Appendix A

Total Maximum Daily Load (TMDL) Summary

Framework Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area:

Volume II – Final Report

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Prepared for the Montana Department of Environmental Quality

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1.0 INTRODUCTION

The TMDL and water quality restoration planning process in Montana involves several steps. The first step consists of characterizing the environment in which the water bodies exist (this step is referred to as “watershed characterization”). This is followed by developing a thorough understanding of the water quality problem (what pollutant is causing the impairment and how is the impairment manifested in the water body – referred to in this report as “water quality impairment status”) and establishing water quality goals (“targets”). Once the water quality problem has been defined, the next step is to identify all significant sources of pollutants (“source assessment”). Then, the maximum load of a pollutant (for example, sediment, nutrients, or metals) that a water body is able to assimilate and still fully support its designated uses is determined (the total maximum daily load or TMDL). Next, the pollutant load is allocated among all sources within the watershed, including natural sources (i.e., “allocation”), and voluntary (for nonpoint sources) and regulatory control (for point sources) measures are identified for attaining the source allocations (i.e., “restoration strategy”). Last, a monitoring plan and associated corrective feedback loop are established to ensure that the control measures are effective at restoring water quality and all designated beneficial water uses.

The actual Total Maximum Daily Load is typically expressed as follows:

TMDL = LA + WLA + MOS

Where

LA = the load allocation, or the allocation to non-point sources
WLA = the waste load allocation, or the allocation to point sources
MOS = the margin of safety

Appendix A presents the TMDLs and associated allocations and margins of safety for all of the impaired waters in the Lake Helena TMDL Planning Area (Table 1-1). The water body/pollutant combinations addressed in Appendix A are listed in Table 1-2. A summary is presented in Section 15.

Table 1-1. 303(d) Listed Streams

Clancy Creek	Corbin Creek	Golconda Creek
Granite Creek (Austin Creek)	Granite Creek (Sevenmile Creek)	Jackson Creek
Jennie’s Fork	Lake Helena	Lump Gulch
Middle Fork Warm Springs Creek	North Fork Warm Springs Creek	Prickly Pear Creek
Sevenmile Creek	Silver Creek	Skelly Gulch
Spring Creek	Tenmile Creek	Warm Springs Creek

Table 1-2. Water quality status of suspected impaired water bodies and required TMDLs in the Lake Helena watershed.

Water Body Name and Number	Impairment Causes[a]	Impairment Status[b]	Action
Clancy Creek, MT41I006_120	Siltation/Suspended Solids	Impaired	A TMDL is presented in Section 2.0
	Nutrients	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 2.0.
Corbin Creek, MT41I006_090	Suspended Solids	Impaired	A TMDL is presented in Section 3.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 3.0.
	Temperature	Unknown	A TMDL will not be written at this time.
	Salinity/TDS/Chloride	Impaired for salinity and TDS. Not impaired for Chloride.	A TMDL will not be written. Impairments will be addressed by the metals TMDLs (Section 3.1).
Golconda Creek, MT41I006_070	Suspended Solids/ Turbidity	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for cadmium and lead are presented in Section 4.0.
Granite Creek, MT41I006_179	No pollutants	NA	No TMDL required.
Granite Creek, MT41I006_230	Metals	Unknown (dewatered stream)	A TMDL will not be written at this time.
Jackson Creek, MT41I006_190	Sediment	Not impaired	No TMDL required.
Jennie's Fork, MT41I006_210	Siltation	Impaired	A TMDL is presented in Section 5.0.
	Metals	Impaired	A TMDL for lead is presented in Section 5.0.
Lake Helena, MT41I007_010	Suspended Solids	Unknown	A TMDL will not be written at this time.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 6.0.
	Metals	Impaired	TMDLs for arsenic and lead are presented in Section 6.0.
	Temperature	Unknown	A TMDL will not be written at this time.
Lump Gulch, MT41I006_130	Suspended Solids	Impaired	A TMDL is presented in Section 7.0.
	Metals	Impaired	TMDLs for cadmium, copper, lead, and zinc are presented in Section 7.0.
Middle Fork Warm Springs Creek, MT41I006_100	Siltation	Impaired	A TMDL is presented in Section 14.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, lead, and zinc are presented in Section 14.0.
North Fork Warm Springs Creek, MT41I006_180	Siltation	Impaired	A TMDL is presented in Section 14.0.
	Low DO, Organic Enrichment	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for arsenic, cadmium, and zinc are presented in Section 14.0.
Prickly Pear Creek, MT41I006_060	Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Metals	Impaired	A TMDL for lead is presented in Section 8.0.
Prickly Pear Creek, MT41I006_050	Siltation/ Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Metals	Impaired	TMDLs for cadmium, lead, and zinc are presented in Section 8.0.
Prickly Pear Creek, MT41I006_040	Siltation/ Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 8.0.
	Temperature[c]	Impaired	A TMDL is presented in Section 8.0.

Table 1-2. Water quality status of suspected impaired water bodies and required TMDLs in the Lake Helena watershed.

Water Body Name and Number	Impairment Causes[a]	Impairment Status[b]	Action
Prickly Pear Creek, MT41I006_030	Siltation/ Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 8.0.
	Metals	Impaired	TMDLs for arsenic and lead are presented in Section 8.0.
	Temperature	Impaired	A TMDL is presented in Section 8.0.
Prickly Pear Creek, MT41I006_020	Siltation/ Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 8.0.
	Total Ammonia	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for arsenic, cadmium, and lead are presented in Section 8.0.
	Temperature	Impaired	A TMDL is presented in Section 8.0.
Prickly Pear Creek, MT41I006_010	Metals	Not evaluated	TMDL needs will be addressed as part of the Hauser Reservoir TMDL.
Sevenmile Creek, MT41I006_160	Siltation	Impaired	A TMDL is presented in Section 9.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 9.0.
	Metals	Impaired	TMDLs for arsenic, copper, and lead are presented in Section 9.0.
Silver Creek, MT41I006_150	Metals	Impaired	TMDL for arsenic is presented in Section 10.0.
	Priority organics	Not impaired	No TMDL required.
Skelly Gulch, MT41I006_220	Siltation	Impaired	A TMDL is presented in Section 11.0.
	Metals	Not impaired	No TMDL required.
Spring Creek, MT41I006_080	Suspended Solids	Impaired	A TMDL is presented in Section 12.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 12.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 12.0.
Tenmile Creek, MT41I006_141	Siltation	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 13.0.
Tenmile Creek, MT41I006_142	Siltation	Impaired	A TMDL is presented in Section 13.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 13.0.
Tenmile Creek, MT41I006_143	Siltation	Impaired	A TMDL is presented in Section 13.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 13.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 13.0.
Warm Springs Creek, MT41I006_110	Suspended Solids/ Siltation	Impaired	A TMDL is presented in Section 14.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, lead, and zinc are presented in Section 14.0.

[a]303(d) listed cause of impairment. See water body-by-water body discussions in the following sections and/or Volume I for details regarding 303(d) listing history.
[b]Impairment status is based on Volume I.
[c] Impairment causes that have not been reflected on past 303(d) lists but that were identified during this review.

2.0 CLANCY CREEK

Clancy Creek from the headwaters to the mouth (Segment MT41I006_120, 11.6 miles) was listed as impaired on the Montana 1996 303(d) list because of siltation, suspended solids, nutrients, and metals. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, fishery, and drinking water beneficial uses were listed as impaired because of arsenic, lead, mercury, metals, and siltation. The additional analyses and evaluations described in Volume I found that sediment (suspended solids and siltation), arsenic, cadmium, copper, lead, and zinc are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.12 of the Volume I Report). Nutrients are not impairing beneficial uses, and therefore no TMDLs will be presented. There were insufficient data to determine if mercury is impairing beneficial uses.

Conceptual restoration strategies and the required TMDL elements for sediment and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

2.1 METALS

The available water chemistry data suggest that aquatic life and fish in Clancy Creek are impaired by arsenic, cadmium, copper, lead, and zinc. The following sections present the required TMDL elements for these pollutants.

2.1.1 Sources of Metals in the Clancy Creek Watershed

Besides anthropogenic sediment-associated metals sources, significant contributors of metals to the stream segment are the historical mining activities in the upper watershed. The source assessment showed that, among the 303(d)-listed segments in the Lake Helena TPA, placer mine tailings are the most extensive on Clancy Creek. The headwaters of the watershed fall within the Colorado mining district while the rest is within the Clancy mining district. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, underground, and surface-underground mining activities in the watershed. The historical mining types include placer, lode, and mill. In the past these mines produced manganese, lead, silver, copper, zinc, and gold. Three mines in the headwaters—Gregory, Argentine, and Crawley Camp—are within the Colorado district and are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. The state's inventory shows at least 10 other mines in the headwaters area of this watershed. Modeled sources and their metals loadings to Clancy Creek are presented in Figure 2-1 through Figure 2-5. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

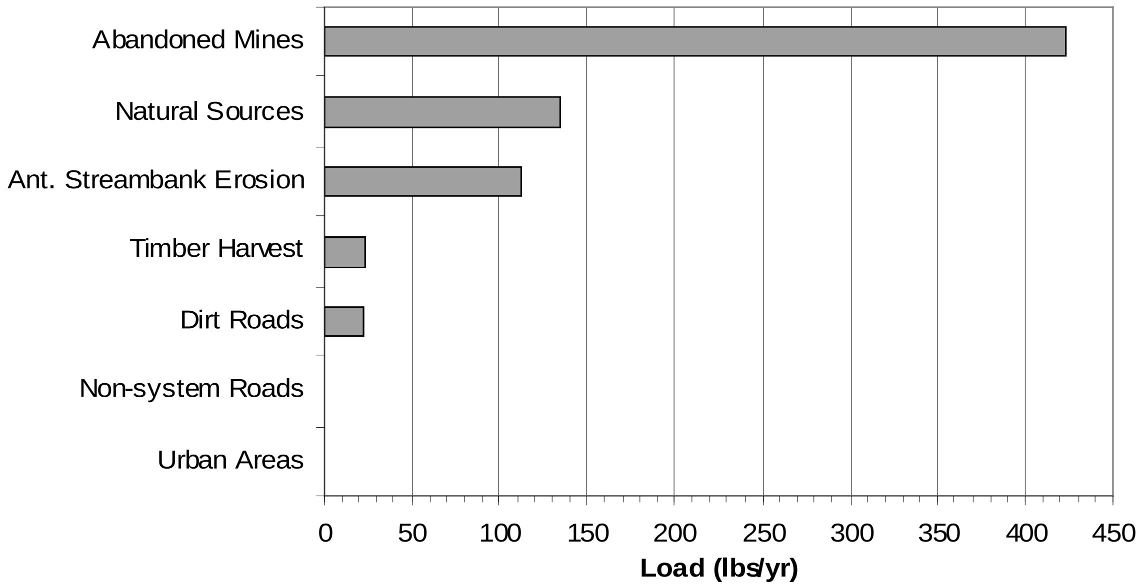

Figure 2-1. Sources of arsenic loadings to Clancy Creek.

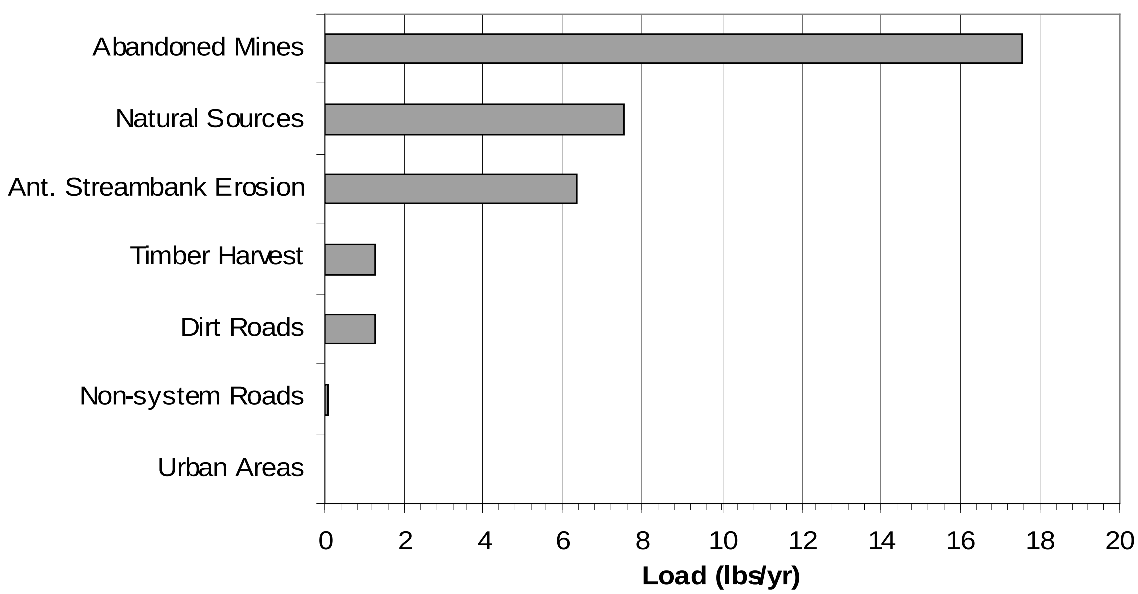

Figure 2-2. Sources of cadmium loadings to Clancy Creek.

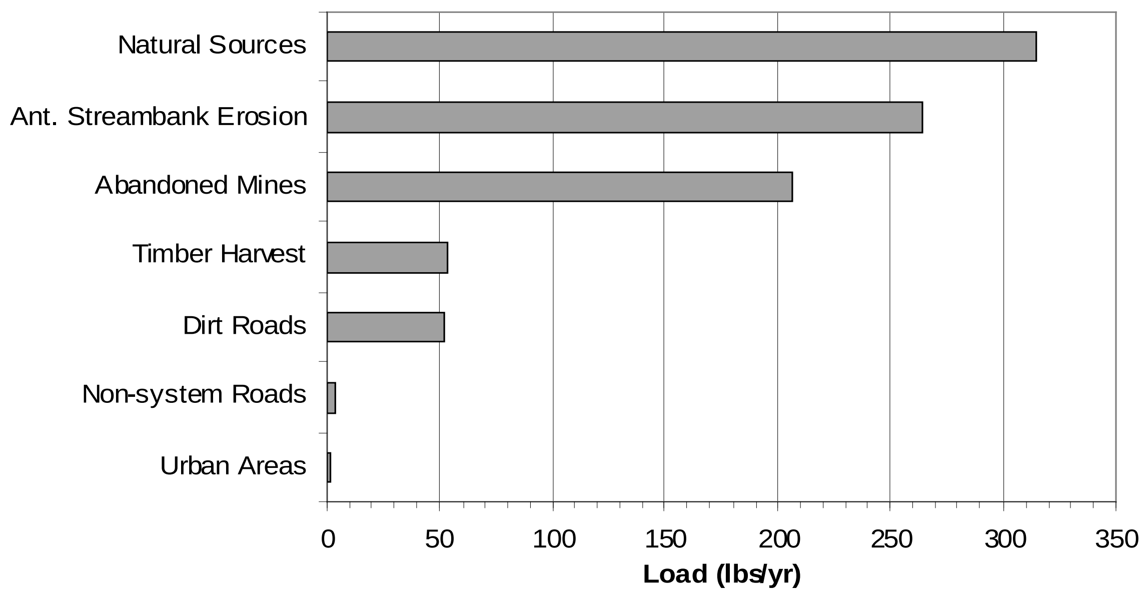

Figure 2-3. Sources of copper loadings to Clancy Creek.

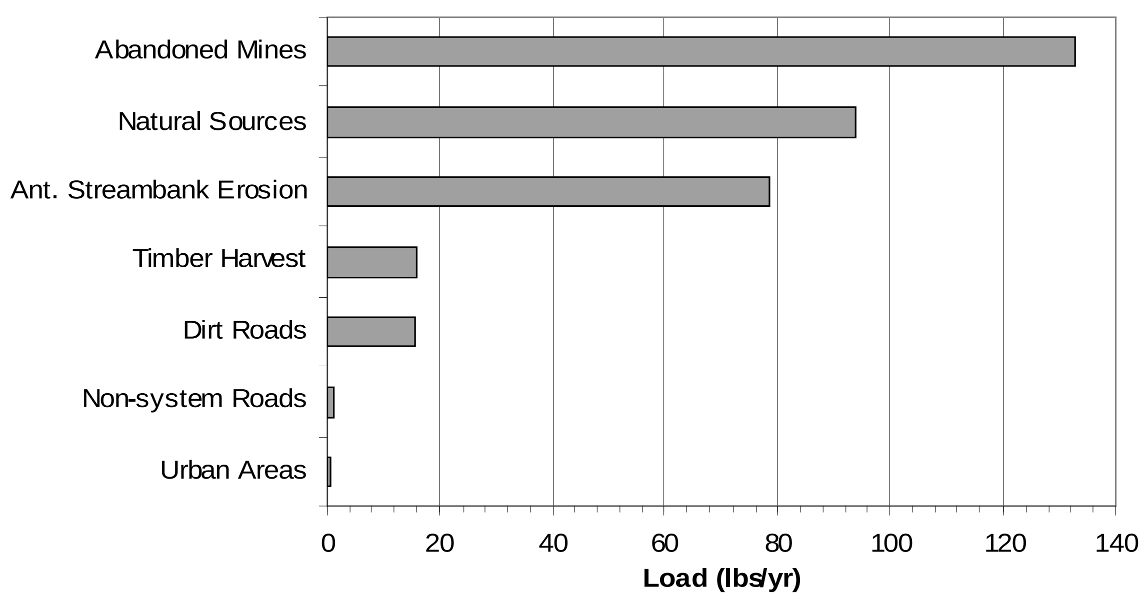

Figure 2-4. Sources of lead loadings to Clancy Creek.

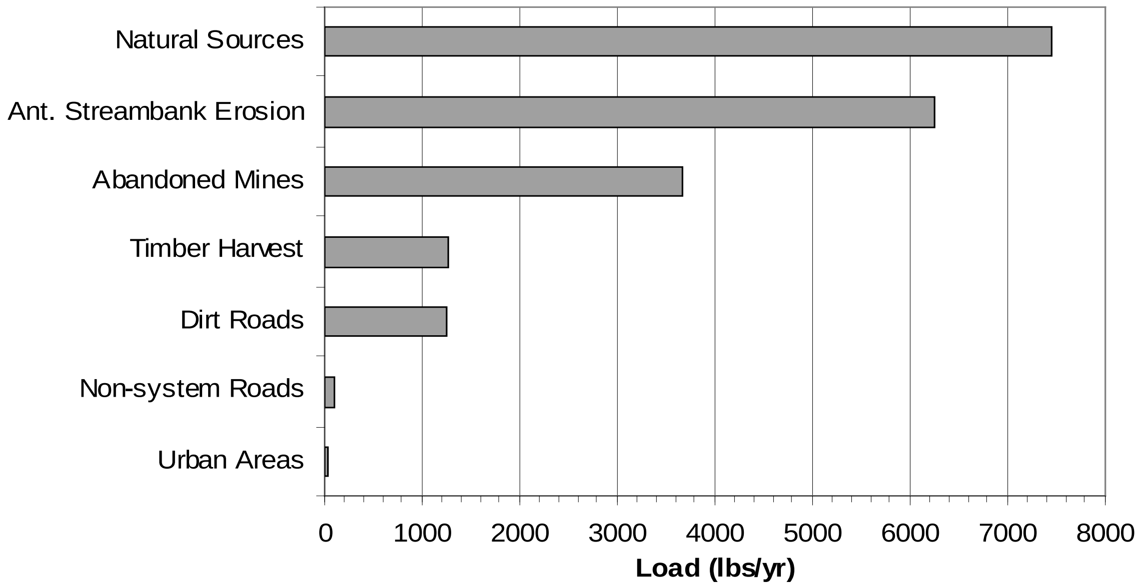

Figure 2-5. Sources of zinc loadings to Clancy Creek.

2.1.2 Water Quality Goals/Targets

The ultimate goal of this TMDL is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Clancy Creek are presented in Table 2-1.

Table 2-1. Montana numeric surface water quality standards for metals in Clancy Creek.

Parameter	Aquatic Life (acute) (μg/L)[a]	Aquatic Life (chronic) (μg/L)[b]	Human Health (μg/L)[a]
Arsenic (TR)	340	150	10 [d]
Cadmium (TR)	2.3 at 105.6 mg/L hardness[c]	0.3 at 105.6 mg/L hardness[c]	5
Copper (TR)	14.6 at 105.6 mg/L hardness[c]	9.6 at 105.6 mg/L hardness[c]	1,300
Lead (TR)	86.3 at 105.6 mg/L hardness[c]	3.3 at 105.6 mg/L hardness[c]	15
Zinc (TR)	126.5 at 105.6 mg/L hardness[c]	126.5 at 105.6 mg/L hardness[c]	2,000

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] The human health standard for arsenic is currently 18 μg/L, but will change to 10 μg/L in 2006.

2.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 2-2 through Table 2-6. Based on the results of the source assessment (Section 2.1.1), the recommended implementation strategy to address the metals problem in Clancy Creek is to reduce metals loadings from abandoned mines, along with the implementation of the sediment TMDLs. As shown in Table 2-2 through Table 2-6, the hypothesis is that an overall, watershed scale metals load reduction of 61, 61, 42, 54, and 47 percent for arsenic, cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current mining sources by 73, 77, 37, 70, and 60 percent for arsenic, cadmium, copper, lead, and zinc, respectively.

Table 2-2. TMDL, Allocations, and Margin of Safety for Clancy Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	422.9	73	114.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	112.9	81	20.9	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1.7	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	22.9	97	0.7	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	22.4	60	9.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.8	80	0.2	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	583.6	75	145.1		
	Natural Sources	134.3	0	134.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**717.9**	**61**	**279.4**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 145.1 lbs/yr + 134.3 lbs/yr + 0 = 279.4 lbs/yr** **TMDL = 0 + 0.40 lbs/day + 0.37 lbs/day + 0 = 0.77 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 2-3. TMDL, Allocations, and Margin of Safety for Clancy Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	17.5	77	4.0	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	6.3	81	1.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.1	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	1.3	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1.3	60	0.5	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.0	80	0.0	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	26.5	78	5.7		
	Natural Sources	7.5	0	7.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**34.0**	**61**	**13.2**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 5.7 lbs/yr + 7.5 lbs/yr + 0 = 13.2 lbs/yr** **TMDL = 0 + 0.016 lbs/day + 0.020 lbs/day + 0 = 0.036 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 2-4. TMDL, Allocations, and Margin of Safety for Clancy Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	206.2	37	130.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	264.2	81	49.0	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	4.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	53.7	97	1.6	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	52.5	60	21.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.9	80	0.4	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	582.5	65	202.8		
	Natural Sources	314.5	0	314.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**897.0**	**42**	**517.6**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 202.8 lbs/yr + 314.5 lbs/yr + 0 = 517.6 lbs/yr** **TMDL = 0 + 0.56 lbs/day + 0.86 lbs/day + 0 = 1.42 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 2-5. TMDL, Allocations, and Margin of Safety for Clancy Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	132.9	70	40.5	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	78.8	81	14.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	16.0	97	0.5	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. [1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	15.7	60	6.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.6	80	0.1	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	245.2	75	62.0		
	Natural Sources	93.8	0	93.8	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**339.0**	**54**	**155.8**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 62.0 lbs/yr + 93.8 lbs/yr + 0 = 155.8 lbs/yr** **TMDL = 0 + 0.17 lbs/day + 0.26 lbs/day + 0 = 0.43 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 2-6. TMDL, Allocations, and Margin of Safety for Clancy Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	3,673.2	60	1,457.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	6,259.7	81	1,161.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	95.4	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	1,271.2	97	38.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1,244.0	60	497.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	45.8	80	9.2	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	12,589.3	75	3,163.7		
	Natural Sources	7,449.6	0	7,449.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**20,038.9**	**47**	**10,613.3**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 3164 lbs/yr + 7450 lbs/yr + 0 = 10,613 lbs/yr** **TMDL = 0 + 8.7 lbs/day + 20.4 lbs/day + 0 = 29.1 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

2.2 SEDIMENT

The available data suggest that aquatic life and fish in Clancy Creek are impaired by siltation/sediment. The following sections present the required TMDL elements for these pollutants. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that they are adequate for making relative comparisons, they should not be used directly as quantity estimates.

2.2.1 Sources of Sediment in the Clancy Creek Watershed

As shown in Figure 2-6, the primary anthropogenic sources of sediment in the Clancy Creek watershed, in order of importance, are streambank erosion, timber harvest, unpaved roads, urban development, and non-system roads/trails. Streambank erosion was primarily caused by riparian grazing, stream channelization from road encroachment, historic mine tailings piles, and channel encisement. Throughout much of the segment length, Clancy Creek Road (unpaved) is directly adjacent to the stream. The close proximity of the road to the stream prohibits sufficient riparian buffer width establishment to intercept road based sediment. Due to the lack of buffer width, removal of road shoulder vegetation from road grading activities, and the inherent erodibility of the granitic geology, road sediment is readily transported to Clancy Creek. Sediment from silvicultural activities is largely confined to mining claims in the upper watershed where riparian buffer width is insufficient to intercept all related eroded sediment. Urban development is confined within the downstream area of the watershed where new residential construction is occurring. Non-system roads and trails were observed in the upper watershed. These roads/trails are a problematic sediment source because no run-off mitigation structures have been constructed, and they are typically located on steep topography, frequently near watercourses.

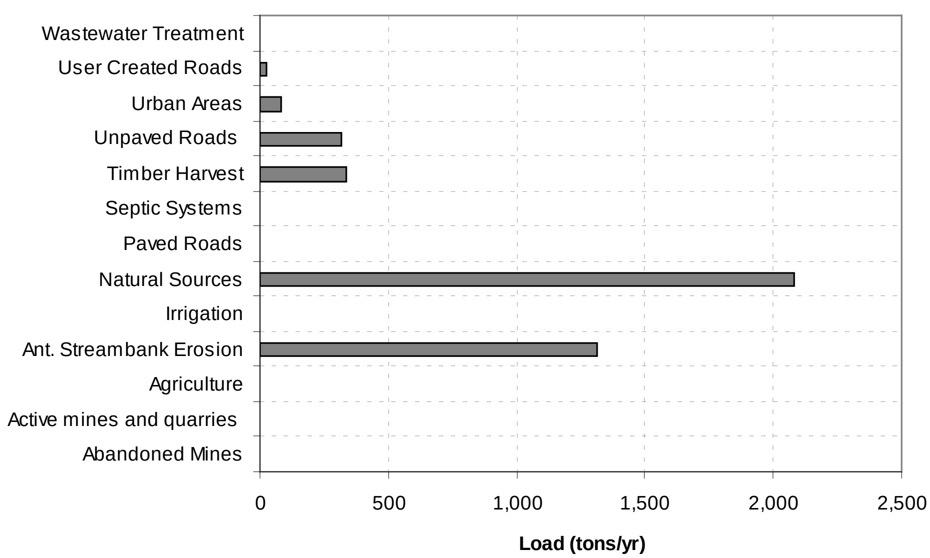

Figure 2-6. Total annual sediment load from all potentially significant sediment sources in the Clancy Creek Watershed.

2.2.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 2-7. Based on the results of the source assessment (Section 2.2.1), the recommended implementation strategy to address the sediment problem in Clancy Creek is to reduce sediment loading from the primary anthropogenic sediment sources – streambank erosion, dirt roads, and timber harvest. As shown in Table 2-7, the hypothesis is that an overall, watershed scale sediment load reduction of 40 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current timber harvest, dirt roads, anthropogenic bank erosion, urban areas, and non-system roads by 97, 60, 81, 80, and 100 percent, respectively.

Table 2-7. TMDL, Allocations, and Margin of Safety for Clancy Creek - Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Anthropogenic Streambank Erosion	1,315	81	250	It is estimated that there are 13.5 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	28	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	333	97	10	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	318	60	127	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	83	80	17	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed including vegetated buffer strips, engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	2,077	81	404		
	Natural Sources	2,082	0	2,082	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**4,159**	**40**	**2,486**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 404 tons/yr + 2,082 tons/yr + 0 = 2,486 tons/yr** **TMDL = 0 + 1.1 tons/day + 5.7 tons/day + 0 = 6.8 tons/day**					

3.0 CORBIN CREEK

Corbin Creek from the headwaters to the mouth (Segment MT41I006_090, 2.5 miles) was listed as impaired on the Montana 1996 303(d) list because of suspended solids, metals, pH, salinity/total dissolved solids/chlorides, and other inorganics. Aquatic life, coldwater fisheries, agriculture, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, fishery, agriculture, industrial, recreational, and drinking water beneficial uses were listed as impaired because of metals, pH, suspended solids, and thermal modifications. The additional analyses and evaluations described in Volume I found that sediment (suspended solids), arsenic, cadmium, copper, lead, zinc, and salinity/TDS are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.7 of the Volume I Report). There were insufficient credible data to determine if thermal modifications are impairing beneficial uses. Additional monitoring for temperature is proposed in Appendix H.

Conceptual restoration strategies and the required TMDL elements for sediment, metals (i.e., arsenic, cadmium, copper, lead, and zinc), and salinity/TDS are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

3.1 Metals

The available water chemistry data suggest that aquatic life and fish in Corbin Creek are impaired by arsenic, cadmium, copper, lead, and zinc. The following sections present the required TMDL elements for these pollutants. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

3.1.1 Sources of Metals in the Corbin Creek Watershed

Besides anthropogenic sediment-associated metals sources, historical hard rock mining activities in the watershed are significant contributors of metals to Corbin Creek. Most of the drainage area falls within the Colorado mining district of Montana, with a small part of the headwaters in the Clancy district. The MBMG Abandoned and Inactive Mines database reports mineral location, surface, surface-underground, and underground mining activities in the watershed. The historical mining types include placer mining. In the past, these mines produced copper, silver, lead, zinc, and gold. Two of the mines in the basin are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites: Bertha and Alta mines – both in the Colorado mining district portion of the watershed. As was mentioned, recent mine reclamation efforts have taken place in the watershed. In 2000, approximately 154,000 cubic yards of spoil were removed from the drainage. Several portals and a deep vertical shaft were sealed. A repository approximately of eight acres in size was constructed on a ridge adjacent to the site and the spoil was encapsulated in an impervious liner and buried to eliminate any leaching into the surface or underground water systems. The entire site was re-seeded with a native grass mixture. Modeled sources and their metals loadings to Corbin Creek are presented in Figure 3-1 through Figure 3-5.

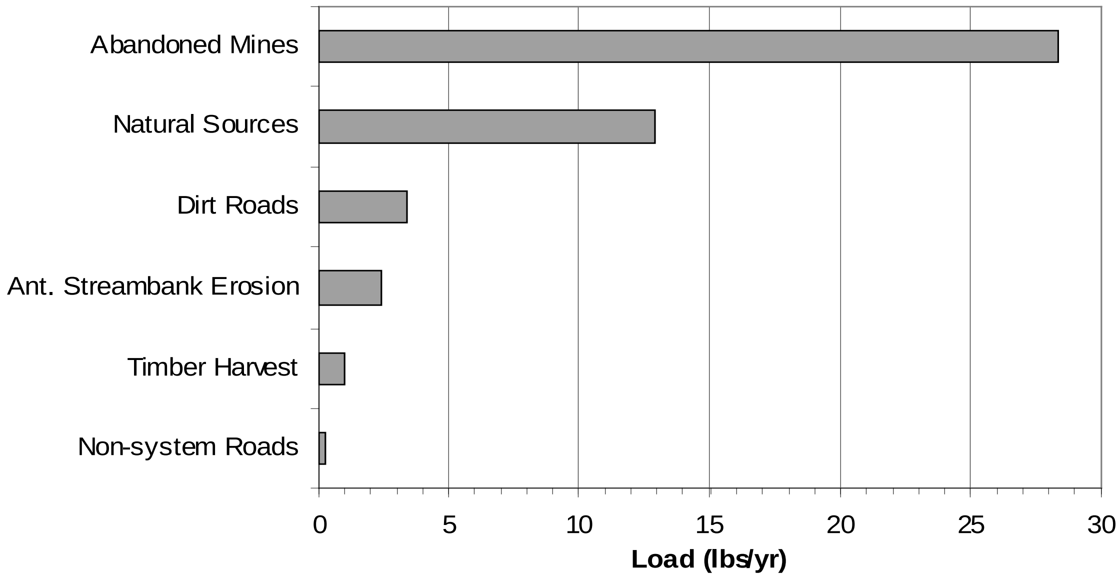

Figure 3-1. Sources of arsenic loadings to Corbin Creek.

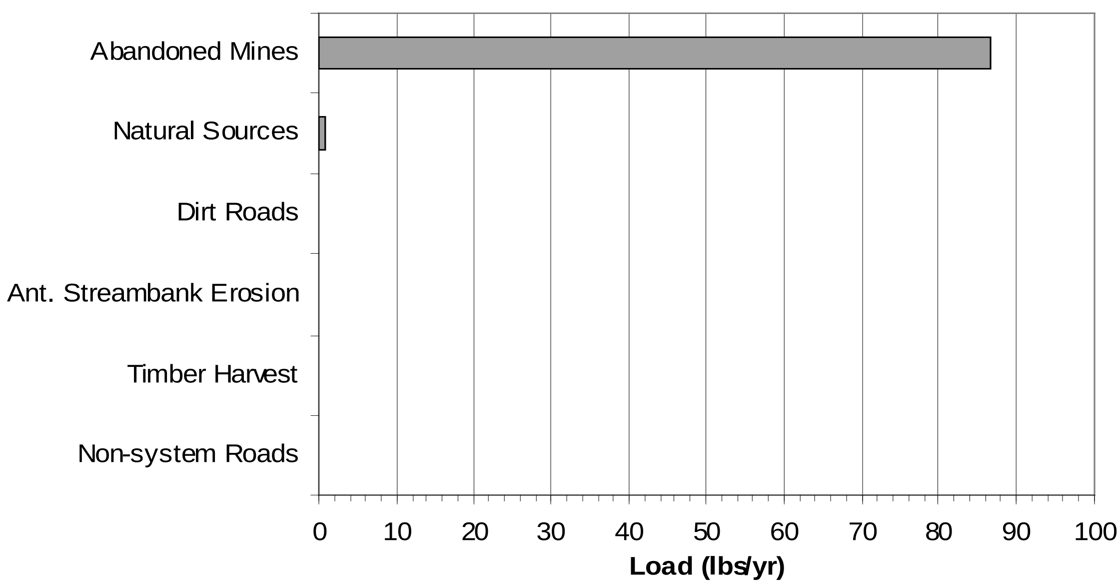

Figure 3-2. Sources of cadmium loadings to Corbin Creek.

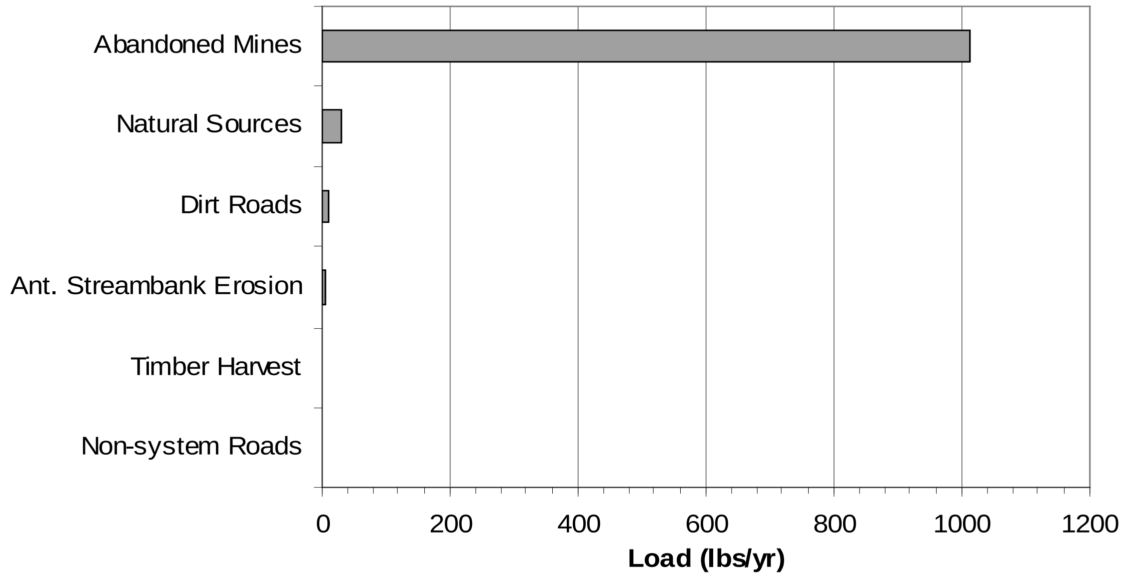

Figure 3-3. Sources of copper loadings to Corbin Creek

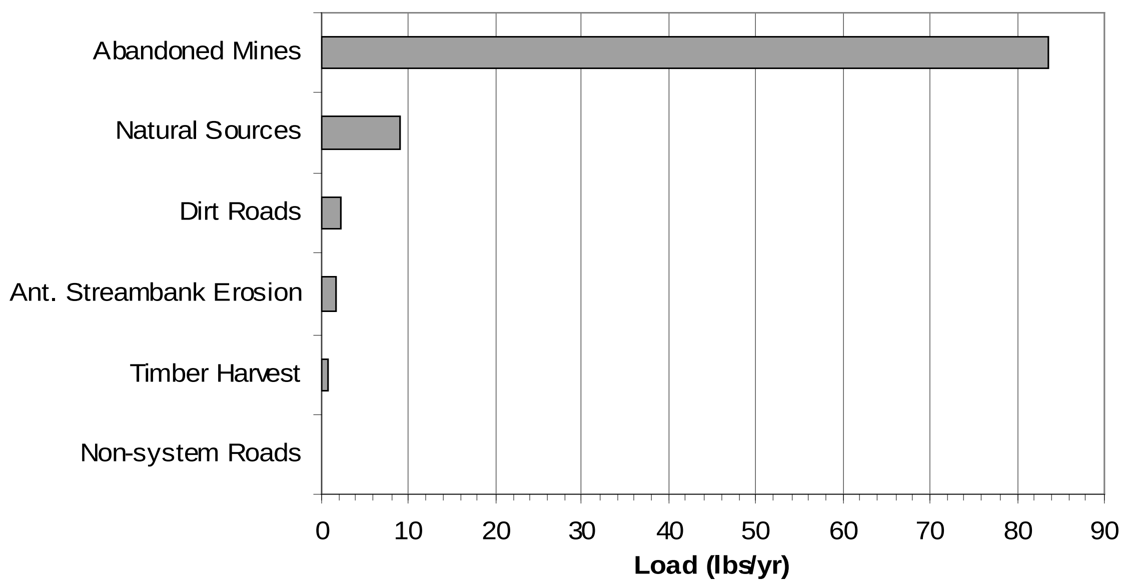

Figure 3-4. Sources of lead loadings to Corbin Creek.

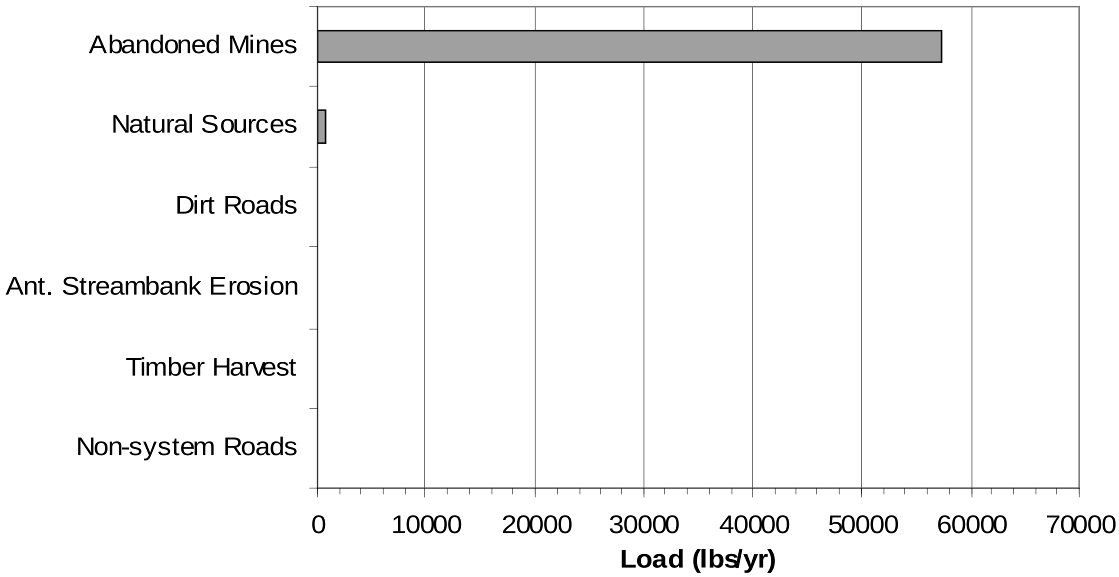

Figure 3-5. Sources of zinc loadings to Corbin Creek.

3.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDLs is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Corbin Creek are presented in Table 3-1.

