DEQ

Montana Department
of Environmental Quality

Red Rock Metals, Sediment and *E. coli* TMDLs and Water Quality Improvement Plan

July 2021

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Document Number xxx

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Suggested citation: Montana DEQ. 2021. Red Rock Metals, Sediment and *E. coli* TMDLs and Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality.

ACKNOWLEDGEMENTS

DEQ would like to acknowledge multiple people and entities for their contributions in the development of the TMDLs contained in this document. The Beaverhead Watershed Committee and Beaverhead Conservation District provided support throughout the Red Rock TMDL planning and development process, aiding with identification of stakeholders and assisting with coordination of stakeholder meetings, public outreach and education, review of draft TMDL document sections, and providing local knowledge of water quality conditions in the watershed. DEQ specifically thanks Zach Owen, Beaverhead Watershed Committee Coordinator, who had a large role in reviewing the document, and Kevin Weiner, USFS, for providing suggestions and data towards development of the sediment TMDLS. DEQ thanks representatives from numerous state and federal agencies took part in the process, including United States Forest Service, Bureau of Land Management, United States Fish and Wildlife Service, Bureau of Reclamation, National Research Conservation Service, and Fish Wildlife and Parks. DEQ also thanks numerous conservation organizations were also involved, including The Nature Conservancy, Centennial Valley Association, and Trout Unlimited. Finally, DEQ thanks the citizens who were involved, including landowners, outfitters, and other interested parties.

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ABBREVIATIONS AND ACRONYMS

Symbol or Unit of Measure	**Definition**
cfs	Cubic Feet per Second
ft	Feet
lbs/day	Pounds per Day
mm	Millimeters
‘	Foot
>	Greater Than
<	Less Than
≥	Greater Than or Equal To
≤	Less Than or Equal To
%	Percent
~	Approximately

Abbreviation or Acronym	**Definition**
AAL	Acute Aquatic Life
AL	Aquatic Life
ARM	Administrative Rules of Montana
Al	Aluminum
As	Arsenic
AUM	Animal Unit Month
BANCS	Bank Assessment for Nonpoint Source Consequences of Sediment (model)
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practice
CAAP	Concentrated Aquatic Animal Production
Cd	Cadmium
CD	Conservation District
CFU	Colony Forming Unit
CWA	Clean Water Act
CFR	Code of Federal Regulations
Cu	Copper
DEQ	Department of Environmental Quality (Montana)
D	Dissolved
DNRC	Department of Natural Resources & Conservation (Montana)
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Incentives Program
FWP	Fish, Wildlife & Parks (Montana)
Fe	Iron
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IR	Integrated Report (Montana Water Quality)
ID	Identification
LA	Load Allocation
MARS	Montana Aquatic Resources Services, Inc.

Abbreviation or Acronym	**Definition**
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
mL	Milliliter
MO	Management Objective
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MWMT	Maximum Weekly Maximum Temperature
N/A	Not Applicable
NHD	National Hydrography Dataset
ND	Not Detected
NRCS	Natural Resources Conservation Service (U.S. Dept. of Agriculture)
Pb	Lead
PEL	Probable Effects Level
PIBO	Pacfish/Infish Biological Opinion
RM	River Mile
SME	Small Miner Exclusion
SMCRA	Surface Mining Control and Reclamation Act
SMZ	Streamside Management Zone
STATSGO	State Soil Geographic Database
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area (Red Rock)
USDA	United States Department of Agriculture
TR	Total Recoverable
USFS	United States Forest Service
TSS	Total Suspended Solids
USGS	United States Geological Survey
W/D	Width to Depth Ratio
WEPP	Water Erosion Prediction Project (model)
WLA	Wasteload Allocation
WRP	Watershed Restoration Plan
Zn	Zinc

HOW THIS DOCUMENT IS ORGANIZED AND WHAT IT CONTAINS

This document addresses all the required components of a TMDL and includes an implementation and monitoring strategy, as well as a strategy to address impairment causes other than sediment and temperature. The TMDL components are summarized within the main body of the document. Additional technical details are contained in the appendices.

This document is organized into three parts, in addition to a preceding document summary. Use the tables below to determine which part(s) to read to find the information most useful to you.

Document Part	Read for:
Part 1	Introductory information that provides the context for this document and defines the total maximum daily load (TMDL) process
Part 2	The TMDL components and how they are derived
Part 3	Information on ways to improve water quality in the Red Rock River watershed and information on developing a local water quality restoration plan

PART 1 – INTRODUCTORY INFORMATION

Part 1 Document Section	Section Contents
Section 1.0 Project Overview	Explains why DEQ writes TMDLs and provides a summary of what water quality impairments are addressed and a table of what TMDLs are included in this document
Section 2.0 Red Rock TMDL Planning Area Description	Describes the physical characteristics and social profile of the watershed
Section 3.0 Montana Water Quality Standards	Discusses the water quality standards that apply to the Red Rock River watershed and the TMDLs in this document
Section 4.0 Defining TMDLs and Their Components	Defines the components of TMDLs and how each is developed

PART 2 – TMDL COMPONENTS

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Metals TMDL Components</td><td rowspan="3">Both pollutant sections include: (a) a discussion of the affected waterbodies and the pollutant’s effect on designated beneficial uses, (b) the information sources and assessment methods used to evaluate stream health and pollutant source contributions, (c) water quality targets and existing water quality conditions, (d) the quantified pollutant loading from the identified sources, (e) the determined TMDL for each waterbody, (f) the allocations of the allowable pollutant load to the identified sources</td></tr>
<tr><td>Section 6.0
Sediment TMDL Components</td></tr>
<tr><td>Section 7.0
E. coli TMDL Components</td></tr>
</table>

Part 2 Document Section	Section Contents
Section 8.0 Public Participation and Public Comments	Describes other agencies and stakeholder groups who were involved with the development of this document and the public participation process used to review the draft document. Addresses comments received during the public review period.

PART 3 – WATER QUALITY RECOMMENDATIONS

Part 3 Document Section	Section Contents
Glossary	Definitions of water quality terminology used in Part 3
Section 9.0 Non-Pollutant Impairments	Describes other problems that could potentially be contributing to water quality impairment and how the TMDLs in this document might address some of these concerns. This section also provides recommendations for combating these problems.
Section 10.0 Water Quality Improvement Plan	Discusses water quality restoration objectives and a strategy to meet the identified objectives and TMDLs.
Section 11.0 Monitoring for Effectiveness	Describes a water quality monitoring plan for evaluating the long-term effectiveness of the Red Rock TMDLs and any implemented restoration projects.

TMDL DOCUMENT SUMMARY

This document presents a total maximum daily load (TMDL) and framework water quality improvement plan for 17 impaired tributaries to the Red Rock River and the Red Rock River (*E.coli*) (see **Figure 1-1**).

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

The Red Rock TMDL TPA is located almost entirely in Beaverhead County, with a small portion in Madison County, and includes the Red Rocks National Wildlife Refuge, Clark Canyon Reservoir and Lima Reservoir (**Figure 1-1**). The Red Rock TPA encompasses and matches the boundaries of the Red Rock River watershed (fourth-code hydrologic unit code 10020001), which begins in the headwaters above the Red Rock National Wildlife Refuge and ends at the outlet of the Clark Canyon Reservoir. The TPA is bounded by the Bitterroot Mountains to the west and south, the Centennial Mountains to the east and the Black Tail and Snow Crest Mountains to the north.

DEQ determined that a number of tributaries do not meet the applicable water quality standards. The scope of the TMDLs in this document address problems with 17 segments impaired for metals, sediment, and or *E. coli* for a total of 35 TMDLs. (**Table DS-1**). Although DEQ recognizes that there are other pollutant listings for the Red Rock TMDL Planning Area, this document addresses only those impairments identified in **Tables DS-1** and **1-1**. Future TMDL projects may require additional TMDLs for this TMDL planning area (**Table 1-2**).

Metals

Fourteen metals TMDLs were prepared for nine waterbody segments in the Red Rock TMDL Planning Area in Bloody Dick, Fish, Little Sheep, Medicine Lodge, Metzel, Muddy, Peet, Price, and Trail Creeks. Elevated concentrations of metals may impair the support of multiple beneficial uses for a waterbody. Elevated concentrations of metals can have a toxic, carcinogenic, or bio-concentrating effect on biota within aquatic ecosystems, and humans and wildlife can suffer acute and chronic effects from consuming water or fish with elevated metals concentrations. DEQ's water quality assessment methods for metals impairments are designed to evaluate the most sensitive use, thus ensuring protection of all designated uses. For metals, the most sensitive uses are drinking water and aquatic life.

The concentration of metals for most streams in the Red Rock TPA does not violate the human health standard, but does violate the standard for protecting aquatic life at long-term exposure. Therefore, TMDLs were prepared indicating the amount of metals that must be reduced at example flows to meet the aquatic life standard. The exceptions were Metzel, Muddy, Preet, and Price Creeks, which exceeded the human health standard for arsenic. For these segments TMDLs for arsenic were prepared describing the amount of arsenic that must be reduced at example flows to meet the human health standard.

Sediment

Sediment was identified as impairing aquatic life in Bean, Big Sheep, Corral, East Fork Clover, Fish, Horse Prairie, Jones, Long, Medicine Lodge, Muddy, O Dell, Peet, Price, Red Rock, Sage, Selway, Tom, and Trail creeks. Sediment is affecting designated uses in these streams by altering aquatic insect communities, reducing fish spawning success, and increasing turbidity. Water quality restoration objectives for sediment were established on the basis of fine sediment levels in trout spawning areas and aquatic insect habitat, stream morphology and available instream habitat as it related to the effects of sediment, and the stability of streambanks. DEQ believes that once these water quality objectives are met, all water uses currently affected by sediment will be restored. DEQ's water quality assessment methods for sediment impairment are designed to evaluate the most sensitive use, thus ensuring protection of all designated uses. For streams in Western Montana, the most sensitive use assessed for sediment is aquatic life.

Sediment loads are quantified for unpaved roads and eroding streambanks for all tributaries with sediment TMDLs, as well as for upland hillslope erosion for Elk Creek. The most significant sources include streamside livestock grazing, removal of streamside vegetation, parallel road segments and undersized culverts, as well as natural sources. The Red Rock TMDL Planning Area sediment TMDLs indicate that reductions in sediment loads ranging from 33% to 52% will satisfy the water quality restoration objectives.

Recommended strategies for achieving the sediment reduction objectives are also presented in this plan. They include best management practices (BMPs) for building and maintaining roads, for riparian (streamside) livestock grazing, and for developing subdivisions. In addition, they include BMPs for expanding riparian buffer areas and using other land, soil, and water conservation practices that improve stream channel conditions and associated riparian vegetation.

E. coli

E.coli TMDLs were identified for the four impaired segments of Horse Prairie, Medicine Lodge, Peet Creek, and Red Rock River (Lower Red Rock Lake to Lima Dam). Elevated concentrations of *E. coli* can put humans at risk for contracting water-borne illnesses. Therefore, elevated instream concentrations of E. coli and other pathogenic pollutants can lead to impairment of a waterbody's designated beneficial use. DEQ's water quality assessment methods for E. coli impairment are designed to evaluate the most sensitive use, thus ensuring protection of all designated uses. For streams in Montana, the most sensitive use assessed for E. coli is primary contact recreation. Water quality restoration goals for E. coli are established based on Montana's numeric water quality standards. DEQ believes that once these water quality goals are met, all uses currently identified as being affected by E. coli will be restored.

This document summarizes E. coli loads for all human caused nonpoint sources such as agricultural sources, malfunctioning septic systems and natural background conditions. It also summarizes state and federal programs that guide TMDL development, as well as potential funding resources for private land owners, to address sources of E. coli pollution.

Implementation of most water quality improvement measures described in this document is based on voluntary actions of watershed stakeholders. Ideally, watershed stakeholders will use this document and associated information as a tool to guide local water quality improvement activities. Such activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations.

A flexible approach to most nonpoint source TMDL implementation activities may be necessary as more knowledge is gained through TMDL implementation and future monitoring. This plan includes a monitoring strategy designed to track progress in meeting TMDL objectives and goals, and to help refine the strategy during its implementation.

Water Quality Improvement Measures
Implementation of most water quality improvement measures described in this plan is based on voluntary actions of watershed stakeholders. Ideally, local watershed groups and/or other watershed stakeholders will use this TMDL document, and associated information, as a tool to guide local water quality improvement activities. Such activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations.

A flexible approach to most nonpoint source TMDL implementation activities may be necessary as more knowledge is gained through implementation and future monitoring. This plan includes a monitoring strategy designed to track progress in meeting TMDL objectives and goals and to help refine the plan during its implementation.

Table DS-1. Impaired Waterbodies in the Red Rock TMDL Planning Area with TMDLs Contained in this Document

Waterbody (Assessment Unit)	Assessment Unit ID	TMDL Prepared	Pollutant Group	Impaired Use
Bean Creek, Headwaters to mouth (Red Rock River)	MT41A004_140	Sediment	Sediment	Aquatic Life
Big Sheep Creek, Headwaters to mouth (Red Rock River)	MT41A003_150	Sediment	Sediment	Aquatic Life
Bloody Dick Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_100	Aluminum	Metals	Aquatic Life
		Lead		
Corral Creek, Headwaters to mouth (Red Rock Creek)	MT41A004_040	Sediment	Sediment	Aquatic Life
East Fork Clover Creek, Headwaters to mouth (Clover Creek)	MT41A004_050	Sediment	Sediment	Aquatic Life
Fish Creek, Headwaters to mouth (Metzel Creek)	MT41A004_030	Aluminum	Metals	Aquatic Life
		Sediment	Sediment	Aquatic Life
Horse Prairie Creek, Headwaters to mouth (Clark Canyon Reservoir)	MT41A003_090	Sediment	Sediment	Aquatic LIfe
		E. coli	Pathogens	
Jones Creek, Headwaters to mouth (Winslow Creek)	MT41A004_130	Sediment	Sediment	Aquatic LIfe

Table DS-1. Impaired Waterbodies in the Red Rock TMDL Planning Area with TMDLs Contained in this Document

Waterbody (Assessment Unit)	Assessment Unit ID	TMDL Prepared	Pollutant Group	Impaired Use
Little Sheep Creek, Headwaters to mouth (Red Rock River)	MT41A003_160	Iron	Metals	Aquatic LIfe
Long Creek, Headwaters to mouth (Red Rock River)	MT41A004_070	Sediment	Sediment	Aquatic LIfe
Medicine Lodge Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_010	Iron	Metals	Aquatic Life
		E.coli	Pathogens	
		Sediment	Sediment	
Metzel Creek, Headwaters to mouth (Red Rock River)	MT41A004_020	Arsenic	Metals	Aquatic Life
Muddy Creek, Confluence Sourdough and Wilson Creek to mouth (Big Sheep Creek)	MT41A003_020	Arsenic	Metals	Aquatic Life
		Iron		
		Sediment	Sediment	Aquatic Life
O'Dell Creek, Headwaters to mouth (Lower Red Rock Lake)	MT41A004_080	Sediment	Sediment	Aquatic Life
Peet Creek, Headwaters to mouth (Red Rock River)	MT41A004_090	Arsenic	Metals	Aquatic Life
		Cadmium		
		Copper		
		Selenium		
		Sediment	Sediment	Aquatic Life
		E. coli	Pathogens	Aquatic Life
Price Creek, Headwaters to mouth (Red Rock River)	MT41A004_010	Arsenic	Metals	Aquatic Life
		Sediment	Sediment	Aquatic Life
Red Rock Creek, Headwaters to mouth (Upper Red Rock Lake)	MT41A004_110	Sediment	Sediment	Aquatic Life
Red Rock River, Lower Red Rock Lake to Lima Dam	MT41A001_020	*E. coli*	Pathogens	Aquatic Life
Sage Creek, Headwaters to mouth (Red Rock River)	MT41A003_140	Sediment	Sediment	Aquatic Life

Table DS-1. Impaired Waterbodies in the Red Rock TMDL Planning Area with TMDLs Contained in this Document

Waterbody (Assessment Unit)	Assessment Unit ID	TMDL Prepared	Pollutant Group	Impaired Use
Selway Creek, Headwaters to mouth (Bloody Dick Creek)	MT41A003_110	Sediment	Sediment	Aquatic Life
Tom Creek, Headwaters to mouth (Upper Red Rock Lake)	MT41A004_100	Sediment	Sediment	Aquatic Life
Trail Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_080	Aluminum	Metals	Aquatic Life
		Sediment	Sediment	Aquatic Life

PART 1
INTRODUCTORY INFORMATION

1.0 Project Overview

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for sediment and temperature problems in the Red Rock TMDL Planning Area (TPA). This document also presents a general framework for resolving these problems. **Figure 1-1** below shows a map of the Red Rock River watershed.

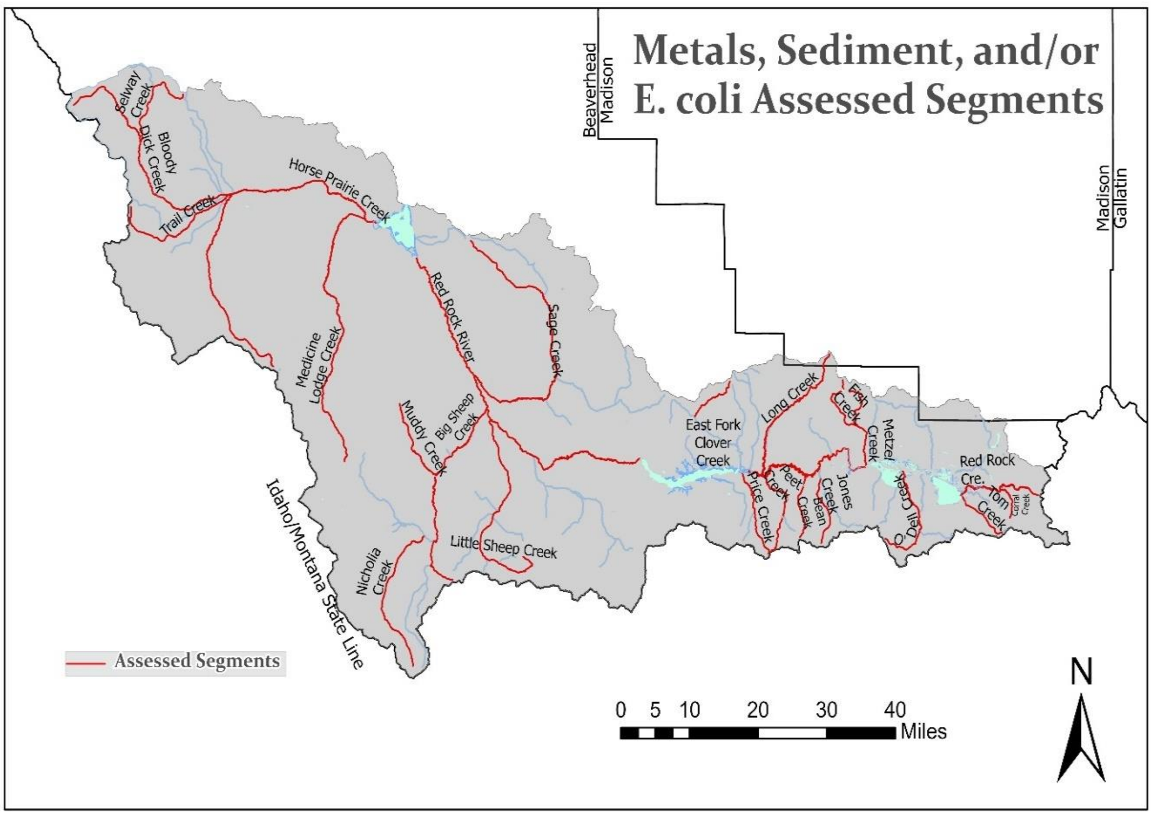

Figure 1-1. Location of the Red Rock River Watershed

1.1 Why We Write TMDLs

The Montana Department of Environmental Quality (DEQ) is charged with protection a clean and healthy environment. This includes actions that protect, maintain, and improve water quality, consistent with the Montana Water Quality Act and the federal Clean Water Act.

Montana's water quality designated use classification system includes the following:

- fish and aquatic life
- wildlife
- recreation
- agriculture

- industry
- drinking water

Each waterbody in Montana has a set of designated uses from the list above. Montana has established water quality standards to protect these uses, and a waterbody that does not meet one or more standards is called an impaired water. Each state must monitor their waters to track if they are supporting their designated uses, and every two years DEQ prepares a Water Quality Integrated Report (IR) which lists all impaired waterbodies and their identified impairment causes. Impairment causes fall within two main categories: pollutant and non-pollutant.

Montana's biennial IR identifies all the state's impaired waterbody segments. The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant. Both Montana state law (Section 75-5-701, Montana Code Annotated (MCA) of the Montana Water Quality Act) and section 303(d) of the federal Clean Water Act require the development of TMDLs for impaired waterbodies when water quality is impaired by a pollutant. TMDLs are not required for non-pollutant causes of impairment.

A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. **Section 4.0** provides more detail on TMDL development and the required TMDL components. In Montana, restoration strategies and monitoring recommendations are also incorporated in TMDL documents to help facilitate TMDL implementation (**Sections 9.0** and **10.0**).

Tables 1-1 and **1-2** identify all impaired waters for the Red Rock TMDL Planning Area from Montana's 2018 303(d) List, and include non-pollutant impairment causes included in Montana's "2020 Water Quality Integrated Report" (DEQ 2020). Both tables provide the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

1.2 Water Quality Impairments and TMDLs Addressed by this Document

Table 1-1 below lists the impairment causes from the "2020 Water Quality Integrated Report" (DEQ 2020) that are addressed in this document (also see **Figure 1-1**). Each pollutant impairment falls within a TMDL pollutant category (i.e., metals, sediment, and *E. coli*), and this document is organized by those categories.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 36 pollutant impairments (**Table 1-1**). There are many non-pollutant types of impairment that are also addressed in this document. As noted above, TMDLs are not required for non-pollutants, although in many situations the solution to one or more pollutant problems will be consistent with, or equivalent to, the solution for one or more non-pollutant problems. The overlap between the pollutant TMDLs and non-pollutant impairment causes is discussed in **Section 9.0**, Non-Pollutant Impairments. **Section 10.0**, Water Quality Improvement Plan, also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

1.3 Completed TMDLs and Future TMDL Development

Although DEQ recognizes that there are other pollutant listings for this TMDL planning area without completed TMDLs (**Table 1-2**), this document only addresses those identified in **Table 1-1** above. This is because DEQ sometimes develops TMDLs in a watershed at varying phases, with a focus on one or a couple of specific pollutant types. TMDLs to be addressed by a future project are listed in **Table 1-2.**

Table 1-1 Water Quality Impairment Causes for the Red Rock TMDL Planning Area Addressed in this Document[1].

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Pollutant Category
Bean Creek, Headwaters to mouth (Red Rock River)	MT41A004_140	Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
		Flow regime modification	Addressed by sediment TMDL
Big Sheep Creek, Headwaters to mouth (Red Rock River)	MT41A003_150	Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
		Flow regime modification	Addressed by sediment TMDL
Bloody Dick Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_100	Aluminum	Metals
		Lead	
Cabin Creek, headwaters to mouth (Big Sheep Creek)	MT41A003_030	Alteration in streamside or littoral vegetative covers	Addressed in document (**Sections 9 and 10**); not linked to a TMDL
Corral Creek, Headwaters to mouth (Red Rock Creek)	MT41A004_040	Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
East Fork Clover Creek, Headwaters to mouth (Clover Creek)	MT41A004_050	Sedimentation-Siltation	Sediment

Table 1-1 Water Quality Impairment Causes for the Red Rock TMDL Planning Area Addressed in this Document[1].

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Pollutant Category
Fish Creek, Headwaters to mouth (Metzel Creek)	MT41A004_030	Aluminum	Metals
		Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
Hell Roaring Creek, headwaters to mouth (Red Rock Creek)	MT41A004_060	Alternation in streamside or littoral vegetative covers	Addressed in document (**Sections 9 and 10**); not linked to a TMDL
Horse Prairie Creek, Headwaters to mouth (Clark Canyon Reservoir)	MT41A003_090	Sedimentation-Siltation	Sediment
		E. coli	Pathogens
		Flow regime modification	Addressed by sediment TMDL
Jones Creek, Headwaters to mouth (Winslow Creek)	MT41A004_130	Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
		Flow regime modification	Addressed by sediment TMDL
Little Sheep Creek, Headwaters to mouth (Red Rock River)	MT41A003_160	Iron	Metals
		Habitat Alterations	Addressed by sediment TMDL
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
Long Creek, Headwaters to mouth (Red Rock River)	MT41A004_070	Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL

Table 1-1 Water Quality Impairment Causes for the Red Rock TMDL Planning Area Addressed in this Document[1].

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Pollutant Category
		Flow regime modification	Addressed by sediment TMDL
Medicine Lodge Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_010	Iron	Metals
		E.coli	Pathogens
		Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
		Flow regime modification	Addressed by sediment TMDL
Metzel Creek, Headwaters to mouth (Red Rock River)	MT41A004_020	Arsenic	Metals
Muddy Creek, Confluence Sourdough and Wilson Creek to mouth (Big Sheep Creek)	MT41A003_020	Arsenic	Metals
		Iron	
		Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
O'Dell Creek, Headwaters to mouth (Lower Red Rock Lake)	MT41A004_080	Sediment	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
Peet Creek, Headwaters to mouth (Red Rock River)	MT41A004_090	Arsenic	Metals
		Cadmium	
		Copper	
		Selenium	
		Sedimentation-Siltation	Sediment
		E. coli	Pathogens
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL

Table 1-1 Water Quality Impairment Causes for the Red Rock TMDL Planning Area Addressed in this Document[1].

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Pollutant Category
		Flow regime modification	Addressed by sediment TMDL
Price Creek, Headwaters to mouth (Red Rock River)	MT41A004_010	Arsenic	Metals
		Sedimentation-Siltation	Sediment
		Flow regime modification	Addressed by sediment TMDL
Red Rock Creek, Headwaters to mouth (Upper Red Rock Lake)	MT41A004_110	Sedimentation-Siltation	Sediment
Red Rock River, Lower Red Rock Lake to Lima Dam	MT41A001_020	*E. coli*	Pathogens
Sage Creek, Headwaters to mouth (Red Rock River)	MT41A003_140	Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
Selway Creek, Headwaters to mouth (Bloody Dick Creek)	MT41A003_110	Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
Tom Creek, Headwaters to mouth (Upper Red Rock Lake)	MT41A004_100	Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL
		Flow regime modification	Addressed by sediment TMDL
Trail Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_080	Aluminum	Metals
		Sedimentation-Siltation	Sediment
		Alteration in Streamside or littoral vegetative covers	Addressed by sediment TMDL

Table 1-1 Water Quality Impairment Causes for the Red Rock TMDL Planning Area Addressed in this Document[1].

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Pollutant Category

[1] All waterbody segments within Montana's Water Quality Integrated Report are indexed to the National Hydrography Dataset (NHD)

Table 1-2. Water Quality Impairment Causes for the Red Rock TMDL Planning Area to be Addressed in a Future Project

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Pollutant Category
Bloody Dick Creek, headwaters to mouth (Horse Prairie Creek)	MT41A003_100	Total Phosphorous	Nutrients
Big Sheep Creek, headwaters to mouth (Red Rock River)	MT41A003_160	Total Nitrogen	Nutrients
		Total Phosphorous	
		Algae	Nutrients
Cabin Creek, headwaters to mouth (Big Sheep Creek)	MT41A003_030	Total Phosphorous	Nutrients
Clark Canyon Reservoir	MT41A002_010	Flow regime modification	Non applicable; non-pollutant
Corral Creek, headwaters to mouth (Red Rock Creek)	MT41A004_040	Total Phosphorous	Nutrients
East Fork Clover Creek, headwaters to mouth (Clover Creek)	MT41A004_050	Total Phosphorous	Nutrients
Fish Creek, headwaters to mouth (Metzel Creek)	MT41A004_030	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
		Chlorophyll a	Nutrients
Horse Prairie Creek, headwaters to mouth (Clark Canyon Reservoir)	MT41A003_090	Mercury	Metals
		Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Jones Creek, headwaters to mouth (Winslow Creek)	MT41A004_130	Algae	Nutrients
		Total Phosphorous	Nutrients
Little Sheep Creek, headwaters to mouth (Red Rock River)	MT41A003_160	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients

Lower Red Rock Lake	MT41A005_020	Sedimentation – Siltation	Sediment
		Flow regime modification	Non applicable; non-pollutant
Medicine Lodge Creek, headwaters to mouth	MT41A003_010	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
		Temperature	Temperature
Metzel Creek, headwaters to mouth (Red Rock River)	MT41A004_020	Total Phosphorous	Nutrients
Muddy Creek, confluence of Sourdough and Wilson Creek to mouth (Big Sheep Creek)	MT41A003_020	Total Phosphorous	Nutrients
Nicholia Creek, headwaters to mouth (Horse Prairie Creek)	MT41A003_040	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Peet Creek, headwaters to mouth (Red Rock River)	MT41A004_090	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Price Creek, headwaters to mouth (Red Rock River)	MT41A004_010	Total Phosphorous	Nutrients
Red Rock River (Lima Dam to Clark Canyon Reservoir)	MT41A001_010	Sedimentation – Siltation	Sediment
		Temperature	Temperature
		Habitat alterations	Non applicable; non-pollutant
		Flow regime modification	Non applicable; non-pollutant
		Alteration in streamside or littoral vegetative covers	Non applicable; non-pollutant
		Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients

Red Rock River (Lower Red Rock Lake to Lima Dam)	MT41A001_020	Sedimentation – Siltation	Sediment
		Temperature	Temperature
		Alteration in streamside or littoral vegetative covers	Non applicable; non-pollutant
		Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Sage Creek, headwaters to mouth (Red Rock River)	MT41A003_140	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Selway Creek (headwaters to mouth (Bloody Dick Creek)	MT41A003_110	Total Phosphorous	Nutrients
Trail Creek, headwaters to mouth (Bloody Dick Creek)	MT41A003_080	Total Phosphorous	Nutrients
Upper Red Rock Lake	MT41A005_030	Sedimentation – Siltation	Sediment
		Flow regime modification	Non applicable; non-pollutant

2.0 Red Rock TMDL Planning Area Description

2.1 Physical Characteristics

The following information describes the physical characteristics of the Red Rock TPA, including location, topography, climate, hydrology, and geology.

2.1.1 Location

The Red Rock TMDL TPA is located almost entirely in Beaverhead County, with a small portion in Madison County, and includes the Red Rocks National Wildlife Refuge, Clark Canyon Reservoir and Lima Reservoir (**Figure 1-1**). The Red Rock TPA encompasses and matches the boundaries of the Red Rock River watershed (fourth-code hydrologic unit code 10020001), which begins in the headwaters above the Red Rock National Wildlife Refuge and ends at the outlet of the Clark Canyon Reservoir. The TPA is bounded by the Bitterroot Mountains to the west and south, the Centennial Mountains to the east and the Black Tail and Snow Crest Mountains to the north.

2.1.2 Topography

Elevations in the TPA range from approximately 5,630 feet above mean sea level at Clark Canyon Reservoir, to nearly 10,203 feet above sea level at the summit of Mount Jefferson in the Centennial Range. The majority of the TPA is between 6,500 and 8,000 feet, as shown in **Figure 2-1.**

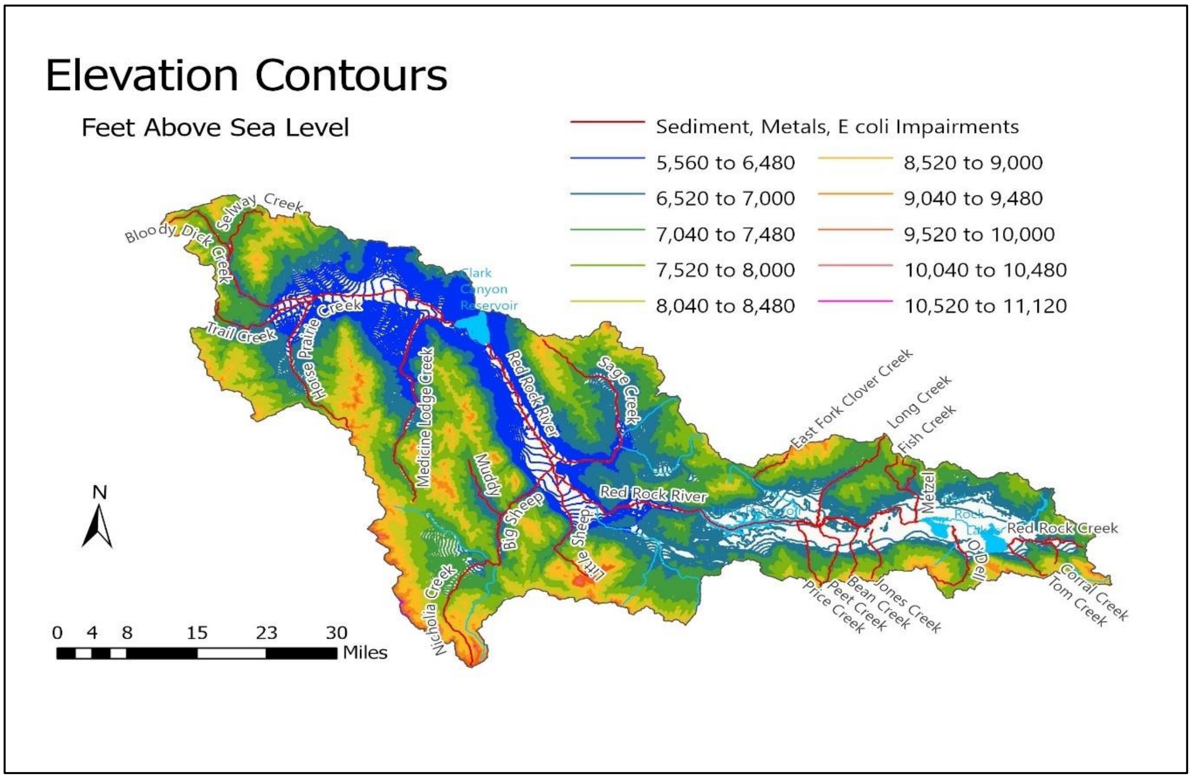

Figure 2-1. Topography of the Red Rock TMDL Planning Area

2.1.3 Climate

The climate of the Red Rock watershed is typical of high elevation intermountain basins of the northern Rocky Mountains in southwestern Montana, with long, cold winters, mild summers, and sparse precipitation. Annual precipitation is highly variable, both temporally and spatially (**Figure 2-2)**. For instance, mean annual precipitation at Lakeview, Montana, is 19.69 inches (6,690 feet above sea level) while the average annual precipitation at Lima, Montana is 12.1 inches (6270 above sea level) (Kendy and Tresch 1996). May and June are typically the wettest months. Precipitation during these months comprises 27% of the annual average. Air temperature is similarly variable y (**Figure 2-3**), with a mean annual air temperature at Lakeview, Montana around 34.8 degrees Fahrenheit (1.5°C). January is typically the coldest month with a mean monthly air temperature of approximately 11.3 degrees Fahrenheit (-11.5°C) and July is the warmest month with a mean monthly air temperature of approximately 58.6 degrees Fahrenheit (14.7°C) (Kendy and Tresch 1996).

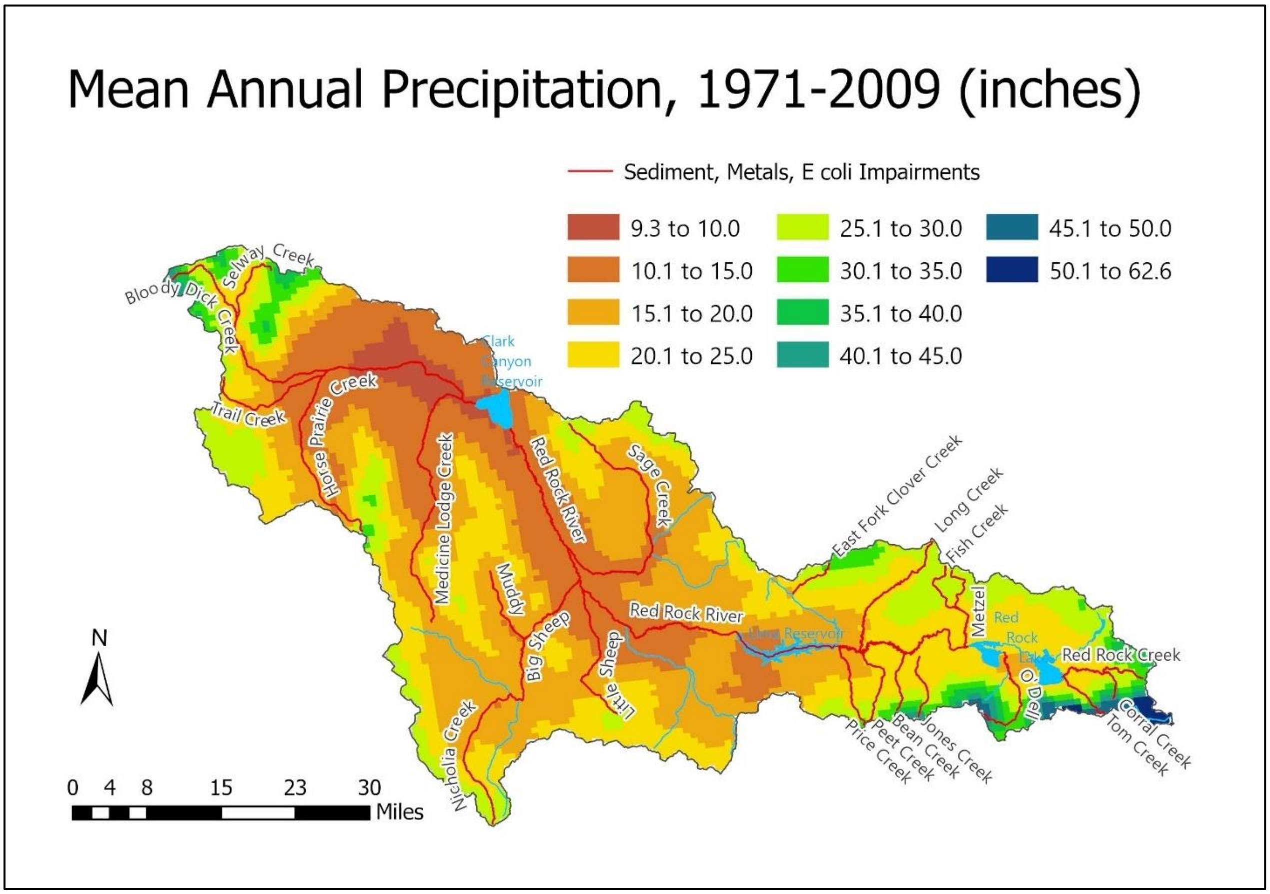

Figure 2-2. Mean Annual Precipitation of the Red Rock TMDL Planning Area

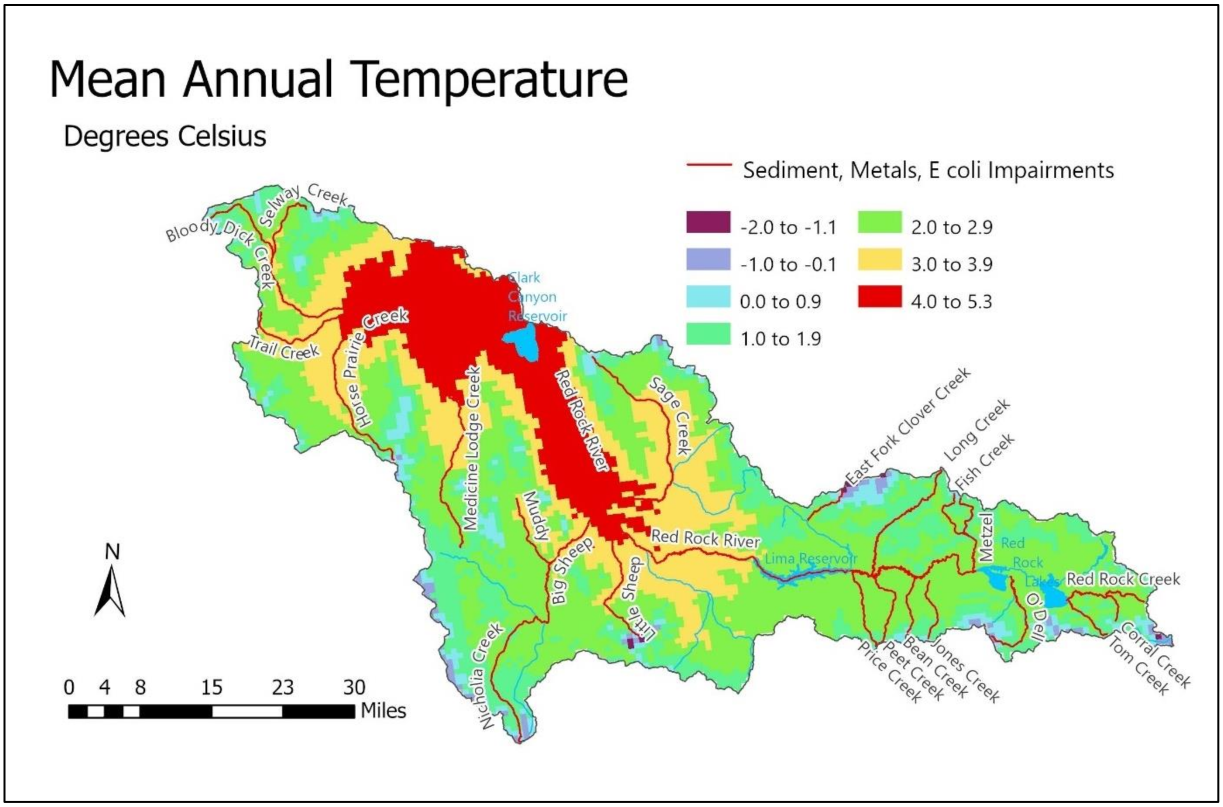

Figure 2-3. Mean Annual Temperatures in the Red Rock TMDL Planning Area

2.1.4 Hydrology

The Red Rock River originates in the upper Centennial Valley at the outlet of Upper Red Rock Lake. Tributaries to Upper Red Rock Lake start near the Continental Divide, and flow westward into the upper Centennial Valley. From Upper Red Rock Lake the river flows through the Red Rock Lakes National Wildlife Refuge to Lower Red Rock Lake. Upper and Lower Red Rock lakes are less than 8 feet deep and are rimmed by marshes (Sondereger et al, 1982). Downstream from the refuge, the river meanders about 13 miles to the Lima Reservoir, an irrigation project completed in 1934. Downstream from the reservoir, the river flows through the Red Rock Valley for about 30 miles before entering Clark Canyon reservoir.

Operation of the Lima Reservoir influences the flow regime in the Red Rock River. This is demonstrated graphically in hydrographs of Red Rock River discharge, measured at USGS gaging station 06012500 (Red Rock River below Lima Reservoir). The peak of these hydrographs is shifted later in the year and shows several late season peaks that are not typical for this area. These conditions are a result of controlled release of stored water. The low flow regime is fairly stable, reflecting average low-flow discharge from the reservoir. No flow data was reported for this station outside of the growing season.

The State of Montana Fish, Wildlife and Parks (MT FWP) maintains a list of Montana streams that support important fisheries or contribute to important fisheries (i.e. provide spawning and rearing habitats) that are significantly dewatered. Dewatering refers to a reduction in streamflow below the point where stream habitat is adequate for fish. The two categories of dewatering are “chronic” – streams where dewatering is a significant problem in virtually all years and “periodic” – streams where dewatering is a significant problem only in drought or water-short years.

Most man-made dewatering occurs during the irrigation season (July-September) and although most dewatering is the result of irrigation withdrawals, a few of the streams listed are dewatered due to dam regulation for agriculture or by natural causes. The number of miles of a given stream may vary from year to year depending on the amount of water available in the stream system. Chronic dewatering in the Red Rock TPA is limited to Junction, Big Sheep, and Horse Prairie Creeks as well as the Red Rock River. Periodic dewatering occurs in Jones, Peet, Big Beaver, Little Sheep, Sage, Medicine Lodge, Bloody Dick and Trail Creeks. Dewatered streams are shown on **Figure 2-4.**

Tributary streams generally are not monitored by U.S. Geological Survey (USGS) gaging stations. Their streamflow generally follows a hydrograph typical for the region, highest in May and June. These are the months with the greatest amount of precipitation and snowmelt runoff. Streamflow begins to decline in late June or early July, reaching minimum flow levels in September when streams may go dry. Streamflow begins to rebound in October and November when fall storms supplement the base-flow levels. However, water withdrawals may affect these patterns .

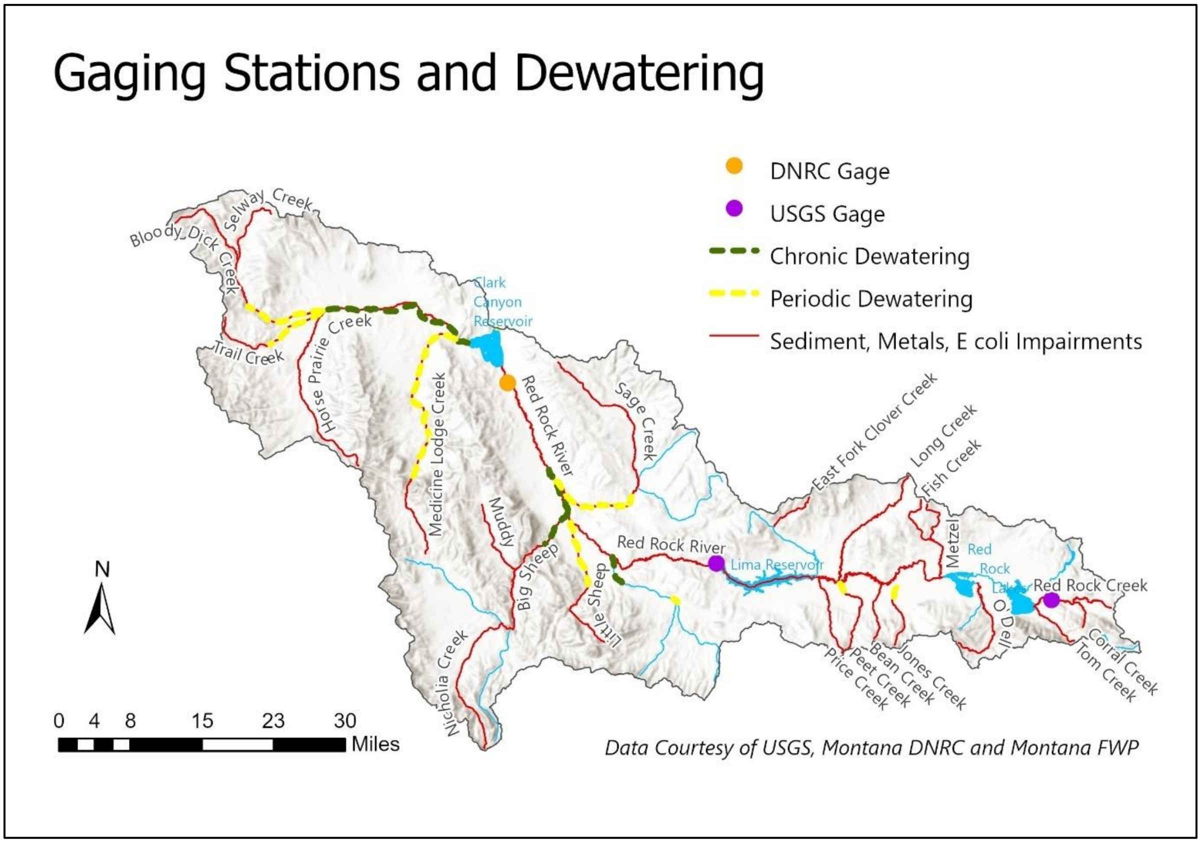

Figure 2-4. Locations of Dewatering and Stream Gauges in the Red Rock TMDL Planning Area

2.1.5 Geology and Soils

The Red Rock watershed is surrounded by metamorphic, sedimentary, and volcanic bedrock (Kendy and Tresch 1996) (**Figure 2-5**). In the Centennial Valley on the east side of the watershed, a fault divides the Centennial Mountains into an upthrown eastern half and a downthrown western half. The eastern half of the Centennial Mountains is a Precambrian metamorphic block comprised of gneiss and quartzite overlain by Paleozoic and lower Mesozoic rocks including shale, sandstone, siltstone, and carbonates

(**Figure 2-5**). The western half of the Centennial Mountains is composed of Cretaceous sandstone, limestone and mudstone overlain by Tertiary volcanic rocks. More than 6,000 ft. of Tertiary sediments interbedded with volcanic and volcanoclastic rock fill the Centennial Valley floor. The margins of the valley are composed of volcanic ash flow tuffs of early Pleistocene age and Tertiary sediments adjacent to bedrock. Quaternary basin-fill deposits of glacial and alluvial origin underlie most of the basin. Springs are common, and are used for livestock and irrigation.

The Red Rock Valley portion of the watershed, extending from the west side of Lima Valley to Clark Canyon Reservoir, is primarily comprised of Precambrian metamorphic rocks such as schist, as well as sedimentary deposits (Kendy and Tresch 1996). Mississippian limestone forms prominent cliffs. Outcrops of reddish pebble and boulder conglomerates are present, and. floodplains consist of well-sorted and rounded pebbles. Groundwater typically contains high calcium bicarbonate and dissolved-solids concentrations.

Less is known about the geology of the Horse Prairie Valley portion of the watershed which is west of Clark Canyon Reservoir (Kendy and Tresch 1996). However, it is also comprised of metamorphic, sedimentary, and volcanic bedrock. In the Horse Prairie Valley area, complex layers of sandstone and limestone are similarly overlain by tuff and volcanic deposits Coal beds in portions are as much as 7 feet thick, but have low economic potential due to high ash and sulfur content and complex structures. Unconsolidated sand, silt, and gravel underlie the floodplains of Horse Prairie, Medicine Lodge, and other major tributaries. Wells typically obtain water from sedimentary deposits near the surface. Due to the high amount of iron and sulfur in some of the well water, treatment is often necessary.

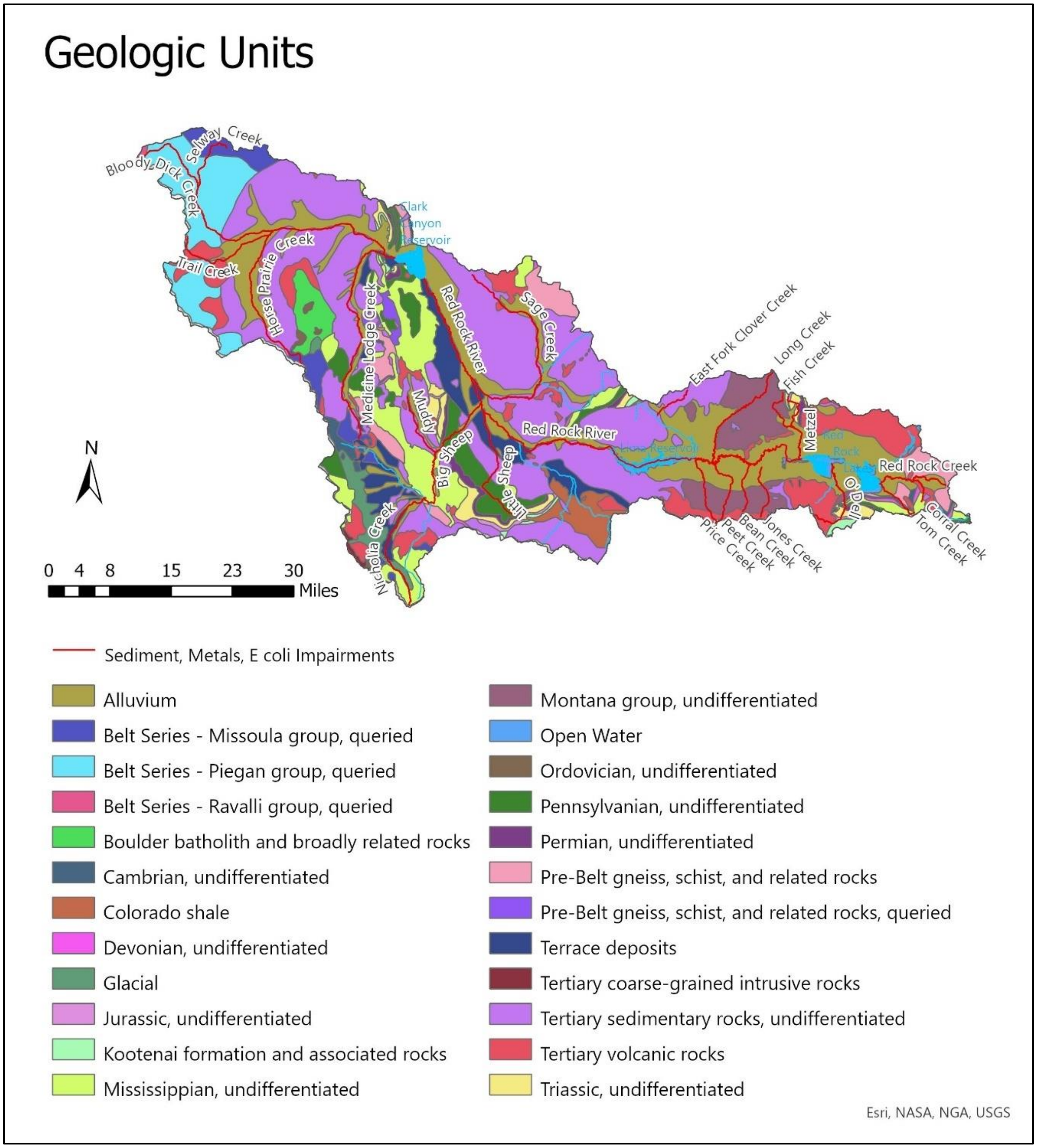

Figure 2-5. Generalized Geology of the Red Rock TMDL Planning Area

In general, the characteristics of the soils on the valley bottom in the Centennial Valley are varied due to changes in parent material, vegetation, and the effect of climactic forces such as wind, water, and ice (UFWS 2009). Topography and time have also had important influences. Soils range in texture from loamy sand to heavy clay. The better drained soils on the alluvial fans are predominately loamy-textured containing variable amounts of gravel, cobble, and stone. The soil in the Centennial Mountains east of the Odell Creek drainage consists principally of carbonate mineral. The soils north of the Red Rock lakes become sandier and have considerably less gravel in the profile (USFWS 2009). The mountainous area west of Odell Creek in the Centennial Valley, and extending to the Horse Prairie Valley, is both igneous and sedimentary in origin, and the soils are more clayey with less lime carbonate.

