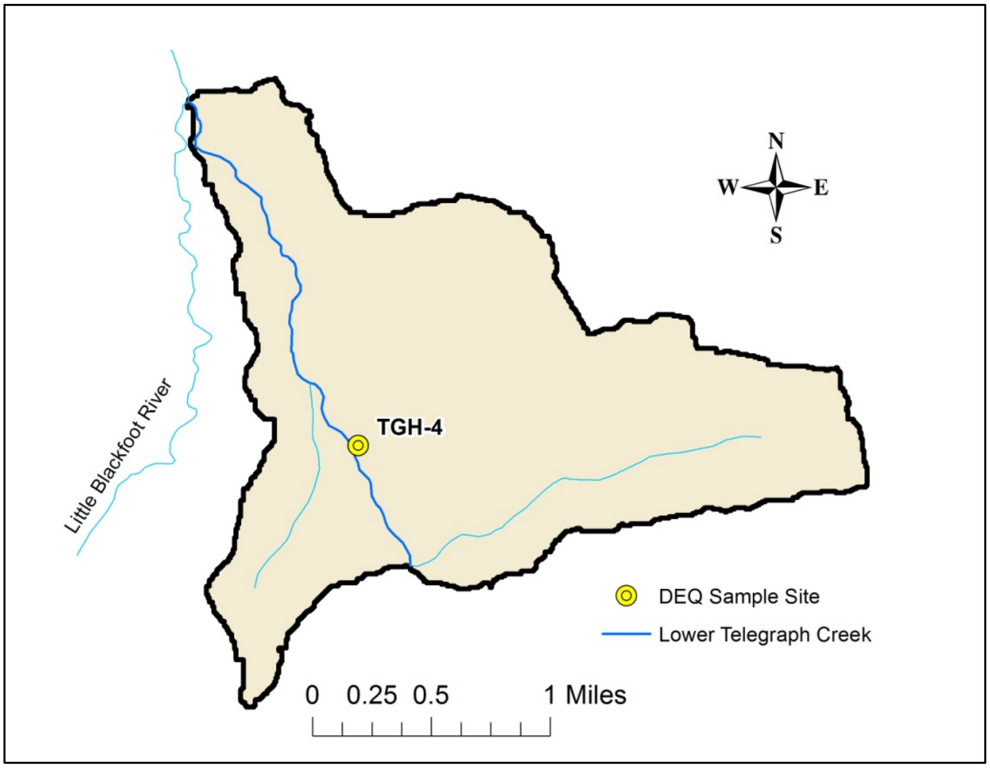

Figure 11-1. Lower Telegraph Creek Monitoring Sites

11.1 Sources of Aluminum

The lower Telegraph Creek basin contains no abandoned mines or permitted point sources. The source of human-related metals loading to lower Telegraph Creek is abandoned mines in the upper Telegraph Creek basin described separately in **Section 10.1** and **Appendix F** of the 2011 Little Blackfoot Watershed TMDL Document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

11.2 Existing Data and Comparison to Water Quality Targets

The current aluminum dataset consists of four samples collected at one site by DEQ's Water Quality Protection Bureau in 2008 and 2009 (see **Figure 11-1**). Two of the four samples exceeded the chronic aquatic life criteria target but one had a pH concentration less than 6.5. As discussed previously in the metals target section (**Section 2.1**), based on an interpretation of the narrative standard the assessment concludes aluminum is impairing aquatic life beneficial uses in lower Telegraph Creek. Every sample collected during high flow conditions exceeded aluminum targets while no exceedances were observed outside that time period. **Table 11-1** compares existing aluminum data to the targets described in **Section 2.1**.

Table 11-1 Lower Telegraph Creek data summary and target exceedances

Parameter	Aluminum
Number of samples	4
Date of samples	2008-2009
% of samples considered high flow	50%
Chronic AL criteria exceedance rate > 10%?	Yes
> 2x acute AL criteria exceeded?	No
Human health criteria exceeded?	No
NOAA PEL exceeded?	NA
Human caused sources present?	Yes
Impairment Determination	Impaired

11.3 Lower Telegraph Creek TMDLs

Previously established TMDLs for metals on Telegraph Creek's lower segment were broken into a composite wasteload allocation representing the total load from the upper watershed (**WLA_{UpTele}**) and a load allocation to natural background sources in the lower Telegraph Creek watershed (**LA_{Nat}**) as expressed by the following formula:

$TMDL_{LwrTele} = WLA_{UpTele} + LA_{LwrTele}$

The same allocation scheme was chosen for aluminum. The **WLA_{UpTele}** is equivalent to the TMDL calculated for Telegraph Creek's upper segment in **Section 10.3** and the natural background load (**LA_{Nat}**) is the difference between lower Telegraph Creek's TMDL and **WLA_{UpTele}**. TMDLs were calculated using the appropriate target concentration, and the streamflow value observed at site TGH-4 in May 2009. The data quality of the flow measurement at TGH-4 in August of that year was suspect so the summer flow value was estimated by applying the same relative increase to TGH-3A as that observed between sites TGH-3 to TGH-4 in August 2008. Existing loads were calculated using the same inputs as the TMDLs but using the aluminum concentrations observed at TGH-4 in May and August of 2009 instead of the target concentrations. **Table 11-2** provides example TMDLs, allocations and necessary percent reductions; however because TMDLs are flow dependent, actual TMDLs will not always match **Table 11-2**.

Table 11-2. Lower Telegraph Creek example aluminum TMDLs and allocations

Metal	Flow	$TMDL_{LwrTele}$	WLA_{UpTele}	$LA_{LwrTele}$	Existing Load	% Reduction
Aluminum	High flow	43.870	42.357	1.569	80.680	46%
	Low flow	2.048	0.897	1.151	0.706	0%

All units are lbs/day

The current dataset suggests that the aluminum TMDL is met during low flow conditions but that a 46% reduction in loading is required during high flow time periods. **Table 3-1** lists the inputs used to calculate lower Telegraph Creek's example TMDL.

12.0 Un-named Creek (MT76G006_010)

Un-named Creek, from the headwaters to the mouth at Ontario Creek (0.8 miles), previously had TMDLs developed for arsenic, cadmium, copper, iron, lead, mercury, pH and zinc (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). DEQ reassessed the waterbody in 2013 and added aluminum to the list of pollutants impairing aquatic life beneficial uses. This addendum addresses the aluminum impairment by establishing an aluminum TMDL for Un-named Creek.