Table 3-1. Montana numeric surface water quality standards for metals in Spring Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10 [d]
Cadmium (TR)	8.95 at 400 mg/L hardness[c]	0.75 at 400 mg/L hardness[c]	5
Copper (TR)	51.0 at 400 mg/L hardness[c]	29.8 at 400 mg/L hardness[c]	1,300
Lead (TR)	468.3 at 400 mg/L hardness[c]	18.2 at 400 mg/L hardness[c]	15
Zinc (TR)	392.6 at 400 mg/L hardness[c]	392.6 at 400 mg/L hardness[c]	2,000

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

3.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 3-2 through Table 3-6. Based on the results of the source assessment (Section 3.1.1), the recommended implementation strategy to address the metals problem in Corbin Creek is to continue to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 3-2 through Table 3-6, the hypothesis is that an overall, watershed scale metals load reduction of 25, 97, 89, 66, and 97 percent for arsenic, cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from historical mining sources by 23, 98, 92, 73, and 99 percent for arsenic, cadmium, copper, lead, and zinc, respectively. These loads and corresponding load reductions represent water quality conditions based on based on limited water quality data taken on the summer of 2003.

Table 3-2. TMDL, Allocations, and Margin of Safety for Corbin Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	28.4	23	21.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	2.4	92	0.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.3	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	1.0	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	3.4	60	1.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	35.5	34	23.3		
	Natural Sources	12.9	0	12.9	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**48.4**	**25**	**36.2**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 23.3 lbs/yr + 12.9 lbs/yr + 0 = 36.2 lbs/yr** **TMDL = 0 + 0.06 lbs/day + 0.04 lbs/day + 0 = 0.10 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 3-3. TMDL, Allocations, and Margin of Safety for Corbin Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	86.6	98	2.0	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	0.1	92	0.0	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.1	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.2	60	0.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	87.0	98	2.1		
	Natural Sources	0.7	0	0.7	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**87.7**	**97**	**2.8**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 2.1 lbs/yr + 0.7 lbs/yr + 0 = 2.8 lbs/yr** **TMDL = 0 + 0.005 lbs/day + 0.002 lbs/day + 0 = 0.007 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 3-4. TMDL, Allocations, and Margin of Safety for Corbin Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	1,012.0	92	80.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	5.5	92	0.4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.6	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	2.3	97	0.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	7.9	60	3.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1028.3	92	84.4		
	Natural Sources	30.2	0	30.2	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1058.5**	**89**	**114.6**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 84.4 lbs/yr + 30.2 lbs/yr + 0 = 114.6 lbs/yr** **TMDL = 0 + 0.23 lbs/day + 0.08 lbs/day + 0 = 0.31 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 3-5. TMDL, Allocations, and Margin of Safety for Corbin Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	83.6	72	23.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	1.6	92	0.1	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.2	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.7	97	0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.3	60	0.9	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	88.4	73	24.2		
	Natural Sources	9.0	0	9.0	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**97.4**	**66**	**33.2**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 24.2 lbs/yr + 9.0 lbs/yr + 0 = 33.2 lbs/yr** **TMDL = 0 + 0.07 lbs/day + 0.02 lbs/day + 0 = 0.09 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 3-6. TMDL, Allocations, and Margin of Safety for Corbin Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	57,293.9	98	859.4	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	130.6	92	10.5	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	14.3	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	53.4	97	1.6	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	186.4	60	74.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	57,678.6	98	946.1		
	Natural Sources	714.6	0	714.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**58,393.2**	**97**	**1,660.7**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 946.1 lbs/yr + 714.6 lbs/yr + 0 = 1,660.7 lbs/yr** **TMDL = 0 + 2.6 lbs/day + 1.9 lbs/day + 0 = 4.5 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

3.2 Salinity/Total Dissolved Solids

As discussed in Section 3.1, beneficial uses in Corbin Creek are impaired by metals, and load reductions are necessary to meet water quality standards. The Volume I report also found that salinity/total dissolved solids (TDS) are impairing beneficial uses in Corbin Creek. However, the reason for the salinity/TDS impairment appears to be due primarily to dissolved metal concentrations. Metals are usually one small portion of the total dissolved solids in a stream. However, high metals concentrations (as seen in Corbin Creek) also result in elevated total dissolved solids and salinity. The metals data for Corbin Creek show that trace metals make up an unusually large proportion of the total dissolved solids in Corbin Creek. Arsenic, cadmium, copper, lead, and zinc make up almost 2 percent of the total dissolved solids in the stream – three orders of magnitude more than in other surveyed streams in the Lake Helena watershed (see Volume I report). Iron (although not sampled) is also most likely very high as well, because red precipitates were noted in the stream during sampling.

This evidence, combined with the lack of traditional salinity/TDS sources (e.g., saline seeps, irrigation returns, or oil/gas wells) suggests that metals concentrations in Corbin Creek are the primary cause of the salinity/TDS impairment. As such, there is no need at this time for a salinity/TDS TMDL, as the salinity impairment should be addressed with the metals TMDLs (see Section 3.1).

3.3 Sediment

The available data suggest that aquatic life and fish in Corbin Creek are impaired by siltation/sediment. The following sections present the required TMDL elements for these pollutants. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

3.3.1 Sources of Sediment in the Corbin Creek Watershed

As shown in Figure 3-6, the primary anthropogenic sources of sediment in the Corbin Creek watershed, in order of sediment load are: unpaved roads, anthropogenic streambank erosion, abandoned mines, timber harvest, and non-system roads/trails.

Throughout much of its segment length, Corbin Creek Road (unpaved) is directly adjacent to the stream. The close proximity of the road to the stream channel, combined with a lack of any significant riparian vegetation in the lower watershed results in large quantities road based sediment being delivered to the stream. Additionally, a large portion of the total road length in the watershed is steep and generates significant sediment loads. However, between the preliminary source assessment in 2003 and the secondary source assessment conducted during the summer of 2005, a steep “switch-back” section of road was graveled, helping to reduce erosion. Nonetheless, additional lengths of steep, un-graveled road grade are present and continue to deliver sediment and in isolated locations in the upper watershed large gullies have developed.

Observed streambank erosion throughout this segment is largely the result of riparian grazing, stream channelization and historic mining activity. Abandoned mines contribute 16 percent of the total Corbin Creek anthropogenic sediment load. This load is related to two abandoned mines, the Blackjack and the Bertha, which is a high priority mine partially reclaimed by Montana DEQ. Model results indicate Bertha continues to produce notable sediment quantities. Minimal timber harvest activities are occurring in the Corbin watershed, but modeled data suggest that active sediment delivery is occurring. Sediment from silvicultural activities is largely confined to mining claims in the central watershed. Non-system roads/trails were observed in the central and upper watershed, these are mostly related to historic mining activity. These roads/trails are a problematic sediment source because they are typically located in steep topography where run-off diversion structures were not constructed.

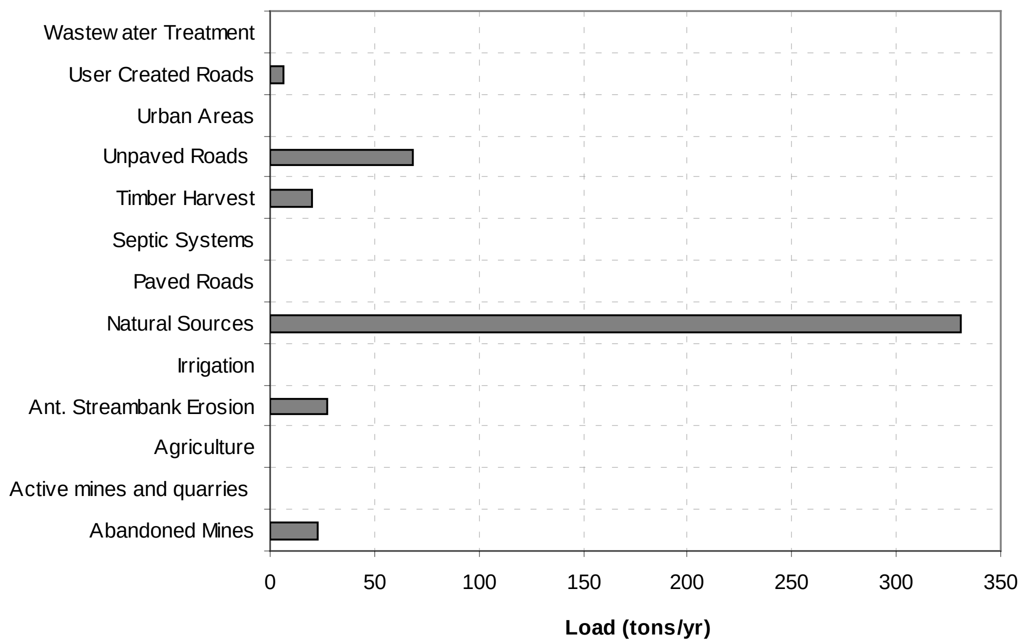

Figure 3-6. Total annual sediment load from all potentially significant sediment sources in the Corbin Creek Watershed.

3.3.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

3.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 3-7. Based on the results of the source assessment (Section 3.3.1), the recommended implementation strategy to address the siltation problem in Corbin Creek is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, anthropogenic streambank erosion, abandoned mines, timber harvest, and non-system roads. As shown in Table 3-7, the hypothesis is that an overall, watershed scale sediment load reduction of 23 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, anthropogenic streambank erosion, abandoned mines, timber harvest, and non-system roads by 60, 92, 79, 97, and 100 percent, respectively.

Table 3-7. TMDL, Allocations, and Margin of Safety for Corbin Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	23	71	7	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	27	92	2	It is estimated that there are 0.7 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	6	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	20	97	1	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate. The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Unpaved Roads	68	60	27	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix C of the Volume I Report).	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	144	77	37		
	Natural Sources	331	0	331	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**475**	**23**	**368**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 37 tons/yr + 331 tons/yr + 0 = 368 tons/yr** **TMDL = 0 + 0.10 tons/day + 0.9 tons/day + 0 = 1.0 tons/day**					

4.0 GOLCONDA CREEK

Golconda Creek from the headwaters to the mouth (Segment MT41I006_070, 3.7 miles) was listed as impaired on the Montana 1996 303(d) list because of metals, suspended solids, turbidity, and unknown toxicity. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, fishery, and drinking water beneficial uses were listed as impaired because of metals. The additional analyses and evaluations described in Volume I found that sediment (suspended solids and turbidity), cadmium and lead are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.6 of the Volume I Report).

Conceptual restoration strategies and the required TMDL elements for sediment and metals (i.e., cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

4.1 METALS

The limited water chemistry data suggest that Golconda Creek is impaired by cadmium and lead. TMDLs are presented in the following sections to address the cadmium and lead impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix C).

4.1.1 Sources of Metals in the Golconda Creek Watershed

Besides anthropogenic sediment-associated metals sources, relevant sources of metals in the stream are the historical mining activities in the watershed. During source assessment efforts, old mining areas were observed in tributary drainages to the west of the main stem of Golconda Creek, and significant mining disturbances were observed on private lands near the main stem. The entire drainage area of the stream falls within the Alhambra mining district of Montana. The MBMG Abandoned and Inactive Mines database reports surface-underground, prospect, and underground mining activities in the watershed. The historical mining types include lode mining. In the past these mines produced copper, silver, lead, gold, and zinc. The State of Montana’s inventory of mine sites shows three mines in the drainage: Buckeye, Golconda, and Big Chief. The last of these three is closest to the stream and once produced lead, zinc, gold, and silver. None of the mines in the basin is listed in the State of Montana’s inventory of High Priority Abandoned Hardrock Mine Sites. Modeled sources and their metals loadings to Golconda Creek are presented in Figure 4-1 and Figure 4-2.

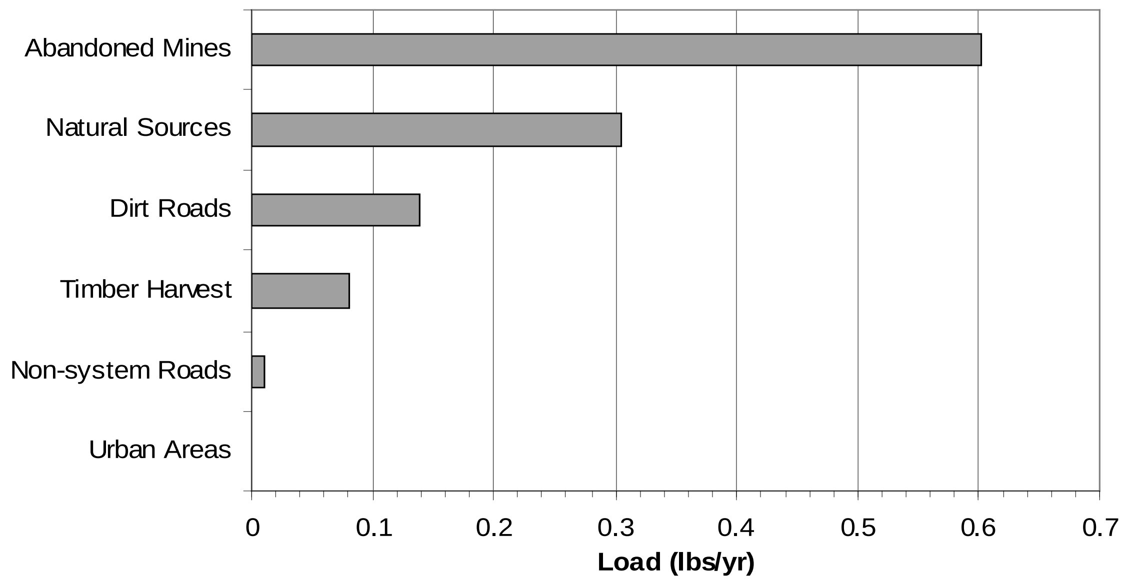

Figure 4-1. Sources of cadmium loadings to Golconda Creek.

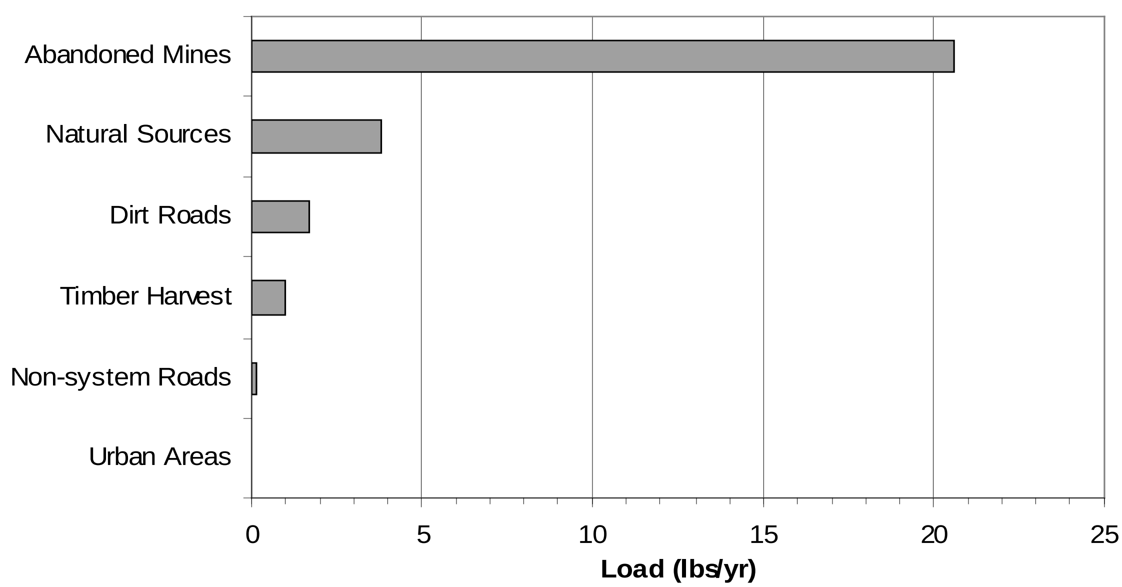

Figure 4-2. Sources of lead loadings to Golconda Creek.

4.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDLs is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in the Golconda Creek are presented in Table 4-1.

Table 4-1. Montana numeric surface water quality standards for metals in Golconda Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Cadmium (TR)	0.8 at 38.5 mg/L hardness[c]	0.1 at 38.5 mg/L hardness[c]	5
Lead (TR)	23.9 at 38.5 mg/L hardness[c]	0.9 at 38.5 mg/L hardness[c]	15

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).

4.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 4-2 and Table 4-3. Based on the results of the source assessment (Section 4.1.1), the recommended implementation strategy to address the metals problem in Golconda Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 4-2 and Table 4-3, the hypothesis is that an overall, watershed scale metals load reduction of 41 and 77 percent for cadmium and lead respectively will result in achievement of the applicable water quality standards. Golconda Creek already meets applicable water quality standards for arsenic, copper, and zinc. The proposal for achieving the load reduction is to reduce loads from historical mining sources by 49 and 92 percent for cadmium and lead.

Table 4-2. TMDL, Allocations, and Margin of Safety for Golconda Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.6	49	0.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Non-system Roads	0.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.1	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.1	60	0.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	0.8	50	0.4		
	Natural Sources	0.3	0	0.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Golconda Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**1.1**	**41**	**0.7**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 0.4 lbs/yr + 0.3 lbs/yr + 0 = 0.7 lbs/yr** **TMDL = 0 + 0.0011 lbs/day + 0.0008 lbs/day + 0 = 0.0019 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 4-3. TMDL, Allocations, and Margin of Safety for Golconda Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	20.6	92	1.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Non-system Roads	0.1	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	1.0	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1.7	60	0.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	23.4	89	2.5		
	Natural Sources	3.8	0	3.8	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Golconda Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**27.2**	**77**	**6.3**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 2.5 lbs/yr + 3.8 lbs/yr + 0 = 6.3 lbs/yr** **TMDL = 0 + 0.007 lbs/day + 0.010 lbs/day + 0 = 0.017 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

5.0 JENNIE'S FORK FROM THE HEADWATERS TO THE MOUTH

Jennie's Fork from the headwaters to the mouth (Segment MT41I006_210, 1.2 miles) was listed as impaired on the Montana 1996 303(d) list because of siltation and metals. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, there were insufficient credible data to evaluate beneficial uses. The additional analyses and evaluations described in Volume I found that sediment (siltation) and lead are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.3.1 of the Volume I Report).

Conceptual restoration strategies and the required TMDL elements for sediment and lead are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

5.1 METALS

The limited water column samples suggest that Jennie's Fork is impaired by lead. A TMDL is presented in the following sections to address the lead impairment. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

5.1.1 Sources of Metals in the Jennie's Fork Watershed

Besides anthropogenic sediment-associated metals sources, significant contributors of metals to the stream segment are historical hard rock mining activities in the upper watershed. The watershed falls within the Marysville mining district. The MBMG Abandoned and Inactive Mines database reports mineral location mining activities in the watershed. The historical mining type is lode mining. In the past these mines produced gold, silver, and lead. One mine in the watershed, Bald Mountain, is listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. During the source assessment conducted by EPA in 2003 as a part of the TMDL project, it was learned that Jennie's Fork's point of origin is a mine shaft on Mount Belmont. The state has conducted significant reclamation work at this location and mining was active at this particular site until the late 1990s. Modeled sources and their lead loadings to Jennie's Fork are presented in Figure 5-1.

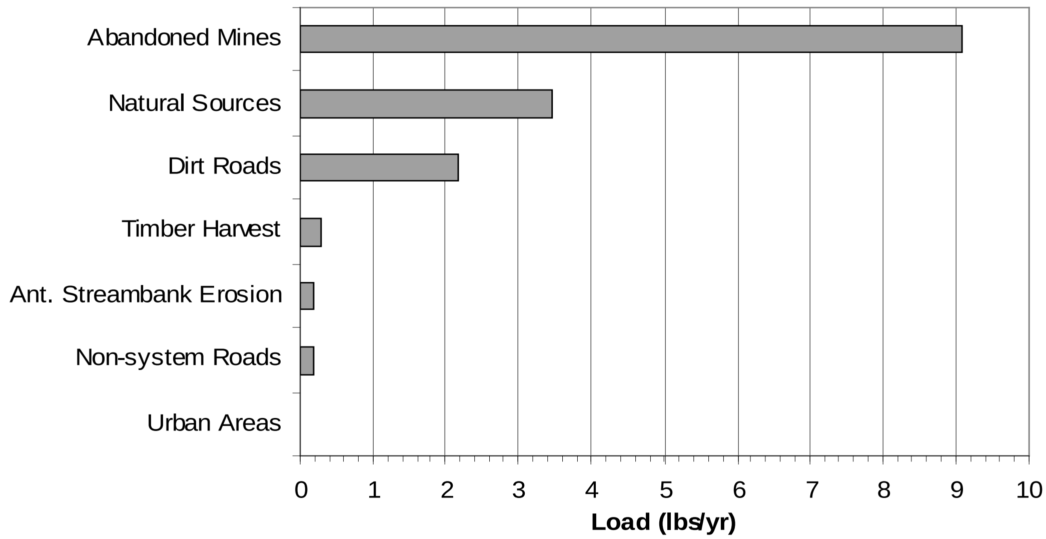

Figure 5-1. Sources of lead loadings to Jennie's Fork.

5.1.2 Water Quality Goals/Targets

The ultimate goal of the lead TMDL is to attain and maintain the applicable Montana numeric standard. Montana water quality metals standards for lead are dependent on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Jennie's Fork are presented in Table 5-1.

Table 5-1. Montana numeric surface water quality standards for metals in Jennie's Fork.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Lead (TR)	118.7 at 135.8 mg/L hardness[c]	4.6 at at 135.8 mg/L hardness[c]	15

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).

5.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 5-2. Based on the results of the source assessment (Section 5.1.1), the recommended implementation strategy to address the metals problem in Jennie's Fork is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 5-2, the hypothesis is that an overall, watershed scale metals load reduction of 46 percent for lead will result in achievement of the applicable water quality standards. Jennie's Fork already meets applicable water quality standards for arsenic, cadmium, copper and zinc. The proposal for achieving the load reduction is to reduce loads from mining sources by 57 percent for lead.

Table 5-2. TMDL, Allocations, and Margin of Safety for Jennie's Fork – Lead.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	9.1	57	3.9	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	0.2	44	0.1	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 44% (see Table 5-3), thereby reducing sediment associated metals loads from streambank erosion by 44%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.3	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.2	60	0.9	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 5-3).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	12.0	59	4.9		
	Natural Sources	3.5	0	3.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Jennie's Fork Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**15.5**	**46**	**8.4**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 4.9 tons/yr + 3.5 tons/yr + 0 = 8.4 lbs/yr** **TMDL = 0 + 0.013 tons/day + 0.010 tons/day + 0 = 0.023 tons/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

5.2 SEDIMENT

Based on the weight of evidence, cold-water fishery and aquatic life beneficial uses in Jennie's Fork are impaired by siltation (see Volume I Report). A TMDL is presented in the following sections to address the siltation impairment. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

5.2.1 Sources of Sediment in the Jennie's Fork Watershed

As shown in Figure 5-2, the primary anthropogenic sources of sediment in the Jennie's Fork watershed, in order of sediment load are unpaved roads, timber harvest, non-system roads, and anthropogenic streambank erosion.

The Jennie's Fork watershed has a high road density related to the town of Marysville, historic mining activity and the Great Divide ski area (all unpaved roads). During the sediment source assessment significant quantities of sediment were observed entering Jennie's Fork from the ski area parking lot during spring snowmelt run-off from the area's ski runs. Timber harvest activities have occurred throughout the upper watershed on mining claims and for the creation of ski runs at Great Divide. Non-system roads are associated with ski area and/or historic mining activities. Anthropogenic streambank erosion in this segment is largely the result of grazing impacts, road encroachment, stream channelization and historic mining activity.

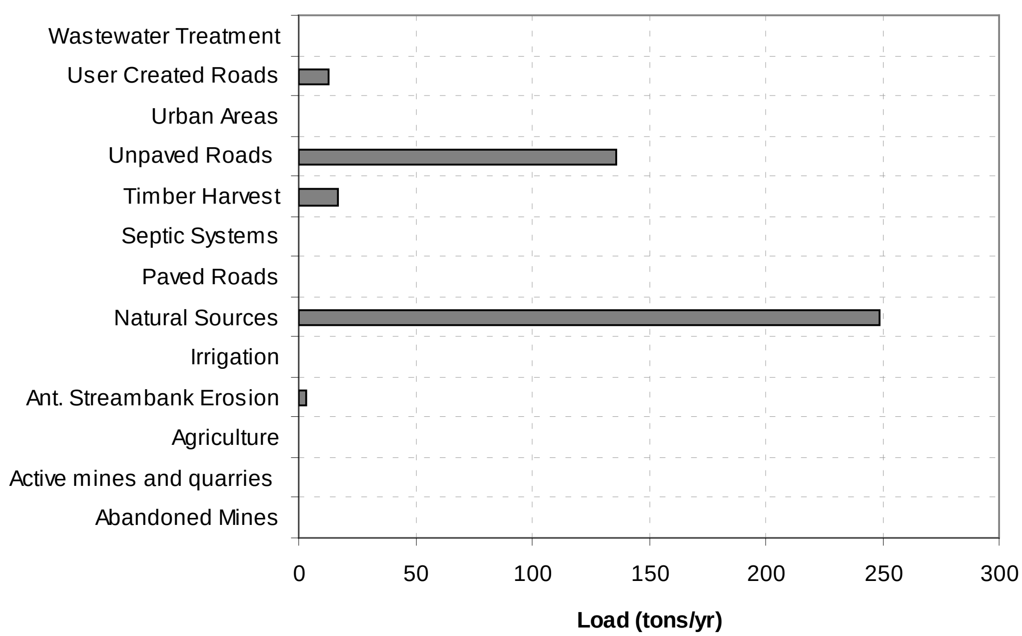

Figure 5-2. Total annual sediment load from all potentially significant sediment sources in the Jennie's Fork Watershed.

5.2.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

5.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 5-3. Based on the results of the source assessment (Section 5.2.1), the recommended implementation strategy to address the siltation problem in Jennie's Fork is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, timber harvest, non-system roads anthropogenic streambank erosion. As shown in Table 5-3, the hypothesis is that an overall, watershed scale sediment load reduction of 27 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, timber harvest, non-system roads, and anthropogenic streambank erosion by 60, 97, 100, and 44 percent, respectively.

Table 5-3. TMDL, Allocations, and Margin of Safety for Jennie's Fork – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
	Anthropogenic Streambank Erosion	3	44	1.7	It is estimated that there are 0.2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	13	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	17	97	0.5	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	136	60	54.4	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix C of the Volume I Report).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	169	67	57		
	Natural Sources	249	0	249	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Jennie's Fork Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**418**	**27**	**306**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 57 tons/yr + 249 tons/yr + 0 = 306 tons/yr** **TMDL = 0 + 0.16 tons/day + 0.68 tons/day + 0 = 0.84 tons/day**					

6.0 LAKE HELENA

Lake Helena (Segment MT41I007_010) was listed as impaired because of metals, nutrients, suspended solids, and thermal modifications on the Montana 1996 303(d) list. Aquatic life, coldwater fisheries, and recreation uses were the listed impaired beneficial uses. On subsequent 303(d) lists (2000, 2002, and 2004), lead and arsenic were the only listed causes of impairment, and only for drinking water uses. Reassessment of the listed pollutants using a weight of evidence approach found that metals are impairing aquatic life and fishery beneficial uses. There was insufficient information to determine if suspended solids and thermal modifications are impairing beneficial uses (see Volume I report). Conceptual restoration strategies and the required TMDL elements for metals are presented in the following subsections.

Available data also suggests that nutrients are decreasing water clarity and increasing the incidence of algal blooms in Lake Helena. However, insufficient data are available to determine the nutrient concentration threshold, above which beneficial uses in Lake Helena would be impaired. Given that model simulations indicate that nutrient loading in the Lake Helena Watershed is increasing, and water quality conditions are predicted to deteriorate, a pro-active TMDL is presented herein for nutrients in Lake Helena. As described below, an adaptive management strategy is proposed to revise the Lake Helena nutrient TMDL in the future based on future data collection efforts.

6.1 METALS

The limited water chemistry data suggest that Lake Helena is impaired by arsenic and lead. TMDLs are presented in the following sections to address the arsenic and lead impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

6.1.1 Sources of Metals in the Lake Helena Watershed

Waterborne contaminants originating within many of the 303(d) listed stream drainages are ultimately transported to Lake Helena. Metals sources for most of these major tributaries are summarized in Chapters 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, and 14 of this Appendix (Appendix A). Local sediment sources also contribute to an increase in arsenic loading to Lake Helena. In addition, contaminated bottom sediment is a potential metals source. These sources are discussed in Appendix F (LSPC modeling) and Appendix C of the Volume I Report. Modeled sources and their metals loadings to Lake Helena are presented in Figure 6-1 and Figure 6-2.

6.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDLs is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for lead is dependant on the ambient water hardness and can therefore vary by water body. The target concentrations for metals in Lake Helena are presented in Table 6-1.

Table 6-1. Montana numeric surface water quality standards for metals in Lake Helena.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10[d]
Lead (TR)	157.6 at 169.7 mg/L hardness[c]	6.1 at 169.7 mg/L hardness[c]	15

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

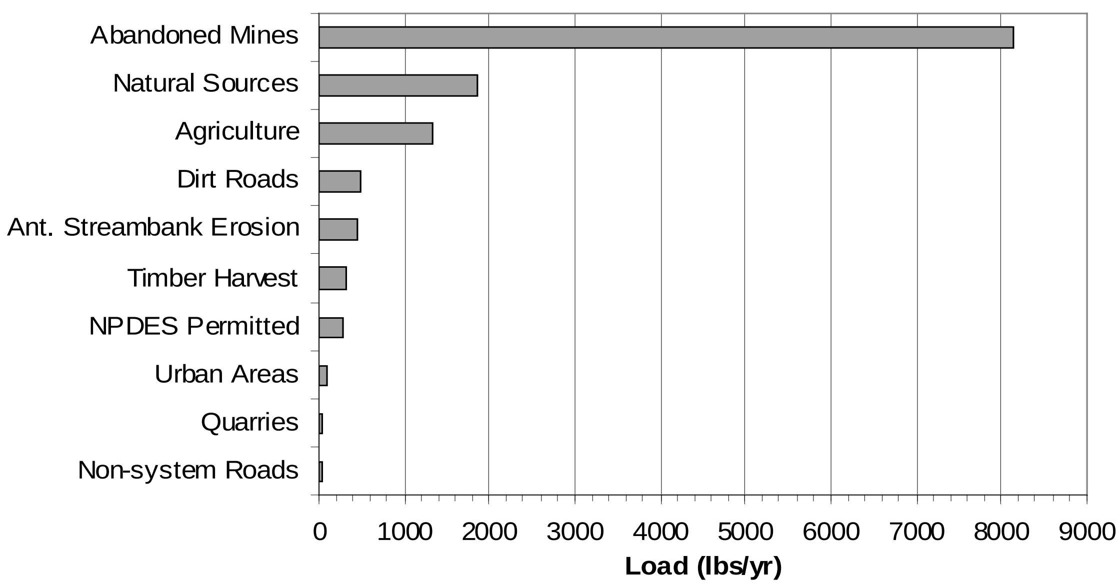

Figure 6-1. Sources of arsenic loadings to Lake Helena.

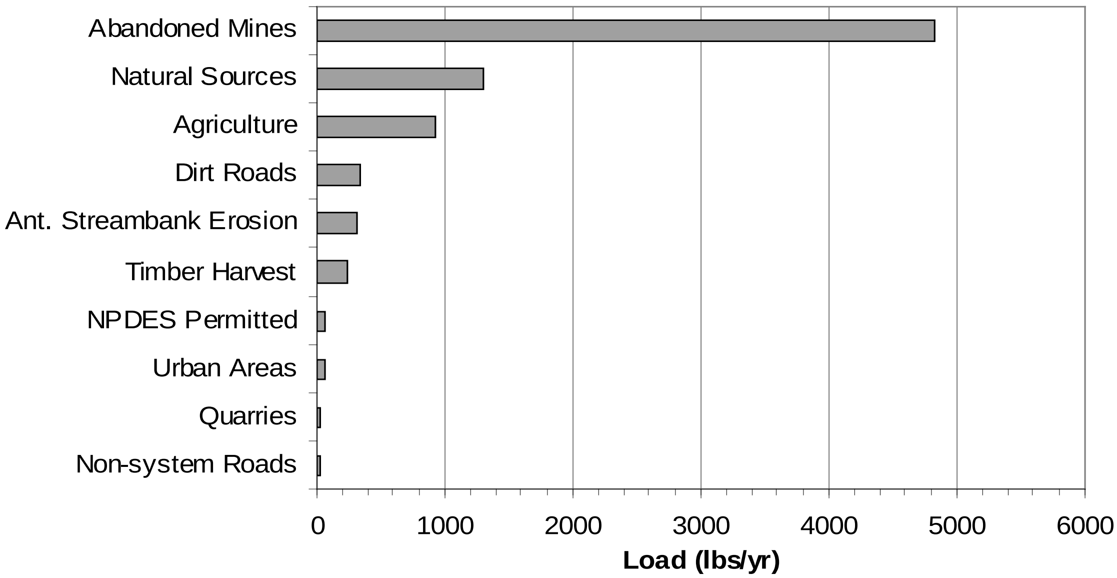

Figure 6-2. Sources of lead loadings to Lake Helena.

6.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations, and margin of safety are presented in Table 6-2 and Table 6-3. Based on the results of the source assessment (Section 6.1.1) the recommended implementation strategy to address the metals problem in Lake Helena is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 6-2 and Table 6-3, the hypothesis is that an overall, watershed scale metals load reduction of 61 and 66 percent for arsenic and lead, respectively, will result in achievement of the applicable water quality standards. Lake Helena already meets applicable water quality standards for cadmium, copper, and zinc. The proposal for achieving the load reduction is to reduce loads from mining sources by 68 and 77 percent for arsenic and lead.

Table 6-2. TMDL, Allocations, and Margin of Safety for Lake Helena – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	8,129.6	68	2,619.7	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	1,325.5	90	127.4	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	446.9	82	79.1	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	38.5	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	38.8	0	38.8	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	325.7	97	10.4	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	502.6	60	201.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	94.1	80	19.1	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	10,901.7	72%	3,095.5		
	Natural Sources	1,859.5	0	1,859.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
	All Point Sources	271.0	45	149.2	The permitted point sources of metals include MT Tunnels Mines and ASARCO. The current permit limits have been applied.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**13,032.2**	**61**	**5,104.2**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 149.2 + 3,095.5 lbs/yr + 1,859.5 lbs/yr + 0 = 5,104.2 lbs/yr** **TMDL = 0.41 + 8.48 lbs/day + 5.09 lbs/day + 0 = 13.98 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 6-3. TMDL, Allocations, and Margin of Safety for Lake Helena – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	4,833.9	77	1,100.7	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	925.5	90	88.9	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	312.1	82	55.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	26.9	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	27.1	0	27.1	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	227.4	97	7.3	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	350.9	60	140.4	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	65.7	80	13.3	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	6,769.5	79	1,432.9		
	Natural Sources	1,298.3	0	1,298.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	66.8	0	66.8	The permitted point sources of metals include MT Tunnels Mines and ASARCO. The current permit limits have been applied.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**8,134.6**	**66**	**2,798.0**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 66.8 + 1,432.9 lbs/yr + 1,298.3 lbs/yr + 0 = 2,798 lbs/yr** **TMDL = 0.18 + 3.92 lbs/day + 3.56 lbs/day + 0 = 7.66 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

6.2 NUTRIENTS

6.2.1 Limiting Nutrient

Nitrogen and phosphorus are the two elements most commonly limiting algal growth in lakes and streams. Some indication of whether nitrogen or phosphorus is growth limiting may be obtained by determining the weight ratio of the appropriate forms of nitrogen and phosphorus found in a river or lake, and comparing that with the stoichiometric ratio required for growth. Where the ratio of nitrogen to phosphorus is greater than 15:1, phosphorus is more likely limiting than nitrogen. If the ratio is less than 5:1, nitrogen is more likely limiting than phosphorus. If the ratio is less than 15 but greater than 5, either N or P could be limiting, or an N and P co-limitation could be present. For assessing nutrient limitations in streams, the N:P ratios are usually computed on the basis of the soluble inorganic forms of N and P (i.e. TSIN:SRP). For lakes, nutrient ratios are commonly computed on the basis of the total forms of N and P. This is because nutrients may cycle in lakes and become soluble over time or under certain physical and chemical conditions. Total N and total P relate better overall to seasonal and lake wide productivity.

It is important to know which nutrient is limiting such that control efforts can focus on the nutrient most likely causing the beneficial use impairments.

A review was performed of the available nitrogen and phosphorus data for Lake Helena. Four water column samples collected by the Montana Department of Environmental Quality in early August 2002 showed an average total N to total P ratio of 9.6:1, with a range from 8.5 to 10.3. Four samples collected by Land & Water Consulting in late August 2003 showed a TN:TP ratio of 2.7:1, with a range of 2.6 to 2.8. Three additional samples collected by Land & Water during runoff conditions in late June 2003 showed a TN:TP ratio of 9.3:1 with a range of 7.8 to 10.2. A fourth sample collected near the lake inlet produced a ratio of 50.5:1 due to a very low total P measurement, which may have been in error.

The Lake Helena nutrient ratio data presented above point to a conclusion that algae growth in the lake is either nitrogen limited (August 2003), or N and/or P limited (August 2002, June 2003). Based on these total nutrient ratio data, it can be concluded that the lake is not overwhelmingly phosphorus limited. Computing the N:P ratios using the soluble inorganic nutrient fractions suggests a stronger nitrogen limitation in Lake Helena, rather than a co- or P-limitation.

In the absence of a strong case for either N or P limitation, TMDLs are presented below for both nitrogen and phosphorus.

6.2.2 Nitrogen

6.2.2.1 Sources of Nitrogen in the Lake Helena Watershed

At the watershed scale (i.e., the entire Lake Helena Watershed), septic systems (29 percent), return flows from the Helena Valley Irrigation System (17 percent), municipal wastewater treatment facilities (11 percent), and urban areas (6 percent) comprise the most significant sources of total nitrogen (TN) (Figure 6-3). Also, in localized areas, TN loading from agricultural and single family residential sources may be far more significant than this source category appears to be at the watershed scale.

6.2.2.2 Water Quality Goals/Targets

Insufficient data are currently available to establish TN targets for Lake Helena. A strategy to establish targets in the future is presented in Volume II, Section 3.2.3.

6.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

Since no concentration targets have been proposed for Lake Helena, it is assumed that the load reductions for Prickly Pear Creek (the largest tributary to Lake Helena) adequately approximate the necessary load reductions. A TN load reduction of 80 percent is therefore proposed as an interim load reduction goal. This will be revised in the future following the strategy presented in Volume II, Section 3.0.

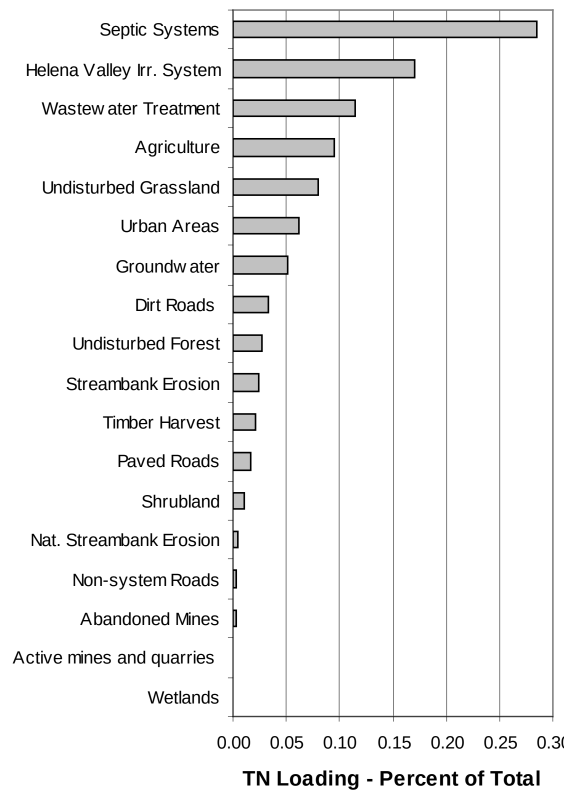

Figure 6-3. Percent of the total annual nitrogen load from all potentially significant nitrogen sources in the entire Lake Helena Watershed.

The proposed approach acknowledges that it may not be possible to attain the an 80 percent TN load reduction, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality will continue to degrade if no action is taken to reduce loading. Therefore, the proposed approach seeks the maximum attainable nitrogen load reductions from non-point sources, includes a phased wasteload allocation to reduce point sources loads, and, in recognition of the fact that it a TN concentration target has not yet been established, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 6-4. The phased wasteload allocation is presented in Appendix I and the adaptive management strategy is presented in Volume II, Section 3.0. Finally, a summary of estimated loads, proposed reductions, and post-reduction loads for all sources considered in the TN analysis is presented in Table 6-5.