The USGS Water Resources Division created a dataset of hydrology-relevant soil attributes (Schwarz and Alexander, 1995), based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. K-factor values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Susceptibility to erosion is mapped on **Figure 2-6**, with soil units assigned to the following ranges: low (0.0-0.2), moderate-low (0.2-0.4) and moderate-high (0.4-0.5). Values of >0.6 are considered highly susceptible to erosion. There are very few values greater than 0.5-0.6 (highest susceptibility to erosion) in the TPA; however, there are multiple portions of the watershed in the next-highest erosion category of 0.41-0.5 that have moderate to high susceptibility to erosion.

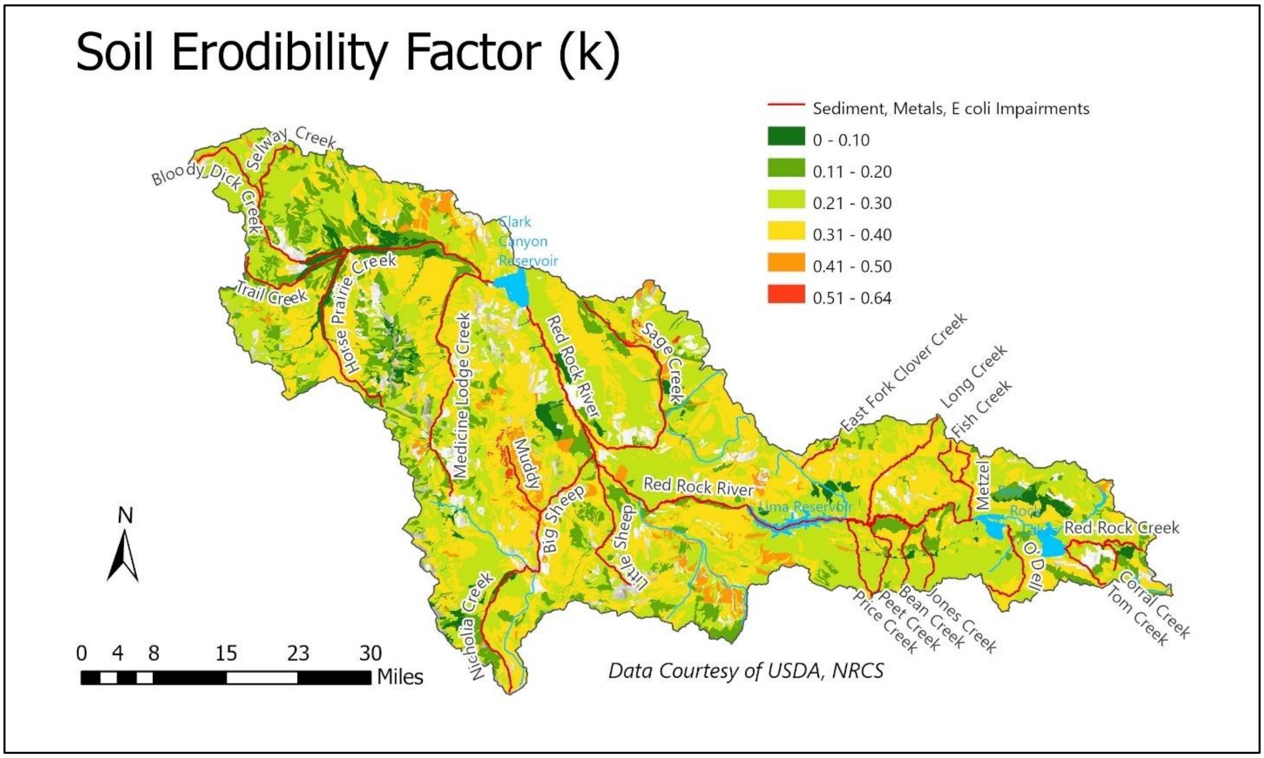

Figure 2-6. Soil Erodibility of the Red Rock TMDL Planning Area

2.2 Ecological Profile

This section describes the ecology of the Red Rock TPA, including the ecoregions mapped within it, land cover, fire history, and the distribution of fish species of concern.

2.2.1 Ecoregions

The Red Rock TPA is located in the Middle Rockies Level III Ecoregion. Eight Level IV Ecoregions are mapped within the TPA (Woods, et al., 2002), as shown on **Figure 2-7.** These include: Barren Mountains, Alpine Zone, Dry Gneissic-Schistose-Volcanic Hills, Central Basin, Dry Intermontane Sagebrush Valleys, Eastern Gravelly Mountains, Forested Beaverhead Mountains and Western Beaverhead Mountains. Further info can be found at the link below:
https://www.epa.gov/eco-research/ecoregion-download-files-state-region-8#pane-24 .

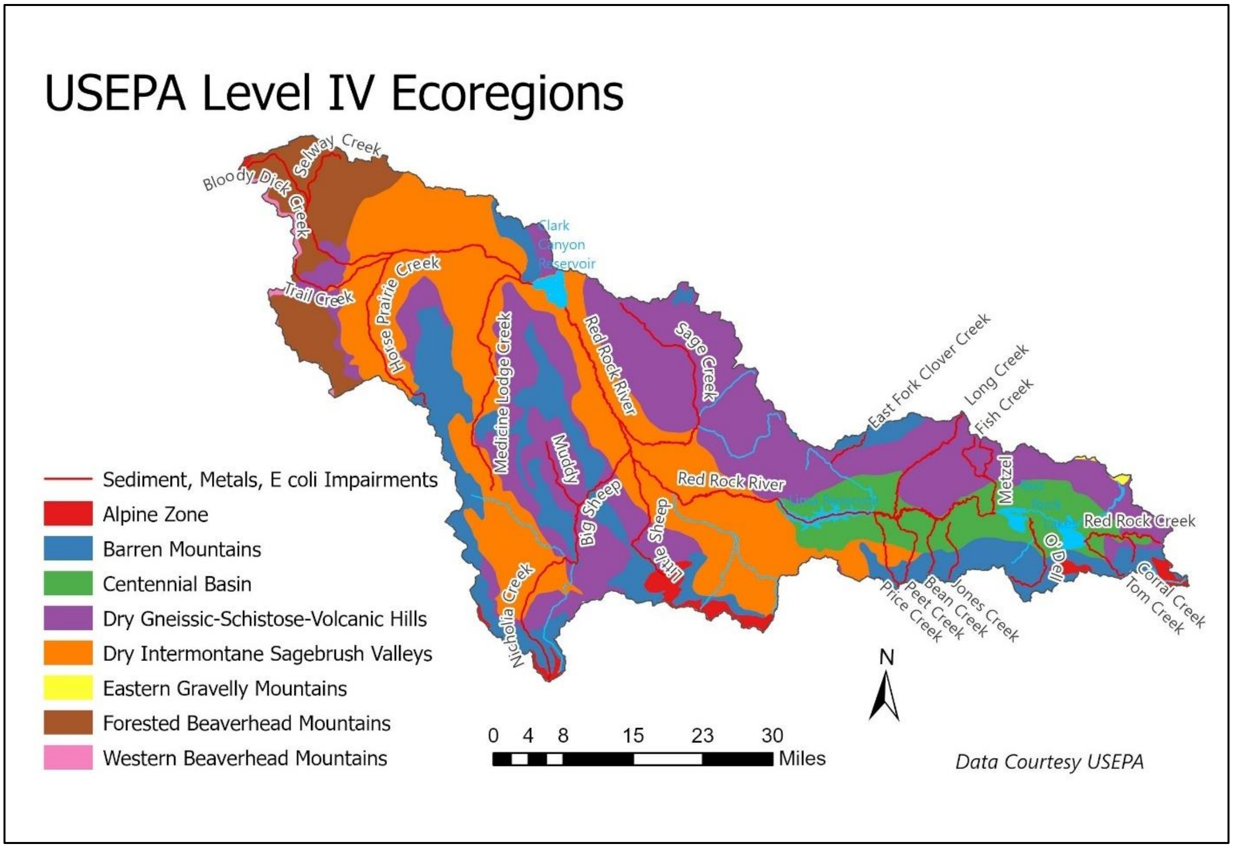

Figure 2-7. Level IV Ecoregions in the Red Rock TMDL Planning Area

2.2.2 Land Cover

Historic land uses included mining, timber harvest, fur trapping and agriculture, the latter of which consists primarily of ranching. A large portion of the watershed is used for agriculture, primarily as rangeland. Current land use in the watershed is dominated by cattle production, and to a less significant degree grain cropping. Other land uses in the basin are recreation, and to a limited degree logging and mining. The most intensive recreation use is Red Rock Lakes National Wildlife refuge. There are no maintained trails in the refuge and access to some areas is prohibited during certain times of the year. The refuge is staffed year-round but accessibility to the refuge in the winter is often difficult.

The lowland areas are dominated by sagebrush and shrubland and steppe, and the upland areas are covered with evergreen forest. Land cover is mapped below in **Figure 2-8**, based on the 2017 version of a map developed by the Montana Heritage Program: https://mslservices.mt.gov/Geographic_Information/Data/DataList/datalist_Details.aspx?did={B24A26F3-0BAD-42FC-858A-426FD5DF1063}.

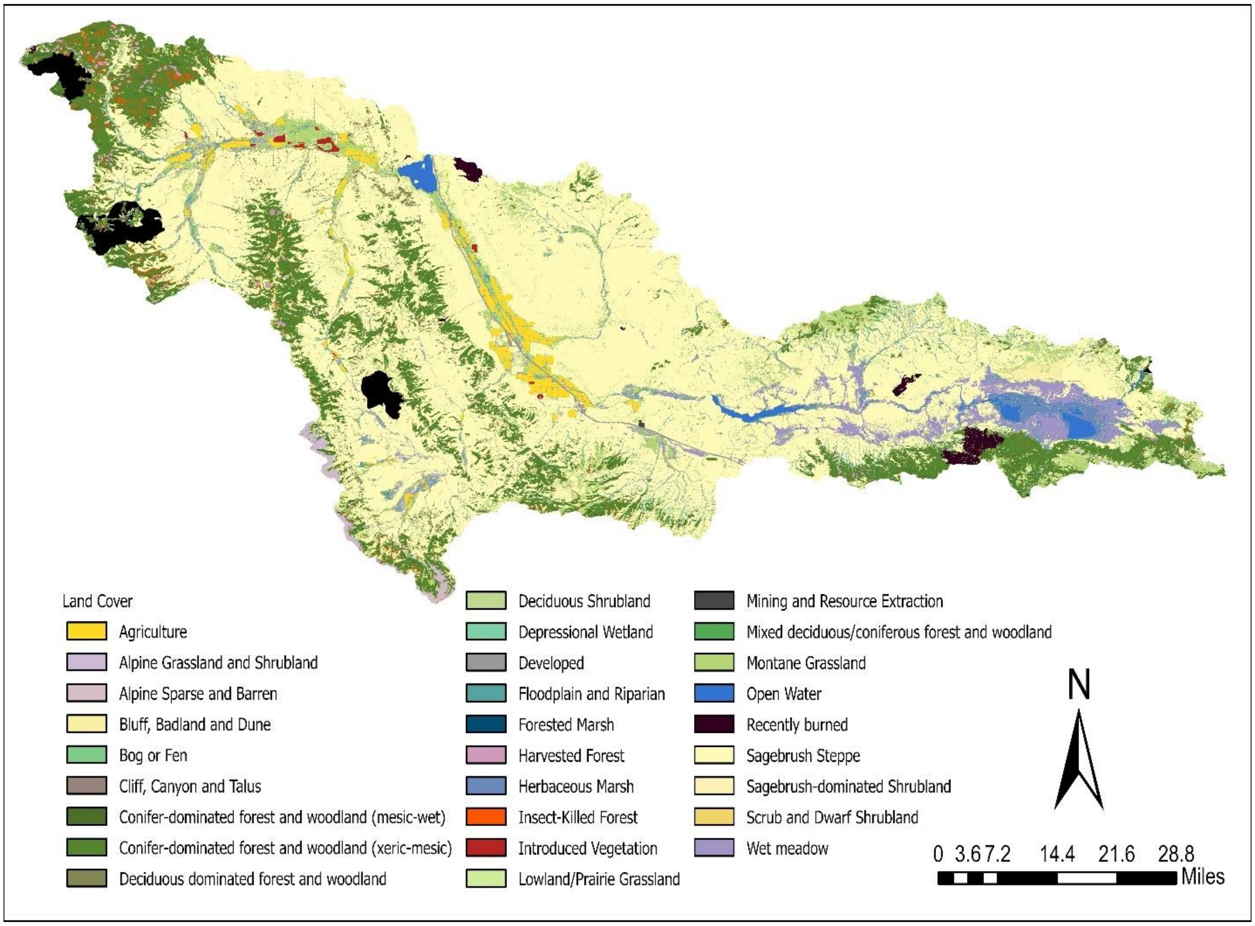

Figure 2-8. Land Cover in the Red Rock TMDL Planning Area

2.2.3 Fire History

The TPA experienced relatively large fire years in 2020, and 2003. In 2020 approximately 18,300 acres burned and in 2003 approximately 14,500 acres burned. The largest of the 2020 fires was the 12,000 acres Bear Creek Fire, and the largest of the 2003 fires was the 9,500 acres Winslow Fire.

Three large fires occurred in 2018 or 2020. These and other fires acres are shown in **Figure 2-9.**

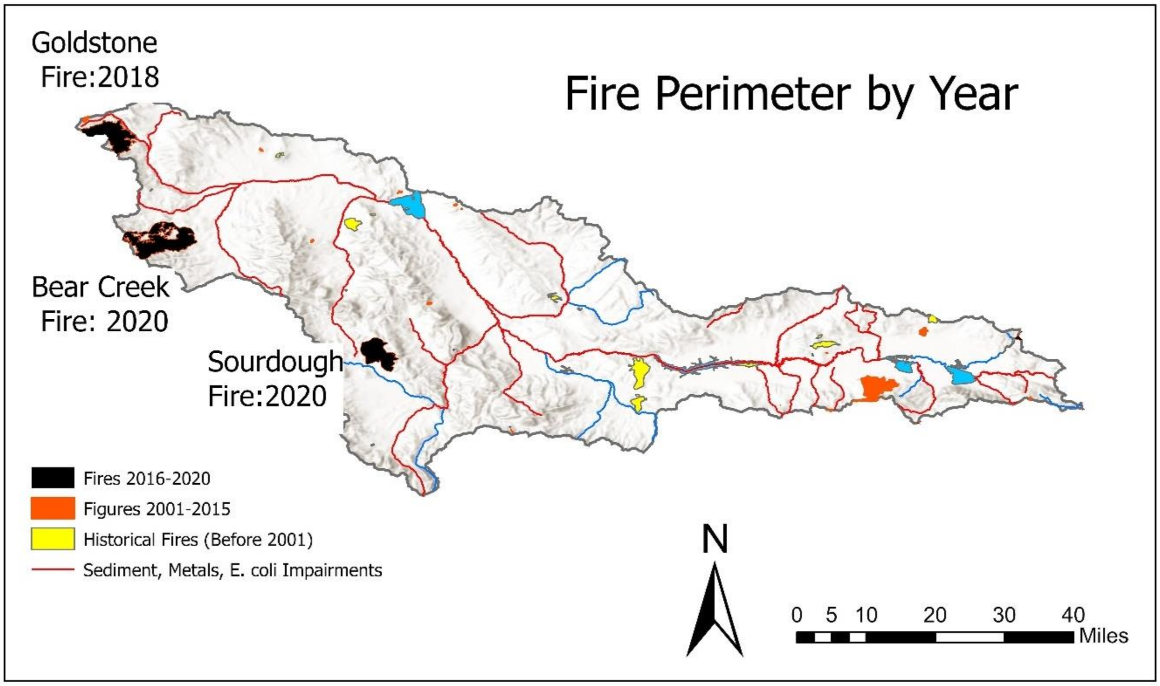

Figure 2-9. Fire History (1987-2020) of the Red Rock TMDL Planning Area

2.2.4 Fish Distribution

Montana Fish, Wildlife and Parks reports Westslope cutthroat trout in the TPA, generally in upland tributary streams. Yellowstone cutthroat trout have been reported in tributaries to the Red Rock Lakes and in Lima Reservoir. Artic Grayling have been reported in Red Rock Lakes, tributaries to the Red Rock Lakes and the main stem of the Red Rock River downstream of Red Rock Lakes. Fish distribution is shown on in **Figure 2-10.**

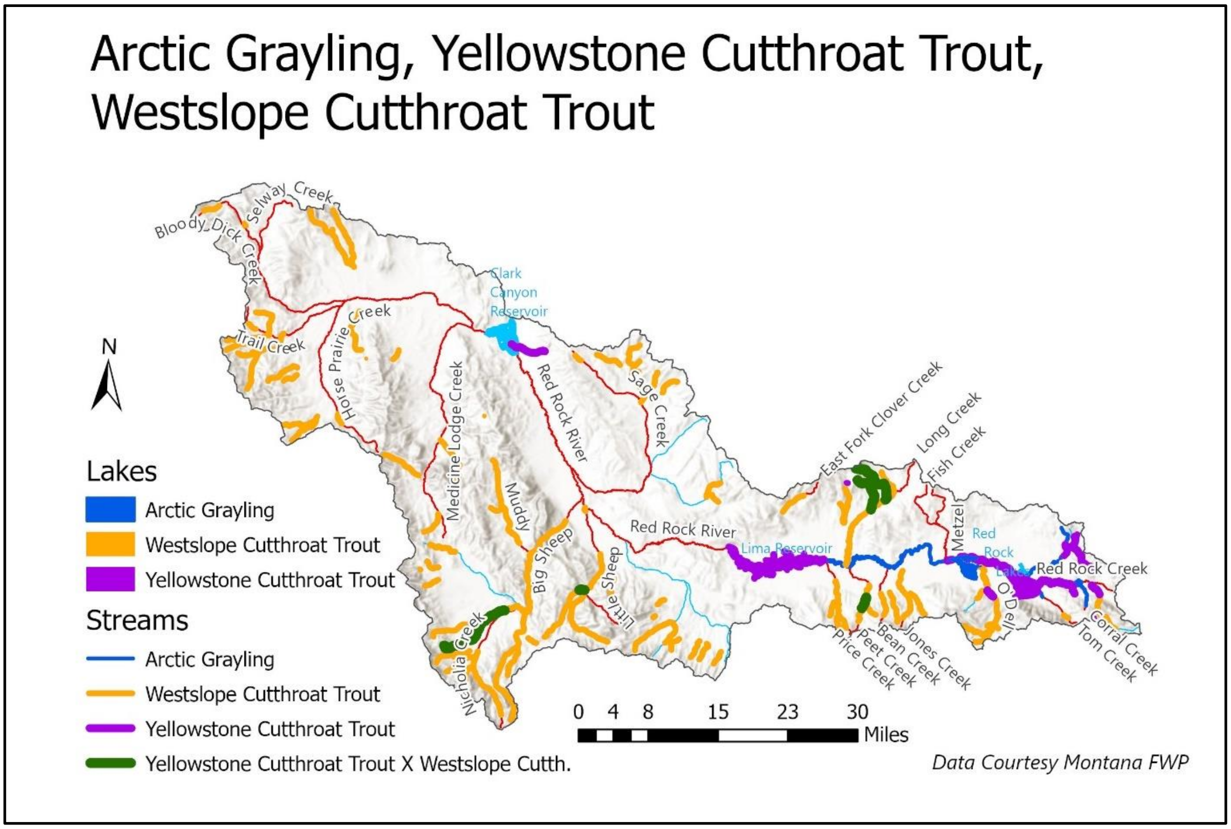

Figure 2-10. Westslope Cutthroat Trout, Yellowstone Cutthroat Trout, and Arctic Grayling Distribution in the Red Rock TMDL Planning Area

2.3 Social Profile

The following section describes the human geography of the TPA. This includes population distribution, land management, land ownership and agriculture land use.

2.3.1 Population Density

As of the 2020 census, approximately 9,450 people resided in Beaverhead County (**Figure 2-11**). Lima is the largest town in the Red Rock Watershed. As of the 2020 census, the population of Lima was 221. Major transportation corridors in the TPA include Interstate 15 and Highway 324.

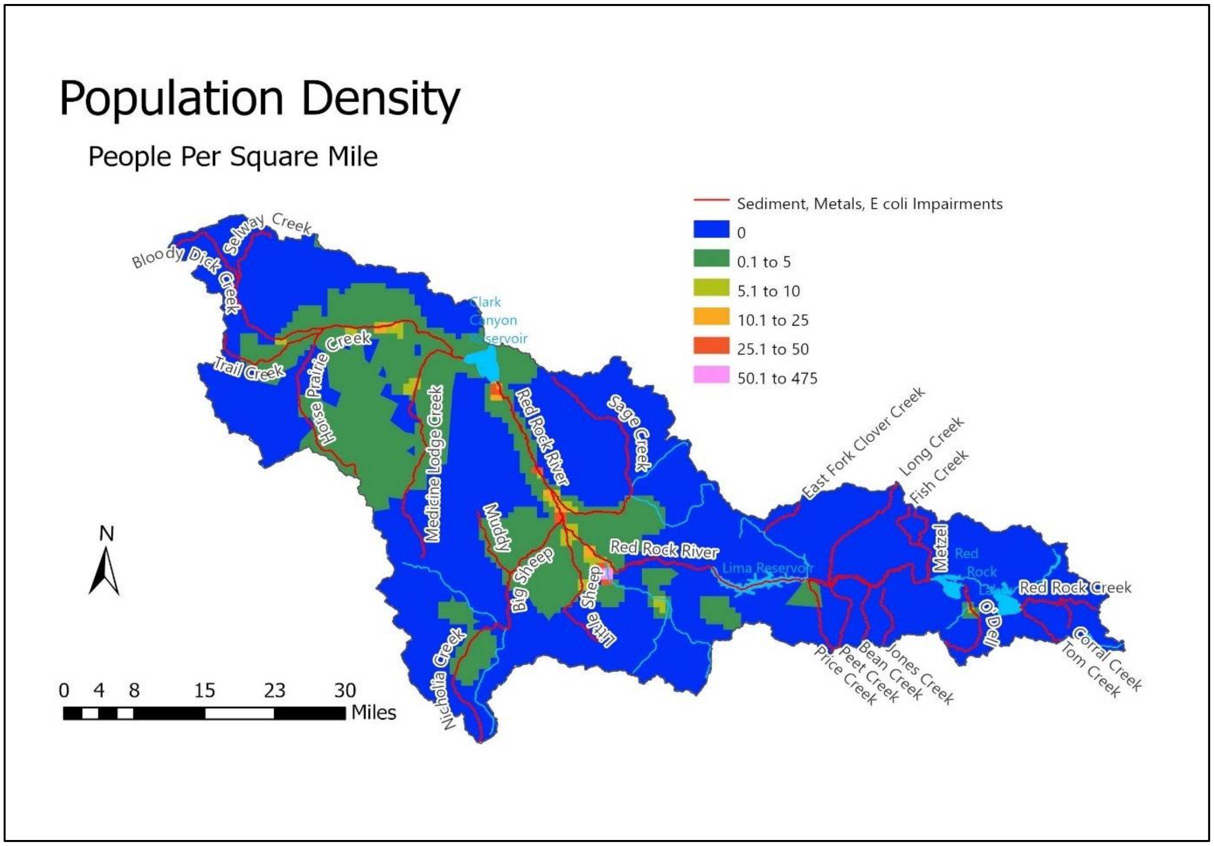

Figure 2-11. Population Density in the Red Rock TMDL Planning Area

2.3.2 Land Management

Roughly 58% of the TPA is under federal management (28% BLM, 26% USFS, 3% USFWS, 1% USDS and 0.2 % Bureau of Reclamation,) 12% is state lands, about 29% is in private ownership and less than 1 % is in local government ownership (**Figure 2-12**). In general, USFS lands occupy the higher, timbered areas, and the lower elevations are mostly private lands with some BLM and State Trust Lands. The US Bureau of Reclamation owns and manages the Clark Canyon Reservoir.

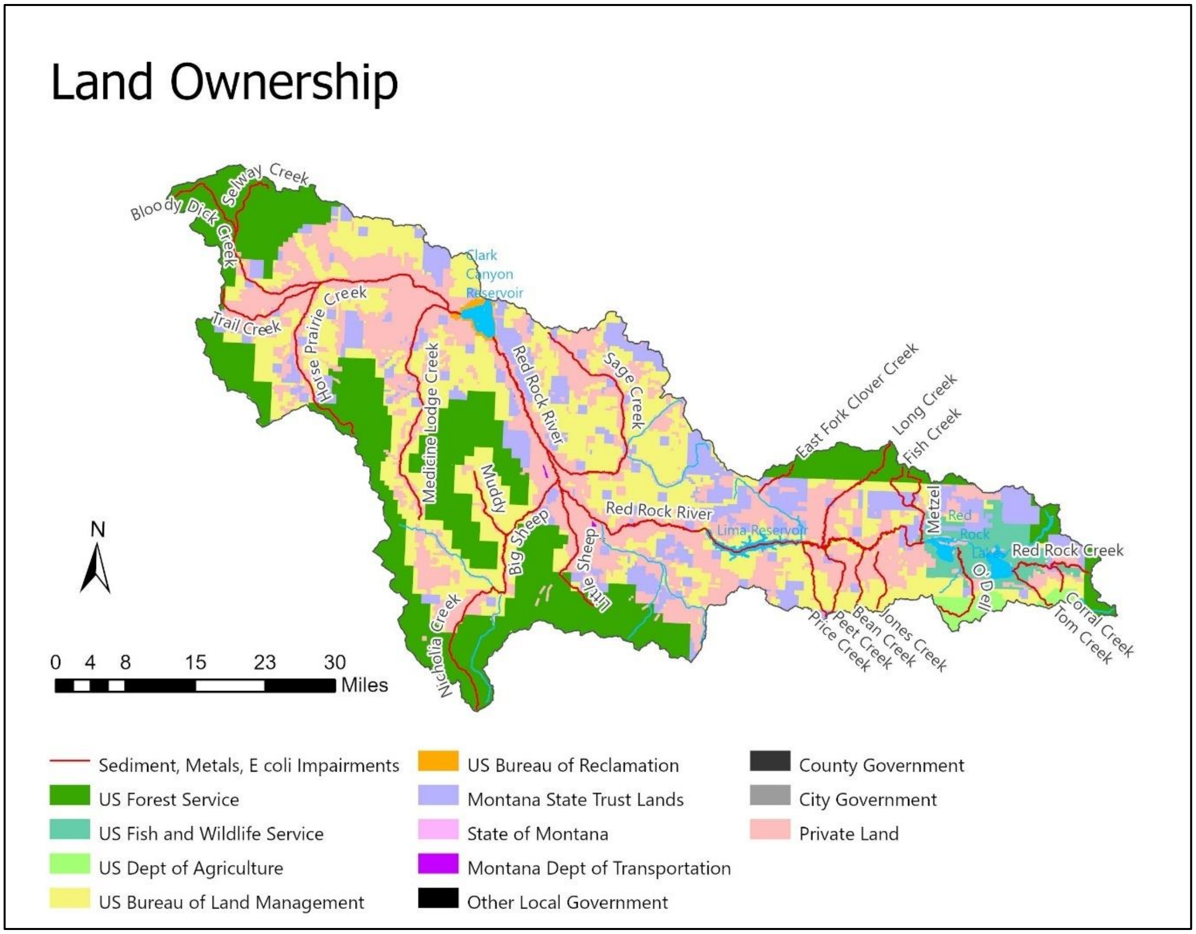

Figure 2-12. Land Management in the Red Rock TMDL Planning Area

2.3.3 Agricultural Land Use

Irrigated lands are present in the watershed, using both flood irrigation and pivot irrigation methods and to a limited degree sprinkler irrigation (**Figure 2-13**). This map is based on the Department of Revenue's 2019 Final Land Classification, which is used for land valuation. In early 2009, all agriculture producers who own private parcels in the state were mailed maps of their parcels in agriculture or forestry use with instructions to return maps that were incorrectly classified. Department of Revenue technicians updated the database based on the feedback from landowners. Since 2010 the data continues to be actively updated on a yearly basis using the most current imagery available and/or per land classification change requests from landowners and county agricultural and forest appraisal staff.

Grazing is common on both private lands and public lands. BLM and USFS grazing allotments shown on the map total 703,347 and 392,555 acres, respectively (**Figure 2-14**). Private grazing operations are not specifically identified; however, much of the uncolored area on the map includes private land where grazing occurs.

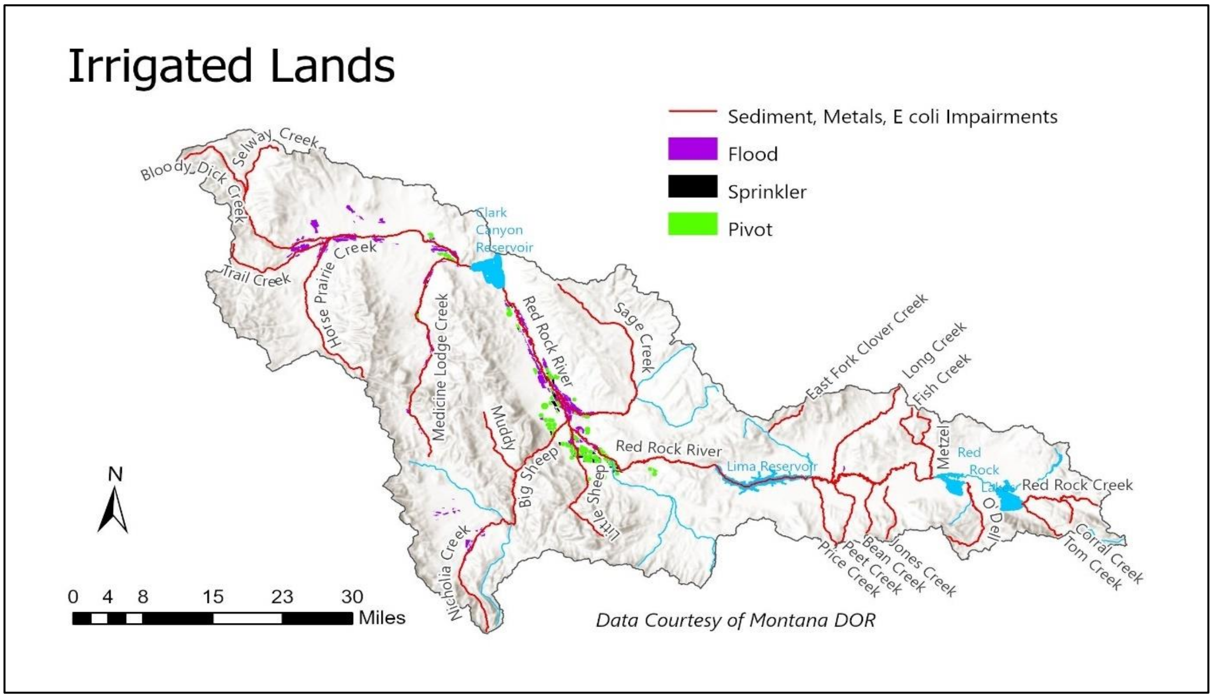

Figure 2-13. Irrigated Lands in the Red Rock TMDL Planning Area

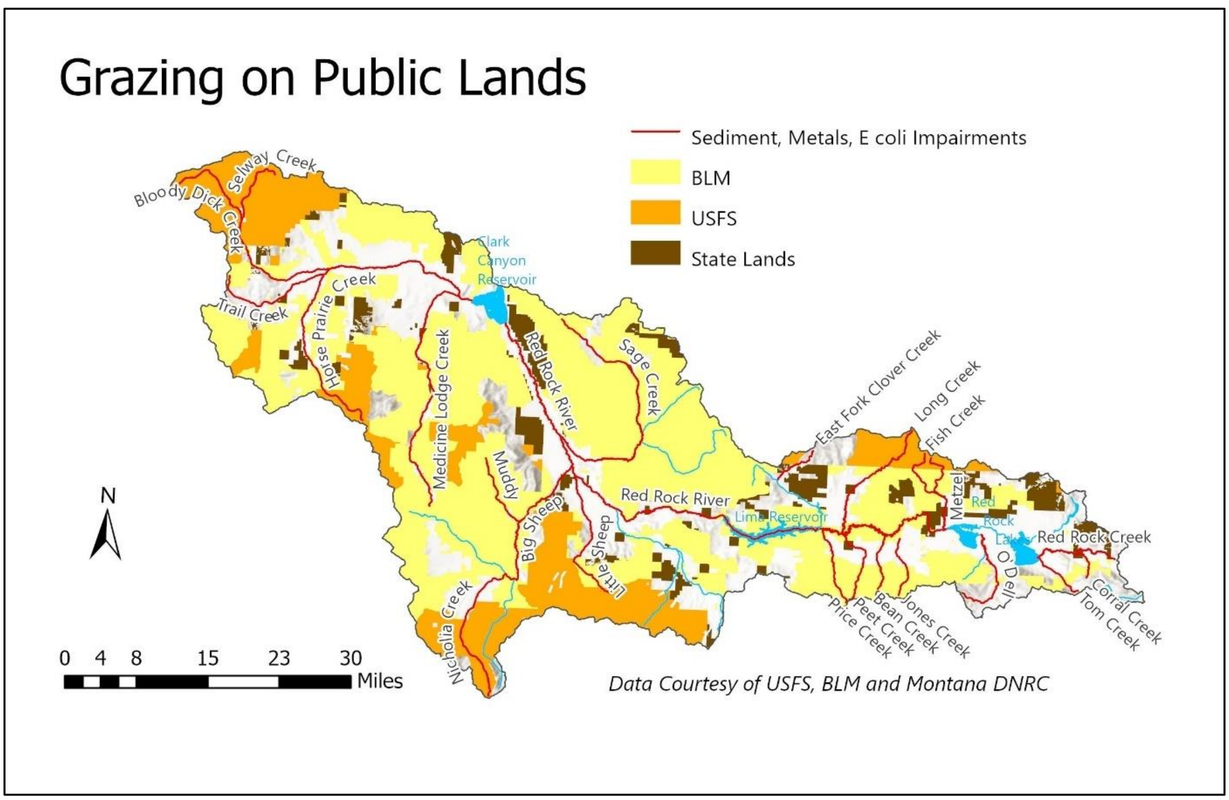

Figure 2-14. Grazing Activity in the Red Rock TMDL Planning Area

2.3.4 Wastewater Discharges

Sources of pollution originating from a point source wastewater discharge are permitted and regulated through the Montana Pollutant Discharge Elimination System (MPDES) administered by Montana DEQ. The goal of the MPDES program is to control point source discharges of wastewater such that water quality in state surface water is protected. Levels of water quality that are required to maintain the various beneficial uses of state surface waters are set forth in the state's water quality standards. There are two types of discharge permits: general and individual. There are currently no MPDES-permitted wastewater discharges in the Red Rock TPA.

A MPDES General Permit is a permit for wastewater discharges associated with common activities, such as concentrated animal feeding operations and storm water discharges from construction or industrial activity. Authorizations for General Permits are issued if a facility or activity falls within the guidelines of the existing permit. Individual MPDES Permits regulate wastewater discharges from point sources that do not fall under the guidelines for a General Permit. The individual permitting process is more rigorous, as individual permits address the specific conditions of the facility or activity needing authorization.
All point sources of wastewater discharge are required to obtain and comply with MPDES permits. The effluent limitations and other conditions for certain categories of wastewaters are required to be treated to federally-specified minimum levels based on available and achievable water treatment technologies. Additionally, effluent limits and permit conditions are established to protect beneficial uses and applicable water quality standards.

Each MPDES permit issued is designed to protect the state surface water quality at the point of discharge. In addition, recognizing the dynamic nature of streams and the potential additive or cumulative effects of pollutants, MPDES permits also address stream reach or basin-wide pollution problems. If a TMDL has been developed for a waterbody, any wasteload allocations (WLAs) are incorporated into the applicable MPDES permits with discharges into that waterbody.

3.0 Montana Water Quality Standards

The Montana Water Quality Act provides for the restoration and maintenance of the chemical, physical, and biological integrity of the state's surface waters so that they support all designated uses. Water quality standards are used to determine impairment, establish water quality targets, and to formulate the TMDLs and allocations.

Montana's water quality standards, and water quality standards in general, include three main parts:

1. Stream classifications and designated uses
2. Numeric and narrative water quality criteria designed to protect designated uses
3. Nondegradation provisions

Montana's water quality standards also incorporate prohibitions against water quality degradation as well as point source permitting and other water quality protection requirements.

Those water quality standards that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards may be found in the Montana Water Quality Act (75-5-301,302 Montana Code Annotated (MCA)), Montana's Surface Water Quality Standards and Procedures (Administrative Rules of Montana (ARM) 17.30.601-670), and **Appendix A**, Regulatory Framework and Reference Condition Approach.

3.1 Stream Classifications and Designated Beneficial Uses

Stream classification is the assignment (designation) of a single group of uses to a waterbody based on the potential of the waterbody to support those uses. Designated uses, or beneficial uses, are simple narrative descriptions of water quality expectations or water quality goals. Montana waters are classified for multiple uses. All streams and lakes within the Red Rock River TMDL Planning Area are classified as B-1 (ARM 17.30.623). In accordance with ARM 17.30.623, waters classified as B-1 are to be maintained suitable for:

- Culinary and food processing purposes after conventional treatment (Drinking Water)
- Bathing, swimming, and recreation (Primary Contact Recreation)
- Growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers (Aquatic Life)
- Agricultural and industrial water supply

While a waterbody might not actually be used for a designated use (e.g., drinking water supply), its water quality still must be maintained suitable for that designated use. More detailed descriptions of Montana's surface water classifications and designated uses are provided in **Appendix A**. DEQ's water quality assessment methods are designed to evaluate the most sensitive uses for each pollutant group addressed within this document, thus ensuring protection of all designated uses (DEQ 2011). For streams in Western Montana, the most sensitive use assessed for sediment and temperature is aquatic life. Based on DEQ's recent water quality assessment of segments in the Red Rock TPA during 2017 and 2018, DEQ determined that 22 waterbody segments in the Red Rock TMDL Planning Area do not meet the metals, sediment, and/or *E. coli* water quality standards (**Table 3-1**).

It is important to note that waterbodies monitored by Montana DEQ are assigned an assessment unit (**Table 3-1**). Assessment units can be the full length of a stream, the full extent of a lake or reservoir, or they may be a portion of a lake or of a stream (a stream segment). Streams may be broken into individual segments, determined by a variety of factors such as stream length for very long streams, or lakes may be broken by ownership boundaries (tribal versus state, for example).

Table 3-1. Impaired Waterbodies in the Red Rock TMDL Planning Area with TMDLs Contains in this Document

Waterbody (Assessment Unit)	Assessment Unit ID	Impairment Cause[1]	Impaired Use
Bean Creek, Headwaters to mouth (Red Rock River)	MT41A004_140	Sediment	Aquatic Life
Big Sheep Creek, Headwaters to mouth (Red Rock River)	MT41A003_150	Sediment	Aquatic Life
Bloody Dick Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_100	Metals	Aquatic Life
Corral Creek, Headwaters to mouth (Red Rock Creek)	MT41A004_040	Sediment	Aquatic Life
East Fork Clover Creek, Headwaters to mouth (Clover Creek)	MT41A004_050	Sediment	Aquatic Life
Fish Creek, Headwaters to mouth (Metzel Creek)	MT41A004_030	Metals	Aquatic Life
		Sediment	Aquatic Life
Horse Prairie Creek, Headwaters to mouth (Clark Canyon Reservoir)	MT41A003_090	Sediment	Aquatic LIfe
		Pathogens	
Jones Creek, Headwaters to mouth (Winslow Creek)	MT41A004_130	Sediment	Aquatic LIfe
Little Sheep Creek, Headwaters to mouth (Red Rock River)	MT41A003_160	Metals	Aquatic LIfe
Long Creek, Headwaters to mouth (Red Rock River)	MT41A004_070	Sediment	Aquatic LIfe
Medicine Lodge Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_010	Metals	Aquatic Life
		Pathogens	
		Sediment	
Metzel Creek, Headwaters to mouth (Red Rock River)	MT41A004_020	Metals	Aquatic Life
Muddy Creek, Confluence Sourdough and Wilson Creek to mouth (Big Sheep Creek)	MT41A003_020	Metals	Aquatic Life
		Sediment	Aquatic Life
O'Dell Creek, Headwaters to mouth (Lower Red Rock Lake)	MT41A004_080	Sediment	Aquatic Life

Table 3-1. Impaired Waterbodies in the Red Rock TMDL Planning Area with TMDLs Contains in this Document

Waterbody (Assessment Unit)	Assessment Unit ID	Impairment Cause[1]	Impaired Use
Peet Creek, Headwaters to mouth (Red Rock River)	MT41A004_090	Metals	Aquatic Life
		Sediment	Aquatic Life
		Pathogens	Aquatic Life
Price Creek, Headwaters to mouth (Red Rock River)	MT41A004_010	Metals	Aquatic Life
		Sediment	Aquatic Life
Red Rock Creek, Headwaters to mouth (Upper Red Rock Lake)	MT41A004_110	Sediment	Aquatic Life
Red Rock River, Lower Red Rock Lake to Lima Dam	MT41A001_020	Pathogens	Aquatic Life
Sage Creek, Headwaters to mouth (Red Rock River)	MT41A003_140	Sediment	Aquatic Life
Selway Creek, Headwaters to mouth (Bloody Dick Creek)	MT41A003_110	Sediment	Aquatic Life
Tom Creek, Headwaters to mouth (Upper Red Rock Lake)	MT41A004_100	Sediment	Aquatic Life
Trail Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_080	Metals	Aquatic Life
		Sediment	Aquatic Life

[1]Only includes those impairment causes addressed by TMDLs in this document

3.2 Numeric and Narrative Water Quality Standards

Montana's water quality standards include numeric and narrative criteria that protect the designated uses described above. Numeric standards define the allowable concentrations, frequency, and duration of specific pollutants so as not to impair designated uses.

Numeric standards apply to pollutants that are known to have adverse effects on human health, aquatic life, or other beneficial uses of water (e.g., metals, nutrients, *E. coli*, organic chemicals, and other toxic constituents). Narrative standards are developed when there is insufficient information to develop numeric standards and/or the natural variability makes it impractical to develop numeric standards. Narrative standards describe the allowable or desired condition and are also designed to protect the designated beneficial uses. This condition is often defined as an allowable increase above "naturally occurring." DEQ often uses the naturally occurring condition, called a "reference condition," to help determine whether or not narrative standards are being met (see **Appendix A**). For sediment and temperature TMDL development in the Red Rock TMDL Planning Area, only narrative standards are applicable; they are summarized in **Appendix A**.

3.3 Nondegradation Provisions

Nondegradation is addressed via the Nondegradation Policy within Montana state statute (75-5-303, MCA) and via Montana's nondegradation rules (ARM 17.30.7). The Nondegradation Policy states that existing uses of state waters and the level of water quality necessary to protect those uses must be maintained and protected. Montana nondegradation rules apply to any new or increased point or nonpoint source resulting in a change of existing water quality occurring on or after April 29, 1993 (ARM 17.30.702).

4.0 Defining TMDLs and Their Components

A total maximum daily load (TMDL) is a tool for implementing water quality standards and is based on the relationship between pollutant sources and water quality conditions. More specifically, a TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive from all sources and still meet water quality standards. The ultimate goal of the TMDL is to identify an approach to achieve and maintain water quality standards.

Pollutant sources are generally defined as two categories: point sources and nonpoint sources. Point sources are often linked to community wastewater treatment or industrial facilities with discernible, confined and discrete conveyances, such as pipes or ditches from which pollutants are being, or may be, discharged to a waterbody. Some sources such as return flows from irrigated agriculture are not included in this definition. Pollutant loading sources that do not meet the definition of a point source are considered nonpoint sources. Nonpoint sources are associated with diffuse pollutant loading to a waterbody and are often linked to runoff from agricultural, urban, or forestry activities, as well as streambank erosion and groundwater seepage that can occur from these activities. Natural background loading and atmospheric deposition are both considered types of nonpoint sources.

As part of TMDL development, the allowable load is divided among all significant contributing point and nonpoint sources. For point sources, the allocated loads are called “wasteload allocations” (WLAs). For nonpoint sources, the allocated loads are called “load allocations” (LAs).

A TMDL is expressed by the equation: TMDL = ΣWLA + ΣLA + MOS, where:

ΣWLA is the sum of the wasteload allocation(s) (point sources)
ΣLA is the sum of the load allocation(s) (nonpoint sources)
MOS = margin of safety

TMDL development must include a margin of safety (MOS), which can be explicitly incorporated into the above equation as shown. Alternatively, the MOS can be implicit in the TMDL, meaning that the explicit MOS in the above equation is equal to zero and can therefore be removed from the above equation. A TMDL must also ensure that the waterbody will be able to meet and maintain water quality standards for all applicable seasonal variations (e.g., changes in pollutant loading during the year, or seasonal water quality standards).

Development of each TMDL has four major components:

- Determining water quality targets
- Quantifying pollutant sources
- Establishing the total allowable pollutant load
- Allocating the total allowable pollutant load to their sources

Although the way a TMDL is expressed can vary by pollutant, these four components are common to all TMDLs, regardless of pollutant. Each component is described in further detail in the following subsections.

Figure 4-1 illustrates how numerous sources contribute to the existing load and how the TMDL is defined. The existing load can be compared to the allowable load to determine the amount of pollutant reduction needed.

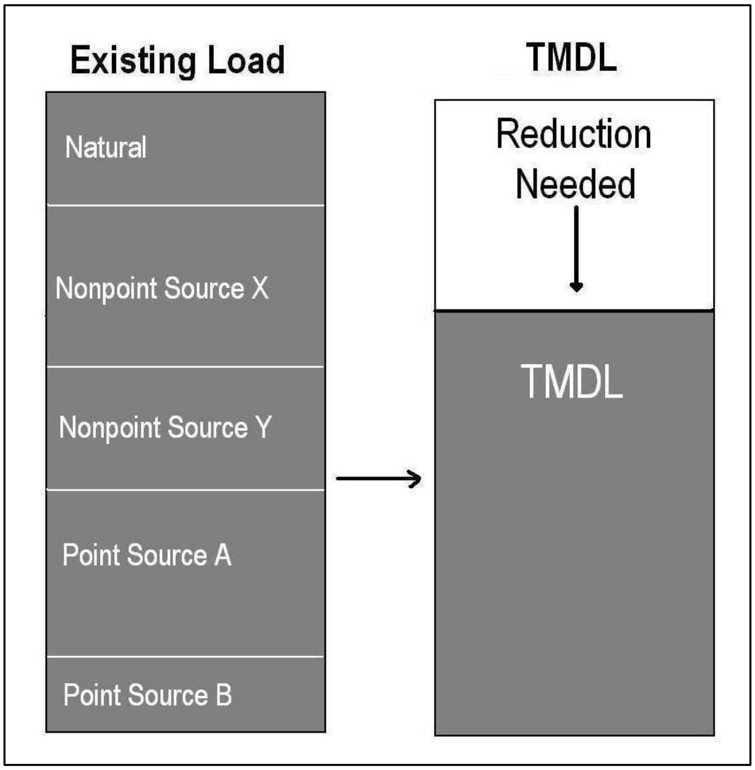

Figure 4-1: Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

For each pollutant, TMDL water quality targets are applied to one or more parameters that link directly to the impaired beneficial use(s) and applicable water quality standard(s). For pollutants with established numeric water quality standards, the numeric value(s) are used as the TMDL targets. For pollutants with narrative water quality standard(s), the targets provide a translation of how the narrative standard(s) applies to the waterbody. Comparing existing stream conditions to target values allows for a better understanding of the extent and severity of the problem.

4.2 Quantifying Pollutant Sources

The goal of TMDL source assessment is to identify all significant pollutant loading sources, including natural background loading, and quantify them so that the relative pollutant contributions can be determined. Because the effects of pollutants on water quality can vary throughout the year, assessing pollutant sources includes an evaluation of the seasonal variability of the pollutant loading. The source assessment helps to define the extent of the problem by linking the pollutant load to specific sources in the watershed.

Source assessments are conducted on a watershed scale and can vary in level of detail resulting in reasonably accurate estimates or gross allotments, depending on the data availability and the techniques used for predicting the loading (40 CFR 130.2(i)). Montana TMDL development often includes a combination of approaches, depending on the level of desired certainty for setting allocations and guiding implementation activities.

Nonpoint sources are quantified by source categories (e.g., eroding streambanks or unpaved roads) and/or by land uses (e.g., crop production or forestry). These source categories and land uses can be divided further by ownership, such as federal, state, or private. Alternatively, most, or all, nonpoint pollutant sources in a sub-watershed or source area can be combined for quantification and TMDL load allocation purposes.

Pollutant loading is typically quantified for each individual surface water point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Through MPDES permit requirements, point source dischargers provide discharge and other information that can be used for source assessment purposes. The allowable loading within each MPDES surface water permit condition must be consistent with the assumptions and requirements of the available WLA developed within the TMDL (40 CFR 122.44).

4.3 Establishing the Total Allowable Load

TMDL development requires a determination of the total allowable load over the appropriate time period necessary to comply with the applicable water quality standard(s). Per EPA requirements (40 CFR 130.2), "TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure." Where a stream is impaired by a pollutant for which numeric water quality criteria exist, the TMDL, or allowable load, is typically calculated as a function of streamflow and the numeric criteria. This results in a mass per unit time TMDL expression such as pounds per day. This same approach can be applied when a numeric target is developed to interpret a narrative standard.

Although a "TMDL" is specifically defined as a "daily load," determining a daily load may not be consistent with the applicable water quality standard(s), or may not be practical from a water quality management perspective. Therefore, the TMDL will ultimately be defined as the total allowable loading during a time period that is appropriate for applying the water quality standard(s) and which is consistent with established approaches to properly characterize, quantify, and manage pollutant sources in a given watershed. For example, sediment TMDLs may be expressed as an allowable annual load.

Some narrative standards, such as those for sediment, often have a suite of targets. In many of these situations it is difficult to link the desired target values to highly variable, and often episodic, instream loading conditions. In such cases the TMDL is often expressed as a percent reduction in total loading based on source quantification results and an evaluation of load reduction potential (**Figure 4-1**). The degree by which existing conditions exceed desired target values can also be used to justify a percent reduction value for a TMDL.

Even if the TMDL is preferably expressed using a time period other than daily, an allowable daily loading rate will also be calculated to meet specific requirements of the federal Clean Water Act. Where this occurs, TMDL implementation and the development of allocations will still be based on the preferred time period, as noted above.

4.4 Determining Pollutant Allocations

Once the allowable load (the TMDL) is determined, that total must be divided among the contributing sources so that the sum of the allocations is equal to the TMDL, consistent with the above TMDL equation. For sediment, the allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices (BMPs) and other reasonable conservation practices. Where a TMDL is variable based on streamflow, nonpoint source load allocations are often variable based on this same receiving streamflow. On the other hand, point source wasteload allocations are often based on conservative streamflow and discharge conditions and/or can be variable based on the point source discharge flow and a discharge concentration limit. Where the TMDL is a function of streamflow, the TMDL and allocations are calculated for example high and low flow stream conditions.

Figure 4-2 illustrates how the TMDL is allocated to different sources using WLAs for point sources and load allocations (LA) for natural and nonpoint sources. Although some flexibility in allocations is possible, the sum of all allocations must meet the TMDL for all segments of the waterbody. **Figure 4-2** shows multiple point and nonpoint source allocations. In Montana, nonpoint source allocations are sometimes grouped into one composite allocation. This composite load allocation approach is applied in cases where data is limited, there is significant source assessment uncertainty, and/or DEQ has determined that the best approach is to provide stakeholders with flexibility in addressing sources, allowing them to choose where to focus on improved land management practices and other remediation or restoration efforts.

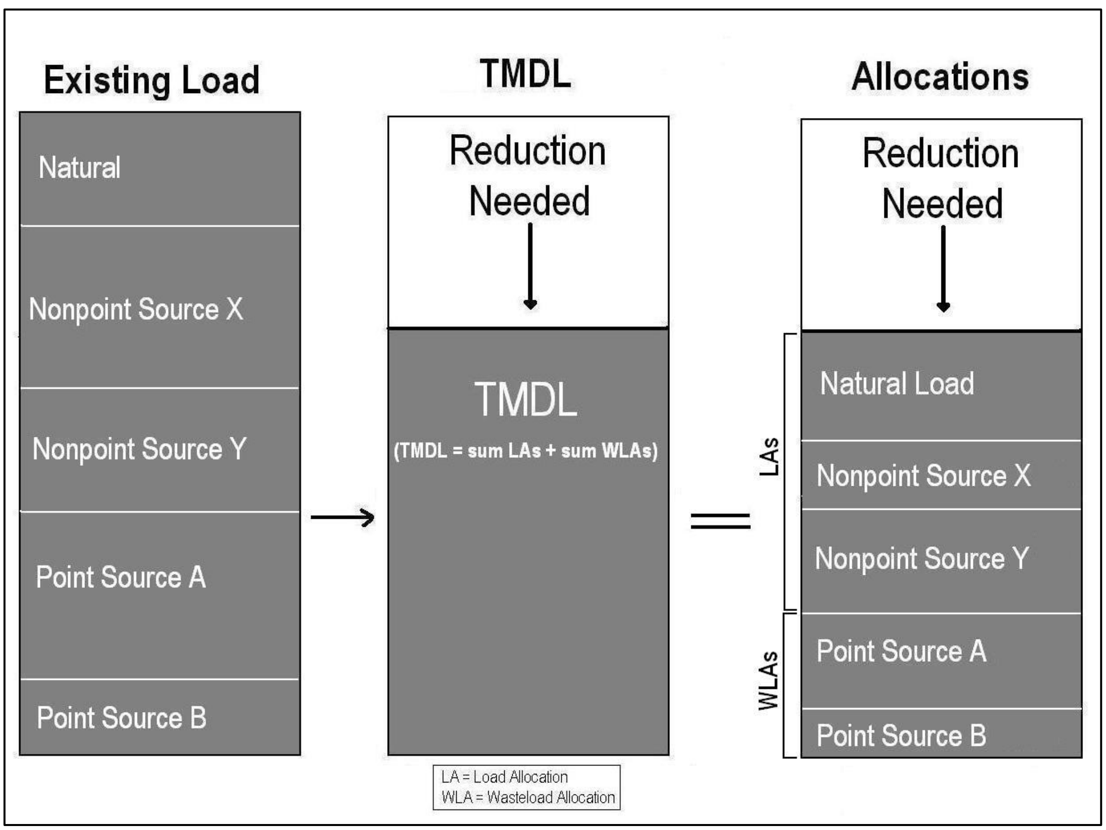

Figure 4.2: Schematic Diagram of a TMDL and its Allocations

4.5 Implementing TMDL Allocations

Montana law (Section 75-5-703, MCA of the Montana Water Quality Act) requires that wasteload allocations be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Per federal regulation (40 CFR 122.44), the discharge permit effluent limits must be consistent with the assumptions and requirements of the available WLA developed within the TMDL.