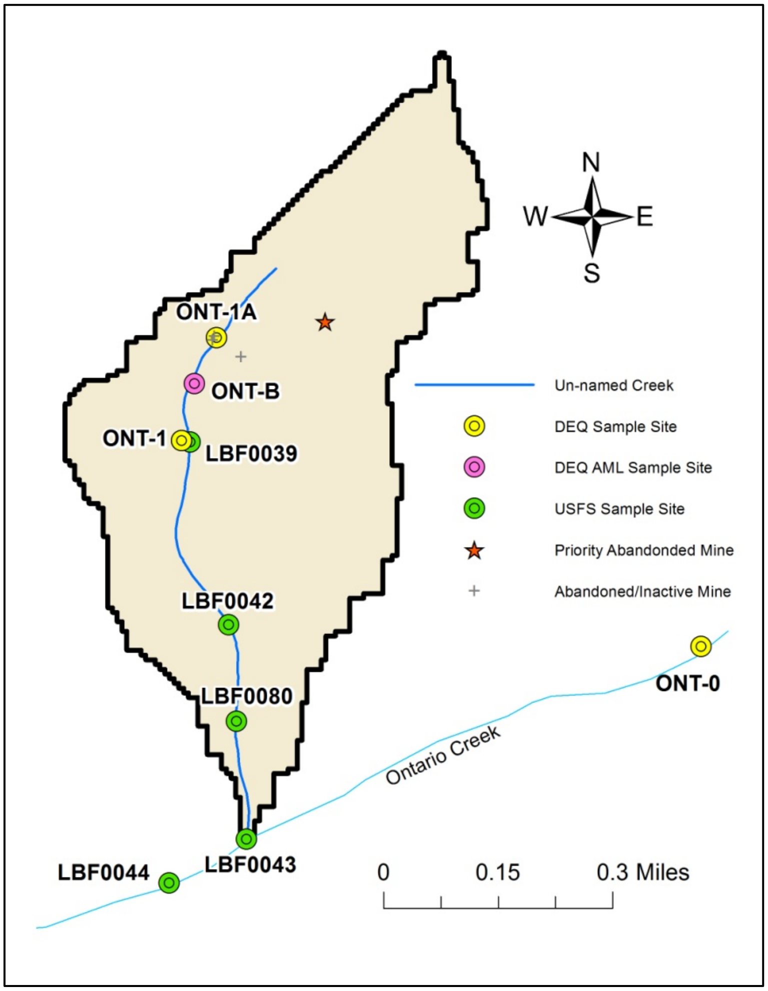

Figure 12-1. Un-named Creek Monitoring Sites

12.1 Sources of Aluminum

According to DEQ and MBMG databases the Un-named Creek basin contains two abandoned mines. A detailed description of the Amanda Mine is not available and it is suspected to be an insignificant source of metals loading. The most probable source of aluminum loading to Un-named Creek is the Ontario Mine and Millsite which is identified by the state as a high priority abandoned mine and has been the subject of two reclamation projects and two university studies (Olsen, 2004; Milodragovich, 2003). Prior to reclamation, the Ontario Mine site consisted of multiple discharging adits, waste rock piles and tailings extending a distance down Ontario Creek. MBMG sampling in 1995 near site ONT-1 found dissolved aluminum concentrations in Un-named Creek to be a staggering 4,376 µg/L, or nearly six times the acute aquatic life target (Hargrave et al., 1998). An adit discharge tested even higher at 11,000 µg/L. The same monitoring showed the aluminum concentration in Ontario Creek above Un-named Creek met targets and was a more moderate 53 µg/L. In 2003, the USFS removed tailings on Forest Service property and two years later the DEQ AML program addressed waste rock on private property (Tetra Tech, Inc., 2006). DEQ's reclamation activities removed bare tailings piles and armored the adit drainage channel with rock, but did not stop or treat the adit discharge which is a significant source of aluminum. Additionally, tailings that had naturally re-vegetated were left in place (Olsen, 2004). There are no permitted point sources in the basin. A more comprehensive description of the Ontario Mine is located in **Appendix F** of the 2011 Little Blackfoot Watershed TMDL Document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

12.2 Existing Data and Comparison to Water Quality Targets

Two master theses studied conditions before and after reclamation efforts at the Ontario Mine and Millsite. One study occurred before reclamation and attempted to determine if the wetland below the mine adit was improving water quality. The wetland's influence varied by metals constituent and season although it was shown to consistently reduce aluminum loads and concentrations (Milodragovich, 2003). Another study investigated the interaction of metals and plant uptake at the Ontario Mine site following initial remediation performed by the USFS but before the 2005 DEQ reclamation (Olsen, 2004). This research found that significantly more aluminum, along with other metals, was bioavailable to plants initially following remediation. DEQ's AML Program and the USFS have established monitoring sites to sample the surface water of Un-named Creek however their analyses did not include dissolved aluminum so the results cannot be compared to TMDL targets.

The current aluminum dataset consists of two water samples collected at one site by DEQ's Water Quality Protection Bureau in 2008 and 2009 (see **Figure 12-1**). Both aluminum samples exceeded the chronic aquatic life target and one was more than double the acute aquatic life target. Both samples also had pH concentrations less than 6.5, however as discussed previously in the metals target section (**Section 2.1**), based on an interpretation of the narrative standard the assessment concludes aluminum is impairing aquatic life beneficial uses. All Un-named Creek data used in this addendum were collected in 2008 and 2009 following mine reclamation at the Ontario Mine. Even so, one of the current samples had a dissolved aluminum concentration of 4,110 µg/L which is similar to the conditions MBMG observed in 1995 prior to reclamation. This is likely because the discharging adit was not addressed. **Table 12-1** compares existing aluminum data to the targets described in **Section 2.1**.