Table 6-4. TMDL, Allocations, and Margin of Safety for Lake Helena – Nitrogen.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.9	71	0.2	Nutrient loading from abandoned mines is primarily a function of associated sediment loading. Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%. Sediment-associated nitrogen will decrease accordingly (71%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Active Mines	0.4	0	0.4	BMPs for active mines were assumed to not be cost effective because the loads represent such a small fraction of the current overall loads.	Current loads from active mines are based on modeled storm water runoff and literature values for runoff concentrations. The current loads are likely overestimated because DEQ reports that there has never been a discharge from the MT Tunnels Mine site (the only significant active mine in the watershed).
	Agriculture	33.2	88	3.9	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	8.5	85	1.3	It is estimated that there are 82.8 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Helena Valley Irrigation District (HVID)	60.1	50	30.0	It is difficult to estimate potential load reductions from the HVID due to its unique and complex nature. No appropriate literature values are available. A 50 percent reduction has therefore been selected based on best professional judgment.	Estimates of current loads from the HVID are based on limited sampling data and potential load reductions are based on best professional judgment. Therefore, the estimated load and load reduction may be under or overestimated.
	Non-system Roads	0.9	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	5.7	30	4.0	An average nitrogen removal efficiency of 30% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	101.5	0.5	101.0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 0.5% decrease in TN. Replacing failing septic systems with level 2 treatment could result in a 1.7% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated. No specific data were available about the actual percentage of failing systems.
	Timber Harvest	7.6	97	0.2	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	11.5	60	4.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	21.8	30	15.3	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	252.1	36	160.9		
	Natural Sources	60.9	0	60.9	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	40.4	89	4.4	Nitrogen Point sources are listed in Table 6-5. The allocations for the WWTPs are based on the phased approach described in Appendix I. Load reductions for known failing lagoons are presented in Table 6-5. No allocations are proposed for lagoons thought to be operating as designed.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**353.4**	**36**	**226.2**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 4.4 + 160.9 tons/yr + 60.9 tons/yr + 0 = 226.2 tons/yr** **TMDL = 0.01 + 0.44 tons/day + 0.17 tons/day + 0 = 0.62 tons/day**					

Table 6-5. Estimated loads and load reductions for all sources of TN in the Lake Helena watershed.

Source Category	Source	Estimated TN Load (tons/yr)	Estimated Reductions (%)	Remaining Load (tons/yr)
Anthropogenic Nonpoint Sources	Timber Harvest	7.6	97%	0.2
	Unpaved Roads	11.5	60%	4.6
	Non-system Roads	0.9	100%	0.0
	Paved Roads	5.7	30%	4.0
	Active mines and quarries	0.4	0%	0.4
	Abandoned Mines	0.9	71%	0.2
	Agriculture	33.2	88%	3.9
	Urban Areas	21.8	30%	15.3
	Anthropogenic Streambank Erosion	8.5	85%	1.3
	Helena Valley Irrigation System	60.1	50%	30.0
	Septic Systems	101.5	0.5%	101.0
	Total Anthropogenic NPS Load	**252.1**	36%	**160.9**
Natural Nonpoint Sources	Fullgrowth Forest	9.5	0%	9.5
	Wetlands	0.1	0%	0.1
	Shrubland	3.5	0%	3.5
	Grassland	28.2	0%	28.2
	Nat. Streambank Erosion	1.6	0%	1.6
	Groundwater	18.0	0%	18.0
	Total Natural NPS Load	**60.9**	0%	**60.9**
Point Sources	City of Helena	31.8	92%	2.5[1]
	East Helena	6.5	97%	0.2[1]
	Evergreen Nursing Home	0.1	0%	0.1
	Treasure State Acres subdivision	0.1	50%	0.0
	Tenmile and Pleasant Valley subdivisions	0.8	21%	0.6
	Mountain View law enforcement academy	0.2	0%	0.2
	Eastgate Subdivision	0.1	0%	0.1
	Leisure Village mobile home park	0.8	20%	0.7
	Total Point Source	**40.4**	89%	**4.4**
Total	**Totals**	**353.4**	36%	**226.2**

[1]See Appendix I for a description of the phased wasteload allocation for these point sources.

6.2.3 Phosphorus

6.2.3.1 Sources of Phosphorus in the Lake Helena Watershed

At the watershed scale (i.e., the entire Lake Helena Watershed), municipal wastewater treatment facilities (28 percent), return flows from the Helena Valley Irrigation System (15 percent), agriculture (14 percent), unpaved roads (5 percent), and urban areas (4 percent) comprise the most significant sources of total phosphorus (TP) (Figure 6-4). Also, in localized areas, phosphorus loading from agricultural and single family residential sources may be far more significant that this source category appears to be at the watershed scale.

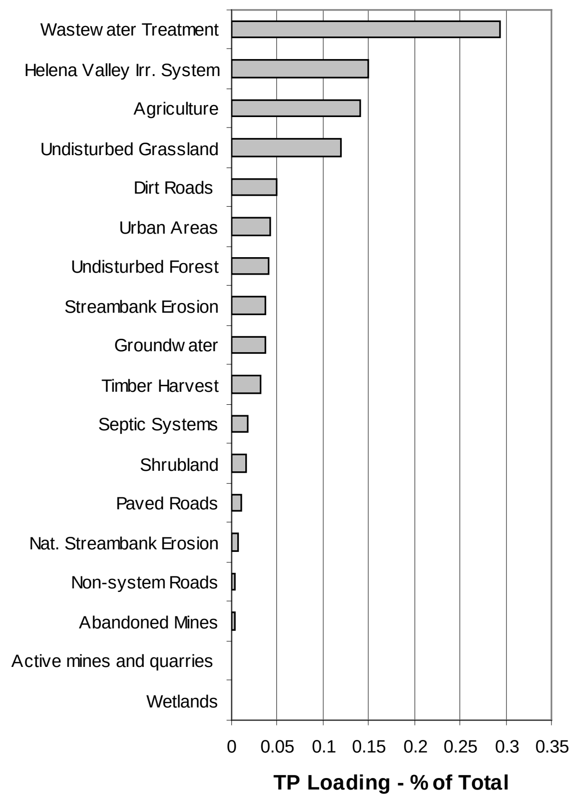

Figure 6-4. Percent of the total annual phosphorus load from all potentially significant phosphorus sources in the entire Lake Helena Creek Watershed.

6.2.3.2 Water Quality Goals/Targets

Insufficient data are currently available to establish TP targets for Lake Helena. A strategy to establish targets in the future is presented in Volume II, Section 3.2.3.

6.2.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

Since no concentration targets have been proposed for Lake Helena, it is assumed that the load reductions for Prickly Pear Creek (the largest tributary to Lake Helena) adequately approximate the necessary load reductions. A TP load reduction of 87 percent is therefore proposed as an interim TP load reduction goal. This will be revised in the future following the strategy presented in Volume II, Section 3.0.

The proposed approach acknowledges that it may not be possible to attain the an 87 percent TP load reduction, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality will continue to degrade if no action is taken to reduce loading. Therefore, the proposed approach seeks the maximum attainable TP load reductions from non-point sources, includes a phased wasteload allocation to reduce point sources loads, and, in recognition of the fact that it a TP concentration target has not yet been established, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 6-6. The phased wasteload allocation is presented in Appendix I and the adaptive management strategy is presented in Volume II, Section 3.0. Finally, a summary of estimated loads, proposed reductions, and post-reduction loads for all sources considered in the TP analysis is presented in Table 1-1.

Table 6-6. TMDL, Allocations, and Margin of Safety for Lake Helena – Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.2	71	0.1	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%. Sediment-associated phosphorus will decrease accordingly (71%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated phosphorus reductions could be over or under estimated.
	Active Mines	0.1	0	0.1	BMPs for active mines were assumed to not be cost effective because the loads represent such a small fraction of the current overall loads.	Current loads from active mines are based on modeled storm water runoff and literature values for runoff concentrations. The current loads are likely overestimated because DEQ reports that there has never been a discharge from the MT Tunnels Mine site (the only significant active mine in the watershed).
	Agriculture	7.2	89	0.8	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	1.8	85	0.3	It is estimated that there are 48.0 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Helena Valley Irrigation District (HVID)	7.6	50	3.8	It is difficult to estimate potential load reductions from the HVID due to its unique and complex nature. No appropriate literature values are available. A 50 percent reduction has therefore been selected based on best professional judgment.	Estimates of current loads from the HVID are based on limited sampling data and potential load reductions are based on best professional judgment. Therefore, the estimated load and load reduction may be under or overestimated.
	Non-system Roads	0.2	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.6	50	0.3	An average phosphorus removal efficiency of 50% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	0.9	100	0.0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	1.6	97	0.1	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.5	60	1.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	2.2	50	1.1	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	24.9	70	7.6		
	Natural Sources	11.3	0.0	11.3	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	15.0	88	1.8	Phosphorus point sources are listed in Table 6-7. The allocations for the WWTPs are based on the phased approach described in Appendix I. Load reductions for known failing lagoons are presented in Table 6-7. No allocations are proposed for lagoons thought to be operating as designed.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**51.2**	**60**	**20.7**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 1.8 tons/yr + 7.6 tons/yr + 11.3 tons/yr + 0 = 20.7 tons/yr** **TMDL = 0.01 + 0.02 tons/day + 0.03 tons/day + 0 = 0.06 tons/day**					

Table 6-7. Estimated loads and load reductions for all sources of TP in the Lake Helena watershed.

Source Category	Source	Estimated TP Load (tons/yr)	Estimated Reductions (%)	Remaining Load (tons/yr)
Anthropogenic Nonpoint Sources	Timber Harvest	1.6	97%	0.1
	Unpaved Roads	2.5	60%	1.0
	Non-system Roads	0.2	100%	0.0
	Paved Roads	0.6	50%	0.3
	Active mines and quarries	0.1	0%	0.1
	Abandoned Mines	0.2	71%	0.1
	Agriculture	7.2	89%	0.8
	Urban Areas	2.2	50%	1.1
	Anthropogenic Streambank Erosion	1.8	85%	0.3
	Helena Valley Irrigation System	7.6	50%	3.8
	Septic Systems	0.9	100%	0.0
	Total Anthropogenic NPS	**24.9**	**70%**	**7.6**
Natural Nonpoint Sources	Fullgrowth Forest	2.1	0%	2.1
	Wetlands	0.0	0%	0.0
	Shrubland	0.8	0%	0.8
	Grassland	6.1	0%	6.1
	Nat. Streambank Erosion	0.4	0%	0.4
	Groundwater	1.9	0%	1.9
	Total Natural NPS	**11.3**	**0%**	**11.3**
Point Sources	City of Helena	13.5	98%	0.3[1]
	East Helena	1.0	0%	1.0[1]
	Evergreen Nursing Home	0.0	0%	0.0
	Treasure State Acres subdivision	0.1	33%	0.1
	Tenmile and Pleasant Valley subdivisions	0.1	14%	0.1
	Mountain View law enforcement academy	0.1	0%	0.1
	Eastgate Subdivision	0.1	0%	0.1
	Leisure Village mobile home park	0.1	13%	0.1
	Total Point Source	**15.0**	**88%**	**1.8**
Total		**51.2**	**60%**	**20.7**

[1]See Appendix I for a description of the phased wasteload allocation for these point sources.

7.0 LUMP GULCH

Lump Gulch from the headwaters to the mouth (Segment MT41I006_130, 14.5 miles) was listed as impaired on the Montana 1996 303(d) list because of suspended solids and metals. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, fishery, and drinking water beneficial uses were listed as impaired because of cadmium, copper, lead, mercury, metals, and zinc. The additional analyses and evaluations described in Volume I found that sediment (suspended solids), cadmium, copper, lead, and zinc are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.13 of the Volume I Report). There were insufficient data to determine if mercury is impairing beneficial uses.

Conceptual restoration strategies and the required TMDL elements for sediment and metals (i.e., cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

7.1 METALS

The recent water chemistry data suggest that Lump Gulch is impaired by cadmium, copper, lead, and zinc. TMDLs are presented in the following sections to address the impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

7.1.1 Sources of Metals in the Lump Gulch Watershed

Besides anthropogenic sediment-associated metals sources, significant contributors of metals to the stream are historical mining activities in the upper watershed. The headwaters of the watershed fall within the Clancy mining district. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, surface, and underground mining activities in the watershed. The historical mining types include placer, lode, and mill. In the past these mines produced lead, copper, zinc, silver, gold, and uranium. In the headwaters area there are over 10 historical hard rock mines, including 4 sites in Frohner Basin and the Clancy district— Nellie Grant, Frohner (two mines), and General Grant—that are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. The aerial photography assessment showed the drainage to be disrupted by historical mining dams at the Frohner Meadows Mine. The Helena National Forest documented along this stretch of the stream included road sediment delivery points, mine waste rock dumps, a mining dam, and channel incision. Modeled sources and their metals loadings to Lump Gulch are presented in Figure 7-1 through Figure 7-4.

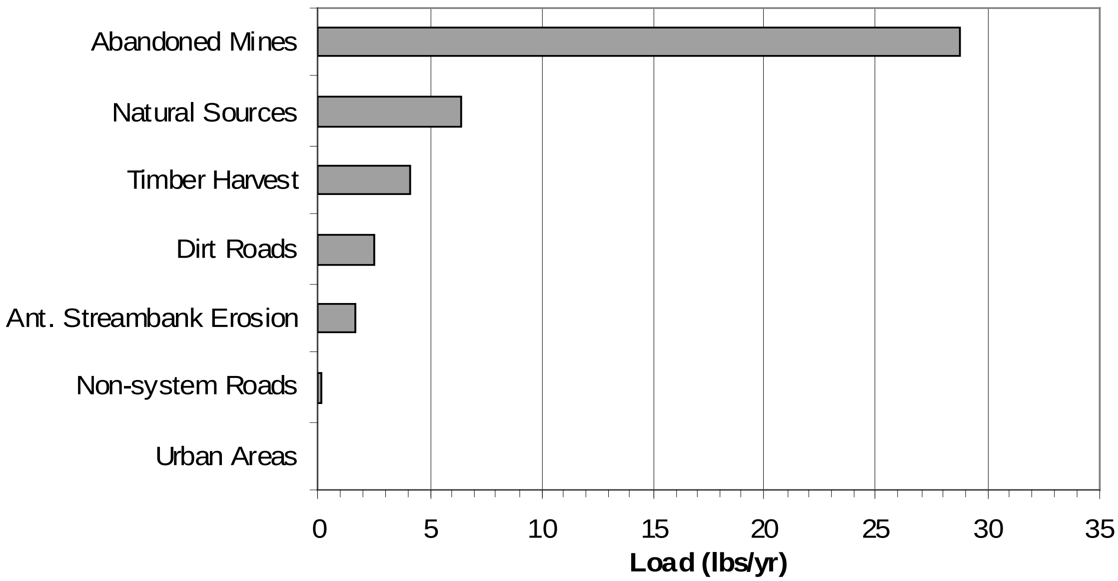

Figure 7-1. Sources of cadmium loadings to Lump Gulch.

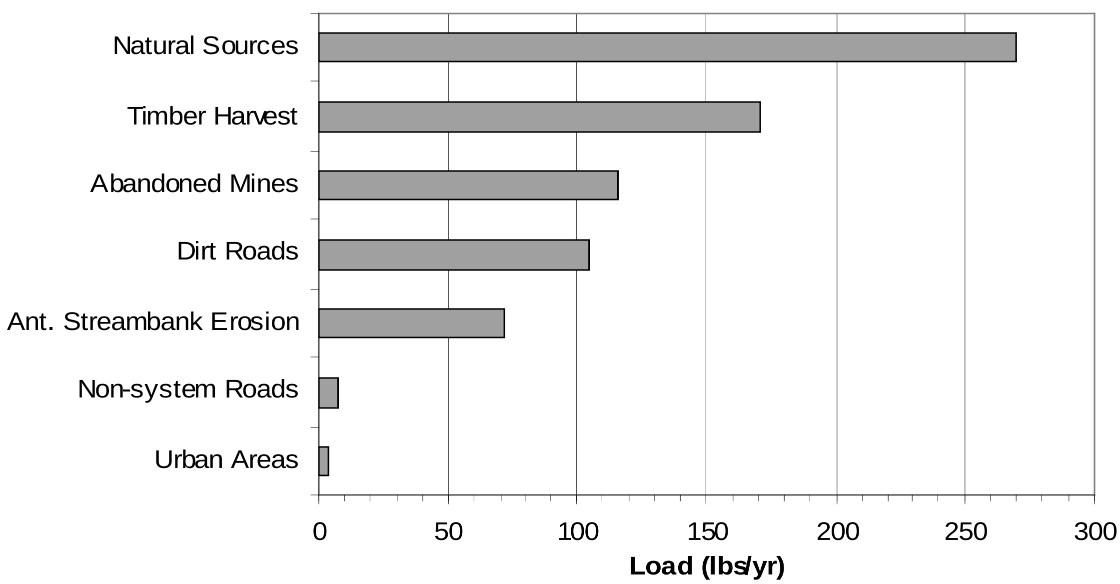

Figure 7-2. Sources of copper loadings to Lump Gulch.

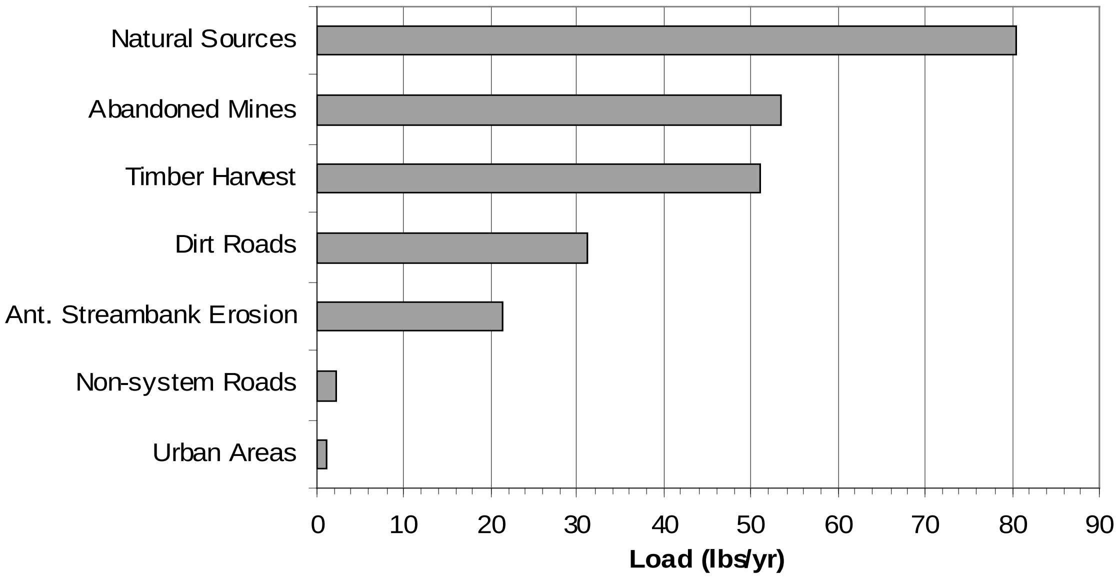

Figure 7-3. Sources of lead loadings to Lump Gulch.

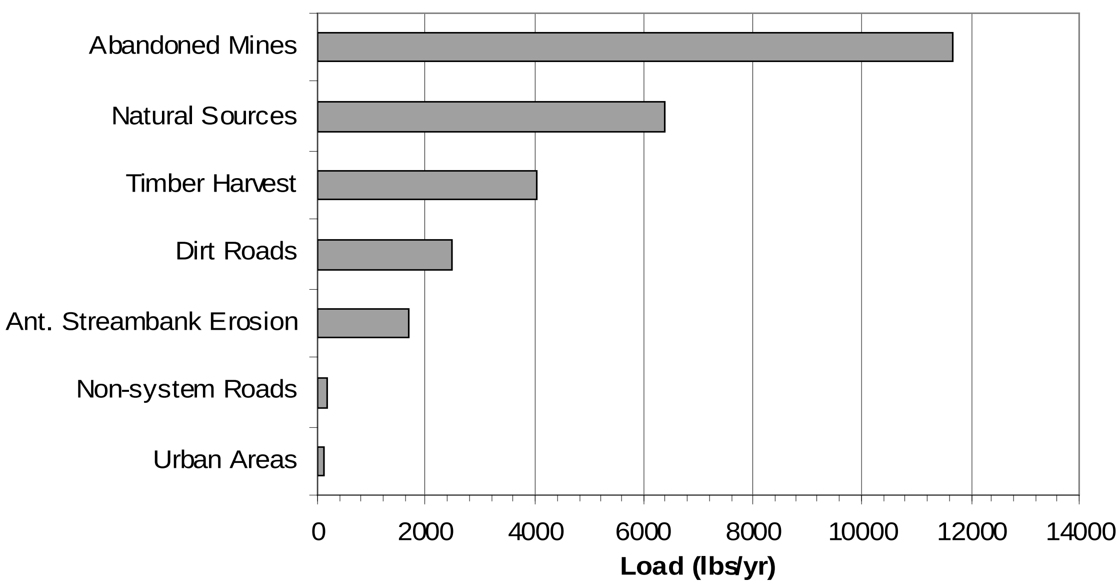

Figure 7-4. Sources of zinc loadings to Lump Gulch.

7.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDLs is to attain and maintain the applicable Montana numeric standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Lump Gulch are presented in Table 7-1.

Table 7-1. Montana numeric surface water quality standards for metals in Lump Gulch.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Cadmium (TR)	1.1 at 51.4 mg/L hardness[c]	0.2 at 51.4 mg/L hardness[c]	5
Copper (TR)	7.4 at 51.4 mg/L hardness[c]	5.2 at 51.4 mg/L hardness[c]	1,300
Lead (TR)	34.6 at 51.4 mg/L hardness[c]	1.3 at 51.4 mg/L hardness[c]	15
Zinc (TR)	68.6 at 51.4 mg/L hardness[c]	68.6 at 51.4 mg/L hardness[c]	2,000

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

7.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 7-2 through Table 7-5. Based on the results of the source assessment (Section 7.1.1), the recommended implementation strategy to address the metals problem in Lump Gulch is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 7-2 through Table 7-5, the hypothesis is that an overall, watershed scale metals load reduction of 76, 39, 44, and 68 percent for cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. Lump Gulch already meets applicable water quality standards for arsenic. The proposal for achieving the load reduction is to reduce loads from historical mining sources by 92, 0, 35, and 96 percent for cadmium, copper, lead, and zinc, respectively.

Table 7-2. TMDL, Allocations, and Margin of Safety for Lump Gulch – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	28.8	92	2.4	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	1.7	75	0.4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 75% (see Table 7-6), thereby reducing sediment associated metals loads from streambank erosion by 75%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	4.1	96	0.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.5	60	1.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 7-6).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.1	80	0.0	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 7-6), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	37.4	90	3.9		
	Natural Sources	6.5	0	6.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Lump Gulch Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**43.9**	**76**	**10.4**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 3.9 lbs/yr + 6.5 lbs/yr + 0 = 10.4 lbs/yr** **TMDL = 0 + 0.01 lbs/day + 0.02 lbs/day + 0 = 0.03 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 7-3. TMDL, Allocations, and Margin of Safety for Lump Gulch – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	116.0	0	116.0	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	72.1	75	18.0	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 75% (see Table 7-6), thereby reducing sediment associated metals loads from streambank erosion by 75%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	8.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	171.1	96	6.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	104.5	60	41.8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 7-6).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	4.2	80	0.8	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 7-6), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	475.9	62	182.8		
	Natural Sources	270.0	0	270.0	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Lump Gulch Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**745.9**	**39**	**452.8**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 182.8 lbs/yr + 270.0 lbs/yr + 0 = 452.8 lbs/yr** **TMDL = 0 + 0.50 lbs/day + 0.74 lbs/day + 0 = 1.24 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 7-4. TMDL, Allocations, and Margin of Safety for Lump Gulch – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	53.5	35	34.9	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	21.5	75	5.4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 75% (see Table 7-6), thereby reducing sediment associated metals loads from streambank erosion by 75%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	2.4	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	51.0	96	1.8	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	31.2	60	12.5	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 7-6).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.2	80	0.2	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 7-6), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	160.8	66	54.8		
	Natural Sources	80.5	0	80.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Lump Gulch Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**241.3**	**44**	**135.3**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 54.8 lbs/yr + 80.5 lbs/yr + 0 = 135.3 lbs/yr** **TMDL = 0 + 0.15 lbs/day + 0.22 lbs/day + 0 = 0.37 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 7-5. TMDL, Allocations, and Margin of Safety for Lump Gulch – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	11,676.7	96	506.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	1,707.3	75	426.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 75% (see Table 7-6), thereby reducing sediment associated metals loads from streambank erosion by 75%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	189.9	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	4,054.2	96	146.8	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2,476.6	60	990.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 7-6).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	99.2	80	19.8	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 7-6), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	20,203.9	90	2,090.6		
	Natural Sources	6,395.3	0	6,395.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Lump Gulch Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**26,599.2**	**68**	**8,485.9**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 2,090.6 lbs/yr + 6,395.3 lbs/yr + 0 = 8,485.9 lbs/yr** **TMDL = 0 + 5.7 lbs/day + 17.5 lbs/day + 0 = 23.2 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

7.2 SEDIMENT

The available data suggest that Warm Springs Creek is impaired by sediment (See Volume I Report). TMDLs are presented in the following sections to address the sediment impairments. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

7.2.1 Sources of Sediment in the Lump Gulch Watershed

As shown in Figure 7-5, the primary anthropogenic sources of sediment in the Lump Gulch watershed, in order of sediment load are: timber harvest, unpaved roads, anthropogenic streambank erosion, urban areas, abandoned mines, and non-system roads/trails.

Significant timber harvest activities have occurred in the Lump Gulch watershed on private land, state land (DNRC school trust land) and BLM property. Model results suggest that sediment related to silvicultural activities within the watershed generate the greatest quantity of anthropogenically induced sediment. In the upper watershed, much of the timber harvest has occurred on mining claims; these units are typically harvested using a clear-cut silvicultural prescription. Throughout much of the central area of the segment length, Lump Gulch Road is directly adjacent to the stream. The erodible parent material, the high road usage, close proximity to the stream channel, and a narrow riparian buffer throughout much of the upper watershed results in large quantities road based sediment being delivered to the stream. Residential areas populate the lower third of the watershed. Modeled sediment load from this land use was 140 tons. Observed streambank erosion is largely the result of riparian grazing, road encroachment, stream channelization and historic mining activity. Three abandoned mines, Nellie Grant, Frohner, and Yama Group are present in the upper watershed. DEQ reclaimed Nellie Grant, and is consequently generating minimal sediment. Frohner and Yama remain un-reclaimed and continue to produce sediment. Non-system roads/trails were observed in the central and upper watershed. These roads/trails are mostly related to historic mining activity and public land areas, and are a problematic sediment source because run-off mitigation structures were not constructed, and they are typically located in steep topography, frequently near watercourses.

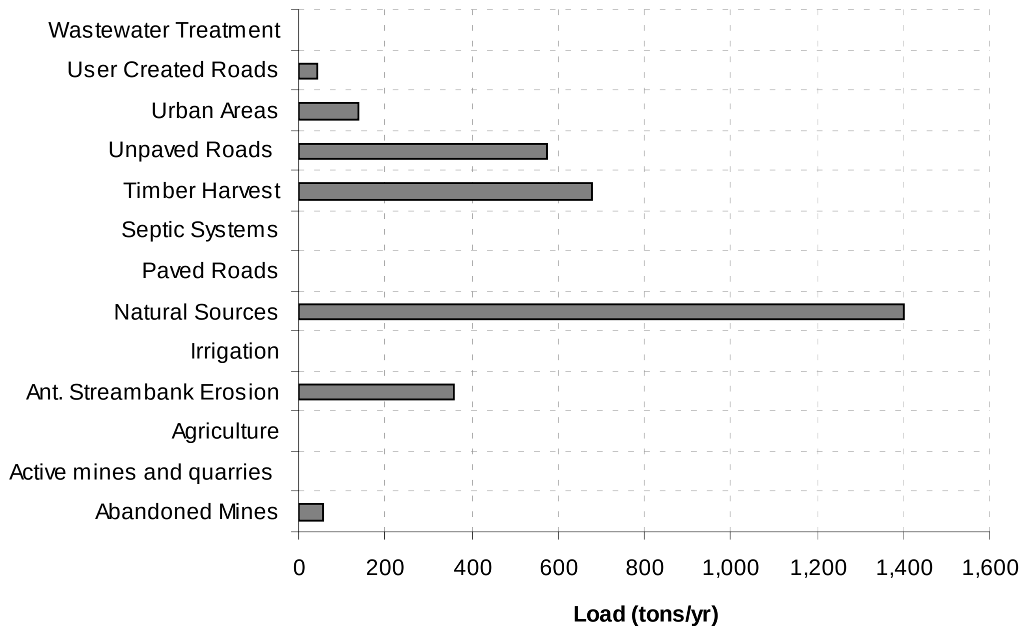

Figure 7-5. Total annual sediment load from all potentially significant sediment sources in the Lump Gulch Watershed.

7.2.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

7.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 7-6. Based on the results of the source assessment (Section 7.2), the recommended implementation strategy to address the siltation problem in Lump Gulch is to reduce sediment loading from the primary anthropogenic sediment sources – timber harvest, unpaved roads, anthropogenic streambank erosion, urban areas, abandoned mines, and non-system roads. As shown in Table 7-6, the hypothesis is that an overall, watershed scale sediment load reduction of 45 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current timber harvest, unpaved roads, anthropogenic streambank erosion, urban areas, abandoned mines, and non-system roads by 97, 60, 75, 80, 79, and 100 percent respectively.

Table 7-6. TMDL, Allocations, and Margin of Safety for Lump Gulch – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	55	79	12	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	359	75	90	It is estimated that there are 6.1 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	44	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	681	97	20	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	576	60	230	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	140	80	28	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,855	81	380		
	Natural Sources	1,400	0	1,400	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Lump Gulch Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total[1]		**3,255**	**45**	**1,780**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 380 tons/yr + 1,400 tons/yr + 0 = 1,780 tons/yr** **TMDL = 0 + 1.1 tons/day + 3.8 tons/day + 0 = 4.9 tons/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

8.0 PRICKLY PEAR CREEK

Six segments of Prickly Pear Creek have appeared on various Montana 303(d) lists: Prickly Pear Creek from Headwaters to Spring Creek (MT41I006_060), Prickly Pear Creek from Spring Creek to Lump Gulch (MT41I006_050), Prickly Pear Creek from Lump Gulch to Wylie Drive (MT41I006_040), Prickly Pear Creek from Wylie Drive to Helena Wastewater Treatment Plant Discharge (MT41I006_030), Prickly Pear Creek from Helena WWTP Discharge Ditch to Lake Helena (MT41I006_020), and Prickly Pear Creek from Lake Helena to Hauser Reservoir (MT41I006_010). Impaired uses and causes of impairment varied by segment and by 303(d) list.

Volume I presented additional data and analyses for the 303(d) listed segments in Prickly Pear Creek. Using a weight of evidence approach, the impairment status of each segment was updated. Segment MT41I006_010 of Prickly Pear Creek was not evaluated in Volume I because it is located downstream of Lake Helena, and will therefore be addressed as part of the Hauser Lake TMDL Planning Area.

The following paragraphs summarize the 303(d) listings and Volume I analyses for each segment in Prickly Pear Creek:

- **Prickly Pear Creek from Headwaters to Spring Creek (MT41I006_060)** – In 1996, the cold-water fishery use in this 8.7-mile headwater segment of Prickly Pear Creek was listed as threatened due to suspended solids and metals. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of metals. The additional analyses and evaluations described in Volume I found that lead and sediment (suspended solids) are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.1 of the Volume I Report).
- **Prickly Pear Creek from Spring Creek to Lump Gulch (MT41I006_050) –** In 1996, aquatic life and cold-water fisheries beneficial uses in this 7-mile segment of Prickly Pear Creek were listed as impaired because of suspended solids and siltation. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of metals and siltation. The additional analyses and evaluations described in Volume I found that cadmium, lead, zinc, and sediment (suspended solids and siltation) are impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.2 of the Volume I Report).
- **Prickly Pear Creek from Lump Gulch to Wylie Drive (MT41I006_040) –** In 1996, the aquatic life and cold-water fishery beneficial uses in this 11-mile segment of Prickly Pear Creek were listed as impaired because of metals. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of metals and siltation. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, zinc, and sediment (siltation) are impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.3 of the Volume I Report).
- **Prickly Pear Creek from Wylie Drive to Helena Wastewater Treatment Plant Discharge (MT41I006_030) –** In 1996, the aquatic life, drinking water, and cold-water fishery beneficial uses in this 6.1-mile segment of Prickly Pear Creek were listed as impaired because of siltation, suspended solids, and metals. In 2002 and 2004, aquatic

life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of metals, nutrients, siltation, and thermal modifications. The additional analyses and evaluations described in Volume I found that arsenic, lead, nutrients, sediment (siltation and suspended solids), and thermal modifications are impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.4 of the Volume I Report).

- **Prickly Pear Creek from Helena WWTP Discharge Ditch to Lake Helena (MT41I006_020) –** In 1996, the aquatic life, drinking water, and cold-water fishery beneficial uses in this 9.1-mile segment of Prickly Pear Creek were listed as impaired because of siltation, suspended solids, metals, nutrients, and unionized ammonia. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of siltation, metals, nutrients, thermal modifications, and unionized ammonia. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, lead, nutrients, sediment (suspended solids and siltation), and thermal modifications are impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.5 of the Volume I Report). Ammonia is not impairing beneficial uses, and therefore no TMDL will be presented.

Conceptual restoration strategies and the required TMDL elements for sediment, nutrients, thermal modifications, and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix C, D, E, F, G, and K.

8.1 Metals

Water chemistry data suggest that Prickly Pear Creek is impaired by arsenic, cadmium, copper, lead, and zinc (See Volume I Report). TMDLs are presented in the following sections to address the metals impairments.

8.1.1 Sources of Metals in the Prickly Pear Creek Watershed

The following discussion will incorporate TMDL development for Prickly Pear Creek as a single, holistic system composed of the five 303(d) listed segments. The metals loads shown are cumulative and include the five listed Prickly Pear segments, as well as all other listed tributary segments. This includes Spring Creek, Clancy Creek, Corbin Creek, Golconda Creek, Jackson Creek, Lump Gulch, North Fork, Middle Fork, and main Warm Springs Creek, upper, middle and lower Tenmile Creek, Skelly Gulch, and Sevenmile Creek. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

Prickly Pear Creek from Headwaters to Spring Creek (MT41I006_060) – A tributary stream and historical mining activities in the immediate drainage area comprise the most significant sources of metals to this stream segment. Golconda Creek flows into this segment and is a significant contributor of metals. Most of the drainage area falls within the Alhambra mining district, although there are sections of Elkhorn and Colorado mining districts in the basin. The Montana Bureau of Mines and Geology (MBMG) Abandoned and Inactive Mines database shows placer, mineral prospect, surface, surface-underground, and underground historical mining activities in the drainage area of the stream. The mining types listed include lode and placer. In the past, these mines produced silver, lead, zinc, manganese, molybdenum, and gold. None of the mines in the drainage area of this segment are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites.

Prickly Pear Creek from Spring Creek to Lump Gulch (MT41I006_050) – Relevant sources of metals to the stream segment are upstream sources (MT41I006_060), tributary streams, and historical mining activities in the immediate drainage area. The segment's upstream reach and tributaries (including Spring Creek, Clancy Creek, and Warm Springs Creek) are contributing metals loads. In addition, during field sampling efforts, spring seeps were noted entering Prickly Pear Creek from placer tailings piles along the stream. The immediate drainage area of the listed segment falls within the Alhambra and Clancy mining districts. The MBMG Abandoned and Inactive Mines database reports mineral location, surface, surface-underground, underground, and other, "unknown" mining activities in the immediate drainage area of the stream segment. The historical mining types include lode and placer. In the past these mines produced gold, silver, copper, lead, zinc, and uranium. None of the mines in the immediate drainage area of this segment are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites.

Prickly Pear Creek from Lump Gulch to Wylie Drive (MT41I006_040) – Relevant sources of metals in the stream segment are upstream sources, tributary streams, and historical mining activities in the immediate drainage area. The segment's upstream reach (MT41I006_050) and the tributary Lump Gulch contribute metals loads. The immediate drainage area falls within the Alhambra, Clancy, and Montana City mining districts. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, processing plant, prospect, surface, surface-underground, and other, unknown mining activities in the immediate drainage area of the stream segment. The historical mining types include lode, mill, placer, quarry, and smelter. In the past these mines produced gold, silver, copper, and lead. None of the mines in the immediate drainage area of this segment are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. The ASARCO East Helena Lead Smelter is located in this subwatershed (NPDES Permit MT0030147) and is permitted to discharge arsenic, cadmium, copper, lead and zinc to the stream. Current permit limits are 1.140 mg/L for arsenic, 0.1374 mg/L for cadmium, 1.122 mg/L for copper, 0.239 mg/L for lead, and 0.77 mg/L for zinc.

Prickly Pear Creek from Wylie Drive to Helena Wastewater Treatment Plant Discharge (MT41I006_030) – Upstream reaches comprise the primary contributors of metals to this segment.

Prickly Pear Creek from Helena WWTP Discharge Ditch to Lake Helena (MT41I006_020) – Upstream reaches comprise the primary contributors of metals to this segment.

Modeled sources and their metals loadings to Prickly Pear Creek are presented in Figure 8-1 through Figure 8-5.

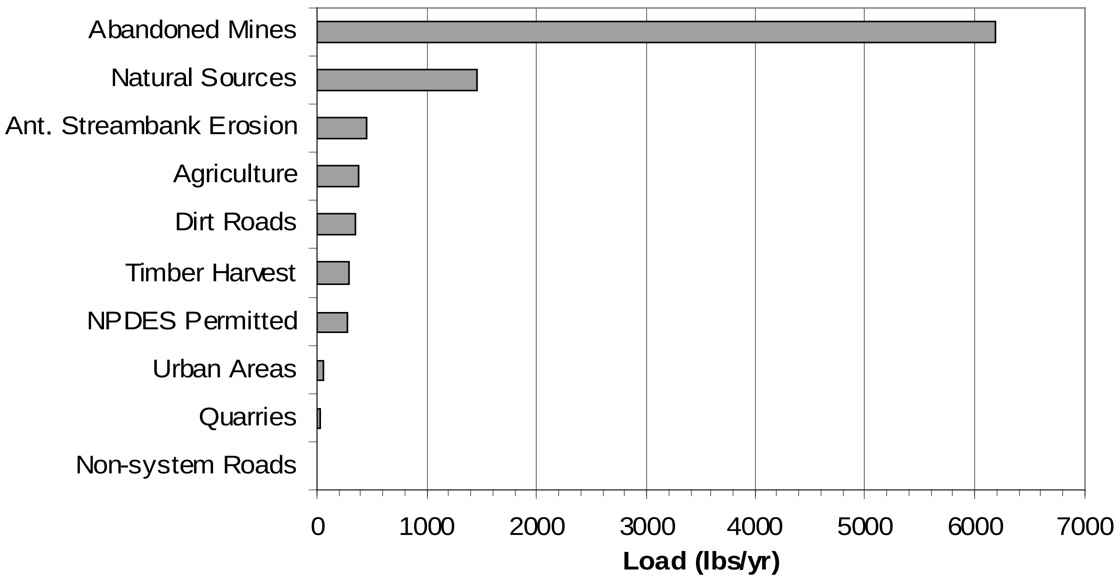

Figure 8-1. Sources of arsenic loadings to Prickly Pear Creek.

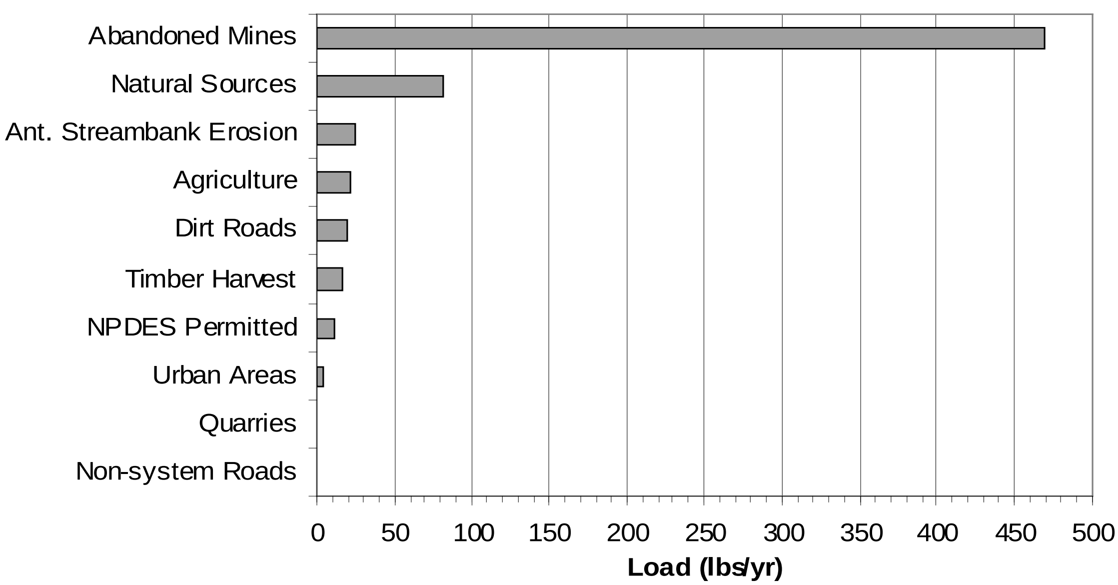

Figure 8-2. Sources of cadmium loadings to Prickly Pear Creek.