Because of limited state and federal regulatory requirements, nonpoint source reductions linked to LAs are implemented primarily through voluntary measures, although there are some important nonpoint source regulatory requirements, such as Montana streamside management zone law and applicable septic system requirements.

This document contains several key components to assist stakeholders in implementing nonpoint source controls. **Section 10** provides a water quality improvement plan that discusses restoration strategies by pollutant group and source category, and provides recommended BMPs per source category (e.g., grazing, cropland, urban, etc.). **Section 10.7** discusses potential funding sources that stakeholders can use to implement best management practices (BMPs) for nonpoint sources. Other site-specific pollutant sources are discussed throughout the document, and can be used to target implementation activities. DEQ's Nonpoint Source Program helps to coordinate water quality improvement projects for nonpoint sources of pollution throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (DEQ 2017) further discusses nonpoint source implementation strategies at the state level.

DEQ uses an adaptive management approach to implementing TMDLs to ensure that water quality standards are met over time (outlined in **Section 10.0**). This includes a monitoring strategy and an implementation review that is required by Montana statute (Section 75-5-703, MCA of the Montana Water Quality Act). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

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PART 2 TMDL COMPONENTS

5.0 Metals TMDL Components

This portion of the document focuses on metals as an identified cause of water quality impairment in the Red Rock TMDL Planning Area (TPA). It describes: (1) how excess metals impairs beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to metals impairments in the planning area, (4) the sources of metals based on recent studies, and (5) the metal TMDLs and their rationales.

5.1 Effects of Excess Metals on Beneficial Uses

Waterbodies with elevated metals concentrations can impair beneficial uses such as aquatic life, coldwater fisheries, and drinking water. Within aquatic ecosystems, elevated concentrations of metals can have a toxic, carcinogenic, or bio-concentrating effect on biota. Likewise, humans and wildlife can suffer acute and chronic effects from consuming water or fish with elevated metals concentrations. Because elevated metals concentrations can be toxic to plants and animals, high metals concentrations in irrigation or stock water may affect agricultural uses. Although arsenic and selenium are metalloids and nonmetals, they are treated as metals for TMDL development due to the similarity in sources, environmental effects, and restoration strategies.

5.2 Stream Segments of Concern

A total of ten waterbody segments in the Red Rock TPA are listed as impaired due to metals-related causes on the 2020 Montana 303(d) List (**Table 5-1**) (DEQ, 2020). Nine of these will be addressed in this document. A TMDL will not be completed for mercury in Horse Prairie Creek at this time. Additional data collection is needed to complete a mercury TMDL for Horse Prairie Creek. While Nicholia Creek was listed for Aluminum on the 2020 303(d) list, this listing was in error and will be removed from the 2020 list.

All ten metals-impaired streams are classified by DEQ as B-1. Waters classified as B-1 are to be maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply (Administrative Rules of Montana (ARM) 17.30.623(1)).

Metals-related 303(d) listings in the Red Rock TPA include arsenic, aluminum, cadmium, copper, iron, lead, mercury, and selenium (**Table 5-1**).

Table 5-1. Waterbody Segments with Metals Listings on the 2020 303(d) List

Waterbody (Assessment Unit)	**Assessment Unit ID**	**Metal Impairment Cause**
Bloody Dick Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_100	Aluminum, Lead
Fish Creek, Headwaters to mouth (Metzel Creek)	MT41A004_030	Aluminum
Horse Prairie Creek, * Headwaters to mouth (Clark Canyon Reservoir)	MT41A003_090	Mercury
Little Sheep Creek, Headwaters to mouth (Red Rock River)	MT41A003_160	Iron
Medicine Lodge Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_010	Iron
Metzel Creek, Headwaters to mouth (Red Rock River)	MT41A004_020	Arsenic
Muddy Creek, Confluence of Sourdough and Wilson Creek to mouth (Big Sheep Creek)	MT41A003_020	Arsenic, Iron
Nicholia Creek** Headwaters to mouth (Big Sheep Creek)	MT41A003_040	Aluminum
Peet Creek, Headwaters to mouth (Red Rock River)	MT41A004_090	Arsenic, Cadmium, Copper, Selenium
Price Creek, Headwaters to mouth (Red Rock River)	MT41A004_010	Arsenic
Trail Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_080	Aluminum

*A TMDL will not be developed at this time for Horse Prairie Creek due to a lack of data

**The listing for Nicholia Creek was in error and will be removed from the 2022 list; No TMDL will be developed

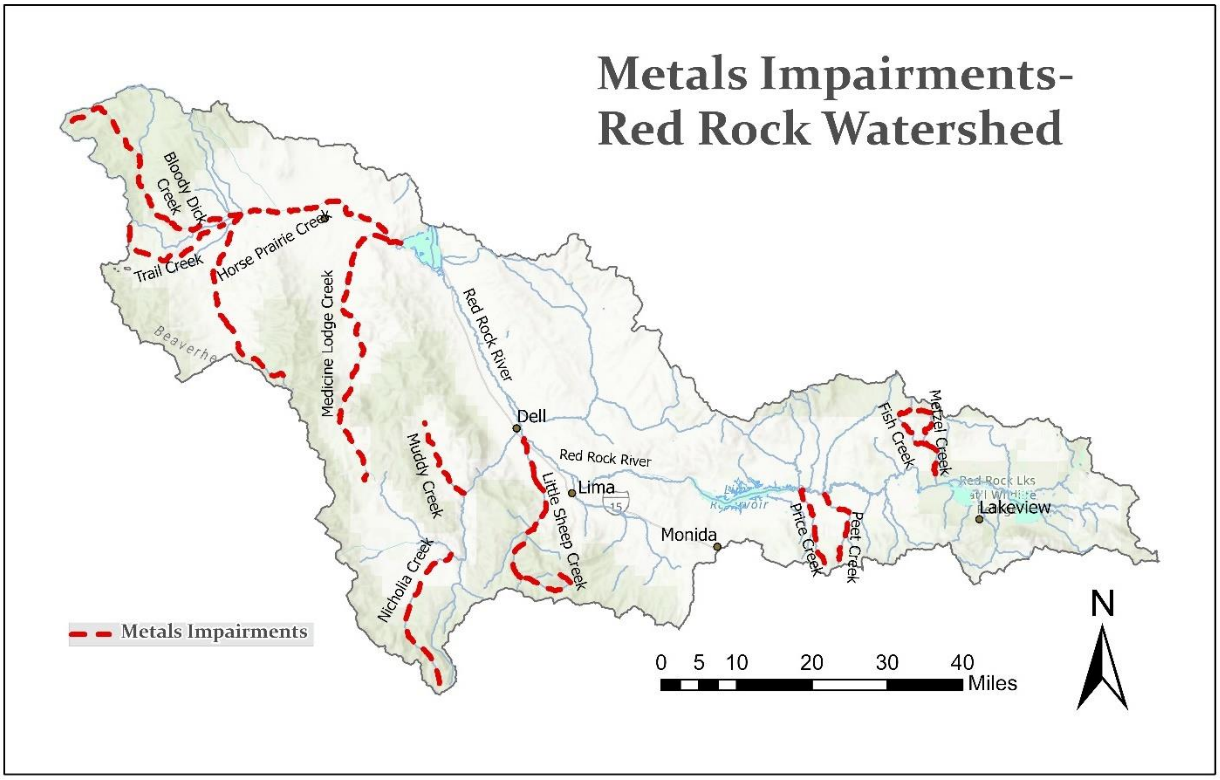

Figure 5-1. Waterbodies with a Metals Listing on the 2020 303(d) List

5.3 Water Quality Data and Information Sources

Water quality data used in TMDL development includes DEQ-collected between 2012 and 2019, available in the national Water Quality Portal (https://www.waterqualitydata.us/). **Table 5-2** provides a summary of data sources used in TMDL development. Summaries of this data are provided in **Sections 5.4.3.1** through **5.4.3.10** for each of the impaired waterbody segments. Water quality data used in developing the TMDLs can also be found in **Appendix B**.

Water quality data collected by DEQ were used to aid in the initial coarse level source assessment and to help determine sampling locations for additional data collection but are not used within this document in the existing data review due to potential data quality and reliability issues (e.g., reporting limits higher than water quality standards and uncertainty regarding collection, analysis and recording methods) and because conditions may have changed substantially since data collection.

GIS data used in development of this document included the DEQ Abandoned Hardrock Mines database, the DEQ Active Hardrock Mines records, the Montana Bureau of Mines and Geology (MBMG) Abandoned and Inactive Mines database, and the DEQ Opencut Mines records.

Table 5-2. Water Quality Data Evaluated for TMDL Development

Data Source and Data Year	Type of Data	Data Location
Montana DEQ 2012-2019	Water quality and metals sediment sampling for impairment determination and TMDL development	Water Quality Portal (https://www.waterqualitydata.us/)

5.4 Water Quality Data and Comparison to Targets

This section describes the available water quality data and how it was compiled and evaluated for attainment of water quality targets. It presents the evaluation framework, metals water quality targets used in the evaluation, and metals targets attainment evaluations for each impaired waterbody. I

5.4.1 Metals TMDL Evaluation Framework

Evaluating attainment of water quality standards for metals-related impairments, and subsequent determination of whether a TMDL is necessary for each waterbody segment involves three steps:

1. Development of numeric water quality targets that represent water quality conditions that are unimpaired for the pollutant of concern:
   A required component of TMDL plans is the establishment of numeric water quality criteria or *targets* that represent a condition that meets Montana's ambient water quality standards. Numeric targets are measurable water quality indicators that, either by themselves or in combination with others, reflect attainment of water quality criteria or represent a water quality condition that is unimpaired for the pollutant of concern. Metals water quality targets are presented in **Section 5.4.2**.

2. Comparison of existing data with water quality targets to evaluate water quality target attainment and, consequently, determine whether a TMDL is necessary:
   Attainment of water quality targets is evaluated by comparing existing water quality data and information to established metals water quality targets. Where exceedances of water quality targets are documented (i.e., the targets are not met), a TMDL is developed. If sufficient recent data indicate no impairment, the data is incorporated into 303(d) list files and the cause is either not listed or removed from the list (if already present). If there are no recent target exceedances, but there is insufficient data to fully evaluate all seasonal flow conditions, then an impairment determination cannot be made and TMDL development is not pursued.

3. Evaluation of metals sources:
   Sources of metals in a watershed are both natural and anthropogenic. During TMDL development, multiple records are consulted to identify potential sources. These primarily include the DEQ Abandoned Hardrock Mines database, the DEQ Active Hardrock Mines records, the Montana Bureau of Mines and Geology (MBMG) Abandoned and Inactive Mines database, the DEQ Opencut Mines records, and the Montana Point Sources Discharge Elimination System (MPDES) database. Historical records and other documentation from public agencies may be used. Professionals and citizens may be consulted to provide input on potential sources.

5.4.2 Metals Water Quality Targets

Water quality targets for metals-related impairments in the Red Rock TMDL Planning Area (TPA) consist of metals water quality targets (**Table 5-3**) and metals sediment quality targets (**Table 5-4**). Metals water quality targets are based on numeric acute and chronic metals water quality criteria for the protection of aquatic life and human health as defined in Circular DEQ-7 (Montana Department of Environmental Quality, 2019). The metals sediment quality targets are based on narrative criteria for toxins in sediment. Throughout this document, the terms “standard”, “criteria” and “target” are used somewhat interchangeably.

5.4.2.1 Metals Water Quality Criteria

Metals numeric water quality criteria include values for protecting human health and for protecting aquatic life and apply as water quality standards for the streams addressed within this section due to their B-1 classifications (**Section 3.0**). Aquatic life criteria include values for both acute and chronic effects. For any given pollutant, the most stringent of these criteria is adopted as the water quality target to protect all beneficial uses.

Hardness describes the amount of dissolved minerals in water. Typically, calcium and magnesium contribute the most to hardness. The higher the concentration of hardness-creating elements in rock and soils, the harder the water. Hardness is a natural component of water, but human activities such as lime from agricultural fields can also increase hardness. Hardness-creating elements are non-toxic but normally absorb into living organisms more easily than toxic metals. If the water has high hardness, the amount of toxic metals that are absorbed into animals is generally less. This explains why the toxicity of most metals increases with decreasing hardness.

Water quality criteria (Acute Aquatic Life (AAL), Chronic Aquatic Life (CAL), Human Health) for hardness-dependent parameters of concern (cadmium, copper, lead) are provided at water hardness values of 25 milligrams per liter (mg/L) and 100 mg/L, respectively, and are shown in **Table 5-3**. Relatively low concentrations of hardness-dependent metals are considered toxic at 25 mg/L while higher concentrations are considered toxic at the example concentration of 100 mg/L.

Values are also provided for parameters that are not hardness-dependent: aluminum, arsenic, iron, selenium, and mercury. These criteria translate into the applicable water quality targets and are expressed in micrograms per liter (µg/L), which is equivalent to parts per billion.

Acute and chronic toxicity aquatic life criteria are intended to protect aquatic life uses, while the human health criteria is intended to protect drinking water uses. Aluminum criteria is based on estimates of the dissolved concentration (D), whereas the other criteria are based on the total recoverable (TR) concentration.

The evaluation process summarized below is derived from DEQ’s assessment method for determining metals impairments:

- A waterbody is considered impaired if a single sample exceeds the human health target.
- If more than 10% of the samples exceed the Acute Aquatic Life or Chronic Aquatic Life target, then the waterbody is considered impaired for that pollutant.

- If both the AAL and CAL target exceedance rates are equal to or less than 10%, for a given metal, then it is not considered a cause of aquatic life impairment to the waterbody. A minimum of eight samples are required, and samples must represent both high and low flow conditions.
- There are two exceptions to the 10% aquatic life exceedance rate rule: a) if a single sample exceeds the AAL target by more than a factor of two, the waterbody is considered impaired regardless of the remaining data set; and b) if the exceedance rate is greater than 10% but no anthropogenic metals sources are identified, DEQ management is consulted for a case-by-case review.

Table 5-3. Metals Numeric Water Quality Targets Applicable to the Red Rock TMDL Planning Area

Metal of Concern	Aquatic Life Criteria (µg/L) at 25 mg/L Hardness		Aquatic Life Criteria (µg/L) at 100 mg/L Hardness		Human Health Criteria (µg/L)
	Acute	Chronic	Acute	Chronic	
Aluminum, Dissolved, pH 6.5 to 9.0 only	750	87	750	87	---
Arsenic, TR	340	150	340	150	10
Cadmium, TR	0.49	0.25	1.90	0.79	5
Copper, TR	3.79	2.85	13.90	9.32	1,300
Iron, TR	---	1,000	---	1,000	---
Lead, TR	13.98	0.545	81.65	3.18	15
Mercury, TR	1.7	0.91	1.7	0.91	0.05
Selenium, TR	20	5	20	5	50

*TR = total recoverable

5.4.2.2 Metals Sediment Quality Criteria

Stream sediment data may also be indicative of impairment caused by elevated metals and are used as a supplementary indicator of impairment. In addition to directly impairing aquatic life that interacts with the elevated metals in the sediment, the elevated sediment values can also be an indicator of elevated concentrations of metals that become suspended during runoff conditions. This can be a particularly important supplemental indicator when high flow data is lacking. The state of Montana does not currently have numeric water quality criteria for metals in stream sediment, however general water quality prohibitions state that *"state surface waters must be free from substances…that will…create concentrations or combinations of materials that are toxic or harmful to aquatic life" (ARM 17.30.637(1)(d)).*

The National Oceanic and Atmospheric Administration (NOAA) developed Screening Quick Reference Tables for stream sediment quality that provides concentration guidelines for metals in freshwater sediment (see **Table 5-4**). Screening criteria concentrations come from a variety of research studies and are expressed in Probable Effects Levels (PEL). PELs represent the sediment concentration above which toxic effects to aquatic life frequently occur, and are calculated as the geometric mean of the 50th percentile concentration of the toxic effects data set and the 85th percentile of the no-effect data set (Buchman, 1999).

Sediment Probable Effect Levels act as a screening tool and secondary target that may assist in identification of elevated metals in stream. Where in-stream water quality data exceed water quality targets, sediment quality data provide supporting information, but they are not used to make impairment determinations. **Table 5-4** contains the PEL values (mg/kg) for parameters of concern in the Red Rock TMDL Planning Area. Note that there are no published PEL values for iron, aluminum, and selenium.

Table 5-4. Screening Level Criteria for Sediment Metals Concentrations

Metal of Concern	Probable Effects Level (mg/kg)
Aluminum	--
Arsenic	17.0
Cadmium	3.5
Copper	197
Iron	--
Lead	91.3
Mercury	0.486
Selenium	--
Zinc	315

5.4.3 Existing Conditions and Comparison to Targets

For each waterbody segment listed on the 2020 303(d) List for metals (**Table 5-1**), recent water quality data were evaluated relative to the water quality targets to make a TMDL development determination. A TMDL will be written for all impaired stream segments in the Red Rock TPA. The exception is mercury in Horse Prairie Creek, for which a TMDL will not be developed at this time. This section describes water quality data exceedances for impaired stream segments with TMDLs in this document. All raw water quality data collected by DEQ can be found in **Appendix B**.

In those cases where a concentration of a pollutant was reported as less than the detection limit, half of the detection limit was used for statistical purposes. This approach did not affect exceedance rates or impairment determinations since detection limits are below target values.

5.4.3.1 Bloody Dick Creek (MT41A003_100)

Metals water quality data were used to evaluate attainment of water quality targets in Bloody Dick Creek. Water quality data used for this evaluation were comprised of 2012-2017 high and low flow sampling data collected by Montana DEQ for stream assessment and TMDL development (**Tables 5-5** and **5-16**). Water quality data was collected for the following metals parameters: aluminum, arsenic, cadmium, copper, iron, lead, selenium, silver, and zinc (**Appendix B**). Aluminum concentrations in over 10% of samples were above the chronic aquatic life standard of 87 µg/L, and lead concentrations in over 10% of samples were above the hardness-based lead chronic aquatic life standard. These exceedances indicate an impairment according to DEQ's criteria (**Section 5.4.1**). Measurements for all other parameters were below the water quality standards in **Table 5-3**.

Sediment data may support the impairment listing but is not used for the impairment determination Between 2015 and 2019, six sediment samples collected at water quality sampling sites across the subwatershed as well as one additional site (**Figure 5-2**). Samples were analyzed for arsenic, cadmium, copper, iron, lead, mercury, and zinc. All measured values were below the sediment toxicity criteria in **Table 5-4**. Aluminum was not measured; however, there is no sediment toxicity criteria for aluminum.

Table 5-5. Bloody Dick Creek Metals Water Quality Data Summary

Measurement	Aluminum (D)	Lead (TR)
# Samples	16	16
Minimum Concentration	<9 µg/L	0.037 µg/L
Maximum Concentration	257 µg/L	1.0 µg/L
Median Concentration	62 µg/L	0.3 µg/L
# Acute Aquatic Life Exceedances	0	0
Acute Aquatic Life Exceedance Rate	0%	0%
# Chronic Aquatic Life Exceedances	6	6
Chronic Aquatic Life Exceedance Rate	31.2%	17.5%
# Human Health Exceedances	0	0

D=Dissolved; TR = Total Recoverable

5.4.3.2 Fish Creek (MT41A004_030)

Water quality data used for this evaluation were comprised of 2016-2018 high and low flow sampling data collected by Montana DEQ for waterbody assessment and TMDL development (**Tables 5-6** and **5-17**). Water quality data was collected for the following metals parameters: aluminum, arsenic, cadmium, chromium, copper, iron, lead, selenium, silver, and zinc. Aluminum concentrations in over 10% of samples were above the chronic aquatic life standard of 87 µg/L, indicating an impairment according to DEQ's criteria (**Section 5.4.1**). Measurements for all other parameters were below the water quality standards in **Table 5-3**.

Sediment data may support the impairment listing but is not used for the impairment determination. In addition to water samples, sediment samples were collected at the same sites in July 2017 and analyzed for arsenic, cadmium, chromium, copper, iron, mercury, and zinc (**Figure 5-3**). All measured values were below the sediment toxicity criteria. Aluminum was not measured; however, there is no sediment toxicity criteria for aluminum.

Table 5-6. Fish Creek Metals Water Quality Data Summary

Measurement	Aluminum (D)
# Samples	16
Minimum Concentration	12 µg/L
Maximum Concentration	183 µg/L
Median Concentration	21 µg/L
# Acute Exceedances	0
Acute Exceedance Rate	0%
# Chronic Exceedances	3
Chronic Exceedance Rate	12.50%
# Human Health Exceedances	0

D = Dissolved

5.4.3.3 Little Sheep Creek (MT41A003_160)

Water quality data used for this evaluation was comprised of high and low flow sampling data collected by Montana DEQ from 2015-2018 for waterbody assessment and TMDL development (**Tables 5-7** and **5-18**). Water quality data was collected for the following metals parameters: aluminum, arsenic, cadmium, chromium, copper, iron, lead, selenium, silver, and zinc. Iron concentrations in over 10% of samples exceeded the chronic aquatic life standard for iron of 1,000 µg/L, indicating an impairment according to DEQ's criteria (**Section 5.4.1**). Measurements for all other parameters were below the water quality standards in **Table 5-3**.

Sediment data may support the impairment listing but is not used for the impairment determination. In addition to water quality samples, one sediment sample at the most downstream site (**Figure 5-4**) was collected in July 2015 and analyzed for arsenic, cadmium, chromium, cadmium, copper, iron, mercury, and zinc. This site did not exceed the water quality targets for iron or any of the other metals parameters. All measured values for sediment were also below the sediment toxicity criteria. There is no sediment toxicity criteria for iron; however, the amount of iron measured was 9,020 mg/kg, which was below the average collected for the Red Rock watershed of 13,826 mg/kg.

Table 5-7. Little Sheep Creek Metals Water Quality Data Summary

Measurement	Iron (TR)
# Samples	10
Minimum Concentration	14 µg/L
Maximum Concentration	3,340 µg/L
Median Concentration	60 µg/L
# Acute Exceedances	0
Acute Exceedance Rate	0 %
# of Samples that are ≥ 2 X the Acute Standard	0
# Chronic Exceedances	2
Chronic Exceedance Rate	20.00 %
# Human Health Exceedances	0

TR = Total Recoverable

5.4.3.4 Medicine Lodge Creek (MT41A003_010)

Water quality data used for this evaluation was comprised of high and low flow sampling data collected by Montana DEQ from 2015-2018 for waterbody assessment and TMDL development (**Tables 5-8** and **5-19**). Water quality data was collected for the following metals parameters: aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, and zinc. Iron concentrations in over 10% of samples exceeded the chronic aquatic life standard of 1,000 µg/L, indicating an impairment according to DEQ's criteria (**Section 5.4.1**). Measurements for all other parameters were below the water quality standards in **Table 5-3**.

Sediment data may support the impairment listing but is not used for the impairment determination. Between 2015-2017, three sediment samples were also collected from the three sampling sites closest to the mouth (**Figure 5-5**) and analyzed for arsenic, cadmium, copper, chromium, iron, lead, mercury, and zinc. All measured values were below the sediment toxicity criteria in **Table 5-4**. The average of iron measured was 17,266 mg/kg, which is a high value compared to the average for the Red Rock watershed of 13,826 mg/kg. This sample adds support to the iron listing, as it is potentially indicative of iron loading. However, there is no toxicity standard for iron in sediment.

Table 5-8. Medicine Lodge Creek Metals Water Quality Data Summary

Measurement	Iron (TR)
# Samples	16
Minimum Concentration	140 µg/L
Maximum Concentration	1750 µg/L
Median Concentration	310 µg/L
# Acute Exceedances	0
Acute Exceedance Rate	0 %
# of Samples that are ≥ 2 X the Acute Standard	0
# Chronic Exceedances	2
Chronic Exceedance Rate	12.5 %
# Human Health Exceedances	0

TR = total recoverable

5.4.3.5 Metzel Creek (MT41A004_020)

Water quality data used for this evaluation was comprised of high and low flow sampling data collected by Montana DEQ from 2016-2018 for waterbody assessment and TMDL development (**Tables 5-9** and **5-20**). Water quality data was collected for the following metals parameters: aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, and zinc (**Appendix B**). Arsenic concentrations in portions of Metzel Creek are above the Human Health criterion of 10 µg/L. Three samples exceeded the arsenic standard. Only one sample must exceed Human Health criteria to be considered impaired for arsenic according to DEQ's decision matrix in **Section 5.4.1**. Measurements for all other parameters were below the water quality standards in **Table 5-3**.

Sediment data may support the impairment listing but is not used for the impairment determination. In July 2017 two sediment samples were also collected from the two sampling sites (**Figure 5-6**) on Metzel Creek and analyzed for arsenic, cadmium, copper, chromium, iron, lead, mercury, and zinc. All measured values were below the sediment toxicity criteria in **Table 5-4**.

Table 5-9. Metzel Creek Metals Water Quality Data Summary

Measurement	Arsenic (TR)
# Samples	10
Minimum Concentration	1 µg/L
Maximum Concentration	13 µg/L
Median Concentration	2 µg/L
# Acute Exceedances	0
Acute Exceedance Rate	0 %
# Chronic Exceedances	0
Chronic Exceedance Rate	0 %
# Human Health Exceedances	3

TR = total recoverable

5.4.3.6 Muddy Creek (MT41A003_020)

Water quality data used for this evaluation was comprised of high and low flow sampling data collected by Montana DEQ from 2015-2017 for waterbody assessment and TMDL development (**Tables 5-10** and

5-21). Water samples were analyzed for the following metals parameters: aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, and zinc. Over 10% of samples collected from Muddy Creek exceeded the chronic standard for iron of 1,000 µg/L, indicating an impairment according to DEQ's criteria (**Section 5.4.1**). One sample exceeded the arsenic standard of 10 µg/L. However, only one sample must exceed Human Health criteria to be considered impaired for arsenic according to DEQ's decision matrix in **Section 5.4.1**. Measurements for all other parameters were below the water quality standards in **Table 5-3**.

Sediment data may support the impairment listing but is not used for the impairment determination. In 2015 and 2017 two sediment samples were also collected on Muddy Creek at the two most downstream sites (**Figure 5-7**). They were analyzed for arsenic, cadmium, copper, chromium, iron, lead, mercury, and zinc. All measured values were below the sediment toxicity criteria in **Table 5-4**. There is no toxicity standard for iron in sediment. However, the average iron concentration was 12,100 mg/kg, which is below the average for the Red Rock watershed of 13,826 mg/kg.

Table 5-10. Muddy Creek Metals Water Quality Data Summary

Measurement	Arsenic (TR)	Iron (TR)
# Samples	16	16
Minimum Concentration*	7 µg/L	180 µg/L
Maximum Concentration*	12 µg/L	5940 µg/L
Median Concentration	8 µg/L	435 µg/L
# Acute Exceedances	0	0
Acute Exceedance Rate	0 %	0 %
# Chronic Exceedances	0	3
Chronic Exceedance Rate	0 %	18.75 %
# Human Health Exceedances	1	0

5.4.3.7 Peet Creek (MT41A004_090)

Water quality data used for this evaluation was comprised of high and low flow sampling data collected by Montana DEQ fin 2017 and 2018 for waterbody assessment and TMDL development (**Tables 5-11** and **5-21**). Water samples were analyzed for the following metals parameters: aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, and zinc. Over 10% of samples exceeded the acute and chronic aquatic life standards for cadmium and copper. In addition, over 10% of samples exceeded the chronic aquatic life standard for selenium of 5 µg/L. These are indicators of impairment for cadmium, copper, and selenium, according to DEQ's decision matrix in **Section 5.4.1**. The arsenic concentration in one sample was above the Human Health criterion of 10 µg/L. Only one sample must exceed Human Health criteria to be considered impaired for arsenic according to DEQ's decision matrix in **Section 5.4.1**. Measurements for all other parameters were below the water quality standards in **Table 5-3**.

Sediment data may support the impairment listing but is not used for the impairment determination. In 2017 two sediment samples were also collected on Peet Creek at the water sampling sites (**Figure 5-9**). They were analyzed for arsenic, cadmium, copper, iron, lead, selenium, silver, and zinc. All measured values were below the sediment toxicity criteria in **Table 5-4.**

Table 5-11. Peet Creek Metals Water Quality Data Summary

Measurement	Arsenic (TR)	Cadmium (TR)	Copper (TR)	Selenium (TR)
# Samples	8	8	8	8
Minimum Concentration	<1	0.02 µg/L	0.51 µg/L	0.04 µg/L
Maximum Concentration	15	4.31 µg/L	16 µg/L	8 µg/L
Median Concentration	2	0.03 µg/L	0.82 µg/L	0.35 µg/L
# Acute Aquatic Life Exceedances	0	1	1	0
Acute Aquatic Life Exceedance Rate	0	12.5%	12.5%	0%
# Chronic Aquatic Life Exceedances	0	2	1	1
Chronic Aquatic Life Exceedance Rate	0	25.0%	12.50%	12.50%
# Human Health Exceedances	1	0	0	0

TR = Total Recoverable

5.4.3.8 Price Creek (MT41A004_010)

Water quality data used for this evaluation was comprised of high and low flow sampling data collected by Montana DEQ from 2012-2017 for waterbody assessment and TMDL development (**Tables 5-12** and **5-22**). Water quality data was collected for the following metals parameters: aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, and zinc. The data indicate that one sample exceeded the arsenic Human Health criterion of 10 µg/L. Only one sample must exceed Human Health criteria to be considered impaired for arsenic according to DEQ's decision matrix in **Section 5.4.1**. Measurements for all other parameters were below the water quality standards in **Table 5-3**.

Sediment data may support the impairment listing but is not used for the impairment determination. Between 2013 and 2017, samples were collected at the four water quality sampling sites (**Figure 5-9**) and analyzed for arsenic, cadmium, copper, iron, lead, selenium, silver, and zinc. All measured values were below the sediment toxicity criteria in **Table 5-4.**

Table 5-12. Price Creek Metals Water Quality Data Summary

Measurement	Arsenic (TR)
# Samples	16
Minimum Concentration	<1
Maximum Concentration	14
Median Concentration	2
# Acute Aquatic Life Exceedances	0
Acute Aquatic Life Exceedance Rate	0%
# Chronic Aquatic Life Exceedances	0
Chronic Aquatic Life Exceedance Rate	0%
# Human Health Exceedances	1

TR = total recoverable

5.4.3.9 Trail Creek (MT41A003_080)

Water quality data used for this evaluation was comprised of high and low flow sampling data collected by Montana DEQ in 2017 and 2018 for waterbody assessment and TMDL development (**Tables 5-13** and **5-23**). Water quality data was collected for the following metals parameters: aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, and zinc. Over 10% of samples exceeded the chronic aluminum standard of 87 µg/L, which indicates impairment according to DEQ's decision matrix (**Section 5.4.1**). Measurements for all other parameters were below the water quality standards in **Table 5-3**.

Between 2013 and 2017, three sediment samples were also collected and analyzed for arsenic, cadmium, chromium copper, iron, lead, mercury, and zinc. All measured values were below the sediment toxicity criteria in **Table 5-4**. Aluminum was not measured; however, there is no sediment criteria for aluminum.

Table 5-13. Trail Creek Metals Water Quality Data Summary

Measurement	Aluminum (D)
# Samples	14
Minimum Concentration	10
Maximum Concentration	141
Median Concentration	29.5
# Acute Aquatic Life Exceedances	0
Acute Aquatic Life Exceedance Rate	0%
# Chronic Aquatic Life Exceedances	3
Chronic Aquatic Life Exceedance Rate	21.42%
# Human Health Exceedances	0

D = dissolved

5.4.4 Metals Target Attainment Evaluation and TMDL Development Summary

Eleven individual stream segments are listed as impaired for metals-related impairments in the Red Rock TMDL Planning Area (**Table 5-1**); TMDLs were prepared for ten of these segments, representing the waterbody/pollutant combinations in **Table 5-1** with the exception of mercury in Horse Prairie Creek.

5.5 Source Assessment

This section provides the approach and results of the source assessment, which characterizes the type and extent of sources contributing metals loading to impaired streams. This section also establishes the basis for TMDL development and allocations to specific source categories in each of the subwatersheds identified in **Table 5-1**. Source characterization and assessment to determine the major sources in each of the metal impaired waterbodies was accomplished by using monitoring data, aerial photos, Geographic Information System (GIS) analysis, field reconnaissance, and literature reviews. Assessment of existing metals sources is needed to understand load allocations (LAs), and potential load reductions for different source categories. Source characterization links metals sources to loading and supports the formulation of the allocation portion of the TMDL.

The source assessment examined water quality data under various hydrologic conditions to characterize water chemistry metal conditions. Concentrations of metals typically increase during high flows as metals enter streams through runoff from adjacent mine tailings, adits (mine entrances) discharging water, and mobilized streambed and bank sediments. Total suspended solids typically increase in conjunction with the increase in metals concentrations when metals are resuspended from sediments or washed into the stream from overland flow. Except for aluminum (which has standard based on the dissolved fraction), these metals bound to sediments are considered part of the overall metals load. In some cases, high flows may decrease concentrations as metal inputs are diluted with rainwater or groundwater. However, metals can also enter the stream from groundwater. While groundwater discharges of metals into streams tend to occur year-round, they are more apparent during low flow when surface water inputs are minimal.

Decreases in stream flow due to seasonal variation or water withdrawals can also have complex effects on metals concentrations in streams. If water is removed from a stream with a high metals concentration and tributary or groundwater inputs downstream have a low metals concentration, this will decrease the overall concentration of metals. However, if a metals source enters a stream that is already experiencing low flow, this will increase the overall concentration of metals.

One of the biggest impacts that flow and seasonal impacts can have is indirect through changes in hardness. As hardness increases, the toxicity (or harmfulness to humans and aquatic life) of most metals decreases. Streams tend to naturally increase in hardness from upstream to downstream, as calcium and other elements that increase hardness are contributed from soils and agricultural practices.

Historical mining in the Red Rock TPA has been identified as the major contributing source of metals to the impaired waters. According to the DEQ Abandoned Mine and Montana Bureau of Mining and Geology databases, a total of 86 abandoned mines occur in the subwatersheds of the metals-impaired segments evaluated in this document. In addition, according to the USGS Mineral Resource Data system (https://mrdata.usgs.gov/mrds), at least 12 prospect sites occur where material disturbed in the search for metals; all of these USGS prospect sites occur in the Trail Creek subwatershed. The abandoned mines predominately include previous lode mines. Lode mines refer to when the metal is embedded within the rock and must be extracted. Alternatively, placer mines refer to deposits that have naturally separated from the rock and can essentially be sifted out. A mill site is often located adjacent to lode or placer sites and may be used to process the mining material. Due to the potentially high levels of metals in upland sediment, any non-mining earth moving activities that add sediment to the stream also contribute to increases in metals concentrations.

A brief description of the different mining activities that either currently occur or have the potential to occur in the watershed are below. Currently, there are no active hardrock mining permits or ongoing exploration mining activities in the watershed.

Abandoned mines

Abandoned mines are inactive mines that ceased operation prior to the passage of modern mining regulations. Abandoned mine sites may range from small ground disturbances to areas with adits (old mining entrances which can be dry or discharging) and/or tailings and waste rock piles of different sizes. Waste rock dumps and tailings occur mainly in upland areas; however, they can also occur in the floodplain, streamside, or in stream channels. Depending on the parent geology, site stability, level of remediation and or re-vegetation, the capacity of these sites to leach metals and/or generate acid mine drainage and the associated effects of mining wastes on stream water quality can vary greatly.

Priority abandoned mines

Priority mines are abandoned mines that have been identified specifically by Montana DEQ to have potential threats to the environment or public safety. Two priority mines are found in the Red Rock TPA study area. These are all within the Trail Creek subwatershed and the larger Horse Prairie Creek subwatershed (Trail Creek is a tributary to Horse Prairie Creek).

Active hardrock mines
Hardrock mining refers to various underground mining techniques designed to excavate metals. No active hardrock mines are found in the Red Rock TPA . Hardrock mining operator permits are obtained for mines that disturb more than 5 acres of surface and include quarries, roads, and processing areas (82-4-301, MCA). Mines that excavate gravel, soil, clay scoria, bentonite, or peat, which require an opencut mining permit instead (see below). Hardrock mining permits require environmental baseline information, an operating plan, and a reclamation plan. All activity must be bonded, and an environmental review must be conducted.

Opencut mines
Opencut mining permits are specifically for gravel, soil, clay scoria, bentonite, or peat, while hardrock mining permits cover all other materials. Opencut mines are those that strip or excavate more than 10,000 cubic yards of soil, overburden, or mine material from a site (82-4-403(7), MCA). Open cut mining permit holders must ensure that surface water and groundwater will be given appropriate protection, consistent with state law, from deterioration of water quality and quantity that may arise because of the opencut operation. Eleven opencut mines are found in the Red Rock TPA. Two of these are within the drainages of subwatershed evaluated in this document (**Table 5-14**).

MPDES discharges
Any entity that wishes to discharge water to a surface water of the state must first obtain a Montana Pollutant Discharge Elimination System (MPDES) permit. MPDES permits regulate wastewater by limiting the quantities of pollutants to be discharged to protect public health and aquatic life (75-5-101, MCA). DEQ can issue general or individual permits. A general permit is a permit for discharges associated with common activities, such as construction or industrial activity. Authorizations for general permits are issued if a facility or activity falls within the guidelines of the existing permit including limited discharges during rare events. Individual MPDES permits regulate discharges from point sources that do not fall under the guidelines for a general permit. The individual permitting process is more rigorous, as individual permits address the specific conditions of the facility or activity needing authorization. Individual MPDES permittees are required to report on the concentration and amount of discharge leaving their facilities. Currently, no MPDES permits are present in the Red Rock TPA

Small Miner Exclusions and Exploration Activities
Small Miner Exclusions (SMEs) are not permits but notarized affidavits to miners, which attest they will disturb less than 5 acres of surface (82-4-301, MCA). An exploration license is intended for exploratory operations to assess the feasibility of mining and can include surface disturbance as well as trenches, tunnels, and adits (82-4-332, MCA). One Small Miner Exclusion is present in the Red Rock TPA. No Exploration licenses are present in the Red Rock TPA. The current SME permit present in the Red Rock TPA is on Kelmbeck Creek, which is a tributary to the Red Rock River but is not upstream of any segments addressed in this TMDL document.

This source assessment identifies the known location of abandoned mines as well as priority abandoned mines, active hard rock mines, active opencut mines, active small miner exclusions, and active exploratory activities. The Red Rock TPA contains two priority abandoned mines, all in the Trail Creek subwatershed, which flows into Horse Prairie Creek. One active Small Minor Exclusion and eleven active opencut mines are present in the Red Rock TPA. Two of the active opencut mines are in drainages of segments evaluated in this TMDL document (**Table 5-14**; Little Sheep Creek and Medicine Lodge Creek). There are currently no active hardrock mines in the Red Rock TPA. There are also no Montana Pollutant Discharge Elimination System (MPDES) permits (known surface water discharges). However, any future

MPDES permitted discharges must meet metals water quality standards. Hardrock, opencut, small mining, and exploration activities that discharge to surface waters are required to have a MPDES permit. However, in most cases, opencut, small miner exclusion , and exploration activities are considered to contribute zero or negligible amounts of metals to surface waters as required by applicable state laws and do not have MPDES permits. MPDES permits most often accompany active hardrock mining permits. **Table 5-14** lists active mining permits in the Red Rock watershed

Table 5-14. Mining Permits in the Red Rock Watershed

Type	Permit /ID Number	Name	Drainage
Opencut	864	Barrett (Beaverhead County Road Department)	Horse Prairie Creek
Opencut	1374	Martinell (JTL Group/Empire Sand and Gravel	Red Rock River
Opencut	2951	Mcarthy Pit/Hallow Contracting	Clark Canyon Reservoir
Opencut	140	Lima (Department of Transportation)	Red Rock River
Opencut	2067	Alaska Basin State Pit (Beaverhead Co. Road Department)	Red Rock Lakes
Opencut	1291	Cross Ranch	Horse Prairie Creek
Opencut	2087	Snowline (Beaverhead Co. Road Department	Junction Creek
Opencut	1990	H161-Town of Lima	Little Sheep Creek*
Opencut	3020	Big Sheep Creek State Pit (Beaverhead Co Road Dept)	Red Rock River
Opencut	1293	Martinell (Jim Gilman Excavating)	Big Sheep Creek
Opencut	2758	Craver Creek (Beaverhead County Road Department)	Craver Creek (trib of Medicine Lodge Creek)*
Small Mining Exclusion	18-118	Norman Sloan	Kelmbeck Creek (trib of Red Rock River)
Priority Abandoned	01-216	Last Chance #1	Trail Creek*, Bloody Dick Creek*, Horse Prairie Creek*
Priority Abandoned	01-500/01-211	Thorium City	Trail Creek*, Bloody Dick Creek*, Horse Prairie Creek*

*Located within a subwatershed covered by a TMDL in this document

5.5.1 Bloody Dick Creek Source Assessment (MT41A003_100)

Bloody Dick Creek originates at an elevation of approximately 8,700 feet along the Beaverhead mountain range and flows southeast into Horse Prairie Creek. The approximately 30-mile reach of Bloody Dick Creek from the headwaters to the confluence with Horse Prairie Creek. Bloody Dick Creek is listed as impaired for aluminum and lead.

This subwatershed is primarily in public ownership by the U.S. Forest Service (USFS), with some BLM, State Trust Lands, and private lands near the mouth of Bloody Dick Creek **(Figure 5-2)**.

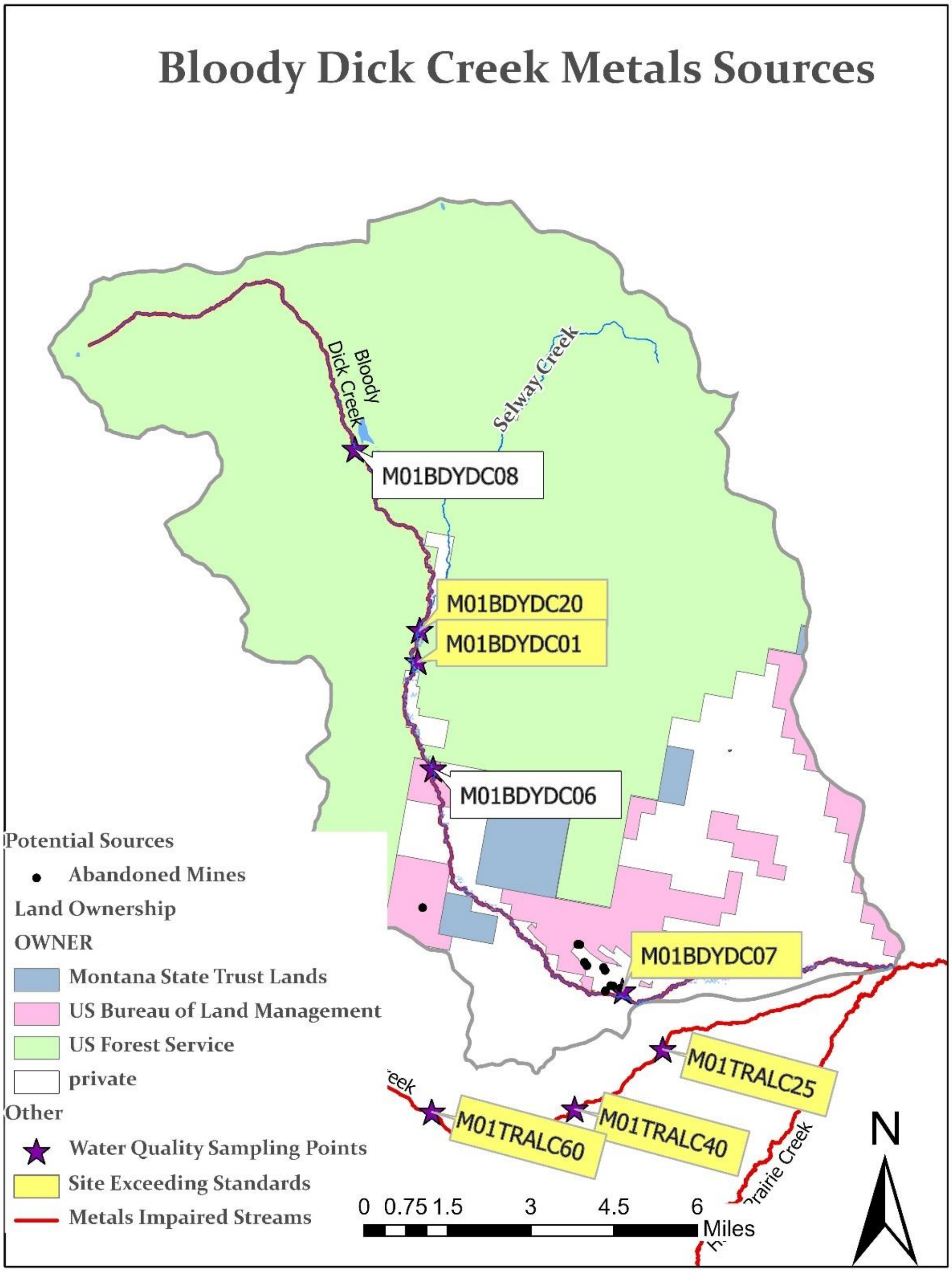

Figure 5-2. Bloody Dick Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

The source of metals in Bloody Dick Creek can largely be attributed to documented abandoned mines, undocumented abandoned mines, and natural sources. DEQ and MBMG records indicate that there are seven abandoned mines in the Bloody Dick Creek watershed, including six lode mines and one mine of unknown type (**Figure 5-2**). However, these are located near the mouth, below sampling points that exceed the Aluminum water quality standard. Given that the Red Rock geology has geology and soils characterized by high metal content, any non-mining earth-moving activities that transport sediment to the stream also contribute metals to the creek.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected from 2012 to 2017 by Montana DEQ. Sites M01BDYDC20 and M01BDYDC01, below the confluence with Selway Creek, exceeded the chronic aluminum standard while the most downstream site M01BDYDC07 exceeded both the chronic aluminum and chronic lead standards. The low hardness present in Bloody Dick Creek contributed to the exceedance of the lead standard as relatively low levels of lead can be toxic at low hardness levels. In addition to the sample sites on Bloody Dick Creek, the three sample sites on the tributary of Trial Creek also exceeded standards and are shown in **Figure 5-2**.

Water quality data used in developing the TMDL for Bloody Dick Creek is provided below in **Table 5-15** and can be found at the water quality portal (https://www.waterqualitydata.us/) and in **Appendix B** of this document.

Table 5-15. Bloody Dick Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Alum-inum** (µg/L) **(D)**	**Lead** (µg/L) **(TR)**	**TSS** (mg/L)
M01BDYDC08	MT DEQ	8/15/2016	12	5.49	<9	< .3	<4
M01BDYDC20	MT DEQ	5/31/2017	10	450.5	**157**	<.3	6
M01BDYDC01	MT DEQ	6/10/2016	10	52.76	**166**	< .3	4
M01BDYDC01	MT DEQ	7/19/2016	12	12.12	47	< .3	<4
M01BDYDC01	MT DEQ	8/8/2016	13	9.22	57	< .3	<4
M01BDYDC01	MT DEQ	9/26/2016	14	8.97	57	< .3	<4
M01BDYDC06	MT DEQ	6/22/2012	10.7	66.07	70	< .5	2
M01BDYDC06	MT DEQ	7/22/2012	12.7	19.32	60	< .5	<1
M01BDYDC06	MT DEQ	6/29/2013	11	65.67	57	< .3	1
M01BDYDC06	MT DEQ	8/30/2017	13.5	18.81	54	< 1	3
M01BDYDC07	MT DEQ	6/11/2015	12	189.6	**135**	< .3	3.5
M01BDYDC07	MT DEQ	7/31/2015	14.9	21.95	<9	< .3	<1
M01BDYDC07	MT DEQ	6/6/2016	11	485.81	**146**	**0.7***	10
M01BDYDC07	MT DEQ	7/19/2016	14	31.09	59	0.3	<4

Table 5-15. Bloody Dick Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	Collecting Entity	Sampling Date	Hardness (mg/L)	Flow (cfs)	Aluminum (µg/L) (D)	Lead (µg/L) (TR)	TSS (mg/L)
M01BDYDC07	MT DEQ	8/9/2016	14	21.77	67	0.4	<4
M01BDYDC07	MT DEQ	5/30/2017	11	164.2	**257**	**0.8***	10

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; D=Dissolved; TR=Total recoverable
* Values denoted by an asterisk exceed chronic water quality targets

5.5.2 Fish Creek Source Assessment (MT41A004_030)

Fish Creek originates in the Gravelly Mountains at approximately 8,000 feet, before flowing south into Metzel Creek. Metzel Creek then enters the Red Rock River at the outlet of lower Red Rock Lake. The approximately 8-mile segment of Fish Creek from the headwaters to the mouth is considered impaired for aluminum. Ownership in Fish Creek is by USFS, BLM, and State Trust Lands (**Figure 5-3**).

Metals Sources

No documented abandoned mines are in the Fish Creek subwatershed according to the DEQ and MBMG databases (**Figure 5-3**). However, many abandoned mines are undocumented and undocumented abandoned mines are a possible source of metals to Fish Creek. Given that the Red Rock geology has geology and soils characterized by high metal content, any non-mining earth-moving activities that transport sediment to the stream also contribute metals to the creek.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected Fish Creek from 2016-2018. Both sample sites on Fish Creek do not meet the chronic aquatic life aluminum standard of 87 µg/L. Exceedances occurred during the summer months, when flows were low potentially due to water withdrawals. Total suspended solids measurements were relatively high when exceedances occurred, suggested that the lead may is being resuspended from sediment during summer rain events.

Water quality data used in developing the TMDL for Fish Creek is provided below in **Table 5-16** and can be found at the water quality portal (https://www.waterqualitydata.us/) and in **Appendix B**.

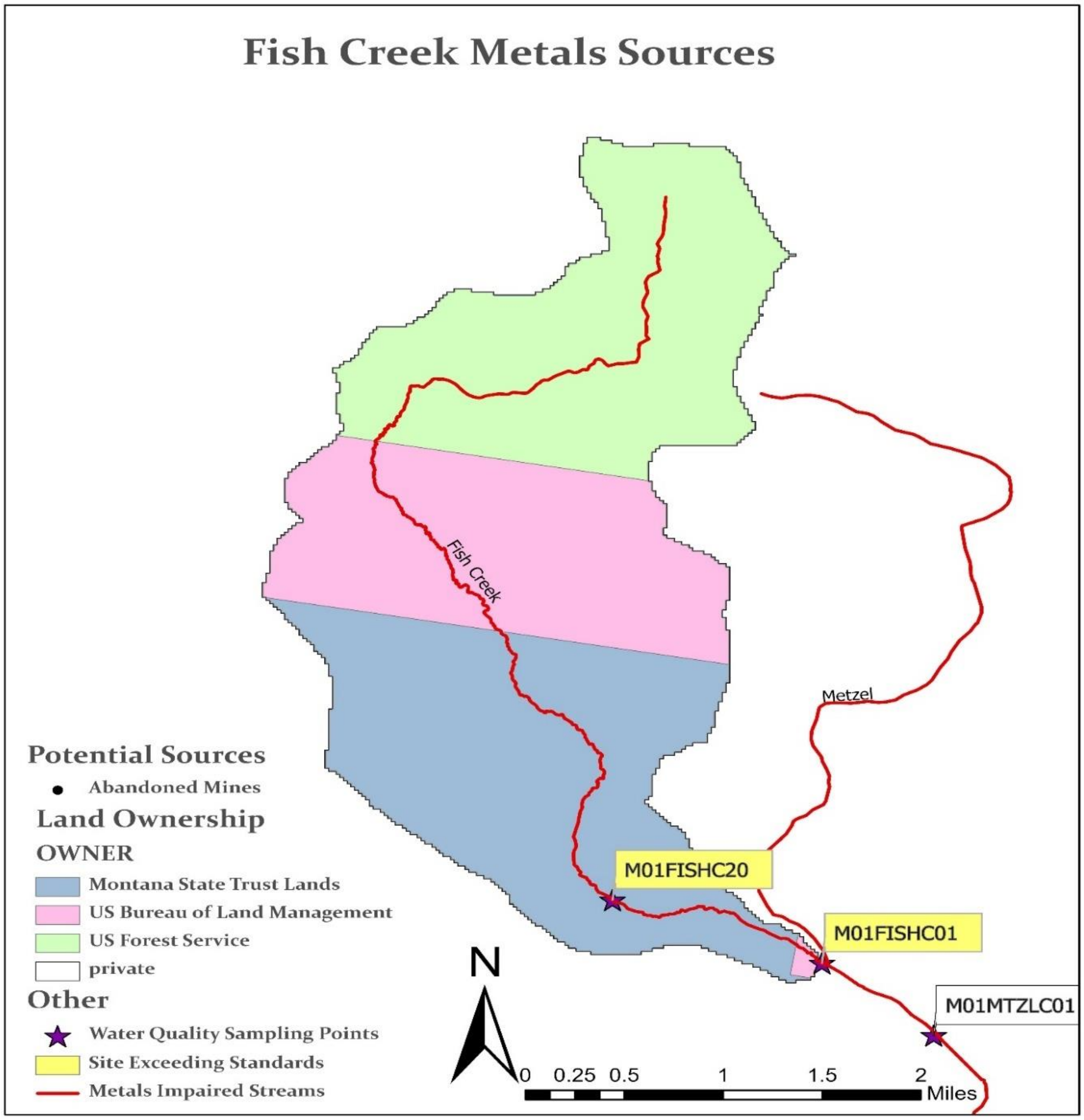

Figure 5-3. Fish Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Table 5-16. Fish Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L**)**	**Flow** (cfs)	**Aluminum** (µg/L) **TR**	**TSS** (mg/L)
M01FISHC20	MT DEQ	6/6/2017	153	4.26	16	41
M01FISHC20	MT DEQ	7/18/2017	136	1.02	14	12
M01FISHC20	MT DEQ	7/28/2017	153	0.82	**120***	18
M01FISHC20	MT DEQ	8/16/2017	132	0.7	19	10

Table 5-16. Fish Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Aluminum** (µg/L) **TR**	**TSS** (mg/L)
M01FISHC20	MT DEQ	8/24/2017	134	0.65	40	5
M01FISHC20	MT DEQ	9/7/2017	136	0.62	17	6
M01FISHC20	MT DEQ	9/28/2017	130	0.8	58	13
M01FISHC01	MT DEQ	9/28/2016	153	0.63	23	20
M01FISHC01	MT DEQ	6/6/2017	158	2.25	21	47
M01FISHC01	MT DEQ	7/18/2017	136	1.2	15	9
M01FISHC01	MT DEQ	7/28/2017	147	0.91	**183***	24
M01FISHC01	MT DEQ	8/16/2017	138	0.98	16	10
M01FISHC01	MT DEQ	8/24/2017	133	0.74	40	5
M01FISHC01	MT DEQ	9/7/2017	134	0.43	21	10
M01FISHC01	MT DEQ	9/28/2017	131	0.72	60	9
M01FISHC01	MT DEQ	6/6/2018	164	4.63	12	44

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; TR=Total Recoverable
* Values denoted by an asterisk exceed water quality targets
TR=total recoverable

5.5.3 Little Sheep Creek Source Assessment (MT41A003_160)

Little Sheep Creek subwatershed originates at an elevation of 8,580 feet within the Beaverhead Mountains. It flows north into the Red Rock River. The approximately 22 miles of Little Sheep Creek is listed as impaired for iron.