Table 12-1 Un-named Creek data summary and target exceedances

Parameter	Aluminum
Number of samples	2
Date of samples	2008-2009
% of samples considered high flow	0%
Chronic AL criteria exceedance rate > 10%?	Yes
> 2x acute AL criteria exceeded?	Yes
Human health criteria exceeded?	No
NOAA PEL exceeded?	NA
Human caused sources present?	Yes
Impairment Determination	Impaired

12.3 Un-named Creek TMDLs

Previously established TMDLs for metals on Un-named Creek were broken into a wasteload allocation assigned to the Ontario Mine (**$WLA_{OntarioM}$**) and a load allocation representing the natural background load (**LA_{Nat}**) as expressed by the following formula:

$TMDL_{Un\text{-}named} = WLA_{OntarioM} + LA_{Nat}$

The same allocation scheme was chosen for aluminum. The natural background load was calculated using data collected at ONT-0, a site on Ontario Creek upstream of mining sources that had no target exceedances. The TMDL was calculated using the appropriate target concentration and the streamflow value observed at site ONT-1 in August 2009. The existing load was calculated using the same inputs as the TMDL but using aluminum concentrations observed at ONT-1 in August 2009 instead of the target concentration. **Table 12-2** provides the example TMDL, allocations and necessary percent reduction; however because TMDLs are flow dependent, actual TMDLs will not always match **Table 12-2**.

Table 12-2. Un-named Creek example aluminum TMDL and allocations

Metal	Flow	$TMDL_{Un\text{-}named}$	$WLA_{OntarioM}$	LA_{Nat}	Existing Load	% Reduction
Aluminum	Low flow	0.033	0.018	0.015	0.140	76%

All units are lbs/day

The current dataset suggests that a large reduction in aluminum loading is required during low flow conditions. With high flow data lacking, it is not possible to investigate conditions during that time period. **Table 3-1** lists the inputs used to calculate Un-named Creek's example TMDL.

13.0 RESTORATION STRATEGY

Actions that could be taken to help meet water quality standards in these nine stream segments should closely follow the strategy outlined in **Section 9.0** of the 2011 Little Blackfoot Watershed TMDL document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011). In summary, restoration objectives must address discharging mine adits and prevent mine wastes from impacting surface waters though both overland flow and groundwater contamination.

One potential funding source, the Upper Clark Fork River Basin Restoration Fund, has changed slightly from what was presented in the 2011 Little Blackfoot Watershed TMDL document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011) therefore it will be discussed in this addendum. Previous descriptions of the other funding sources remain accurate. To review, the Upper Clark Fork River Basin Restoration Fund, was obtained through a series of settlements against the Atlantic Richfield Company (ARCO) for injuries to natural resources caused by the company's historic mining and mineral processing activities in the Upper Clark Fork River Basin, especially in the area surrounding Butte and Anaconda, MT. From 2000 through 2010 the fund, which is administered by the Montana Department of Justice's Natural Resource Damage Program (NRDP), awarded annual restoration grants funded largely by interest earned from the fund monies. Then in December 2011, around the same time that the 2011 Little Blackfoot Watershed TMDL document was finalized, the Governor approved a framework document that described how the remaining fund balance would be allocated. The framework identified three separate resource categories to fund: groundwater, aquatic and terrestrial. A year later the Governor signed the Final Upper Clark Fork River Basin Aquatic and Terrestrial Resources Restoration Plans which further detailed restoration actions for the fund's aquatic and terrestrial resource categories and specified geographic areas and project types that would be covered (Natural Resource Damage Program, 2012).

The revised plan dedicates over $2.7 million to aquatic projects in the Little Blackfoot watershed and the following waterbodies have been identified as priorities: the lower segment of the Little Blackfoot River (Priority 1), the upper segment of the Little Blackfoot River (Priority 2), both Dog Creek segments (Priority 2), part of Snowshoe Creek (Priority 2), and part of Spotted Dog Creek (Priority 2) (Natural Resource Damage Program, 2012). The stated goals of restoration are to improve riparian habitat, instream habitat, fish passage, and address flow augmentation issues. Montana solicited, and in June 2012, received restoration proposals from the public. The state will again solicit restoration proposals from the public at various times in the future as the plan continues to be revised. Projects have been prioritized and implementation of the first round of proposals will begin soon (Natural Resource Damage Program, 2012).

14.0 Stakeholder and Public Participation

Stakeholder and public involvement is a component of total maximum daily load (TMDL) planning supported by the U.S. Environmental Protection Agency's (EPA) guidelines and required by Montana state law (Montana Code Annotated (MCA) 75-5-703, 75-5-704) which directs the Montana Department of Environmental Quality (DEQ) to consult with watershed advisory groups and local conservation districts during the TMDL development process. Technical advisors, stakeholders and interested parties, state and federal agencies, interest groups, and the public were solicited to participate throughout the TMDL development process.

14.1 Participants and Roles

Throughout completion of the addendum, DEQ worked with stakeholders to keep them apprised of project status and solicited input from a TMDL advisory group. A description of the participants in the development of these TMDLs and their roles is contained below.

Montana Department of Environmental Quality
Montana state law (MCA 75-5-703) directs DEQ to develop all necessary TMDLs. DEQ has provided resources toward completion of these TMDLs in terms of staff, funding, internal planning, data collection, technical assessments, document development, and stakeholder communication and coordination. DEQ has worked with other state and federal agencies to gather data and conduct technical assessments. DEQ has also partnered with watershed organizations to collect data and coordinate local outreach activities for this project.

United States Environmental Protection Agency
EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act (CWA). Section 303(d) of the CWA directs states to develop TMDLs, and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program and is responsible for final TMDL approval. Project management was primarily provided by the EPA Regional Office in Helena, MT.

TMDL Advisory Group
The Little Blackfoot TMDL Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Little Blackfoot watershed, and also representatives of applicable interest groups. All members were solicited to participate in an advisory capacity per Montana state law (75-5-703 and 704). DEQ requested participation from the interest groups defined in MCA 75-5-704 which included local city and county representatives, livestock-oriented and farming-oriented agriculture representatives, conservation groups, watershed groups, state and federal land management agencies, and representatives of recreation and tourism interests. The advisory group also included additional stakeholders and landowners with an interest in maintaining and improving water quality and riparian resources. All individuals who participated in the advisory group for the original TMDL document in 2011 were solicited again for input regarding this addendum.

Advisory group involvement was voluntary and the level of involvement was at the discretion of the individual members. Members had the opportunity to provide comments and review the draft addendum prior to the public comment period. Final technical decisions regarding document modifications resided with DEQ. Communications with group members was conducted primarily through e-mail or telephone correspondence.