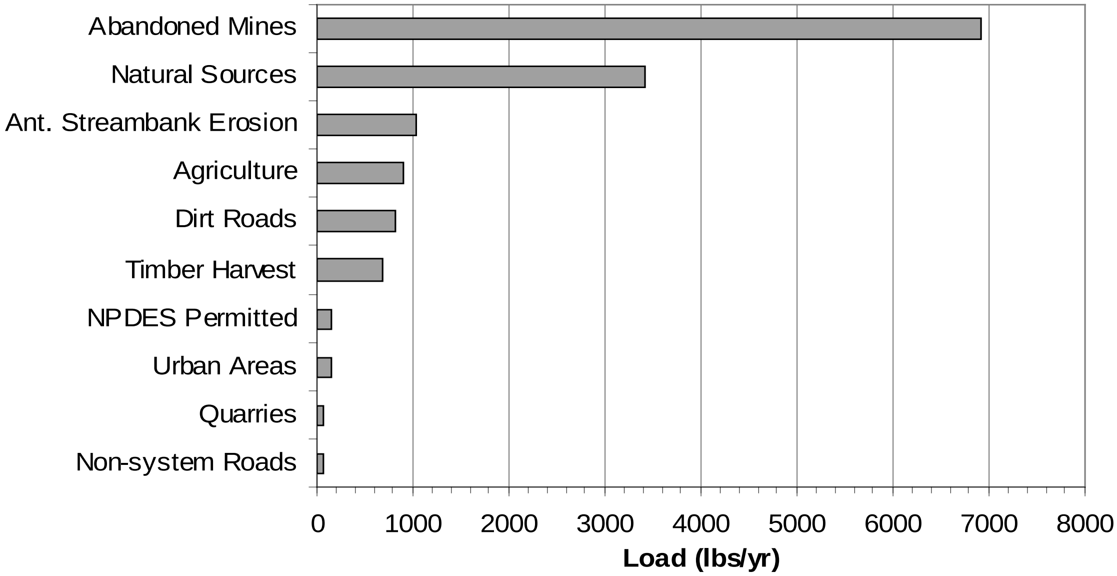

Figure 8-3. Sources of copper loadings to Prickly Pear Creek.

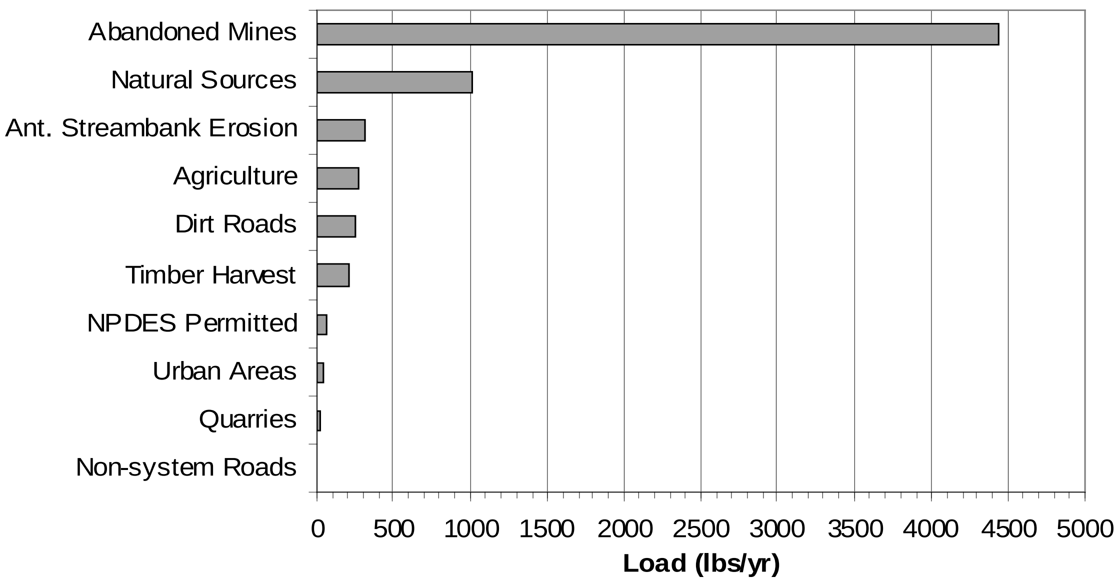

Figure 8-4. Sources of lead loadings to Prickly Pear Creek.

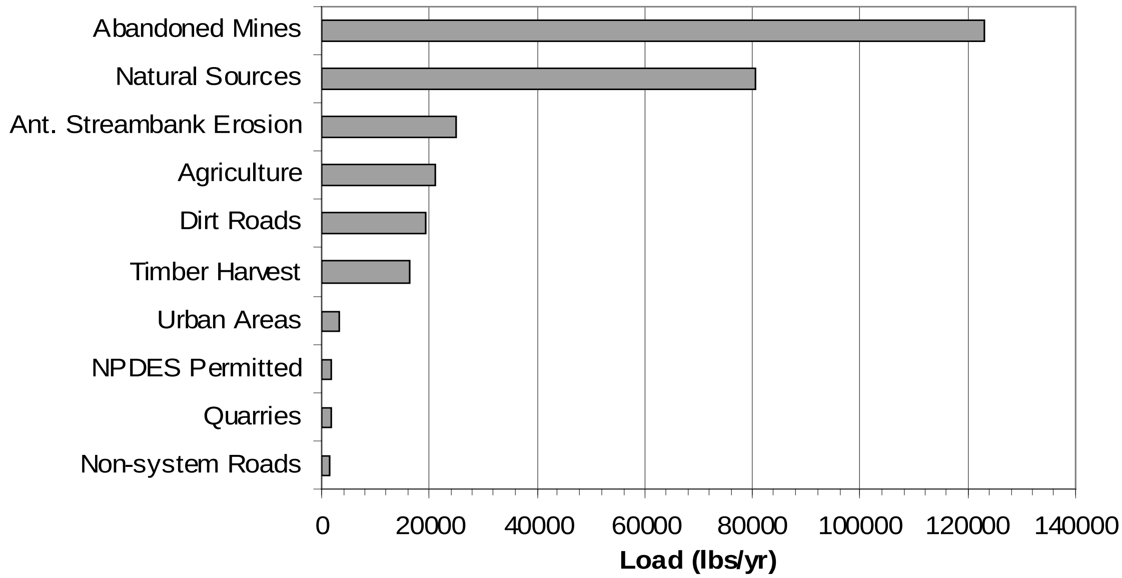

Figure 8-5. Sources of zinc loadings to Prickly Pear Creek.

8.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDL is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in the main stem segments of Prickly Pear Creek are presented in Table 8-1.

Table 8-1. Montana numeric surface water quality standards for metals in Prickly Pear Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10 [d]
Cadmium (TR)	5.2 at 235.1 mg/L hardness[c]	0.5 at 235.1 mg/L hardness[c]	5
Copper (TR)	31.0 at 235.1 mg/L hardness[c]	18.9 at 235.1 mg/L hardness[c]	1,300
Lead (TR)	238.5 at 235.1 mg/L hardness[c]	9.2 at 235.1 mg/L hardness[c]	15
Zinc (TR)	249.9 at 235.1 mg/L hardness[c]	249.9 at 235.1 mg/L hardness[c]	2,000

8.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 8-2 through Table 8-6. Based on the results of the source assessment (Section 8.1.1), the recommended implementation strategy to address the metals problem in Prickly Pear Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 8-2 through Table 8-6, the hypothesis is that an overall, watershed scale metals load reduction of 58, 74, 58, 69, and 60 percent for arsenic, cadmium, copper, lead and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from mining sources by 67, 87, 76, 83, and 85 percent for arsenic, cadmium, copper, lead and zinc respectively.

Table 8-2. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	6,180	67.3	2,020	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	383	88	47	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	447	82	79	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	27	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	31	0	31	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	296	97	10	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	349	60	139	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	60	80	12	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	7,771	70	2,338		
	Natural Sources	1,456	0	1,456	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	271	45	149	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent. At this point in time, Montana Tunnel's permitted concentration is 290 ug/L while the criteria is 10 ug/L. Loads were reduced to the current arsenic water quality standard.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**9,498**	**58**	**3,943**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 149+ 2,338 lbs/yr + 1,456 lbs/yr + 0 = 3,943 lbs/yr** **TMDL = 0.4 + 6.4 lbs/day + 4.0 lbs/day + 0 = 10.8 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 8-3. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	469	87	60	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	22	88	3	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	25	82	4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	2	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	2	0	2	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	17	97	1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	20	60	8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	3	80	1	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	558	86	77		
	Natural Sources	82	0	82	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	12	0	12	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent. No reductions were required because permits limits already meet current water quality standards.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**652**	**74**	**171**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 12+ 77 lbs/yr + 82 lbs/yr + 0 = 171 lbs/yr** **TMDL = 0.04 + 0.21 lbs/day + 0.22 lbs/day + 0 = 0.47 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 8-4. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	6,917	76	1,668	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	896	88	110	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	1,046	82	185	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	63	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	72	0	72	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.[1]	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	694	97	22	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	816	60	326	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	140	80	29	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	10,644	77	2,412		
	Natural Sources	3,408	0	3,408	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	149	0	149	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent. No reductions were required because permits limits already meet current water quality standards.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**14,200**	**58**	**5,969**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 149+ 2,412 lbs/yr + 3,408 lbs/yr + 0 = 5,969 lbs/yr** **TMDL = 0.4 + 6.6 lbs/day + 9.3 lbs/day + 0 = 16.3 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 8-5. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	4,434	82	777	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	267	88	33	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	312	82	55	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	19	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	22	0	22	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	207	97	7	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	243	60	97	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	42	80	9	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	5,545	82	999		
	Natural Sources	1,016	0	1,016	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	67	0	67	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent. No reductions were required because permits limits already meet current water quality standards.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**6,628**	**69**	**2,082**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 67+ 999 lbs/yr + 1,016 lbs/yr + 0 = 2,082 lbs/yr** **TMDL = 0.2 + 2.7 lbs/day + 2.8 lbs/day + 0 = 5.7 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 8-6. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	122,935	85	18,267	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	21,212	88	2,610	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	24,774	82	4,380	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1,482	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	1,711	0	1,711	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	16,438	97	530	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	19,330	60	7,732	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	3,324	80	679	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	211,206	83	35,909		
	Natural Sources	80,731	0	80,731	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	1,977	0	1,977	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent. No reductions were required because permits limits already meet current water quality standards.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**293,914**	**60**	**118,617**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 1,977+ 35,909 lbs/yr + 80,731 lbs/yr + 0 = 118,617 lbs/yr** **TMDL = 6 + 98 lbs/day + 221 lbs/day + 0 = 325 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

8.2 NUTRIENTS

8.2.1 Limiting Nutrients

Nitrogen and phosphorus are the two elements most commonly limiting algal growth in lakes and streams. Some indication of whether nitrogen or phosphorus is growth limiting may be obtained by determining the weight ratio of the appropriate forms of nitrogen and phosphorus found in a river or lake, and comparing that with the stoichiometric ratio required for growth. Where the ratio of nitrogen to phosphorus is greater than 15:1, phosphorus is more likely limiting than nitrogen. If the ratio is less than 5:1, nitrogen is more likely limiting than phosphorus. If the ratio is less than 15 but greater than 5, it's a tossup as to which one is limiting, i.e. either N or P could be limiting, or an N and P co-limitation could be present. For assessing nutrient limitations in streams, the N:P ratios are usually computed on the basis of the soluble inorganic forms of N and P (i.e. TSIN:SRP). For lakes, nutrient ratios are commonly computed on the basis of the total forms of N and P. This is because nutrients may cycle in lakes and become soluble over time or under certain physical and chemical conditions. Total N and total P relate better overall to seasonal and lake wide productivity.

It is important to know which nutrient is limiting such that control efforts can focus on the nutrient most likely causing the beneficial use impairments. A discussion on nutrient limitation in Prickly Pear Creek and Lake Helena, the primary receiving water body, is presented below.

8.2.1.1 Prickly Pear Creek

Nutrient data for two distinct reaches of lower Prickly Pear Creek were reviewed. It has been observed that in-stream nutrient concentrations are significantly higher below the City of Helena's municipal wastewater outfall than above the discharge, although other nutrient sources may also be present in the interim segment of the creek. It is important to examine nutrient ratios above and below these source inputs because it may influence the selection of appropriate control measures.

Soluble N to P ratios in Prickly Pear Creek at or just below East Helena documented during 2003 ranged from 1.1:1 to 5.4:1 and averaged 3.4:1, indicating that nitrogen was the limiting nutrient.

Soluble N to P ratios in Prickly Pear Creek below York Road (above Stansfield Lake) ranged from 70:1 to 85:1 during monitoring conducted in 2003. This section of the stream is dominated by groundwater discharge during the summer irrigation season and is not typical of upstream or downstream sections of Prickly Pear Creek. This section of the stream was strongly phosphorus limited.

Soluble N to P ratios in Prickly Pear Creek above Tenmile Creek (Sierra Road crossing) ranged from 2.6 to 4.6 and averaged 3.6:1 indicating a strong nitrogen limitation.

The soluble N to soluble P ratios were similar in much of Prickly Pear Creek from East Helena to above the Tenmile Creek confluence, with the exception of the dewatered, groundwater dominated segment just below York Road. Ratios were similar even though the in-stream nutrient concentrations in the reach below the City of Helena's wastewater outfall were an order of magnitude higher overall than in reach near East Helena.

8.2.1.2 Lake Helena

A review was performed of the available nitrogen and phosphorus data for Lake Helena. Four water column samples collected by the Montana Department of Environmental Quality in early August 2002 showed an average total N to total P ratio of 9.6:1, with a range from 8.5 to 10.3. Four samples collected by Land & Water Consulting in late August 2003 showed a TN:TP ratio of 2.7:1, with a range of 2.6 to 2.8. Three additional samples collected by Land & Water during runoff conditions in late June 2003 showed a TN:TP ratio of 9.3:1 with a range of 7.8 to 10.2. A fourth sample collected near the lake inlet produced a ratio of 50.5:1 due to a very low total P measurement, which may have been in error.

The Lake Helena nutrient ratio data presented above point to a conclusion that algae growth in the lake is either nitrogen limited (August 2003), or N and/or P limited (August 2002, June 2003). Based on these total nutrient ratio data, it can be concluded that the lake is not overwhelmingly phosphorus limited. Computing the N:P ratios using the soluble inorganic nutrient fractions suggests a stronger nitrogen limitation in Lake Helena, rather than a co- or P-limitation.

In the absence of a strong case for either N or P limitation, TMDLs are presented below for both nitrogen and phosphorus.

8.2.2 Nitrogen

8.2.2.1 Sources of Nitrogen in the Prickly Pear Creek Watershed

As shown in Figure 8-6, the primary anthropogenic sources of nitrogen in the Prickly Pear Creek watershed, in order of importance include municipal wastewater treatment facilities (21 percent), septic systems (20 percent), urban areas (7 percent), agriculture (7 percent), dirt roads (5 percent), anthropogenic streambank erosion (4 percent), and timber harvest (4 percent). Although dewatering does not directly contribute a nutrient load to Prickly Pear Creek, irrigation diversions reduce flows downstream of the City of East Helena significantly most summers. This result in increased in-stream nutrient concentrations and, by increasing stream temperatures (see Section 8.4), may exacerbate the symptoms of nutrient loading (e.g., algal growth and depressed dissolved oxygen levels). Also, in localized areas, nutrient loading from agricultural (predominantly grazing) and single family residential sources may be far more significant that this source category appears to be at the watershed scale.

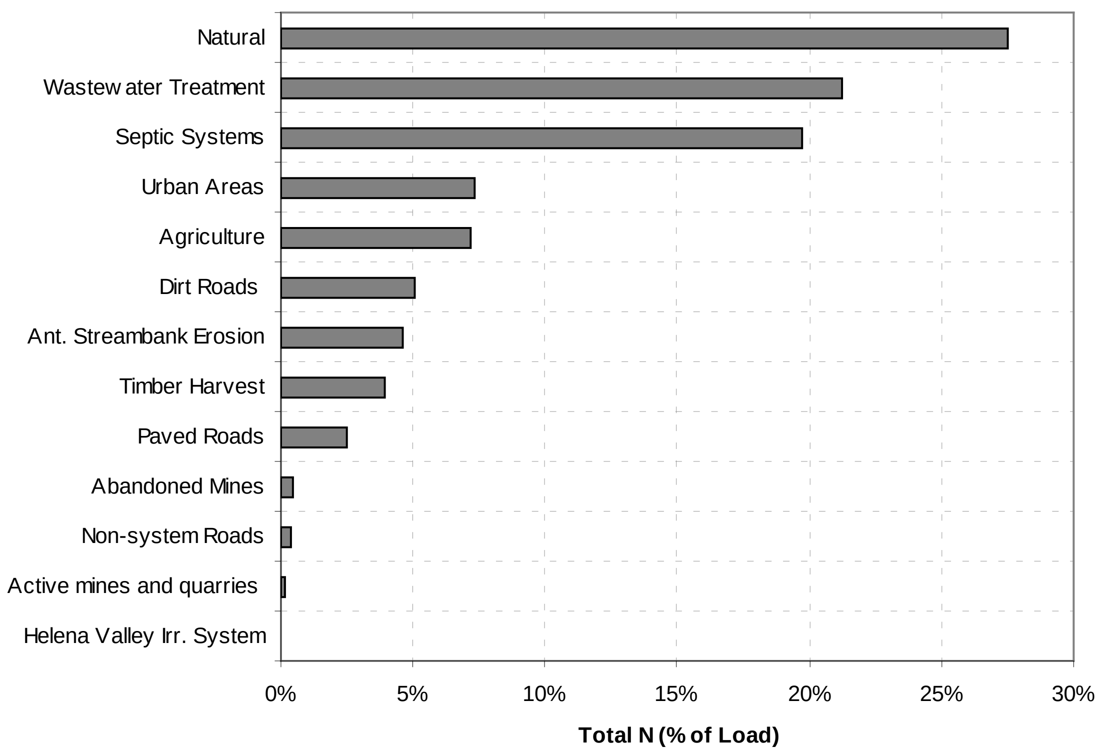

Figure 8-6. Percent of the annual TN load from all potentially significant nitrogen sources in the Prickly Pear Creek Watershed.

8.2.2.2 Water Quality Goals/Targets

The proposed interim water quality target for TN in Prickly Pear Creek is 0.33 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

8.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the nitrogen TMDL is to attain full beneficial use support in Prickly Pear Creek. In the absence of better data/information, the interim target presented in Section 8.2.2.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 80 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, and point source loads were reduced by 90 percent, the maximum attainable nitrogen load reduction for the Prickly Pear Creek Watershed is estimated to be only 39 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Prickly Pear Creek will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TN load reductions from non-point sources, includes a phased wasteload allocation to reduce point sources loads, and, in recognition of the fact that it may not be possible to attain the TN target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 8-7 and Table 8-8. The phased wasteload allocation is presented in Appendix I and the adaptive management strategy is presented in Volume II, Section 3.0.

Table 8-7. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Nitrogen.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.9	71	0.3	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%. Sediment-associated nitrogen will decrease accordingly (71%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Active Mines	0.3	0	0.3	BMPs for active mines were assumed to not be cost effective because the loads represent such a small fraction of the current overall loads.	Current loads from active mines are based on modeled storm water runoff and literature values for runoff concentrations. The current loads are likely overestimated because DEQ reports that there has never been a discharge from the MT Tunnels Mine site (the only significant active mine in the watershed).
	Agriculture	13.3	88	1.6	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	8.5	85	1.3	It is estimated that there are 13.2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.7	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	4.7	30	3.3	An average nitrogen removal efficiency of 30% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	37.0	0.5	36.8	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 0.5% decrease in TN. Replacing failing septic systems with level 2 treatment could result in a 1.8% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	7.2	97	0.2	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	9.3	60	3.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	13.6	30	9.5	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	95.5	40	57.0		
	Natural Sources	51.0	0	51.0	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	39.6	91	3.7	Nitrogen point sources are listed in Table 8-8. The allocations for the WWTPs are based on the phased approach described in Appendix I. Load reductions for known failing lagoons are presented in Table 8-8. No allocations are proposed for lagoons thought to be operating as designed.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**186.1**	**39**	**111.7**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 3.7 tons/yr + 57.0 tons/yr + 51.0 tons/yr + 0 = 111.7 tons/yr** **TMDL = 0.01 + 0.16 tons/day + 0.14 tons/day + 0 = 0.31 tons/day**					

Table 8-8. Estimated loads and load reductions for all sources of TN in the Prickly Pear Creek watershed.

Source Category	Source	Estimated TN Load (tons/yr)	Estimated Reductions (%)	Remaining Load (tons/yr)
Anthropogenic Nonpoint Sources	Abandoned Mines	0.9	71	0.3
	Active Mines	0.3	0	0.3
	Agriculture	13.3	88	1.6
	Anthropogenic Streambank Erosion	8.5	85	1.3
	Non-system Roads	0.7	100	0.0
	Paved Roads	4.7	30	3.3
	Septic Systems	37.0	0.5	36.8
	Timber Harvest	7.2	97	0.2
	Unpaved Roads	9.3	60	3.7
	Urban Areas	13.6	30	9.5
	Total Anthropogenic NPS Load	**95.5**	40	**57.0**
Natural Nonpoint Sources	Fullgrowth Forest	9.3	0	9.3
	Wetlands	0.1	0	0.1
	Shrubland	3.0	0	3.0
	Grassland	23.9	0	23.9
	Nat. Streambank Erosion	1.6	0	1.6
	Groundwater	13.1	0	13.1
	Total Natural NPS Load	**51.0**	**0**	**51.0**
Anthropogenic Point Sources	City of Helena	31.8	92	2.5
	East Helena	6.5	97	0.2
	Evergreen Nursing Home	0.1	0	0.1
	Treasure State Acres subdivision	0.1	50	0.0
	Tenmile and Pleasant Valley subdivisions	0.8	21	0.6
	Mountain View law enforcement academy	0.2	0	0.2
	Eastgate Subdivision	0.1	0	0.1
	Total Point Source	**39.6**	91	**3.7**
Total	**Totals**	**186.1**	39	**111.7**

8.2.3 Phosphorus

8.2.3.1 Sources of Phosphorus in the Prickly Pear Creek Watershed

As shown in Figure 8-7, the primary anthropogenic sources of phosphorus in the Prickly Pear Creek watershed, in order of importance, are municipal wastewater treatment (42%), agriculture (8%), dirt roads (6%), anthropogenic streambank erosion (5%), timber harvest (4%) and urban areas (4%). As with nitrogen, dewatering may also be a complicating factor for phosphorus and, in localized areas, phosphorus loading from agricultural (predominantly grazing) and single family residential sources may be far more significant that this source category appears to be at the watershed scale.

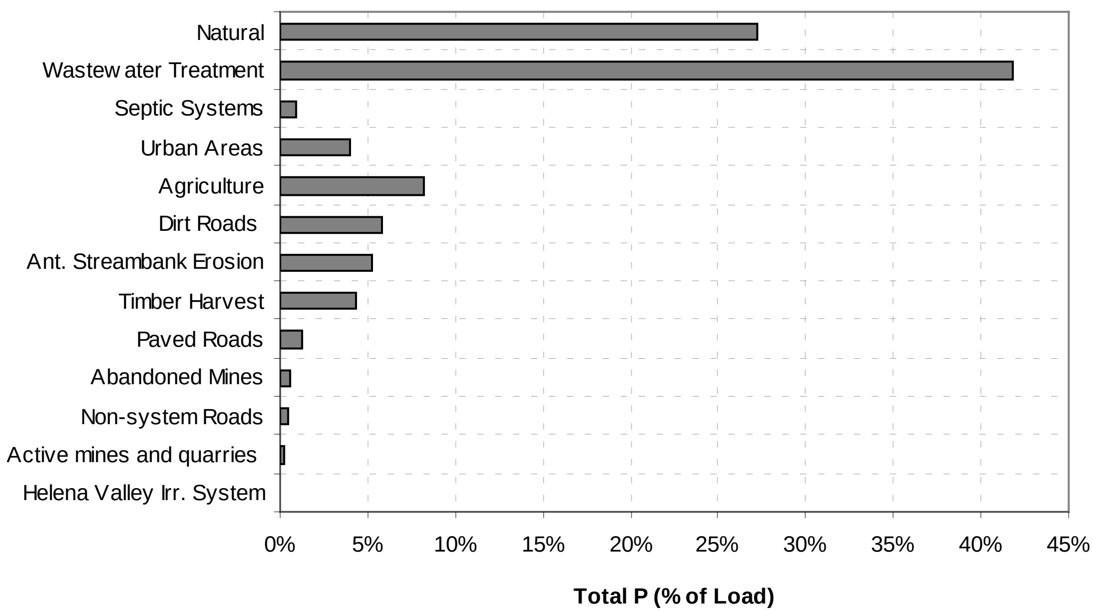

Figure 8-7. Percent of the annual TP load from all potentially significant phosphorus sources in the Spring Creek Watershed.

8.2.3.2 Water Quality Goals/Targets

The proposed interim water quality target for TP in Prickly Pear Creek is 0.04 mg/L (See Volume I Section 3.2.3). A strategy to revise this target, if deemed appropriate, is presented in Volume I, Section 3.2.3.

8.2.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the phosphorus TMDL is to attain full beneficial use support in Prickly Pear Creek. In the absence of better data/information, the interim target presented in Section 1.1.2.2 is assumed to represent the phosphorus level below which all beneficial uses would be supported. A phosphorus load reduction of 87 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, and point source loads were reduced by 98 percent, the maximum attainable phosphorus load reduction for the Prickly Pear Creek Watershed is estimated to be only 62 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Prickly Pear Creek will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable phosphorus load reductions from non-point sources, includes a phased wasteload allocation to reduce point sources loads, and, in recognition of the fact that it may not be possible to attain the phosphorus target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 8-9 and Table 8-10. The phased wasteload allocation is presented in Appendix I and the adaptive management strategy is presented in Volume II, Section 3.0.

Table 8-9. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek –Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.2	71	0.1	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%. Sediment-associated phosphorus will decrease accordingly (71%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Active Mines	0.1	0	0.1	BMPs for active mines were assumed to not be cost effective because the loads represent such a small fraction of the current overall loads.	Current loads from active mines are based on modeled storm water runoff and literature values for runoff concentrations. The current loads are likely overestimated because DEQ reports that there has never been a discharge from the MT Tunnels Mine site (the only significant active mine in the watershed).
	Agriculture	2.9	90	0.3	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	1.9	90	0.2	It is estimated that there are 13.2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.2	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.5	50	0.3	An average phosphorus removal efficiency of 50% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	0.3	100	0.0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	1.6	97	0	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.1	60	0.8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.4	50	0.7	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	11.0	78	2.4		
	Natural Sources	9.6	0	9.6	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	14.9	89	1.6	Phosphorus point sources are listed in Table 8-10. The allocations for the WWTPs are based on the phased approach described in Appendix I. Load reductions for known failing lagoons are presented in Table 8-10. No allocations are proposed for lagoons thought to be operating as designed.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**35.5**	**62**	**13.6**		
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 1.6 tons/yr + 2.4 tons/yr + 9.6 tons/yr + 0 = 13.6 tons/yr TMDL = 0.001 tons/day + 0.006 tons/day + 0.026 tons/day + 0 = 0.033 tons/day**					

Table 8-10. Estimated loads and load reductions for all sources of TP in the Prickly Pear Creek watershed.

Source Category	Source	Estimated TP Load (tons/yr)	Estimated Reductions (%)	Remaining Load (tons/yr)
Anthropogenic Nonpoint Sources	Abandoned Mines	0.2	71	0.1
	Active Mines	0.1	0	0.1
	Agriculture	2.9	90	0.3
	Anthropogenic Streambank Erosion	1.9	90	0.2
	Non-system Roads	0.2	100	0
	Paved Roads	0.5	50	0.3
	Septic Systems	0.3	100	0
	Timber Harvest	1.6	97	0
	Unpaved Roads	2.1	60	0.8
	Urban Areas	1.4	50	0.7
	Total Anthropogenic NPS	**11.0**	**78**	**2.4**
Natural Nonpoint Sources	Fullgrowth Forest	2.0	0	2.0
	Wetlands	0.02	0	0.02
	Shrubland	0.6	0	0.6
	Grassland	5.2	0	5.2
	Nat. Streambank Erosion	0.4	0	0.4
	Groundwater	1.4	0	1.4
	Total Natural NPS	**9.6**	**0**	**9.6**
Anthropogenic Point Sources	City of Helena	13.5	98	0.3
	East Helena	1.0	0	1.0
	Evergreen Nursing Home	0	0	0
	Treasure State Acres subdivision	0.1	33	0.1
	Tenmile and Pleasant Valley subdivisions	0.1	14	0.1
	Mountain View law enforcement academy	0.1	0	0.1
	Eastgate Subdivision	0.1	0	0.1
	Total Point Source	**14.9**	**89**	**1.6**
Total		**35.5**	**62**	**13.6**

8.3 Sediment

Based on the results summarized in Volume I, Prickly Pear Creek is impaired due to excessive levels of sediment from the headwaters downstream to Lake Helena. The following sediment TMDL addresses all five water quality limited segments described in Section 1.0.

8.3.1 Sources of Sediment in the Prickly Pear Creek Watershed

As shown in Figure 8-8 the primary anthropogenic sources of sediment in the Prickly Pear Creek watershed, in order of sediment load are agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, abandoned mines, and active mines and quarries. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that they are adequate for making relative comparisons, they should not be used directly as quantity estimates.

Agriculture was the single greatest sediment source within the greater Prickly Pear Creek watershed, representing 32 percent of the total anthropogenic sediment load. As a land-use, agriculture occurs in the lower elevation areas of the watershed including middle and lower Tenmile, Sevenmile and Prickly Pear Creek watersheds. On a segment scale, two central Prickly Pear segments, Lump Gulch to Wylie Drive (MT41I006_040), and Wylie Drive to Helena Wastewater Treatment Plant Discharge (MT41I006_030), produced the greatest quantities of agriculture related sediment in the entire Prickly Pear watershed; 2,792 and 1,284 tons respectively. Unpaved roads were the second greatest anthropogenic sediment source, accounting for 23 percent of this load. Prickly Pear Creek from Lump Gulch to Wylie Drive (MT41I006_040) was the segment that produced the greatest quantity of road related sediment, 701 tons. This load is generated from high road densities related to sub-division development throughout this segment. Segments within the greater Prickly Pear Creek watershed that generate the largest streambank erosion sediment loads include Clancy Creek, Sevenmile Creek, and Prickly Pear above Lake Helena watersheds, respectively. Causes of streambank erosion in these watersheds are riparian grazing, road encroachment, stream channelization, riparian vegetation removal, and historic mining activity.

Watersheds that produced the greatest quantity of sediment related to timber harvest were Lump Gulch, Prickly Pear Creek above Wylie Drive, upper Tenmile Creek, and Clancy Creek, respectively. All of which produced more than 300 tons of sediment per year from silviculture activities. Sediment from urban areas is related to developed areas in the lower watersheds throughout the Helena Valley and the central Prickly Pear drainage. Non-system roads/trails occur throughout the entire watershed. Densities of these roads/trails are typically greater on public lands of the upper areas of the watershed. A total of thirty abandoned mines were identified to be capable of delivering sediment to perennial stream channels throughout the greater Prickly Pear Creek watershed. Five of these mines – Alta, Bertha, Corbin Flats, Gregory, and Nellie Grant – have been reclaimed by Montana DEQ. All of the mines are located in the upper tributary watersheds. Sediment from active mines and quarries is generated in lower Tenmile and Prickly Pear watersheds and is related to gravel pit operations and the like. Additionally, the Helena Wastewater Treatment Plant, the largest suspended sediment discharger in the watershed, generates a total suspended sediment load from of 54 tons per year. The meager size of this source relative to the previously described source categories warrants minimal concern or attention.

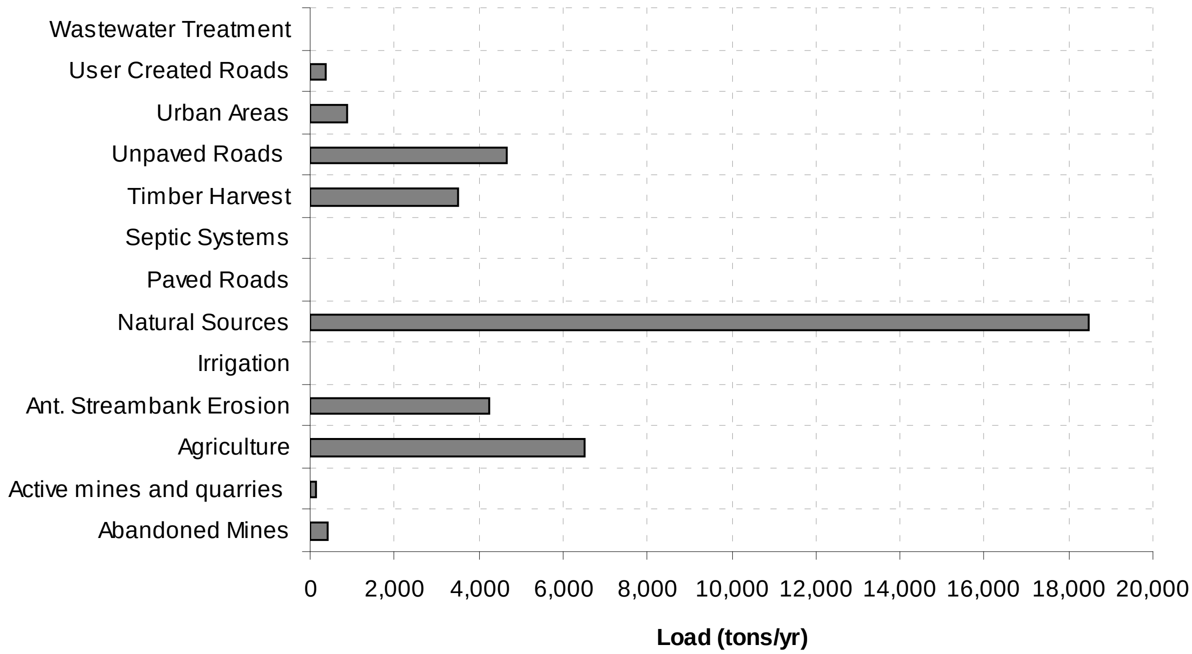

Figure 8-8. Total annual sediment load from all potentially significant sediment sources in the Prickly Pear Creek Watershed.

8.3.2 Water Quality Goals/Targets

The ultimate goal of this sediment TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.3.3.

8.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 8-11. The TMDL is presented at the scale of the entire Prickly Pear Creek watershed. Note that individual sediment TMDLs have also been prepared for the following tributaries: Clancy Creek (MT41I006_120), Corbin Creek (MT41I006_090), Golconda Creek (MT41I006_070), Jackson Creek (MT41I006_190), Sevenmile Creek (MT41I006_160), Jennie's Fork (MT41I006_210), Skelly Gulch (MT41I006_220), Lump Gulch (MT41I006_130), Spring Creek (MT41I006_080), Middle Fork Warm Springs Creek (MT41I006_100), Tenmile Creek (MT41I006_141), North Fork Warm Springs Creek (MT41I006_180), Tenmile Creek (MT41I006_142), Tenmile Creek (MT41I006_143), and Warm Springs Creek (MT41I006_110). TMDLs for the individual tributaries are presented in Appendix A.

Based on the results of the source assessment (Section 8.3.1), the recommended implementation strategy to address the siltation problem in Prickly Pear Creek is to reduce sediment loading from the primary anthropogenic sediment sources – agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, abandoned mines, and active mines and quarries. As shown in Table 8-11, the hypothesis is that an overall, watershed scale sediment load reduction of 38 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, and abandoned mines by 60, 60, 85, 97, 80, 100, and 79 percent, respectively.

Table 8-11. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	424	71	123	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Agriculture	6,526	60	2,610	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing erosion.	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	4,244	85	637	It is estimated that there are 13.2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	367	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	144	0	144	Loading estimates reflect no reduction in load allocation. This is due to the small load size relative to other sediment sources.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	3,493	97	105	It is assumed that sediment loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	4,655	60	1,862	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	855	80	171	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	20,708	73	5,652		
	Natural Sources	18,480	0	18,480	It is assumed that the sediment loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	54	0	54	Sediment Point Sources: City of Helena WWTP. This load is considered insignificant, and therefore no wasteload reduction is required.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**39,242**	**38**	**24,186**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 54+ 5,652 tons/yr + 18,480 tons/yr + 0 = 24,186 tons/yr** **TMDL = 0.1 + 15.5 tons/day + 50.7 tons/day + 0 = 66.3 tons/day**					

8.4 TEMPERATURE

Measured in-stream temperatures, riparian assessments, and modeling all suggest that Prickly Pear Creek (from where to where including what segments) is impaired by temperature (see Volume I Report). TMDLs are presented in the following sections to address the temperature impairment in Prickly Pear Creek.

8.4.1 Sources of Temperature Impairment in the Prickly Pear Creek Watershed

Sources of temperature impairment were identified through field assessments, aerial surveys, and MPDES data. There are three key sources of thermal modifications in the watershed – flow alterations, riparian degradation, and point sources. The following sections summarize each source of impairment. More detailed descriptions are included in Appendix G.

8.4.1.1 Flow Alterations

Flow alterations indirectly impact stream temperature because of simple energy mechanics. When there is less water in the stream, the water is easier to heat. Flow alterations exist throughout Prickly Pear Creek in the form of irrigation withdrawals, industrial withdrawals, and dams. These flow alterations are pervasive throughout the lower six miles of the stream due to intense agriculture and industry near the Helena Valley. Figure 8-9 shows the major diversions and dams identified during the Prickly Pear Creek source assessment. Four major diversions were identified on Prickly Pear Creek between the confluence with Lump Gulch and Lake Helena. During the field assessment, it was noted that flows were almost entirely diverted out of Prickly Pear Creek, with almost no flow occurring in the segment between the Wylie Drive Bridge and the confluence with the Helena WWTP outfall. Montana Fish, Wildlife, and Parks considers this segment "chronically dewatered" during most years (MFWP, 2005).

Synoptic flow measurements, USGS gaging station records, and the DNRC water rights database were used to construct recent summer flows and diversions along Prickly Pear Creek from Lump Gulch to Lake Helena. The creek was divided into five segments to create a simple summer (i.e., critical conditions) flow budget based on data measured on or estimated for August 7, 2003. The modeling segments are described in Table 8-12, and Table 8-13 describes the flow budget for August 7, 2003.

The flow budget was then input into a stream temperature model (SSTEMP) to predict the impact of flow diversions on stream temperatures. Details for the SSTEMP modeling, as well as the flow budget, are included in Appendix G.

The SSTEMP model predicted that flow alterations in Segments 1, 2, and 3 cumulatively raise the stream temperature by 1.8 degrees Fahrenheit during critical low flow summer months. The impact of any flow alterations located downstream of Segment 3 could not be evaluated because Prickly Pear Creek – during summer low flows – is not hydrologically connected due to dewatering.

Table 8-12. Temperature impaired segments of Prickly Pear Creek and the corresponding SSTEMP modeling segments.

303(d) Segment	Modeling Segment	Location
MT41I006_040	Segment 1a	Confluence with Lump Gulch to USGS gage #06061500 (3.5 miles).
	Segment 1b	Confluence with Lump Gulch to confluence with McClellan Creek (6.8 miles).
	Segment 2	Confluence with McClellan Creek to ASARCO Dam (1.7 miles).
	Segment 3	ASARCO Dam to Wylie Drive (1.7 miles).
MT41I006_030	Segment 4	Wylie Drive to Helena Wastewater Treatment Plant discharge (4.3 miles)
MT41I006_020	Segment 5a	Helena Wastewater Treatment Plant to Sierra Road (2.7 miles).
	Segment 5b	Helena Wastewater Treatment Plan to the mouth (5.9 miles).

Table 8-13. Summary of major summer inflows and outflows along lower Prickly Pear Creek.

303(d) Segment	Modeling Segment	Flow Gains (cfs)	Flow Losses (cfs)	Flow Budget (cfs)	Flow Sources/ Withdrawals
MT41I006_040	1	1.4	None	+1.4	Tributary Inflow and Groundwater Discharge
	2	9.9	9.9	0.0	Tributary Inflow *(Irrigation Diversions)*
	3	None	6.0	-6.0	*(Irrigation Diversions)*
MT41I006_030	4*	1.5	3.0	-1.5	Groundwater Discharge *(Irrigation Diversions)*
MT41I006_020	5	15.0	None	+15.0	Groundwater Discharge and Irrigation Return

* Segment 4 is totally dewatered, but flow gains from groundwater discharge occur near the end of the reach. Therefore, flows between Segments 3, 4,and 5 are not hydrologically connected.