The predominant ownership in Little Sheep Creek is USFS in the headwaters and private lands near the mouth. A smaller proportion of lands are in BLM and State Trust Lands (**Figure 5-4**).

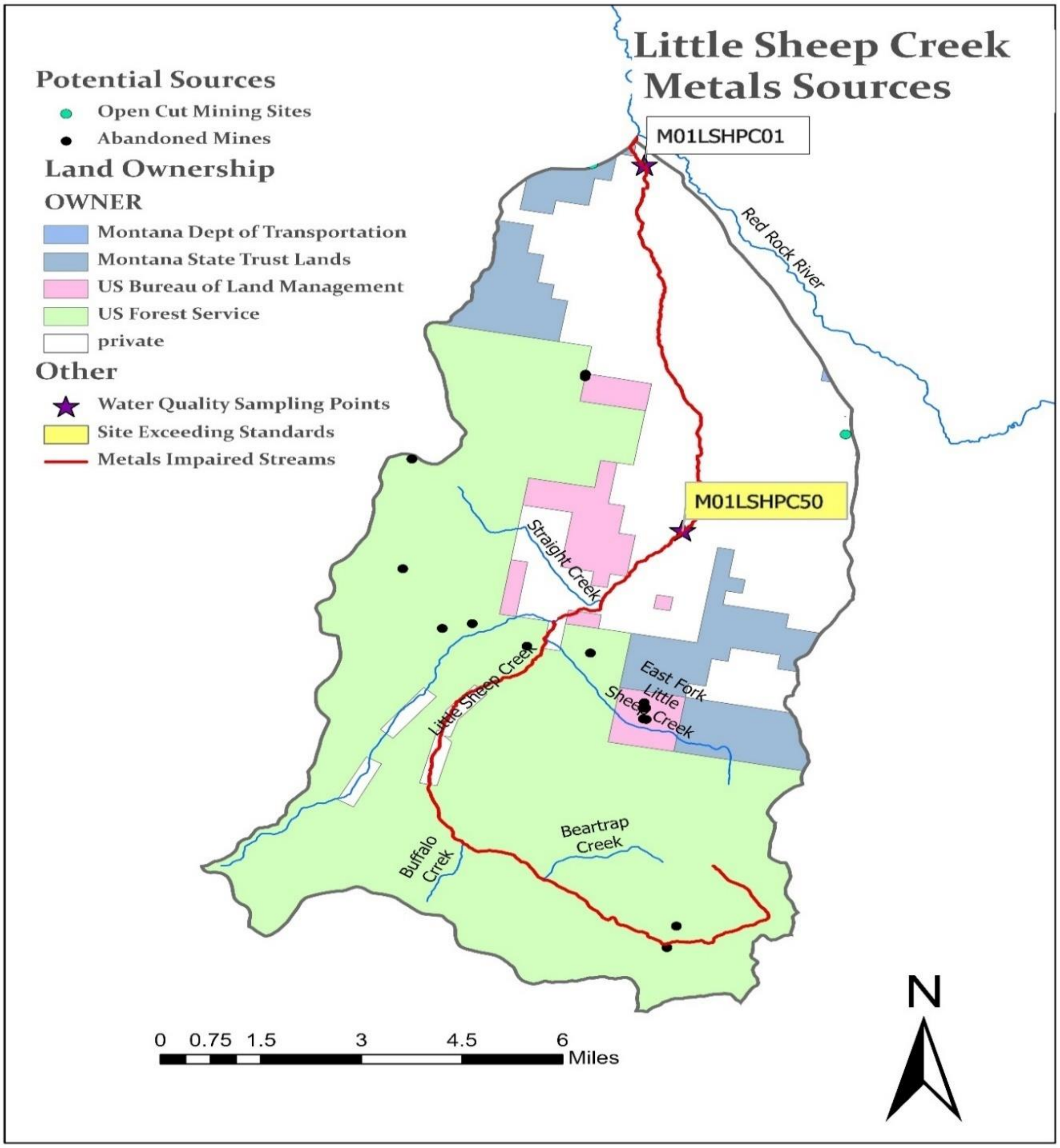

Figure 5-4. Little Sheep Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

The source of metals can largely be attributed to abandoned mines. According to the DEQ and MBMG databases, 13 known abandoned mines occur in the Little Sheep Creek drainage (**Figure 5-4**). These include 10 lode mines, and three mines of an unknown type. The commodities targeted as part of these previous mining operations included barium, gypsum, phosphate, uranium, fluorine, and iron. One opencut mining site, operated by the town of Lima, is currently operational in the subwatershed but does not have any permitted point discharges into Little Sheep Creek. Given that the Red Rock geology has geology and soils characterized by high metal content, any non-mining earth-moving activities that transport sediment to the stream also contribute metals to the creek.

Opencut Mines

Town of Lima (No. 1990)

There is one small "opencut" mine in the Little Sheep Creek subwatershed. This is an approximately 9 acre gravel pit used by the Town of Lima for road maintenance. It is the responsibility of the permit holder to adhere to the conditions of the permit and ensure that surface and groundwater are not being impacted. This mine does not have an MPDES permit to discharge into Little Sheep Creek.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected from 2015 to 2018. Samples at the upstream site exceeded the chronic aquatic life iron standard (1,000 µg/L) The upstream site exceeded the standard during high flow events. These high levels of iron coincided with high suspended sediment concentrations, indicating that the mobilization of bottom sediments may be occurring and causing elevated iron. The downstream site did not exceed the iron water quality standard. Water quality data indicate potential complex interactions between water withdrawals and metals concentrations. Iron-rich water in the upstream portion of the watershed is potentially being withdrawn, while inputs from small drainages and runoff enter downstream and cause dilution of iron concentrations.

Water quality data used in developing the TMDL for Little Sheep Creek is provided below in **Table 5-17** and can be found at the water quality portal (https://www.waterqualitydata.us/) and in **Appendix B** of this document.

Table 5-17. Little Sheep Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Iron** (µg/L) **TR**	**TSS** (mg/L)
M01LSHPC50	MT DEQ	6/5/2017	292	10.79	**3,340***	247
M01LSHPC50	MT DEQ	6/6/2018	272	16.71	**1,240***	82
M01LSHPC01	MT DEQ	7/30/2015	255	8.5	60	<1
M01LSHPC01	MT DEQ	8/16/2016	255	6.9	60	<4
M01LSHPC01	MT DEQ	9/27/2016	245	2.32	30	<4
M01LSHPC01	MT DEQ	6/5/2017	246	2.59	14	<4
M01LSHPC01	MT DEQ	7/17/2017	216	16.78	90	3
M01LSHPC01	MT DEQ	8/18/2017	236	12.67	50	1.6
M01LSHPC01	MT DEQ	9/11/2017	227	22.29	20	2
M01LSHPC01	MT DEQ	6/4/2018	220	11.64	100	3.2

TSS = Total Suspended Solids; MT DEQ=Montana DEQ

* Values denoted by an asterisk exceed chronic water quality targets

TR=total recoverable

5.5.4 Medicine Lodge Creek Source Assessment (MT41A003_010)

Medicine Lodge Creek originates in the Beaverhead Mountains at an elevation of approximately 8,500 feet, flowing north into Horse Prairie Creek.(**Figure 5-5**). The approximately 35 miles of Medicine Lodge Creek from the headwaters to the mouth is considered impaired for iron. Ownership is predominately public lands owned by the USFS and BLM, with a smaller portion in private and State Trust Lands. (**Figure 5-5**).

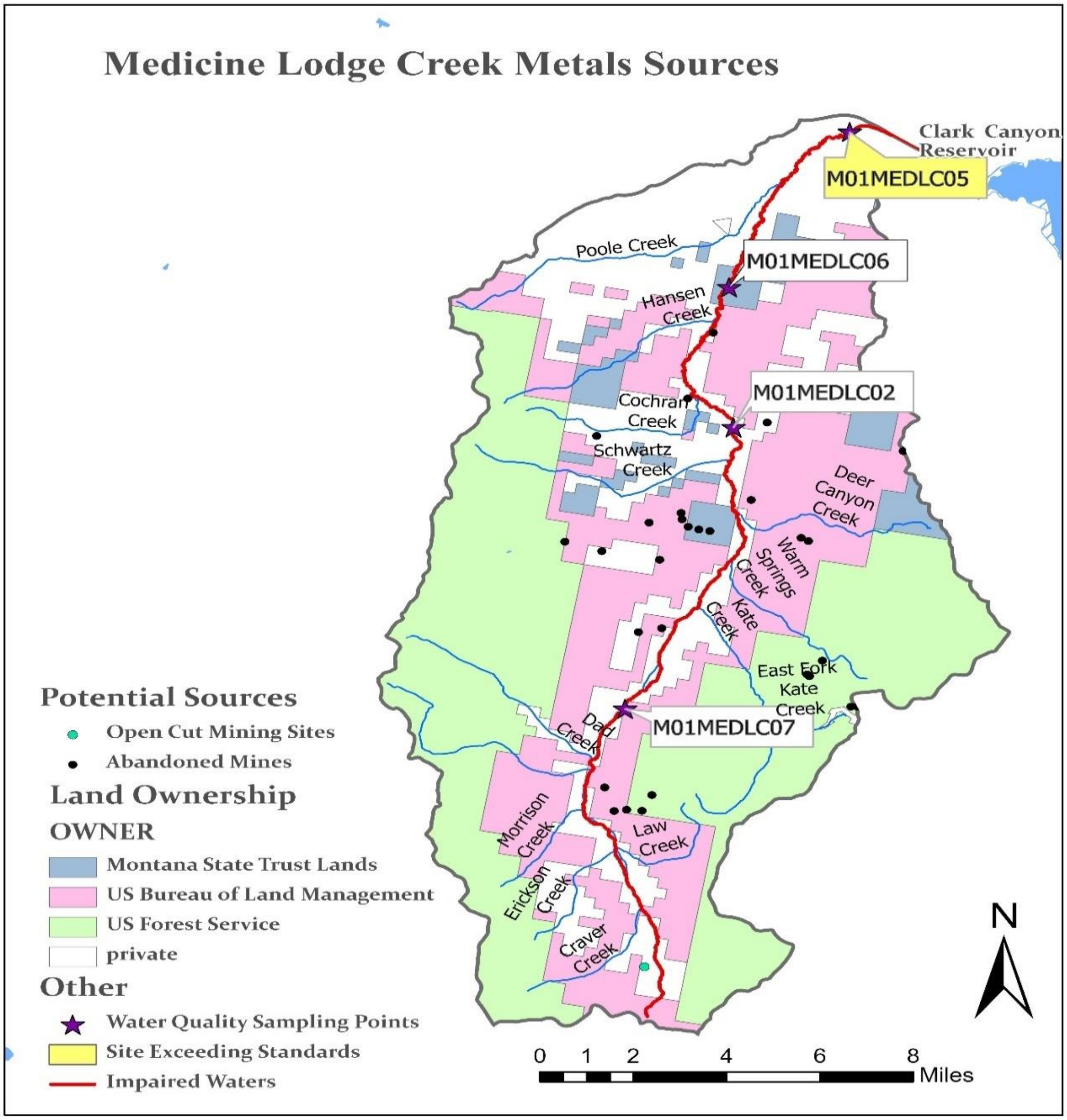

Figure 5-5. Medicine Lodge Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

The source of metals can largely be attributed to abandoned mines. According to the DEQ and MBMG databases, 32 known abandoned mines are present in the Medicine Lodge Creek drainage (**Figure 5-5**). These primarily include lode mines. A variety of commodities were mined in the Medicine Lodge Creek subwatershed including asbestos, lead, fluorine, thorium, and gold. Six of these abandoned mines are associated with the Ames-Peterson Reclamation Project conducted in 1990. This reclamation project included debris cleanup, salvage and replacement of topsoil, grading, and seeding and mulching of disturbed areas. Mine adits were also closed (Hydrometrics 1991). The final report of completed work submitted by the contractor as part of this reclamation project (Hydrometrics 1991) does not describe whether water quality improvements occurred because of this project. Given that the Red Rock watershed has geology and soils characterized by high metal content, any non-mining earth-moving activities that transport sediment to the stream also contribute metals to the creek.

<u>Opencut Mines</u>

Craver Creek (No. 2758)

There is one small "opencut" mine adjacent to Craver Creek, a tributary of Medicine Lodge Creek This is an approximately 16-acre gravel pit used for road maintenance. It is the responsibility of the permit holder to adhere to the conditions of the permit and ensure that surface and groundwater are not being impacted. This mine does not have an MPDES permit to discharge into Craver or Medicine Lodge Creek.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples from 2015 to 2017. The most downstream site, M01MEDLC05, exceeded the chronic aquatic life standard for iron (1,000 µg/L) during low flow events. These sampling events coincided high total suspended solids concentrations. No known abandoned mines exist between this site and the next site upstream, M01MEDLC06, which did not exceed the iron standard. Data suggests that, while the source of iron is previous mining activities, the standard is not exceeded when flows are high enough to provide a dilution effect. Therefore, low flows contribute to the exceedance of the standard.

Water quality data used in developing the TMDL for Medicine Lodge Creek is provided below in **Table 5-18** and can be found at the water quality portal (https://www.waterqualitydata.us/) and **Appendix B**.

Table 5-18. Medicine Lodge Creek Water Quality Data and Target Exceedances, From Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Iron** (µg/L) **TR**	**TSS** (mg/L)
M01MEDLC07	MT DEQ	8/15/2016	89	2.12	160	<4
M01MEDLC07	MT DEQ	6/1/2017	71	176.47	470	13
M01MEDLC02	MT DEQ	8/15/2016	209	9.73	310	11
M01MEDLC02	MT DEQ	5/31/2017	208	39.77	630	22
M01MEDLC06	MT DEQ	6/13/2016	186	46.15	740	20
M01MEDLC06	MT DEQ	7/20/2016	236	10	170	<4
M01MEDLC06	MT DEQ	8/10/2016	246	8.31	140	<4
M01MEDLC06	MT DEQ	9/27/2016	287	4.18	200	<4
M01MEDLC06	MT DEQ	7/27/2017	230	17.36	540	12
M01MEDLC06	MT DEQ	8/23/2017	265	6.63	250	4
M01MEDLC06	MT DEQ	9/27/2017	301	14.03	350	10
M01MEDLC05	MT DEQ	6/10/2015	312	5.1	**1,750***	75.5
M01MEDLC05	MT DEQ	7/31/2015	245	0.2	260	2
M01MEDLC05	MT DEQ	6/6/2016	272	0.42	**1,470***	51

Table 5-18. Medicine Lodge Creek Water Quality Data and Target Exceedances, From Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Iron** (µg/L) **TR**	**TSS** (mg/L)
M01MEDLC05	MT DEQ	7/19/2016	280	1	430	10
M01MEDLC05	MT DEQ	8/10/2016	263	3.7	200	5

TSS = Total Suspended Solids; MT DEQ=Montana DEQ
* Values denoted by an asterisk exceed water quality targets
TR=Total Recoverable

5.5.5 Metzel Creek Source Assessment (MT41A004_020)

Metzel Creek originates in the Gravelly mountains at an elevation of approximately 8,500 feet, flowing south and entering the Red Rock River at the outlet of Lower Red Rock Lake (**Figure 5-6**). The approximately 13.5 miles of Metzel Creek from the headwaters to the Red Rock River is considered impaired for iron. The Metzel Creek subwatershed is comprised of a wide range of ownership including USFS, BLM, State Trust Lands, and a small portion in USFWS and private lands **(Figure 5-6**).

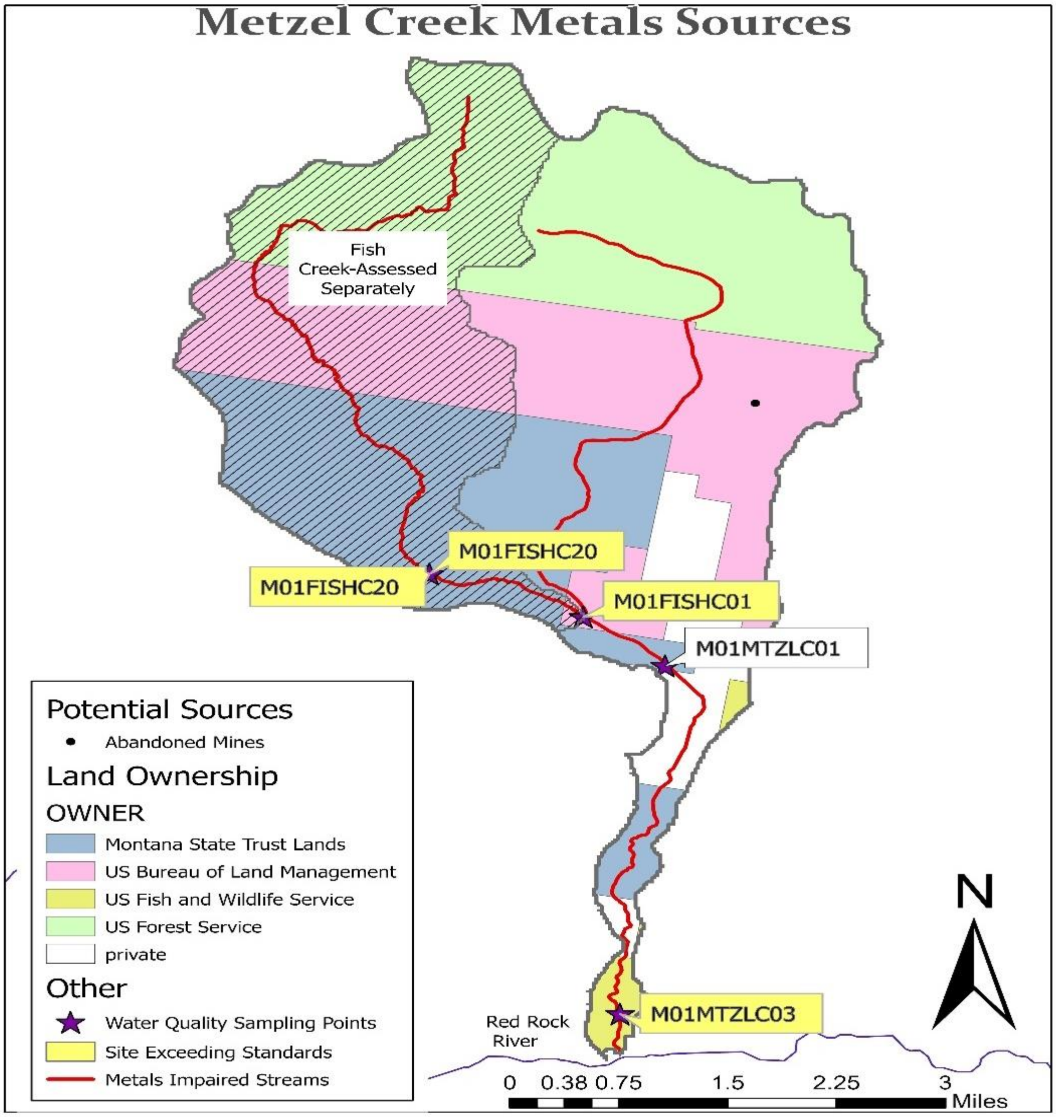

Figure 5-6. Metzel Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

The source of metals can largely be attributed to abandoned mines. High levels of arsenic above the human health standard of 10 µg/L were measured at the most downstream site, M01MTZLC03. Only one documented abandoned mine is present in this watershed, which is a phosphate/uranium mine. However, phosphate/uranium mine tailings are known to contain elevated levels of arsenic. Unaccounted for abandoned mines in this drainage may also be contributing to high arsenic concentrations. In addition, given that the Red Rock geology has geology and soils characterized by high metal content, any non-mining earth-moving activities that transport sediment to the stream may contribute metals to the creek.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected in Metzel Creek from 2016 to 2018. Water quality data used in developing the TMDL for Metzel Creek are provided below in **Table 5-19** and can be found at the water quality portal (https://www.waterqualitydata.us/) and **Appendix B**. The most downstream site had elevated levels of arsenic during all flow conditions.

Table 5-19. Metzel Creek Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	Collecting Entity	Sampling Date	Hardness (mg/L)	Flow (cfs)	Arsenic (µg/L) TR	TSS (mg/L)
M01MTZLC01	MT DEQ	9/28/2016	216	1.2	1	23
M01MTZLC01	MT DEQ	6/6/2017	196	3.14	2	51
M01MTZLC01	MT DEQ	7/18/2017	190	1.41	2	12
M01MTZLC01	MT DEQ	8/16/2017	211	1.47	1	16
M01MTZLC01	MT DEQ	9/7/2017	213	1.18	2	33
M01MTZLC01	MT DEQ	6/6/2018	170	4.01	2	41
M01MTZLC03	MT DEQ	6/7/2017	172	4.61	9	2.8
M01MTZLC03	MT DEQ	7/18/2017	219	2.7	**11***	2.8
M01MTZLC03	MT DEQ	8/17/2017	234	3.87	**11***	2
M01MTZLC03	MT DEQ	9/6/2017	233	2.6	**13***	6

TSS = Total Suspended Solids; MT DEQ=Montana DEQ
* Values denoted by an asterisk exceed water quality targets
TR=Total Recoverable

5.5.6 Muddy Creek Source Assessment (MT41A003_020)

The headwaters of the Muddy Creek subwatershed originate at an elevation of approximately 8,900 feet in the Tendoy mountains. Muddy Creek flows south from the confluence of Wilson and Sourdough Creeks to the confluence of Big Sheep Creek. The approximately eleven miles of Muddy Creek is listed as impaired for arsenic and iron. The majority of Muddy Creek is in ownership by the USFS and BLM, with a smaller portion in private lands (**Figure 5-7**).

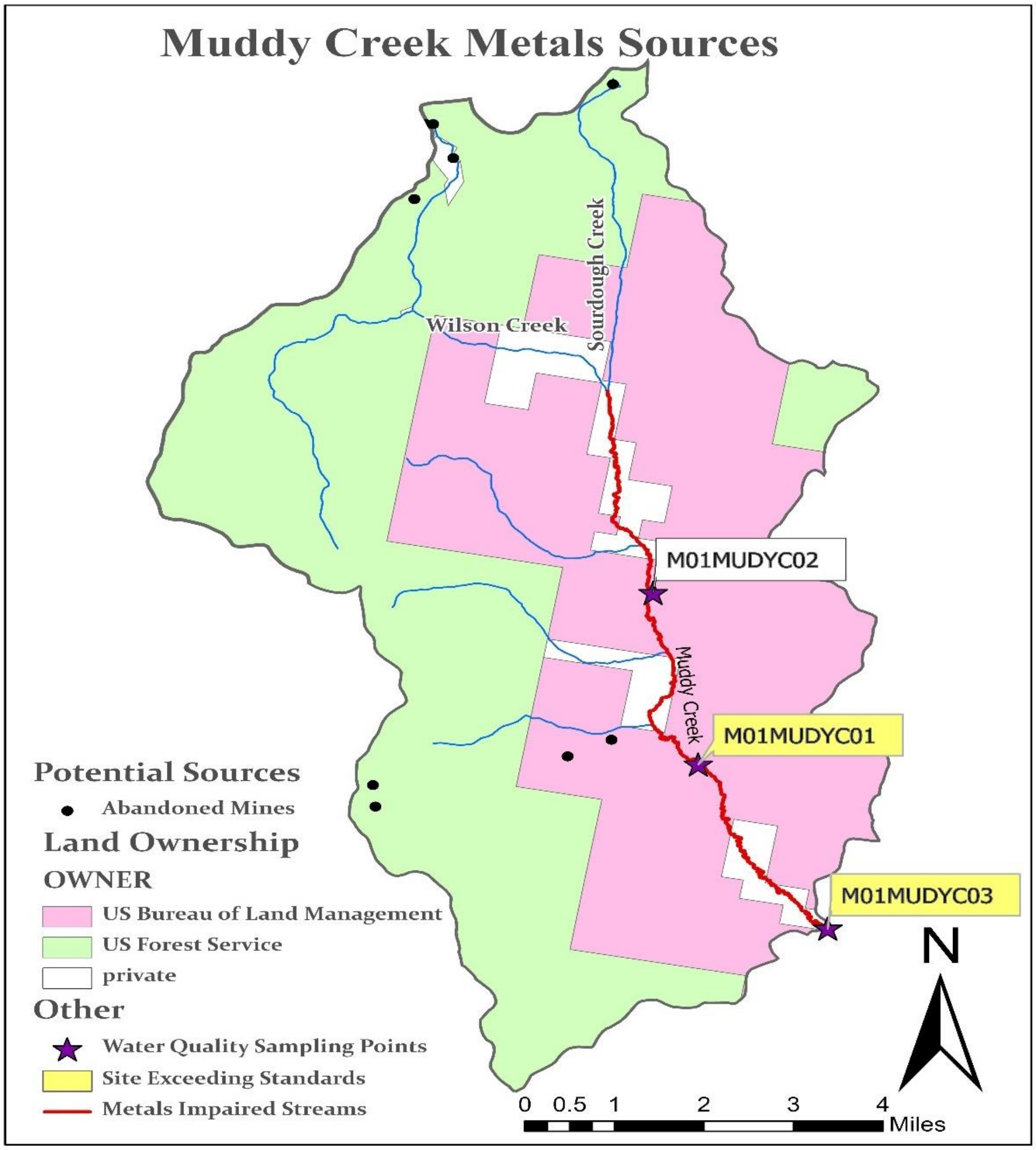

Figure 5-7. Muddy Creek Potential Metals Sources and Sampling Locations

Metals Sources

A primary source of metals is abandoned mines. According to DEQ and the Montana Bureau of Mines and Geology (MBMG) GIS coverages, eight abandoned mines exist in the Muddy Creek subwatershed (**Figure 5-7**), including 3 lode mines and five mines of unknown type. Graphite was one of the primary metals mined in Muddy Creek drainage. Given that the Red Rock geology has geology and soils characterized by high metal content, any non-mining earth-moving activities that transport sediment to the stream also contribute metals to the creek.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected in Muddy Creek from 2015 to 2017. Muddy Creek was found to exceed the chronic iron standard and human health standard for arsenic. The iron standard was exceeded at the two downstream sites during several sampling events. The arsenic standard was exceeded at only one site M01MUDYC01, which was in the middle of the impaired segment. However, arsenic concentrations were near the standard for the entire length of Muddy Creek. The exceedances coincided with high total suspended solids concentrations and increased flow, indicating that metals are potentially being stored in the sediments and mobilized during rain events.

Water quality data used in developing the TMDL for Muddy Creek is provided below in **Table 5-20** and can be found at the water quality portal (https://www.waterqualitydata.us/) and **Appendix B**.

Table 5-20. Muddy Creek Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	Collecting Entity	Sampling Date	Hardness (mg/L)	Flow (cfs)	Arsenic (ug/L) TR	Iron (µg/L) TR	TSS (mg/L)
M01MUDYC02	MT DEQ	6/14/2016	184	1.18	8	860	35
M01MUDYC02	MT DEQ	7/21/2016	203		8	520	52
M01MUDYC02	MT DEQ	6/1/2017	190	2.84	7	400	14
M01MUDYC02	MT DEQ	7/13/2017	--	1.11	7	470	20
M01MUDYC02	MT DEQ	8/18/2017	200	1.02	7	480	16
M01MUDYC02	MT DEQ	9/12/2017	191	0.77	7	210	6
M01MUDYC01	MT DEQ	6/10/2015	246	0.67	10	810	43
M01MUDYC01	MT DEQ	7/29/2015	172	0.16	10	240	5
M01MUDYC01	MT DEQ	6/8/2016	225	1.33	**12***	**5,940***	223
M01MUDYC01	MT DEQ	7/21/2016	185		8	210	9
M01MUDYC01	MT DEQ	8/17/2016	167	0.47	7	180	4
M01MUDYC01	MT DEQ	6/1/2017	199	2.33	9	**1,020***	39
M01MUDYC01	MT DEQ	7/13/2017	--	1.42	10	360	12
M01MUDYC01	MT DEQ	8/18/2017	190	0.86	7	250	7
M01MUDYC01	MT DEQ	9/12/2017	170	0.56	9	210	6
M01MUDYC03	MT DEQ	9/27/2016	228	--	8	**1,370***	49

TSS = Total Suspended Solids; MT DEQ = Montana DEQ; TR=Total Recoverable
* Values denoted by an asterisk exceed water quality targets

5.5.7 Peet Creek Source Assessment (MT41A004_090)

Peet Creek originates in the Centennial mountains at an elevation of approximately 8,600 feet. It flows north into the Red Rock River. The ten miles of Peet Creek from the headwaters to the confluence of the Red Rock River is considered impaired for arsenic, selenium, copper, and cadmium.

The predominant ownership in the upper 30% of the subwatershed is BLM Lands. The lower portion of the subwatershed is in predominately private lands. State Trust Lands are also present in the subwatershed (**Figure 5-8**).

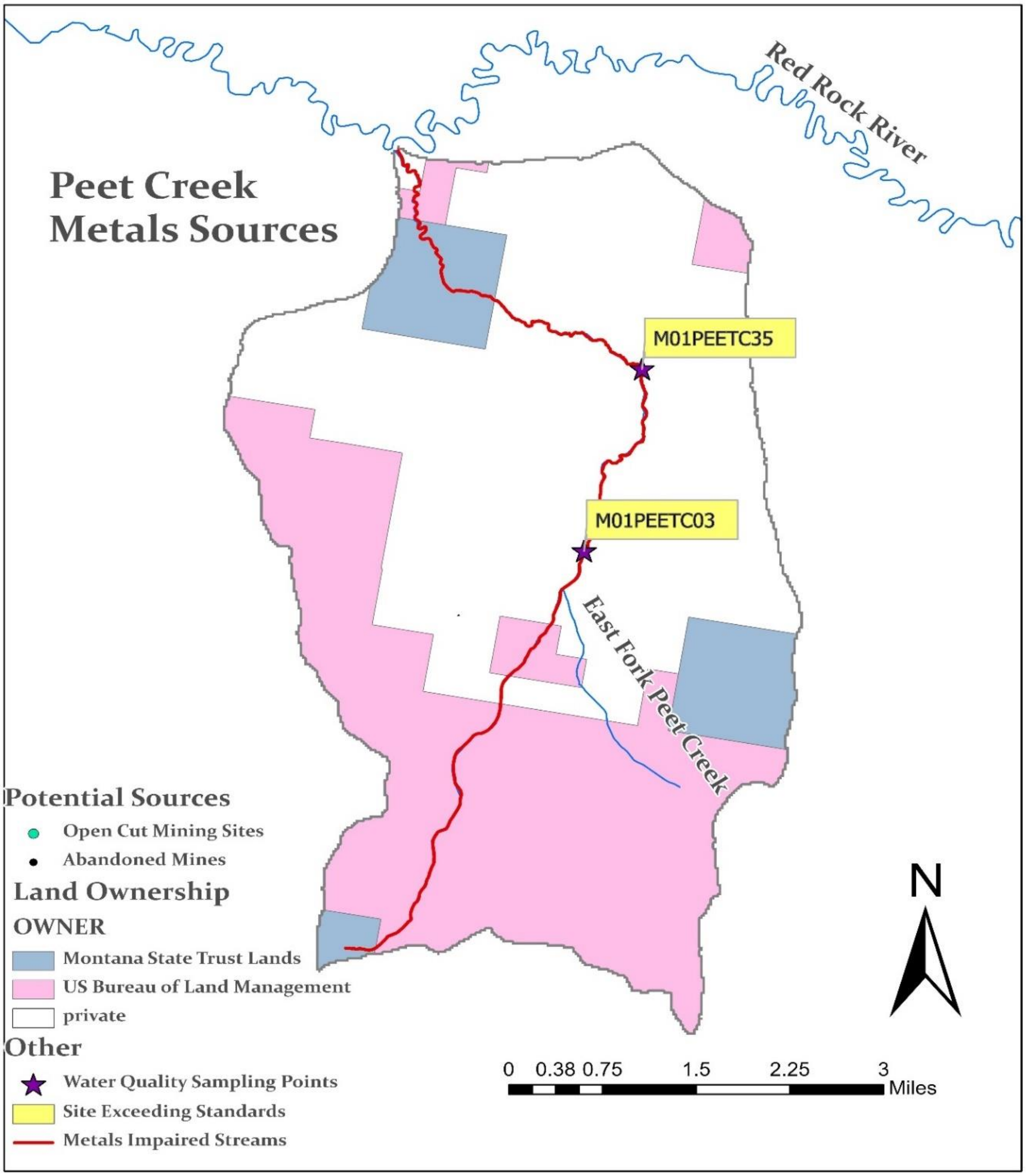

Figure 5-8. Peet Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow.

Metals Sources

No abandoned mines are present in Peet Creek according to the MBMG or DEQ databases (**Figure 5-8**). However, given the extensive history of mining in the Red Rock watershed, undocumented abandoned mines may occur in the subwatershed. Given that the Red Rock geology has geology and soils characterized by high metal content, any non-mining earth-moving activities that transport sediment to the stream also contribute metals to the creek and can be a significant source of metals.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected in 2017 and 2018. Exceedance of the chronic aquatic life standard for selenium occurred at the most downstream site, M01PEETC35. Exceedance of the human health standard for arsenic also occurred at the most downstream site, M01PEETC35. Exceedance of both the acute and chronic aquatic life standard for copper and cadmium occurred at M01PEETC35. Exceedance of both the acute and chronic aquatic life standard for cadmium also occurred at the upper site, M01PEETC03. These exceedances occurred during low flows, although not all low flow conditions exhibited an exceedance of these standards. These findings suggest complex interactions between metals sources, groundwater, and streamflows.

Water quality data used in developing the TMDL for Peet Creek is provided below in **Table 5-21** and can be found at the water quality portal (https://www.waterqualitydata.us/) and **Appendix B**.

Table 5-21. Peet Creek Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collect-ing Entity**	**Sampling Date**	**Hard-ness** (mg/L)	**Flow** (cfs)	**As** (µg/L) **TR**	**Se** (µg/L) **TR**	**Cu** (µg/L) **TR**	**Cd** (µg/L) **TR**	**TSS** (mg/L)
M01PEETC03	MT DEQ	6/7/2017	113	5.31	2	0.7	2	0.21	27
M01PEETC03	MT DEQ	7/19/2017	141	3.13	2	0.14	0.61	0.02	11
M01PEETC03	MT DEQ	8/17/2017	131	0.97	2	0.22	0.64	0.02	15
M01PEETC03	MT DEQ	9/8/2017	115	1.01	4	2	3	**1.04***	5
M01PEETC03	MT DEQ	6/6/2018	136	6.83	1	0.47	1	0.04	36
M01PEETC35	MT DEQ	7/19/2017	161	1.35	2	0.04	0.51	0.02	6
M01PEETC35	MT DEQ	8/17/2017	116	1.72	6	0.13	0.64	0.02	11
M01PEETC35	MT DEQ	9/8/2017	113	0.74	**15***	**8***	**16***	**4.31***	8

MT DEQ = Montana DEQ; As = Arsenic; Se = Selenium; Cu = Copper; Cd = Cadmium; TSS = Total Suspended Solids; TR = Total Recoverable

* Values denoted with an asterisk exceed water quality targets

5.5.8 Price Creek Source Assessment (MT41A004_010)

Price Creek flows north into the Red Rock River. The approximately 10.5 miles of Price Creek from the headwaters to the confluence of the Red Rock River is considered impaired for arsenic. The predominant ownership in the upper watershed is by the BLM and State Trust Lands, with a smaller portion near the mouth in private lands (**Figure 5-9**).

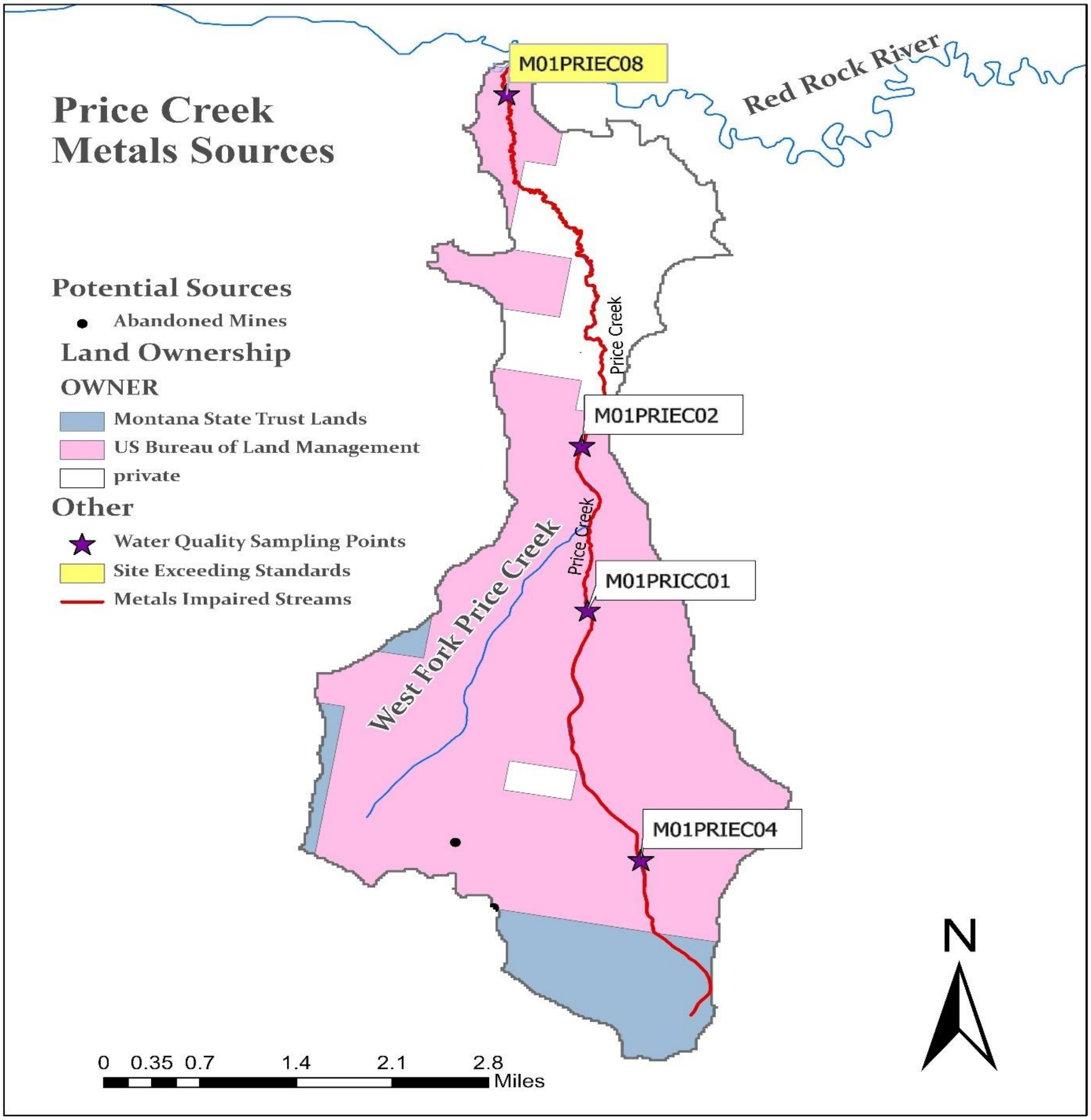

Figure 5-9. Price Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

Abandoned mines are considered a source of metals to Price Creek. According to the DEQ and MBMG abandoned mines databases, two abandoned lode mines are present in Price Creek that produced pumice. Given that the Red Rock geology has geology and soils characterized by high metal content, any non-mining earth-moving activities that transport sediment to the stream also contribute metals to the creek and be a source of metals.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected from 2012-2017. Exceedance of the human health standard for arsenic occurred at the most downstream sampling site of M01PRIEC08 during low flow conditions. Water quality data indicate that dewatering is contributing to high arsenic in Price Creek. When flows are not extremely low due to apparent water withdrawals, the arsenic standard is generally met.

Water quality data used in developing the TMDL for Price Creek is provided below in **Table 5-22** and can be found at the water quality portal (https://www.waterqualitydata.us/) and **Appendix B**.

Table 5-22. Price Creek Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Arsenic** (µg/L) **TR**	**TSS** (mg/L)
M01PRIEC04	MT DEQ	6/7/2017	29	1.64	2	2
M01PRIEC04	MT DEQ	7/19/2017	41	0.33	1	1.2
M01PRIEC04	MT DEQ	8/15/2017	43	0.19	1	1.2
M01PRIEC04	MT DEQ	9/8/2017	43	0.14	1	2.4
M01PRICC01	MT DEQ	7/12/2012	103	1.19	2	3
M01PRICC01	MT DEQ	6/23/2012	103	2.48	2	8
M01PRICC01	MT DEQ	7/9/2013	104	NA	3	23
M01PRICC01	MT DEQ	8/28/2017	78.7	0.86	1	24.5
M01PRIEC02	MT DEQ	9/28/2016	110	0.91	2	8
M01PRIEC02	MT DEQ	6/7/2017	128	5.76	2	27
M01PRIEC02	MT DEQ	7/19/2017	125	1.45	1	9
M01PRIEC02	MT DEQ	8/15/2017	116	1.81	1	10
M01PRIEC02	MT DEQ	9/11/2017	87	1.14	2	4
M01PRIEC08	MT DEQ	6/7/2017	257	2.23	4	<4
M01PRIEC08	MT DEQ	7/19/2017	467	0.04	**10***	42
M01PRIEC08	MT DEQ	8/15/2017	523	NA	**14***	145

TSS = Total Suspended Solids; MT DEQ = Montana DEQ; TR = Total Recoverable
* Values denoted by an asterisk exceed water quality targets

5.5.9 Trail Creek Source Assessment (MT41A003_080)

Trail Creek originates at an elevation of approximately 8,700 feet along the foothills of the Beaverhead mountains and flows east to meet Bloody Dick Creek. The approximately 13-mile reach of Trail Creek from the headwaters to the confluence with Bloody Dick Creek is impaired for aluminum.

The headwaters of the subwatershed are primarily in public ownership by the USFS, BLM, and State Trust Lands. The lower portion is primarily in private ownership (**Figure 5-10)**.

Metals Sources

The primary source of aluminum in Trail Creek subwatershed is abandoned mines. MBMG and DEQ databases show 15 abandoned mines in the Trail Creek watershed, including four mines considered priority mines by DEQ. The commodities previously mined in the watershed included thorium, manganese, and uranium. In addition, the watershed contained 12 sites where prospecting for metals occurred according to the USGS Mineral Resource Data System, although it is unknown the extent of mining that occurred at these sites. Given that the Red Rock geology has geology and soils characterized by high metal content, any non-mining earth-moving activities that transport sediment to the stream also contributes metals to the creek and be another significant source of metals.

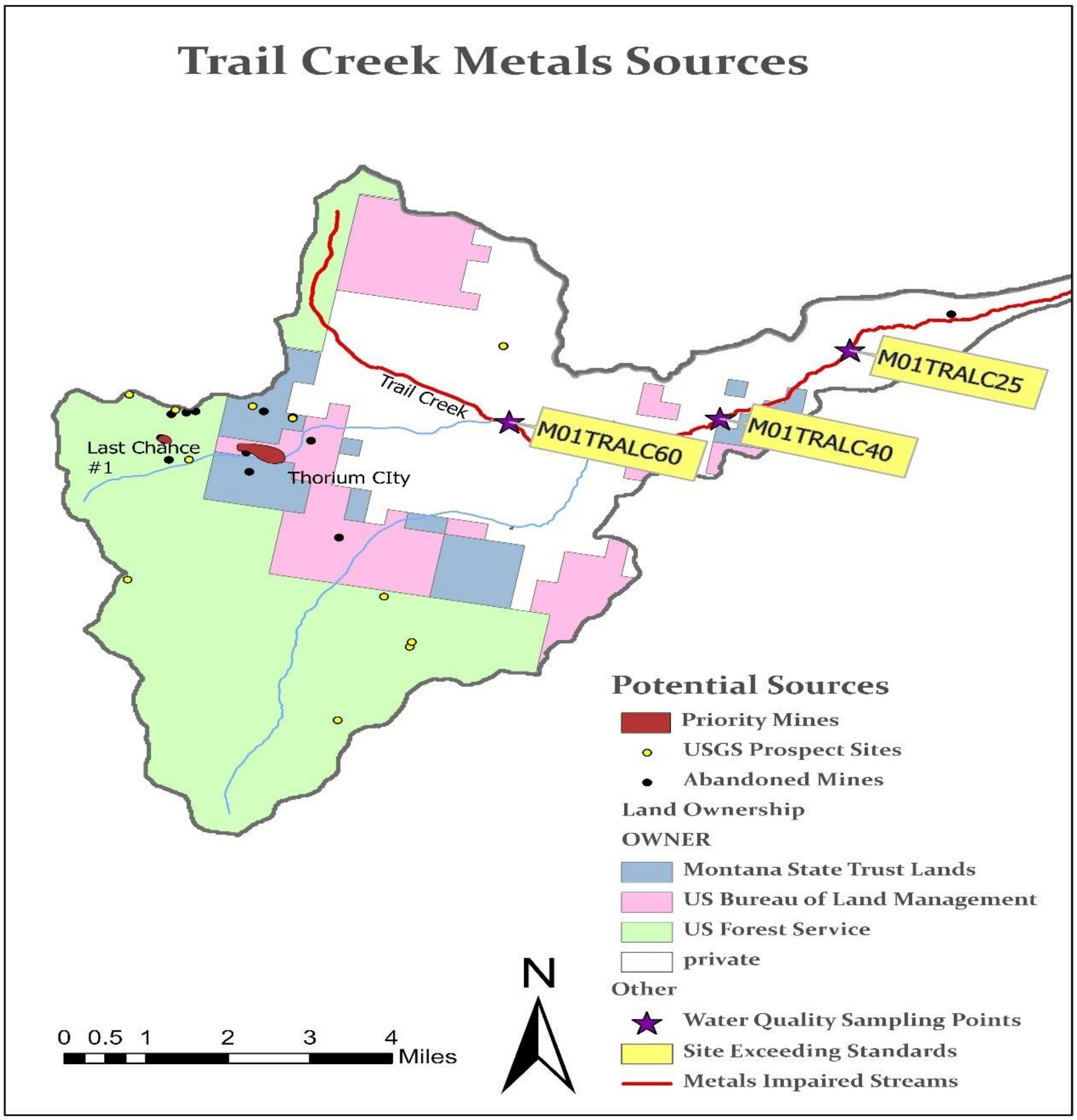

Figure 5-10. Trail Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Priority Abandoned Mines

Two of the abandoned mines in Trail Creek Watershed are considered priority mines by the Montana Department of Environmental Quality. Priority mines are abandoned mines that have been identified specifically by Montana DEQ to have potential threats to the environment or public safety. The Montana DEQ uses Abandoned and Inactive Mines Scoring System (AIMSS) to evaluate most priority mines for health and safety, with a value near 0 indicating low health and safety concerns. A survey was conducted of most priority mines in Montana in 1994, and a AIMSS score was determined at that time.

Last Chance #1 Mine (01-216)

This previous uranium mining site was investigated in 1993. No discharging adits, filled shafts, seeps or springs were observed during investigations. Potential safety hazards included an adit with a locked gate, a highwall associated with a trench cut, and a steep unstable waste dump. The nearest surface water drainage was a small intermittent stream located about 250 feet from the bottom of the waste dump. No runoff was observed from the waste dump to the drainage. This site was not evaluated in the 1994 survey and does not have an AIMSS score.

Thorium City (01-500)

A site visit was conducted in 1994 (Montana Department of State Lands 1994). This site is in the North Frying Pan Creek drainage. Previous data was also collected in 1993 and in 1986 by the Bureau of Land Management. No mine tailings were observed in 1994. No discharging adits, filled shafts, seeps or springs were observed during the visit. The main contaminant remaining at this site is radioactive waste. However, no radioactive isotopes were identified in Frying Pan Creek during the 1994 survey. This site had an AIMSS health score of 0.003 during the 1994 survey, which was the lowest score for evaluated priority mining sites in Montana. It also received an AIMSS safety ranking of 0.000, which was the lowest score received and indicated low potential safety issues.

Water quality data used in developing the TMDL for Trail Creek are provided below in **Table 5-23** and can be found at the water quality portal (https://www.waterqualitydata.us/) and in **Appendix B** of this document.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected in 2017 and 2018. While all high flow events resulted in elevated aluminum concentrations, concentrations during only the highest flow event exceeded the standard. Exceedance of the aluminum standard occurred at all three sample sites.

Table 5-23. Trail Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Al** (µg/L) **D**	**TSS** (mg/L)
M01TRALC60	MT DEQ	5/31/2017	26	38.16	**141***	7
M01TRALC60	MT DEQ	7/10/2017	NA	3.69	54	13
M01TRALC60	MT DEQ	8/14/2017	43	2.84	29	9
M01TRALC60	MT DEQ	9/14/2017	40	2.29	19	1.6
M01TRALC60	MT DEQ	6/7/2018	26	29.68	85	7
M01TRALC40	MT DEQ	5/31/2017	30	118.56	**112***	18
M01TRALC40	MT DEQ	7/10/2017	NA	16.1	22	6
M01TRALC40	MT DEQ	8/14/2017	53	11.63	30	4
M01TRALC40	MT DEQ	9/14/2017	49	5.11	10	0.4
M01TRALC25	MT DEQ	5/31/2017	33	77.78	**107***	38
M01TRALC25	MT DEQ	7/10/2017	NA	4.61	21	2.8
M01TRALC25	MT DEQ	8/14/2017	47	12.59	21	8
M01TRALC25	MT DEQ	9/14/2017	50	3.51	11	0.4
M01TRALC25	MT DEQ	6/7/2018	32	55.96	74	11

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; Al = Aluminum; NA = Not Applicable (no data collected)
* Values denoted by an asterisk exceed human health target

5.6 Approach to Total Maximum Daily Loads

This section describes the general approach used for TMDL development and presents TMDLs for each of the waterbody-pollutant combinations under different flow conditions. **Section 5.7** describes in further detail the specific TMDLs for each waterbody-pollutant combination and outlines the allocations to each source category. **Section 5.7** also discusses loading estimates and load allocations established for high and low flow scenarios, depending on when each pollutant was exceeded. Loading estimates and allocations are based on observed water quality data and flow conditions measured during these time periods.

Because streamflow varies seasonally, TMDLs are not expressed as a static value, but as an equation of the appropriate target multiplied by flow as shown in **Equation 51**:

Equation 5-1: TMDL (lbs/day) = (X) (Y) (0.0054)

*X = lowest applicable water quality target in µg/L (**Table 5-26**)*
Y = streamflow in cubic feet per second (cfs)
0.0054 = conversion factor

As flow increases, the allowable load (TMDL) increases as shown by the example **Figure 5-11** for lead. Graphs detailing the change in allowable load for each pollutant are found in **Appendix C**, TMDL Examples and Calculations. It is important to remember that the TMDLs in these figures are based on the applicable water quality standard (**Table 5-24)**, and that the allowable load increases with flow and in many cases, is hardness dependent. For all metals in the Red Rock TPA, the lowest applicable standard was the chronic aquatic life standard, except for arsenic in Muddy, Metzel, Peet, and Price creeks, which exceeded the human health standard.