Area Landowners
Since 56% of the planning area is in private ownership, local landowner cooperation in the TMDL process was critical. Their contribution has included access for stream sampling and field assessments and personal descriptions of seasonal water quality and streamflow characteristics. DEQ sincerely thanks the area landowners for their logistical support and informative participation in impromptu water resource and land management discussions with our field staff and consultants.

14.2 Response to Public Comments

Upon completion of the draft addendum, and prior to submittal to EPA, DEQ issues a press release and enters into a public comment period. During this timeframe, the draft document is made available for general public comment, and DEQ addresses and responds to all formal public comments.

The formal public comment period was initiated on February 5, 2014 and closed on February 26, 2014. The draft document was posted on DEQ's website and hard copies were made available at the Deer Lodge Valley Conservation District in Deer Lodge, MT and at the State Library in Helena, MT. A public informational meeting and open house was held in Avon, MT on February 24, 2014. EPA and DEQ provided an overview of the document, answered questions, and solicited public input and comment on the TMDLs. The announcement for the meeting was distributed to the Little Blackfoot TMDL Advisory Group, Statewide TMDL Advisory Group, Water Pollution Control Advisory Council, Deer Lodge Valley and North Powell conservation districts, and other interested parties via e-mail. Notice of the meeting was also advertised in the following newspapers: Independent Record (Helena) and Silver State Post (Deer Lodge/Powell County).

One formal comment was received during the public comment period. Excerpts of the comment and DEQ's response are presented below. The original comment letter is held on file at DEQ and may be viewed upon request.

Comment 1:
We have a specific concern regarding the use of the aluminum aquatic life standard (ALS). As stated in the addendum, Montana's numeric aluminum criteria only apply within a pH range of 6.5-9.0 standard units and list acute and chronic ALS for aluminum as 750 and 87 µg/L, with a trigger value [or detection limit] of 30 µg/L.

We do not consider the use of the aluminum ALS to be appropriate for all waters in the Little Blackfoot watershed. Several of the TMDL listed stream sections have pH less than 6.5, with some stream levels detected as low as 3.1. Even though pH values less than 6.5 are commonly found, the document states that the chronic ALS criterion (87 µg/L) will be applied as the aluminum threshold. While the document acknowledges that aluminum is lethal to fish when pH is less than 6.5, no additional information is provided to support the use of the existing chronic standard in these waters. We recommend that a translation of the narrative standard be completed to better understand the toxicity of aluminum under low pH conditions. A quick review of literature values shows that aluminum concentrations significantly below 87 µg/L result in reduced growth and even death in salmonids under low pH conditions.

DEQ's Response:
DEQ is aware of literature indicating aluminum concentrations below 87 µg/L are toxic to some aquatic life species at sensitive life stages in waters with pH values less than 6.5. At this time, DEQ has not had the opportunity to conduct a thorough review of those studies to determine their applicability to the streams in the Little Blackfoot watershed. Despite this, DEQ felt it was important to include water quality samples with pH less than 6.5 standard units in the assessment and 303(d) listing process because of the documented toxicity of aluminum under low pH conditions. For acidic streams, DEQ chose to translate the narrative standard (ARM 17.30.637) to equate to the chronic aquatic life criterion of 87 µg /L dissolved aluminum. That concentration was chosen because it is nationally well-established and derived from extensive toxicology tests; however, this does not preclude DEQ from applying a different translation in the future. This aquatic life target has been applied to acidic waters by other states for assessment purposes (U.S. Environmental Protection Agency, Region 6, 2012) and has been used in previous Montana TMDLs approved by EPA (Montana Department of Environmental Quality, 2011).

In the Little Blackfoot watershed, most of the aluminum samples collected in waters below pH 6.5 were either below detection (30 µg/L) or well above the 87 µg/L target, therefore translating the narrative standard to a lower target would not have significantly affected the listing decisions. Another important consideration is that waters with abnormally low pH in the Little Blackfoot watershed are a consequence of historic mining and conditions associated with acid mine drainage. All of the TMDL stream segments included in this addendum have other metal parameters impairing aquatic life beneficial uses in addition to aluminum. DEQ believes mitigating the effects of acid mine drainage should reduce aluminum concentrations in surface waters and raise the pH of streams to a more neutral value within the 6.5-9 standard units range, wherein the numeric chronic aquatic life criterion of 87 µg /L would apply.