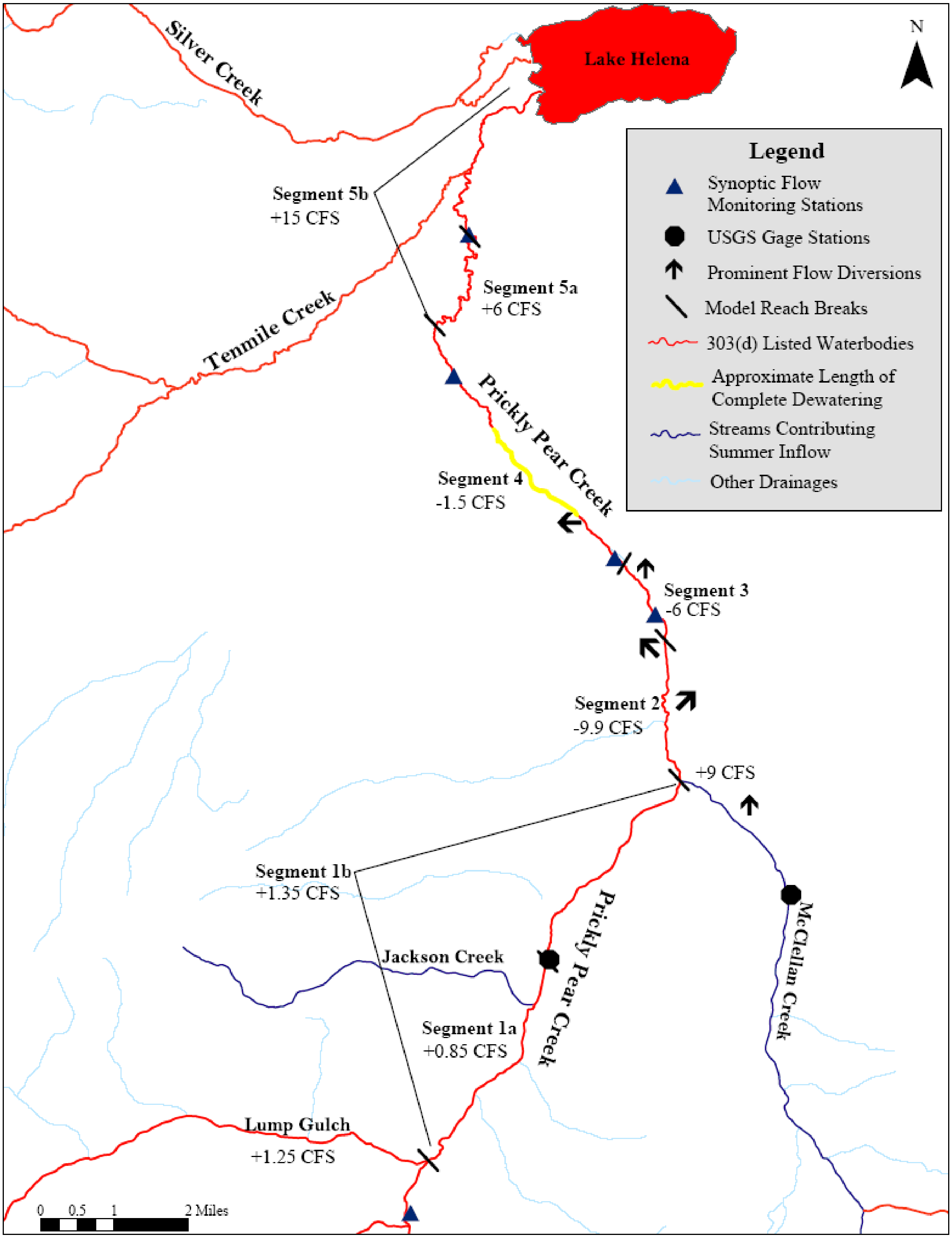

Figure 8-9. General overview of major summer inflows and outflows along lower Prickly Pear Creek.

8.4.1.2 Riparian Degradation

Among other things, Stream temperature is a function of riparian vegetation – more riparian vegetation generally translates into more stream shade, and lower stream temperatures. Riparian data from numerous sources were evaluated to assess the riparian condition of Prickly Pear Creek. Proper Functioning Condition (PFC) assessments were conducted at three sites along lower Prickly Pear Creek in 2003 (see Figure 8-9). The most upstream site ranked as functional, but at risk. Segments 4 and 5 (downstream most segments) ranked as non-functional, indicating severe riparian degradation along these segments.

Quantitative riparian vegetation data were obtained for the SSTEMP stream temperature model. Data were collected at 11 sites in 2005 and included topographic altitude (degrees), distance to vegetation, angle to vegetation top (degrees), vegetation height (ft), vegetation type, vegetation crown (ft), vegetation offset (ft), and vegetation density (%). The measured existing data are summarized in Figure 8-10, and assessment locations are shown in Figure 8-9. Detailed information about the riparian survey is included in Appendix G.

Natural riparian conditions (i.e., the maximum potential riparian vegetation) were estimated based on the measured data, comparable reference streams, and best professional judgment. Figure 8-11 summarizes theoretical maximum potential riparian measurements for the riparian field inventory sites along lower Prickly Pear Creek. Comparing the maximum potential and existing riparian conditions, it appears that current riparian vegetation is located farther from the stream, with vegetation having less height and density. Also, there is a lack of mature cottonwood trees in the current riparian area.

Both the natural and existing riparian conditions were input into the SSTEMP stream temperature model (see Appendix G). Existing and natural conditions were compared to quantify the effect of riparian degradation on stream temperature during a critical low flow summer event (as measured on August 7, 2003). The SSTEMP model predicted that the cumulative impact of riparian degradation to existing stream temperatures is 0.90 degrees Fahrenheit. This is the cumulative impact of riparian degradation through Segment 3 (Lump Gulch to the Wylie Drive Bridge). The impact of any flow alterations located downstream of Segment 3 could not be evaluated because Prickly Pear Creek – during summer low flows – is not hydrologically connected because of dewatering (see Section 8.4.1.1).

Figure 8-10. Summary of the existing riparian conditions for Prickly Pear Creek.

Sample Location ID[1]	Topographic Altitude (degrees)		Vegetation Height (ft)		Vegetation Type		Vegetation Crown (ft)		Vegetation Offset (ft)		Vegetation Density (%)	
	East	West	East	West	East	West	East	West	East	West	East	West
Segment 1-1	8	4	24	0	willow/alder	grass	8	0	1	0	85	7
Segment 1-2	22	7	24	14	willow/alder	willow/alder	18	23	1	2	40	60
Segment 1-3	5	4	28	27	willow/alder	willow/alder	20	12	2	5	70	85
Segment 3 -1	7	27	17	0	willow some alder	grass	5	0	8	0	90	0
Segment 3 -2	4	6	34	52	cottonwood/willow	cottonwood/willow	15	15	0.5	4	70	45
Segment 4 -1	3	10	12	45	willow/alder	cottonwood/willow	7	27	4	2	20	90
Segment 4 -2	10	2	0	5	Grass	sparse willows	0	6	0	1	0	1
Segment 4 -3	5	5	11	0	Willow	grass	14	0	30	0	20	0
Segment 5 -1	9	2	0	0	Grass	grass	0	0	0	0	0	0
Segment 5 -2	1	5	8	6	Willow	willow	18	30	55	55	20	40
Segment 5 -3	7	5	10	0	Willow	grass	5	0	5	0	90	0

[1]Number references refer to upstream to downstream inventory locations. Refer to Table 8-14 for actual locations.

Figure 8-11. Summary of theorized maximum potential riparian conditions for Prickly Pear Creek.

Sample Location ID	Topographic Altitude (degrees)		Vegetation Height (ft)		Vegetation Type		Vegetation Crown (ft)		Vegetation Offset (ft)		Vegetation Density (%)	
	East	West	East	West	East	West	East	West	East	West	East	West
Segment 1	10	12	25	15	willow/alder	willow/alder	10	15	2	1	60	65
Segment 2	10	12	15	15	willow/alder	willow/cottonwood	10	15	3	2	50	55
Segment 3	10	13	20	10	willow/cottonwood	willow/alder	15	10	2	2	60	50
Segment 4	10	15	10	15	willow/cottonwood	willow/cottonwood	15	15	2	2	65	55
Segment 5	10	10	15	25	willow/cottonwood	cottonwood/willow	15	30	2	5	55	50

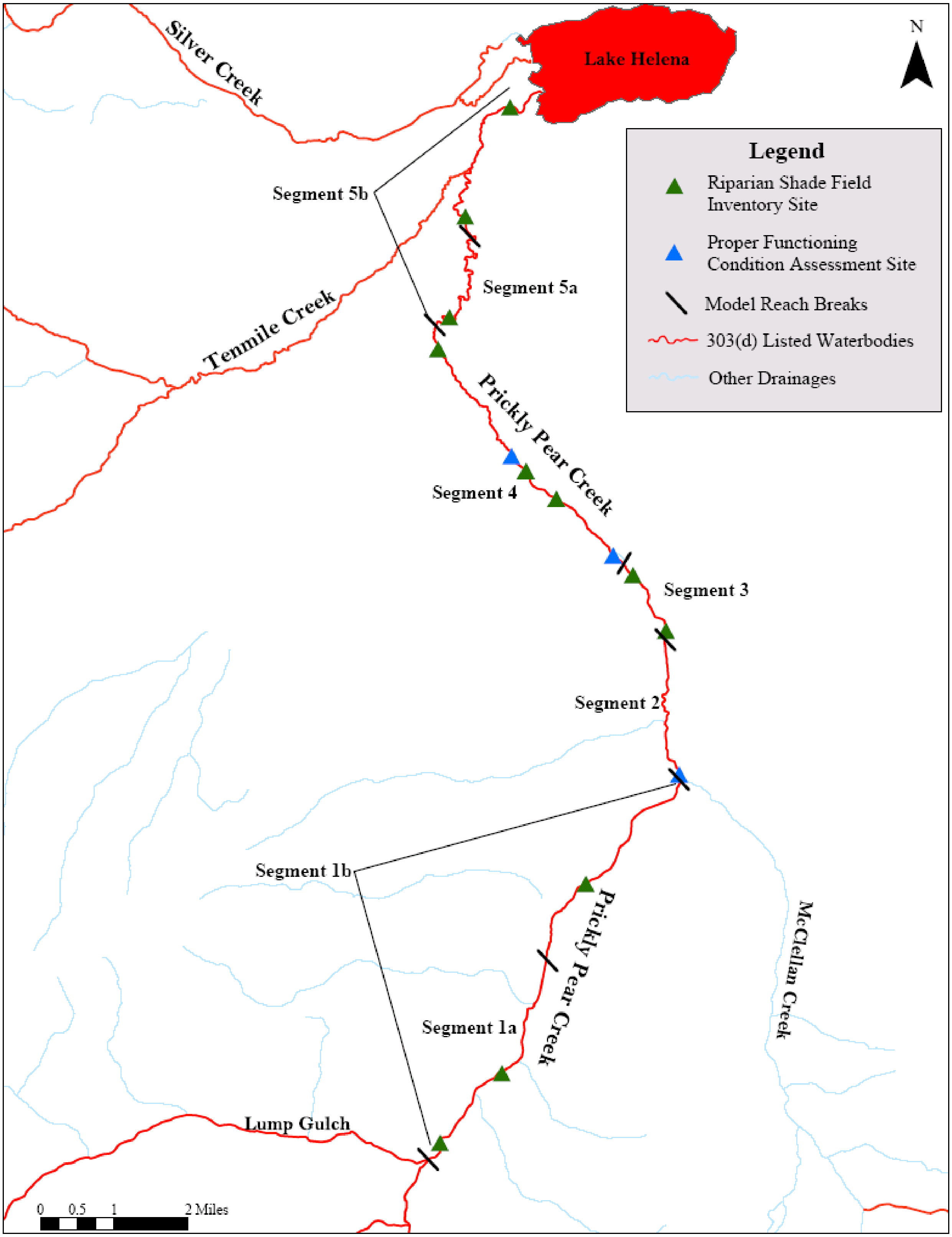

Table 8-14. Riparian field evaluation sites along lower Prickly Pear Creek.

8.4.1.3 Point Sources

There are five entities with MPDES permits along lower Prickly Pear Creek – Ash Grove Cement Company (MT0000451), Air Liquide America Corporation (MT0000426), ASARCO (MT0030147), City of East Helena WWTP (MT0022560), and City of Helena WWTP (MT0000949). An analysis of discharge and temperature data suggests that Ash Grove Cement Company, Air Liquide America Corporation, and ASARCO are having negligible impacts to temperature in Prickly Pear Creek. This is mostly due to the fact that these three facilities rarely (if ever) discharge to surface water. The City of East Helena and City of Helena WWTP outfalls may be having larger impacts to stream temperature. They contribute an average of 3.1 and 0.20 MGD, respectively, and the Helena WWTP effluent potentially constitutes the majority of flow in Segment 5 during summer months. However, neither facility monitors effluent temperature. Therefore, potential impacts from these facilities could not be evaluated at this time. Additional effluent monitoring for both facilities is proposed (see the Sampling and Analysis Plan in Appendix H), and the temperature TMDLs may have to be revised when the new monitoring data are assessed.

8.4.1.4 Summary of Sources

Stream temperature is a function of many parameters such as air temperature, humidity, cloud cover, riparian vegetation, point sources, and stream flow or volume. Of these, riparian vegetation, flow, and point sources are the sources that can be directly influenced and controlled by human activity. As shown in Sections 8.4.1.1 and 8.4.1.2, flow alterations and riparian degradation are increasing stream temperatures in Prickly Pear Creek. Point sources are having minimal impact. The cumulative effect of all three sources is presented below in Table 8-15. Combined, stream temperature in Prickly Pear Creek through Segment 3 is 2.7 ± 0.5 degrees Fahrenheit greater than the natural stream temperature. The cumulative impact of stream temperature from Lump Gulch to the mouth (Segments 1 through 5) could not be evaluated because the stream is completely dewatered in Segment 4, and therefore Prickly Pear Creek is not hydrologically connected from the upstream to the downstream segments. Detailed information about SSTEMP and the modeling assumptions can be found in Appendix G.

Table 8-15. Sources and amount of thermal modifications in Prickly Pear Creek.

303(d) Segment	Modeling Segment[1]	Riparian Vegetation	Flow Alterations	Point Sources	Total Thermal Modification
MT41I006_040	1	0.0 °F	0.0 °F	None	0.0 °F
	2	0.6 °F	1.0 °F	Insignificant	1.6 °F ± 0.5 °F
	3	0.9 °F	1.8 °F	None	2.7 °F ± 0.5 °F
MT41I006_030	4[2]	NA	NA	NA	NA
MT41I006_020	5[3]	2.1 °F	None	None	0.5 °F ± 1.2 °F

[1] Thermal modifications presented here are cumulative from Lump Gulch through the end of the evaluated modeling segment.
[2] Reaches 4 is dewatered and could not be evaluated with the SSTEMP model.
[3] Reach 5 consists of groundwater recharge and irrigation returns, and flows are not hydrologically connected to upstream segments during critical low flow summer months.

8.5 WATER QUALITY GOALS/TARGETS

The ultimate goal of this plan and associated TMDLs is to attain and maintain water quality standards. Montana's water quality standards for temperature are numeric. However, the definition of 'naturally occurring' water temperature within the state standard must be interpreted to derive measurable water quality goals.

Since the success of this plan and associated TMDLs will be formally evaluated five years after it is approved (i.e., 2011 assuming approval in 2006), flexibility must be provided herein for the interpretation of 'naturally occurring' water temperature in Prickly Pear Creek. The water quality standards and indicators presented in Table 8-16 are proposed as end-point water quality goals (i.e., targets) for temperature, in recognition of the fact that they may need to be changed in the future as new information becomes available and/or DEQ implements a new methodology for interpreting 'naturally occurring' water temperature.

The suite of indicators used to evaluate compliance with Montana's temperature standards in the future should be selected based on the best data and information available, and/or the current DEQ methodology available, at that time.

Table 8-16. Proposed Temperature Water Quality Endpoints.

Water Quality Indicator	State Water Quality Standard	
Water Temperature: A change in temperature due to anthropogenic sources, or variation from a reference condition.	**B-1 Class Waters:** ≤ 1^{o} F when water temperature is < 67 ^{o} F ≤ 0.5^{o} F when water temperature is > 67 ^{o} F **I Class Waters:** No increase in naturally occurring water temperature.	
Water Quality Indicator	**Rationale for Selection of this Indicator**	**Proposed Criteria**
Percent Shade	Shading provided by riparian vegetation is a significant factor for reducing thermal energy input to Prickly Pear Creek. Riparian vegetation can also influence channel form and the amount of surface area exposed to solar heating.	60 Percent
Fish Population Metrics	The presence of cold-water fish can be an indication of the temperature suitability of a stream, when the waterbody is not limited by other water quality or habitat constraints.	MFISH rating of "best" or "substantial"
Stream Flow	Because water has a high specific heat capacity, larger volumes of water are subject to fewer fluctuations in temperature. By increasing flow, the stream will be more resistant to temperature increases.	Maintain MFWP's recommended year round aquatic life survival flow targets: 8 to 22 cfs for Prickly Pear Creek from the headwaters to East Helena, 14 to 30 cfs from East Helena to Lake Helena.

8.6 Total Maximum Daily Load, Allocations, and Margin of Safety

8.6.1 Prickly Pear Creek from Lump Gulch to the Wylie Drive Bridge

The goal of the temperature TMDL is to attain full beneficial use support in Prickly Pear Creek. The TMDLs presented here are based on an average, drought, summer low flow condition, which is considered the critical condition for evaluating temperature impairment. Based on the SSTEMP modeling analysis, the natural average daily temperature at the end of Segment 3 (Wylie Drive Bridge) is 66.5 degrees Fahrenheit. Montana's numeric temperature standards allow for a one degree Fahrenheit increase from the natural stream temperature. Therefore, the temperature target for Prickly Pear Creek at the Wylie Drive Bridge is 67.5 degrees. A 0.5 degree margin of safety was then applied to account for the reported uncertainties in the SSTEMP model (95 percent confidence interval), making the target temperature 67.0 degrees Fahrenheit.

The SSTEMP model and measured data reported that the existing average stream temperature at the Wylie Drive Bridge is 69.2 degrees Fahrenheit. This is a result of riparian degradation (0.9 °F), flow alterations (1.8 °F), and natural background temperature (66.5 °F). Therefore, a 2.2-degree reduction in stream temperature is needed to achieve the temperature target of 67.0 degrees Fahrenheit.

Recognizing that flow and riparian vegetation are correlated, the necessary temperature reduction can be achieved through several possible scenarios where flow in the creek is augmented (i.e., less flow alterations) and/or riparian vegetation is restored. Table 8-17 summarizes the most feasible scenario for Prickly Pear Creek (Lump Gulch to the Wylie Drive Bridge), where riparian vegetation is restored to the maximum potential along the entire 10.2 mile reach of Prickly Pear Creek, and flows are augmented by a minimum amount (8.5 cubic feet per second) to achieve the necessary temperature reduction of 2.2 degrees Fahrenheit. Again, this is simply one scenario in which it is possible to achieve the target.

It is recognized here that neither Montana DEQ nor USEPA has authority to regulate non-point sources (i.e., riparian vegetation or flow). Therefore, implementation of this TMDL will be voluntary, with watershed stakeholders ultimately deciding the restoration strategy.

Table 8-17. Temperature TMDL for Prickly Pear Creek from Lump Gulch to Wylie Drive.

Allocation	Thermal Source	Current Temperature	Temperature Reduction	Allowable Temperature	Rationale/Assumptions
Load Allocation	Riparian Degradation	0.9 °F	100%	0.0 °F	Ideally, all riparian vegetation should be restored to the maximum potential to increase shading by an average of 40%
	Flow Alteration	1.8 °F	72%	0.5 °F	Ideally, stream flows should meet minimum requirements set forth by MFWP. However, for the purpose of this TMDL scenario, flows were augmented by 8.5 cfs to achieve the temperature reduction of 2.2 °F
	Total – All Anthropogenic Nonpoint Sources	2.7 °F	81%	0.5 °F	
	Natural Background	66.5 °F	None	66.5 °F	Background conditions were modeled as having the maximum potential riparian vegetation, and no flow diversions, for a critical low flow summer time period.
Waste Load Allocation	All Point Sources	0.0 °F	None	0.0 °F	Point source loads are minimal when compared to riparian vegetation and flow alterations. Additional monitoring is needed to quantify the effect of the Helena and East Helena WWTP outfalls.
Margin of Safety		NA	0.0	0.5 °F	The 95% confidence interval for the SSTEMP model was ± 0.5 °F. This amount was subtracted from the calculated allowable temperature (67.5 °F) to derive the temperature target of 67.0 °F.
Total		**69.2 °F**	**2.2 °F**	**67.0 °F**	The ***Allowable Temperature*** is the natural temp (66.5 °F) + 1 °F, and minus 0.5 °F to account for the margin of safety.

[1] Values presented in the Table are average daily stream temperatures for a critical summer low flow time period.

8.6.2 Prickly Pear Creek from the Wylie Drive Bridge to the Mouth

Prickly Pear Creek from the Wylie Drive Bridge to Lake Helena (modeling segments 4 and 5) presents a unique challenge for temperature allocations. Prickly Pear Creek from Wylie Drive to the Helena WWTP outfall (Segment 4) has a section that is completely dewatered. According to model results, temperatures within the dewatered segment may be 5.4 degrees F greater than average natural temperatures. However modeling results are unreliable because the segment could not be properly calibrated.

The segment of Prickly Pear Creek downstream of the completely dewatered reach (Segment 5) presents a challenge due to the hydrologic disconnection of surface water. Water in this segment mostly consists of groundwater recharge and irrigation returns, and cumulative thermal modifications from upstream do not currently carry over into Segment 5 during critical low flow summer periods. Therefore, when analyzed as a single segment, Prickly Pear Creek from the Helena WWTP outfall to the mouth is not exceeding the numeric temperature water quality standard for a B-1 stream. The daily average existing temperature during critical conditions is only 0.5 degrees F greater than the average natural temperature during the same time period.

Although thermal allocations are not quantifiable at this time, Prickly Pear Creek from the Wylie Drive Bridge to Lake Helena is still considered impaired because of thermal modifications. First, riparian areas were in poor condition along this section of the creek (see Section 8.4.1.2). This condition exceeds the target defined in Section 8.5 – i.e., no significant disturbance of riparian vegetation. Second, this segment does not achieve the flow target selected by MFWP – i.e., maintain a flow of ranging from 14 to 30 cfs throughout the lower segments of Prickly Pear Creek. And third, if this segment was hydrologically connected to the upstream segments of Prickly Pear Creek, the thermal impairments from upstream would most likely carry through to the mouth, and this segment would be impaired. Voluntary efforts to improve the riparian condition and in-stream flows along this portion of the stream should be pursued in an attempt to bring the stream in compliance with the temperature water quality targets, and with Montana Fish, Wildlife, and Parks flow recommendations. Because of the dewatering, Prickly Pear Creek from the Wylie Drive Bridge to the Helena WWTP outfall is also considered impaired because of flow alterations. Aquatic life and fishery beneficial uses are impaired. No flow TMDLs will be presented at this time.

9.0 SEVENMILE CREEK

Sevenmile Creek from the headwaters to the mouth (Segment MT41I006_160, 7.8 miles) was listed as impaired on the Montana 1996 303(d) list because of siltation. Coldwater fisheries were the listed impaired beneficial uses. In 2002 and 2004, aquatic life and coldwater fishery beneficial uses were listed as impaired because of metals, nutrients, and siltation. The additional analyses and evaluations described in Volume I found that nutrients, sediment (siltation), copper, and lead are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.2.5 of the Volume I Report).

Conceptual restoration strategies and the required TMDL elements for nutrients, sediment, and metals (i.e., copper and lead) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix C, D, E, F, and K.

9.1 METALS

The available water chemistry data suggest that Sevenmile Creek is impaired due to arsenic, copper, and lead. TMDLs are presented in the following sections to address the arsenic, copper, and lead impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

9.1.1 Sources of Metals in the Sevenmile Creek Watershed

Historic mining activities comprise the most significant source of metals to Sevenmile Creek. Most of the drainage area falls within the Scratchgravel Hills and Austin mining districts. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, surface, surface-underground, underground, and other unknown” mining activities in the watershed. The historical mining types include placer, lode, and stockpile. In the past these mines produced gold, iron, lead, silver, copper, manganese, and arsenic. None of the mines in the immediate drainage area of this segment are listed in the State of Montana’s inventory of High Priority Abandoned Hardrock Mine Sites. The Helena National Forest documented evidence of placer mining and one mine waste rock dump within the stream bankfull width in Skelly Gulch, a tributary of Sevenmile Creek, during the source assessment. Modeled sources and their metals loadings to Sevenmile Creek are presented in Figure 9-1 through Figure 9-3.

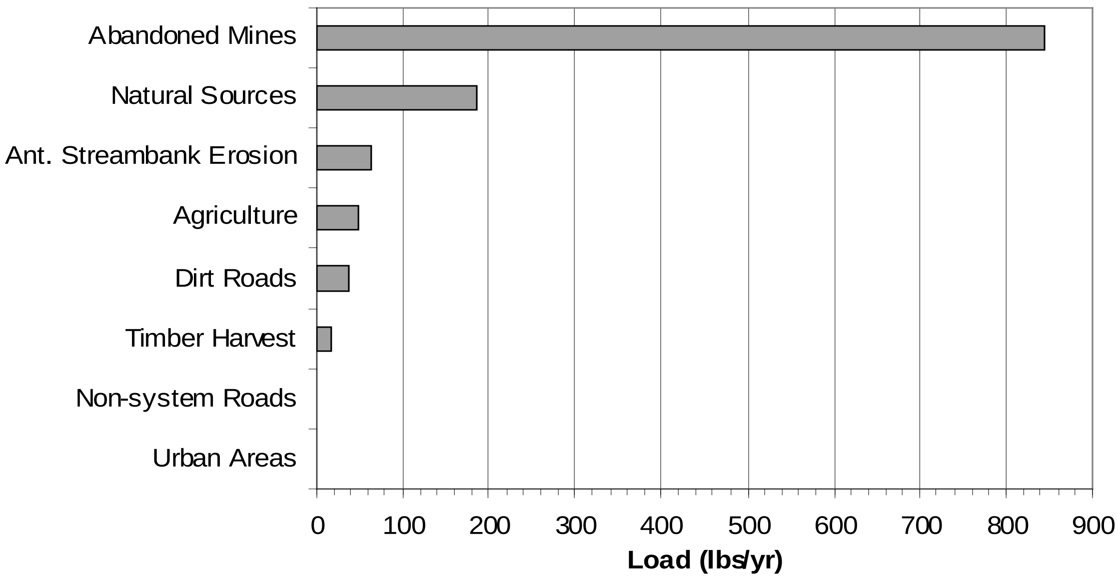

Figure 9-1. Sources of arsenic loadings to Sevenmile Creek.

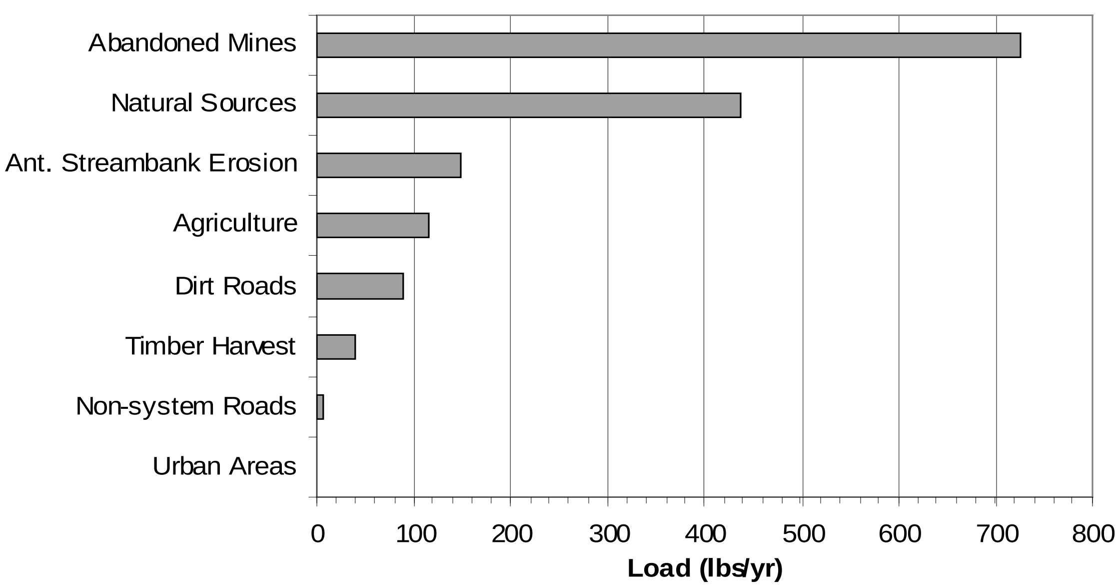

Figure 9-2. Sources of copper loadings to Sevenmile Creek.

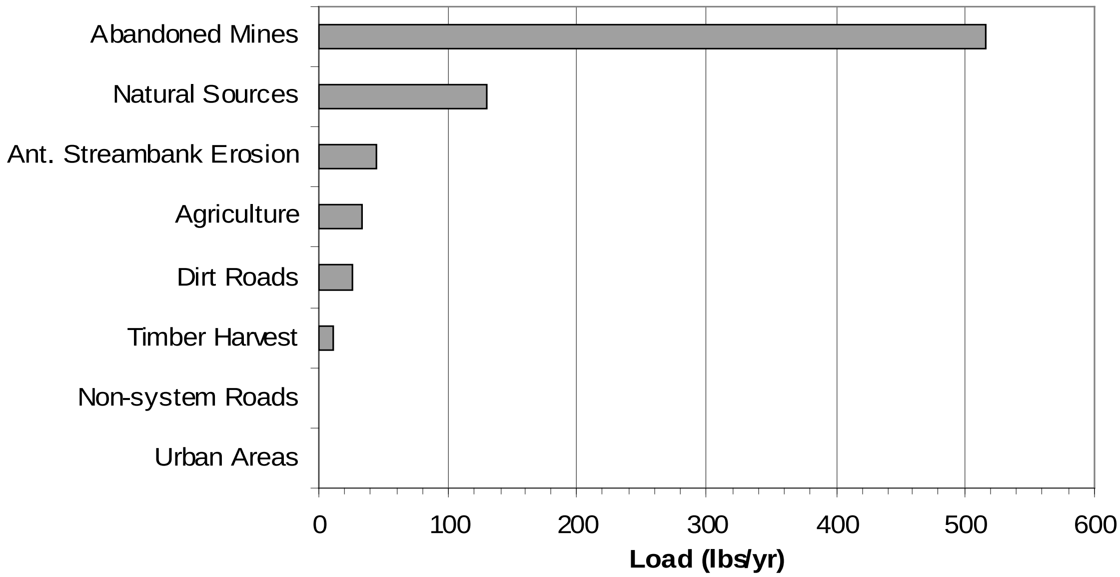

Figure 9-3. Sources of lead loadings to Sevenmile Creek.

9.1.2 Water Quality Goals/Targets

The ultimate goal of these metals TMDL is to attain and maintain the applicable Montana numeric standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Sevenmile Creek are presented in Table 9-1.

Table 9-1. Montana numeric surface water quality standards for metals in Sevenmile Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10 [d]
Copper (TR)	33.6 at 256.4 mg/L hardness[c]	20.4 at 256.4 mg/L hardness[c]	1,300
Lead (TR)	266.2 at 256.4 mg/L hardness[c]	10.3 at 256.4 mg/L hardness[c]	15

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

9.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 9-2 though Table 9-4. Based on the results of the source assessment (Section 9.1.1), the recommended implementation strategy to address the metals problem in Sevenmile Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 9-2 though Table 9-4, the hypothesis is that an overall, watershed scale metals load reduction of 52, 47, and 63 percent for arsenic, copper, and lead, respectively, will result in achievement of the applicable water quality standards. Sevenmile Creek already meets applicable water quality standards for cadmium and zinc. The proposal for achieving the load reduction is to reduce loads from mining sources 58, 58, and 75 percent for arsenic, copper, and lead, respectively.

Table 9-2. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	844.8	58	354.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	49.7	64	18.0	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	63.7	94	3.7	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 94% (see Table 9-7), thereby reducing sediment associated metals loads from streambank erosion by 94%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	2.9	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	16.5	97	0.5	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	38.3	60	15.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 9-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.3	80	0.3	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 9-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,017.2	61	392.0		
	Natural Sources	186.6	0	186.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Sevenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1,203.8**	**52**	**578.7**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 392.0 lbs/yr + 186.6 lbs/yr + 0 = 578.7 lbs/yr** **TMDL = 0 + 1.1 lbs/day + 0.5 lbs/day + 0 = 1.6 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 9-3. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	725.1	58	302.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	116.3	64	42.2	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	149.2	94	8.7	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 94% (see Table 9-7), thereby reducing sediment associated metals loads from streambank erosion by 94%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	6.9	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	38.7	97	1.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	89.6	60	35.8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 9-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	3.0	80	0.6	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 9-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,128.8	65.4	391		
	Natural Sources	437.0	0	437	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Sevenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1,565.8**	**47**	**828**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 391 lbs/yr + 437 lbs/yr + 0 = 828 lbs/yr** **TMDL = 0 + 1.1 lbs/day + 1.2 lbs/day + 0 = 2.3 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 9-4. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	516.1	75	127.0	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	34.7	64	12.6	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	44.5	94	2.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 94% (see Table 9-7), thereby reducing sediment associated metals loads from streambank erosion by 94%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	2.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	11.5	97	0.3	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	26.7	60	10.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 9-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.9	80	0.2	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 9-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	636.4	76	153.4		
	Natural Sources	130.3	0	130.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Sevenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**766.7**	**63**	**283.7**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 153.4 lbs/yr + 130.3 lbs/yr + 0 = 283.7 lbs/yr** **TMDL = 0 + 0.42 lbs/day + 0.36 lbs/day + 0 = 0.78 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

9.2 NUTRIENTS

The weight of evidence suggests that Sevenmile Creek (from headwaters to mouth) is impaired by nutrients (see Volume I Report). TMDLs are presented in the following sections to address the nutrient impairment. In the absence of a strong case for either N or P limitation in the ultimate receiving water body (i.e., Lake Helena), TMDLs are presented below for both TN and TP.

9.2.1 Nitrogen

9.2.1.1 Sources of Nitrogen in the Sevenmile Creek Watershed

As shown in Figure 9-4, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of nitrogen in the Sevenmile Creek watershed, in order of importance, are septic systems, urban areas, anthropogenic streambank erosion, dirt roads, and timber harvest activities. Additionally, Diffuse sediment and possibly nutrient sources from rural housing and stream dewatering were noted in the 2003 source assessment as potential sources of nutrients at the local scale (See Volume I).

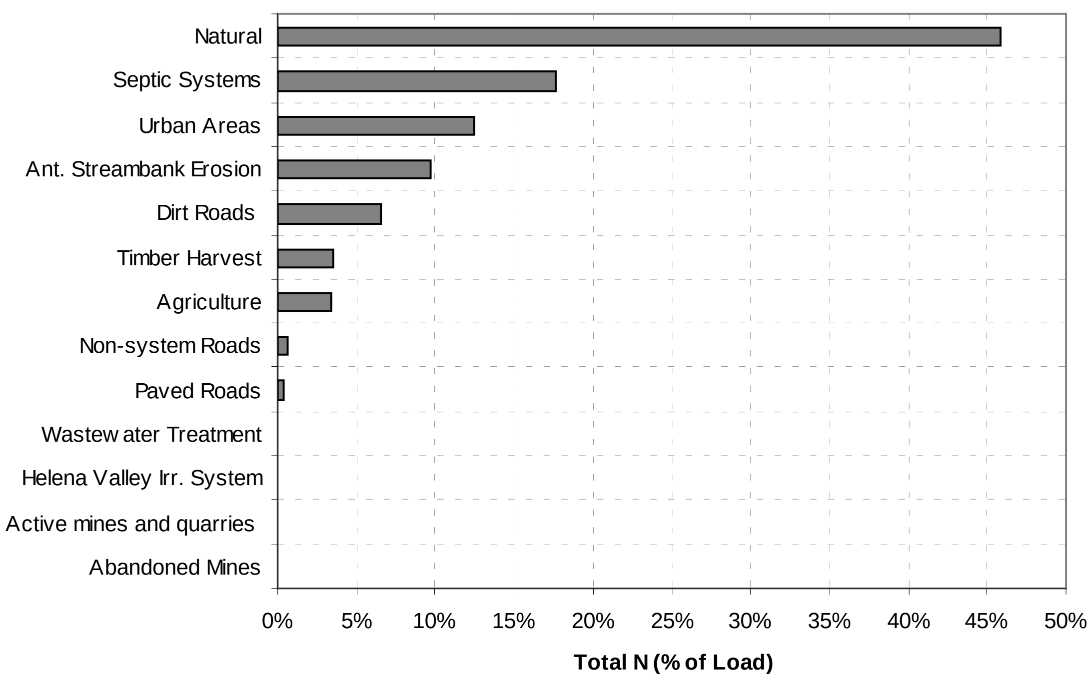

Figure 9-4. Percent of the annual TN load from all potentially significant sources in the Sevenmile Creek Watershed.

9.2.1.2 Water Quality Goals/Targets

The proposed interim water quality target for TN in Sevenmile Creek is 0.33 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

9.2.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations, and margin of safety are presented in Table 9-5. Based on the results of the source assessment (Section 9.2.1.1), the recommended implementation strategy to address the nitrogen problem in Sevenmile Creek is to reduce sediment-associated nitrogen loading from the primary anthropogenic sediment sources – anthropogenic bank erosion, dirt roads, and timber harvest. Though citizen education of proper septic system operation and maintenance will likely reduce phosphorus and bacterial loading from septic systems, the reduction in nitrogen loading is insignificant because even properly functioning septic systems have poor nitrogen removal. It is not likely that City sewer will expand to this subwatershed, so nitrogen loads from septic systems will likely not be reduced.

As shown in Table 9-5, the hypothesis is that an overall, watershed scale nitrogen load reduction of 65 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce sediment loads from current timber harvest by 97 percent, dirt roads by 60 percent, non system roads by 100 percent, agriculture 55 percent, urban areas 30 percent, and anthropogenic bank erosion by 94 percent, which will in turn decrease loading of sorbed nitrogen. In combination, these reductions are predicted to reduce the total nitrogen by 21 percent.

The goal of the nitrogen TMDL is to attain full beneficial use support in Sevenmile Creek. In the absence of better data/information, the interim target presented in Section 9.2.1.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 58 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable nitrogen load reduction for the Sevenmile Creek Watershed is estimated to be only 20 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Sevenmile Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TN load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TN target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 9-5. The adaptive management strategy is presented in Volume II, Section 3.2.3.1.

Table 9-5. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Nitrogen.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Agriculture	1.49	50	0.67	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	0.53	94	0.03	It is estimated that there are 5.3 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.09	100	0.00	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.06	30	0.04	An average nitrogen removal efficiency of 30% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	2.74	0.4	2.73	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 0.4% decrease in TN. Replacing failing septic systems with level 2 treatment could result in a 1.6% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	0.55	97	0.02	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1.01	60	0.40	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.93	30	1.35	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	8.40	38	5.24		
	Natural Sources	7.02	0	7.02	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0.00	0	0.00	There are no point sources of nitrogen in the Sevenmile Creek Watershed.	
Margin of Safety		NA	0	0.00	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**15.42**	**21**	**12.26**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 5.24 tons/yr + 7.02 tons/yr + 0 = 12.26 tons/yr** **TMDL = 0 + 0.014 tons/day + 0.019 tons/day + 0 = 0.033 tons/day**					

9.2.2 Phosphorus

9.2.2.1 Sources of Phosphorus in the Sevenmile Creek Watershed

As shown in Figure 9-5, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of phosphorus in the Sevenmile Creek watershed, in order of importance, are anthropogenic streambank erosion, dirt roads, urban areas, timber harvest, and agriculture. Additionally, Mine reclamation, horse pastures/riparian grazing and streambank stability problems were noted as potential nutrient sources in the 2003 source assessment as potential sources of nutrients at the local scale (See Volume I). Dirt roads were cited as a major contributor to sediment loading in streams. Diffuse sediment and possibly nutrient sources from rural housing and stream dewatering were noted in the 2003 source assessment for potential nutrient sources.