Table 5-24. Formulas Used to Determine Water Quality Targets for Development of TMDLs

Metal	Lowest Applicable Target	Equation
Aluminum	• Chronic aquatic life standard (87 µg/L)	NA
Arsenic	• Human health standard (10 µg/L)	NA
Cadmium	• Chronic aquatic life standard (varies according to water hardness)	• = EXP (0.7977*(LN (hardness))-3.909)
Copper	• Chronic aquatic life standard (varies according to water hardness)	• = EXP (0.8545*(LN (hardness))-1.702)
Iron	• Chronic aquatic life standard (constant of 1,000 µg/L)	• = 1,000 µg/L
Lead	• Hardness less than 339 mg/L as CaCO3, chronic aquatic life standard applies (varies according to water hardness) • Hardness equal to or greater than 339 mg/L as CaCO3, human health standard applies (constant of 15 µg/L)	• = EXP (1.273*(LN (hardness))-4.705) • = 15 µg/L
Selenium	• Chronic aquatic life standard (5 µg/L)	NA
Zinc	• Acute and chronic aquatic life standards are identical and therefore apply equally (both vary equally according to hardness)	• = EXP (0.8473*(LN (hardness)) +0.884)

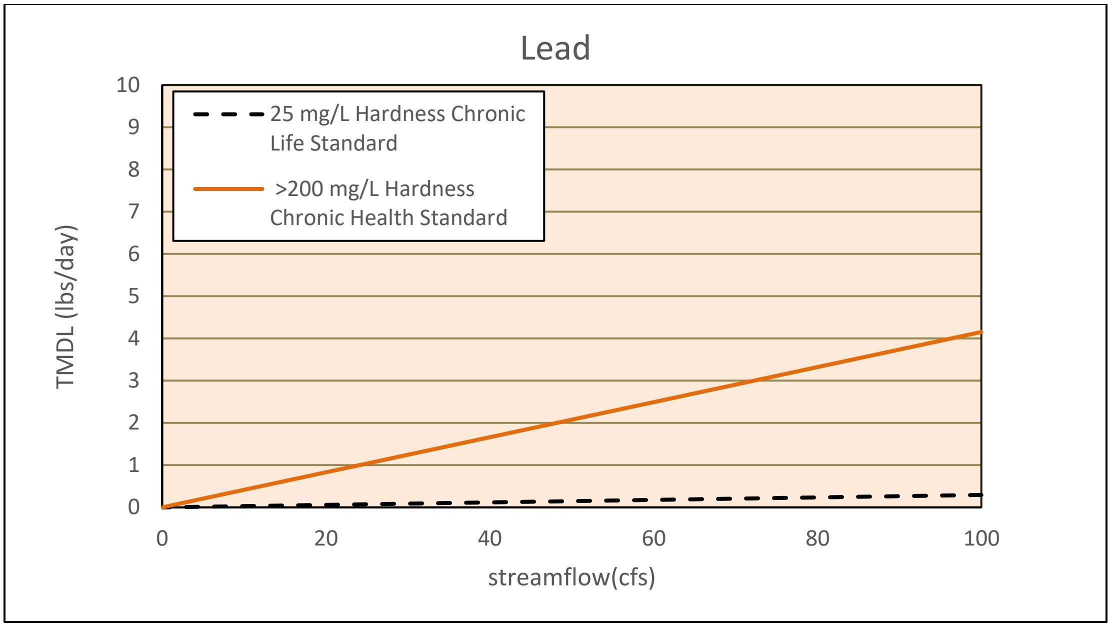

Figure 5-11 Graph illustrating the TMDL for Lead at Different Hardness and Flow Levels; Refer to Appendix C for Similar Graphs for Other Pollutants

5.6.1 Approach to Metals Allocations

The TMDL is comprised of the sum of the load allocations (LA) and wasteload allocations (WLA) to all significant nonpoint and point sources, respectively (natural and human), plus a margin of safety (MOS) that accounts for uncertainties in loading and receiving water analyses. WLAs are allowable pollutant loads that are assigned to permitted and non-permitted point sources. LAs include the pollutant load from naturally occurring sources.

In addition to metals load allocations, the TMDL must also consider the seasonal variability of metals loads and adaptive management strategies to address uncertainties inherent in environmental analyses. This is accomplished using a margin of safety (MOS) in the TMDL calculation. These elements are combined in the following equation:

Equation 5-2: TMDL = ΣLA + ΣWLA + MOS

LA = Load allocation or the portion of the TMDL allocated to natural background (LA_{nb})
WLA = Wasteload allocation to abandoned mines and human sources (Comp WLA_{AB+HS}),
and point sources with active MPDES permits (WLA_{ACTIVE})
MOS = Margin of Safety

The MOS is an accounting of uncertainty about the relationship between metals loads and receiving water quality. An implicit MOS, as discussed later in **Section 5-8**, is applied to all metals TMDLs. Therefore, the explicit MOS in the above equation is equal to zero and no longer included within the equation and discussion of allocations in this section.

Metals allocations are based on metal sources, which include the following:

- Natural background (non-anthropogenic sources such as influences from local geology)
- Abandoned mines and other human sources

- in-stream and floodplain metals deposits from historical mining operations
- drainage/runoff from abandoned mines, including adits (entrances) and tailings (waste piles)
- disturbance from permitted mines that fall under the opencut mining permits, small miner exclusion, and exploratory mining activities that do not require an MPDES permit
- upland disturbances from human activities (agriculture, recreation)
- any other nonpoint sources, which can accelerate erosion of mineralized soils

5.6.1.1 Natural Background Loading (LA_{NB})

Natural background loading of metals occurs as a result of regional and local geologic conditions. Therefore, natural background loading was accounted for separately from other human-caused sources in the TMDL allocations.

Natural background concentrations were estimated from DEQ water quality sampling sites with similar natural geology as the streams in the Red Rock watershed receiving TMDLs, but with low mining impacts. DEQ sample sites with similar geology as sites in the Red Rock were determined using ecoregion boundaries (**Figure 2-7**). ArcGIS was used to select the sites that had no known active or abandoned mines upstream based on the MBMG and DEQ Abandoned Mines layers. Next, the median value of each metal parameter across all visits to a site was determined. The 75th percentile of these site-level values in an ecoregion was used to estimate the representative chemistry for that ecoregion. However, because the preliminary analysis indicated that most of the parameters did not vary by ecoregion, the average of site-level values across all ecoregions was used as the natural background concentration for most parameters.

The exception was aluminum, arsenic, and lead. These parameters varied by eco-region. Reference-site values were averaged across each ecoregion that comprised a large portion of the watershed upstream of sampling points. For instance, Bloody Dick and Trail creeks flow through both ecoregions 17aa and 17ab.The aluminum background concentration of 24 µg/L for Bloody Dick and Trail creeks was determined as the average of 11.28 µg/L (75th percentile for ecoregion 17aa) and 35.05 µg/L (75th percentile for Ecoregion 17ab). Refer to **Table 5-26** for final natural background concentrations and to **Appendix B**, Water Quality Data, for a list of raw reference water quality data.

Table 5-25. Background Concentrations Used in Load Allocations

Parameter	Level III Ecoregions of Reference Sites	Subwatersheds Applied	Sample Count	Background Concentration (µg/L)
Aluminum	17aa,17ab	Bloody Dick, Trail	8	24
	17af,17ab	Fish	11	62
	17aa,17e	Nicholia	4	56
Arsenic	17af,17ab	Metzel	12	3
	17aa,17b	Muddy	6	3
	17aa,17af,17e	Peet, Price	14	6
Cadmium	All	All	22	0.06
Copper	All	All	22	0.9
Iron	All	All	22	221
Lead	17aa,17ab	Bloody Dick	8	0.48

Table 5-25. Background Concentrations Used in Load Allocations

Parameter	Level III Ecoregions of Reference Sites	Subwatersheds Applied	Sample Count	Background Concentration (µg/L)
Selenium	All	All	21	1.1

The natural background load is equal to the natural background allocation under all conditions in this document and can be calculated for each flow for each stream as follows:

Equation 5-3: LA_{NB} = Natural Background Load Allocation (lbs/day) = (X) (Y) (k)
*X = Natural background concentration in µg/L (provided in **Table 5-25**)*
Y = streamflow in cubic feet per second
k = conversion factor of 0.0054

If future monitoring allows for determination of a more representative natural background loading contribution or indicates different background concentrations than indicated in **Table 5-26**, the allocations may be changed via an adaptive management process (**Section 8-2**)

5.6.1.2 Abandoned Mines and Other Human Caused Sources (Comp WLA_{AB+HS})

The contribution from all historical mining activities (e.g., abandoned mines, waste rock, tailings, etc.) and all other human caused metals sources (agriculture, roads etc.) in a contributing area or entire watershed is grouped into a composite WLA for abandoned mines and human sources. This approach assumes that reductions in metals loading can be achieved through the remediation of the abandoned mines and the use of best management practices (BMPs) to control the other pollutant loads. The composite $CompWLA_{AB+HS}$ is determined by calculating the difference between the TMDL and the sum of the natural background load and the load from any active MPDES-permitted mines or upstream sources (**Section 5.6.1.4**).

In the case of the metals impaired subwatersheds in the Red Rock TPA, there is not enough data from individual abandoned mines to allocate a percentage of the TMDL to an individual site. However, because the available information is insufficient to rule out the possible existence of features at abandoned mine sites that meet the Clean Water Act definition of a point source, which is "a discernible, confined, and discrete conveyance…from which pollutants are or may be discharged (40 CFR 122.2), the WLA includes metals coming from abandoned mines (WLA_{AB}).

There are also human activities that take place in these subwatersheds that may be mobilizing metals via increased erosion. These potential human-caused sources are diffuse low impact sources (e.g., roads, activities associated with agriculture, other sediment/metals producing sources). In most cases, the connection between these land disturbances and their potential contributions of metals pollution is not clear. However, these sources cannot be completely discounted as potential metals loading pathways or sources. While opencut and small miner exclusion mining operations are generally considered to have a zero or negligible contribution, any contribution from these sources is also included in the human-caused sources portion of the equation (WLA_{HS}).

5.6.1.3 Active Mines (WLA_{ACTIVE})

No mining operations with MPDES permits are currently present in the Red Rock watershed. However, any future dischargers would be required to provide a record of potential contaminants leaving their facilities. The WLA_{ACTIVE} allocation is estimated by summing the load for each outfall associated with individual permittees having MPDES permits.

Equation 5-4: WLA_{ACTIVE} = ΣWasteload Allocation from Individual Active Permits (lbs/day) = (X) (Y) (k)
*X = Water quality standard in µg/L (provided in **Table 5-26**)*
Y = flow from all outfall
k = conversion factor of 0.0054

5.6.2 Approach to Calculating Metals TMDLs and Allocations

TMDLs address impairments that are a result of water quality standard exceedances. Metals allocations consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. The WLA_{ACTIVE} was set to zero given the lack of MPDES permits in the watershed. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation. Metals TMDLs are described by the following equation:

Equation 5-6: TMDL = LA_{NB} + WLA_{ACTIVE} + Comp WLA_{AB+HS}

LA_{NB} *= Load allocation to natural background sources*
Comp WLA_{AB+HS} = *Wasteload allocation to abandoned mining point sources and all other human sources*
WLA_{ACTIVE} *=Wasteload allocation from active mines with effective MPDES permits, if applicable*

To determine the percent reduction needed, the TMDL must be compared to the Existing Load, which depends on the current metals concentration:

Equation 5-7: Existing load (lbs/day) = (X) (Y) (0.0054)
X = Metal concentration in water (µg/L) (highest for given flow conditions; see below)
Y = streamflow in cubic feet per second (cfs)

Low-flow sampling conditions were considered to occur when the stream flow was less than 50% of the maximum flow collected at the site, where high flow conditions were considered to occur when the stream flow was greater than 50% of the maximum flow at the site. The following steps were used to calculate wasteload allocations and amount of reductions needed to meet water quality standards, unless otherwise indicated:

Step 1: Use equations in **Table 5-26** to determine the concentration of the pollutant that is toxic at the lowest hardness value measured for the low and high flow conditions. If the hardness value is less than 25 *µg/L*, substitute a value of 25 *µg/L* for the hardness value.
Step 2: Multiply the concentration in step 1 by the highest stream flow within the low and high flow conditions, and conversion factor (**Equation 52**) to obtain the TMDL.
Step 3: Calculate the natural background load allocation (LA_{NB}) using **Equation 53** using concentrations in **Table 5-27** and the stream flows used in step 2.
Step 4: Subtract the LA_{NB} from the TMDL to determine the Comp WLA_{AB+HS}
Step 5: The percent reduction needed is the reduction in anthropogenic loading needed to meet water quality criteria:
(Existing Load –TMDL) / (Existing Load) * 100

Using the highest stream flow and concentrations measured within the low and high flow conditions allowed for a significant margin of safety by basing the example TMDL on a maximum amount of loading previously measured at the site. Exceptions to this approach occurred if all exceedances occurred upstream or downstream of a particular location with an apparent change in stream flow or concentration indicating a possible source. In this case, only data from the site (s) where exceedances occurred were used. These exceptions are described in **Sections 5.7.1 through 5.7.10**, which gives the allocations for each segment.

These TMDL examples are based on previously measured water quality data and streamflow data, but do not represent all conditions that could occur. Refer to **Appendix C** for example TMDLs with increasing stream flow.

5.7 Metal TMDLs and Allocations by Waterbody Segment

Metals TMDLs are presented herein and summarized in **Tables 5-28** through **5-37**. A TMDL is a calculation of the maximum pollutant load a waterbody can receive while maintaining water quality standards (**Sections 4.0** and **5.6**). The TMDLs presented below are based on the most stringent applicable water quality criteria identified in **Table 5-24** and an example streamflow and/or hardness. To determine the TMDL at a different streamflow and hardness, refer to **Table 5-24** and **Appendix C.**

In the sections that follow, a loading summary and source load allocations are provided for each waterbody-pollutant combination for which a TMDL is prepared. Loading summaries are based on the sample data used for metals target evaluations. For each waterbody-pollutant combination, water quality and flow volume data are used to calculate metals loading estimates and the required percent load reduction to achieve the TMDL. Load estimations and allocations are based on a limited data set and are assumed to approximate general metals loading during high and low flow conditions. Refer to **Appendix C** for specific data and calculations used in developing allocations.

5.7.1 Bloody Dick Creek TMDLs and Allocations (MT41A003_100)

TMDLs for Bloody Dick Creek address impairments that are a result of aluminum and lead water quality standard exceedances. No readily identifiable individual sources are present from human activities or active mines. Therefore, metals allocations for Bloody Dick Creek consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

Water quality data indicate that low hardness levels are present in Bloody Dick Creek. The low and high flow condition was based on hardness and flow collected at site M01BDYDC07, which had the highest concentrations of both aluminum and lead. The TMDL for both lead and aluminum was exceeded at low and high flow events (**Table 5-26**).

Table 5-26. Bloody Dick Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Aluminum	Low	263.17	89.07	24.57	64.50	66%
	High	361.72	215.54	59.45	156.09	40%

Table 5-26. Bloody Dick Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Lead	Low	0.72	0.56	0.49	0.066	22%
	High	1.73	1.35	1.19	0.16	22%

*Example conditions based upon: low flow =189.6 cfs; low flow hardness=25; low flow aluminum concentration=257; low flow lead concentration=0.70 µg/L; natural lead concentration=0.4 µg/L; high flow=458.81 cfs; high flow hardness=25; high flow aluminum concentration=146 µg/L; high flow lead concentration=0.70 µg/L; natural aluminum concentration 24 µg/L

5.7.2 Fish Creek TMDLs and Allocations (MT41A004_030)

TMDLs for Fish Creek address impairments that are a result of aluminum water quality standard exceedances. individual sources are present from human activities or active mines .Therefore, metals allocations for Fish Creek consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

The TMDL for aluminum was exceeded at low flows (**Table 5-27**).

Table 5-27. Fish Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Aluminum	Low	2.22	1.05	0.75	0.30	52%
	High	0.40	2.18	1.55	0.63	0%

*Example conditions for lead based upon: low flow=2.25 cfs; low flow concentration= 183 µg/L; high flow=4.63 cfs; high flow concentration = 16 µg/L; natural aluminum concentration = 62 µg/L

5.7.3 Little Sheep Creek TMDLs and Allocations (MT41A003_160)

TMDLs for Little Sheep Creek address impairments that are a result of iron water quality standard exceedances. No readily identifiable individual sources are present from human activities or active mines. Therefore, metals allocations for Little Sheep Creek consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6.1.**

The TMDL for iron was exceeded at low and high flow events. Both exceedances occur at the upstream site M01LSHPC50 and the TMDL examples are based on data from this site (**Table 5-28**).

Table 5-28. Little Sheep Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow	Existing Load* (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Iron	Low	194.61	58.26	12.87	45.39	70%
	High	149.25	120.36	26.60	93.76	19%

Table 5-28. Little Sheep Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow	Existing Load* (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed

*Example conditions based upon: low flow=10.79 cfs; low flow concentration=3,340 µg/L; high flow = 22.29 cfs; high flow concentration = 1,240 µg/L; natural iron concentration=221 µg/L

5.7.4 Medicine Lodge Creek TMDLs and Allocations (MT41A003_010)

TMDLs for Medicine Lodge Creek address impairments that are a result of iron water quality standard exceedances. No readily identifiable individual sources are present from human activities or active mines. Therefore, metals allocations for Medicine Lodge Creek consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

The TMDL for iron was exceeded at both low and high flow events. The TMDL examples are based on data collected at the only site where exceedances were documented, the downstream site M01MEDLC05 (**Table 5-29**).

Table 5-29. Medicine Lodge Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Iron	Low	3.33	2.27	0.50	1.77	32%
	High	48.19	27.54	6.09	21.45	43%

*Example conditions for high and low flow based upon: low flow =0.42 cfs; low flow concentration = 1,470 ug/L; high flow =5.10 cfs; high flow concentration=1,750 ug/L; natural iron concentration=221 µg/L

5.7.5 Metzel Creek TMDLs and Allocations (MT41A004_020)

TMDLs for Metzel Creek address impairments that are a result of arsenic water quality standard exceedances. No readily identifiable individual sources are present from human activities or active mines. Therefore, metals allocations for Metzel Creek consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

The TMDL for arsenic was exceeded during both low and high flow events. All exceedances occur at the downstream site M01MTZLC03 near the mouth and the example TMDLs are based on data collected at that site (**Table 5-30**).

Table 5-30. Metzel Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Arsenic	Low	0.19	0.145	0.0445	0.10	23%
	High	0.32	0.25	0.075	0.17	23%

Table 5-30. Metzel Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed

* Example conditions based upon: low flow=2.70 cfs; low flow arsenic concentration = 13 µg/L; high flow=4.61 cfs; high flow arsenic concentration =13 µg/L; natural arsenic concentration = 3 µg/L

5.7.6 Muddy Creek TMDLs and Allocations (MT41A003_020)

TMDLs for Muddy Creek address impairments that are a result of arsenic and iron water quality standard exceedances. No readily identifiable individual sources are present from human activities or active mines. Therefore, metals allocations for Muddy Creek consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

Arsenic and iron TMDL exceedances occurred at high flows (**Table 5-31**).

Table 5-31. Muddy Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Arsenic	Low	0.037	0.046	0.014	0.033	0%
	High	0.15	0.125	0.038	0.088	16%
Iron	Low	3.76	4.65	1.03	3.62	0%
	High	74.73	12.58	2.78	9.80	83%

* Example conditions based upon: low flow=0.86 cfs; low flow arsenic concentration= 8 µg/L; low flow iron concentration=810 µg/L; high flow=2.33 cfs; high flow arsenic concentration =12 µg/L; high flow iron concentration = 5,940 µg/L; natural arsenic concentration=3 µg/L; natural iron concentration =221 µg/L

5.7.7 Peet Creek TMDLs and Allocations (MT41A004_090)

TMDLs for Peet Creek address impairments that are a result of cadmium, copper, and selenium water quality standard exceedances. No readily identifiable individual sources are present from human activities or active mines Therefore, metals allocations consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6.1**.

The TMDLs for cadmium, copper, and selenium were exceeded at low flows (**Table 5-32**).

Table 5-32. Peet Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Arsenic	Low	0.133	0.088	0.053	0.035	33%
	High	0.221	0.369	0.221	0.148	0%
Cadmium	Low	0.038	0.008	0.001	0.007	79%

Table 5-32. Peet Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
	High	0.007	0.032	0.002	0.030	0%
Copper	Low	0.142	0.092	0.008	0.084	35%
	High	0.074	0.382	0.033	0.349	0%
Selenium	Low	0.071	0.044	0.010	0.034	36%
	High	0.008	0.184	0.041	0.144	0%

*Example conditions based upon low flow=1.64 cfs; low flow hardness=113; low flow arsenic concentration = 15 µg/L; low flow cadmium concentration = 4.31 µg/L; low flow copper concentration =16 µg/L; low flow selenium concentration = 8 µg/L; high flow=6.83 cfs; high flow hardness=113; high flow arsenic concentration = 6 µg/L ; high flow cadmium concentration =0.21 µg/L; high flow copper concentration = 2 µg/L; high flow selenium concentration =0.22 µg/L; natural cadmium concentration =0.06 µg/L; natural copper concentration =0.90 µg/L; natural selenium concentration= 1.10 µg/L

5.7.8 Price Creek TMDLs and Allocations (MT41A004_010)

TMDLs for Price Creek address impairments that are a result of arsenic water quality standard exceedances. There are no readily identifiable individual sources are present from human activities or active mines. Therefore, metals allocations for Price Creek consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

The arsenic TMDL was exceeded during low flows (**Table 5-33**).

Table 5-33. Price Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Arsenic	Low	0.00302	0.00216	0.00130	0.00086	28%
	High	0.048	0.120	0.072	0.048	0%

*Example conditions based upon: low flow =0.040 cfs; low flow concentration =14 µg/L, high flow=2.23 cfs; high flow concentration = 4 µg/L; natural arsenic concentration = 6 µg/L

5.7.9 Trail Creek TMDLs and Allocations (MT41A003_080)

TMDLs for Trail Creek address impairments that are a result of an aluminum water quality standard exceedance. There are no readily identifiable individual sources are present from human activities or active mines. Therefore, metals allocations for Trail Creek consist of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

Samples at all sites exceeded the chronic aluminum standard. The aluminum TMDL was exceeded at low and high flow events (**Table 5-34**).

Table 5-34. Trail Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Aluminum	Low	42.61	26.29	7.25	19.04	38%
	High	71.71	55.70	15.36	40.34	22%

*Example conditions based upon: low flow=55.96 cfs; low flow concentration = 141 µg/L; high flow =118.56 cfs; high flow concentration = 112 µg/L; natural aluminum concentration = 24 µg/L

5.8 Metals Seasonality and Margin of Safety

All TMDL documents must consider the seasonal variability (seasonality) and influence of varying water flows on water quality impairment conditions, TMDLs, and allocations. TMDL development must also incorporate a margin of safety (MOS) to account for uncertainties in pollutant sources and other watershed conditions and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes the considerations of seasonality and an MOS in the Red Rock TPA metals TMDL development process.

5.8.1 Seasonality

Seasonality addresses the need to ensure year-round beneficial use support. Seasonality is considered for assessing loading conditions and for developing water quality targets, TMDLs, and allocation schemes. In general, it is considered typical for high flows to occur in spring and the lowest flows to occur in summer, near the time of irrigation water withdrawals. However, high and low flows can occur at any time. For metals TMDLs, consideration of streamflow is important because metals loading pathways and water hardness change from high to low flow conditions. During high flows, overland flow and erosion of metals-contaminated soils and mine wastes tend to be the major cause of elevated metals concentrations. During low flow, groundwater and/or mine adit discharges may be a more significant contributing source of elevated metals concentrations. Additional loading sources that are dependent on streamflow and/or seasonality include contributions such as stormwater runoff and natural background. Seasonality/flow effects are addressed in this document as follows:

- Metals concentrations and loading conditions are evaluated for both high flow and low flow conditions. DEQ's assessment method uses a combination of both high and low flow sampling for target evaluation since abandoned mines and other metals sources can lead to elevated metals loading during high and/or low flow conditions.
- Metals TMDLs incorporate streamflow as part of the TMDL equation.
- Metals concentration targets apply year-round, with monitoring criteria for target attainment developed to address flow-related seasonal water quality extremes associated with loading and hardness variations.
- A sediment chemistry target is often applied as a supplemental indicator to help capture impacts from episodic metals loading events that could be attributed to high flow runoff conditions.
- When applicable, targets, TMDLs and load reduction are developed for example high and low flow conditions. The TMDL equation incorporates all potential flow conditions that may occur during any season.

5.8.2 Margin of Safety

The margin of safety (MOS) is to ensure that TMDLs and allocations are sufficient to sustain conditions that will support designated uses. All metals TMDLs in this document incorporate an implicit MOS in several ways, using conservative assumptions throughout the TMDL development process, as summarized below:

- DEQ's assessment process includes a mix of high and low flow sampling since abandoned mines and other metals sources may contribute to elevated metals loading during high and/or low flow stream conditions. The seasonality considerations help identify the low range of hardness values and thus the lower range of applicable TMDL values shown within the TMDL graphs and captured within the example TMDLs.
- Target attainment, refinement of allocations, and, in some cases, impairment validations and TMDL-development decisions are all based on an adaptive management approach that relies on future monitoring and assessment for updating planning and implementation efforts.
- Although a 10% exceedance rate is allowed for chronic and acute based aquatic life targets, the TMDLs are set so the lowest applicable target is satisfied 100% of the time. This focuses remediation and restoration efforts toward 100% compliance with all targets, thereby providing a MOS for the majority of conditions. As part of this, the existing water quality conditions and needed load reductions are based on the highest measured value for a given flow condition to consistently achieve the TMDL.
- The monitoring results used to estimate existing water quality conditions are instantaneous measurements used to estimate a daily load, whereas chronic aquatic life standards are based on average conditions over a 96-hour period. This provides a MOS since a four-day loading limit could potentially allow higher daily loads, in practice.
- The lowest or most stringent numeric water quality standard was used for TMDL target and impairment determination for all waterbody – pollutant combinations. This ensures protection of all beneficial uses.
- Sediment metals concentration criteria were used as a supplemental indicator target. This helps ensure that episodic loading events were not missed as part of the sampling and assessment activity.
- The TMDLs are based on numeric water quality standards for Montana, which follow nationally recommended water quality standards developed by EPA or were determined using scientifically-based rationale by Montana DEQ.

5.9 Uncertainty and Adaptive Management

DEQ maintains Standard Sampling Analysis Plans (MTDEQ 2020) and internal data quality and assurance protocols to ensure that data is of known (and acceptable) quality.

The accuracy of source assessments and loading analyses is another source of uncertainty. Most sources are based on Geographic Information System tools, water chemistry or sediment data collected, and known relationships pertaining to processes on the landscape. An adaptive management approach that revisits or updates knowledge and assumptions to improve these estimates is vital to maintaining stakeholder involvement.

The metals TMDLs developed for the Red Rock TMDL Planning Area are based on future attainment of water quality standards. To achieve this, all significant sources of metals loading must be addressed via all reasonable land, soil, and water conservation practices. **Section 8** further describes potential water quality improvements recommendations.

DEQ recognizes however, that despite all reasonable efforts, this may not be possible due to natural background conditions and/or the potential presence of unalterable human-caused sources that cannot be fully addressed via reasonable remediation approaches. For this reason, an adaptive management approach is adopted for all metals targets described within this document. Under this adaptive management approach, all metals impairments that required TMDLs will ultimately fall into one of the categories identified below:

- Restoration achieves the metal pollutant targets and all beneficial uses are supported.
- Targets are not attained because of insufficient controls; therefore, impairment remains, and additional source remedies are needed.
- Targets are not attained after all reasonable best management practices (BMPs) and applicable abandoned mine remediation activities are applied. Under these circumstances, site-specific standards may be necessary.
- Targets are unattainable due to naturally occurring metals sources. Under this scenario, site-specific water quality standards and/or the reclassification of the waterbody may be necessary. This would then lead to a new target (and TMDL) for the pollutant(s) of concern, and the new target would reflect the background condition.

DEQ conducts revisits sites as time and resources allows, often to understand how water quality is responding to changes in land use or restoration activities. This monitoring and restoration conducted by other parties (e.g., USFS, the Montana Department of Natural Resources & Conservation's (DNRC) Trust Lands Management Division, Montana Bureau of Mines and Geology, conservation organizations) should be incorporated into the target attainment and review process. This data and resources can be used towards listing or delisting of waterbodies on the Impaired Waterbodies List. Cooperation among agency land managers in the adaptive management process for metals TMDLs will help identify further cleanup and load reduction needs, evaluate monitoring results, and identify water quality trends.

6.0 Sediment TMDL Components

This portion of the document focuses on sediment as a cause of water quality impairment in the Red Rock Total Maximum Daily Load (TMDL) Planning Area (TPA). It describes: (1) how excess sediment impairs beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to sediment impairments in the planning area, (4) the sources of sediment, based on recent studies, and (5) the sediment TMDLs and their rationales.

6.1 Effects of Excess Sediment on Beneficial Uses

Sediment is a naturally occurring component of healthy and stable stream and lake ecosystems. Regular flooding allows sediment deposition to build floodplain soils and point bars, and it prevents excess scour of the stream channel (Knighton 1998). Riparian and wetland vegetation and natural instream barriers such as large woody debris, beaver dams, or overhanging vegetation help trap sediment and build channel and floodplain features. When these barriers are absent or excessive sediment enters the system from increased bank erosion or other sources, it may alter channel form and function and affect fish and other aquatic life by increasing turbidity and causing excess sediment to accumulate in critical aquatic habitat areas (Suttle et al. 2004, Sullivan et al. 2010).

Specifically, sediment may block light and cause a decline in plant and algal growth, and it may also interfere with fish and macroinvertebrate survival and reproduction. Fine sediment deposition reduces availability of suitable spawning habitat for salmonid fishes, such as trout, and can smother eggs or fry (Bowerman et al. 2014). Effects from excess sediment are not limited to suspended or fine sediment; an accumulation of larger sediment (e.g., cobbles) can fill pools, reduce the percentage of desirable particle sizes for fish spawning, and cause channel overwidening (which may lead to additional sediment loading and/or increased temperatures). This larger sediment can also reduce or eliminate flow in some stream reaches when it is deposited in excess within the channel, causing flow to go subsurface (May and Lee, 2004). Although fish and aquatic life are typically the most sensitive beneficial uses regarding sediment, excess sediment may also affect other uses. For example, high concentrations of suspended sediment in streams can cause water to appear murky and discolored, negatively impacting recreational use, and can increase filtration costs for water treatment facilities that provide safe drinking water.

6.2 Sediment TMDL Stream Segments

Based on the comparison of existing conditions to water quality targets, Montana Department of Environmental Quality (DEQ) evaluated 19 segments and developed 18 sediment TMDLs in the Red Rock TPA (**Table 6-1**)**:** Bean, Big Sheep, Corral, East Fork Clover, Fish, Horse Prairie, Long, Jones, Medicine Lodge, Muddy, O'Dell, Peet, Price, Sage, Red Rock, Selway, Tom, and Trail Creeks (**Figure 6-1**). A TMDL was not developed for Bloody Dick Creek, which met targets (**Appendix D**) TMDLs for the sediment-impaired waterbodies of Red Rock River and Upper and Lower Red Rock Lakes require more data and analysis and were not written as part of this document. For a complete list of streams evaluated for sediment and details of the DEQ 2017-2018 sampling effort, see **Appendix D**. Habitat alterations are non-pollutant impairment causes commonly associated with sediment impairment. TMDLs are limited to pollutants, but implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some non-pollutant impairments (further discussed in **Section 8.0**).

Table 6-1. Sediment TMDLs in this Document

Waterbody (Assessment Unit)	Assessment Unit ID
Bean Creek	MT41A004_140
Big Sheep Creek	MT41A003_150
Corral Creek	MT41A004_040
East Fork Clover Creek	MT41A004_050
Fish Creek	MT41A004_030
Horse Prairie Creek	MT41A003_090
Long Creek	MT41A004_070
Jones Creek	MT41A004_130
Medicine Lodge Creek	MT41A003_010
Muddy Creek	MT41A003_020
O'Dell Creek	MT41A004_080
Peet Creek	MT41A004_090
Price Creek	MT41A004_010
Sage Creek	MT41A003_140
Red Rock Creek	MT41A004_110
Selway Creek	MT41A003_110
Tom Creek	MT41A004_100
Trail Creek	MT41A003_080

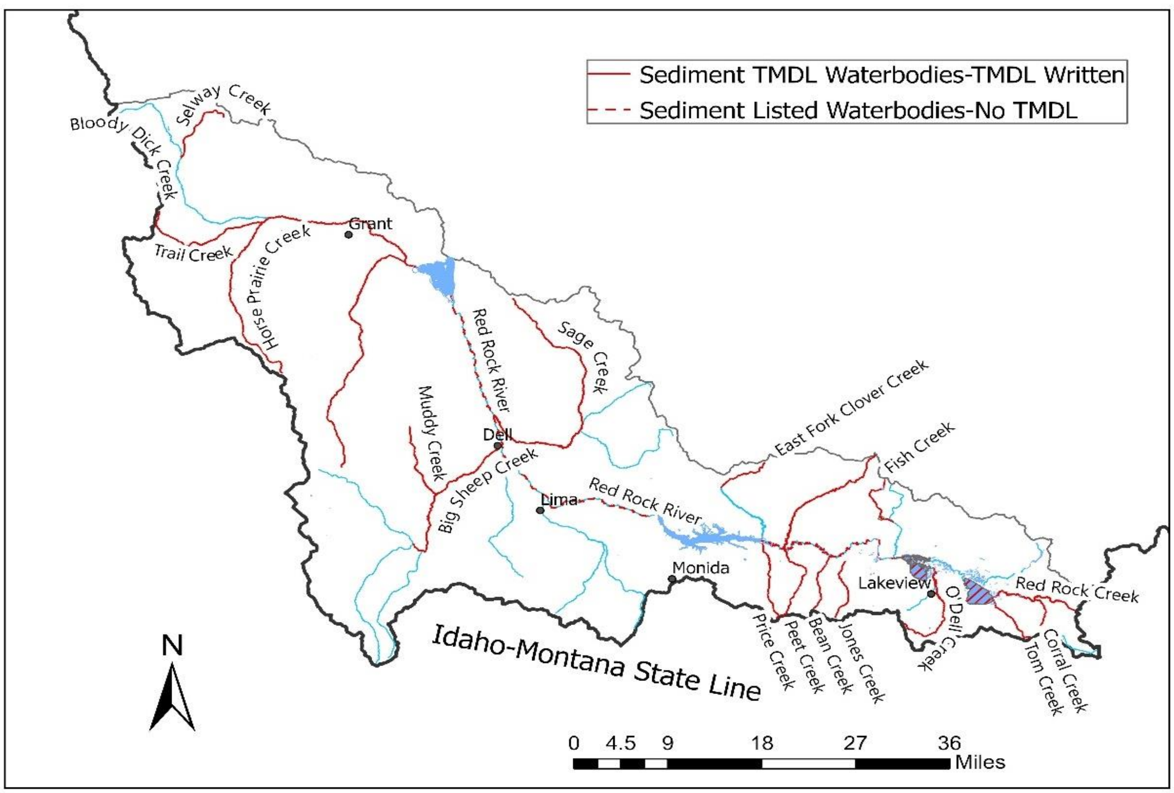

Figure 6-1. Sediment TMDL Stream Segments in the Red Rock TMDL Planning Area

6.3 Information Sources and Assessment Methods

Sediment TMDL development involves a review of available sediment and habitat data and field investigations to characterize overall stream health conditions and quantify sources of sediment loading. DEQ compiled available sediment data and performed additional field investigations during 2017 and 2018 according to DEQ's Standard Operating Procedure for sediment collection (Makarowski 2019) and DEQ's field methodology for sediment and habitat source assessment (DEQ 2012b). Summarized field approach can be found in **Appendix D**. The data sources listed below were used to characterize water quality and/or develop TMDL targets:

- DEQ Assessment Files (cwaic.mt.gov)
- DEQ Sediment and Habitat Assessment Field Data (DEQ 2017-2018)
- DEQ Bank Erosion Hazard Index and Greenline Field Data (DEQ 2017-2018)
- DEQ Unpaved Road GIS Assessment (DEQ 2021)
- U.S. Forest Service Pacfish/Infish Biological Opinion (PIBO) Program Data
- DEQ reference site data
- Other data and reports

6.4 Water Quality Targets and Target Development Rationale

The concept of water quality targets is presented in **Section 4.1**. This section provides the rationale for each sediment-related target parameter and discusses the basis of the target values. In developing targets, natural variation within and among streams must be considered. DEQ uses the reference condition to gage natural variability and assess the effects of pollutants with narrative standards, such as sediment, see **Appendix A** for more detail. The preferred approach to establishing the reference condition is using reference site data; however, modeling, professional judgment, and literature values may also be used. Although sediment water quality targets typically relate most directly to the aquatic life beneficial use, the targets are intended to protect all designated beneficial uses because they are based on the reference approach, which strives for the highest achievable quality condition.

Several statistical approaches that DEQ uses for target development are discussed in **Appendix A**. They include using percentiles of reference data. If reference data is unavailable, other approaches may be used. Although the basis for target values may differ by parameter, the goal is to define achievable sediment conditions that represent a translation of the narrative sediment standards, which indicate that there can be no increases in sediment above naturally occurring concentrations which are likely to create a harm to beneficial uses, such as drinking water, recreation, and aquatic life.

6.4.1 Targets Summary

Consistent with EPA guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999), water quality targets for the Red Rock TMDL Planning Area include a suite of measurements of instream siltation, channel form, and habitat characteristics that contribute to loading, storage, and transport of sediment, or that demonstrate those effects. Water quality targets most closely linked to sediment accumulation or sediment-related effects to aquatic life habitat are given the most weight (i.e., fine sediment indices).

Sediment-related water quality targets for the Red Rock TPA are summarized in **Table 6-2** and described in detail in the sections that follow. These targets are based on reference site data discussed in **Section 5.4.2**.

the exceedance of one or more target values does not necessarily equate to an impairment determination; the relative magnitude to which one or more targets are exceeded is taken into account, as well as the existing 303(d) listing (e.g., impaired stream listing) status for sediment. The combination of target analysis, qualitative observations, and sound scientific professional judgment is crucial when assessing stream condition. Site-specific conditions such as recent wildfires, changes in beaver activity, flow variability, or other natural long term or episodic events within a watershed may warrant the selection of unique indicator values that differ from those presented below, or alternate interpretation of the data relative to the sediment target values. For all water quality targets, future surveys should document stable (if meeting criterion) or improving trends.

Target parameters and values are based on the current best available information but will be assessed during future TMDL reviews for their applicability and may be modified if new information provides a better understanding of reference conditions or if assessment metrics or field protocols are modified.

Table 6-2. Sediment targets for the Red Rock TMDL Planning Area

Parameter Type	Target Description	Criterion applicable to:	Target
Fine Sediment	Percentage of surface fine sediment < 6 mm in riffles via pebble count (site value) (1)	Channel slope ≤ 2% (excludes E channels)	≤ 19%
		Channel slope > 2%	≤ 16%
		Rosgen E channels	≤ 28%
	Percentage of surface fine sediment < 2mm in riffles via pebble count (site value) (1)	Channel slope ≤ 2% (excludes E channels)	≤ 17%
		Channel slope > 2%	≤ 12%
		Rosgen E channels	≤ 22%
	Percentage of fine surface sediment < 6mm in pool tails via grid toss (site average) (1)	Channel slope ≤ 2% (excludes E channels)	≤ 15%
		Channel slope > 2%	≤ 13%
		Rosgen E channels	≤ 22%
Channel Form and Stability	Bankfull width/depth ratio (site average) (2)	< 15 ft bankfull width	≤ 11
		15 ft - 30 ft bankfull width	≤ 24
		> 30 ft bankfull width	≤ 30
	Entrenchment ratio (site average)	Rosgen A stream type	≤ 1.6
		Rosgen B stream type	≥ 1.2
		Rosgen C and E stream types	≥ 2.0
Instream Habitat	Residual pool depth (site average) (2)	< 15’ bankfull width	≥ 0.7 ft
		15’-30’ bankfull width	≥ 0.9 ft
		> 30’ bankfull width	≥ 1.4 ft
	Pools/1000 ft (2)	< 15’ bankfull width	≥ 16
		15’-30’ bankfull width	≥ 4

Table 6-2. Sediment targets for the Red Rock TMDL Planning Area

Parameter Type	Target Description	Criterion applicable to:	Target
		> 30’ bankfull width	≥ 3

[1] Primary indicator used to determine sediment impairment (Kusnierz et al., 2013)
[2] Primary indicator used to determine habitat impairment (Kusnierz et al., 2013)

6.4.2 Target Development Rationale

Targets were developed using a statistical approach consistent with **Appendix A**. Targets represent naturally occurring conditions, which is consistent Montana’s water quality standard for sediment as described in **Section 3.2**.

6.4.2.1 Percent Fine Sediment < 6mm and < 2mm in Riffles via Pebble Count

Surface fine sediment measured in riffles by a modified Wolman pebble count (Wolman, 1954) can point to excessive sediment loading. Pebble counts by DEQ at reference sites and at stream assessment sites in the Red Rock TMDL Planning Area were conducted in four riffles per sampling site for a total of at least 400 particles.

Targets vary by channel slope categories. High gradient reaches are typically “transport” reaches where slope and velocity are conducive to the movement of sediment through a system. Conversely, low gradient reaches tend to deposit sediment on the stream bottom. As a result, it is expected that transport reaches will have less percent surface fines than low gradient reaches and thus targets are split into ≤ 2% and > 2% channel slope categories. Due to the high sinuosity (>1.5) of Rosgen E channels), fine sediment is readily stored and they tend to have a higher percentage of fines than other channel types. Because of this inherent difference, Rosgen E channels were examined separately. The targets for percent fine sediment < 6mm and < 2 mm in riffles are set at less than or equal to the 75th percentile of the combined DEQ Middle Rockies reference datasets for all streams except E channels in which the sites used as reference are described in **Appendix B** (**Table B-4**).

Target values should be compared to the overall site value from the individual pebble counts.

Table 6-3. DEQ data summary for reference sites and Red Rock TPA assessment sites for percent fine sediment < 6 mm. Targets are shown in bold

Data Source	Sample Size	Minimum	Median	Maximum	Target
DEQ reference data – Channel Slope ≤ 2% (excludes E channels)	3	0.3	8.7	29.1	**19**[a]
DEQ reference data – Channel Slope > 2%	12	0.5	13.0	20.5	**16**[a]
Supplemental Reference Sites (E channels only)	4	13.0	20.0	49.2	**28**[a]

[a] 75th percentile of the dataset

Table 6-4. DEQ data summary for reference sites and Red Rock TPA assessment sites for percent fine sediment < 2 mm. Targets are shown in **bold**

Data Source	Sample Size	Minimum	Median	Maximum	Target
DEQ reference data – Channel Slope ≤ 2% (excludes E channels)	3	0.3	7.4	27.1	**17**[a]
DEQ reference data – Channel Slope > 2%	12	0.5	11.1	18.5	**12**[a]
Supplemental Reference Sites (E channels only)	4	10.1	15.0	43.2	**22**[a]

[a] 75th percentile of the dataset

6.4.2.2 Percent Fine Sediment < 6mm in Pool Tails via Grid Toss

Grid toss measurements in pool tails assess the level of fine sediment accumulation in macro-invertebrate habitat and potential fish spawning sites. Three tosses of a 49-point grid (Kramer, et al., 1993) were used to estimate the percent surface fine sediment < 6mm in each pool tail in the Red Rock TPA. The percent fines < 6mm value in each pool tail were averaged to yield a site value. In addition to the data collected by DEQ, data collected by the PACFISH-INFISH Biological Opinion survey (PIBO) was also used (Archer et al. 2012). For the PIBO reference data, the value for each site was averaged across all site visits. The targets for percent fine sediment < 6mm in pool tails are set at less than or equal to the 75th percentile of the combined DEQ and PIBO Middle Rockies reference datasets for all streams except Rosgen E channels in which the sites used as reference are described in **Appendix D (Table 6-5)**. Similar to the riffle fines targets, pool tail targets were split into ≤ 2% and > 2% channel slope categories.

Table 6-5. Data summary for PIBO reference sites and Red Rock TPA assessment sites for percent fine sediment < 6mm via grid toss in pool tails. Targets are shown in bold

Data Source	Sample Size	Minimum	Median	Maximum	Target
DEQ and PIBO reference data – Channel Slope ≤ 2% (excludes E channels)	27	1.3	8.8	90.3	**15**[a]
DEQ and PIBO reference data – Channel Slope > 2%	30	0.5	6.5	95.8	**13**[a]
Supplemental Reference SItes (E channels only)	4	1.0	10.0	49.2	**22**[a]

[a] 75th percentile of the dataset

6.4.2.3 Width/Depth Ratio

DEQ Statistical analyses determined that width/depth ratio varied by bankfull width, therefore bankfull width was used to assign target values. The target values for width/depth ratio are based on the 75th percentile of the combined DEQ and PIBO Middle Rockies reference datasets and are defined by bankfull width category (**Table 6-6**). Values greater than the target represent an over widening of the channel.

Table 6-6. Data summary for DEQ and PIBO Middle Rockies reference sites for width/depth ratios. Targets are shown in bold

Data Source	Sample Size	Minimum	Median	Maximum	Target
< 15 ft bankfull width	17	6.4	10.6	14.9	**11**
15 - 30 ft bankfull width	34	14.2	20.1	43.4	**24**
> 30 ft bankfull width	5	25.5	29.1	34.4	**30**

6.4.2.4 Entrenchment Ratio

The entrenchment ratio is an index value used to describe the degree of vertical containment of a river channel. It is measured as the width of the flood prone area at an elevation twice bankfull depth, divided by the bankfull width. Delineative criteria based on Rosgen stream type classification for entrenchment was used (Rosgen, 1996). These literature values will serve as the basis for the entrenchment ratio targets in the Red Rock TPA **(Table 6-7)**.

Table 6-7. Entrenchment targets for the Red Rock TMDL Planning Area

Rosgen Stream Type	Target Value
A	**>1**
B	**≥ 1.4**
C, E	**≥ 2.2**

6.4.2.5 Instream Habitat Measures

The instream habitat measures are important indicators of sediment input and movement as well as fish and aquatic life support, but they may be given less weight in the target evaluation if they do not seem to be directly related to sediment impacts. The use of instream habitat measures in evaluating or characterizing sediment impairment needs to be considered from the perspective of whether these measures are linked to fine, coarse, or total sediment loading.

Residual Pool Depth

The residual pool depth is the difference in the maximum depth of a pool and the pool crest depth, which is the depth at the downstream end of the pool before it becomes a riffle. These measures varied by bankfull width, and therefore were developed for different bankfull width categories. For development of this target, both DEQ and PIBO data were used. The definition of pools for the PIBO protocol is similar to the definition used for DEQ site assessment data collection; both define a pool as having its maximum depth greater than or equal to 1.5 times the pool tail crest depth. However, the PIBO protocol only counts pools greater than half the wetted channel width whereas DEQ data collected during 2017 and 2018 counted all pools encountered. As a result, the DEQ dataset could potentially have a greater pool frequency and more pools with a smaller residual pool depth. When comparing the two datasets, however, there is little difference in residual pool depth (**Table 6-8**). As a result, the two were combined to develop the residual pool depth target.

Table 6-8. Residual pool depth and pool count comparisons between the DEQ and PIBO reference datasets

Dataset	Residual Pool Depth 25th Percentile (feet)			Pools/1000 feet 25th Percentile		
	< 15 ft bankfull width	15 - 30 ft bankfull width	> 30 ft bankfull width	< 15 ft bankfull width	15 - 30 ft bankfull width	> 30 ft bankfull width
DEQ Reference	0.7	0.9	1.3	25.8	12.0	3.9
PIBO Reference	0.7	0.9	1.6	11.2	3.9	3.9

Because the targets for residual pool depth and pool frequency are minimum values (i.e., larger values represent a preferred condition), the targets were based on the 25th percentile of the combined DEQ and PIBO reference datasets (**Table 6-9**). Target comparisons should be based on the reach average residual pool depth value. Because residual pool depths may indicate if excess sediment is limiting pool habitat, this parameter will be particularly valuable for future trend analysis. Future monitoring should document an improving trend (i.e., deeper pools and higher residual pool depths) at sites which fail to meet the target criteria.

Table 6-9. Data summary for DEQ and PIBO Middle Rockies reference sites for residual pool depth. Targets are shown in bold

Data Source	Sample Size	Minimum	Median	Maximum	Target
< 15 ft bankfull width	18	0.3	1.0	3.8	**0.7**
15 - 30 ft bankfull width	35	0	1.3	2.1	**0.9**
> 30 ft bankfull width	6	1.1	1.6	2.1	**1.4**

Pool Frequency

Pool frequency is the number of measured pools per site and scaled to frequency per 1,000 feet of stream reach. As mentioned in the previous section, methods for identification of pools between the DEQ and PIBO datasets differed because PIBO only counts pools greater than 1.5 times the wetted width. However, when all pools were counted regardless of size, the majority were greater than one half the wetted channel width. As a result, the two datasets were combined and the 25th percentile was used to develop the pool frequency targets (**Table 6-10**), A higher frequency value represents a preferred condition.

Table 6-10. Data summary for PIBO reference sites and Red Rock TPA assessment sites for pools/1,000 feet. Targets are shown in bold

Data Source	Sample Size	Minimum	Median	Maximum	Target
< 15 ft bankfull width	18	2.4	26.3	66.5	**16**
15 - 30 ft bankfull width	36	0	9.4	54.3	**4**
> 30 ft bankfull width	6	2.5	5.6	11.2	**3**

6.4.3 Existing Condition and Comparison to Water Quality Targets

This section presents summaries and evaluations of relevant water quality data for Red Rock TPA waterbodies assessed for sediment and found to be impaired. A summary for Bloody Dick Creek, which was evaluated for sediment and found not to be impaired, can be found in **Appendix D**. The weight-of-evidence approach using a suite of water quality targets, described in **Section 4.1**, has been applied to each waterbody evaluated. Data presented in this section comes primarily from sediment, habitat, BEHI (Bank Erosion Hazard Index), and greenline data collected by DEQ during summer 2017 and 2018. Results of the 2017-2018 data collection are supported by additional data in the DEQ Assessment Files, DEQ reference data, and PIBO managed site data (versus reference which was used for target development). However, this section is not intended to provide an exhaustive review of all available data. Throughout these summaries, “hummocking” and “pugging” will be referenced. “Hummocking” refers to a series of knob-like feature that protrudes from the ground, which may be in whole or part caused by livestock grazing (Booth et al. 2015). “Pugging” refers to when soil is churned up and pushed down by livestock. In the process, vegetation is buried and roots are exposed by the damage from the hoofs (Beukes et al., 2013). Both of these may be indicators of grazing activities.

6.4.3.1 Bean Creek (MT41A004_140)

Bean Creek (MT41A004_140) is listed for sedimentation-siltation on the 2020 303(d) List. This segment is also listed for alteration in streamside or littoral vegetative cover and flow regime modifications, which are non-pollutant listings that are linked to sediment impairment. Bean Creek is in the southeastern portion of the Red Rock watershed and flows approximately 6.6 miles from south to north to its confluence with the Red Rock River between Lima Reservoir and Lower Red Rock Creek.

Physical Condition and Sediment Sources

In 2017 DEQ collected qualitative sediment, habitat and riparian condition data from one site on Bean Creek, BEAN01 (**Appendix D**). Quantitative sediment data was not collected from additional sites because of lack of sufficient site access. In addition, DEQ staff examined aerial photos for potential impacts and sources of sediment.

The site evaluated was located about 0.4 miles upstream from South Valley Rd near the foothills. At this site, the stream flows through conifer forest, the riparian vegetation is relatively intact with sufficient binding rootmass, and banks are heavily vegetated with horsetail, moss, and assorted grasses and forbs. Some undercut banks are observed where conifer roots have scoured out. The substrate is gravel and cobble as well as a relatively large amount of fine sand; this fine sediment is likely from natural sources from upstream and laterally-scouring banks nearby as well as human sources from cattle grazing, recreational use from old footbridge caved in and widened crossings) and an adjacent road up gradient. Overall, the channel appeared stable and willows were dense and vigorous just upstream.

Once the channel entered the valley floor farther downstream, grazing impacts become heavier and the channel exhibited widening, hummocking, and bank failure. The middle third of the channel was impacted by channel form modifications (straightening) and water withdrawals.

Aerial photos indicated that the lower portion of the Bean Creek impaired segment is highly impacted by grazing and flow modification. The segment located downstream of South Valley Road had an average of 0-20% of intact natural riparian vegetation based on aerial photos.

Summary

Visual observations and aerial images indicate that the channel is modified and impacted by human activities (grazing and flow modifications) and there is insufficient information to change the existing pre-2020 impairment listings. Bean Creek remains listed on the 2020 303 (d) list for sediment/siltation, alteration of littoral and streamside vegetation, and flow modification.

6.4.3.2 Big Sheep Creek (MT41A003_150)

Big Sheep Creek (MT41A003_150) is listed for sedimentation-siltation on the 2020 303(d) List. This segment is also listed for alteration in streamside or littoral vegetative cover and flow regime modifications, which are non-pollutant listings that are linked to sediment impairment. The segment is located in the central portion of the Redrock watershed and flows 21.8 miles northeast from the confluence of Nicholia and Cabin Creeks, eventually meeting the Redrock River near Dell, Montana.

Physical Condition and Sediment Sources

In 2017 and 2018 DEQ collected sediment, habitat, and riparian condition data from two sites on Big Sheep Creek: BGSH04-02 and BGSH10-02 (**Appendix D).**

BGSH04-02

Site BGSH04-02 was the upstream site in this segment. The streambed is comprised primarily of coarse gravel and cobble. Streambanks are comprised of a combination of sand/clay, fine gravel, and coarse gravel and larger material. Vegetation consisted of approximately 23% sedges/rushes, 45% grasses/forbs, 5% shrubs/trees, and the remainder in non-vegetated ground cover including bare ground, rock, and riprap. Channel restoration has occurred along this reach in recent years to improve fish habitat, channel stability and riparian vegetation. Some outer bank erosion and some point bars have formed. About 23% of the banks were eroded with 17% attributed to natural causes, 81% to historical causes (past grazing and other land-use), and 2% to transportation-related causes.

BGSH10-02

Site BGSH10-02 was located about two miles upstream of the mouth. The streambed is comprised primarily of mixed gravel sizes and some cobble. Streambanks are composed primarily of sand and clay with some fine gravel and coarse gravel or larger sediment. This site has a riparian area comprised primarily of willow, rushes, poplar trees and grasses; Canada thistle is common. Woody species have good regeneration potential with many samplings and seedlings, but density is low and heavily browsed by cattle. During surveys it was noted that the upland is heavily grazed and cattle have unrestricted access to the stream limiting the riparian buffer width and vegetation density and causing bare ground in places. The stream channel appears to be widening and getting shallower, and aggradation is likely due to the high upstream sediment loads amplified by water diversions that reduce sediment transport capacity. Heavy filamentous algae was also observed during the assessment (**Figure 6-2**). About 14% of the site length had eroding banks with 81% being attributed to irrigation-related activities and 19% attributed to riparian grazing.