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16.0 METALS DATA

Table 16-1. Surface water data used in this addendum

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
American Gulch Creek	DOG-3	5/28/2008	DEQ	85	16.2	7.81	70	14	-	< .08	2	-	1040	1.8	-	< 1	10
American Gulch Creek	DOG-3	7/24/2008	DEQ	163	0.76	8.15	< 30	14	-	< .08	< 1	-	290	< .5	-	< 1	< 10
American Gulch Creek	DOG-3	5/22/2009	DEQ	99	13.37	7.64	< 30	13	-	0.55	7	-	-	6.4	-	-	70
American Gulch Creek	DOG-3	8/25/2009	DEQ	149	0.85	7.64	< 30	16	-	< .08	< 1	-	-	< .5	-	-	< 10
Carpenter Creek	CAR-1	5/29/2008	DEQ	157	33.68	8.17	< 30	4	-	< .08	2	-	160	< .5	-	< 1	< 10
Carpenter Creek	CAR-1	7/25/2008	DEQ	222	3.69	8.45	< 30	4	-	< .08	< 1	-	70	< .5	-	< 1	< 10
Carpenter Creek	CAR-1	5/19/2009	DEQ	146	29.09	8.26	< 30	4	-	0.41	2	-	-	< .5	-	-	< 10
Carpenter Creek	CAR-1	8/31/2009	DEQ	187	3.58	8.29	< 30	5	-	< .08	1	-	-	< .5	-	-	< 10
Dog Creek, lower	DOG-8	5/29/2008	DEQ	53	119.17	7.86	350	4	-	< .08	6	-	790	4.4	-	< 1	20
Dog Creek, lower	DOG-8	7/22/2008	DEQ	121	17.35	8.22	30	6	-	< .08	2	-	360	2.3	-	< 1	< 10
Dog Creek, lower	DOG-8	5/19/2009	DEQ	49	247.6	6.71	130	5	-	1.21	7	-	-	6.4	-	-	20
Dog Creek, lower	DOG-8	8/26/2009	DEQ	134	12.17	7.97	< 30	8	-	< .08	3	-	-	1.7	-	-	< 10
Dog Creek, upper	25-179-SW5	9/22/2003	AML	142	2.5	8.14	-	13	-	< 1	< 10	-	570	12	-	-	10
Dog Creek, upper	25-179-SW4	9/22/2003	AML	142	2.5	8.14	-	13	-	< 1	-	-	610	14	-	-	10
Dog Creek, upper	25-179-SW1	9/22/2003	AML	145	0.19	8.1	-	4	-	< 1	-	-	140	9	-	-	110
Dog Creek, upper	25-179-SW2	9/22/2003	AML	160	0.14	7.94	-	13	-	< 1	-	-	410	3	-	-	20
Dog Creek, upper	DOG-2	5/28/2008	DEQ	86	11.92	7.83	140	15	-	0.35	10	-	350	10	-	< 1	80
Dog Creek, upper	DOG-1	5/28/2008	DEQ	82	8.93	7.73	170	5	-	1.9	17	-	280	6	-	< 1	280
Dog Creek, upper	DOG-2	7/24/2008	DEQ	171	3.34	8.17	< 30	26	-	1.2	6	-	330	13	-	< 1	50
Dog Creek, upper	DOG-1	7/24/2008	DEQ	174	1.96	8.15	< 30	10	-	2	7	-	100	7.8	-	< 1	140
Dog Creek, upper	DOG-2	5/22/2009	DEQ	99	13.28	7.88	< 30	13	-	0.88	8	-	-	13.5	-	-	80
Dog Creek, upper	DOG-1	5/22/2009	DEQ	105	8.9	7.82	90	7	-	3.36	20	-	-	10.4	-	-	290
Dog Creek, upper	DOG-2	8/25/2009	DEQ	164	0.95	7.76	< 30	35	-	0.39	8	-	-	15.1	-	-	40
Dog Creek, upper	DOG-1	8/25/2009	DEQ	155	0.12	7.76	< 30	9	-	1.77	10	-	-	9.9	-	-	160
Hope Creek	DOG-5	5/28/2009	DEQ	94	25.93	7.87	110	< 3	-	1.02	2	-	-	0.5	-	-	< 10
Hope Creek	DOG-5	8/25/2009	DEQ	197	4.47	7.79	< 30	< 3	-	< .08	< 1	-	-	< .5	-	-	< 10
Little Blackfoot River, lower	12324590/LBF-10	3/21/2001	USGS	103	128	8	-	8	-	< 0.1	4.2	-	690	1.01	-	-	8
Little Blackfoot River, lower	12324590/LBF-10	5/3/2001	USGS	79.1	383	8	-	6	-	< 0.1	3	-	701	1.79	-	-	6
Little Blackfoot River, lower	12324590/LBF-10	5/22/2001	USGS	83.4	319	8.2	-	5	-	< 0.1	1.8	-	269	< 1	-	-	3
Little Blackfoot River, lower	12324590/LBF-10	6/5/2001	USGS	119	455	8.1	-	7	-	0.1	2.7	-	428	1.17	-	-	6
Little Blackfoot River, lower	12324590/LBF-10	9/4/2001	USGS	142	19	8.4	-	6	-	< 0.1	1.3	-	42	< 1	-	-	< 1
Little Blackfoot River, lower	12324590/LBF-10	11/8/2001	USGS	130	63	8.1	-	5	-	< 0.1	0.9	-	38	< 1	-	-	1
Little Blackfoot River, lower	12324590/LBF-10	4/9/2002	USGS	88	197	8.1	-	6	-	< 0.1	2.5	-	383	< 1	-	-	3
Little Blackfoot River, lower	12324590/LBF-10	5/29/2002	USGS	80.2	414	8.2	-	6	-	0.04	2.9	-	591	1.41	-	-	6
Little Blackfoot River, lower	12324590/LBF-10	6/4/2002	USGS	85.6	372	8.1	-	6	-	0.03	2	-	279	< 1	-	-	4
Little Blackfoot River, lower	12324590/LBF-10	6/24/2002	USGS	102	289	8.4	-	6	-	0.02	1.7	-	157	< 1	-	-	2
Little Blackfoot River, lower	12324590/LBF-10	8/21/2002	USGS	121	51	8.6	-	6	-	0.02	1	-	73	< 1	-	-	1
Little Blackfoot River, lower	12324590/LBF-10	5/27/2003	USGS	68.2	747	7.9	-	8	-	0.1	4.9	-	-	4.38	-	-	15
Little Blackfoot River, lower	12324590/LBF-10	8/27/2003	USGS	172	25	8	-	5	-	< .04	1.1	-	64	0.06	-	-	< 2
Little Blackfoot River, lower	12324590/LBF-10	9/22/2003	USGS	152	40	8.2	-	5	-	< .04	2.3	-	51	0.07	-	-	1
Little Blackfoot River, lower	12324590/LBF-10	11/19/2003	USGS	136	61	8.2	-	4	-	< .04	1.1	-	124	0.2	-	-	1
Little Blackfoot River, lower	12324590/LBF-10	4/20/2004	USGS	95.6	168	8.3	-	5	-	< .04	1.9	-	237	0.56	-	-	3
Little Blackfoot River, lower	12324590/LBF-10	5/17/2004	USGS	114	141	8.4	-	5	-	< .04	1.6	-	199	0.43	-	-	2