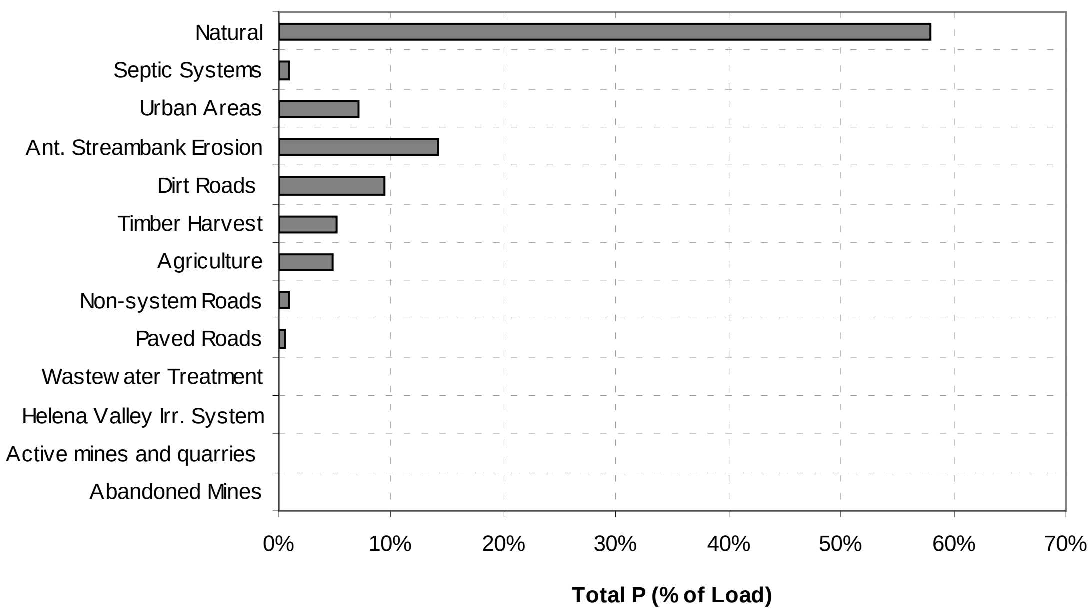

Figure 9-5. Percent of the annual TP load from all potentially significant sources in the Sevenmile Creek Watershed.

9.2.2.2 Water Quality Goals/Targets

The proposed interim water quality target for TP in Spring Creek is 0.04 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

9.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the phosphorus TMDL is to attain full beneficial use support in Sevenmile Creek. In the absence of better data/information, the interim target presented in Section 9.2.2.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A TP load reduction of 79 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable phosphorus load reduction for the Spring Creek Watershed is estimated to be only 32 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Sevenmile Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TP load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TP target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 9-6. The adaptive management strategy is presented in Volume II, Section 3.2.3.1.

Table 9-6. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
LA	Agriculture	0.11	55	0.05	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	0.33	94	0.02	It is estimated that there are 5.3 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.02	100	0.00	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.01	50	0.01	An average phosphorus removal efficiency of 50% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	0.02	100	0.00	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	0.12	97	0.00	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.22	60	0.09	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.16	50	0.08	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	0.99	75	0.25		
	Natural Sources	1.34	0	1.34	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	0	0	There are no point sources of phosphorus in the Sevenmile Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**2.33**	**32**	**1.59**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 0.25 tons/yr + 1.34 tons/yr + 0 = 1.59 tons/yr** **TMDL = 0 + 0.0007 tons/day + 0.0037 tons/day + 0 = 0.0044 tons/day**					

9.3 Sediment

The weight of evidence suggests that Sevenmile Creek (from headwaters to mouth) is impaired by sediment/siltation (see Volume I Report). TMDLs are presented in the following sections to address the sediment impairment. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

9.3.1 Sources of Sediment in the Sevenmile Creek Watershed

As shown in Figure 9-6, the primary anthropogenic sources of sediment in the Sevenmile Creek watershed, in order of sediment load are, anthropogenic streambank erosion, unpaved roads, timber harvest, agriculture, non-system roads/trails, and urban areas.

Anthropogenic streambank erosion occurs throughout Sevenmile Creek. This sediment source is largely a result of riparian grazing impacts, animal feedlot/confinement areas, road and railroad encroachment, stream channelization, beaver dam removal and historic mining activity. Sediment from unpaved roads was the second largest anthropogenic sediment source in the segment. Sediment is entering at road crossings along the main stem and tributaries. Timber harvest activities have occurred in the uplands of the watershed on DNRC and BLM lands. Watershed modeling shows erosion from agricultural activities occurring throughout the central and lower watershed. Non-system roads/trails were observed in the uplands of the Sevenmile Creek watershed. The lack of drainage structures on these roads can lead to disproportionately large volumes of sediment being generated from this source.

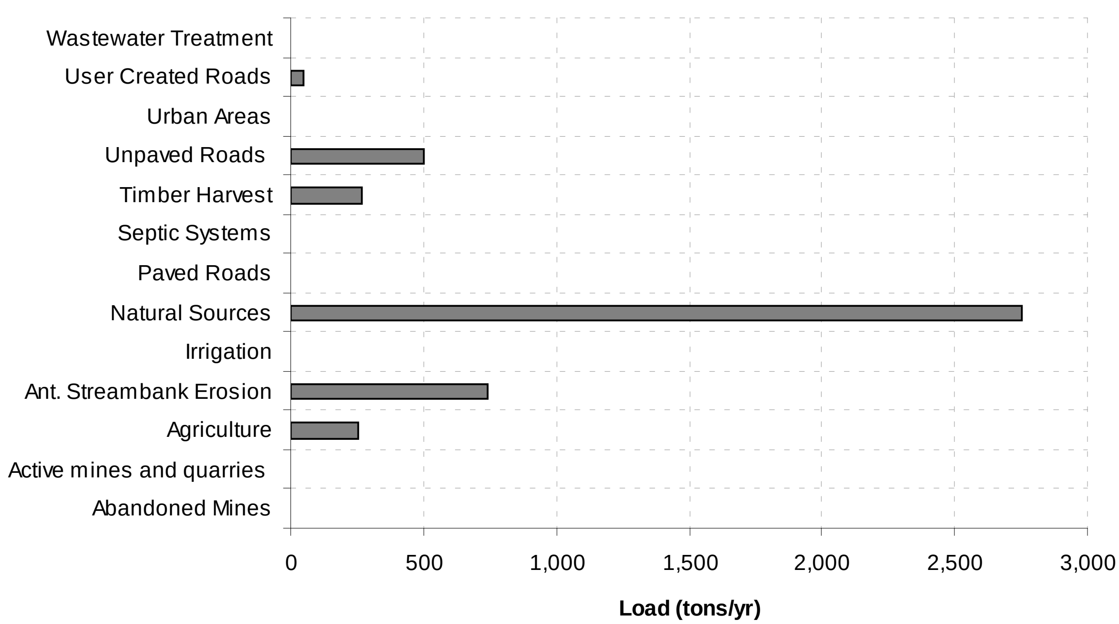

Figure 9-6. Total annual sediment load from all potentially significant sources in the Sevenmile Creek Watershed.

9.3.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

9.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 9-7. Based on the results of the source assessment (Section 9.3.1), the recommended implementation strategy to address the siltation problem in Sevenmile Creek is to reduce sediment loading from the primary anthropogenic sediment sources – anthropogenic streambank erosion, unpaved roads, timber harvest, agriculture, non-system roads, and urban areas. As shown in Table 9-7, the hypothesis is that an overall, watershed scale sediment load reduction of 33 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current anthropogenic streambank erosion, unpaved roads, timber harvest, agriculture, non-system roads, and urban areas by 97, 60, 97, 60, 100, and 80 percent, respectively.

Table 9-7. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Agriculture	257	60	93	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil erosion.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	743	94	44	It is estimated that there are 5.3 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	46	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	270	97	8	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	504	60	202	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	5	80	1	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,825	83	348		
	Natural Sources	2,752	0	2,752	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Sevenmile Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**4,577**	**33**	**3,100**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 348 tons/yr + 2,752 tons/yr + 0 = 3,100 tons/yr** **TMDL = 0 + 1.0 tons/day + 7.5 tons/day + 0 = 8.5 tons/day**					

10.0 SILVER CREEK

Silver Creek from the headwaters to the mouth (Segment MT41I006_150, 21.6 miles) was listed as impaired on the Montana 1996 303(d) list because of metals and priority organics. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, coldwater fisheries, and drinking water supply beneficial uses were listed as impaired because of metals and priority organics. The additional analyses and evaluations described in Volume I found that arsenic is currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.3.2 of the Volume I Report). Priority organics are not impairing beneficial uses, and therefore no TMDL will be presented.

Conceptual restoration strategies and the required TMDL elements for arsenic are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix E and F.

10.1 METALS

The water chemistry data suggest that Silver Creek is impaired by arsenic. TMDLs are presented in the following sections to address the arsenic impairment. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

10.1.1 Sources of Metals in the Silver Creek Watershed

Besides sediment-associated metals sources, significant contributors of metals to the stream segment are upstream sources and historical hard rock mining activities in the upper watershed. Jennie's Fork is a tributary and contributes to the metals loads. The sub-watershed falls within the Marysville, Scratchgravel Hills, and Austin mining districts. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, prospect, surface, surface-underground, and underground mining activities in the watershed. The historical mining types include lode, mill, and placer. In the past these mines produced gold, silver, manganese, lead, iron, copper, and zinc. Five mine sites in the watershed are listed in the State of Montana’s inventory of High Priority Abandoned Hardrock Mine Sites and fall within the Marysville district: Goldsil Mill Site, Drumlummon Mine/Mine Site, Argo Mill Site, Drumlummon Mine/Mill Site, and Belmont. Modeled sources and their arsenic loadings to Silver Creek are presented in Figure 10-1.

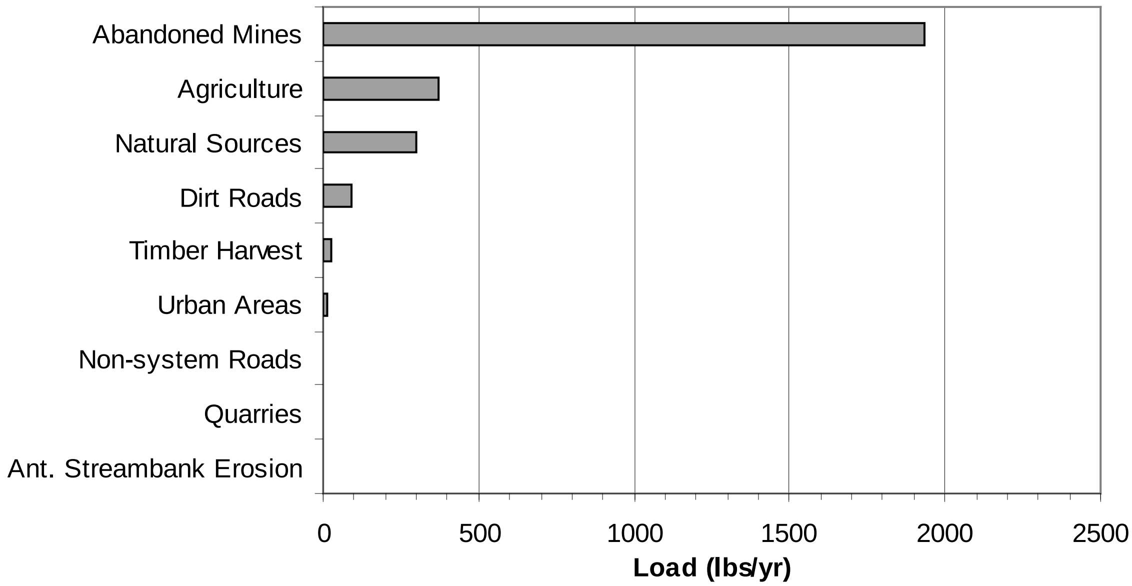

Figure 10-1. Sources of arsenic loadings to Silver Creek.

10.1.2 Water Quality Goals/Targets

The ultimate goal of this TMDL is to attain and maintain the applicable Montana numeric standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Silver Creek are presented in Table 10-1.

Table 10-1. Montana numeric surface water quality standards for metals in Silver Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[c]
Arsenic (TR)	340	150	10 [d]

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

10.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 10-2. Based on the results of the source assessment (Section 10.1.1), the recommended implementation strategy to address the metals problem in Silver Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 10-2, the hypothesis is that an overall, watershed scale metals load reduction of 65 percent for arsenic will result in achievement of the applicable water quality standards. Silver Creek already meets applicable water quality standards for cadmium, copper, lead, and zinc. The proposal for achieving the load reduction is to reduce loads from mining sources by 70 percent for arsenic.

Table 10-2. TMDL, Allocations, and Margin of Safety for Silver Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	1,936.1	70	580.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	371.9	88	44.6	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	0.3	44	0.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 44%, thereby reducing sediment associated metals loads from streambank erosion by 44%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	7.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	2.0	0	2.0	Only the portion of land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	25.7	97	0.8	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	94.1	60	37.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	16.1	80	3.2	It is assumed that urban BMPs will reduce sediment loads by 80), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	2,453.4	72	669		
	Natural Sources	299.1	0	299	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Silver Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**2,752.5**	**65**	**968**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 669 lbs/yr + 299 lbs/yr + 0 = 968 lbs/yr** **TMDL = 0 + 1.8 lbs/day + 0.8 lbs/day + 0 = 2.6 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

11.0 SKELLY GULCH

Skelly Gulch from the headwaters to the mouth (Segment MT41I006_220, 7.7 miles) was listed as impaired on the Montana 1996 303(d) list because of siltation. Aquatic life and coldwater fisheries were the listed impaired beneficial uses. In 2002 and 2004, aquatic life, coldwater fisheries, and drinking water supply beneficial uses were listed as impaired because of metals and siltation. The additional analyses and evaluations described in Volume I found that sediment (siltation) is currently impairing aquatic life and fishery beneficial uses (see Section 3.4.2.4 of the Volume I Report). There were insufficient credible data to determine if metals are impairing beneficial uses, and no TMDLs are presented at this time. Additional monitoring is proposed in Appendix H.

Conceptual restoration strategies and the required TMDL elements for sediment are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D.

11.1 Sediment

The weight of evidence suggests that Skelly Gulch is impaired because of sediment (siltation). TMDLs are presented in the following sections to address the siltation impairment. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

11.1.1 Sources of Sediment in the Skelly Gulch Watershed

As shown in Figure 11-1, the primary anthropogenic sources of sediment in the Skelly Gulch watershed, in order of sediment load are: unpaved roads, timber harvest, anthropogenic streambank erosion, and non-system roads.

Throughout much of the lower portion of the segment length, Skelly Gulch Road (unpaved) is adjacent to the stream with minimal, if any, riparian buffer width. In the central watershed, the road is elevated away from the channel and likely ceases to be, or is a reduced sediment source. However, the road crosses Skelly Gulch in this area via bridge and a stream ford. Sediment is undoubtedly entering at the stream ford location. Upstream of this crossing, the road again is elevated away from the channel and is likely not contributing sediment between this area and the Helena National Forest property boundary. Five road crossings related to timber harvest units were identified as sediment sources within Helena National Forest ownership. Timber harvest activities have occurred in the upper watershed on Helena National Forest property. Evidence of historic timber harvest was observed in the central area of the watershed. Observed streambank erosion is largely the result of riparian grazing, road encroachment, stream channelization and historic mining activity. Non-system roads/trails were observed in the central watershed. These features are problematic sediment sources because they lack any run-off diversion structures.

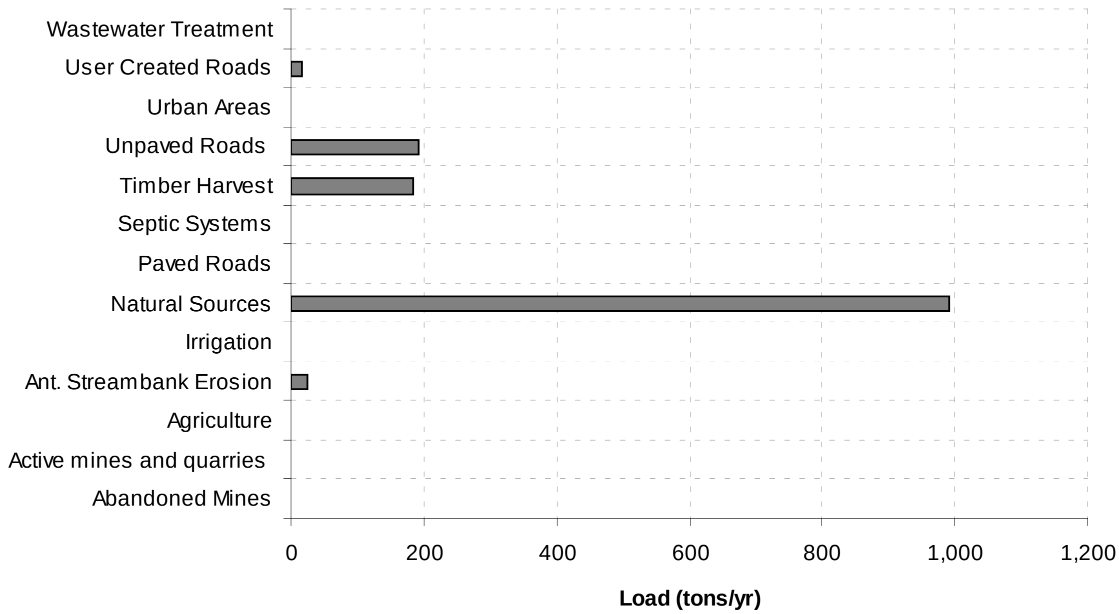

Figure 11-1. Total annual sediment load from all potentially significant sediment sources in the Skelly Gulch Watershed.

11.1.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

11.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 11-1. Based on the results of the source assessment (Section 11.1.1), the recommended implementation strategy to address the siltation problem in Skelly Gulch is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, timber harvest, anthropogenic streambank erosion, and non-system roads. As shown in Table 11-1, the hypothesis is that an overall, watershed scale sediment load reduction of 22 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, timber harvest, and non-system roads by 60, 97, and 100 percent, respectively. Modeled streambank erosion sediment load currently related to anthropogenic sources is essentially the same value as that modeled for reference conditions (within 0.4 tons which is well within the margin of error for the modeling exercise). Based on the near reference condition of the anthropogenic streambank load, no reduction in this source category is advised. However, all efforts should be made to eliminate any and all sources of human caused streambank erosion.

Table 11-1. TMDL, Allocations, and Margin of Safety for Skelly Gulch – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Anthropogenic Streambank Erosion	24	0.0	24	It is estimated that there are 1.0 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	17	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	183	97	5	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	192	60	77	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	416	76	106		
	Natural Sources	991	0	991	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Skelly Gulch Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total[1]		**1,407**	**22**	**1,097**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 106 tons/yr + 991 tons/yr + 0 = 1,097 tons/yr** **TMDL = 0 + 0.3 tons/day + 2.7 tons/day + 0 = 3.0 tons/day**					

12.0 SPRING CREEK

Spring Creek from Corbin Creek to the mouth (Segment MT41I006_080, 1.7 miles) was listed as impaired on the Montana 1996 303(d) list because of suspended solids, nutrients, metals, and pH. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002, aquatic life, coldwater fisheries, and drinking water supply beneficial uses were listed as impaired because of metals. Spring Creek did not appear on the 2004-303(d) list because of insufficient credible data. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, zinc, nutrients, and sediment (suspended solids) are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.8 of the Volume I Report). pH is not impairing beneficial uses, and therefore no TMDL will be presented.

Conceptual restoration strategies and the required TMDL elements for nutrients, sediment, and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix C, D, E, F, and G.

12.1 METALS

The available metals data suggest that Spring Creek is impaired by arsenic, cadmium, copper, lead, and zinc. TMDLs are presented in the following sections to address the arsenic, cadmium, copper, lead, and zinc impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

12.1.1 Sources of Metals in the Spring Creek Watershed

Besides anthropogenic sediment-associated metals sources, relevant sources of metals to Spring Creek include Corbin Creek, historical mining activities in the immediate drainage area, and possibly, the Montana Tunnels Mine in the headwaters of the watershed. Flow from Corbin Creek and historical mill tailings deposits throughout the watershed are contributors of metals to the stream. Most of the drainage area falls within the Colorado mining district, although there is a small section in the Clancy mining district. The MBMG Abandoned and Inactive Mines database shows mineral location and underground mining activities in the drainage area of the stream. The historical mining types include lode, placer, and mill. In the past these mines produced silver, copper, lead, zinc, gold, and uranium. Within the basin, the Corbin Flats Mine is listed in the State of Montana’s inventory of High Priority Abandoned Hardrock Mine Sites. Three other mines in the Colorado mining district and upstream of the listed segment are also listed in State of Montana’s inventory of High Priority Abandoned Hardrock Mine Sites: Washington, Bluebird, and the Wickes Smelter.

NPDES Permit MT0028428 Montana Tunnels Mine is permitted to discharge arsenic, cadmium, copper, lead and zinc to the stream. Current permit limits are 290ug/L for arsenic, 4ug/L for cadmium, 10ug/L for copper, 50 ug/L for lead, and 120 ug/L for zinc. The permit limit for arsenic is 29 times greater than the human health criteria for arsenic. It should be noted, however that this facility recycles all the water used, and according to PCS, no discharge has ever been observed from this facility.

Modeled sources and their metals loadings to Spring Creek are presented in Figure 12-1 through Figure 12-5.

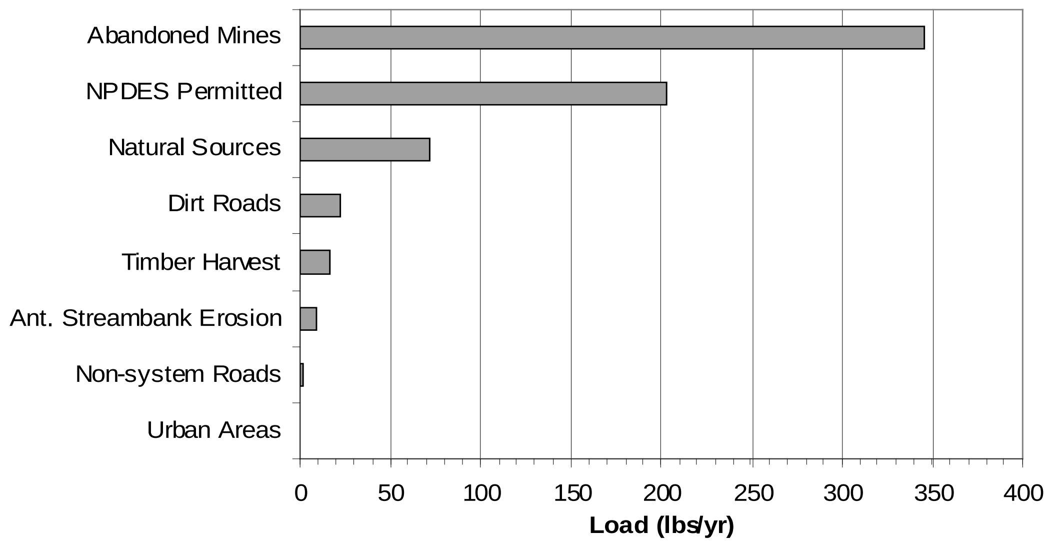

Figure 12-1. Sources of arsenic loadings to Spring Creek.

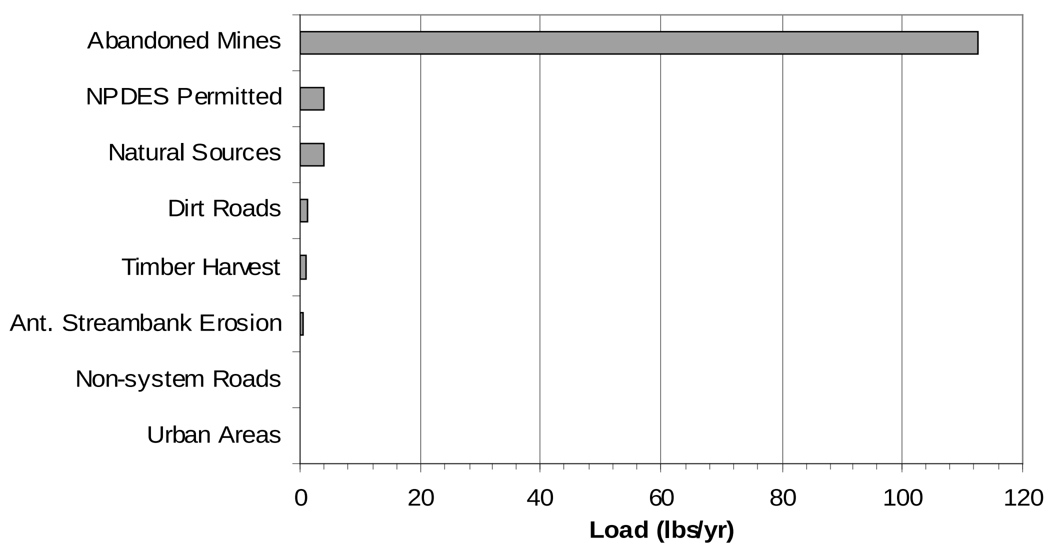

Figure 12-2. Sources of cadmium loadings to Spring Creek.

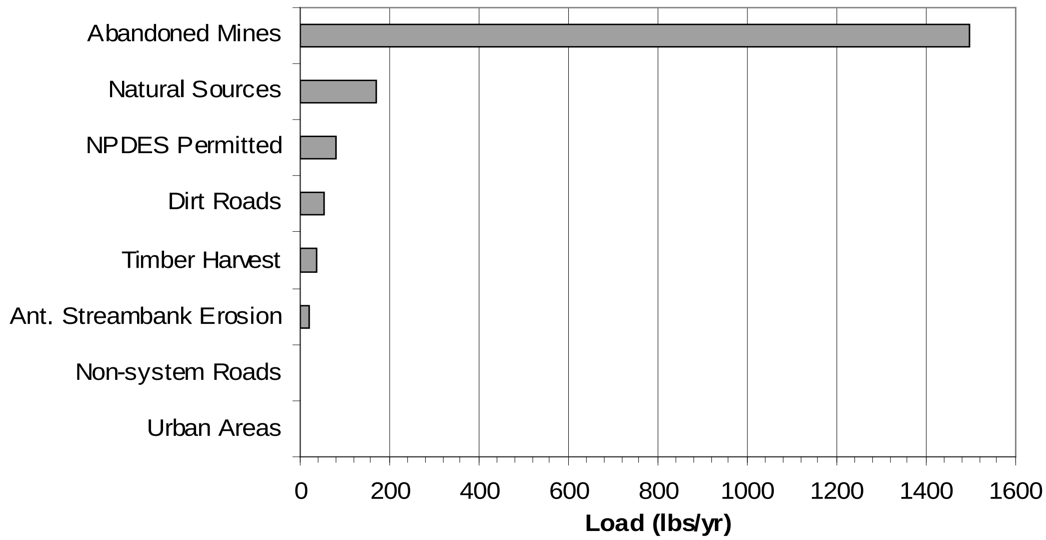

Figure 12-3. Sources of copper loadings to Spring Creek.

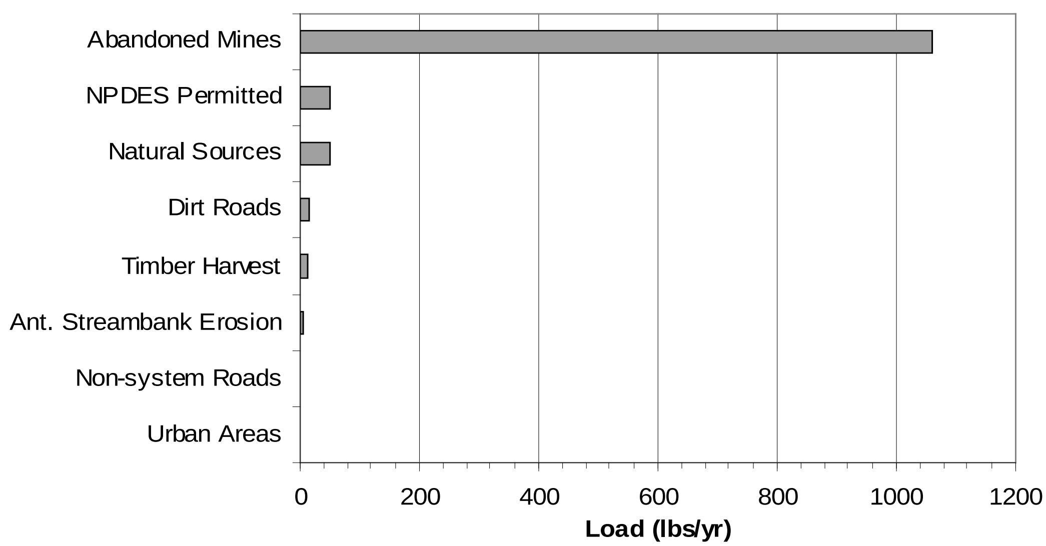

Figure 12-4. Sources of lead loadings to Spring Creek.

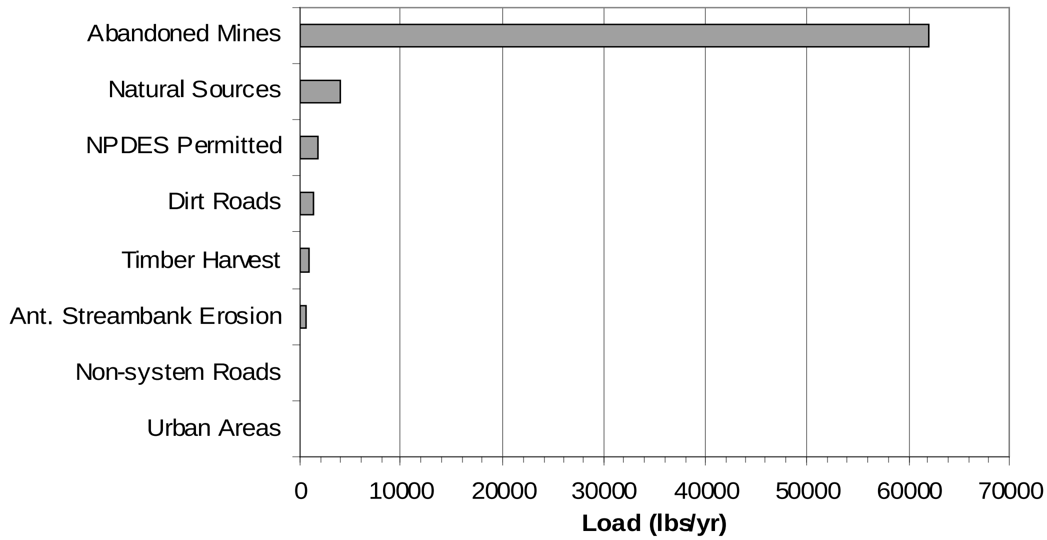

Figure 12-5. Sources of zinc loadings to Spring Creek.

12.1.2 Water Quality Goals/Targets

The ultimate goal of theses metals TMDL is to attain and maintain the applicable Montana numeric standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Spring Creek are presented in Table 12-1.

Table 12-1. Montana numeric surface water quality standards for metals in Spring Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10 [d]
Cadmium (TR)	8.95 at 400 mg/L hardness[c]	0.75 at 400 mg/L hardness[c]	5
Copper (TR)	51.0 at 400 mg/L hardness[c]	29.8 at 400 mg/L hardness[c]	1,300
Lead (TR)	468.3 at 400 mg/L hardness[c]	18.2 at 400 mg/L hardness[c]	15
Zinc (TR)	392.6 at 400 mg/L hardness[c]	392.6 at 400 mg/L hardness[c]	2,000

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

12.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 12-2 through Table 12-6. Based on the results of the source assessment (Section 12.1.1), the recommended implementation strategy to address the metals problem in Spring Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 12-2 through Table 12-6, the hypothesis is that an overall, watershed scale metals load reduction of 56, 87, 64, 82, and 81 percent for arsenic, cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from historical mining sources by 62, 94, 73, 90, and 94 percent for arsenic, cadmium, copper, lead, and zinc, respectively. A reduction of 60 percent in permitted arsenic load from the Montana Tunnels Mine is also recommended.

Table 12-2. TMDL, Allocations, and Margin of Safety for Spring Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	345.2	62	131.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	9.6	97	0.3	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1.7	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	16.7	97	0.5	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	22.5	60	9.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	395.7	64	141.0		
	Natural Sources	72.4	0	72.4	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	203.1	60	81.2	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**671.2**	**56**	**294.6**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 81.2 + 141.0 lbs/yr + 72.4 lbs/yr + 0 = 294.6 lbs/yr** **TMDL = 0.22 + 0.39 lbs/day + 0.20 lbs/day + 0 = 0.81 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 12-3. TMDL, Allocations, and Margin of Safety for Spring Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	112.6	94	7.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	0.5	97	0.0	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.1	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.9	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1.3	60	0.5	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	115.4	93	7.7		
	Natural Sources	4.1	0	4.1	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	4.1	0	4.1	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**123.6**	**87**	**15.9**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 4.1 + 7.7 lbs/yr + 4.1 lbs/yr + 0 = 15.9 lbs/yr** **TMDL = 0.011 + 0.021 lbs/day + 0.011 lbs/day + 0 = 0.043 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 12-4. TMDL, Allocations, and Margin of Safety for Spring Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	1,495.2	73	397.9	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	22.5	97	0.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	4.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	39.0	97	1.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	52.7	60	21.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.1	80	0.0	An average 80% reduction for sediment-associated metals is assumed.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,613.5	74	420.8		
	Natural Sources	169.6	0	169.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	77.6	0	77.6	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1,860.7**	**64**	**668.0**		
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 77.6 + 420.8 lbs/yr + 169.6 lbs/yr + 0 = 668.0 lbs/yr TMDL = 0.22 + 1.15 lbs/day + 0.46 lbs/day + 0 = 1.83 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 12-5. TMDL, Allocations, and Margin of Safety for Spring Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	1,058.1	89	111.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	6.7	97	0.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	11.6	97	0.4	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	15.7	60	6.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,093.3	89	118.1		
	Natural Sources	50.6	0	50.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	51.1	0	51.1	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1,195.0**	**82**	**219.8**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 51.1 + 118.1 lbs/yr + 50.6 lbs/yr + 0 = 219.8 lbs/yr** **TMDL = 0.14 + 0.32 lbs/day + 0.14 lbs/day + 0 = 0.60 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 12-6. TMDL, Allocations, and Margin of Safety for Spring Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	62,184.3	94	4,051.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	533.6	97	14.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	95.7	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	924.3	97	29.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1,247.7	60	499.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	3.1	80	0.62	An average 80% reduction for sediment-associated metals is assumed.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	69,006	87	8,612		
	Natural Sources	4,017	0	4,017	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	1,770	0	1,770	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**74,793**	**81**	**14,399**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 1,770 + 8,612 lbs/yr + 4,017 lbs/yr + 0 = 14,399 lbs/yr** **TMDL = 4.8 + 23.6 lbs/day + 11.0 lbs/day + 0 = 39.4 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

12.2 Nutrients

The weight of evidence suggests that Spring Creek is impaired because of nutrients. TMDLs are presented in the following sections to address the nutrient impairments. In the absence of a strong case for either N or P limitation in the ultimate receiving water bodies (i.e., Prickly Pear Creek and Lake Helena), TMDLs are presented below for both nitrogen and phosphorus.

12.2.1 Nitrogen

12.2.2 Sources of Nitrogen in the Spring Creek Watershed

As shown in Figure 12-6, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of nitrogen in the Spring Creek watershed, in order of importance, are dirt roads, septic systems, timber harvest, abandoned mines, and anthropogenic streambank erosion. Additionally, Mine reclamation, horse pastures/riparian grazing and streambank stability problems were noted in the 2003 source assessment as potential sources of nutrients at the local scale (See Volume I).

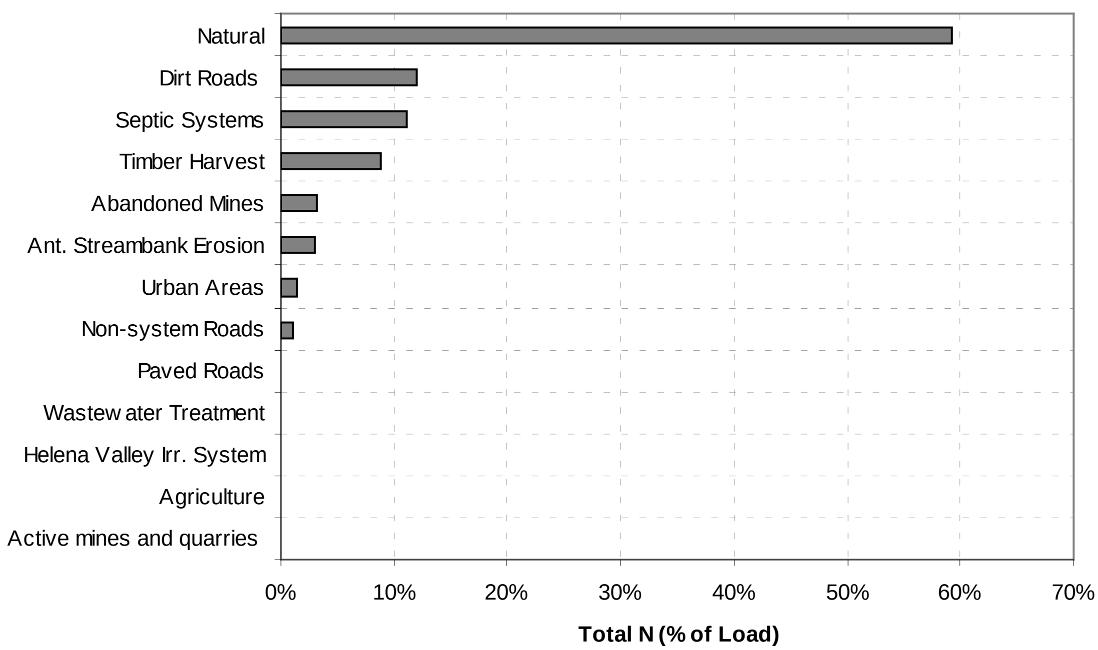

Figure 12-6. Percent of the total annual nitrogen load from all potentially significant nitrogen sources in the Spring Creek Watershed.

12.2.2.2 Water Quality Goals/Targets

The proposed interim water quality target for TN in Spring Creek is 0.33 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

12.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the nitrogen TMDL is to attain full beneficial use support in Spring Creek. In the absence of better data/information, the interim target presented in Section 12.2.2.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 75 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable nitrogen load reduction for the Spring Creek Watershed is estimated to be only 22 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Spring Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TN load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TN target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 12-7. The adaptive management strategy is presented in Volume II, Section 3.2.3.1.

Table 12-7. TMDL, Allocations, and Margin of Safety for Spring Creek – Nitrogen.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.24	67	0.08	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 67%. Sediment-associated nitrogen will decrease accordingly (67%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	0.22	97	0.01	It is estimated that there are 4.4 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.08	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Septic Systems	0.85	1.2	0.84	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 1.2% decrease in TN. Replacing failing septic systems with level 2 treatment could result in a 2.6% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated. No specific data were available about the actual percentage of failing systems.
	Timber Harvest	0.67	97	0.02	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.91	60	0.36	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.10	30	0.07	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	3.07	55	1.38		
	Natural Sources	4.46	0	4.46	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	The Montana Tunnels Mine is located in this watershed and has an NPDES permit. However, no surface water discharges have been recorded in the Montana DEQ permit records (1987-2005) and they are unlikely to occur.	It is possible (although unlikely) for a discharge from this facility to occur (e.g., due to equipment malfunction or an extreme storm event). The current load might therefore be under-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**7.53**	**22**	**5.84**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 1.38 tons/yr + 4.46 tons/yr + 0 = 5.84 tons/yr** **TMDL = 0 + 0.004 tons/day + 0.012 tons/day + 0 = 0.016 tons/day**					

12.2.3 Phosphorus

12.2.3.1 Sources of Phosphorus in the Spring Creek Watershed

As shown in Figure 12-7, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of phosphorus in the Spring Creek watershed, in order of importance, are dirt roads, timber harvest, abandoned mines, and anthropogenic streambank erosion. Additionally, mine reclamation, horse pastures/riparian grazing and streambank stability problems were noted in the 2003 source assessment as potential sources of nutrients at the local scale (See Volume I).

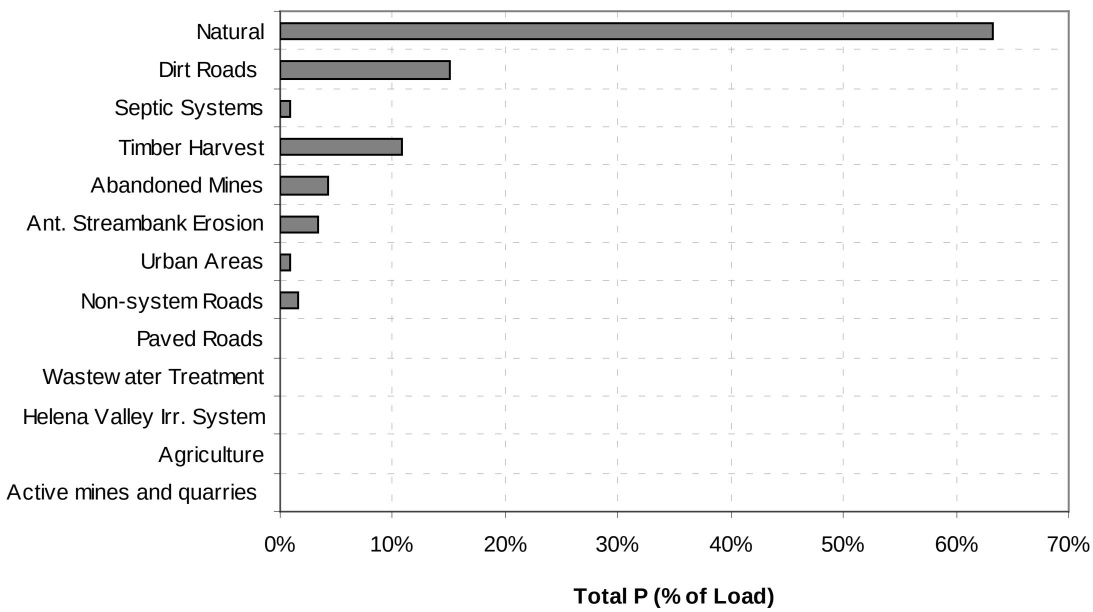

Figure 12-7. Percent of the total annual phosphorus load from all potentially significant phosphorus sources in the Spring Creek Watershed.