Additional data collection

In addition to the sediment sites, habitat and riparian quality were observed at two additional sites. Site M01BIGSHC02, approximately 2 miles below the Cabin and Nicholia Creek confluence, has riparian vegetation consisting primarily of dense, vigorous mature willows and sedges along the channel margins. Overall the vegetation was in excellent condition with little indication of human impacts observed. Channel morphology also appeared intact. The site has stable banks, cobble and boulder substrate, and ample fish habitat. Some seemingly excess filamentous algae was present during the site visit. Site M01SHEPC01, below the confluence with Muddy Creek, has riparian vegetation that is primarily sedges and rushes although upland grasses are encroaching. For a long reach upstream, willows are nearly absent except a few, mature, isolated individuals, possibly due to historic removal. It appears the channel has widened. Although it is naturally straight and confined by the canyon, the road may be restricting sinuosity. Dense macrophyte beds are common, as well as moderate amounts of filamentous algae. The channel is quite stable in this canyon portion. However, immediately upstream above the canyon, the channel is experiencing lateral cutting, unstable banks, and meander cut-offs are forming.

Figure 6-2. Lack of riparian vegetation, sediment, and filamentous algae at BGSH10-02a.

Comparison to Water Quality Targets

Fine sediment parameters (riffle fines less than 2mm, riffle fines less than 6mm, and pool tail fines less than 6mm) were evaluated against reference data independently for each sediment site because the sites differ in slope. The average of both sites was used to evaluate coarse sediment and instream habitat parameters because both sites are in the same reference bankfull width category.

The existing physical data in comparison with the targets for Big Sheep Creek are summarized in **Table 6-11**. All bolded cells are not meeting the target; depending on the target parameter, this may equate to being below or above the target value.

Data collected by DEQ in 2017 and 2018 indicate that the upstream site is meeting fine sediment targets. However, two out of three fine sediment parameters are significantly different than targets at the downstream site. Width/depth ratio and residual pool depth was within reference range, although pool count was outside reference range (indicating fewer pools than optimal). Entrenchment ratio was within expected range given stream type.

Summary

The assessment indicates Big Sheep Creek is impaired for sediment. The assessment also indicates Big Sheep Creek is impaired for littoral/streamside habitat alteration. In some reaches, especially upstream and within the canyon, the riparian vegetation consists primarily of dense, vigorous mature willows and sedges along the channel margins and overall the vegetation is in excellent condition with no indication of human impacts observed. However, in other unconfined reaches where livestock impacts are heavier, the riparian buffer width and density is limited, and bare ground and noxious weeds are common. In some reaches, willows are nearly absent, possibly due to historic removal. Woody species have good regeneration potential with many saplings and seedlings, but density is low and they are browsed quite heavily.

Table 6-11. Existing sediment-related data for Big Sheep Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
BGSH04-02	2018	22.8	3	C	10	8	4	17.1	3.71	1.36	7.2
BGSH10-02	2017	18.5	2	C	**34**	**26**	5	15.4	2.65	1.24	9.6
Average	Evaluated at the site-level[1]						4.5	16.25	3.18	1.3	**8.4**

[1]Fine sediment parameters were evaluated based on individual sites because sites differed in slope category. Other habitat parameters were based on average values.

6.4.3.3 Corral Creek (MT41A004_040)

Corral Creek (MT41A004_040) is listed for sedimentation-siltation on the 2020 303(d) List. This segment is also listed for alteration in streamside or littoral vegetative cover, which is a non-pollutant listing that is linked to sediment impairment. Corral Creek is in the southeastern portion of the Red Rock watershed and flows northwest approximately four miles to its confluence with Red Rock Creek. Much of the segment is influenced by beaver and therefore methods for evaluating sediment were not applicable everywhere.

Physical Condition and Sediment Sources

In 2017 DEQ collected sediment, habitat, and riparian condition data from one site on Corral Creek (CRRL06-01) (**Appendix D).**

CRRL06-01

Site CRRL06-01 is located near South Valley Road. The streambed is comprised primarily of mixed gravel, sand, and silt. The banks are comprised of sand and clay. There are many willows, including saplings and seedlings, although some exhibit evidence of browse (umbrella-shaped and animal trails) and contain a lot of dead branches. Ground cover is primarily grass, clover and some rushes. Banks and channel features are impacted by livestock and hoof shear and pugging[1] is prevalent. Pools are primarily shallow with fine sediment and the riffle substrate is small gravel and fine sediment. Up to 47% of the banks are eroded, with nearly 100% of this attributed to grazing activities.

Additional data collection
Additional habitat and riparian data was collected at two sites, M01CORLC30 and M01CORLC02.

Site M01CORLC30 is between the mouth and South Valley Road. Surrounding vegetation consists of vigorous willows, sedge and rushes. The reach exhibits beaver influence (indistinct riffle-pool sequence, macrophytes, sand and silt substrate) but appears stable and at potential. The site appears to be recovering following historically heavy grazing which caused hummocking and clubbed willows. With the presence of beavers, the reach appears to be at potential.

Site M01CORLC02 is located less than a mile above the mouth. The most apparent feature of this site is that it is in a state of recovery from past heavy grazing; soil disturbance is evident in the uplands and hummocking, pugging, and bank scars from previous access points are common. However, the riparian vegetation is recovering very well (nearly all channel margins, banks, and the wide riparian zone is densely vegetated with sedges and rushes) and hummocks are healing. Willows are common but lacking in areas where grazing influence was heaviest. The channel is influenced by beaver. Riffles are lacking due to beaver activity, and macrophyte beds and filamentous algae are common. The channel resembles a spring creek (crystal clear water, deep, slow-moving and the substrate is dominated by fine sand and silt). The channel appears stable and should continue to improve with continuation of appropriate land management.

Comparison to Water Quality Targets
Fine sediment parameters (riffle fines less than 2mm, riffle fines less than 6mm, and pool tail fines less than 6mm) were evaluated against reference data; both riffle fines parameters are outside reference range (indicating excess fine sediment is being deposited in riffles) and the pool tail fines are within reference range (**Table 6-12**). For coarse sediment and instream habitat parameters, width/depth ratio and pool count are within reference range but residual pool depth is outside reference range (indicating pools are not as deep as desirable and may be filling with excess sediment). Entrenchment ratio is within expected range given stream type. Additional sediment monitoring was attempted but much of the stream channel is influenced by beaver activity.

Most indicators for riparian degradation, loss of instream habitat, and alteration in geomorphology rated as optimal or sub-optimal. However, aerial images indicated that there were areas that are experiencing riparian and channel disturbance due to high intensity livestock impacts which were not represented during site visits.

Table 6-12. Existing sediment-related data for Corral Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Asses smen	Mean BFW	Gradi ent	Existi ng	Riffle Pebble Count	Grid Toss	Channel Form	Instream Habitat

					% <6mm	**% <2mm**	**Pool % <6mm**	**W/D Ratio**	**Entrenchment Ratio**	**Residual Pool Depth (ft)**	**Pools / 1000 ft**
CRRL06-01	2017	6.1	1	E	**41**	**34**	3	6.4	14.77	**0.57**	25.7

Summary
Some reaches have banks and channel features that continue to be impacted by livestock (hoof shear and pugging). Past soil disturbance is evident in the uplands and hummocking, pugging, and bank scars from previous access points are common. However, some reaches are in a state of recovery following historically heavy grazing. The channel appears stable and is reforming and revegetating in these reaches. These improvements should continue with continuation of appropriate land management.

6.4.3.4 East Fork Clover Creek (MT41A004_050)
East Fork Clover Creek (MT41A004_050) is listed for sedimentation-siltation on the 2020 303(d) List. Prior to 2020, this segment was also listed for alteration in streamside or littoral/vegetative cover, which is non-pollutant listings that can often be linked to sediment impairment. However, a delisting for littoral/vegetative cover occurred in 2020. The segment flows approximately 6 miles from the headwaters to a confluence with Clover Creek.

Physical Condition and Sediment Sources
In 2018 DEQ collected sediment, habitat, and riparian condition data from two sites on East Fork Clover Creek: ECLV07-01 and ECLV07-02 (**Appendix D**).

ECLV07-01
Site ECLV07-01, located approximately one mile upstream from the mouth. The streambed is comprised primarily of coarse gravel, and the bank composition is predominately sand and clay. This site has a highly sinuous channel with a series of step pools and gravel substrate in short riffles. Streambanks are composed almost entirely of sand and clay (near 100%). About 15% of the banks were eroded, with 15% being attributed to grazing-related activities and 85% attributed to historical grazing or other activities with signs of recovery. Canadian thistle and plants indicative of erosion were present. Some bank erosion was evident on inner and outer bank, but this was not extensive (**Figure 6-3**).

ECLV07-02
ECLV07-02, closer to the mouth, and had plentiful vegetation of predominately willows. The streambed is comprised primarily of gravels, with some fine sand and silt, and the banks are comprised primarily of sand and clay. The sinuous channel exhibited mostly stable banks which were soft where vegetation was missing. Streambanks are composed almost entirely of sand and clay. About 4% of the banks were eroded, with 50% being attributed to grazing-related activities and 50% being attributed to natural factors.

Comparison to Water Quality Targets
Both sites represent the same reach type (Middle Rockies ecoregion, reach slope 2 to 4 percent, stream order 2, and unconfined). The average of both sites was used to evaluate all fine sediment parameters and coarse sediment and instream habitat parameters against reference data. The existing physical data in comparison with the targets for East Fork Clover Creek are summarized in **Table 6-13**. All bolded cells

are not meeting the target; depending on the target parameter, this may equate to being below or above the target value.

All three fine sediment parameters are within reference range, indicating excess fine sediment is not accumulating in these sensitive habitats. Entrenchment ratio is within expected range given stream type. However, all three course and instream habitat parameters are outside reference range, indicating the channel is getting wider and shallower, pools may be filling, and pools are less frequent than desirable.

The assessment indicates East Fork Clover Creek is not impaired for habitat or alteration of littoral/streamside vegetation. Overall, the riparian area is vegetated with vigorous and plentiful vegetation, especially willows. The stream has high buffering capacity on both banks; riparian width decreases in the upper reaches as the channel becomes more confined. However, in some places, livestock have caused near bank pugging and plants indicative of disturbance were observed, including noxious weeds.

Table 6-13. Existing sediment-related data for East Fork Clover Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
ECLV07-01	2018	7.2	3.9	E	13	10	13	5.8	5.73	0.76	29.4
ECLV07-02	2018	9.2	2.9	E	17	16	10	9.8	8.41	0.56	15
Average[1]	2018	8.2	3.4	E	15	13	11.5	**7.8**	7.07	**0.66**	**22.2**

[1]All parameters were based on averages across sites, because they were both E channels.

Figure 6-3. Gravel substrate and riparian vegetation at site ECLV07-01

Summary
Data collected by DEQ indicate that East Fork Clover Creek is impaired for sediment. Only coarse sediment/habitat targets were exceeded, indicating that the main source of sediment impairment may be historical and that the stream may meet targets in the near future if Best Management Practices continue to be observed and/or continued restoration actions are undertaken.

Based on these findings, East Fork Clover Creek was delisted in 2020 for riparian degradation and alteration in streamside or littoral vegetation cover. While there are some areas where livestock have caused pugging and disturbance, in general the riparian zone is well vegetated and has high buffering capacity on both banks.

6.4.3.5 *Fish Creek (MT41A004_030)*

Fish Creek (MT41A004_030) is listed for sedimentation-siltation. In addition, the segment is listed for alteration in stream-side or littoral vegetation on the 2020 303(d) List which is a non-pollutant listing that is often linked to sediment impairment. The segment is located in the northeastern portion of the watershed and flows southeast approximately 8 miles to its confluence with Metzel Creek.

Physical Condition and Sediment Sources
In 2017 DEQ collected sediment, habitat, and riparian condition data from two sites on Fish Creek: *FISH06-02* and *FISH06-01* (**Appendix D)**.

FISH06-02
FISH06-02 is located approximately 2 miles upstream from the mouth, has been grazed in the past, and has mature willows that exhibit clubbing. The riparian vegetation is estimated as 97% wetland plants

including willow and 3% grasses and forbs. Banks are undercut but past bank erosion appears to be stabilizing. About 8 % of the site length has eroding banks with nearly 100% attributed to historical causes such as past logging and grazing.

FISH06-01
Site FISH06-01 is the lower site near the mouth. Streambanks are comprised predominately of sand and clay. The streambed is predominately gravel, but also has a large proportion of fine silt (~30%) riparian vegetation is estimated as 86% wetland plants including willow and shrubby cinquefoil and 14% grasses and forbs. About 2% of the site length as eroding banks with nearly 100% attributed to historical causes such as logging and grazing. Past impacts from cattle grazing are apparent, including pugging, hummocking, lateral bank erosion and widening, although the site appears to be grazed less frequently or heavily and the channel is beginning to recover.

Comparison to Water Quality Targets
Fine sediment parameters (riffle fines less than 2mm, riffle fines less than 6mm, and pool tail fines less than 6mm) were evaluated against reference data independently for each site because the sites differ in slope. The average of both sites was used to evaluate coarse sediment and instream habitat parameters (width/depth ratio, residual pool depth and pools/1000 ft) because both sites are in the same bankfull category.

The assessment indicates that Fish Creek is impaired for sediment (**Table 6-14**). For both sites, all three fine sediment parameters are outside reference range (indicating that excess fine sediment is accumulating in riffles and pool tails. Three coarse sediment and instream habitat parameters are outside the reference range (indicating the channel is getting shallower and wider, pools are not as deep as optimal and may be filling with excess sediment, and there are fewer pools than desirable). However, entrenchment ratio is within expected range given stream type.

The assessment indicates Fish Creek is impaired for alteration instream-side or littoral vegetation, and this 303(d) remains on the 2020 list. Grazing management appears to be improving and riparian conditions are recovering, although not yet fully recovered. The upper reaches have more dense riparian vegetation with more woody species cover, but they exhibit impacts from past grazing and mature willows exhibit clubbing from browse.

Table 6-14. Existing sediment-related data for Fish Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
FISH06-02	2017	6.2	5.3	E	**32**	**24**	**24**	7.4	3.44	0.84	22.7

Table 6-14. Existing sediment-related data for Fish Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
FISH06-01	2017	5.9	0.4	E	**45**	**37**	**39**	7.8	9.12	0.55	21.7
Average	Evaluated at the site-level[1]							**7.6**	6.28	**0.69**	**22.2**

[1]Fine sediment parameters were evaluated based on individual sites because sites differed in slope. Other habitat parameters were based on average values given similar width.

Summary
Data collected by DEQ in 2017 support the listing of Fish Creek for sediment and for alteration in streamside or littoral vegetation cover. In the lower reaches, the channel has been impacted by livestock grazing, including pugging, hummocking, lateral bank erosion and widening, although in some cases the channel is beginning to recover. In the upper reaches, grazing impacts are also observed but banks appear to be stabilizing; substrate is predominantly gravel and cobble with minimal fine sediment except within macrophyte beds. Continued restoration and implementation of Best Management Practices will continue to reduce sediment loads.

6.4.3.6 Horse Prairie(MT41A003_090)
Horse Prairie Creek (MT41A003_090) is listed for sedimentation-siltation and flow regime modification on the 2020 303(d) List. The segment is in the northwestern portion of the Red Rock River watershed and flows approximately 47 miles northeast to its confluence with Clark Canyon Reservoir.

Physical Condition and Sediment Sources
In 2017, DEQ collected sediment, habitat, and riparian condition data from two sites on Horse Prairie Creek: HRSP11-02a and HRSP12-01a (**Appendix D**).

HRSP11-02
HRSP11-02 is the uppermost of the two reaches, about 2.5 miles above the confluence with Trail Creek. The streambanks are predominately sand and clay, but also have large proportions of coarse and fine gravel. The streambed is comprised primarily of mixed gravel. Riparian vegetation is estimated as 34% wetland plants including willows, 10% grasses and forbs, and 6% shrubs and trees. Willows are present but in decline. Livestock grazing is the dominant land use and grazing has limited the riparian buffer width. Bank substrate is primarily sand and clay. The channel has widened and become shallower than optimal. Bank slumps are visible but often revegetated. About 23% of the banks are eroded, which was attributed to natural factors (49%), cropland activities (31%), and irrigation/flow manipulation activities (20%).

HRSP12-01
Site HRSP12-01 is closer to the mouth. The streambanks are comprised predominately of sand and clay, but also have fine gravel, coarse gravel, and cobble. The streambed is comprised largely of mixed gravel. The predominant riparian vegetation is 48% sedges and rushes, 35% grasses and forbs, and 8% shrubs and trees. Willows are abundant, although willow health appears to be in decline. The stream channel is stable and has intact pool-riffle sequences. However, riffle substrates had sand present due to dense macrophyte beds. During the visit, pools were also diverse with both deep and shallow pools. Fish habitat appeared to be optimal with deep pools, overhanging vegetation, undercut banks and cobbles. Portions of the reach are heavily used by livestock. The banks are comprised of approximately 80% sand/clay and 20% fine gravel. Approximately 30 % of the banks are eroding, with 66% attributable to historic grazing and other activities, 18 % to natural factors, and 16% to current grazing.

Additional data collection
Habitat and riparian condition were evaluated at three additional sites. Site M01HRSPC01 is above Maiden Creek confluence. The riparian vegetation consists primarily of willow and sedges with the noxious weed Canada thistle growing throughout. Pasture grasses are encroaching and grazing limits the width and density of the riparian buffer across much of the landscape. The channel generally appears stable but is widening and slightly aggrading. Sediment deposition is apparent, and turbidity was observed at the site; substrate is embedded. Some hummocking and bank instability is present, particularly where cattle frequently access the channel. Macrophytes are common.

Site M01HRSPC04, mid-segment below Bloody Dick Creek, has very dense riparian vegetation, especially willows and sedges along channel margins, and some rose and currant. The channel exhibits bank erosion, unstable banks on some outer bends, fine sediment deposition within the channel and point bars, and high sediment load from upstream sources. However, the healthy riparian zone is moderating these effects. There is no clear indication of grazing impacts.

Site M01HRSPC01 is the lowermost site near the mouth just above confluence with Clark Canyon Reservoir. Riparian vegetation at this site consists of very dense willows up to the water's edge on both banks and some sedges and other grasses along the channel margin; mature cottonwoods can be seen in the distance. The channel is mostly a long riffle with less pool habitat exists and appears stable.

Comparison to Water Quality Targets
Since both sites are in the same width and slope category, the average was evaluated for all parameters. The assessment indicates that Horse Prairie Creek is impaired for sediment. All of the fine sediment parameters indicate impairment. For coarse sediment and instream habitat parameters, residual pool depth is within reference range but width/depth ratio and pool count are outside reference range (indicating the channel is getting wider and shallower and pools are less frequent than desirable). Entrenchment ratio is within the expected range given stream type.
(**Table 6-15**).

Table 6-15. Existing sediment-related data for Horse Prairie Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
HRSP11-02	2017	15	1	B	18	13	5	14.8	1.75	1.67	10.9
HRSP12-01	2017	24.6	1	C	26	12	0	20	4.53	1.9	9.2
Average[1]	2017	19.7	1	B,C	**22**	12.5	2.5	**17.4**	3.14	1.785	**10.05**

[1]All parameters were evaluated based on averages, because sites were in the same slope and width categories.

Summary
The sediment/siltation listing for Horse Prairie Creek is supported based on the current land management practices that are contributing human sources of sediment, the human-caused erosion observed, and the failures of instream sediment targets. The channel generally appears stable, but it has incised in some reaches and is widening and slightly aggrading in others; many bank slumps are revegetating. Some bank instability and hummocking due to grazing is observed particularly where cattle frequently access the channel. Sediment deposition is apparent, and turbidity is observed; substrate is embedded. Two large tributaries (Trail Creek and Medicine Lodge Creek) are also impaired for sediment.

Riparian condition varies; some reaches, especially those lower in the watershed, have dense and vigorous willow- and sedge-dominated riparian buffers. However, in others, willow health appears to be in decline and grazing and pasture encroachment are limiting riparian density and continuity. Restoration and implementation of Best Management Practices will continue to reduce sediment loads and improve riparian conditions.

6.4.3.7 Jones Creek (MT41A004_130)
Jones Creek (MT41A004_130) is listed for sedimentation-siltation. In addition, this segment is listed for alteration in streamside or littoral vegetation, and flow regime modification on the 2020 303(d) List, which are non-pollutant listings that can be linked to sediment impairment. Jones Creek is in the southeastern portion of the Red Rock watershed and flows north approximately eight miles to its confluence with the Red Rock River between Lima Reservoir and Lower Red Rock Lake.

Physical Condition and Sediment Sources
In 2017 DEQ collected sediment, habitat and riparian condition data from one site on Jones Creek, JONSC03. Quantitative sediment data was not collected because of lack of sufficient site access. Aerial images were evaluated to further characterize channel condition.

JONSC03

Site JONSC03 is approximately mid-segment near the South Valley Road crossing. The riparian zone is in poor condition with very few willows and sedges and substantial bare ground and disturbed soils on both banks due to unrestricted cattle access. The channel appears to have historically downcut and is now widening and attempting to stabilize with banks forming within the incised channel. However, livestock pressure causes hoof shear, pugging, and trampling of forming banks; this is leading to aggradation and excessive fine sediment deposition throughout the channel and banks that are largely devoid of binding rootmass. A headgate downstream appears to alter the flow path, transport capacity, and grade of the stream channel. Upstream, a pasture appears to have been rested and riparian vegetation and channel stability is recovering.

Aerial imagery indicates that 0-20% of the lower portion of the segment has an intact riparian zone within a 100 -foot buffer. In addition, visual observations during visits to the stream indicated excess siltation (**Figure 6-4**).

Summary
Visual observations and aerial images indicate that the channel is modified and impacted by human activities (grazing and flow modifications) and there is insufficient information to change the existing impairment listings. Jones Creek remains listed on the 2020 303 (d) list for sediment/siltation, alteration of littoral and streamside vegetation, and flow modification.

Figure 6-4. Culvert and siltation in Jones Creek about two miles downstream of the South Valley Road crossing.

6.4.3.8 Long Creek (MT41A004_070)
Long Creek (MT41A004_070) is listed for sedimentation-siltation. In addition, this segment is listed for alteration in streamside or littoral vegetation, and flow regime modification on the 2020 303(d) List,

which are non-pollutant listings that can be linked to sediment impairment. The segment flows approximately 24 miles southwest to its confluence with the Red Rock River between Lima Reservoir and Lower Red Rock Lake.

Physical Condition and Sediment Sources

Sediment, habitat, and riparian condition data were collected at two sites in 2017: LONG06-01 and LONG07-01 (**Appendix D**).

LONG06-01

LONG06-01 is located approximately 11 miles above the mouth. The streambanks are comprised almost entirely of sand and clay, while the streambed is mixed gravel and cobble. Riparian vegetation consists of approximately 56% sedges and rushes, 42% grasses and forbs, and 2% shrubs and trees. Bank composition consists of nearly 100% sand and clay. The channel is incised and has experienced grazing impacts (pugging and hummocking) but the channel appears to be recovering (**Figure 6-5**). Banks are undercut in many places and bank sloughs at cut banks are common but revegetating. Sparse clusters of willows in the riparian zone been heavily grazed but are regrowing. During the assessment, substrate in riffles and pool tails primarily included embedded cobbles and gravel. Macrophytes were common. Approximately 1% of the banks were found to be eroded, 80% of which was attributed to historical grazing and other factors and 20% which was attributed to natural factors.

LONG07-01

LONG07-01 is approximately 4 miles above the mouth. The streambed is comprised of mixed gravel and silt, while the streambed is comprised predominately of sand and clay with some fine and coarse gravel. Riparian vegetation is primarily willows, grasses, sedges, and rushes; Canada thistle is abundant. Evidence of past heavy grazing remains in the riparian area, but vegetation has recovered and is thriving. Banks are stable but the site appears to have downcut, narrowing the channel and leaving tall banks. Bank composition is predominantly sand and clay, with some fine gravel and coarse gravel and larger material. During the assessment, approximately 6% of the bank's length was estimated to be eroded, of which 58% was attributed to historical grazing and other activities and 42% was attributed to current grazing activities.

Additional data collection

In addition, to the two sediment sites, three sediment sites were used to evaluate habitat and alteration to littoral or vegetative covers.

Site M01LONGC01 has primarily willows, cinquefoil, sedges, and rushes, as well as some disturbance-caused plants including Canada thistle. The surrounding upland is pasture grass and sagebrush and the primary land use is livestock grazing. Banks are well-vegetated although soil disturbance is apparent and hoof shear induced bank erosion and headcuts are observed. The channel appears to have incised quite a bit in the past, although beaver activity appears to be stabilizing the channel to avoid continued downcutting. Fine sediment is likely attributed to both natural (beaver) and human (livestock) sources.

Site M01LONGC04 is located about 9 miles above the mouth. At this road crossing there is a distinct contrast between the upstream side and downstream. Upstream, no recent grazing is evident, and the site is generally in optimal condition. Beaver activity is likely. In stark contrast, the downstream portion is heavily impacted by grazing and is nearly devoid of vegetation except clubbed willows that have been heavily browsed. The channel is experiencing heavy bank erosion induced by cattle trampling, hoof shear, trails/crossings, and no riparian vegetation cover and is laterally unstable. Excess fine sediment deposition is visible.

Site M01LONGC03, approximately 2 miles above the mouth, has primarily sedges and grasses with few mature willows and many saplings and seedlings starting to populate the riparian zone. Canada thistle is widespread. Surrounding land use is primarily grazing and several cattle crossings and access were observed. The channel appears to have been substantially incised over time as evidenced by tall cut banks and downcut into the landscape, although the channel appears to have stabilized as banks are rebuilding and revegetating within the incised channel, and grazing management appears to have improved.

Comparison to Water Quality Targets

The average of both sediment sites was used to evaluate all sediment parameters against reference condition because both sites were in the same slope and bankfull width categories.

The assessment indicated that Long Creek is impaired for sediment (**Table 6-16**). For fine sediment, the riffle fines less than 2 mm is within reference range, but riffle fines < 6 mm and pool tail fines were outside reference range, indicating some excess fine sediment is being deposited in sensitive riffle and pool tail substrates. For coarse sediment and instream habitat parameters, residual pool depth is within reference range, but width/depth ratio and pool count are outside reference range (indicating the channel is getting wider and shallower) and pools are less frequent than desirable. Entrenchment ratio is within expected range given stream type.

Based on the assessment, alteration in stream-side or littoral vegetative cover also remains as a cause of impairment on the 2020 303(d) list.

Table 6-16. Existing sediment-related data for Long Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
LONG06-01	2017	12.1	0.3	E	19	13	27	9.2	2.26	2.03	8.4
LONG07-01	2017	12.1	1.5	E	28	21	14	9.4	2.39	1.04	17.5
Average[1]	2017	12.1	0.9	E	**23.5**	17	**20.5**	**9.3**	2.32	1.54	**12.95**

[1]All parameters were evaluated based on averages, because sites were in the same slope and width categories.

Figure 6-5. Condition of banks at LONG06-01a.

Summary

Data collected by DEQ in 2017 support the listing of Long Creek for sediment/siltation and alteration in streamside or littoral vegetation cover. Fine sediment is likely attributed to both natural (beaver) and human (livestock) sources. Evidence of past heavy grazing remain in riparian area, and portions of the channel are heavily impacted by grazing and some areas are nearly devoid of vegetation except for heavily browsed willows. However, vegetation is recovering and thriving in other places as grazing management appears to have improved. Banks are generally well-vegetated although soil disturbance is apparent and hoof shear has induced bank erosion, headcuts, pugging, and hummocking in other areas. Continued restoration and implementation of Best Management Practices will help to reduce sediment loads.

6.4.3.9 Medicine Lodge Creek (MT41A003_010)

Medicine Lodge Creek (MT41A003_010) is listed for sedimentation-siltation on the 2020 303(d) List. In addition, this segment is listed for alteration in streamside or littoral vegetative covers and flow regime modifications which are non-pollutant listings that can often be linked to sediment impairment. It is in the northwestern portion of the Red Rock watershed and flows approximately 35 miles northeast to its confluence with Horse Prairie Creek just upstream from Clark Canyon Reservoir.

Physical Condition and Sediment Sources

Sediment, habitat, and riparian condition data was collected at two sites in 2017: MDLG04-07 and MDLG06-05.

MDLG04-07

MDLG04-07 is in the upper reaches approximately 12 miles below the headwaters. The streambed is comprised primarily of coarse gravel, where the streambanks are comprised of sand and clay with some coarse gravel. This site has abundant willows, sedges, and rushes. Cattle grazing though impacts the site destabilizing banks, limiting willow growth, and causing sagebrush encroachment and Canada thistle grows throughout. The predominate bank composition is sand and clay with some coarse gravel and larger. The channel has widened in some locations at this site and pugging and hummocking is visible along much of the banks. Instream habitat complexity is good with deep pools, cobbles, large woody debris, undercut banks, overhanging vegetation, and isolated backwaters. Approximately 16% of the banks was estimated to be eroded, with 79% from grazing and 21% from natural factors.

MDLG06-05
Site MDLG06-05, between Noble and Hansen Creek confluences, has abundant willows, sedges, and rushes through the riparian zone. The streamed is comprised of mixed gravel and fine sediment. The bank composition is almost entirely sand and clay with lesser amounts of fine gravel and coarser material. Good instream habitat complexity is present with deep pools, large woody debris, undercut banks, overhanging vegetation and dense macrophyte beds. However, buffer width is limited on the left side of the creek due to livestock grazing. Cows and unpaved road crossings are present (**Figure 6-6**), affecting the longitudinal connectivity of riparian vegetation. Willow health appears to be declining. Some hoof shear was observed, and noxious weeds are present (Canada thistle). The creek has some evidence of downcutting and cattle-induced bank erosion. Substrates were covered with thick filamentous algae during the site visit. The bank composition is approximately 70 % sand/clay, 10% fine gravel, and 20% coarse gravel/cobble. The assessment indicated that 10 percent of banks are eroding, of which approximately 76% can be attributed to riparian grazing and 24% to natural sources.

Additional data collection
In addition to the sediment sampling sites, habitat and riparian condition was documented at two additional sites.

At an unnamed upper site, below Erickson Creek, the sedges are quite dense and are vegetating nearly the entire channel margin, although they appear disturbed in many places due to cattle grazing (pugging and hummocking apparent). This site has the fewest willows of all sites visited, though sapling recruitment is observed and potential for regeneration exists. The surrounding uplands appear rather heavily grazed (many cattle trails), and cattle have open access to the entire stream channel. Sedges are helping to maintain bank stability, although sediment deposits and widespread pugging and hummocking may worsen over time leading to further sediment problems. Sediment impacts may be further amplified by flow alterations and diminished transport capacity.

Site M01MEDLC02, below Schwartz Creek, has riparian vegetation that is primarily willow with fewer sedges and more pasture grass encroachment. Banks are less stable where hayfields encroach on the channel and limit willow growth and riparian buffer width and where grazing has destabilized banks. Flow conditions appear optimal at this site with a riffle-pool sequence, although a network of irrigation ditches is upstream.

Comparison to Water Quality Targets
To evaluate fine sediment parameters, the average of two sites was used against reference data as both sites are similar in slope and bankfull width. For coarse sediment and instream habitat parameters, the two sites were evaluated independently against reference data because the sites represent different bankfull width categories.

Riffle fines less than 2mm and pool tail fines is within reference range, but riffle fines < 6 mm is outside of reference range (indicating that excess fine sediment is accumulating in riffles) (**Table 6-17**). For site

MDLG04-07, residual pool depth is within reference range, but width/depth ratio and pool count were outside reference range, indicating the channel is getting wider and shallower and pool habitat is less common than desirable. For MDLG06-05a, width/depth ratio and residual pool depth is within reference range, but pool count is outside reference range (also indicating pool habitat is less common than desirable). For both sites, entrenchment ratio is within expected range given stream type.

Figure 6-6. Unpaved crossing at site MDLG06-05a.

Because the bankfull width of site MDLG06-05 (15ft) is exactly the value that is used to stratify categories for assessment, an alternate analysis was also conducted to confirm if using a different reference dataset makes a difference in the assessment outcome. The average of both sites for coarse sediment and instream habitat parameters was also compared to the reference dataset for less than 15 ft. The bankfull and the residual pool depth remained within reference range, pool count remained outside of reference range (indicating impairment), and width/depth ratio was now outside reference range (also indicating impairment).

Table 6-17. Existing sediment-related data for Medicine Lodge Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
MDLG04-07	2017	14.2	1	B	18	7	1	**14.1**	1.92	1.13	**18.5**

Table 6-17. Existing sediment-related data for Medicine Lodge Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
MDLG06-05	2017	15	0.7	B	28	16	4	11.1	1.65	1.2	**10.9**
Average[1]	2017	14.6	0.85	B	**23**	11.5	2.5	Evaluated at the site-level			

Fine sediment parameters were evaluated based on site-averages because sites were in the same slope category, and other habitat parameters were based on individual parameters because sites differed in width category.

Summary

Data collected by DEQ supports the listing of Medicine Lodge Creek for sediment. One of three fine sediment parameters and two of four coarse sediment parameters differ significantly from reference condition. The channel exhibits some evidence of downcutting. Sedges are helping to maintain bank stability, although hoof shear, pugging and hummocking as well as instability due to pasture encroachment was observed and may worsen. Sediment impacts may be further amplified by flow alterations and diminished transport capacity.

The assessment also supports the listing of Medicine Lodge Creek for alteration of littoral/streamside habitats. Much of the riparian corridor has abundant willows, sedges, and rushes. However, riparian health appears to be declining in some areas and riparian width is limited in places due to livestock grazing and pasture encroachment. Continued restoration and implementation of Best Management Practices will help to reduce sediment loads.

6.4.3.10 Muddy Creek (MT41A003_020)

Muddy Creek (MT41A003_020) is listed for sedimentation-siltation on the 2020 303(d) List. In addition, this segment is listed for alteration in streamside or littoral vegetative covers which is a non-pollutant listing that can often be linked to sediment impairment. Muddy Creek is located in the southcentral portion of the Red Rock watershed and flows southeast approximately 11 miles to its confluence with Big Sheep Creek.

Physical Condition and Sediment Sources

Sediment, habitat, and riparian condition data was collected at two sites in2017: MDDY01-04 and MDDY02-01.

MDDY01-04

MDDY01-04 is the upper reach approximately 7 miles above the mouth. Sand and clay comprise almost 100% of the bank composition, while the streambed is comprised of mixed gravel and a large amount of fine sediment. The riparian area consists almost entirely of dense sedges and rushes (73%) which extend in a wide but confined riparian corridor around an otherwise narrow stream channel. Grasses and forbs are also present (5%). Woody species occur (20%) but are infrequent and heavily browsed. Some areas of bare ground occur (2%). Hummocking by cattle is common and banks are failing or receding, particularly where access is easy for cattle. The channel is naturally confined in a steep, rugged landscape with natural sediment sources from nearby tall banks, although upland grazing and riparian trampling is likely increasing sediment load beyond transport capacity. Substrate is primarily fine material. Macrophytes are present, with high turbidity and moderate filamentous algae present. Approximately 2 percent of the bank is eroded, with nearly 100% attributed to riparian grazing.

MDDY02-01.
Site *MDDY02-01* is located approximately 4 miles upstream from mouth. The bank composition is approximately 90% sand and clay, and 10% fine gravel. The streambed composition is a mix of gravel and fine sediment. There is little to no riparian vegetation and sagebrush is abundant along the riparian buffer. This site is somewhat incised and downcutting, and floodplain access is limited. Undercut banks are prevalent throughout reach. Substrate in riffles were embedded and features are difficult to distinguish. Livestock influence the site. Macrophyte beds are common. Approximately 10 percent of the bank is eroded, with 76% attributed to riparian grazing and 24% attributed to natural factors.

Additional data collection
In addition to sediment data, habitat data and riparian condition was evaluated at one site near the mouth, M01MUDYC03. The riparian vegetation is primarily sedges along the channel margin and there is some upland encroachment from upland vegetation into the riparian zone, including non-native grasses, sage, and field pennycress. Canada thistle is present and competes with the sedges. The stream channel is downcut and, although naturally confined by the landscape, cut banks are taller than expected and salt seeps and crusts are seen along these banks. The site is also affected by grazing causing widening of the stream, hummocking and soil disturbance. Most riparian indicators and instream habitat indicators were marginal or poor.

Comparison to Water Quality Targets
Fine sediment parameters were evaluated against reference data independently because the sites differ in slope (**Table 6-18**). The average of both sites was used to evaluate habitat parameters because both sites are the same bankfull width category. For site MDDY01-04a and site MDDY02-01a, all three fine sediment parameters are outside of reference range. Width/depth ratio is within reference range. Residual pool depth and pool count are outside reference range. Entrenchment ratio is within expected range given stream type.

Table 6-18. Existing sediment-related data for Muddy Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
MDDY01-04	2017	2.1	4	E	**33**	**22**	**40**	2.3	2.93	0.62	22.4
MDDY02-01	2017	5.9	1	E	**59**	**47**	**43**	6.5	3.69	0.51	13.5

Table 6-18. Existing sediment-related data for Muddy Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
MDDY01-04	2017	2.1	4	E	**33**	**22**	**40**	2.3	2.93	0.62	22.4
Average[1]	Evaluated at the site-level							4.4	3.31	**0.565**	**17.95**

[1]Fine sediment parameters were evaluated based on site-averages because sites were in the same slope category, and other habitat parameters were based on individual parameters because sites differed in width category.

Summary

Data collected by DEQ support the listing of Muddy Creek for sediment/siltation and for alteration in streamside or littoral vegetation cover. The channel is naturally confined in a steep, rugged landscape with natural sediment sources from nearby tall banks, but upland grazing and riparian trampling is likely increasing sediment load beyond transport capacity. The channel in places is somewhat incised and downcutting, and floodplain access is limited. Hummocking from cattle impacts is common and banks are failing or receding in many areas. Many sections have little to no riparian vegetation. Restoration and implementation of Best Management Practices will help to reduce sediment loads and improve riparian condition.

6.4.3.11 O'Dell Creek (MT41A004_080)

O' Dell Creek (MT41A004_080) is listed for sedimentation-siltation on the 2020 303(d) List. In addition, this segment is listed for alteration in streamside or littoral vegetative cover which is a non-pollutant listing that can often be linked to sediment impairment. O Dell Creek is located in the southeastern portion of the Red Rock watershed and flows north approximately 16 miles to its confluence with Lower Red Rock Lake.

Physical Condition and Sediment Sources

Sediment, habitat, and riparian condition data was collected at only one site (ODLL09-02) in 2017 due to beaver activity at another proposed sampling location.

ODLL09-02

Sediment site ODLL09-02 is located near the South Valley Road crossing. The majority of bank composition is sand and clay, with a lesser amount in fine gravel and larger material. The streambed is comprised primarily of coarse gravel. Willows, sedge, horsetail (15%) and mixed forbs (77%) dominate the riparian zone understory, with some shrubs/trees (1%) and bare rock (7%). Canadian thistle is present. The channel splits near the road into two large channels but returns to a single channel. Silt accumulates in some places but mostly along channel margins. There is apparent aggradation and bank erosion, although the channel is generally stable with a defined riffle-pool sequence and no evidence of downcutting or excess bank erosion. Although human disturbances are not apparent at this site, it is suspected that natural factors (beaver activity) and upstream logging activities (active during site visit) and water diversions may be impacting the flow regime and sediment transport capacity. No evidence of heavy grazing was present during the site visit. The percent eroded bank was estimated at 29%.

Additional data collection

An additional site, M01ODELC05, near the mouth, was evaluated for habitat and riparian condition. The site is heavily grazed with riparian vegetation impacts including limited regeneration of willows, grass encroachment on sedges and rushes, heavy browse, and clubbed willows. Bank stability varies depending on where cattle are concentrated. Pools and glides are dominant features. Substrate is comprised of silt to small gravel. Beaver activity upstream may be affecting flow velocities during runoff, limiting sediment transport.

Comparison to Water Quality Targets

Fine sediment, coarse sediment, and instream habitat parameters were evaluated against reference conditions. Fine sediment data is within reference range. Residual pool depth and pool count are within reference range, but width/depth ratio is outside reference range, suggesting the channel is becoming wider and shallower (**Table 6-19**).

Most indicators for riparian degradation, loss of instream habitat, and alteration in geomorphology rated as optimal or sub-optimal; several were marginal and poor. However, aerial images indicate areas of high intensity grazing impacts on riparian vegetation and channel width which were not well represented during site visits.

Table 6-19. Existing sediment-related data for O' Dell Creek relative to targets. Values that do not meet the target are in bold and shaded

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
ODLL09-02	2017	22.3	1	C	12	9	12	**18.5**	3.89	2.19	15.4

Summary

Data collected by DEQ support the listing of O' Dell Creek for sediment/siltation and for alteration in streamside or littoral vegetation cover. Following this assessment turbidity was delisted and does not occur on the 2020 303(d) list, since the sediment-related impairment is more accurately captured via the sedimentation/siltation cause.

Only one site was able to be monitored fully for sediment parameters. At this site, all three fine sediment and three of four coarse sediment and morphology parameters did not differ significantly from reference conditions. However, field observations and aerial images indicate substantial impact from livestock grazing in other areas which has led to riparian disturbance, bank erosion and failure, and channel widening, particularly near the mouth.

Upstream, riparian vegetation is robust and dominated by willows, sedge, horsetail and mixed forbs and beavery activity is prevalent. Mid-segment, the channel is stable with a defined riffle-pool sequence and no evidence of downcutting or excess bank erosion. However, the listing is largely due to conditions in downstream reaches, where field observations and aerial images indicate that there are areas where livestock grazing pressure is especially high; in these areas, willow regeneration is limited and mature willows are heavily browsed, pasture grass is encroaching on riparian species, and the channel is trampled and widening. Restoration and implementation of Best Management Practices will help to reduce sediment loads and improve riparian condition.

6.4.3.12 Peet Creek

Peet Creek (MT41A004_090) is listed for sedimentation-siltation. In addition, this segment is listed for alteration in streamside or littoral vegetation, and flow regime modification on the 2020 303(d) List, which are non-pollutant listings that can be linked to sediment impairment. Peet Creek is in the southeastern portion of the Red Rock River watershed and flows approximately 10 miles north to its confluence with the Red Rock River between Lower Red Rock Lake and Lima Reservoir.

Physical Condition and Sediment Sources

In 2017 DEQ collected sediment, habitat, and riparian condition data from one site on Peet Creek, PEETC03. Quantitative sediment data was not collected because of lack of sufficient site access.

PEETC03

Site M01PEETC03 is near the South Valley Road crossing (**Figure 6-7**). Substrate consists of cobble and gravel although livestock activity appears to be contributing substantial fine sediment into the stream. The riparian vegetation is notably impacted by cattle; some sedges remain along channel margins, but substantial bare ground exists, and upland pasture grasses are encroaching on the riparian zone. Willows are present but sparse and have been heavily browsed, as have the remaining sedges; the channel lacks shade. The channel has been notably downcut, the stream is widening from cattle use within the incised stream channel, and the riffle-pool sequence is interrupted.

Additional data collection

Aerial imagery indicates that 0-20% of the lower portion of the segment downstream of the intersection with South Valley Road has an intact riparian zone including a 100 -foot riparian buffer.

Summary

Visual observations and aerial images indicate that the channel is modified and impacted by human activities (grazing and flow modifications) and there is insufficient information to change the existing impairment listings. Peet Creek remains listed on the 2020 303 (d) list for sediment/siltation, alteration of littoral and streamside vegetation, and flow modification.

Figure 6-7. Trampling of banks on Peet Creek near the South Valley Road crossing.

6.4.3.13 Price Creek (MT41A004_010)

Price (MT41A004_110) is listed for sedimentation-siltation on the 2020 303(d) List. In addition, this segment was previously listed for alteration in streamside or littoral vegetative covers, which was removed in 2020. The stream is also listed for flow regime modifications. Price Creek is in the southeastern portion of the Red Rock watershed and flows northwest approximately 10.5 miles to its confluence with the Red Rock River just above Lima Reservoir.

Physical Condition and Sediment Sources

Two sites were intended to be evaluated for sediment in Price Creek: PRIC06-02a and PRIC06-05a. However, only PRIC06-02a had water at the time of sampling in 2017. Sediment, habitat, and riparian condition data were collected at this site.

PRIC06-02

Site MPRIC06-02 is upstream of South Valley Rd. The bank composition is almost 100% sand, with some clay, and the streambed composition is coarse gravel and fine sediment. The riparian vegetation is primarily wetland vegetation including willows, dogwood, cinquefoil, sedges, and rushes (72%). Approximately 10% is forbs and grasses, and 18% is shrubs and trees. There is minor encroachment of sage and pasture grasses where willows are lacking. The surrounding uplands are grazed, though the riparian area is in good condition. The channel appears stable and naturally incised since this location is situated where the channel exits a steep canyon and enters the valley. There may be some excess fines here but overall the channel appears to be effectively transporting and sorting sediment. One small water diversion structure does not appear to be having a large effect on stream function.

Additional data collection

Although dry, site M01PRIEC08 near the mouth had been trampled and exhibited pugging, hummocking, and hoof shear. Fine sediment is prolific within the channel. Floodprone width is narrow and may be downcutting due to sporadic flow events.

Site M01PRIEC04 is near the headwaters and has robust riparian vegetation including horsetail, thimbleberry and gooseberry with other native grasses and forbs in a conifer forest. The channel is stable and shows no indication of excess fine sediment; riffles and pools are intact and there is not visible bank erosion linked to human activity. Cattle grazing is pervasive throughout the area although impacts to the stream appear minimal due to densely-vegetated, steep terrain around the stream corridor.

Comparison to Water Quality Targets

Fine sediment parameters were evaluated against reference data and all three parameters are outside reference range (indicating excess fine sediment is accumulating in riffles and pool tails). Coarse sediment and instream habitat parameters were also evaluated against reference data and pool count is within reference range, but width/depth ratio and residual pool depth are outside reference range (indicating the channel is getting wider and shallower and has shallower pools than is desirable). Entrenchment ratio is within expected range given stream type (**Table 6-20**).

Table 6-20. Existing sediment-related data for Price Creek relative to targets. Values that do not meet the target are in bold.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
PRIC06-02	2017	7.8	2		**38**	**34**	**13**	**11.5**	2.37	**0.66**	32.7

Summary

Data collected in 2017 support the listing of Price Creek for sediment/siltation. In the upper reaches, the channel is stable and shows no indication of excess fine sediment; riffles and pools are intact and there is not visible bank erosion linked to human activity. Cattle grazing is pervasive throughout the area although impacts to the stream appear minimal due to densely-vegetated steep terrain around the stream corridor. In the middle reaches, the channel appears stable and naturally incised since this location is situated where the channel exits a steep canyon and enters the valley. There may be some excess fine sediment, but the channel generally appears to be transporting and sorting sediment well. However, in the most downstream reaches, high embeddedness was observed and there is frequent dewatering.

The findings do not support a listing for alteration of littoral and streamside habitats, and Price Creek was delisted for this in 2020. The upper reaches have robust riparian vegetation including horsetail, thimbleberry and gooseberry with other native grasses and forbs in a conifer forest. In the middle reaches, the uplands are grazed by the riparian vegetation is relatively intact; primarily willows, dogwood, rose, cinquefoil, sedges, and rushes with minor encroachment of sage and pasture grasses where willows are lacking. Near the mouth, sedges and rushes are plentiful along the channel margin but the channel experiences heavy grazing impacts.

6.4.3.14 Red Rock Creek (MT41A004_110)

Redrock Creek (MT41A004_110) is listed for sedimentation-siltation on the 2020 303(d) List. Red Rock Creek is in the southeastern potion of the Red Rock watershed and flows west approximately 18 miles to its confluence with Upper Red Rock Lake.

Physical Condition and Sediment Sources

Sediment, habitat, and riparian condition data was collected at two sites in 2017, site RRCR06-04 and site RRCR06-06 (**Appendix D**).

RRCR06-04

Site RRCR06-04, immediately above Corral Creek, is densely vegetated with willows. Banks appear stable but undercut and are comprised primarily of sand and clay, and to a lesser extent fine gravel and larger. Stream substrate consists of primarily of coarse gravels and fine sediment, with some very coarse gravel and large cobble. Overall, the understory is comprised of approximately 53% wetland vegetation (primarily willows, sedges, and rushes), 43% grasses and forbs, 2 % shrubs and trees, and 2 % bare ground. The riffle and pool features are not well-defined and high-water levels during baseflow prevented some sediment sampling. Depositional bars have formed. The area is not heavily browsed. Approximately 19% of the bank is eroded, with 100% attributed to historical grazing and other land-uses.

RRCR06-06

Site M01RDRKC40 (RRCR06-06a) is located north of South Valley Road. The understory riparian zone is comprised of 61% wetland vegetation (primarily willows, sedges, and rushes), 20% other grasses and forbs, 18% shrubs and trees, and 1% rock. The bank composition is almost 100% sand or clay. Substrate throughout the reach is a mix of gravel and cobble with sand and silt deposits along most channel margins. The width and continuity of the riparian buffer is largely intact but there are sporadic areas where riparian vegetation is impacted by past or infrequent grazing. Bank stability is good, although there is evidence of past instability and banks are undercut on inner and outer bends. Several bank sloughs and slumps were observed, although they have revegetated and stabilized. This reach has mostly glide and run features. Approximately 1% of the bank is eroded, with 80% attributed to natural sources and 20% attributed to historical grazing and other land-use.

Additional data collection

In addition to the sediment sites, two sites were evaluated for habitat and riparian condition.

Site M01RDRKC02 is below Corral Creek. The riparian vegetation is dense and vigorous and is comprised of willows and sedges and rushes along nearly the entire channel margin. Canada thistle is very common in areas of disturbance. The only exception to riparian vigor is the limited riparian vegetation growth and buffer width noted by the old roadway several hundred feet upstream from this site, where past grazing impacts and road/bridge impacts have contributed to bank erosion, widening, and hoof shear. The channel is clear, deep and cold and has excellent fish cover, especially undercut banks, deep pools, and glides.

Site M01RDRKC01 is the lowermost site located approximately 4 miles above the mouth. The riparian buffer width and overall vigor is in optimal condition in most places. The channel margins and banks are densely vegetated with sedges and rushes and a very wide belt of willows that extend throughout most of the valley. Beaver activity is common and several dams are observed in this portion of the stream. The channel is deep, clear and cold with excellent sinuosity and very deep scour pools. As is seen in several photos, there are areas near Elk Lake Road and the trailhead where the stream is scouring into tall erosive hillsides; this scour is likely to be due to natural factors but possibly amplified by human activity (recreation access). A segment of this stream appears to have been historically channelized and straightened although the channel is clearly in a natural form now. The channel substrate has quite a bit of gravel but lots of fine sediment has accumulated which is likely due, in large part, to beaver activity.

Comparison to Water Quality Targets

Sediment assessment parameters were collected at two sites in 2017. Both sites were in the same slope and width category, and so the averages were evaluated.

In all scenarios, both riffle fine parameters are outside of reference range (indicating excess sediment in riffles) (**Table 6-21**). Pool tail fines is within reference range. Width/depth ratio and residual pool depth are both within reference range, and pool count is outside reference range (indicating fewer than desirable pools). Entrenchment ratio is within expected range given stream type.

Table 6-21. Existing sediment-related data for Redrock Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
RRCR06-04	2017	26.2	1	C	**46**	**42**	4	10.8	>8.21	1.5	7.4
RRCR06-06	2017	21.6	1.5	C	**16**	**13**	**13**	12.6	3.07	1.3	5
Average[1]	2017	23.9	0.75	C	**31**	**27.5**	**8.5**	11.7	3.07	1.4	**6.2**

[1]Fine sediment and habitat parameters were evaluated based on site-averages because sites were in the same slope and width categories.

Summary

Data collected by DEQ supports the sediment/siltation listing. All three fine sediment parameters and one of four coarse sediment and morphology parameters differ significantly from reference condition. Generally, channel form appears stable, with good sinuosity and no apparent incision. However, there are areas where the stream is scouring into tall erosive hillsides; this scour is likely to be due to natural factors but possibly amplified by human activity (recreation access). Bank stability is good, although there is evidence of past instability and banks are undercut on inner and outer bends. Several banks sloughs and slumps were observed, although they have revegetated and stabilized.

Data collected by DEQ does not support the listing of alteration in streamside or littoral vegetation cover, and this listing was removed in 2020. The riparian buffer width and overall vigor is in optimal condition in most places. The channel margins and banks are densely vegetated with sedges and rushes and a very wide belt of willows that extend throughout most of the valley. Beaver activity is common, and several dams are observed. There are areas where riparian vegetation is impacted by past or infrequent grazing which has caused widening and hoof shear, and sporadic areas where grazing impacts are concentrated and having worse impact on riparian vegetation, bank stability, and channel morphology. However, the riparian zone is generally in good condition.

6.4.3.15 Sage Creek (MT41A003_140)

Sage Creek (MT41A003_140) is listed for sedimentation-siltation on the 2020 303(d) List. Sage Creek is in the north central portion of the Red Rock watershed and flows southwest approximately 40 miles to its confluence with the Red Rock River near the mouth. In addition, this segment is listed for alteration in streamside or littoral vegetative cover which is a non-pollutant listing that can often be linked to sediment impairment.

Physical Condition and Sediment Sources

Sediment, habitat, and riparian condition data were collected from Sage Creek at two sites in 2017: Sage 16-04 and Sage 16-04 (**Appendix D**).

Sage 16-04

Sediment site 16-04a is located above the confluence with Little Sage Creek. Banks are comprised primarily of sand and clay, with some gravel sizes or larger. Streambed composition is primarily gravel and some cobble. The site has willows, currant, sedges and non-native grasses, but the riparian buffer has narrowed. The channel has widened, and the uplands appear heavily grazed at times. A large amount of fine sediment has accumulated throughout the entire stream bottom and the mid-channel bars are common. Macrophytes are also common. Approximately 21% of banks are eroded, with 72 % attributed to natural factors, 16% attributed to historic grazing and other activities, and 12% attributed to current grazing.