Table 16-1. Surface water data used in this addendum

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
Little Blackfoot River, lower	12324590/LBF-10	6/1/2004	USGS	105	249	8.3	-	5	-	0.03	1.7	-	215	0.46	-	-	3
Little Blackfoot River, lower	C01LTBLR01/LBF-10	6/30/2004	DEQ	139	120	7.58	-	6	< 1	< 0.1	1	-	100	1	-	-	1
Little Blackfoot River, lower	12324590/LBF-10	7/19/2004	USGS	130	73	8.7	-	7	-	< .04	1.2	-	61	0.08	-	-	< 2
Little Blackfoot River, lower	12324590/LBF-10	8/20/2004	USGS	161	20	8.6	-	6	-	< .04	1.6	-	76	0.08	-	-	< 2
Little Blackfoot River, lower	C01LTBLR01/LBF-10	7/21/2005	DEQ	130	105	7.43	-	6	< 1	< .08	1	-	70	< .5	-	-	1
Little Blackfoot River, lower	LBF-9	5/29/2008	DEQ	71	846	-	140	6	-	< .08	4	-	960	1.8	-	< 1	10
Little Blackfoot River, lower	LBF-10	5/29/2008	DEQ	75	1317	7.73	110	6	-	< .08	4	-	1110	1.8	-	< 1	10
Little Blackfoot River, lower	LBF-7	5/29/2008	DEQ	40	1192.6	7.76	170	6	-	< .08	4	-	570	2.3	-	< 1	20
Little Blackfoot River, lower	LBF-7	7/25/2008	DEQ	85	79.57	7.83	< 30	6	-	< .08	< 1	-	110	3.3	-	< 1	< 10
Little Blackfoot River, lower	LBF-10	7/26/2008	DEQ	138	100.63	8.21	< 30	6	-	< .08	< 1	-	90	< .5	-	< 1	< 10
Little Blackfoot River, lower	LBF-9	7/26/2008	DEQ	122	105.13	8.22	< 30	6	-	< .08	< 1	-	90	< .5	-	< 1	< 10
Little Blackfoot River, lower	LBF-10	5/20/2009	DEQ	67	1555.5	7.6	< 30	14	-	0.2	11	-	-	9.2	-	-	30
Little Blackfoot River, lower	LBF-9	5/20/2009	DEQ	60	1452.3	7.59	< 30	13	-	0.1	8	-	-	8.1	-	-	30
Little Blackfoot River, lower	LBF-7	5/20/2009	DEQ	37	1009.6	6.65	60	15	-	0.16	7	-	-	12.1	-	-	40
Little Blackfoot River, lower	LBF-9	9/1/2009	DEQ	125	63.33	8.09	< 30	6	-	< .08	1	-	-	< .5	-	-	< 10
Little Blackfoot River, lower	LBF-10	9/1/2009	DEQ	138	58.2	8.04	< 30	5	-	< .08	1	-	-	< .5	-	-	< 10
Little Blackfoot River, lower	LBF-7	9/1/2009	DEQ	84	51.1	8.13	< 30	6	< 1	< .08	1	-	80	< .5	-	< 1	< 10
Little Blackfoot River, upper	LBF-1	5/27/2008	DEQ	6	55.94	6.43	110	< 3	-	< .08	2	-	160	< .5	-	< 1	< 10
Little Blackfoot River, upper	LBF-2	5/27/2008	DEQ	36	135.58	6.77	90	< 3	-	< .08	2	-	460	< .5	-	< 1	< 10
Little Blackfoot River, upper	LBF-4	5/28/2008	DEQ	31	187.67	6.93	110	7	-	< .08	3	< 5	620	2.6	-	< 1	20
Little Blackfoot River, upper	LBF-5	5/29/2008	DEQ	29	1179.6	7.33	140	5	-	< .08	3	-	470	1.7	-	< 1	10
Little Blackfoot River, upper	LBF-3	5/30/2008	DEQ	30	272.9	7.53	150	4	-	< .08	3	< 5	370	1.1	-	< 1	10
Little Blackfoot River, upper	LBF-1	7/21/2008	DEQ	8	8.34	7.53	< 30	< 3	-	< .08	< 1	-	60	< .5	-	< 1	< 10
Little Blackfoot River, upper	LBF-5	7/21/2008	DEQ	64	45.22	7.64	< 30	7	-	< .08	< 1	-	100	< .5	-	< 1	< 10
Little Blackfoot River, upper	LBF0066	7/22/2008	USFS	67	-	-	-	21	-	< .08	< 1	-	150	< .5	-	< 1	20
Little Blackfoot River, upper	LBF0065	7/22/2008	USFS	69	-	-	-	24	-	< .08	< 1	-	230	< .5	-	< 1	20
Little Blackfoot River, upper	LBF-2	7/23/2008	DEQ	51	20.88	7.97	< 30	< 3	-	< .08	< 1	-	< 50	< .5	-	< 1	< 10
Little Blackfoot River, upper	LBF-3	7/25/2008	DEQ	51	29.79	7.89	40	6	-	< .08	< 1	< 5	< 50	0.8	-	< 1	< 10
Little Blackfoot River, upper	LBF-4	7/25/2008	DEQ	58	23.82	7.91	< 30	7	-	< .08	< 1	< 5	60	< .5	-	< 1	< 10
Little Blackfoot River, upper	LBF-5	5/19/2009	DEQ	33	908.13	6.64	90	16	-	0.16	7	-	-	9.6	-	-	30
Little Blackfoot River, upper	LBF-4	5/20/2009	DEQ	31	802.89	6.04	< 30	24	-	1.6	8	23	-	16.4	-	-	50
Little Blackfoot River, upper	LBF-3	5/21/2009	DEQ	31	394.83	6.94	60	14	-	0.75	5	< 5	-	8	-	-	30
Little Blackfoot River, upper	LBF-2	5/21/2009	DEQ	37	171.56	6.84	40	< 3	-	0.62	2	-	-	0.7	-	-	< 10
Little Blackfoot River, upper	LBF-5	8/26/2009	DEQ	65	35.9	7.28	< 30	8	-	< .08	2	-	-	< .5	-	-	< 10
Little Blackfoot River, upper	LBF-2	8/26/2009	DEQ	55	14.45	7.31	< 30	< 3	-	< .08	1	-	-	< .5	-	-	< 10
Little Blackfoot River, upper	LBF-4	9/1/2009	DEQ	55	21.73	8.06	< 30	7	-	< .08	< 1	< 5	-	< .5	-	-	< 10
Little Blackfoot River, upper	LBF-3	9/1/2009	DEQ	52	18.39	7.81	< 30	6	-	< .08	< 1	< 5	-	< .5	-	-	< 10
Monarch Creek	C01MONRC10/MCH-2	8/17/2004	DEQ	16	1	5.86	< 100	< 3	< 1	< 0.1	< 1	-	20	< .5	-	< 1	< 10
Monarch Creek	MCH-2	5/27/2008	DEQ	9.2	13.79	6.35	130	< 3	-	< .08	3	-	190	0.8	< .05	< 1	< 10
Monarch Creek	MCH-1	5/27/2008	DEQ	6	22.82	5.87	70	< 3	-	< .08	1	-	100	< .5	< .05	< 1	< 10
Monarch Creek	MCH-2	7/23/2008	DEQ	15	1.49	7.24	40	< 3	-	< .08	< 1	-	150	< .5	< .05	< 1	< 10
Monarch Creek	MCH-1	7/23/2008	DEQ	9	1.14	7.45	< 30	< 3	-	< .08	< 1	-	< 50	< .5	< .05	< 1	< 10
Monarch Creek	MCH-3	5/21/2009	DEQ	10	38.1	5.96	90	< 3	-	< .08	3	-	570	3.5	< .05	1	< 10
Monarch Creek	MCH-2	8/27/2009	DEQ	15	0.99	4.96	< 30	< 3	-	< .08	< 1	-	30	< .5	< .005	< 1	< 10
Monarch Creek	MCH-1	8/27/2009	DEQ	9	0.93	5.08	< 30	< 3	-	< .08	< 1	-	< 30	< .5	-	< 1	< 10
Ontario Creek	ONT-2	5/27/2008	DEQ	9.2	134.96	6.03	180	8	-	0.09	3	-	320	2.1	< .05	< 1	20