12.2.3.2 Water Quality Goals/Targets

The proposed interim water quality target for TP in Spring Creek is 0.04 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

12.2.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the phosphorus TMDL is to attain full beneficial use support in Spring Creek. In the absence of better data/information, the interim target presented in Section 12.2.3.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 83 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable phosphorus load reduction for the Spring Creek

Watershed is estimated to be only 29 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Spring Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TP load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TP target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 12-8. The adaptive management strategy is presented in Volume II, Section 3.2.3.1.

Table 12-8. TMDL, Allocations, and Margin of Safety for Spring Creek – Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.05	67	0.016	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 67%. Sediment-associated phosphorus will decrease accordingly (67%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated phosphorus reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	0.05	97	0.002	It is estimated that there are 4.4 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.02	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Septic Systems	0.01	100	0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	0.14	97	0.004	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.20	60	0.080	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.01	50	0.005	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	0.48	79	0.11		
	Natural Sources	0.84	0	0.840	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	The Montana Tunnels Mine is located in this watershed and has an NPDES permit. However, no surface water discharges have been recorded in the Montana DEQ permit records (1987-2005) and they are unlikely to occur.	It is possible (although unlikely) for a discharge from this facility to occur (e.g., due to equipment malfunction or an extreme storm event). The current load might therefore be under-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**1.32**	**29**	**0.95**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0+ 0.11 tons/yr + 0.84 tons/yr + 0 = 0.95 tons/yr** **TMDL = 0 + 0.0003 tons/day + 0.0023 tons/day + 0 = 0.0026 tons/day**					

12.3 SEDIMENT

The weight of evidence suggests that Spring Creek is impaired because of siltation (see Volume I Report). TMDLs are presented in the following sections to address the sediment/siltation impairments. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

12.3.1 Sources of Sediment in the Spring Creek Watershed

As shown in Figure 12-8, the primary anthropogenic sources of sediment in the Spring Creek watershed, in order of sediment load are unpaved roads, timber harvest, abandoned mines, anthropogenic streambank erosion, and non-system roads.

Unpaved roads accounted for the greatest percentage (43%) of anthropogenic sediment production in Spring Creek. Road crossings throughout watershed, and direct road tread drainage in the central watershed are contributing to road related sediment impacts. Timber harvest has occurred in the upper watershed, some of which was related to post fire salvage activities. Four abandoned mines (Bluebird, Corbin Flats, Washington, and Salvai) within Spring Creek were identified as being capable of delivering sediment to the channel. The occurrence of anthropogenic streambank erosion is isolated throughout Spring Creek, and largely a result of stream channelization and historic mining activity. Non-system roads/trails were observed in the uplands of the Spring Creek watershed. The lack of drainage structures on these roads can lead to disproportionately large volumes of sediment being generated from this source.

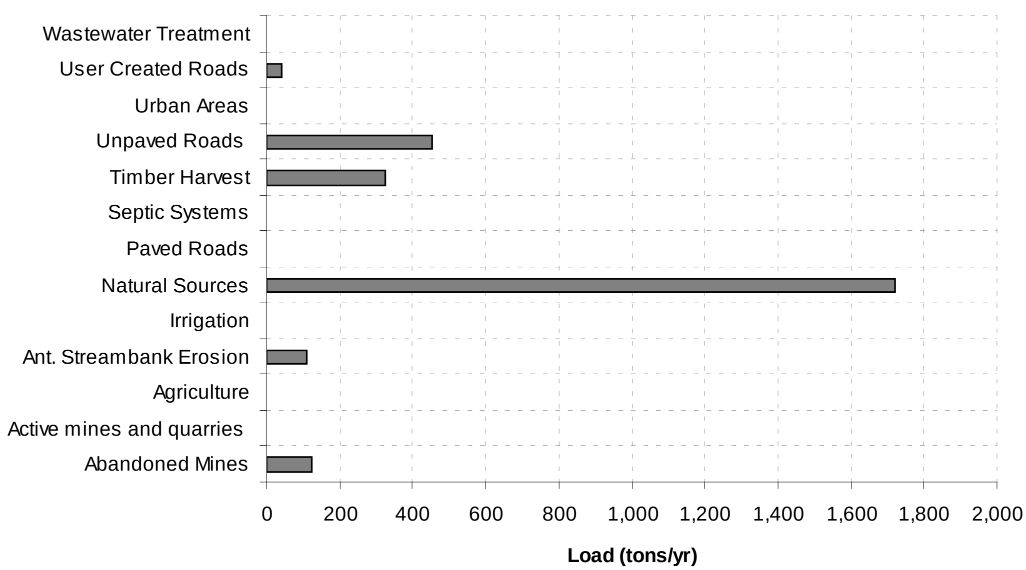

Figure 12-8. Total annual sediment load from all potentially significant sources in the Spring Creek Watershed.

12.3.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

12.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 12-9. Based on the results of the source assessment (Section 12.3.1), the recommended implementation strategy to address the sediment problem in Spring Creek is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, timber harvest, abandoned mines, anthropogenic streambank erosion, and non-system roads. As shown in Table 12-9, the hypothesis is that an overall, watershed scale sediment load reduction of 30 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, timber harvest, abandoned mines, anthropogenic streambank erosion, and non-system roads by 60, 97, 79, 99, and 100 percent, respectively.

Table 12-9. TMDL, Allocations, and Margin of Safety for Spring Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	121	67	40	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 67%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	112	97	3	It is estimated that there are 4.4 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	40	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	326	97	10	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	454	60	182	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,053	78	235		
	Natural Sources	1,719	0	1,719	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Spring Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**2,772**	**30**	**1,954**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 235 tons/yr + 1,719 tons/yr + 0 = 1,954 tons/yr** **TMDL = 0 + 0.6 tons/day + 4.7 tons/day + 0 = 5.3 tons/day**					

13.0 TENMILE CREEK

Three segments of Tenmile Creek have appeared on various Montana 303(d) lists: Tenmile Creek from Headwaters to Helena Public Water Supply Intake upstream of Rimini (MT41I006_141), Tenmile Creek from Helena Public Water Supply Intake upstream of Rimini to Helena Water Treatment Plant (MT41I006_142), and Tenmile Creek from Helena Water Treatment Plant to the Mouth (MT41I006_143). Impaired uses and causes of impairment varied by segment and by 303(d) list.

Volume I of the Lake Helena Report presented additional data and analyses for the 303(d) listed segments in Tenmile Creek. Using a weight of evidence approach, the impairment status of each segment was updated.

The following paragraphs summarize the 303(d) listings and Volume I analyses for Tenmile Creek:

- **Tenmile Creek from Headwaters to Helena Public Water Supply Intake upstream of Rimini (MT41I006_141) –** In 1996, the coldwater fishery drinking water, and aquatic life beneficial uses in the 6.0-mile segment of Tenmile Creek were listed as impaired because of siltation, pH, and metals. In 2002 and 2004, aquatic life, coldwater fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, cadmium, copper, lead, mercury, metals, siltation, and zinc. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, and zinc are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.2.1 of the Volume I Report). Siltation and pH are not impairing beneficial uses, and therefore no TMDLs will be presented. There were insufficient data to determine if mercury is impairing beneficial uses.

- **Tenmile Creek from Helena Public Water Supply Intake upstream of Rimini to Helena Water Treatment Plant (MT41I006_142) –** In 1996, the coldwater fishery drinking water, and aquatic life beneficial uses in the 7.7-mile segment of Tenmile Creek were listed as impaired because of siltation, pH, and metals. In 2002 and 2004, aquatic life, coldwater fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, cadmium, copper, lead, metals, siltation, and zinc. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, zinc, and sediment are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.2.2 of the Volume I Report). pH is not impairing beneficial uses, and therefore no TMDL will be presented.

- **Tenmile Creek from Helena Water Treatment Plant to the Mouth (MT41I006_143) –** In 1996, the coldwater fishery drinking water, and aquatic life beneficial uses in the 15.9-mile segment of Tenmile Creek were listed as impaired because of siltation, pH, and metals. In 2002 and 2004, aquatic life, coldwater fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, cadmium, copper, lead, mercury, metals, nutrients, siltation, zinc. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, zinc, nutrients, and sediment are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.2.3 of the Volume I Report). pH is not impairing beneficial uses, and therefore no TMDLs will be presented. There were insufficient data to determine if mercury is impairing beneficial uses.

Conceptual restoration strategies and the required TMDL elements for nutrients, sediment, and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix C, D, E, and F.

13.1 Metals

The available water chemistry data suggest that Tenmile Creek is impaired by arsenic, cadmium, copper, lead, and zinc (See Volume I Report). TMDLs are presented in the following sections to address the metals impairments. The metals TMDLs are presented at the scale of the entire Tenmile Creek watershed. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

13.1.1 Sources of Metals in the Tenmile Creek Watershed

Tenmile Creek from Headwaters to Helena Public Water Supply Intake upstream of Rimini (MT41I006_141) - Relevant sources of metals to the stream segment are historical hard rock mining activities in the immediate drainage area. The drainage area of this segment of the stream falls within the Rimini mining district. The MBMG Abandoned and Inactive Mines database shows mineral location, placer, surface, surface-underground, underground, and other unknown mining activities in the drainage area of the stream. The historical mining types include lode, mill, and placer. In the past these mines produced gold, silver, lead, copper, manganese, zinc, and arsenic. Of the more than 20 mines present in the headwaters area, 12 are listed in the State of Montana’s inventory of High Priority Abandoned Hardrock Mine Sites: Valley Forge/Susie, Red Water, Red Mountain, Tenmile Mine, National Extension, Monte Cristo, Se Se S13, Queensbury, Peerless Jenny/King, Monitor Creek Tailings, Peter, and Woodrow Wilson. The Helena National Forest documented placer tailings and historical mining dams during the source assessment.

Tenmile Creek from Helena Public Water Supply Intake upstream of Rimini to Helena Water Treatment Plant (MT41I006_142) - Relevant sources of metals in this stream segment include adjacent abandoned mines and pollutant inputs from the stream’s headwaters area (Tenmile Creek 141). The immediate drainage area falls within the Rimini mining district. The MBMG Abandoned and Inactive Mines database reports mineral location, underground, and other, “unknown” mining activities in the drainage area of the stream. The historical mining types include lode and placer. In the past these mines produced gold, silver, lead, and zinc. Four mines are listed in the State of Montana’s inventory of High Priority Abandoned Hardrock Mine Sites: Bear Gulch, Upper Valley Forge, Beatrice, and Armstrong Mine.

Tenmile Creek from Helena Water Treatment Plant to the Mouth (MT41I006_143) - Relevant sources of metals to the stream segment are upstream sources and historical mining activities in the immediate drainage area. The segment's upstream reach (Tenmile Creek 142) also contributes metals. The immediate drainage area falls within the Blue Cloud, Helena, and Scratchgravel Hills mining districts. The MBMG Abandoned and Inactive Mines database reports hot springs, mineral location, placer, surface, surface-underground, underground, and other unknown mining activities in the immediate drainage area of the stream. The historical mining types include lode, mill, and placer. In the past these mines produced gold, silver, copper, lead, uranium, arsenic, and zinc. Six mines are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites: Franklin (Scratchgravel), Joslyn Street Tailings (Helena district) , Lower Tenmile Mine (Rimini), Davis Gulch II (Helena), Spring Hill Tailings (Helena), and Lady Luck (Helena).

Modeled sources and their metals loadings to Tenmile Creek are presented in Figure 13-1 through Figure 13-5. The Upper Tenmile Creek Superfund Mining Area and all other abandoned hard rock mine sites in the Tenmile Creek watershed are included within the source category "Abandoned Mines", which represents the most significant source of all metals.

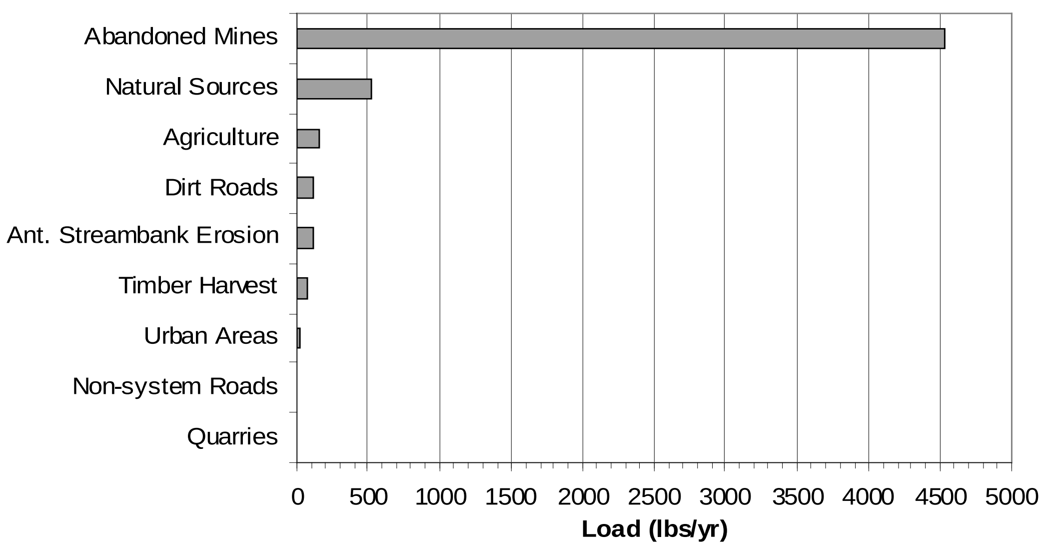

Figure 13-1. Sources of arsenic loadings to Tenmile Creek.

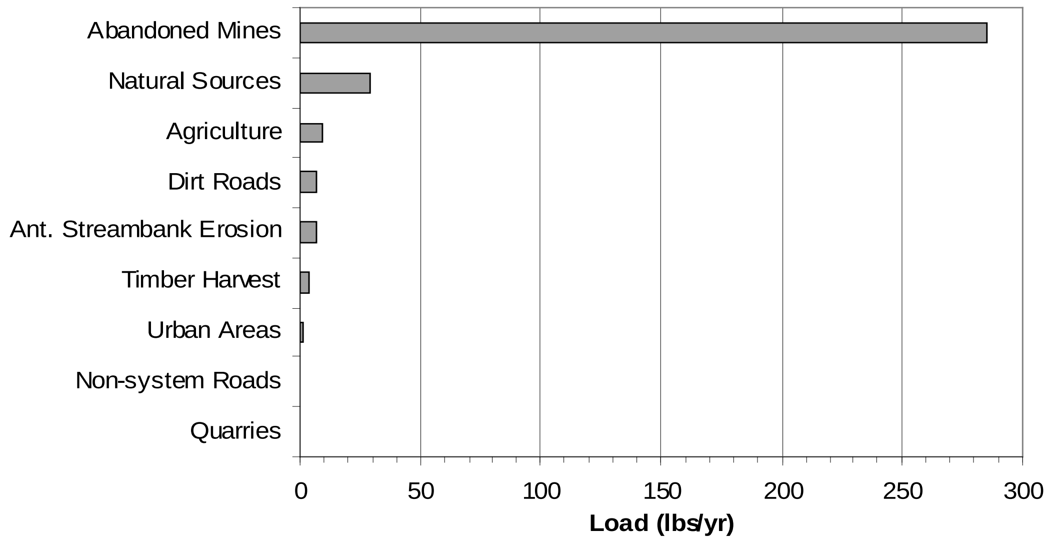

Figure 13-2. Sources of cadmium loadings to Tenmile Creek.

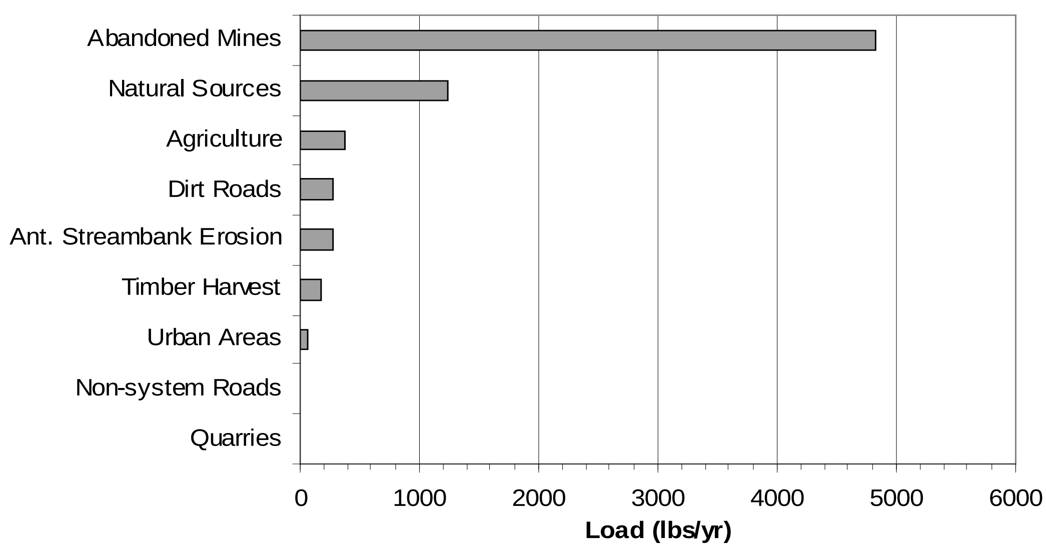

Figure 13-3. Sources of copper loadings to Tenmile Creek.

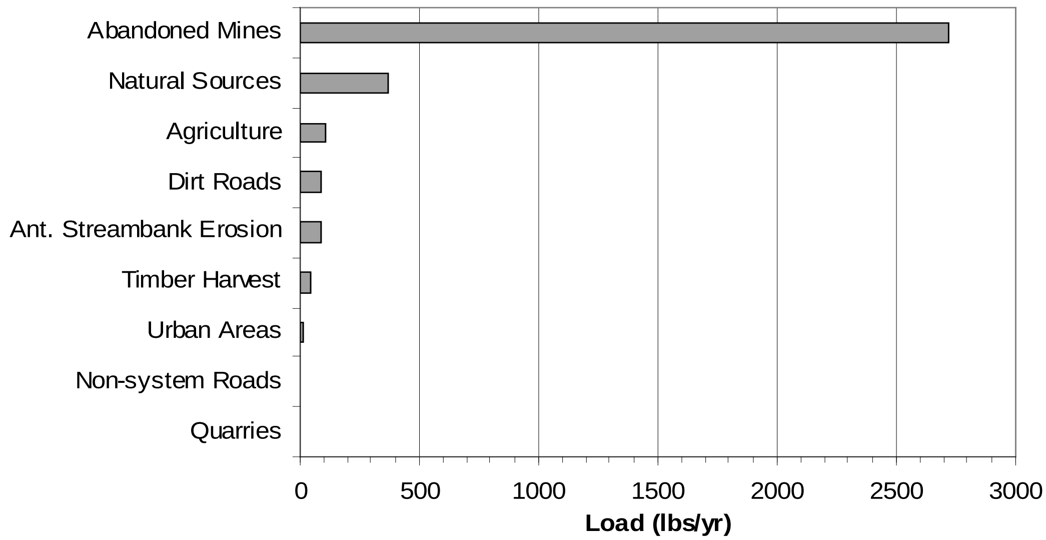

Figure 13-4. Sources of lead loadings to Tenmile Creek.

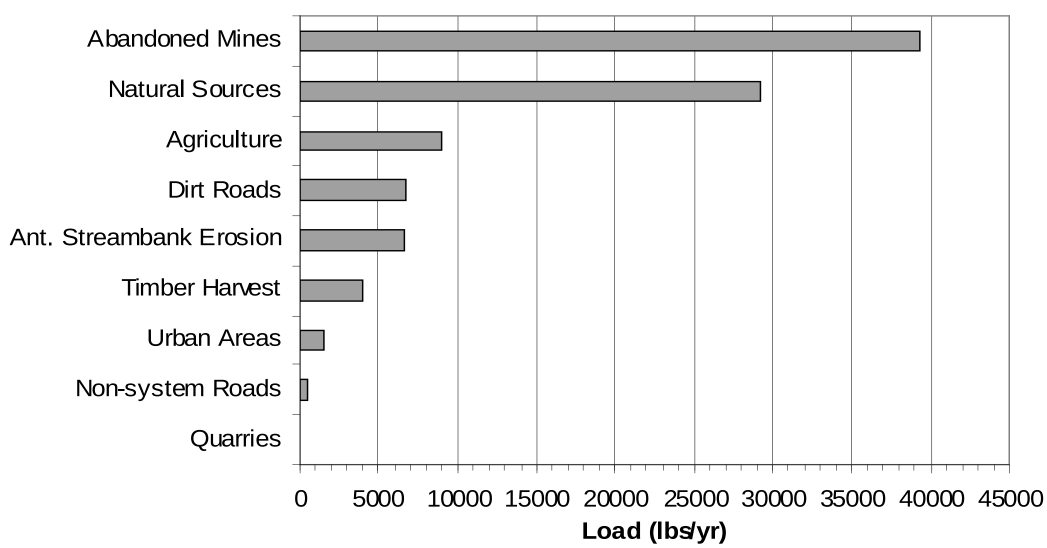

Figure 13-5. Sources of zinc loadings to Tenmile Creek.

13.1.2 Water Quality Goals/Targets

The ultimate goal of the TMDLs for metals is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Tenmile Creek are presented in Table 13-1.

Table 13-1. Montana numeric surface water quality standards for metals in Tenmile Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10[d]
Cadmium (TR)	2.3 at 106.5 mg/L hardness[c]	0.3 at 106.5 mg/L hardness[c]	5
Copper (TR)	14.7 at 106.5 mg/L hardness[c]	9.7 at 106.5 mg/L hardness[c]	1,300
Lead (TR)	87.2 at 106.5 mg/L hardness[c]	3.4 at 106.5 mg/L hardness[c]	15
Zinc (TR)	127.5 at 106.5 mg/L hardness[c]	127.5 at 106.5 mg/L hardness[c]	2,000

Note: TR = total recoverable.
[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

13.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Figure 13-2 through Table 13-6. Based on the results of the source assessment (Section 13.1.1), the recommended implementation strategy to address the metals problem in Tenmile Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Figure 13-2 through Table 13-6, the hypothesis is that an overall, watershed scale metals load reduction of 66, 80, 69, 79, and 55 percent for arsenic, cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from mining sources by 72, 89, 84, 89, and 77 percent for arsenic, cadmium, copper, lead, and zinc, respectively.

It should be noted that EPA developed a site-specific WASP modeling analysis of Upper Tenmile Creek as part of the ongoing Superfund efforts. This model was subsequently used to identify load reductions necessary to meet water quality standards under steady-state flow conditions (Caruso, 2004). The LSPC model was developed to complement the WASP model for three primary reasons: (1) to evaluate water quality standards under all flow conditions (not just low flows); (2) to evaluate the impact of upstream Tenmile Creek reductions on conditions downstream of the WASP model boundary; and (3) to provide a consistent modeling platform throughout the Lake Helena watershed. The findings from the WASP-modeling analysis are similar to those presented here (i.e., load reductions in the range of 60 to 80 percent are required to meet all water quality standards).

Table 13-2. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	4,530.7	72	1,284.9	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	162.1	80	33.1	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	118.5	90	11.7	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	9.3	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	0.8	0	0.8	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	71.6	97	2.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	120.8	60	48.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	26.7	80	5.4	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	5,040.5	72	1,386.3		
	Natural Sources	526.3	0	526.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**5,566.8**	**66**	**1,912.6**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 1,386.3 lbs/yr + 526.3 lbs/yr + 0 = 1,912.6 lbs/yr** **TMDL = 0 + 3.8 lbs/day + 1.4 lbs/day + 0 = 5.2 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 13-3. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	285.2	89	32.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	9.1	80	1.9	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	6.7	90	0.7	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.5	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	0.0	0	0.0	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	4.0	97	0.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	6.8	60	2.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.5	80	0.3	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	313.8	88	38.0		
	Natural Sources	29.6	0	29.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**343.4**	**80**	**67.6**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 38.0 lbs/yr + 29.6 lbs/yr + 0 = 67.6 lbs/yr** **TMDL = 0 + 0.10 lbs/day + 0.08 lbs/day + 0 = 0.18 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 13-4. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	4,822.0	84	762.7	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	379.5	80	77.4	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	277.4	90	27.3	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	21.7	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	1.9	0	1.9	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	167.7	97	5.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	282.9	60	113.2	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	62.4	80	12.7	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	6,015.5	83	1,000.2		
	Natural Sources	1,232.2	0	1,232.2	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**7,247.7**	**69**	**2,232.4**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 1,000.2 lbs/yr + 1,232.2 lbs/yr + 0 = 2,232.4 lbs/yr** **TMDL = 0 + 2.7 lbs/day + 3.4 lbs/day + 0 = 6.1 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 13-5. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	2,714.9	89	295.7	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	113.2	80	23.1	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	82.7	90	8.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	6.5	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	0.6	0	0.6	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	50.0	97	1.5	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	84.4	60	33.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	18.6	80	3.8	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	3,070.9	88	366.6		
	Natural Sources	367.5	0	367.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**3,438.4**	**79**	**734.1**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 366.6 lbs/yr + 367.5 lbs/yr + 0 = 734.1 lbs/yr** **TMDL = 0 + 1.0 lbs/day + 1.0 lbs/day + 0 = 2.0 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 13-6. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	39,384.8	77	8,889.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	8,989.2	80	1,834.2	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	6,570.4	90	647.4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	513.7	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	44.0	0	44.0	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	3,972.9	97	119.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	6,701.5	60	2,680.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1,479.1	80	301.0	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	67,655.6	78	14,515.7		
	Natural Sources	29,189.1	0	29,189.1	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**96,844.7**	**55**	**43,706.0**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 14,515.7 lbs/yr + 29,189.1 lbs/yr + 0 = 43,706.0 lbs/yr** **TMDL = 0 + 39.7 lbs/day + 80.0 lbs/day + 0 = 119.7 lbs/day**					

[1]The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

13.2 NUTRIENTS

The weight-of-evidence suggest that Tenmile Creek is impaired by nutrients (See Volume I Report). TMDLs are presented in the following sections to address the nutrient impairments. The nutrient TMDLs are presented at the scale of the entire Tenmile Creek watershed and the loading analyses presented in this section are based on application of the GWLF model (see Appendix C). In the absence of a strong case for either N or P limitation in the ultimate receiving water bodies (i.e., Prickly Pear Creek and Lake Helena), TMDLs are presented below for both nitrogen and phosphorus.

13.2.1 Nitrogen

13.2.1.1 Sources of Nitrogen in the Tenmile Creek Watershed

As shown in Figure 13-6, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of nitrogen in the Tenmile Creek watershed, in order of importance include septic systems, urban areas, agriculture, anthropogenic streambank erosion, timber harvest and paved roads. Additionally, dewatering has affected the natural hydrology of the stream and the quality of aquatic habitat. Diffuse sediment and possibly nutrients sources from rural housing and subdivisions also affect the stream.

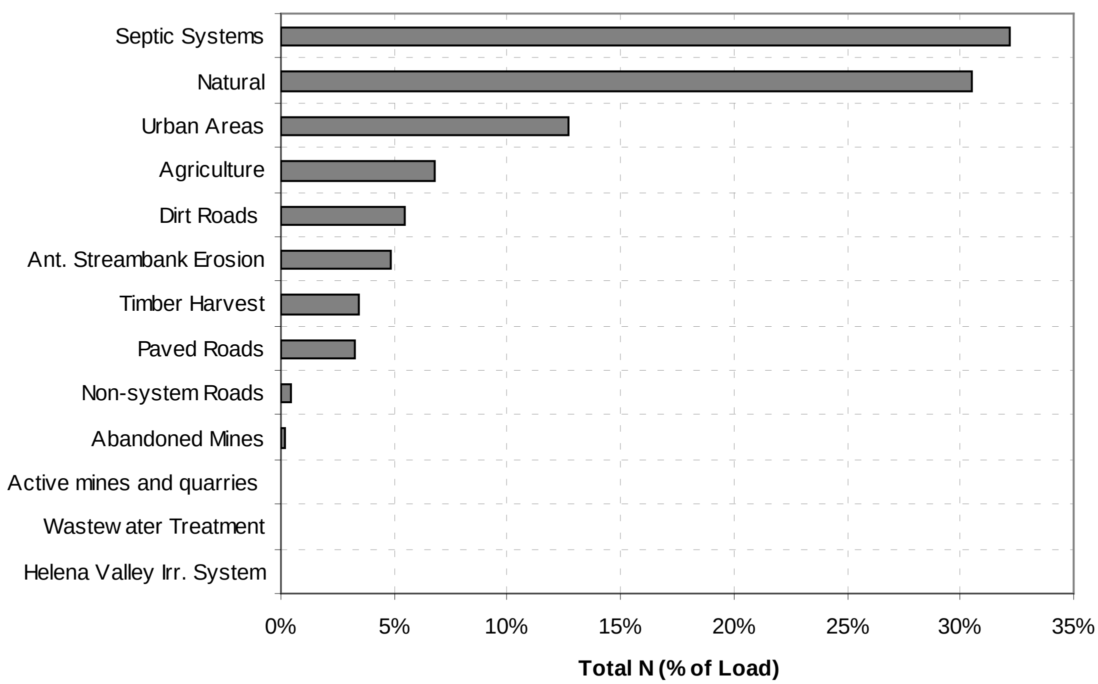

Figure 13-6. Percent of the annual TN load from all potentially significant sources in the Tenmile Creek Watershed.

13.2.1.2 Water Quality Goals/Targets

The proposed interim water quality target for total nitrogen in Tenmile Creek is 0.33 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

13.2.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the nitrogen TMDL is to attain full beneficial use support in Tenmile Creek. In the absence of better data/information, the interim target presented in Section 13.2.1.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 59 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable nitrogen load reduction for the Tenmile Creek Watershed is estimated to be only 23 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Tenmile Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TN load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TN target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 13-7. The adaptive management strategy is presented in Volume II, Section 3.2.3.1

Alternative Load Reduction Strategies

It should also be noted that alternative remedies could be used to meet the in-stream nutrient targets. For example, one restoration strategy under consideration for the Upper Tenmile Creek metals impairments is to bypass water through the City of Helena's Rimini diversion into Tenmile Creek. The bypass would result in less water being diverted by the city for water supply and would increase the minimum flow, essentially helping to dilute both metals and nutrient concentrations.

Table 13-7. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Nitrogen.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.11	79	0.02	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79%. Sediment-associated nitrogen will decrease accordingly (79%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Agriculture	3.87	79	0.81	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	2.76	90	0.28	It is estimated that there are 9.9 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.26	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	1.83	30	1.28	An average nitrogen removal efficiency of 30% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	18.51	0.5	18.42	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 0.5% decrease in TN. Replacing failing septic systems with level 2 treatment could result in a 1.7% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	1.98	97	0.06	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	3.12	60	1.25	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	7.23	30	5.06	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	39.67	33	27.18		
	Natural Sources	17.29	0	17.29	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	Basin Creek Mining (MT0028690), the City of Helena Tenmile Water Treatment Plant (MT0028720), and Pacific Steel and Recycling (storm water) (MTR000430) all have no discharge data available and are likely insignificant sources of nitrogen. Therefore, the WLA is set to zero.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**56.96**	**23**	**44.47**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 27.18 tons/yr + 17.29 tons/yr + 0 = 44.47 tons/yr** **TMDL = 0 + 0.07 tons/day + 0.05 tons/day + 0 = 0.12 tons/day**					

13.2.2 Phosphorus

13.2.2.1 Sources of Phosphorus in the Tenmile Creek Watershed

As shown in Figure 13-7, the primary anthropogenic sources of phosphorus in the Tenmile Creek watershed, in order of importance, are agriculture, urban areas, dirt roads, anthropogenic streambank erosion, timber harvest and paved roads. Additionally, dewatering has affected the natural hydrology of the stream and the quality of aquatic habitat. Diffuse sediment and possibly nutrients sources from rural housing and subdivisions also affect the stream.

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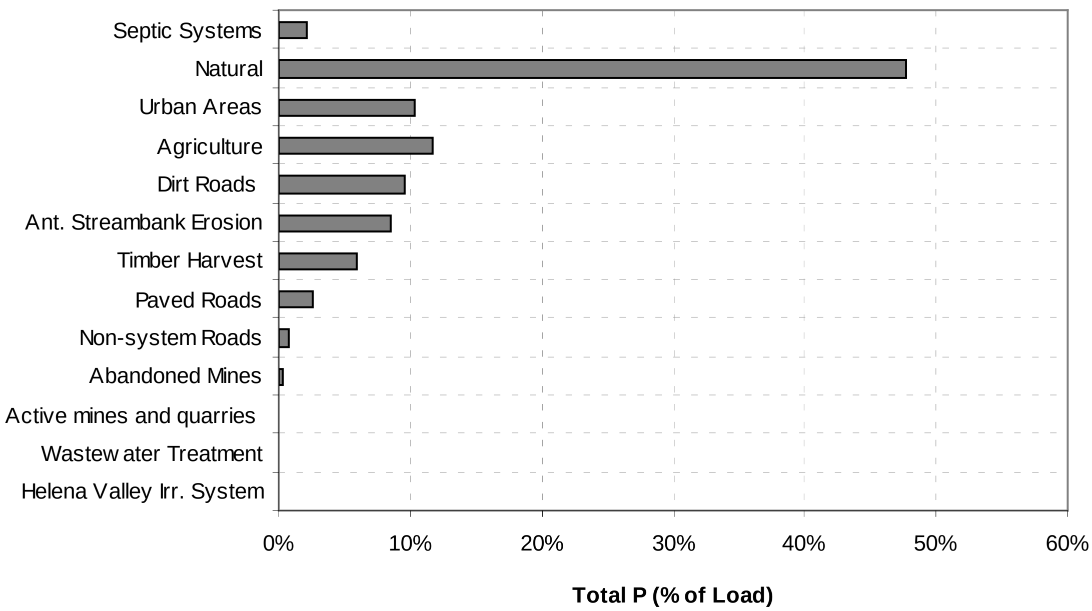

Figure 13-7. Percent of the annual TP load from all potentially significant sources in the Spring Creek Watershed.

13.2.2.2 Water Quality Goals/Targets

The proposed water quality target for total phosphorus in Tenmile Creek is 0.04 mg/L (See Volume I Section 3.2.3). A strategy to revise this target, if deemed appropriate, is presented in Section 3.2.3 of the main report.

13.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the phosphorus TMDL is to attain full beneficial use support in Tenmile Creek. In the absence of better data/information, the interim target presented in Section 13.2.2.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 61 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable TP load reduction for the Tenmile Creek Watershed is estimated to be only 38 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Tenmile Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TP load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TP target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 13-8. The adaptive management strategy is presented in Volume II, Section 3.2.3.1

Table 13-8. TMDL, Allocations, and Margin of Safety for Tenmile Creek –Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.02	79	0	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79%. Sediment-associated phosphorus will decrease accordingly (79%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated phosphorus reductions could be over or under estimated.
	Agriculture	0.84	79	0.18	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	0.61	90	0.06	It is estimated that there are 16.2 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.06	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.18	50	0.09	An average phosphorus removal efficiency of 50% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	0.16	100	0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	0.42	97	0.01	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.69	60	0.28	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.73	50	0.37	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	3.71	73	0.99		
	Natural Sources	3.40	0	3.40	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	Basin Creek Mining (MT0028690), the City of Helena Tenmile Water Treatment Plant (MT0028720), and Pacific Steel and Recycling (storm water) (MTR000430) all have no discharge data available and are likely insignificant sources of phosphorus. Therefore, the WLA is set to zero.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**7.11**	**38**	**4.39**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 0.99 tons/yr + 3.4 tons/yr + 0 = 4.39 tons/yr** **TMDL = 0 + 0.003 tons/day + 0.009 tons/day + 0 = 0.012 tons/day**					

13.3 SEDIMENT

Based on the weight of evidence, the cold-water fishery and aquatic life beneficial uses in Tenmile Creek are impaired by siltation. TMDLs are presented in the following sections to address the sediment impairments. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

13.3.1 Sources of Sediment in the Tenmile Creek Watershed

As shown in Figure 13-8, the primary anthropogenic sources of sediment in the Tenmile Creek watershed, in order of sediment load are agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads/trails, abandoned mines, and active mines and quarries.

Agriculture was the single greatest sediment source within the greater Tenmile Creek watershed, representing 30 percent of the total anthropogenic sediment load. As a land-use, agriculture occurs in the lower elevation areas of the watershed including middle and lower Tenmile Creek, and Sevenmile Creek watersheds. Unpaved roads were the second greatest anthropogenic sediment source, accounting for 24 percent of this load. The majority of the road sediment was generated in high road density watersheds such as upper and lower Tenmile and Sevenmile Creeks. Segments within the greater Tenmile watershed that generate large streambank erosion sediment load include middle and lower Tenmile, and Sevenmile watersheds. Causes of streambank erosion in these watersheds are riparian grazing, road encroachment, stream channelization, riparian vegetation removal, and historic mining activity. Most of the sediment related to timber harvest activities is generated in upper Tenmile Creek, with lesser quantities from middle Tenmile and Skelly Gulch. Sediment from urban areas is largely generated within the middle and lower Tenmile watersheds, and is associated with the rapid development of the Helena Valley. Non-system roads/trails occur throughout the greater watershed, but have higher densities in the public land areas of the upper watershed. Ten abandoned mines (Armstrong, Beatrice, Monitor Creek, National Extension, Peter, Red Mountain, Red Water, Upper Valley Forge, Valley Forge/Susie, and Woodrow Wilson) within Warm Spring Creek were identified as likely delivering sediment to a channel within the Tenmile watershed. All of the mines are located within the upper and middle Tenmile Creek watersheds. None of the mines have been formally reclaimed and thus continue to generate sediment. Sediment from active mines and quarries is solely generated in lower Tenmile Creek and is related to gravel quarries in the western Helena Valley.

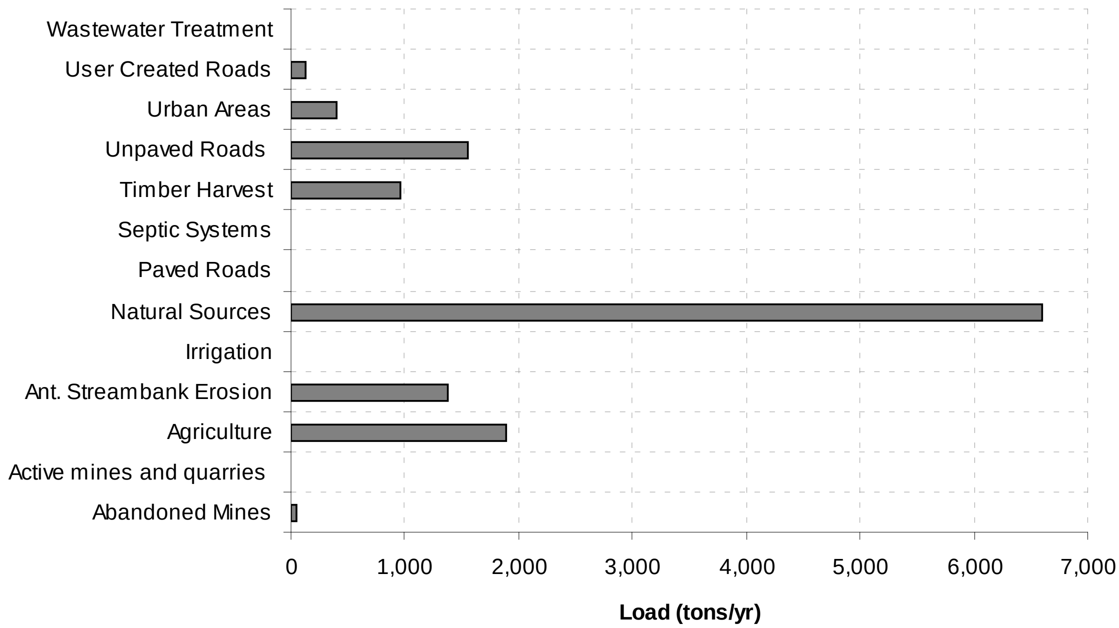

Figure 13-8. Total annual sediment load from all potentially significant sources in the Tenmile Creek Watershed.

13.3.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

13.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 13-9. Based on the results of the source assessment (Section 13.3.1), the recommended implementation strategy to address the sediment problem in Tenmile Creek is to reduce sediment loading from the primary anthropogenic sediment sources – agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, abandoned mines, and active mines and quarries. As shown in Table 13-9, the hypothesis is that an overall, watershed scale sediment load reduction of 36 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, and abandoned mines by 60, 60, 90, 97, 80, 100, and 79 percent, respectively.