Sage19-02

Sediment site SAGE19-02a, near the mouth is in a flood-irrigated hay field with few riparian species. The banks are almost entirely comprised of sand and clay with a small amount of fine gravel and larger sizes. The streambed is comprised primarily of medium gravel, with some fine sediment. Non-native grasses and forbs comprise almost 100% of the vegetated understory. Grasses reach the channels edge; mature willows and cottonwoods are dispersed throughout the reach. Approximately 1% of the bank is eroded, with this erosion attributed to unknown causes.

Additional data collection

In addition to the sediment sites, habitat and riparian condition data was collected at two sites. Site M01SAGEC50 is the upper site about seven miles below the confluence with Long Creek. Dense willows grow along the channel in some places and sedges and other vascular plants line the channel margin. Macrophytes are common. Excess fine sediment has begun to accumulate in the channel. The upland appears heavily grazed and upland vegetation is encroaching on the channel. The channel is stable where riparian vegetation is intact, but portions of the channel with less riparian vegetation is incised, unstable, and hummocked where the riparian area is more impacted by livestock. Instream habitat complexity is good in many places with deep pools, large woody debris, undercut banks, overhanging vegetation, and isolated backwater pools.

Site M01SAGEC03, approximately six miles above the mouth, has diminished riparian health due to impacts from nearby irrigated fields and heavily grazed pasture. There is also an extensive network of irrigation canals in the vicinity, altering the flow regime and disturbing the floodplain. The riparian condition is marginal or poor.

Comparison to Water Quality Targets
To evaluate fine sediment parameters the average of both sites was compared to reference data given that the sites were similar slope categories (**Table 6-22**). For coarse sediment and instream habitat parameters, both sites were compared independently to reference data because they represent different bankfull width categories.

All three fine sediment parameters are outside reference range (indicating excess fine sediment is being deposited in these sensitive habitats). For site SAGE16-04a, residual pool depth is within reference range, but width/depth ratio and pool count are outside reference range (indicating the channel is shallower and wider with fewer pools than desirable). For siteSage19-02a, width/depth ratio and pool count are within reference range, but residual pool depth is outside reference range (indicating pool habitat quality is not desirable). Entrenchment ratio is within expected range given stream type.

Table 6-22. Existing sediment-related data for Sage Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
SAGE16-04	2017	19.9	1	C	23	16	6	**24.6**	2.21	2.53	**8.9**
SAGE19-02	2018	11.1	1	E	41	39	38	5.6	2.65	**0.71**	20.7
Average[1]	2017, 2018	15.5	1	C,E	**32**	**27.5**	**22**	Evaluated at the site-level			

[1]Fine sediment parameters were evaluated based on site-averages because sites were in the same slope category, and other habitat parameters were based on individual parameters because sites differed in width category.

Summary
Data collected by DEQ support the listing of Sage Creek for sediment/siltation. The channel is stable where riparian vegetation is intact, but portions of the channel with less riparian vegetation and more impacted by livestock is incised, unstable, and hummocked. Instream habitat complexity is good in many places with deep pools, large woody debris, undercut banks, overhanging vegetation, and isolated backwater pools. However, the channel has widened in places and a large amount of fine sediment has accumulated throughout the stream bottom; mid-channel bars are common. The channel configuration and flow regime are changed by the irrigation network.

The data support the listing of Sage Creek for alteration in streamside or littoral vegetation cover. The channel, in places, exhibits diminished riparian health due to impacts from nearby irrigated fields and heavily grazed pastures. The upland appears heavily grazed and upland vegetation is encroaching on the channel. Restoration and implementation of Best Management Practices will help to reduce sediment loads and improve riparian condition.

6.4.3.16 Selway Creek (MT41A003_110)

Selway Creek (MT41A003_110) is listed for sedimentation-siltation on the 2020 303(d) List. In addition, this segment is listed for alteration in streamside or littoral vegetative covers which is a non-pollutant listing that can often be linked to sediment impairment. Selway Creek is in the northwestern portion of the Red Rock watershed and flows approximately 9 miles southwest to its confluence with the upper reaches of Bloody Dick Creek.

Physical Condition and Sediment Sources

Sediment, habitat, and riparian condition was assessed at three sites in 2020: SELC05-01a, SELC05-01b, and SELC5-08 (**Appendix D**)

SELC05-01a

Site SELC05-01a, in the upper reaches near Short Creek, has an understory comprised of 72% sedges and rushes, 10% grasses and forbs, 16% small shrubs, and 2% bare ground. The riparian area has no canopy or mid-story cover. Although sedges are present along the channel margin, upland grasses and sage are encroaching. Banks are undercut and the channel is sinuous. Substrate is a mix of large cobble and small gravel, and silt/sand was observed on inside bends and in pools. Bank composition is primary sand and clay (70-90%) with the remainder in fine gravel. The riparian zone is grazed with heavily browsed vegetation and pugging and hummocking prevalent throughout site. Approximately 24% of the bank is eroded, with 100% of this attributed to riparian grazing (**Figure 6-8**).

Figure 6-8. Heavily grazed area along site SELC06-01a.

SELC05-01b

Sediment site SELC05-01b, mid-segment below Mooney Creek, is similar to the site upstream but has a narrower riparian buffer and more evidence of grazing; vegetation is heavily browsed with some hoof shear. Some willow saplings were observed, and upland grass and sage are encroaching on the riparian area. Some banks are undercut, and the channel is braided into 3 or 4 channels in some places. Substrate is a mix of cobbles and gravel with less defined pool tails. Macrophyte beds are large and present throughout site. Bank composition is also primarily sand and clay, but also has coarse gravel and larger sizes. An estimated 27% of the bank is eroded, with almost 100% of this attributed to riparian grazing.

SELC5-08

Site SELC05-08, near the mouth, has dense willows and riparian vegetation is flourishing. Bank composition is typically 70% sand and clay, 20% fine gravel, and 10% coarse gravel or larger sizes. The streambed is predominately gravel and cobble, but also has a large proportion of fine sediment. Cows actively graze the area and cattle trails are common; pugging and hummocking around the stream channel was observed but minimal around site. Some undercut banks. Substrate is primarily cobble, even in pools; riffles are short and steep. Some dense macrophyte growth. Approximately 3% of the bank is eroded with 63% attributed to natural factors and 27% of this attributed to riparian grazing.

Comparison to Water Quality Targets

To evaluate fine sediment parameters, the average of the three sites was compared against reference data because all sites are in the same slope category (**Table 6-23**). For instream habitat parameters, the average of sites with similar bankfull widths (SELC05-01a and SELC05-01b) were compared to reference. Site SELC05-08 was evaluated independently to reference because it is in a different bankfull width category than the others.

The average of pool tail fines is within reference range but both riffle fine parameters were outside reference range (indicating excess sediment is deposited in riffles). Width/depth and entrenchment ratio is within reference range for the average of sites SELC5-01a and SELC05-01b, and for SECL05-08. Residual pool depth is within reference range for the average of SELC5-01a and SELC05-01b but outside reference range for SECL05-08. Both the average of SELC5-01a and SELC05-01b and the value for SECL05-08 are within reference range for pool frequency.

Table 6-23. Existing sediment-related data for Selway Creek relative to targets Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
								12.7	>9.6	**0.76**	22.3
SECL05-08	2015	17.2	1.6	E	48	44	7	SECL05-08 evaluated separately			
SELC05-01a	2015	9.4	0.8	E	36	28	6	6.4	>25.7	0.56	26.7

Table 6-23. Existing sediment-related data for Selway Creek relative to targets Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
SELC05-01b	2015	8.1	1.2	E	24	19	2	9.1	11.4	0.96	13.6
Average	2015	11.5	1.2	E	**36.0**	**30.3**	5.0	7.7	18.5	0.76	20.1

[1]Fine sediment parameters were evaluated based on site-averages because sites were in the same slope category. For habitat parameters, the average sites SELC05-01a and SELC05-01b were evaluated and site SECL05-08 was evaluated separately.

Summary

Data collected by DEQ support the listing of Selway Creek for sediment/siltation. Banks have been trampled by livestock causing hoof shear, pugging and hummocking. Thick macrophyte growth was present at the riffles in this site and large quantities of sediment were observed.

Data collected by DEQ support the listing for alteration in streamside or littoral vegetation cover. The riparian area is disturbed by livestock grazing; vegetation is browsed, willows are lacking in places, and upland plants are encroaching on the riparian area. Restoration and implementation of Best Management Practices will help to reduce sediment loads and improve riparian condition.

6.4.3.17 Tom Creek (MT41A004_100)

Tom Creek (MT41A004_100) is listed for sedimentation/siltation, alteration in streamside and littoral vegetation cover, and flow regime modification on the 2020 303(d) List. Tom Creek is in the southeastern portion of the Red Rock watershed and flows northwest approximately 6.5 miles to its confluence with Upper Red Rock Lake.

Physical Condition and Sediment Sources

Sediment, habitat, and riparian condition was assessed at two sites in 2017: TOMC05-01 and TOMC06-01 (**Appendix D**).

TOMC05-01

Site TOMC05-01a is located above South Valley Road. Understory riparian vegetation is comprised of 8% wetland plants (sedges, rushes, willows, horsetail), 34% grasses and forbs, and 58% shrubs and trees. Willows are common and vigorous with many saplings and seedlings, but other riparian species are less common than expected and the site is experiencing encroachment by upland pasture grasses, forbs, and sagebrush. Canada thistle is common. The channel form is relatively intact and stable with sinuosity as expected and an intact riffle-pool sequence. Some bank erosion is evident, particularly in areas where cattle frequently cross or access water. The substrate is primarily gravel and cobble mix, although excess silt deposition has been occurring along channel margins and substrate throughout the channel is becoming embedded, possibly limiting macroinvertebrate and fish spawning habitat. The water is substantially turbid at times, likely due to upstream cattle activity. The composition of the banks is nearly 100% sand and clay. Approximately 7 % of the banks are eroded, with 90% attributed to natural factors, and 10% attributed to riparian grazing.

T*OMC06-01*

TOMC06-01a located below South Valley Road. The composition of the banks is generally 80% sand and clay, 10% fine gravel, and 10% sizes greater than fine gravel. The streambed composition consists of mixed gravel and cobble sizes, with minimal fines. Riparian vegetation consists primarily of grasses with some small willows; clumps of rushes are growing on slumped banks and hummocks that have fallen into the channel. Large willows and other woody species are growing upstream and downstream of site indicating that potential for woody revegetation is high. Banks are undercut throughout the site but generally appear to be stabilizing as they revegetate. Floodplain access is unrestricted. The site has been historically grazed but appears to be recovering. Approximately 50% of the banks are experiencing some erosion, with 100% attributed to historical land uses including grazing.

Additional data collection

Although additional sites were not accessed upstream from these sites, aerial images indicate riparian and channel disturbances due to heavier cattle influence (e.g., fenceline contrast, cattle trails, channel widening, banks devoid of vegetation).

Comparison to Water Quality Targets

Sediment assessment parameters were collected at two sites from 2017 to 2018 (**Table 6-24**). The average of both sites was used to evaluate fine sediment parameters and habitat parameters given that sites were in the same slope and width categories.

All three fine sediment parameters are in reference range. Residual pool depth was within reference range, but width/depth ratio and pool count were outside of reference range (indicating the channel is wider and shallower and pools are less frequent than desirable). Entrenchment ratio is within expected range given stream type.

Table 6-24. Existing sediment-related data for Tom Creek relative to targets Values that do not meet the target are in bold and shaded

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
TOMC05-01	2017	6.4	2	B	32	20	4	9.8	3.84	0.77	22.8
TOMC06-01	2018	9.1	3	B	5	5	19	10	>2.2	0.73	20.8
Average[1]	2017,2018	7.7	2.5	B	18.5	12.5	11.5	**9.9**	3.84	0.75	**21.8**

[1]Fine sediment and habitat parameters were evaluated based on averages because sites were in the same slope and width categories.

Summary

The data collected by DEQ supports the listing of Tom Creek for sediment/siltation. The substrate is primarily gravel and cobble, although excess silt deposition has been occurring along channel margins and substrate throughout the channel is becoming embedded, possibly limiting macroinvertebrate and fish spawning habitat. Some bank erosion is evident, particularly in areas where cattle frequently cross or access water. Field observations could not be made upstream but aerial imagery indicates that riparian and channel disturbances are prevalent due to heavy livestock influence (The water is substantially turbid at times, apparently due to upstream cattle activity).

The data collected by DEQ also supports the listing of Tom Creek for alteration in streamside or littoral vegetation cover. Riparian vegetation consists primarily of grasses with some small willows; clumps of rushes are growing on slumped banks and hummocks that have fallen into the channel. Field observations could not be made everywhere, but aerial imagery indicates that riparian and channel disturbances are prevalent due to heavy livestock influence (e.g., fenceline contrast, cattle trails, channel widening, banks devoid of vegetation). The lower reaches appear to have been historically grazed but are recovering. Restoration and implementation of Best Management Practices will help to reduce sediment loads and improve riparian condition.

6.4.3.18 Trail Creek (MT41A003_080)

Trail Creek (MT41A003_080) is listed for sedimentation/siltation and alteration in streamside and littoral vegetation cover on the 2020 303(d) List. Trail Creek is in the northwestern portion of the Red Rock watershed and flows approximately 15.6 miles northeast to its confluence with the middle reaches of Horse Prairie Creek.

Physical Condition and Sediment Sources

Two sites were evaluated for sediment, habitat, and riparian condition: TRLC07 and TRLC08 (**Appendix D**).

TRLC07

The upper site, Sediment site TRLC07a, is below the Frying Pan Creek confluence and upstream from a beaver dam. The composition of the banks are approximately 95% sand and clay and 5% sizes greater than fine gravel. The bank composition is predominately coarse gravel, with some fine sediment. The reach has abundant willows, sedges, and forbs. The channel has widened but has a well-established riffle-pool sequence. Pools were diverse and riffles had cobbles, coarse gravel, and sand. Fish habitat is considered optimal with abundant undercut banks, overhanging vegetation, deep pools, and large woody debris. Stream banks exhibit hoof shear. Approximately 5% of the banks are eroding with 39% attributed to natural factors and 61% attributed to riparian grazing.

TRLC08

Sediment site TRLC08a, about 4.5 miles above the mouth, has riparian vegetation that is primarily willows and sedges with pasture grass encroaching. The bank composition is estimated to be 70-100% sand and clay and 0-30% fine gravel or larger. The streamed composition is predominately mixed gravel and cobble, but also is comprised of a large proportion of fine sediment. The overall condition of the riparian area is quite poor; willows appear limited by lower water table from diversions and from livestock browse. Sedges grow along the channel margins but cannot withstand grazing pressure to stabilize banks to full potential. The overall riparian buffer width is particularly restricted here, with what appears to be conversion to pasture in near vicinity and heavy grazing. The reach has a well-defined riffle-pool sequence and deep pools, though the channel is widening and becoming shallower and appears to be aggrading. Excess fine sediment is deposited, and mid-channel bars are forming. Hoof shear and hummocking is observed, and the channel is becoming braided in places. Undercut banks, overhanging vegetation, submerged vegetation, and diverse pools provide good fish habitat in places. Approximately 7% of the banks are eroded, with 89% attribute to current grazing and 11% attributed to natural factors.

Additional data collection

In addition to the sediment sites, two additional sites were evaluated for habitat and riparian condition.

At an unnamed site between TRLC07a and TRLC08a , the riparian area is willow interspersed with pasture grasses and sedges along the channel margin. This site is heavily impacted by grazing and has limited understory and ground cover, mature isolated willows, and a diminished riparian buffer. Pugging and hummocking is observed and banks are destabilizing in places. Lateral cutting is occurring along outside beds and bank sloughing is observed. Inside bends are also being trampled, reducing overall stability. Pool-riffle sequence is generally intact. Fine sediment deposition extends beyond channel margins and gravel/cobble substrate is embedded. Very heavy macrophyte beds grow throughout the reach.

M01TRALC40, near the midpoint of Trail Creek, has a riparian area of primarily willows, sedges along channel margins, and rose and Canadian thistle interspersed throughout. Willow vigor is visibly declining, presumably due to heavy browse and water withdrawals, effectively narrowing the riparian buffer. Much of this area exhibits riparian and native grasses being converted to pasture grasses, and evidence of heavy grazing is apparent. Where vegetation has been limited, the banks are less stable and bank failure is occurring, especially on outside bends leading to excessive lateral cutting. Substrate is primarily gravels and cobbles, although the stream overall appears to be in early stages of aggradation; mid-channel bars are forming, and substrate is becoming embedded.

Comparison to Water Quality Targets

To evaluate fine sediment parameters against reference data, the average of both sediment sites was used because they are in the same slope category (**Table 6-25**). To evaluate coarse sediment and instream habitat parameters, both sites were compared independently to reference data because they are in different reference bankfull width categories. Pool tail fines for the average of the sediment sites were within reference range but both riffle fines parameters are outside reference range (indicating excess fine sediment is deposited in riffles). For site TRLC08a, width/depth ratio and residual pool depth are within reference range, but pool count, and entrenchment ratio is not (indicating channel incision and fewer pools than is desirable). For site TRLC07a, width/depth residual pool depth is within reference range, but width/depth ratio and pool count, and entrenchment ratio are outside reference range (indicating the channel is getting wider and shallower, incision is higher than expected, and fewer pools than desirable).

Table 6-25. Existing sediment-related data for Trail Creek relative to targets. Values that do not meet the target are in bold and shaded.

Reach/ Site ID	Assessment Year	Mean BFW (ft)	Gradient (%)	Existing Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / 1000 ft
TRLC08	2017	15.5	1.0	C	37	32	3	15	**1.9**	1.5	**9.3**
TRLC07	2017	12.8	0.5	C	18	16	7	**15.8**	**1.2**	0.77	**15.1**
Average[1]	2017	14.1	0.75	C	**27.5**	**24**	5	Sites evaluated individually			

[1]Fine sediment parameters were evaluated based on averages because sites were in the same slope category. Habitat factors were evaluated separately because sites were in different width categories.

Summary

The data support the listing of Trail Creek for sediment. The channel is widening and becoming shallower in some areas and appears to be aggrading. Excess fine sediment is deposited, and mid-channel bars are forming. Hoof shear and hummocking is observed, and the channel is becoming braided. Stream banks exhibit some evidence of failure and livestock hoof shear. In other areas, there is evidence of downcutting, and channel incision as indicated by the low entrenchment ratio values.

The data also support the listing of Trail Creek for alteration in littoral and streamside vegetation cover. The overall condition of the riparian area is poor in places; willows appear limited by lowered water table and from livestock browse. Sedges grow along the channel margins but cannot withstand grazing pressure to stabilize banks to full potential. The overall riparian buffer width is restricted in places by conversion to pastureland and heavy grazing.

6.5 Source Assessment and Quantification

This section summarizes the assessment approach, current sediment load estimates, and the determination of the allowable load for each source category. DEQ determines the allowable load by estimating the obtainable load reduction once all reasonable land, soil, and water conservation practices have been implemented. The reduction forms the basis of the allocations and TMDLs provided in **Section 6.7**. This section focuses on three potentially significant sediment source categories and associated controllable human loadings for each of these sediment source categories:

- Streambank erosion
- Upland erosion and riparian health
- Unpaved roads

EPA's guidance for developing sediment TMDLs provides the basic procedure for assessing sources, which includes inventorying all sediment sources to the waterbody. In addition, the guidance suggests using one or more methods to determine the relative magnitude of loading, focusing on the primary and controllable sources (U.S. Environmental Protection Agency, 1999). Federal regulations allow that loading determinations "may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (Water quality planning and management, 40 CFR 130.2(G), 2012). For each impaired waterbody segment, sediment loads from each source category are estimated according to field surveys, load extrapolation, and limited hillslope modeling techniques (described in the sections below). The results include a mix of sediment sizes. Bank erosion involves both fine and coarse sediment loading to the receiving water. Conversely, loading from roads and upland erosion is predominately of fine sediment. The complete methods and results for source assessments for streambank erosion, roads, and upland erosion are found in **Appendices C**, **D**, and **E**, respectively.

Many of the impaired segments evaluated have diversions and agricultural withdrawals located near the mouth. While the following sections estimate the contributions of sediment to the impaired stream segments from eroding streambanks, unpaved roads, and uplands, not all of this sediment reaches downstream waterways.

6.5.1 Eroding Streambank Sediment Assessment

General approach

Human disturbances to riparian vegetation and health and stream hydrology may result in greater lengths of eroding banks and accelerate the erosion rate. This commonly occurs when streambanks change from being well vegetated to being largely, or entirely, unvegetated with vertical banks. Causes of streambank erosion include the following:

- transportation
- riparian grazing
- cropping
- mining
- silviculture
- irrigation-related shifts in stream energy
- other (e.g., historical, or legacy sources)
- natural processes

DEQ assessed streambank erosion for all 18 segments impaired for sediment in the Red Rock TPA. The streambank erosion assessment involved several procedures. First, impaired segments of streams were stratified into reaches with similar gradient, confinement, and stream size using an aerial assessment performed in GIS (DEQ 2015). As part of the aerial photography assessment, the percent of the reach within the 100-foot buffer that was in "natural" riparian condition, with little evidence of grazing or other anthropogenic disturbance was estimated (DEQ 2015). Streambank erosion data were then collected in the field at 30 monitoring reaches in 2017 and 2018. Monitoring reaches were either 500 feet or 1000 feet in length, depending on the width of the stream (**Appendix E**).

For each eroding streambank at each sampled site, channel cross section measurements were collected to estimate the erosive force (i.e., near bank stress) (Rosgen, 1996), and measurements of the bank height, bankfull height, root depth, root density, bank angle, and surface protection were collected as indicators of each streambank's susceptibility to erosion (i.e., bank erosion hazard index or BEHI). A combination of the BEHI score and near bank stress were used to estimate the depth of sediment eroded per year (i.e., retreat rate) using the Bank Erosion for Nonpoint Sources of Sediment (BANCS) model method as described in **Appendix E.** This depth was multiplied by the height and length of the bank to obtain an estimate of the total volume eroded for each sampled bank. This was summed across the sampled site to obtain an estimate of total loading then standardized to a 1,000 foot length (**Appendix E**). For each bank with erosion, the cause of erosion (due to natural factors, roads, riparian grazing, residential/urban land use, historic land use, and other) was estimated in the field, and the loading estimates weighted by these values to determine how each land use contributed to loading amounts (**Appendix E**).

Average loads from field assessed monitoring sites were then extrapolated to the unassessed stream reaches in each impaired segment. This extrapolation was done according to classification of each reach based on the gradient, stream order, and estimated percent of riparian zone in natural vegetation (based on aerial photos) (**Table 6-26**). Data collected from the adjacent Madison watershed was used to supplement these estimates, given a limited number of sites sampled from some categories within the Red Rock TPA (**Table 6-26; Appendix E**). Load extrapolation from the Madison TPA to the Red Rock TPA was adjusted based on the fact that the sampled streams in the Red Rock TPA exhibited a lower percentage of banks with active erosion. The exception was the highest gradient reaches (>10%), which were assumed to have similar loading rates in both watersheds due to similarly low grazing and other pressures. These highest gradient streams (>10%) were given the same value of loading regardless of riparian condition, given that riparian condition had no notable effect on estimates of loading for these reaches. First-order reaches with >10% gradient were also assigned the loading value for the " > 10% gradient category" versus "first order stream category", given the observation that these reaches had lower loading than lower-gradient first order reaches.

Table 6-26. Average loading from sampled reaches used to estimate loading in unsampled reaches.

Sampled Reaches			**Assigned to**	**Unsampled Reaches**			
Gradient	**Order**	**Condition (based on aerial photos)**		**Gradient**	**Order**	**Condition (based on aerial photos)**	**Method**
0-2%	Non 1st	High (> 70%) of riparian zone in natural condition	--->	0-2%	Non 1st	High	Red Rock sampled average + 25%
0-2%	Non 1st	Low (≤ 70%)of riparian zone in natural condition	--->	0-2%	Non 1st	Low	Red sampled average + 25%
>2-4%	Non 1st	High (> 70%) of riparian zone in natural condition	--->	>2-4%	Non 1st	High	Madison sampled average, adjusted for lower loading rates in Red Rock
>2-4%	Non 1st	Low (≤ 70%)of riparian zone in natural condition	--->	>2-4%	Non 1st	Low	Madison sampled average, adjusted for loading rates in Red Rock

Sampled Reaches			Assigned to	Unsampled Reaches			Method
Gradient	Order	Condition (based on aerial photos)		Gradient	Order	Condition (based on aerial photos)	
>4-10%	Non 1st	High (> 70%) of riparian zone in natural condition	--->	>4-10%	Non 1st	High	Madison sampled average, adjusted for lower loading rates in Red Rock and potential improved bank condition given that no high-condition reaches were sampled
>4-10%	Non 1st	Low (≤ 70%)of riparian zone in natural condition	--->	>4-10%	Non 1st	Low	Madison sampled average, adjusted for lower loading rates in Red Rock
> 10%	Non 1st	All land uses	--->	> 10%	Non 1st	All	Madison sampled average, all riparian qualities
Any	1st, except for > 10% gradient	High (> 70%) of riparian zone in natural condition	--->	Any	1st	High	Red Rock average adjusted for potential improved bank condition given that no high-condition reaches were sampled
Any	1st, except for > 10% gradient	Low (≤ 70%)of riparian zone in natural condition; supplement with Madison data	-->	Any	1st	Low	Red Rock sampled value

The assumptions used during the assessment of eroding streambanks are provided below:

- The condition of streambanks at monitored sites sampled during 2017 and 2018 is representative of current conditions within the larger Red Rock TPA.
- For low and mid-gradient reaches, the loading dynamics in the Red Rock watershed are similar to the Madison watershed after adjusting for the fact that the per cent of banks that are eroded is significantly less in the Red Rock watershed compared to the Madison watershed.
- The annual streambank retreat rates used to develop the sediment loading numbers were based on Rosgen BEHI studies in the Lamar Valley of Yellowstone National Park (Rosgen, 2001). The

Red Rock TPA has similar geology including weakly lithified sedimentary geology, with broad areas of volcaniclastic tuff (Kellogg et al. 2007). Therefore, we assumed the retreat rates from Rosgen 2001 can be applied to the Red Rock TPA.

Model results

Substantial human-caused sources of streambank erosion contribute to the sediment loads in the Red Rock TPA. Based on the visual assessment of contributing factors immediately adjacent to eroding streambanks, riparian grazing and the past history of land use activities (usually grazing) contributed large amounts (approximately 19% each) of the sediment load from bank erosion (**Table 6-27**). However, natural sources were determined to be the biggest cause of erosion.

Table 6-27. Estimated sources of bank erosion at sampled sites

Source	Sediment Load (Tons/Year)	Sediment Load (Percent)
Natural	655.1	51.1
Roads	52.9	4.1
Riparian Grazing	252.7	19.7
Other	72.5	5.7
Residential/Urban	2.3	0.2
Historic Grazing and Other Activities	246.5	19.2
Total	**1282.1**	**100**

The extrapolation procedure outlined in **Appendix E** allowed for estimation of total loading from bank erosion for impaired reaches in each segment based on slope, stream order, and condition of the riparian zone. Loading estimates for reaches in each segment were summed to obtain an estimate of total loading from bank erosion for each segment. Estimated streambank erosion loads ranged from 388 tons per year in the East Clover Creek subwatershed to 16,977 tons per year in the Horse Prairie Creek subwatershed (**Table 6-28**). For these calculations, the contributions of sediment from impaired tributary subwatersheds were included in the estimates for Big Sheep Creek (Muddy Creek), Red Rock Creek (Corral Creek), and Horse Prairie Creek (Medicine Lodge, Selway and Trail Creeks).

Table 6-28. Bank erosion loading for the Red Rock subwatersheds, from highest to lowest tons/stream mile/year.

Subwatershed	Estimated Load (Tons/Yr)	Estimated Load Tons/Stream Mile/Year	Stream Miles
O Dell Creek	4156	266.4	15.6
Big Sheep Creek	5377	176.4	30.48
Medicine Lodge Creek	5535	160.4	34.5
Horse Prairie Creek	16977	159.2	106.63
Red Rock Creek	3418	151.9	22.5
Peet Creek	1371	142.8	9.6
Price Creek	1446	137.7	10.5
Selway Creek	1235	136.8	9.03
Tom Creek	872	132.1	6.6
Jones Creek	1071	129.0	8.3

Table 6-28. Bank erosion loading for the Red Rock subwatersheds, from highest to lowest tons/stream mile/year.

Subwatershed	Estimated Load (Tons/Yr)	Estimated Load Tons/Stream Mile/Year	Stream Miles
Bean Creek	810	125.8	6.44
Trail Creek	1894	121.4	15.6
Sage Creek	4627	115.4	40.1
Corral Creek	478	111.2	4.3
Muddy Creek	1191	107.5	11.08
Fish Creek	742	100.3	7.4
East Fork Clover Creek	388	66.9	5.8
Long Creek	1507	63.3	23.8

6.5.2 Unpaved Road Sediment Assessment

General approach

The unpaved road sediment assessment was primarily a GIS analysis. DEQ staff used ArcPro GIS software to locate each unpaved crossing (e.g., bridges, culverts, fords) and stream-adjacent stretch of road within 100-feet of streams (called "parallel road segment") that could contribute sediment to impaired stream segments Red Rock TPA. The amount of sediment contributing from each of these was based on estimates of contributed sediment for different elevations and ownership categories as previously determined for the adjacent Madison watershed (**Appendix F).** An assumption was that the Red Rock watershed has similar landscape and road improvement practices as the Madison watershed. A detailed unpaved roads assessment has been conducted for the Selway watershed (within the Red Rock TPA) by the United States Forest Service, and this was used to validate this method by comparing the amount of estimated sediment entering the stream for both methods.

Both the DEQ and USFS approaches were based on the Water Erosion Prediction Project (WEPP) model (Flanagan and Livingston, 1995). WEPP: Road is an interface, developed by the USFS and other agencies, used to predict runoff, erosion, and sediment delivery from forest roads. The model predicts sediment yields based on the specific soil, climate, ground cover, and topographic conditions collected in the field at each location.

Model results

There was high overlap between the parallel road segments identified using both the DEQ and USFS methods. For source areas identified using both methods, the USFS estimated the amount entering from parallel stream segments at 0.62 tons/stream mile/year, whereas the estimate based on similar surveys in the Madison watershed was 0.84 tons/stream mile/year (**Table 6-29**). The values from all unpaved road categories could not be compared given that Selway Creek contained almost 100% public, high elevation sites. However, this comparison provides support for the use of average values from the Madison assessment for the Red Rock TPA. Approximately 24% less sediment entered streams using the DEQ method. It was assumed that these differences extended to the other elevation/ownership categories. Therefore, the values used for the Madison TMDLS were reduced by 24% in the estimation of loading for the Red Rock TPA (**Table 6-29**)

Table 6-29. Summary of sediment leaving the buffer at parallel road segments and road crossings from the Madison assessment and the adjusted values applied to the Red Rock watershed.

Category	No. Parallel Segments Sampled	Length of Parallel Road Segments Sampled (Miles)	Avg. Sediment Per Mile-Madison (Tons/Yr)	Avg. Sediment Per Mile-Adjusted (Tons/Yr)	No. Cross-ings Sampled	Avg. Sediment per Crossing - Madison (Tons/Yr)	Avg. Sediment Per Crossing-Adjusted (Tons/Yr)
Public, high elevation	3	1.33	0.835	0.635	8	0.272	0.207
Public, low elevation	8	1.05	2.818	2.142	5	0.038	0.029
Private, high* elevation	0	0	NA	0.635	0	NA	0.207
Private, low elevation	5	1.45	0.932	0.708	11	0.136	0.103

*because no private, high elevation sites were sampled, the values from public, high elevation were used for this category

Despite the similarities in loading at the areas that overlapped, the DEQ evaluation identified more crossings and parallel road segments than the USFS evaluation (which primarily focused on accounting for loading from only parallel road segments). The DEQ evaluation resulted in an estimate of sediment loading of 7.6 tons per year for the Selway subwatershed versus approximately 3 tons per year in the USFS evaluation. However, this was a relatively small difference given the wide range of loadings observed across the subwatersheds (**Table 6-30**).

While road conditions can influence sediment inputs, the biggest influence is generally the total number of crossings and parallel road segments. A total of 874 unpaved road crossings and 265 miles of unpaved parallel road segments were identified within the sediment-impaired watersheds of the Red Rock TPA (**Appendix F**). A simple breakdown of the modeled loads shows which subwatersheds are predicted to have the highest sediment contributions attributable to unpaved roads (**Figure 6-9** and **Table 6-30**). It also shows subwatersheds in which unpaved roads have a negligible contribution to the overall sediment load. (**Table 6-30**). Some of the highest estimated contributions are from Horse Prairie Creek, Medicine Lodge Creek, and Big Sheep Creek. The lowest contributions are for East Fork Clover Creek, Corral Creek, and Tom Creek, which had only one or two crossings each and < 0.2 miles of road. Loading per mile may be more indicative of potential inputs to streams than the total load. Muddy, Fish, and Selway Creeks had the highest estimates per mile due to large number of parallel road segments and crossings for the length of streams in these subwatersheds (**Table 6-30**).

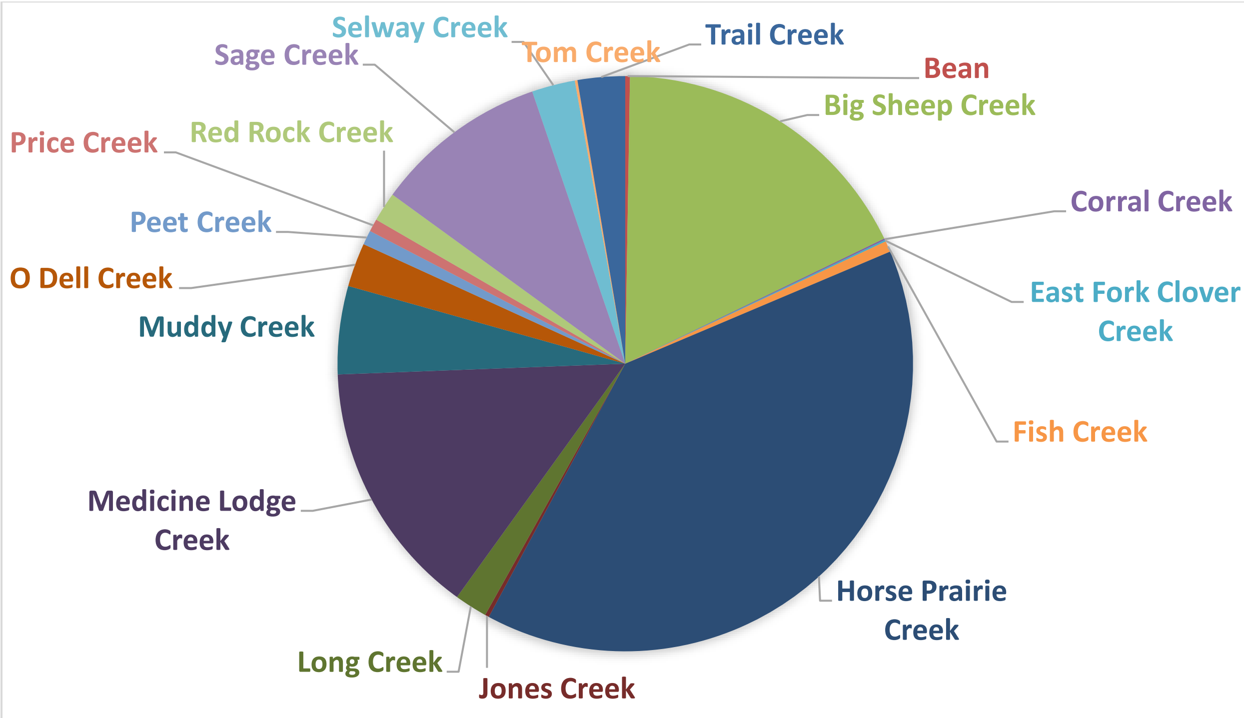

Figure 6-9. Estimated percent sediment contribution from unpaved roads by subwatershed in relation to the total sediment contribution from unpaved roads across the sediment-impaired subwatersheds

Table 6-30. Loading estimates per subwatershed, ranked by decreasing load per stream mile

Subwatershed	No. Crossings	Length of Parallel Road Segments (Miles)	Total Loading (Tons/Yr)	Stream Miles	Tons/Stream Miles/Yr
Muddy Creek	47	8.8	15.3	64.6	0.24
Fish Creek	5	1.4	1.9	8.8	0.23
Selway Creek	25	3.6	7.5	37.7	0.20
Big Sheep Creek	190	24.8	54.4	298.0	0.18
Medicine Lodge Creek	173	20.2	44.6	250.5	0.18
Horse Prairie Creek	451	55.3	121.1	897.3	0.13
O Dell Creek	33	1.3	7.6	53.3	0.14
Trail Creek	25	4.7	8.2	63.1	0.13
Price Creek	9	0.5	2.2	19.3	0.11
Sage Creek	116	11.5	30.1	278.1	0.11
Peet Creek	9	1.0	2.5	25.6	0.10
Long Creek	21	2.2	5.7	59.9	0.10
Bean	2	0.6	0.8	8.6	0.09

Table 6-30. Loading estimates per subwatershed, ranked by decreasing load per stream mile

Subwatershed	No. Crossings	Length of Parallel Road Segments (Miles)	Total Loading (Tons/Yr)	Stream Miles	Tons/Stream Miles/Yr
Red Rock Creek	20	1.5	5.1	69.5	0.07
Jones Creek	2	0.4	0.7	10.4	0.07
Corral Creek	1	0.1	0.3	4.4	0.05
East Fork Clover Creek	1	0.1	0.3	7.7	0.04
Tom Creek	2	0.1	0.5	16.7	0.03

6.5.3 Upland Sediment Assessment

General approach

Upland sediment loading due to hillslope erosion was modeled for each watershed upstream of impaired stream segments using a method that incorporated the Universal Soil Loss Equation (USLE) (**Appendix G**).

The general form of the USLE has been widely used for erosion prediction in the U.S. It includes factors that control sediment runoff from hillslopes:

(1) A = RK(LS)CP (in tons per acre per year)

where soil loss (A) is a function of the rainfall erosivity index (R), soil erodibility factor (K), overland flow slope and length (LS), crop management factor (C), and conservation practice factor (P) (Wischmeier and Smith 1978, Renard et al. 1997). The crop management factor describes the potential erosion due to land use and was estimated based on past consultation with NRCS staff and the literature. Croplands have the highest level of erosion and highest C factor, while forests and wetlands have the lowest contribution and lowest C factors. One of the biggest contributions of sediment was recent fires (< 10 years), which were given a higher C factor compared to unburned areas. In the last three years, there have been three large higher-intensity fires in the Red Rock watershed within the Trail Creek, Big Sheep Creek, and Horse Prairie Creek subwatersheds (**Appendix G**). The data collected to support the 2020 303(d) listing was collected prior to these fires occurring. Therefore, other land-use factors besides fire contributed to the sediment listings. However, because the additional sediment contributed from fires is likely affecting aquatic health of the impaired segments, the fires were included in the source assessment.

Given the drier climate occurring throughout much of Montana, high-intensity fires will likely continue into the future and will potentially increase sediment to streams. In addition to effects of landscape vegetative cover, the intensity of rainfall, slope, and erodibility of soil also had an influence on erosion generated by the model as indicated by the equation.

While the USLE model estimated the amount of sediment generated if all the sediment made it to waterways, research shows that not all sediment enters waterways due to deposition and uptake by plants. The contribution of sediment from each pixel (~30 feet X ~30 feet square) of the watershed to stream flow paths was adjusted based on a published relationship between relative distance to the stream flow path and volume of sediment (Megahan and Ketcheson 1996) and was also adjusted by the width of riparian buffer (forest, grassland, shrub, or wetland; **Table 6-31).** The width of the riparian buffer between each upstream area and the stream was calculated as the length of natural landscape (forest, shrub, grassland, or wetland) between each pixel in the watershed and the stream using ArcGIS.

The estimated sediment entering within the riparian zone was further adjusted based on riparian zone quality. For areas flowing through less than 90 feet of riparian buffer, the quality of the riparian buffer was determined from a GIS analysis of riparian health in each subwatershed which was conducted as part of the bank erosion assessment (**Appendix E**). Pixels flowing through 0-90 feet of riparian buffer with an estimated low quality riparian zone were given a percent reduction of 65%. Pixels flowing through 0-90 feet of riparian buffer with an estimated high quality of riparian zone based on GIS were given a percent reduction of 80% based on the range of values observed in the literature (Wenger et al. 1999).

Coarse validation procedure

The model results for upland contributions of sediment were within the range of expected values. The model estimated the average loss of upland soil across the modeled area at 0.34 tons/acre/year. The average amount expected from western forests is < 0.25 tons/acre/year (Ryan et al. 2011), but the modeled area for the Red Rock TPA also included some cropland, burned areas, and developed areas that resulted in higher values that increased the average. The estimated amount of sediment entering streams was around 0.02 tons/acre/year after incorporating reductions from riparian areas. Field measurements for a similar mountain watershed in Wyoming yielded suspended loads of approximately 0.03 tons/acre/year at near-base flow conditions (Ryan et al. 2011) .

Including recent fires in the model effort added more complexity, but results reflect expected values. The amount estimated from the DEQ model for a recent Bear Creek Fire (in Trail Creek subwatershed) was compared to similar estimates by the USFS using a different type of model which also incorporated USLE (USFS 2020). The amount of sediment leaving the hillside from the fire was higher for the USFS method compared to the DEQ method, 2.3 tons/acre/year versus 1.4 tons/acre/year by DEQ respectively. However, erosion values used by DEQ were chosen to represent those occurring several years post-fire after some recovery, while the USFS modeled conditions represented those occurring before some revegetation.

Model results

Table 6-32 indicates the estimated annual sediment load reaching streams for each subwatershed in the Red Rock TPA. The highest estimate per square mile of watershed area is for Trail Creek, due to the recent fire (USFS 2020). East Fork Clover Creek, Muddy Creek, and Big Sheep Creek also had high contributions per square mile. These higher estimates likely reflect that these watersheds are more dominated by shrubs than forest, and shrublands have a higher C-factor indicating greater potential for soil loss. In addition, Muddy and East Fork Clover Creeks are located within soils that have comparatively higher erodibility than the other subwatersheds. Big Sheep Creek and Muddy Creek additionally have unbuffered cropland and haylands near the mouth that contributed to higher loading.

Table 6-31. Percent of USLE-generated sediment making it to waterways after adjusting for riparian buffers.

Estimated Riparian Buffer Width	Land Use	Percent Reduction in USLE-Model Generated Sediment
0-90 feet	Cropland	25%
0-90 feet	Hayland	65%
0-90 feet	Minimal crop or hay,Low quality	65%
0-90 feet	Minimal crop or hay, High Quality	80%
90-120 feet	Any	90%
> 120 feet	Any	100%

Table 6-32. Upland loading estimates by subwatershed, in order of decreasing loading per square mile.

Subwatershed	Loading (Tons/Yr)	Loading (Tons/Square Mile/Yr)
Trail Creek	1604	31.2
Big Sheep Creek*	5585	23.8
Muddy Creek	1399	21.7
East Fork Clover Creek	174	21.5
Horse Prairie Creek*	9077	21.1
Fish Creek	139	17.4
O Dell Creek	470	16.1
Red Rock Creek*	545	15.0
Medicine Lodge Creek	2803	14.3
Sage Creek	3454	13.9
Tom Creek	107	11.9
Long Creek	466	9.9
Price Creek	135	9.5
Peet Creek	193	7.7
Corral Creek	14	5.6
Jones Creek	45	5.5
Selway Creek	168	5.0
Bean Creek	29	4.9

*=includes tributaries

6.5.4 Source Assessment Summary

Based on field observations, all assessed source categories represent controllable loads within the Red Rock TMDL Planning Area. Because each source category has different seasonal loading rates, the relative percentage of the total load from each source category may vary by season. The intention of the source assessments is to broadly evaluate source effects (e.g., bank erosion, upland erosion, roads). Results for each source assessment category provide an adequate tool to focus water quality restoration activities in the Red Rock TPA. They indicate the relative contribution of sediment to different subwatersheds for each source category and the potential for percent loading reductions with the implementation of improved management practices.

6.6 Determining the Total Allowable Sediment Load

The percent-reduction allocations are based on the BMP scenarios for each major source type (e.g., streambank erosion, upland erosion, and roads). These BMP scenarios are discussed within this section and within associated appendices, and reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and/or field assessments.

Sediment loading was evaluated at the watershed scale and associated sediment reductions are also applied at the watershed scale. All models used to develop scenarios are approximations of actual on-the-ground processes, and field measurements would be necessary to verify these loading estimates. However, they provide a better understanding of sediment sources to be used in watershed restoration efforts. Sediment loading reductions can be achieved through a combination of BMPs, and the most appropriate BMPs will vary.

6.6.1 Streambank Erosion

Streambank erosion is closely linked to the health of the riparian zone because vegetation provides the root and soil structure to hold the streambank soil in place. Therefore, Best Management Practices (BMPs) that involve protecting and restoring vegetation to the riparian zone will typically result in reduced streambank loading. These include improvements in grazing management, road maintenance or relocation, and general reductions in intensity of human activities within the riparian zone.

Field surveys of bank erosion at example reaches in the Red Rock TPA and recently-surveyed Madison TPA were used to estimate average bank erosion for reaches of different gradient, stream, size, and land-use categories. These loading rates were applied to unsampled reaches. At these unsampled reaches, stream size, gradient, and riparian condition was estimated using a GIS framework (**Appendix E**). Sample stream reaches with <70% of the riparian zone in natural condition had higher loading rates than those in ≥70% natural conditions, with natural conditions meaning minimal impact from grazing, transportation, or other human activities occurring within the 100 foot buffer. For the BMP scenario, the estimates of loading at reaches with a low percentage of the riparian zone in natural condition (≤70%) were changed to the adjusted values based on field measurements at reaches with > 70% of the riparian zone in natural conditions (**Table 6-33**).

The methods used to estimate loads, are based on aerial photography, best professional judgment, modeling, and limited on-the-ground access to stream reaches. However, while this method is considered adequate to provide a good approximation of changes in sediment loading due to potential BMPs, it should not be seen as a substitute for on-the-ground reconnaissance. Further, BMPs may still be needed in portions of reaches estimated to have high riparian condition because not all issues can be observed from aerial photography. DEQ recognizes that local landowners and managers are often in a better position to identify the causes of bank erosion and adopt practices to reduce bank erosion wherever practical. Depending on the subwatershed, DEQ estimates that implementing riparian Best Management Practices (BMPs) could decrease the level of human-caused streambank erosion by up to 44% (**Table 6-34**). **Appendix E** contains additional information about the streambank erosion source assessment and associated load estimates for the 303(d) listed streams in the Madison TMDL Planning Area.

Table 6-33. Stream characteristics used to estimate Bank erosion with BMPs at unsampled reaches.

Gradient	Order	Riparian Condition	BMP Adjustment	Pre-BMP Load (Tons/Yr/1000 Ft)	Post-BMP Load (Tons/Yr/1000 Ft)
0-2%	Non 1st	High, > 70% Riparian Zone in Natural Condition	NONE	19.7	19.7
0-2%	Non 1st	Low, ≤ 70% Riparian Zone in Natural Condition	Change to value at reaches with riparian zone in high condition based on Red Rock field data	34.0	19.7
>2-4%	Non 1st	High, > 70% Riparian Zone in Natural Condition	NONE	15.3	15.3
>2-4%	Non 1st	Low, ≤ 70% Riparian Zone in Natural Condition	Change to value at reaches with riparian zone in high condition, based on combination of Red Rock and Madison field data	20.6	15.3
>4-10%	Non 1st	High, > 70% Riparian Zone in Natural Condition	NONE	14.0	14.0
>4-10%	Non 1st	Low, ≤ 70% Riparian Zone in Natural Condition	Change to loading rates from field-assessed reaches in Madison watershed, after changing bank erosion from extreme to very high, very high to high, and from high to moderate	14.0	11.3
> 10%	Non 1st	Any	NONE; very little influence of riparian condition on loading rates	12.5	12.5
Any	1st	High, > 70% Riparian Zone in Natural Condition	NONE	21	21

Table 6-33. Stream characteristics used to estimate Bank erosion with BMPs at unsampled reaches.

Gradient	Order	Riparian Condition	BMP Adjustment	Pre-BMP Load (Tons/Yr/1000 Ft)	Post-BMP Load (Tons/Yr/1000 Ft)
Any	1st	Low, ≤ 70% Riparian Zone in Natural Condition	Change to loading rates from field-assessed Red Rock and Madison data (4 sites), after changing bank erosion from extreme to very high, very high to high, and from high to moderate	21	10.6

Table 6-33. Estimated Percent Reduction in Bank Erosion with BMPs implemented.

Subwatershed	Existing Load (Tons/Yr)	BMP Load Estimated Load (Tons/Yr)	% Reduction
Bean Creek	810	547.0	32%
Big Sheep Creek*	5377	3279.0	39%
Corral Creek	478	292.0	39%
East Fork Clover Creek	388	252.0	35%
Fish Creek	742	489.0	34%
Horse Prairie Creek*	16977	9863.0	42%
Jones Creek	1071	723.0	32%
Long Creek	1507	918.0	39%
Medicine Lodge Creek	5535	3114.0	44%
Muddy Creek	1191	740.0	38%
O Dell Creek	4156	2978.0	28%
Peet Creek	1371	833.0	39%
Price Creek	1371	833.0	39%
Red Rock Creek*	3418	2005.0	41%
Sage Creek	4627	3846.0	17%
Selway Creek	1235	801.0	35%
Tom Creek	872	521.0	40%
Trail Creek	1894	1292	32%

* includes tributaries

6.6.2 Unpaved Roads

Subwatersheds with more crossings and parallel road segments have more potential for loading to streams from unpaved roads. However, Best Management Practices can reduce loading amounts. The average loading from individual crossings and parallel road segments of different ownership/elevation types after BMPs was determined as part of the Madison Sediment TMDLs. To develop estimates of the ability of BMPs to reduce loading, the WEPP: Road model was re-run with the contributing length in the model shortened to 200 feet for crossings and 500 feet for parallel road segments. This represented the type of reduction that could be achieved through actions suggested in Montana's Nonpoint Source Management Plan (DEQ 2017) such as creating vegetated buffers, constructing waterbars, rolling dips, and insloping roads along steep banks (**Table 6-35**). These average values were applied to estimate potential reductions with BMPs for the Red Rock TPA as described in **Appendix F**.

Since crossings had a higher potential sediment reduction due to BMPs than parallel road segments (based on the modeling outputs), subwatersheds with a comparatively higher number of crossings had higher potential percent reductions in sediment from unpaved roads. However, the percent reduction alone is not indicative of subwatersheds with the most potential impacts. Some of the highest percent reductions were for Corral Creek, East Clover Creek, and Tom Creek. These watersheds had only one or two crossings and low or zero miles of parallel road segments. The estimated loading per stream mile from **Table 6-36** may be more important in evaluating potential impacts and potential reductions, with a higher value indicative of more locations where streams and roads intersect.

On the-ground-reconnaissance, such as has been done for portions of Selway Creek and Bloody Dick Creek watersheds by the USFS, can help with identifying impacts and potential for BMPS in subwatersheds with higher loading. As part of this assessment, the USFS determined the type of BMP that would be needed to reduce sediment at a variety of crossings and parallel road segments (**Figure 6-10**). The conditions at parallel road segments and crossings evaluated as part of this survey are likely representative of those occurring across the Red Rock TPA (personal communication, Kevin Weiner). Recommended BMPs included creating vegetated buffers, installing silt fences, modifying or creating road ditches, creating water bars, and reshaping roads (**Figure 6-10**).

Table 6-35. Summary of sediment entering roads from parallel road segments and road crossings, before and after BMPS, as used in the estimates of total loading for each subwatershed.

Unpaved Road Type	Average Sediment Per Mile-Parallel Segments (Tons/Yr)	Average Sediment Per Mile- Parallel Segments BMPs (Tons/Yr)	Average Sediment Per Crossing (Tons/Yr)	Average Sediment per Crossing-BMPs (Tons/Yr)
Public, high elevation	0.64	0.54	0.27	0.06
Public, low elevation	2.14	2.02	0.04	0.02
Private, high elevation	0.64	0.54	0.27	0.06
Private, low elevation	0.71	0.55	0.14	0.09

Table 6-36. Estimated reduction in sediment loads from unpaved roads with BMPs implemented, as potential tons of sediment reduced per stream mile.

Subwatershed	Total Loading (Tons/Yr)	Loading with BMPs-Crossings (Tons/Yr)	% Reduction	Total Stream Miles	Potential Tons Reduced Per Stream Mile
Trail Creek	8.18	4.07	50	63.1	0.065

Table 6-36. Estimated reduction in sediment loads from unpaved roads with BMPs implemented, as potential tons of sediment reduced per stream mile.