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Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
Ontario Creek	ONT-2	7/23/2008	DEQ	14	8.96	7.13	60	9	-	< .08	1	-	70	< .5	< .05	< 1	10
Ontario Creek	LBF0044	10/7/2008	USFS	17	-	6.3	100	9	-	< .08	< 1	-	110	< .5	-	-	130
Ontario Creek	ONT-2	5/21/2009	DEQ	9	238.09	5.8	130	10	-	0.22	4	-	600	4.9	-	-	20
Ontario Creek	ONT-2A	5/21/2009	DEQ	9	112.89	6	150	7	-	1.4	4	-	-	3.3	-	-	20
Ontario Creek	ONT-2	8/26/2009	DEQ	15	5.39	5.54	< 30	10	-	< .08	1	-	40	< .5	-	-	10
Ontario Creek	ONT-2A	8/27/2009	DEQ	11	3.19	4.96	< 30	9	-	0.1	2	-	-	< .5	-	-	20
Ontario Creek	ONT-0	8/27/2009	DEQ	7	0.07	4.29	40	< 3	-	< .08	2	-	140	< .5	-	-	< 10
Ontario Creek	LBF0044	7/20/2010	USFS	-	-	6.8	-	6	-	< .08	< 1	-	180	< .5	< .05	-	110
Spotted Dog Creek	C01SDOGC01	8/18/2005	DEQ	-	3.56	7.95	< 100	4	< 1	< .1	< 1	-	50	< .5	< 0.1	< 1	< 10
Spotted Dog Creek	C01SDOGC02	8/18/2005	DEQ	-	1.08	8.1	< 100	< 3	< 1	< .1	< 1	-	20	< .5	< 0.1	< 1	< 10
Spotted Dog Creek	SPD-4	5/30/2008	DEQ	113	55.38	8.04	100	< 3	-	< .08	2	-	640	< .5	-	< 1	< 10
Spotted Dog Creek	SPD-1	5/30/2008	DEQ	83	10.28	7.97	80	4	-	< .08	2	-	410	< .5	-	< 1	< 10
Spotted Dog Creek	SPD-4	7/25/2008	DEQ	162	12.14	8.18	< 30	4	-	< .08	< 1	-	170	< .5	-	< 1	< 10
Spotted Dog Creek	SPD-1	7/25/2008	DEQ	148	0.87	8.12	< 30	3	-	< .08	< 1	-	< 50	< .5	-	< 1	< 10
Spotted Dog Creek	SPD-4	5/21/2009	DEQ	103	92.18	8.16	< 30	6	-	< .08	3	-	-	0.8	-	-	< 10
Spotted Dog Creek	SPD-4	9/2/2009	DEQ	144	5.45	7.91	< 30	4	-	< .08	1	-	-	< .5	-	-	< 10
Telegraph Creek, lower	TGH-4	5/30/2008	DEQ	15	72.4	7.1	300	< 3	-	0.11	5	-	390	1.1	< .05	< 1	40
Telegraph Creek, lower	TGH-4	7/25/2008	DEQ	38	3.2	7.72	< 30	< 3	-	< .08	2	-	60	< .5	< .05	< 1	30
Telegraph Creek, lower	TGH-4	5/21/2009	DEQ	16	98.38	6.2	160	4	< 1	0.87	5	-	650	1.4	< .05	-	50
Telegraph Creek, lower	TGH-4	8/27/2009	DEQ	42	1.62	6.1	< 30	< 3	< 1	0.08	2	-	140	< .5	< .005	-	20
Telegraph Creek, upper	TGH-3	5/28/2008	DEQ	13	63.59	6.08	260	< 3	-	0.12	5	-	440	0.8	< .05	< 1	50
Telegraph Creek, upper	TGH-3	7/24/2008	DEQ	30	1.96	7.22	40	< 3	-	< .08	2	-	190	< .5	< .05	< 1	20
Telegraph Creek, upper	LOB-SW-03	10/9/2008	AML	23	-	6.6	-	14	-	3	< 10	-	610	-	< 1	-	610
Telegraph Creek, upper	LOB-SW-01	10/9/2008	AML	17	-	7	-	< 5	-	< 1	< 10	-	370	-	< 1	-	30
Telegraph Creek, upper	TGH-3A	5/21/2009	DEQ	13	90.16	6.13	170	3	< 1	1.72	5	-	550	1.4	< .05	-	50
Telegraph Creek, upper	TGH-2B	5/21/2009	DEQ	10	7.76	6.15	160	8	< 1	2.04	6	-	500	1.8	-	-	180
Telegraph Creek, upper	TGH-3A	8/27/2009	DEQ	38	1.91	6.74	< 30	< 3	< 1	0.11	2	-	60	< .5	< .005	-	20
Telegraph Creek, upper	TGH-2B	8/28/2009	DEQ	19	0.1	6.05	< 30	5	< 1	0.76	2	-	< 30	< .5	-	-	130
Un-named Creek	ONT-1	7/23/2008	DEQ	51	-	3.5	4110	13	-	10	94	-	1560	40	< .05	< 1	1580
Un-named Creek	ONT-B	7/28/2008	AML	49	-	3.1	-	190	-	23	260	-	15000	150	< .05	-	3330
Un-named Creek	ONT-1	10/6/2008	DEQ	51	-	-	-	28	-	4.24	34	-	2110	16.7	< .01	-	900
Un-named Creek	LBF0039	10/7/2008	USFS	48	-	3.8	-	< 3	-	6	40	-	460	< .5	-	-	1080
Un-named Creek	LBF0042	10/7/2008	USFS	44	-	4.6	-	238	-	3	30	-	3620	40	-	-	510
Un-named Creek	LBF0043	10/7/2008	USFS	43	-	4.9	-	77	-	3	20	-	630	40	-	-	460
Un-named Creek	LBF0080	10/7/2008	USFS	44	-	4.6	-	29	-	3	20	-	510	20	-	-	500
Un-named Creek	ONT-1	8/27/2009	DEQ	43	0.07	5.4	370	56	-	2.19	25	-	440	9.3	< .005	-	360
Un-named Creek	LBF0043	7/20/2010	USFS	-	-	4.7	-	< 3	-	4	50	-	100	20	< .05	-	650