Table 13-9. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	55	79	12	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79%.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	1,895	60	758	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing erosion.	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	1,380	90	138	It is estimated that there are 16.2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	129	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	10	0	10	Loading estimates reflect no reduction in load allocation. This is due to the small load size relative to other sediment sources.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	957	97	29	It is assumed that sediment loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1,558	60	623	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	393	80	79	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	6,377	74	1,649		
	Natural Sources	6,598	0	6,598	It is assumed that the sediment loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**12,975**	**36**	**8,247**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 1,649 tons/yr + 6,598 tons/yr + 0 = 8,247 tons/yr** **TMDL = 0 + 4.5 tons/day + 18.1 tons/day + 0 = 22.6 tons/day**					

14.0 WARM SPRINGS CREEK, MIDDLE FORK WARM SPRINGS CREEK, AND NORTH FORK WARM SPRINGS CREEK

Three segments in the Warm Springs Creek watershed have appeared on various Montana 303(d) lists: Middle Fork Warm Springs Creek (MT41I006_100), North Fork Warm Springs Creek (MT41I006_180), and Warm Springs Creek (MT41I006_110). Impaired uses and causes of impairment varied by segment and by 303(d) list.

Volume I of the Lake Helena Report presented additional data and analyses for the 303(d) listed segments in Warm Springs Creek. Using a weight of evidence approach, the impairment status of each segment was updated.

The following paragraphs summarize the 303(d) listings and Volume I analyses for Warm Springs Creek, North Fork Warm Springs Creek, and Middle Fork Warm Springs Creek:

- **Middle Fork Warm Springs Creek from the headwaters to the mouth (MT41I006_100) –** In 1996, the cold-water fishery and aquatic life beneficial uses in the 2.7-mile segment of Middle Fork Warm Springs Creek were listed as partially supported because of siltation and metals. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, copper, mercury, metals, siltation, and zinc. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, lead, zinc, and sediment are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.9 of the Volume I Report). Copper is not impairing beneficial uses, and therefore no TMDL will be presented. There were insufficient data to determine if mercury is impairing beneficial uses.

- **North Fork Warm Springs Creek from the headwaters to the mouth (MT41I006_180) –** North Fork Warm Springs Creek was added to the Montana 303(d) list in 1998. The 3.5-mile segment was listed as partially supporting aquatic life and cold-water fishery beneficial uses because of siltation. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, metals, organic enrichment/low DO, and siltation. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, zinc, and sediment are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.10 of the Volume I Report). Nutrients (i.e., organic enrichment/low DO) are not impairing beneficial uses, and therefore no TMDL will be presented.

- **Warm Springs Creek from the headwaters to the mouth (MT41I006_110) –** In 1996, the cold-water fishery and aquatic life beneficial uses in the 8.8-mile segment of Warm Springs Creek were listed as partially supported because of suspended solids and metals. In 2002 and 2004, aquatic life and cold-water fishery beneficial uses were listed as impaired because of siltation. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, lead, zinc, and sediment (suspended solids and siltation) are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.11 of the Volume I Report).

Conceptual restoration strategies and the required TMDL elements for sediment and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

14.1 METALS

The available water chemistry data suggest that Tenmile Creek is impaired by arsenic, cadmium, lead, and zinc (See Volume I Report). TMDLs are presented in the following sections to address the metals impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

14.1.1 Sources of Metals in the Warm Springs Creek Watershed

Middle Fork Warm Springs Creek (MT41I006_100) - Historical hard rock mining activities in the sub-watershed comprise the most significant sources of metals loading. The headwaters of the creek fall within the McClellan mining district while the rest is within the Alhambra mining district. The MBMG Abandoned and Inactive Mines database reports surface, underground, mineral location, and prospect mining activities in the watershed. The historical mining types include placer, lode, and mill. In the past these mines produced gold, silver, lead, and copper. Two of the mines in the upstream section of the sub-watershed, Middle Fork Warm Springs (Alhambra district) and Solar Silver (Warm Springs district), are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites and are slated for cleanup. The state's inventory shows 12 other mines in this watershed. A large tailings mine dump, observed in the middle of the stream during source assessment visits to the watershed, prevented vegetation growth and disrupted the natural channel. Water in upper Middle Fork of Warm Springs Creek had a metallic sheen that might have been associated with the presence of metals ions.

North Fork Warm Springs Creek (MT41I006_180) - Historical mining activities in the watershed in the sub-watershed comprise the most significant sources of metals loading. The majority of the watershed falls within the Alhambra mining district. The MBMG Abandoned and Inactive Mines database reports underground mining activities in the watershed. The historical mining types include lode mining. In the past these mines produced gold, silver, lead, and copper. The state's inventory of mines shows two hard rock mines close to the headwaters and one mine close to the mouth of the stream. None of the mines in the basin are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites.

Warm Springs Creek (MT41I006_110) - Relevant sources of metals in this stream segment include tributaries, possible natural hot springs, and historical mining activities in the immediate drainage area. The tributaries, the North Fork and Middle Fork of Warm Springs, are significant contributors of metals. The immediate drainage area of this stream falls within the Alhambra mining district. The MBMG Abandoned and Inactive Mines database shows hot spring, mineral location, and underground mining activities in the drainage area of the stream. The historical mining types include lode and placer mining. In the past these mines produced gold, silver, lead, copper, and zinc. The Alhambra Hot Springs Mine is listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites.

Modeled sources and representing metals loadings to all segments of Warm Springs Creek are presented in Figure 14-1 through Figure 14-4.

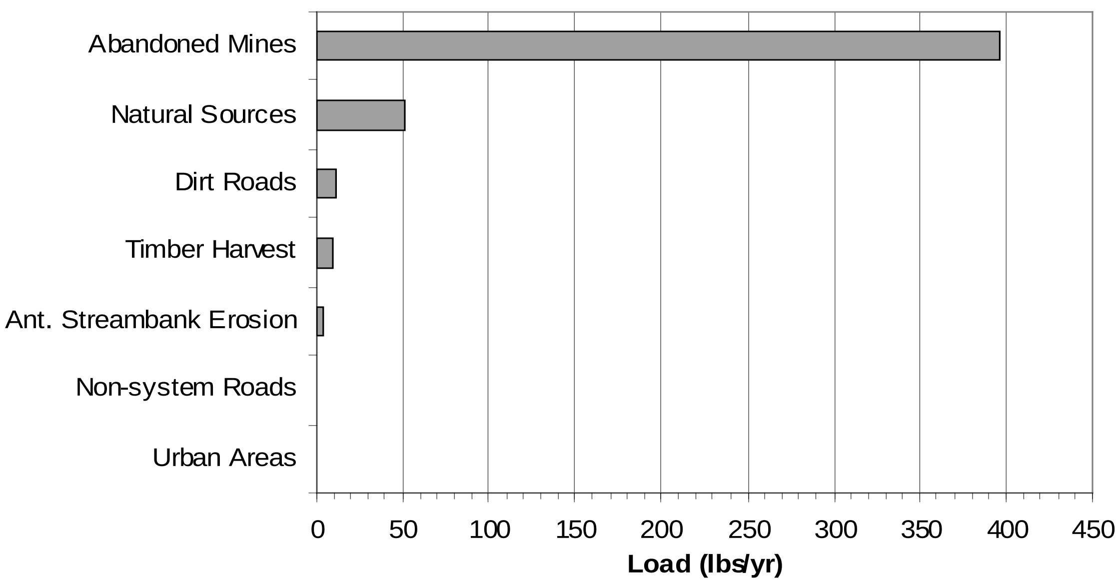

Figure 14-1. Sources of arsenic loadings to Warm Springs Creek.

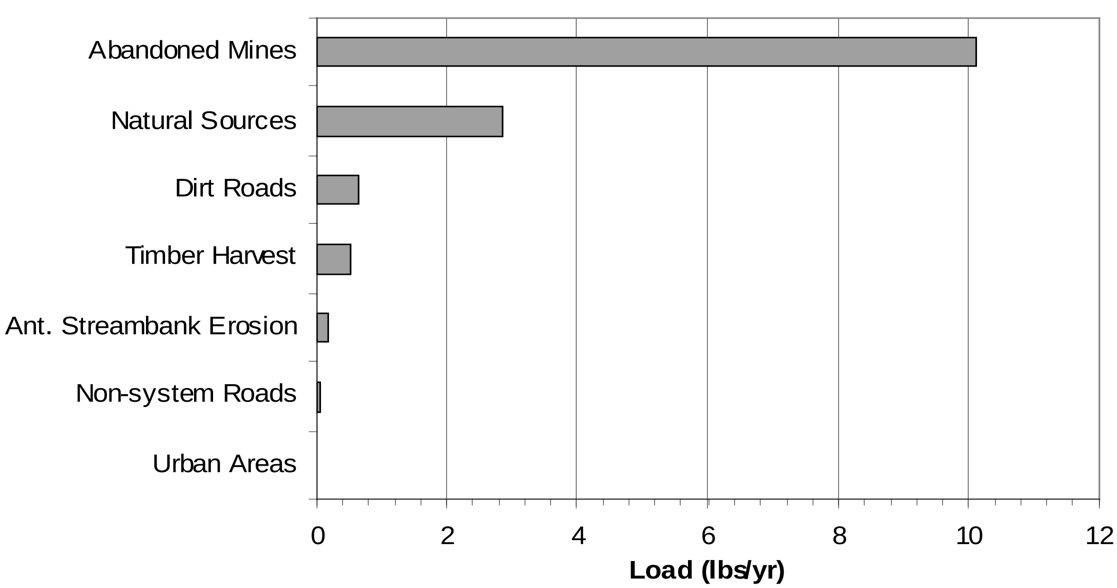

Figure 14-2. Sources of cadmium loadings to Warm Springs Creek.

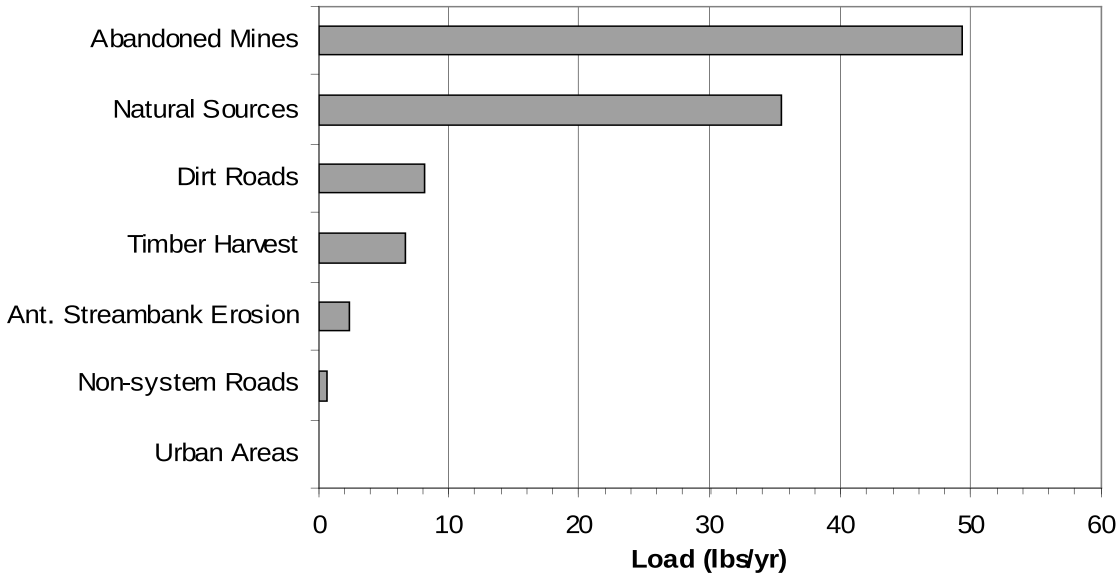

Figure 14-3. Sources of lead loadings to Warm Springs Creek.

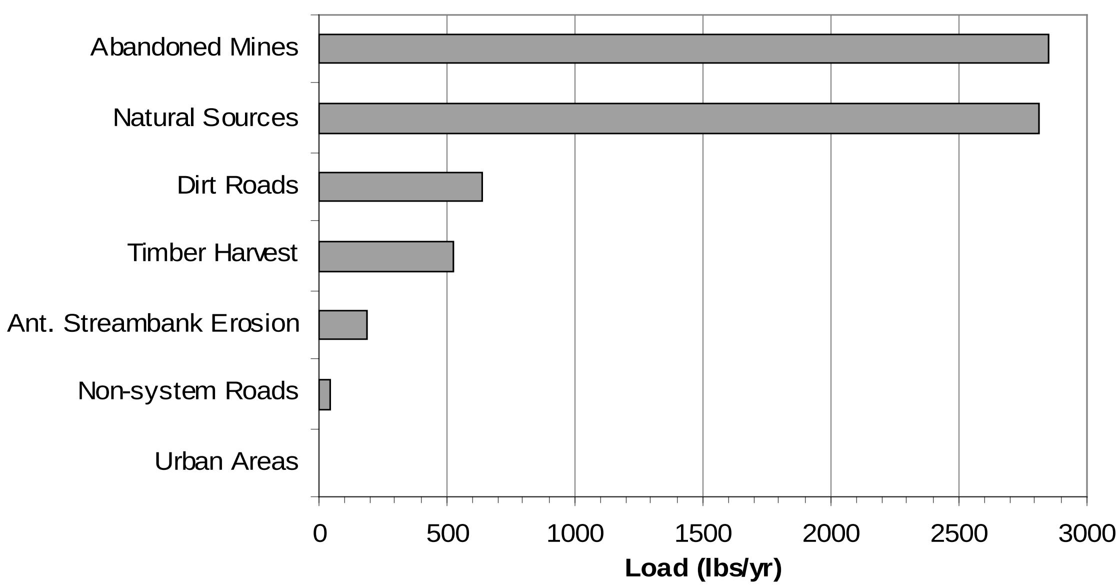

Figure 14-4. Sources of zinc loadings to Warm Springs Creek.

14.1.2 Water Quality Goals/Targets

The ultimate goal of these TMDLs for metals is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in the segments of Warm Springs Creek are presented in Table 14-1.

Table 14-1. Montana numeric surface water quality standards for metals in Warm Springs Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10 [d]
Cadmium (TR)	1.3 at 61.2 mg/L hardness[c]	0.2 at 61.2 mg/L hardness[c]	5
Lead (TR)	43.2 at 61.2 mg/L hardness[c]	1.7 at 61.2 mg/L hardness[c]	15
Zinc (TR)	79.7 at 61.2 mg/L hardness[c]	79.7 at 61.2 mg/L hardness[c]	2,000

14.1.3 Total Maximum Daily Loads, Allocations, and Margin of Safety

The TMDLs, allocations and margin of safety are presented in Tables 14-2 through 14-5. The TMDLs are presented at the scale of the entire Warm Springs Creek watershed and include all tributaries. Based on the results of the source assessment (Section 14.1.1), the recommended implementation strategy to address the metals problem in Warm Springs Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs (see Section 1.2) to reduce sediment attached loading. As shown in Table 14-2 through Table 14-5, the hypothesis is that an overall, watershed scale load reduction of 59, 62, 32, and 44 percent for arsenic, cadmium, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. Warm Springs Creek already meets applicable water quality standards for copper. The proposal for achieving the load reduction is to reduce loads from historical mining by 65, 78, 39, and 71 percent for arsenic, cadmium, lead, and zinc, respectively.

Table 14-2. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	396.7	65	138.1	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	3.3	64	1.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 64% (see Table 14-6), thereby reducing sediment associated metals loads from streambank erosion by 64%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.9	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	9.5	97	0.3	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	11.6	60	4.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 14-6).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban	0.1	80	0.08	An average 80% reduction for sediment-associated metals is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	422.1	66	144.3		
	Natural Sources	50.7	0	50.7	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**472.8**	**59**	**195.0**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 144.3 lbs/yr + 50.7 lbs/yr + 0 = 195.0 lbs/yr** **TMDL = 0 + 0.39 lbs/day + 0.14 lbs/day + 0 = 0.53 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

Table 14-3. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	10.1	77	2.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	0.2	64	0.1	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 64% (see Table 14-6), thereby reducing sediment associated metals loads from streambank erosion by 64%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.0	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.5	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.7	60	0.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 14-6).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	11.5	76	2.7		
	Natural Sources	2.8	0	2.8	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**14.3**	**62**	**5.5**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 2.70 lbs/yr + 2.8 lbs/yr + 0 = 5.5 lbs/yr** **TMDL = 0 + 0.007 lbs/day + 0.008 lbs/day + 0 = 0.015 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

Table 14-4. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	49.4	38	30.4	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	2.3	64	0.8	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 64% (see Table 14-6), thereby reducing sediment associated metals loads from streambank erosion by 64%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.6	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	6.6	97	0.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	8.1	60	3.2	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 14-6).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban	0.1	80	0.0	An average 80% reduction for sediment-associated metals is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	67.1	48	34.6		
	Natural Sources	35.4	0	35.4	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**102.5**	**32**	**70.0**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 34.6 lbs/yr + 35.4 lbs/yr + 0 = 70.0 lbs/yr** **TMDL = 0 + 0.09 lbs/day + 0.10 lbs/day + 0 = 0.19 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

Table 14-5. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	2,849.7	71	814.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	184.2	64	66.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 64% (see Table 14-6), thereby reducing sediment associated metals loads from streambank erosion by 64%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	49.4	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	526.8	97	15.8	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	644.5	60	257.8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 14-6).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban	7.4	80	1.5	An average 80% reduction for sediment-associated metals is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	4,262.0	73	1,156.5		
	Natural Sources	2,814.0	0	2,814.0	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**7,076.0**	**44**	**3,970.5**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 1,156.5 lbs/yr + 2,814.0 lbs/yr + 0 = 3,970.5 lbs/yr** **TMDL = 0 + 3.2 lbs/day + 7.7 lbs/day + 0 = 10.9 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

14.2 SEDIMENT

The available data suggest that Warm Springs Creek is impaired by sediment (See Volume I Report). TMDLs are presented in the following sections to address the sediment impairments. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

14.2.1 Sources of Sediment in the Warm Springs Creek Watershed

As shown in Figure 14-5, the primary anthropogenic sources of sediment in the Warm Springs Creek watershed, in descending order of magnitude are unpaved roads, abandoned mines, timber harvest, anthropogenic streambank erosion, and non-system roads.

Unpaved roads account for the greatest percentage (37 percent) of anthropogenic sediment production throughout Warm Springs Creek. Roads cross, and are adjacent to the channel throughout much of the watershed, particularly in the North and Middle Forks. Six abandoned mines (Middle Fork Warm Springs, Solar Silver, Badger, Newburgh/Flemming, White Pine, Warm Springs tailing adit) within Warm Spring Creek were identified as being capable of delivering sediment to a channel within the Warm Springs watershed. With exception of the Badger mine, all of the mines are located within the Middle Fork Warm Springs. The majority of this sediment is related to erosion from tailings piles and disturbed areas. None of these mines have been formally reclaimed, but isolated areas of some of the mines are becoming vegetated. Most of the timber harvest has occurred in the upper watershed. This activity has largely occurred on steep areas of private land. Anthropogenic streambank erosion is largely confined to the main stem of Warm Springs Creek. Causes of this sediment source include riparian grazing, road encroachment, stream channelization, riparian vegetation removal and historic mining activity. Non-system roads/trails were present throughout the uplands of the Warm Springs watershed. The occurrence of these roads/trails in areas of steep topography, and the associated lack of drainage structures typically leads to disproportionately large volumes of sediment generation from this source.

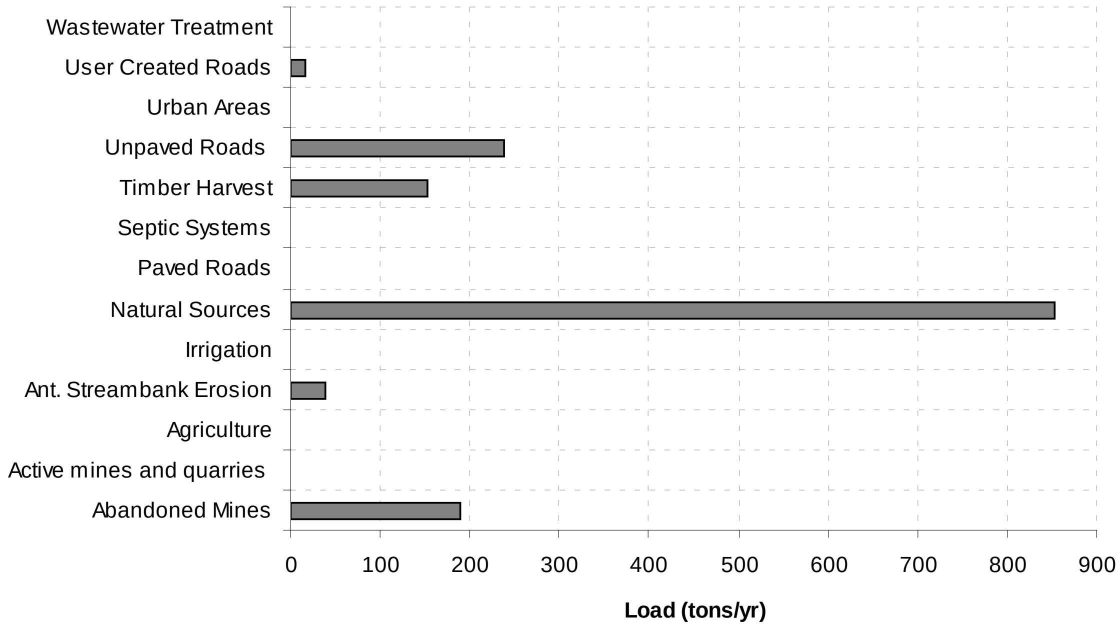

Figure 14-5. Total annual sediment load from all potentially significant sediment sources in the Warm Springs Creek Watershed.

14.2.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

14.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 14-6. The TMDL is presented at the scale of the entire Warm Springs Creek watershed and addresses all of the tributaries. Based on the results of the source assessment (Section 14.2.1), the recommended implementation strategy to address the siltation problem in Warm Springs Creek is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, abandoned mines, timber harvest, anthropogenic streambank erosion, and non-system roads. As shown in Table 14-6, the hypothesis is that an overall, watershed scale sediment load reduction of 32 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, abandoned mines, timber harvest, anthropogenic streambank erosion, and non-system roads by 60, 79, 97, 64, and 100 percent, respectively.

Table 14-6. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	188	67	62	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 67%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	39	64	14	It is estimated that there are 0.9 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	17	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	154	97	5	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	237	60	95	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	635	76	176		
	Natural Sources	854	0	854	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total[1]		**1,489**	**31**	**1,030**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 176 tons/yr + 854 tons/yr + 0 = 1,030 tons/yr** **TMDL = 0 + 0.5 tons/day + 2.3 tons/day + 0 = 2.8 tons/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

15.0 SUMMARY OF TMDLS

In all, 131 303(d) listed waterbody-pollutant combinations were evaluated for the Lake Helena TMDL Planning Area. Of these, 118 have been addressed: 63 through the completion of TMDLs, 41 by other subwatershed-scale TMDLs (e.g., upper reaches of Prickly Pear Creek addressed by a single Prickly Pear Creek Watershed TMDL), and 14 by providing documentation that water quality standards are currently met and no TMDL is necessary. The remaining 13 have not been addressed due to lack of sufficient data to determine the current impairment status or insufficient data to complete the necessary TMDLs. Table 15-1 provides a review of all of the 303(d) listed waterbodies described above, including their impairment status, targets/goals, TMDLs, and supporting documentation.

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Clancy Creek, MT41I006_120	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	2,486 tons/yr	WLA: 0 LA: 2,486 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Nutrients	No nutrient TMDL needed, not exceeding the narrative nutrient standards.			Volume I
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	279.4 lbs/yr	WLA: 0 LA: 279.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 2.3 µg/L at 105.6 mg/L hardness • Aquatic Life (chronic): 0.3 µg/L at 105.6 mg/L hardness • Human Health: 5 µg/L	13.2 lbs/yr	WLA: 0 LA: 13.2 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 14.6 µg/L at 105.6 mg/L hardness • Aquatic Life (chronic): 9.6 µg/L at 105.6 mg/L hardness • Human Health: 1,300 µg/L	517.6 lbs/yr	WLA: 0 LA: 517.6 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 86.3 µg/L at 105.6 mg/L hardness • Aquatic Life (chronic): 3.3 µg/L at 105.6 mg/L hardness • Human Health: 15 µg/L	155.8 lbs/yr	WLA: 0 LA: 155.8 lbs/yr	Volume I; Volume II – Appendix A and F
	Mercury	Insufficient data, not addressed in Volume II.			
	Zinc	• Aquatic Life (acute): 126.5 µg/L at 105.6 mg/L hardness • Aquatic Life (chronic): 126.5 µg/L at 105.6 mg/L hardness • Human Health: 2,000 µg/L	10613.3 lbs/yr	WLA: 0 LA: 10613.3 lbs/yr	Volume I; Volume II – Appendix A and F
Corbin Creek, MT41I006_090	pH	No TMDL needed, not exceeding the standards.			Volume I
	Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	368 tons/yr	WLA: 0 LA: 368 tons/yr	Volume I; Volume II – Appendix A, C, and D

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	36.2 lbs/yr	WLA: 0 LA: 36.2 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 8.95 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 0.75 µg/L at 400 mg/L hardness • Human Health: 5 µg/L	2.8 lbs/yr	WLA: 0 LA: 2.8 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 51.0 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 29.8 µg/L at 400 mg/L hardness • Human Health: 1,300 µg/L	114.6 lbs/yr	WLA: 0 LA: 114.6 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 468.3 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 18.2 µg/L at 400 mg/L hardness • Human Health: 15 µg/L	33.2 lbs/yr	WLA: 0 LA: 33.2 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 392.6 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 392.6 µg/L at 400 mg/L hardness • Human Health: 2,000 µg/L	1,660.7 lbs/yr	WLA: 0 LA: 1,660.7 lbs/yr	Volume I; Volume II – Appendix A and F
	Thermal Modifications	• ≤ 1° F change when water temperature is < 67° F • No significant disturbance of riparian vegetation; Riparian vegetation approaching the maximum potential. • MFISH rating of "best" or "substantial" • Maintain recommended MFWP flows	Volume I stated that, "The available data suggest that impairments due to metals and siltation currently far outweigh any concerns posed by thermal modifications. Fisheries data suggest that the stream is not inhabited by fish. It is not recommended that a TMDL for temperature be prepared at this time. Once pollutant levels are reduced in the stream, Corbin Creek should be able to sustain a fish population and the application of the B-1 temperature targets would be appropriate."		
	Salinity/ TDS/Cl	Addressed as part of the metals goals and TMDLs. Volume I found that, "The impairment is likely associated with extremely high trace metals concentrations rather than high concentrations of sulfates, sodium, or chlorides. The project team finds that a specific TMDL to address salinity and total dissolved solids issues is not warranted pending implementation of a metals TMDL."			
Golconda Creek, MT41I006_070	Unknown Toxicity	The 1996 list did not have more specific details about the "unknown toxicity." Investigations performed during the Volume I report revealed that the unknown toxicity was most likely due to metals. The impairment is addressed as part of the cadmium and lead TMDLs.			Volume I
	Suspended Solids/ Turbidity	No suspended solids or turbidity TMDLs needed, not exceeding the narrative standards.			Volume I
	Cadmium	• Aquatic Life (acute): 0.8 µg/L at 38.5 mg/L hardness • Aquatic Life (chronic): 0.1 µg/L at 38.5 mg/L hardness • Human Health: 5 µg/L	0.7 lb/yr	WLA: 0 LA: 0.7lb/yr	Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Lead	• Aquatic Life (acute): 23.9 µg/L at 38.5 mg/L hardness • Aquatic Life (chronic): 0.9 µg/L at 38.5 mg/L hardness • Human Health: 15 µg/L	6.3 lbs/yr	WLA: 0 LA: 6.3 lbs/yr	Volume I; Volume II – Appendix A and F
Granite Creek MT41I006_179 (Tributary to Austin Creek)	No pollutants	No TMDLs necessary.			Volume I
Granite Creek, MT41I006_230 (Tributary to Sevenmile Creek)	Arsenic	No flow was observed in Granite Creek. Therefore, insufficient information is available to determine impairment status.			Volume I
	Cadmium	No flow was observed in Granite Creek. Therefore, insufficient information is available to determine impairment status.			Volume I
	Lead	No flow was observed in Granite Creek. Therefore, insufficient information is available to determine impairment status.			Volume I
Jackson Creek, MT41I006_190	Siltation	No siltation TMDL needed, not exceeding the narrative standards.			Volume I
Jennie's Fork, MT41I006_210	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	306 tons/yr	WLA: 0 LA: 306 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Lead	• Aquatic Life (acute): 118.7 µg/L at 135.8 mg/L hardness • Aquatic Life (chronic): 4.6 µg/L at 135.8 mg/L hardness • Human Health: 15 µg/L	8.4 lbs/yr	WLA: 0 LA: 8.4 lbs/yr	Volume I; Volume II – Appendix A and F
Lake Helena, MT41I007_010	Suspended Solids	Impairment status unknown. Volume I states, "insufficient information is available to evaluate the degree of potential sediment impairment in Lake Helena, if any. A suitable reference lake would be needed to evaluate the sediment impairment of Lake Helena."			Volume I
	Nutrients	Insufficient data are currently available to establish nutrient targets for Lake Helena. A strategy to establish targets in the future is presented in Volume II, Section 3.2.3. TMDLs are presented based on % reductions for Prickly Pear Creek (the largest tributary to Lake Helena).	TN: 226.2 tons/yr TP: 20.7 tons/yr	**TN** WLA: 4.4 tons/yr LA: 221.8 tons/yr **TP** WLA: 1.8 tons/yr LA: 18.9 tons/yr	Volume I Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	5,104.2 lbs/yr	WLA: 149.2 lbs/yr LA: 4,955.0 lbs/yr	Volume I; Volume II – Appendices A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Lead	• Aquatic Life (acute): 157.6 µg/L at 169.7 mg/L hardness • Aquatic Life (chronic): 6.1 µg/L at 169.7 mg/L hardness • Human Health: 15 µg/L	2,798.0 lbs/yr	WLA: 66.8 lbs/yr LA: 2,731.2 lbs/yr	Volume I; Volume II – Appendices A and F
	Thermal Modifications	Unknown impairment status.			Volume I
Lump Gulch, MT41I006_130	Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	1,780 tons/yr	WLA: 0 LA: 1,780 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Cadmium	• Aquatic Life (acute): 1.1 µg/L at 51.4 mg/L hardness • Aquatic Life (chronic): 0.2 µg/L at 51.4 mg/L hardness • Human Health: 5 µg/L	10.4 lbs/yr	WLA: 0 LA: 10.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 7.4 µg/L at 51.4 mg/L hardness • Aquatic Life (chronic): 5.2 µg/L at 51.4 mg/L hardness • Human Health: 1,300 µg/L	452.8 lbs/yr	WLA: 0 LA: 452.8 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 34.6 µg/L at 51.4 mg/L hardness • Aquatic Life (chronic): 1.3 µg/L at 51.4 mg/L hardness • Human Health: 15 µg/L	135.3 lbs/yr	WLA: 0 LA: 135.3 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 68.6 µg/L at 51.4 mg/L hardness • Aquatic Life (chronic): 68.6 µg/L at 501.4mg/L hardness • Human Health: 2,000 µg/L	8,485.9 lbs/yr	WLA: 0 LA: 8,485.9 lbs/yr	Volume I; Volume II – Appendix A and F
	Mercury	Insufficient data, not addressed in Volume II.			

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Middle Fork Warm Springs Creek, MT41I006_100	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A, C, and D
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 1.3 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 0.2 µg/L at 61.2 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Copper	No copper TMDL needed, not exceeding the standards.			
	Lead	• Aquatic Life (acute): 43.2 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 1.7 µg/L at 61.2 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 79.7 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 79.7 µg/L at 61.2 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Mercury	Insufficient data, not addressed in Volume II.			
North Fork Warm Springs Creek, MT41I006_180	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A, C, and D
	Low DO, organic enrichment	No nutrient TMDL needed, not exceeding the narrative standards.			Volume I
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Cadmium	• Aquatic Life (acute): 1.3 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 0.2 µg/L at 61.2 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 79.7 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 79.7 µg/L at 61.2 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
Prickly Pear Creek, MT41I006_060	Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A, C, and D
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
Prickly Pear Creek, MT41I006_050	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A, C, and D
	Cadmium	• Aquatic Life (acute): 5.2 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 0.5 µg/L at 235.1 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Zinc	• Aquatic Life (acute): 249.9 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 249.9 µg/L at 235.1 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
Prickly Pear Creek, MT41I006_040	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A, C, and D
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 5.2 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 0.5 µg/L at 235.1 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 31.0 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 18.9 µg/L at 235.1 mg/L hardness • Human Health: 1,300 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 249.9 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 249.9 µg/L at 235.1 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Thermal Modifications	• ≤ 1°F when water temperature is < 67°F • 60 Percent Riparian Shade • MFISH rating of "best" or "substantial" • Maintain minimum MFWP recommended flows	67 ºF	WLA: LA: 67 ºF	Volume I; Volume II – Appendix A, Appendix G, Appendix E

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Prickly Pear Creek, MT41I006_030	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 5.2 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 0.5 µg/L at 235.1 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 31.0 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 18.9 µg/L at 235.1 mg/L hardness • Human Health: 1,300 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 249.9 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 249.9 µg/L at 235.1 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Thermal Modifications	• ≤ 1^{o}F when water temperature is < 67^{o}F • 60 Percent Riparian Shade • MFISH rating of "best" or "substantial" • Maintain minimum MFWP recommended flows	No TMDL is presented at this time. This segment is completely dewatered during critical summer low flow conditions. Reassessment should occur once the stream meets recommended minimum summer flows.		Volume I; Volume II – Appendix A, Appendix G, Appendix E

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Prickly Pear Creek, MT41I006_020	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	24,186 tons/yr	WLA: 54 tons/yr LA: 24,132 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	TN: 111.7 tons/yr TP: 13.6 tons/yr	**TN** WLA: 3.7 tons/yr LA: 108.0 tons/yr **TP** WLA: 1.6 ton/yr LA: 12.0 tons/yr	Volume I; Appendix A, C, D, E, and I; Volume II, Section 3.2.3 (Nutrient Strategy)
	Ammonia	No ammonia TMDL needed, not exceeding the standards.			Volume I
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	3,943 lbs/yr	WLA: 149 lbs/yr LA: 3,794 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 5.2 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 0.5 µg/L at 235.1 mg/L hardness • Human Health: 5 µg/L	171 lbs/yr	WLA: 12 lbs/yr LA: 159 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 31.0 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 18.9 µg/L at 235.1 mg/L hardness • Human Health: 1,300 µg/L	5,969 lbs/yr	WLA: 149 lbs/yr LA: 5,820 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	2,082 lbs/yr	WLA: 67 lbs/yr LA: 2,015 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 249.9 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 249.9 µg/L at 235.1 mg/L hardness • Human Health: 2,000 µg/L	118,617 lbs/yr	WLA: 1,977 lbs/yr LA: 116,640 lbs/yr	Volume I; Volume II – Appendix A and F
	Thermal Modifications	• ≤ 1°F when water temperature is < 67°F • 60 Percent Riparian Shade • MFISH rating of "best" or "substantial" • Maintain minimum MFWP recommended flows	No TMDL is presented at this time. This previous segment is completely dewatered during critical summer low flow conditions. Reassessment should occur once the stream meets recommended minimum summer flows.		Volume I; Volume II – Appendix A, Appendix G, Appendix E

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Prickly Pear Creek, MT41I006_010	Metals	This segment of Prickly Pear Creek is located downstream of Lake Helena, and is therefore outside the scope of this assessment. Segment MT41I006_010 will be assessed at a future date as part of the Hauser Lake/Missouri River Planning Area.			
Sevenmile Creek, MT41I006_160	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	3100 tons/yr	WLA: 0 LA: 3100 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	TN: 12.26 tons/yr TP: 1.59 tons/yr	**TN** WLA: 0 tons/yr LA: 12.26 tons/yr **TP** WLA: 0 ton/yr LA: 1.59 tons/yr	Volume I; Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	578.7 lbs/yr	WLA: 0 LA: 578.7 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 33.6 µg/L at 256.4 mg/L hardness • Aquatic Life (chronic): 20.4 µg/L at 256.4 mg/L hardness • Human Health: 1,300 µg/L	828.0 lbs/yr	WLA: 0 LA: 828.0 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 266.2 µg/L at 256.4 mg/L hardness • Aquatic Life (chronic): 10.3 µg/L at 256.4 mg/L hardness • Human Health: 15 µg/L	283.7 lbs/yr	WLA: 0 LA: 283.7 lbs/yr	Volume I; Volume II – Appendix A and F
Silver Creek, MT41I006_150	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	968.3 lbs/yr	WLA: 0 LA: 968.3 lbs/yr	Volume I; Volume II – Appendix A and F
	Priority organics	No TMDL needed, not exceeding standards.			Volume I

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Skelly Gulch, MT41I006_220	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	1,097 tons/yr	WLA: 0 LA: 1,097 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Metals	No TMDL needed, not exceeding standards.			Volume I
Spring Creek, MT41I006_080	Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	1,954 tons/yr	WLA: 0 LA: 1,954 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	TN: 5.84 tons/yr TP: 0.95 tons/yr	**TN** WLA: 0 LA: 5.84 tons/yr **TP** WLA: 0 LA: 0.95 tons/yr	Volume I; Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	294.6 lbs/yr	WLA: 81.2 lbs/yr LA: 213.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 8.95 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 0.75 µg/L at 400 mg/L hardness • Human Health: 5 µg/L	15.9 lbs/yr	WLA: 4.1 lbs/yr LA: 11.8 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 51.0 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 29.8 µg/L at 400 mg/L hardness • Human Health: 1,300 µg/L	668.0 lbs/yr	WLA: 77.6 lbs/yr LA: 590.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 468.3 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 18.2 µg/L at 400 mg/L hardness • Human Health: 15 µg/L	219.8 lbs/yr	WLA: 51.1 lbs/yr LA: 168.7 lbs/yr	Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Zinc	• Aquatic Life (acute): 392.6 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 392.6 µg/L at 400 mg/L hardness • Human Health: 2,000 µg/L	14,399 lbs/yr	WLA: 1,770 lbs/yr LA: 12629 lbs/yr	Volume I; Volume II – Appendix A and F
	pH	No TMDL needed, not exceeding standards.			Volume I
Tenmile Creek, MT41I006_141	Siltation	No TMDL needed, not exceeding standards.			Volume I
	pH	No TMDL needed, not exceeding standards.			Volume I
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 2.3 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 0.3 µg/L at 106.5 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 14.7 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 9.7 µg/L at 106.5 mg/L hardness • Human Health: 1,300 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 87.2 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 3.4 µg/L at 106.5 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Mercury	Insufficient data, not addressed in Volume II.			
	Zinc	• Aquatic Life (acute): 127.5 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 127.5 µg/L at 106.5 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
Tenmile Creek, MT41I006_142	pH	No TMDL needed, not exceeding standards.			Volume I
	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A, C, and D
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Cadmium	• Aquatic Life (acute): 2.3 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 0.3 µg/L at 106.5 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 14.7 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 9.7 µg/L at 106.5 mg/L hardness • Human Health: 1,300 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 87.2 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 3.4 µg/L at 106.5 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 127.5 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 127.5 µg/L at 106.5 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
Tenmile Creek, MT41I006_143	Mercury	Insufficient data, not addressed in Volume II.			
	pH	No TMDL needed, not exceeding standards.			Volume I
	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	8,247 tons/yr	WLA: 0 LA: 8,247 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	TN: 44.47 tons/yr TP: 4.39 tons/yr	**TN** WLA: 0 tons/yr LA: 44.47 tons/yr **TP** WLA: 0 ton/yr LA: 4.39 tons/yr	Volume I; Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	1,912.6 lbs/yr	WLA: 0 LA: 1,912.6 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 2.3 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 0.3 µg/L at 106.5 mg/L hardness • Human Health: 5 µg/L	67.6 lbs/yr	WLA: 0 LA: 67.6 lbs/yr	Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Copper	• Aquatic Life (acute): 14.7 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 9.7 µg/L at 106.5 mg/L hardness • Human Health: 1,300 µg/L	2,232.4 lbs/yr	WLA: 0 LA: 2,232.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 87.2 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 3.4 µg/L at 106.5 mg/L hardness • Human Health: 15 µg/L	734.1 lbs/yr	WLA: 0 LA: 734.1 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 127.5 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 127.5 µg/L at 106.5 mg/L hardness • Human Health: 2,000 µg/L	43,706.0 lbs/yr	WLA: 0 LA: 43,706.0 lbs/yr	Volume I; Volume II – Appendix A and F
Warm Springs Creek, MT41I006_110	Suspended Solids, Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	1,030 tons/yr	WLA: 0 LA: 1,030 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	195.0 lbs/yr	WLA: 0 LA: 195.0 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 1.3 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 0.2 µg/L at 61.2 mg/L hardness • Human Health: 5 µg/L	5.5 lbs/yr	WLA: 0 LA: 5.5 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 43.2 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 1.7 µg/L at 61.2 mg/L hardness • Human Health: 15 µg/L	70.0 lbs/yr	WLA: 0 LA: 70.0 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 79.7 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 79.7 µg/L at 61.2 mg/L hardness • Human Health: 2,000 µg/L	3,970.5 lbs/yr	WLA: 0 LA: 3,970.5 lbs/yr	Volume I; Volume II – Appendix A and F

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