TR = Total Recoverable, T = Total, D = Dissolved Al = Aluminum, As = Arsenic, Be = Beryllium, Cd = Cadmium, Cu = Copper, Fe = Iron, Pb = Lead, Hg = Mercury, Se = Selenium, Zn = Zinc

Table 16-2. Stream sediment data used in this addendum

Waterbody Segment	Site ID	Sample Date	Organization	As (µg/g)	Be (µg/g)	Cd (µg/g)	Cu (µg/g)	Fe (µg/g)	Pb (µg/g)	Hg (µg/g)	Se (µg/g)	Zn (µg/g)
Carpenter Creek	CAR-1	7/25/2008	DEQ	11	-	0.5	37	309000	14	-	< 10	74
Ontario Creek	ONT-2	7/23/2008	DEQ	307	-	7	64	18400	296	-	< 10	569
Ontario Creek	ONT-0	8/27/2009	DEQ	30	-	3.2	37	-	71	-	-	162
Ontario Creek	ONT-2A	8/27/2009	DEQ	430	-	4.7	77	-	357	-	-	340

All metal concentrations analyzed per dry weight as Total Recoverable -As=Arsenic, Be = Beryllium, Cd = Cadmium, Cu = Copper, Fe = Iron, Pb = Lead, Hg = Mercury, Se = Selenium, Zn = Zinc

Table 16-3. Surface water and stream sediment monitoring site locations

Waterbody Segment	Site ID	Organization	Latitude	Longitude
American Gulch Creek	DOG-3	DEQ	46.69667	-112.35231
Carpenter Creek	CAR-1	DEQ	46.63151	-112.54308
Dog Creek, lower	DOG-8	DEQ	46.56071	-112.38686
Dog Creek, upper	25-179-SW1	AML	46.720828	-112.354039
Dog Creek, upper	25-179-SW2	AML	46.704518	-112.352716
Dog Creek, upper	25-179-SW4	AML	46.693602	-112.355765
Dog Creek, upper	25-179-SW5	AML	46.693602	-112.355765
Dog Creek, upper	DOG-1	DEQ	46.71944	-112.35498
Dog Creek, upper	DOG-2	DEQ	46.69793	-112.35215
Hope Creek	DOG-5	DEQ	46.67536	-112.38199
Little Blackfoot River, lower	C01LTBLR01/LBF-10	DEQ	46.51949	-112.79343
Little Blackfoot River, lower	LBF-10	DEQ	46.51949	-112.79343
Little Blackfoot River, lower	LBF-7	DEQ	46.57767	-112.51064
Little Blackfoot River, lower	LBF-9	DEQ	46.54842	-112.67853
Little Blackfoot River, lower	12324590/LBF-10	USGS	46.519651	-112.793376
Little Blackfoot River, upper	LBF-1	DEQ	46.39328	-112.47294
Little Blackfoot River, upper	LBF-2	DEQ	46.45729	-112.41854
Little Blackfoot River, upper	LBF-3	DEQ	46.4852	-112.42915
Little Blackfoot River, upper	LBF-4	DEQ	46.50443	-112.40382
Little Blackfoot River, upper	LBF-5	DEQ	46.55673	-112.40946
Little Blackfoot River, upper	LBF0065	USFS	46.4979	-112.411
Little Blackfoot River, upper	LBF0066	USFS	46.5029	-112.404
Monarch Creek	C01MONRC10/MCH-2	DEQ	46.42699	-112.3942
Monarch Creek	MCH-1	DEQ	46.40935	-112.40897
Monarch Creek	MCH-2	DEQ	46.42699	-112.3942
Monarch Creek	MCH-3	DEQ	46.430281	-112.387378
Ontario Creek	ONT-0	DEQ	46.42365	-112.32684
Ontario Creek	ONT-2	DEQ	46.45528	-112.41389
Ontario Creek	ONT-2A	DEQ	46.43141	-112.38577
Ontario Creek	LBF0044	USFS	46.4188	-112.341
Spotted Dog Creek	C01SDOGC01	DEQ	46.57972	-112.60245
Spotted Dog Creek	C01SDOGC02	DEQ	46.47267	-112.53377
Spotted Dog Creek	SPD-1	DEQ	46.46437	-112.52214
Spotted Dog Creek	SPD-4	DEQ	46.58864	-112.60262
Telegraph Creek, lower	TGH-4	DEQ	46.51041	-112.38012
Telegraph Creek, upper	LOB-SW-01	AML	46.4424	-112.3433
Telegraph Creek, upper	LOB-SW-03	AML	46.4438	-112.3438
Telegraph Creek, upper	TGH-2B	DEQ	46.4584	-112.3401
Telegraph Creek, upper	TGH-3	DEQ	46.48848	-112.37032
Telegraph Creek, upper	TGH-3A	DEQ	46.48967	-112.37138
Un-named Creek	ONT-B	AML	46.4283	-112.341
Un-named Creek	ONT-1	DEQ	46.4272	-112.3413
Un-named Creek	LBF0039	USFS	46.4272	-112.341
Un-named Creek	LBF0042	USFS	46.4237	-112.34
Un-named Creek	LBF0043	USFS	46.4197	-112.339
Un-named Creek	LBF0080	USFS	46.4219	-112.34