Subwatershed	Total Loading (Tons/Yr)	Loading with BMPs-Crossings (Tons/Yr)	% Reduction	Total Stream Miles	Potential Tons Reduced Per Stream Mile
Tom Creek	0.45	0.15	67	16.7	0.018
Selway Creek	7.47	3.46	54	37.7	0.106
Sage Creek	30.07	13.69	54	278.1	0.059
Red Rock Creek	5.11	2.03	60	69.5	0.044
Price Creek	2.17	0.77	65	19.3	0.073
Peet Creek	2.51	1.06	58	25.6	0.057
O Dell Creek	7.61	2.69	65	53.3	0.092
Muddy Creek	15.26	7.57	50	64.6	0.119
Medicine Lodge Creek	44.59	23.09	48	250.5	0.086
Long Creek	5.72	2.47	57	59.9	0.054
Jones Creek	0.66	0.32	52	10.4	0.033
Horse Prairie Creek	120.99	63.07	48	897.3	0.065
Fish Creek	1.95	1.08	45	8.8	0.099
East Fork Clover Creek	0.28	0.16	43	7.7	0.016
Corral Creek	0.27	0.15	44	4.4	0.027
Big Sheep Creek	54.40	25.60	53	298	0.097
Bean	0.78	0.42	46	8.6	0.042

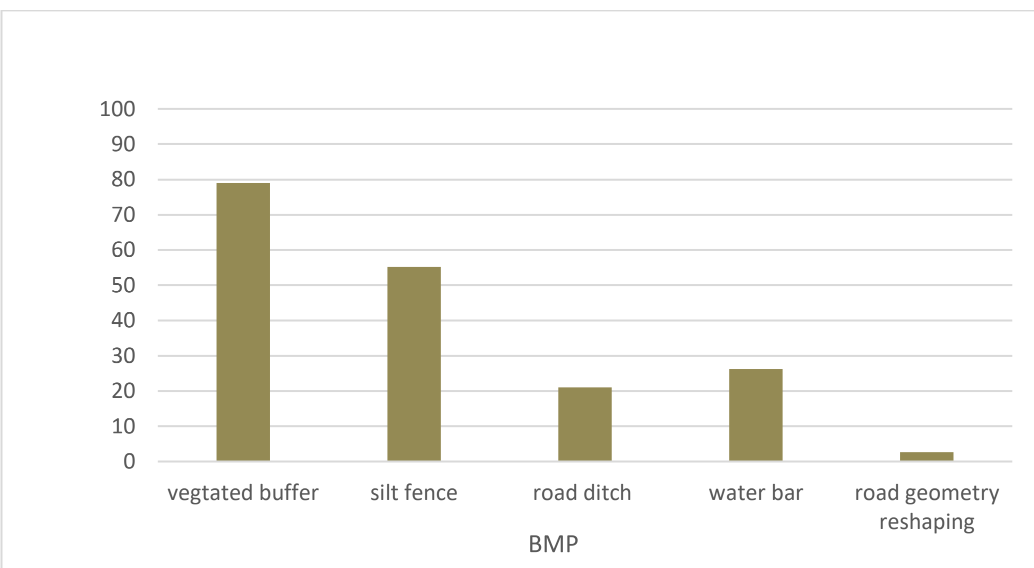

Figure 6-10. Percent of 38 parallel road segments or crossings sampled by the USFS with each recommended Best Management Practice.

6.6.3 Upland Sediment

Land-use practices that reduce the amount of unvegetated soil exposed to wind and water erosion will reduce sediment run-off from uplands. This may include reducing intensity of grazing, particularly near waterways. For agricultural fields, this may include planting cover crops on fallow fields and implementing reduced or conservation tillage practices. Increasing the width and quality of the riparian zone between upland areas with disturbance will also reduce sediment loads to waterways.

DEQ estimated potential reductions in upland sediment loads given three scenarios: 1) implementing upland BMPs by increasing groundcover crops and reduced tillage, reduced grazing activity, and moderate recovery from fire and logging 2) implementing riparian BMPs by increasing vegetation in the 100-foot buffer, and 3) both implementing upland and riparian BMPS. A hypothetical 20% increase in groundcover was used as an estimate of the outcome of implementing BMPs on croplands. A 10% increase in ground cover was used to model less grazing intensity on shrubland and grassland. Re-vegetation in logged areas was increased to what would be expected 3-5 years after a fire. (**Table 6-37; Appendix G**). The potential reduction in sediment depends on riparian buffer width and quality. However, even degraded riparian areas can filter a large percentage of sediment. Values chosen in the model as the percent reduction in sediment are within the range of those found in the literature for varying buffer widths and land-use (Wenger et al. 1999). The quality of the riparian area for the "Primary land use/condition" category was estimated from aerial photos as part of the stratification for the bank erosion assessment.

Table 6-37. Percent reduction included in model for USLE-generated sediment making it to waterways after adjusting for riparian buffers.

Estimated Riparian Buffer Width	Primary Land Use/Condition	Percent Reduction in Sediment- No BMPs	Percent Reduction in Sediment- BMPs
0-90 feet	Cropland	25%	50%
0-90 feet	Hayland	65%	80%
0-90 feet	Non crop or hay, and showing significant signs of degradation	65%	80%
0-90 feet	Non crop or hay, and showing minimal signs of degradation	80%	80%
90-120 feet	Any	90%	90%
> 120 feet	Any	100%	100%

This method provides a very simplified view of the current range of conditions and potential reduction with BMP's, which can only be fully understood with on-the-ground sampling and reconnaissance. Many streams will vary in quality from that based on aerial imagery and GIS summaries. The potential reduction with BMPs was strongly correlated with the percent of the riparian zone in shrubland, cropland, or grassland because these had higher C-factors and potential for erosion than forests and wetlands (representing higher potential for sediment generation), and also had greater potential reduction with improved grazing or other practices (**Table 6-38**). Low quality of riparian buffer also contributed to increased erosion.

Table 6-38. Potential reduction in sediment contributions with upland BMPs, riparian buffer BMPs, or both, arranged from highest to lowest percent reduction.: * =includes tributaries

Subwatershed	Existing Load Delivered to Stream (Tons/Yr)	Upland BMP Only (Tons/Yr)	% Change from Existing Load	Buffer BMP Only (Tons/Yr)	% Change from Existing Load	Upland and Buffer BMPs (Tons/Yr)	% Change from Existing Load
Trail Creek	1604	1105	31	1263	21	869	46
East Fork Clover Creek	174	135	23	128	27	99	43
Fish Creek	139	104	25	105	24	79	43
Sage Creek	3454	2601	25	2614	24	1968	43
Corral Creek	14	12	16	9	37	8	43
Red Rock Creek*	545	319	41	408	25	319	41
Muddy Creek	1399	1071	23	1081	23	827	41
O Dell Creek	470	385	18	340	28	278	41
Price Creek	135	106	21	101	25	80	41
Horse Prairie Creek*	9077	7165	21	6822	25	5395	41
Peet Creek	193	153	21	145	25	115	40
Big Sheep Creek*	5585	4234	24	4640	17	3366	40
Medicine Lodge Creek	2803	2163	23	2195	22	1693	40
Selway Creek	168	141	16	121	28	102	39
Tom Creek	107	91	15	80	25	68	37
Long Creek	466	368	21	353	24	305	35
Jones Creek	45	40	11	34	25	30	33
Bean Creek	29	26	9	23	20	21	27

6.7 Sediment TMDLs and Allocations

The allowable loads described above are determined by modeling reasonable load reduction conditions for each source category. These allowable loads provide the load allocations to each sediment source. Conceptually, the sediment TMDL is the sum of the load allocations. This differs from DEQ's approach for other pollutants (e.g., metals or nutrients) where the TMDL is calculated first and then apportioned amongst contributing sources. The difference between the existing and allowable loads equals the excess amount of sediment causing impaired conditions for each stream. Eliminating this excess load for each source category within an impaired stream's watershed would equate to meeting all load allocations and represents a best path forward toward meeting sediment target conditions at all locations within the stream.

The total allowable sediment load is the sum of the load allocations to: bank erosion (natural and human caused), road sediment, and upland sediment runoff (significant areas where BMPs are obviously lacking).

Although all the sediment loads are presented in units of tons per year, direct comparison of sediment loads between sources is problematic and unpractical. This is because the loading estimates are produced by separate and unrelated models: BEHI, WEPP: Road and USLE. Therefore, the most important consideration is the relative percent reductions between subwatersheds. Percent reduction provides a useful and relatable description of the magnitude of the problem, the degree to which it can be mitigated, and a way to prioritize mitigation efforts and resources.

Sediment load allocations and TMDLs for each stream are provided below in **Tables 6-39** through **6-45** and estimated daily loads can be found in **Appendix H**.

It is important to recognize that the first critical step toward meeting the sediment allocations involves applying and/or maintaining the land management practices or BMPs that will reduce sediment loading. Once these actions have been completed at a given location, the landowner or land manager will have taken action consistent with the intent of the sediment allocation for that location. For many nonpoint source activities, it can take several years to achieve the full load reduction at the location of concern, even though full BMP implementation is in effect. For example, it may take several years for riparian areas to fully recover after implementing grazing BMPs or allowing re-growth in areas of historical riparian degradation It is also important to apply proper BMPs and other water quality protection practices for all new or changing land management activities to limit any potential increased sediment loading. For a description of potential BMP practices, refer to **Section 9.0** and Montana DEQ's Nonpoint Source Management Plan (DEQ 2017).

6.7.1 Bean Creek

Bean Creek subwatershed has very few crossings or parallel segments to contribute sediment. In addition, approximately 50% of uplands are forested, which contributes relatively low sediment loads. The biggest contribution of sediment to Bean Creek is bank erosion (**Table 6-39**). Reaches near the mouth typically have less than 50% of the reach in intact riparian vegetation and high levels of bank erosion.

Table 6-39. Bean Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**810**	**547**	**32**
Unpaved Roads	**0.8**	**0.45**	**44**
Upland Erosion	**29**	**21**	**28**
Total	**839.8**	**568.5**	**32**

6.7.2 Big Sheep Creek

Sediment from unpaved roads was high compared to many of the other subwatersheds in the Red Rock TPA, although the relative contribution from roads is low. Both bank erosion and upland erosion are large contributors of sediment in Big Sheep Creek subwatershed. The watershed is predominately shrubland, which contributes more sediment from uplands than forests due to a higher C factor. Uplands near the mouth and in Muddy Creek tributary also naturally have an extremely high soil erodibility factor. In addition, the lower half of the impaired segment has many sections without intact riparian buffers between uplands and Big Sheep Creek. The recent Bear Creek fire is also contributing to some elevated loading. While the estimated sediment load is high overall across the Big Sheep subwatershed, the potential to reduce sediment is also high if BMPs are implemented (**Table 6-40**).

Table 6-40. Big Sheep Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**5377**	**3279**	**39**
Mainstem	1846	1087	41
Muddy Creek	1191	740	38
Nicholia Creek/Upper	2340	1452	38
Unpaved Roads	**54.4**	**25.6**	53
Mainstem	12.7	6.8	46
Muddy Creek	15.3	7.6	50
Nicholia Creek	26.4	11.1	58
Upland Erosion	**5585**	**3366**	**40**
Mainstem	1846	1087	41
Muddy Creek	1399	827	41
Nicholia Creek/Upper	2340	1452	38
Total	**11016.4**	**6670.6**	**39**

6.7.3 Corral Creek

Corral Creek has only one estimated crossing and a low amount of parallel road segments. Therefore, the contribution of sediment from unpaved roads is extremely low. In addition, the contribution of sediment from uplands is estimated to be low due to a large percentage of the watershed in intact forest. The biggest contribution of sediment is from bank erosion, with many of the reaches having low riparian quality and not having an intact riparian buffer (**Table 6-41)**.

Table 6-41. Corral Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**478**	**292**	**39**
Unpaved Roads	**0.27**	**0.15**	**44**
Upland Erosion	**14**	**8**	**43**
Total	**492.3**	**300.1**	**39**

6.7.4 East Fork Clover Creek

East Fork Clover Creek has only one estimated crossing and a low amount of parallel road segments. Therefore, the contribution of sediment from unpaved roads is extremely low. While many of the reaches have intact riparian buffer, there are still some reaches with less than 70% of the riparian zone with an intact riparian buffer. Therefore, the highest contributor of sediment is from bank erosion. Uplands also contribute a moderate amount of sediment due to a high percentage in shrubland, and the presence of some uplands adjacent to riparian areas with poor riparian quality or width to provide filtering capacity (**Table 6-42**).

Table 6-42. East Fork Clover Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**388**	**252**	**35**
Unpaved Roads	**0.28**	**0.16**	**43**
Upland Erosion	**174**	**98**	**44**
Total	**562.3**	**350.1**	**38**

6.7.5 Fish Creek

Fish Creek has low contributions from unpaved roads due to a low number of parallel road segments and crossings. Bank erosion is estimated to be the biggest contributor of sediment, as many reaches do not have intact riparian vegetation. Upland erosion is moderate. The uplands are predominately comprised of shrubland, which contributes more sediment than forests. In addition, in some cases, there are not adequate riparian buffers between uplands and streams (**Table 6-43**).

Table 6-43. Fish Creek sediment source assessment allocations, and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**742**	**489**	**34**
Unpaved Roads	**2.0**	**1.1**	**45**
Upland Erosion	**139**	**79**	**43**
Total	**882.9**	**569.5**	**35**

6.7.6 Horse Prairie Creek

Complex sediment issues occur in Horse Prairie Creek. Bank erosion is the highest contributor, which is predominately due to lack of adequate riparian vegetation along portions of the mainstem of Horse Prairie Creek and Medicine Lodge Creek. Upland erosion is also relatively high, owing to recent fire activity in Trail Creek subwatershed as well as croplands without adequate riparian zones in the mainstem of Horse Prairie Creek and Medicine Lodge Creek. The mainstem of Horse Prairie Creek, Medicine Lodge Creek, and Selway Creeks also have high estimated sediment loading from unpaved roads, due to the presence of a high density of crossings and parallel road segments. Increased implementation of Best Management Practices and riparian revegetation provide the best opportunity to decrease sediment loads. In addition, revegetation of burned areas will occur over time and result in decreased loads from fire-impacted portions of the landscape (**Table 6-44**).

Table 6-44. Horse Prairie Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**16977**	**9863**	**42**
Mainstem	8313	4656	44
Medicine Lodge Creek	5535	3114	44
Selway Creek	1235	801	35
Trail Creek	1894	1292	32
Unpaved Roads	**121.20**	**63.00**	**48**
Mainstem	60.9	32.5	47
Medicine Lodge Creek	44.6	23.0	48
Selway Creek	7.5	3.4	55
Trail Creek	8.2	4.1	50
Upland Erosion	**9077**	**5395**	**41**
Mainstem	4503	2731	39
Medicine Lodge Creek	2803	1693	40
Selway Creek	168	102	39
Trail Creek	1603	869	46
Total	**26175.2**	**15321.0**	**41**

6.7.7 Jones Creek

Jones Creek subwatershed has very few crossings or parallel segments to contribute sediment. In addition, approximately 50% of uplands are forested, with relatively low estimated sediment loads. The biggest contribution of sediment is bank erosion (**Table 6-45**). Reaches near the mouth typically have less than 50% of the reach in intact riparian vegetation and high levels of bank erosion.

Table 6-45. Jones Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**1071**	**723**	**32**
Unpaved Roads	**0.7**	**0.3**	**51**
Upland Erosion	**45**	**30**	**33**
Total	**1116.7**	**753.3**	**33**

6.7.8 Long Creek

Long Creek has moderate erosion from unpaved roads due to a moderate number of parallel road segments and crossings. However, the contributions from unpaved roads are still much lower than from bank erosion or uplands. Bank erosion is estimated to be the biggest contributor of sediment, as many reaches do not have high-quality intact riparian buffers. Upland erosion is moderate. The uplands are predominately comprised of shrubland, which contribute more sediment than forests. In addition, in some cases, there are not adequate riparian buffers between uplands and streams (**Table 6-46**).

Table 6-46. Long Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**1507**	**918**	**39**
Unpaved Roads	**5.7**	**2.4**	**58**
Upland Erosion	**465**	**304**	**35**
Total	**1977.7**	**1224.4**	**38**

6.7.9 Medicine Lodge Creek

The subwatershed contains a high density of crossings and parallel road segments that contribute sediment. While some portions of the creek have intact riparian zones, there are many with 0% of the riparian zone intact. These reaches have extremely high estimates of loading from bank erosion. In addition, there are numerous upland source areas that do not flow through a riparian buffer before entering the creek. Some of these are in croplands, which have the highest erosion rates. Many opportunities exist to reduce sediment loading through BMPs (**Table 6-47**).

Table 6-47. Medicine Lodge Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**5535**	**3114**	**44**
Unpaved Roads	**44.60**	**23.00**	**48**
Upland Erosion	**2803**	**1694**	**40**
Total	**8382.6**	**4831.0**	**42**

6.7.10 Muddy Creek

Muddy Creek has a moderate amount of unpaved road crossings and segments compared to the other subwatersheds, but the amount of erosion from unpaved roads is still extremely low compared to the other sources (**Table 6-48**). While headwater reaches contain intact riparian zone, reaches near the mouth have only ~20% in intact riparian vegetation and do not have a 100-foot buffer. In addition, the soils in this subwatershed are highly erodible, which contributes to the high upland loading estimates. Many of these upland areas are adjacent to streams. Increased riparian vegetation will both decrease bank erosion and upland loading.

Table 6-48. Muddy Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**1191**	**740**	**38**
Unpaved Roads	**15.3**	**7.6**	**50**
Upland Erosion	**1398**	**827**	**41**
Total	**2604.3**	**1574.6**	**40**

6.7.11 O Dell Creek

The length of crossings and parallel road segments was moderate but much lower than from bank or upland erosion. High sediment loads from bank erosion were attributed to low quality of riparian vegetation in the downstream portion of the segment and potential imbalances from upstream land management activities. Upland erosion was low due to the watershed being predominately in forest. However, near the mouth, many upland areas did not have adequate riparian vegetation to decrease loading to the creek. Therefore, revegetation of riparian zones will decrease bank erosion and upland sources of sediment (**Table 6-49**).

Table 6-49. O Dell Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**4156**	**2978**	**28**
Unpaved Roads	**7.6**	**2.7**	**64**
Upland Erosion	**471**	**278**	**41**
Total	**4634.6**	**3258.7**	**30**

6.7.12 Peet Creek

The length of crossings and parallel road segments was low , resulting in low estimates of loading from unpaved roads. High sediment loads from bank erosion were attributed to low quality of riparian vegetation in the lower half of the segment. Upland erosion was relatively low due a large portion of the watershed being in forest with lower erosion rates. However, near the mouth, many upland areas did not have adequate riparian vegetation to decrease loading to the creek. Therefore, revegetation of riparian zones will decrease bank erosion and upland sources of sediment (**Table 6-50**).

Table 6-50. Peet Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**1371**	**833**	**39**
Unpaved Roads	**2.5**	**1.1**	**56**
Upland Erosion	**193**	**115**	**40**
Total	**1566.5**	**949.1**	**39**

6.7.13 Price Creek

Estimates of loading were similar to adjacent Peet Creek. The length of crossings and parallel road segments was low, resulting in low estimates of loading from unpaved roads. High sediment loads from bank erosion were attributed to low quality of riparian vegetation in the lower half of the segment. Upland erosion was relatively low due a large portion of the watershed being in forest with lower erosion rates. However, near the mouth, many upland areas did not have adequate riparian vegetation to decrease loading to the creek. Therefore, revegetation of riparian zones will decrease bank erosion and upland sources of sediment (**Table 6-51**).

Table 6-51. Price Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**1446**	**910**	**37**
Unpaved Roads	**2.2**	**0.8**	**64**
Upland Erosion	**135**	**80**	**41**
Total	**1583.2**	**990.8**	**37**

6.7.14 Red Rock Creek

The length of crossings and parallel road segments was moderate, but loading was much lower than from bank or upland erosion. High sediment loads from bank erosion were attributed to low quality of riparian vegetation in the downstream portion of the segment. Upland erosion was low due to the watershed being approximately 50% in forest which has low erosion rates. However, near the mouth, many upland areas did not have adequate riparian vegetation to decrease loading to the Red Rock Creek. Therefore, revegetation of riparian zones will decrease bank erosion and upland sources of sediment (**Table 6-52**).

Table 6-52. Red Rock Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**3418**	**2005**	**41**
Red Rock Creek	2940	1713	42
Corral Creek	478	292	39
Unpaved Roads	**5.1**	**2.1**	**59**
Red Rock Creek	4.8	2.0	58
Corral Creek	0.26	0.15	42
Upland Erosion	**545**	**319**	**41**
Red Rock Creek	531	311	41
Corral Creek	14	8	43
Total	**3968.1**	**2326.1**	**41**

6.7.15 Sage Creek

Sage Creek has a high amount of unpaved road crossings and segments compared to the other subwatersheds, but the amount of erosion from unpaved roads is still extremely low compared to the other sources (**Table 6-53**). While headwater reaches contain intact riparian zones, reaches near the mouth have typically 40% or less of the length in intact riparian vegetation and often do not have a 100-foot buffer. In addition, some of the soils in this subwatershed are highly erodible, which contributes to the high upland loading estimates. Some of upland areas with high loading are adjacent to stream segments with poor-quality riparian zones. Increased riparian vegetation will both decrease bank erosion and upland loading in these areas.

Table 6-53. Sage Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	4627	3846	17
Unpaved Roads	30.1	13.7	54
Upland Erosion	3454	1968	43
Total	8111.1	5827.7	28

6.7.16 Selway Creek

The length of crossings and parallel road segments was relatively high for the length of streams in the subwatershed. However, erosion from unpaved roads was still relatively low compared to other sources. Bank erosion was the highest source of loading but was low compared to other subwatersheds, due to many reaches with an intact riparian zone. Upland erosion was also low due to a high percentage of the subwatershed in forest but was elevated slightly due to recent clearcut and salvage logging. (**Table 6-54**). Despite low loading estimates overall, some visited sites had indications of increased sediment. Continued implementation of BMPs will help to reduce sediment loading in the watershed.

Table 6-54. Selway Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	1235	801	35
Unpaved Roads	7.5	3.5	53
Upland Erosion	167	101	40
Total	1409.5	905.5	36

6.7.17 Tom Creek

Estimates of loading were similar to nearby Peet and Price Creeks. The length of crossings and parallel road segments was low resulting in low estimates of loading from unpaved roads. High sediment loads from bank erosion were attributed to low quality of riparian vegetation in the lower half of the segment. Upland erosion was relatively low due a large portion of the watershed being in forest with lower erosion rates. However, especially near the mouth, many upland areas did not have adequate riparian vegetation to decrease loading to the creek. Therefore, revegetation of riparian zones will decrease bank erosion and upland sources of sediment (**Table 6-55**).

Table 6-55. Tom Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	872	521	40
Unpaved Roads	0.5	0.2	60
Upland Erosion	108	70	35
Total	980.5	591.2	40

6.7.18 Trail Creek

The length of crossings and parallel road segments was moderate but loading from unpaved roads was much lower than from bank or upland erosion. Bank erosion varied along Trail Creek, with areas in the headwaters being intact but stream reaches near the mouth lacking intact riparian zones and contributing the most sediment. The biggest source was estimated to be upland erosion. However, much of this loading was attributed to the Bear Creek fire, which was considered in the modeling effort. Based on conditions present before the fire, the main contribution of sediment resulting in the original listing of Trail Creek was bank erosion (**Table 6-56)**.

Table 6-56. Trail Creek sediment source assessment allocations and TMDL.

Sediment Sources	Existing Load (Tons/Year)	Reduced Load (Tons/Year)	Load Allocation (Percent Reduction)
Bank Erosion	**1894**	**1292**	**32**
Unpaved Roads	**8.2**	**4.1**	**50**
Upland Erosion	**1603**	**869**	**46**
Total	**3505.2**	**2165.1**	**38**

7.0 Escherichia coli (*E. coli*) TMDL Components

This portion of the Red Rock *E. coli* TMDL document focuses on *E. coli* as a cause of water quality impairment in the Red Rocks TMDL Planning Area. It describes: (1) how excess *E. coli* impairs beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to *E. coli* impairment in the watershed, (4) the identification of *E. coli* targets and the comparison of those targets to the affected stream segment, (5) the sources of *E. coli* based on recent findings, (6) the proposed *E. coli* TMDLs and rationale, (7) the allocations to significant sources, and (8) the seasonality and margin of safety for the TMDL.

7.1 Effects of Excess *E. coli* on Beneficial Uses

An elevated concentration of *E. coli* can put humans at risk for contracting water-borne illnesses. Therefore, elevated instream concentrations of *E. coli* and other pathogenic pollutants can lead to impairment of a waterbody's beneficial use for primary contact recreation. *E. coli* is a nonpathogenic indicator bacterium that is usually associated with pathogens transmitted by fecal contamination and correlates highly with the presence of fecal contamination (EPA 2001). While its presence does not always prove or disprove the presence of pathogenic bacteria, viruses, or protozoans, it is an indicator that other pathogenic bacteria are likely present. The United States Environmental Protection Agency (EPA) recommends the use of *E. coli* as the preferred indicator organism for pathogenic bacteria forms due to its strong correlation with swimming-related illness.

7.2 Stream Segment of Concern

The Montana 2020 Final Water Quality Integrated Report idicates that primary contact recreation on Horse Prairie Creek (MT41A003_090), Peet Creek (MT41A004_090), Medicine Lodge Creek (MT41A003_010) and the Red Rock River (MT41A001_020) is impaired by *E.* coli (DEQ 2020). **Figure 7-1** contains a map that shows the location of the impaired waters in the Red Rock watershed. The watershed is approximately 1,481,485 acres in size and is comprised of the Upper Red Rock (1,119,178 acres) and the Lower Red Rock (362,307 acres) sub watersheds.

Montana classifies its waterbodies according to the present and future beneficial uses they can support. The assessment units in the Red Rocks watershed that are impaired by *E. coli* all have a B-1 use classification. This means they are to be maintained as suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply (Administrative Rules of Montana [ARM] 17.30.623).

Table 7-1. Stream Segment of Concern for E. coli Impairment Based on the 2020 Integrated Report

Stream Segment (Assessment Unit)	Assessment Unit ID	Use Classification	Pathogen Related Pollutant Impairment
Horse Prairie Creek	MT41A003_090	B-1	Escherichia coli (*E. Coli*)
Peet Creek	MT41A004_090	B-1	Escherichia coli (*E. Coli*)
Medicine Lodge Creek	MT41A003_010	B-1	Escherichia coli (*E. Coli*)
Red Rock River	MT41A001_020	B-1	Escherichia coli (*E. Coli*)

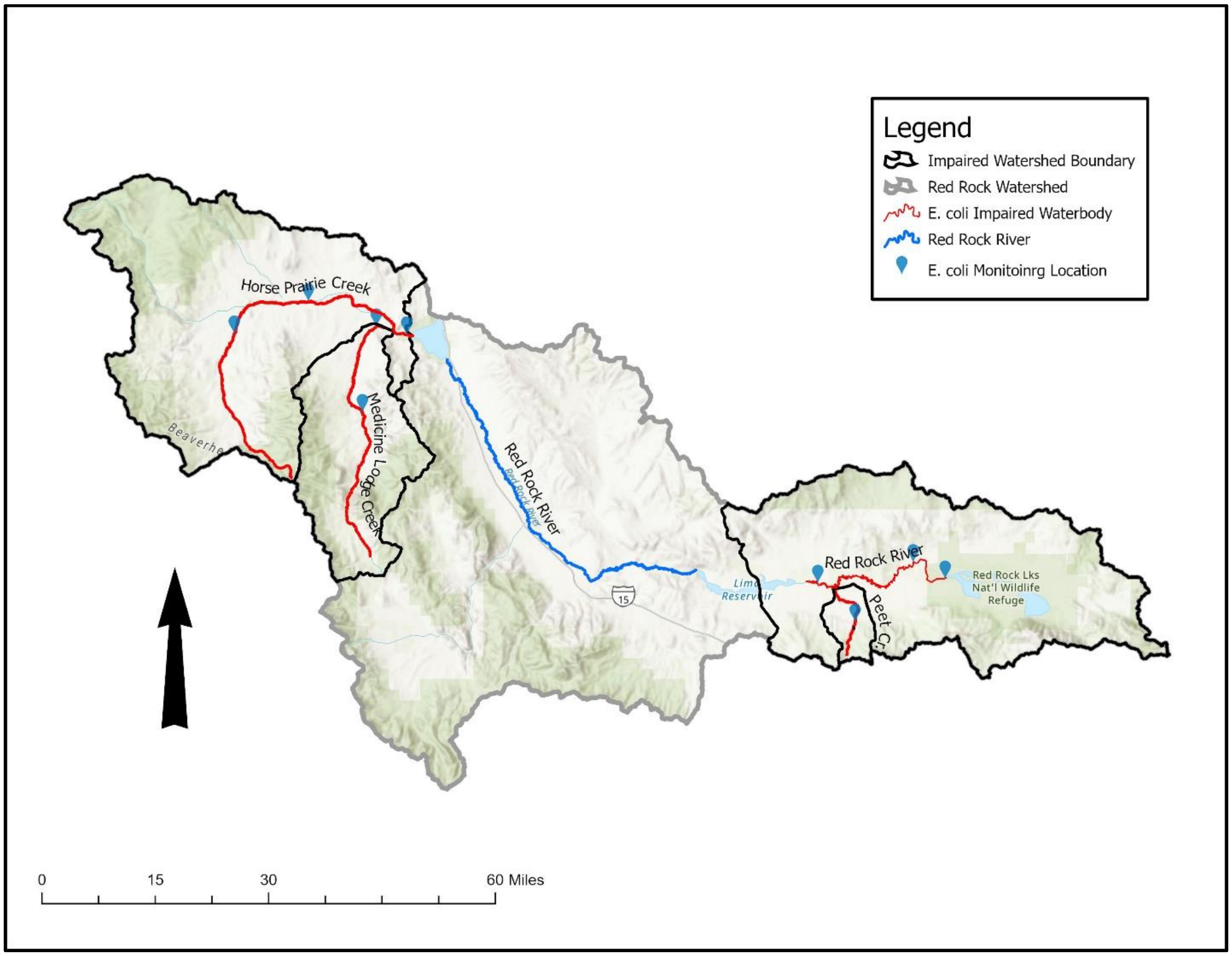

Figure 7-1. Map of the Stream Segments of Concern for E. coli in the Red Rocks Watershed

7.3 Information Sources

Data and information used for impairment determination, source assessment, and TMDL development consisted of:

- Water chemistry and streamflow data collected by DEQ
- Grazing management information from the US Forest Service (USFS) and Bureau of Land Management (BLM)
- Aerial photos
- Geographic Information System (GIS) analysis
- Literature reviews

The data collected by DEQ was catalogued within DEQ's centralized water quality database, and can be found in the national Water Quality Monitoring Council, Water Quality Portal https://www.waterqualitydata.us/.

7.4 Water Quality Targets

Water quality targets are numeric indicators used to evaluate attainment of water quality standards. In this section, *E. coli* water quality targets are presented and compared to recently collected *E. coli* data.

7.4.1 *E. coli* Water Quality Standard and Assessment Methodology

The *E. coli* target in Red Rock watershed is the Montana water quality standard for *E. coli.* Because the numeric values within the standard and the TMDL target values are equal, the term "standard" and "target" are used interchangeably throughout the remainder of **Section 7**. All the impaired waters in the Red Rock watershed (**Table 7-1**) are classified as a B-1 stream, as such the Administrative Rules of Montana (ARM) 17.30.623 (2)(a) apply as follows:

> *The geometric mean number of* E. coli *may not* exceed *126 cfu/100mL and 10% of the total samples may not exceed 252 cfu/100mL during any 30-day period between April 1 through October 31 [ARM 17.30.623 (2)(a)(i)]. From November 1 through March 31, the geometric mean number of E. coli may not exceed 630 cfu/100mL and 10% of the samples may not exceed 1,260 cfu/100mL during any 30-day period [ARM 17.30.623 (2)(a)(ii)].*

The *E. coli* bacteria assessment is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period that are analyzed by the most probable number (MPN) or equivalent membrane filter method [ARM 17.30.620(2)]. The geometric mean is the value obtained by taking the N^{th} root of the product of the measured values, where N equals the number of samples collected, and any sample result below the detection limit is set to the detection limit [ARM 17.30.602(11)]. *E. coli* concentration is expressed in colony forming units (CFU), the number of viable bacteria cells, per 100 milliliters (mL).

If either target (geometric mean or 10% exceedance) is exceeded at any sampling location within the assessment unit (waterbody), the assessment unit is considered impaired by *E. coli* (Makarowski, 2019). The numeric standards identified within **Table 7-2** are the water quality targets. These targets each have an allowable frequency of samples that can be greater than the standard or target and have specific seasons of applicability. **Table 7-2** provides a summary of how the standard varies by season.

Table 7-2. Montana E. coli Water Quality Standard for B-1 Waterbodies

Applicable Period	Magnitude (cfu/100mL)	Measurement Type	Frequency	Dataset Requirement
Summer (4/1 – 10/31)	126	Geometric mean	Not to be exceeded	Minimum five samples obtained during separate 24-hour periods during any consecutive 30-
	252	Single sample	< 10% exceedance rate allowed	
Winter (11/1 – 3/31)	630	Geometric mean	Not to be exceeded	
	1,260	Single sample	< 10% exceedance rate allowed	

7.4.2 Existing Conditions and Comparison to Targets

Water quality data were collected by DEQ during July and August of 2017 to evaluate attainment of the *E. coli* target. Monitoring locations are identified in **Figure 7-1**. In this portion of the document, target attainment is only evaluated for the summer season (**Table 7-2**) because DEQ expects the highest probability of target exceedances and exposure to *E. coli* through primary contact recreation during this time. Additional seasonality considerations are discussed in **Section 7.9**.

In Horse Prairie Creek, 9 *E. coli* samples were collected from 3 sites in 2017. All samples were collected during separate 24-hour periods and within the consecutive 30-day period required by ARM 17.30.620(2). Individual *E. coli* sample values ranged from approximately 198 cfu/100mL to 1,300 cfu/100mL. If either target (geometric mean or 10% exceedance) is exceeded at any sampling location, a waterbody is considered impaired. Because the geometric mean of all the samples is greater than 126 cfu/100mL and 89% of the samples surpass the 10% exceedance rate, Horse Prairie Creek is considered impaired for *E. Coli* (**Table 7-3**) and a TMDL will be developed.

Table 7-3. Horse Prairie Creek *E. coli* Target Evaluation Summary

Site ID	Data Collection Date	Sampling Result (cfu[1]/100mL)	Geometric Mean of all Samples (cfu[1]/100mL)	Target Exceedance[2]		Assessment Determination[3]
				Geometric Mean > 126 cfu[1]/100mL	10% of all *E. coli* Samples > 252 cfu[1]/100mL	
M01HRSPC01	7/11/2017	**461.1**	607.2	Fail (violates target)	Fail (violates target)	Impaired
	7/12/2017	**260.3**				
	7/14/2017	**579.4**				
M01HRSPC03	7/11/2017	**1203.3**				
	7/12/2017	**866.4**				
	7/14/2017	**1299.7**				
M01HRSPC01	7/11/2017	**980.4**				
	7/12/2017	**613.1**				
	7/14/2017	198.1				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Assessment based on2020 impairment determination
Bolded results indicate target exceeded

In Medicine Lodge Creek, 6 *E. coli* samples were collected from 2 sites in 2017. All samples were collected during separate 24-hour periods and within the consecutive 30-day period required by ARM 17.30.620(2). Individual *E. coli* sample values ranged from approximately 727 cfu/100mL to 2,420 cfu/100mL. If either target (geometric mean or 10% exceedance) is exceeded at any sampling location, a waterbody is considered impaired. Because the geometric mean of all the samples was greater than 126 cfu/100mL and because all the samples surpass the 10% exceedance rate, Medicine Lodge Creek is considered impaired for *E. Coli* (**Table 7-4**) and a TMDL will be developed.

Table 7-4. Medicine Lodge Creek *E. coli* Target Evaluation Summary

Site ID	Data Collection Date	Sampling Result (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedance[2]		Assessment Determination[3]
				Geometric Mean > 126 cfu[1]/100mL	10% of all *E. coli* Samples > 252 cfu[1]/100mL	
M01MEDLC02	7/11/2017	**1299.7**	1446	Fail (violates target)	Fail (violates target)	Impaired
	7/12/2017	**727.0**				
	7/14/2017	**1986.3**				
M01MEDLC05	7/11/2017	**>2419.6**				
	7/12/2017	**1299.7**				
	7/14/2017	**1553.1**				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Assessment based on 2020 impairment determination
Bolded results indicate target exceeded

In Peet Creek, 7 *E. coli* samples were collected from 1 site in 2017. One sample was collected outside of the consecutive 30-day period required by ARM 17.30.620(2) and could not be used in the impairment determination. Six of the 7 samples were collected during separate 24-hour periods, within the consecutive 30-day period, and are used for assessment purposes (**Table 7-5**). Individual *E. coli* values ranged from approximately 186 cfu/100mL to 1,203 cfu/100mL. If either target (geometric mean or 10% exceedance) is exceeded at any sampling location, a waterbody is considered impaired. Because the geometric mean of all the samples was greater than 126 cfu/100mL and 83% of the samples surpass the 10% exceedance rate, Peet Creek is considered impaired for *E. Coli* and a TMDL will be developed.

Table 7-5. Peet Creek *E. coli* Target Evaluation Summary

Site ID	Data Collection Date	Sampling Result (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedance[2]		Assessment Determination[3]
				Geometric Mean > 126 cfu/[1]100mL	10% of all *E. coli* Samples > 252 cfu[1]/100mL	
M01PEETC03	7/19/2017	**648.8**	569.5	Fail (violates target)	Fail (violates target)	Impaired
	8/14/2017	**829.7**				
	8/15/2017	186				
	8/16/2017	**1203.3**				
	8/17/2017	**920.8**				
	8/18/2017	**307.6**				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Assessment based on 2020 impairment determination
Bolded results indicate target exceeded

In the Red Rock River, 11 *E. coli* samples were collected from 3 sites in 2017. Two of the 11 samples were collected outside of the 30 day consecutive period required by ARM 17.30.620(2) and could not be used in the impairment determination. Nine of the 11 samples were collected were collected during separate 24-hour periods, within the consecutive 30-day period, and are used for assessment purposes (**Table 7-6**). Individual *E. coli* values ranged from approximately 1 cfu/100mL to 345 cfu/100mL. If either target (geometric mean or 10% exceedance) is exceeded at any sampling location, a waterbody is considered impaired. Because 3 of the samples surpass the 10% exceedance rate the Red Rock River is considered impaired for *E. Coli* and a TMDL will be developed.

Table 7-6. Red Rock River *E. coli* Target Evaluation Summary

Site ID	Data Collection Date	Sampling Result (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedance[2]: Geometric Mean > 126 cfu[1]/100mL	Target Exceedance[2]: 10% of all *E. coli* Samples > 252 cfu[1]/100mL	Assessment Determination[3]
M01RDRKR01	7/17/2017	**344.8**	29.7	Pass (does **not** violate target)	Fail (violates target)	Impaired
	8/15/2017	184.2				
	8/16/2017	**260.3**				
	8/17/2017	**290.9**				
M01RDRKR05	8/15/2017	25				
	8/16/2017	74.4				
M01RDRKR07	8/15/2017	2.0				
	8/16/2017	1.0				
	8/17/2017	1.0				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Assessment based on 2020 impairment determination
Bolded results indicate target exceeded

7.5 TOTAL MAXIMUM DAILY LOAD

This section summarizes the approach used for TMDL development, and presents the TMDL, allocations, and estimated reductions necessary to meet water quality targets for *E. coli* impaired waterbodies in the Red Rocks TMDL Planning Area. **Table 7-7** shows the waterbody, assessment unit, the impairment cause and the TMDLs developed. Loading estimates and load allocations are based on observed water quality data and representative flow conditions and are discussed later in this section.

Table 7-7. E. coli TMDLs Developed in the Red Rock TMDL Planning Area

Stream Segment/Waterbody (Assessment Unit)	Assessment Unit ID	Impairment Cause and TMDL Developed
Horse Prairie Creek	MT41A003_090	Escherichia coli (*E. Coli*)
Peet Creek	MT41A004_090	Escherichia coli (*E. Coli*)
Medicine Lodge Creek	MT41A003_010	Escherichia coli (*E. Coli*)
Red Rock River	MT41A003_010	Escherichia coli (*E. Coli*)

Because streamflow varies seasonally, *E. coli* TMDLs are not expressed as a static value, but as an equation of the appropriate target multiplied by flow, as shown in **Equation 7-1**:

Equation 7-1: TMDL = (X) (Y) (K)/1,000,000

TMDL= Total Maximum Daily Load in million colony forming units/day (Mcfu/day)
*X = E. coli water quality geometric mean target in cfu/100mL (**Table 7-2**)*
Y = streamflow in cubic feet per second (cfs)
K = conversion factor of 2.44×10^7

Like the water quality targets, the TMDLs change seasonally between the winter season (November 1 through March 31) and the summer season (April 1 through October 31). The *E. coli* TMDLs displayed in **Figure 7-2** are based on **Equation 7-1** and show TMDLs based on the geometric mean targets (126 cfu/100mL for the summer season and 630 cfu/100mL for the winter season). The TMDL calculation and the resulting graphical representation of this equation (**Figure 7-2**) assume that if the geometric mean targets of 126 cfu/100mL or 630 cfu/100mL are being met in a waterbody, the 10% exceedance target of 252 cfu/100mL or 1,260 cfu/100mL will also be met.

Figure 7-2 also displays the relationship that the TMDL has to flow; as flow increases, the allowable load (TMDL) increases. The TMDL is not expressed as a load or mass, but instead expressed as the number of colony forming units (cfu) per day due to the nature of the pollutant. This approach is consistent with EPA's recommended analytical method for measuring *E. coli* in ambient waters and the flexibility offered in 40 CFR §130.3(i) to express TMDLs in other appropriate, non-mass based measures. For example, at a flow of 5 cfs, the application of **Equation 7-1** would result in a. *E. coli* TMDL of 15,372 Mcfu/day for the summer period and 76,860 Mcfu/day for the winter period.

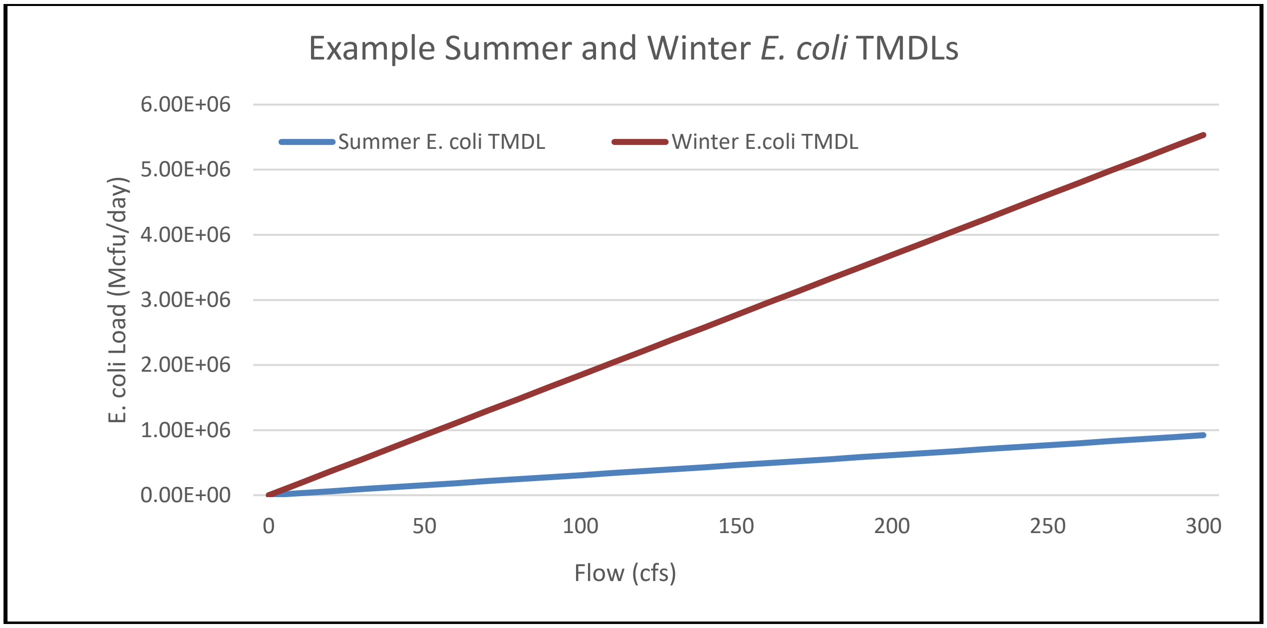

Figure 7-2. TMDLs for E. coli at stream flows ranging from 0 to 300 cfs

7.6 Source Assessment and Quantification

This section provides the approach used for source assessment, which characterizes the type, magnitude, and distribution of sources contributing to *E. coli* impaired waterbodies in the Red Rock watershed. It also establishes the approach used to develop TMDLs and allocations to specific source categories in Red Rock. Source characterization and the assessment to determine the major sources in Red Rocks were conducted using monitoring data and information outlined in **Section 7.4** and discussed further in **Sections 7.6.2** through **7.6.5**.

Assessment of existing *E. coli* sources is needed to develop Load Allocations (LAs) and load reductions for different source categories. Source characterization links *E. coli* sources, *E. coli* loading to streams, and water quality response, and supports the formulation of the allocation portion of the TMDL.

7.6.1 Description of *E. coli* Sources

Within the Red Rocks watershed, there are no surface water point source discharges of *E. coli* covered under Montana Pollutant Discharge Elimination System (MPDES) permits. *E. coli* inputs to the Red Rock watershed come primarily from nonpoint sources (i.e., diffuse sources that cannot easily be pinpointed) and natural background sources. Some of these sources are shown in **Figure 7-3**. DEQ identified the following source categories that potentially contribute *E. coli* to Red Rocks:

- Agriculture (forest and riparian area grazing, irrigated cropping, and pasture/rangeland)
- Subsurface disposal of domestic wastewater and failing septic systems
- Residential development and recreation (domestic pets and recreational use)
- Natural background

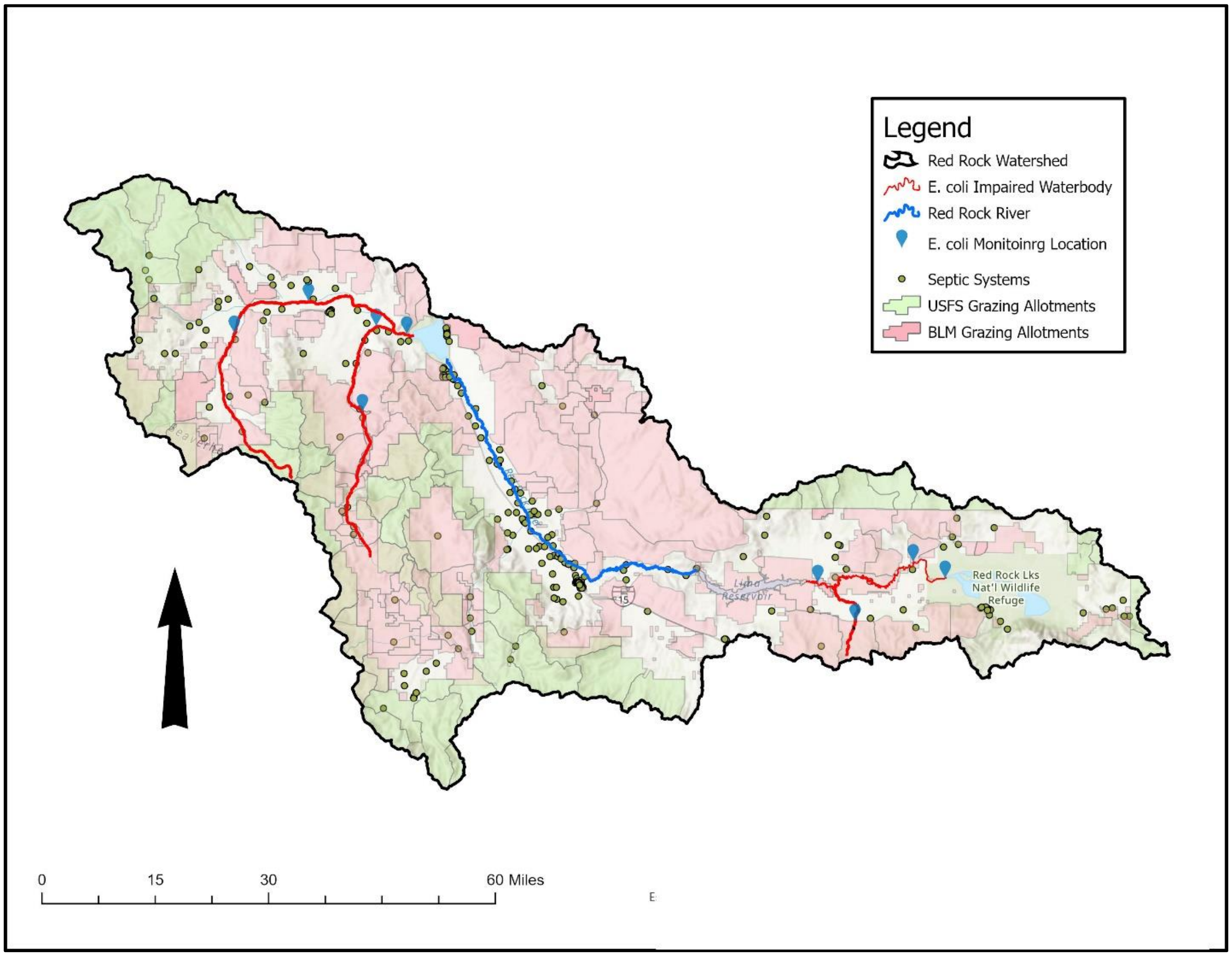

Figure 7-3. Map showing water quality monitoring sites and sources of E. coli in the Red Rocks watershed

7.6.1.1 Natural Background

Natural sources of *E. coli* are primarily from wildlife excrement, mainly from species that utilize riparian and stream corridors. During the development of the Red Rock *E. coli* TMDLs, *E. coli* data were collected at sampling sites throughout the watershed. None of these sampling sites were identified as *E. coli* 'reference' sites for the purposes of quantifying a natural background loads for *E. coli*. As these sites are not considered 'reference', data representative of natural conditions needed to be selected. Background *E. coli* data were collected from 2003-2005 at several sampling sites outside of the Red Rocks watershed that are identified as 'reference' sites by DEQ's water quality standards section (**Table 7-8**). These sites include lightly developed areas of the Blackfoot River near Bonner and Rock Creek near Clinton. For purposes of estimating natural background concentrations for TMDL development, the median reference value of 19.6 cfu/100mL is used as an estimate of natural background sources for the calculation of load allocations in **Sections 7.7 and 7.8**

This represents about 15% of the "summer" standard of 126 cfu/100mL, and 3% of the "winter" standard of 630 cfu/100mL assuming a constant *E. coli* contribution from natural background during both seasons.

Table 7-8. E. coli Reference Site Data and Summary Statistics

Station ID	**Site Name**	**2003** (cfu/100mL)	**2004** (cfu/100mL)	**2005** (cfu/100mL)
C02ROCKC01	Rock Creek near Clinton	48.7	28.4	47.9
C03BLACR01	Blackfoot River near Bonner	1.0	10.8	5.2
	Minimum	1.0		
	Median	19.6		
	Maximum	48.7		
	90th Percentile	48.3		

7.6.1.2 Human Caused Nonpoint Sources

A significant portion of *E. coli* inputs to the impaired waterbodies of the Red Rock watershed come from nonpoint sources (i.e., diffuse sources that cannot easily be pinpointed). Human caused nonpoint sources of *E. coli* in the Red Rock watershed consist primarily of agriculture (pasture, rangeland, and manure applied on cropland), and those other sources that are human caused (subsurface wastewater disposal, domestic pets, recreation etc.). **Figures 7-4 through 7-7** show types of land use including areas of cropland, pasture, and other potential sources. Livestock grazing on private rangeland occurs throughout the watershed but is not specifically identified in these figures.

Agriculture

The transport of *E. coli* from agricultural land to surface water can happen where there is grazing of riparian areas by livestock. The proximity of deposited excrement to nearby surface waters provides an efficient transport route. Excrement deposited in and near a waterbody, and through field application of manure on crops, can travel to surface water via overland runoff and irrigation return flows. The following subsections describe the most prominent land use practices that present these conditions.

Livestock Grazing

Livestock are typically allowed to roam and graze in areas along the valley bottoms during the growing season, and in areas where livestock have direct access to the stream, they can be significant sources of *E. coli*. Livestock grazing in the Red Rock watershed occurs on private and public range and pasturelands. Rangeland differs from pasture in that rangeland has much less biomass. Rangeland is typically grazed during the summer months (June-October). Pastures are typically managed for hay production during the summer and for grazing during the fall and spring. Hay pastures are typically thickly vegetated in the summer and less so in the fall through spring. During the winter grazing period (October through May), trampling and winter feeding further reduces biomass when it is already low. Livestock manure deposition occurs in higher quantities on pasture ground from October through May because of higher cattle density than that found on range and forested areas.

Private land grazing occurs throughout the watershed, and in areas where livestock have direct access to the stream, they can be significant sources of *E. coli*. If not managed properly manure from livestock corrals can runoff into surface water. In addition to private land grazing, there are public land grazing allotments throughout the watershed. The Red Rock watershed is approximately 1.2 million of the 1.48 million acre Red Rock watershed is in federal grazing allotments. The Bureau of Land Management (BLM) and the US Forest Service (USFS) maintain grazing allotments in subbasins throughout the Red Rock watershed. There are approximately 80 USFS grazing allotments in the entire Red Rock watershed accounting for approximately 830,150 acres. Most of these allotments occur in more mountainous areas in the headwaters. The BLM has just over 335 grazing allotments in the entire watershed accounting for approximately 898,000 acres. The vast majority of these occur in the lower reaches of the watershed.

Irrigated and Dryland Cropping

Cropland in the Red Rock watershed is primarily irrigated hay and pastureland (grass and alfalfa), with some irrigated small grains production (U.S. Department of Agriculture, National Agricultural Statistics Service 2019 https://nassgeodata.gmu.edu/CropScape/)Manure applied to cropland can be a source of *E. coli* to surface water if it is not incorporated into the soil correctly, in a timely manner, and applied at agronomic rates. When properly applied, manure can provide an excellent source of fertilizer for crops, but improper application can leave excess manure on the soil surface, which makes it susceptible to being transported waterbodies via overland runoff from precipitation or irrigation. Prior to field application, manure must be properly stored in areas where the risk for transport to surface waters and impacts to shallow groundwater are low. Improper manure storage in areas with a high-water table or areas adjacent to surface water pose the greatest risk for off-site *E. coli* transport. The extent of manure application on cropland in the Red Rock watershed is unknown, but likely minimal in comparison to the application of commercial fertilizers.

Failing or Malfunctioning Septic Systems

Additional sources with the potential to contribute *E. coli* loads to surface waters include residential septic systems, aging and failing septic systems, improperly designed or maintained systems, and faulty residential service connections. Properly located, designed, installed, and maintained, these systems pose no significant loading threat to surface waters. As such, loading from properly functioning systems will not be considered a potential source of *E. coli*. However, improperly installed systems, unmaintained systems and failing systems have the potential to contribute *E. coli* loads where they are in close proximity to surface waters.

Failing or malfunctioning septic systems include individual wastewater systems that are not providing adequate treatment of bacterial contaminants before they reach surface waters. To consider a failing septic system as a source, it would need to produce an effluent stream near a waterbody to provide a significant *E. coli* load. For this to occur, a septic system would need to be in close proximity to the waterbody to receive overland flow from the failing system. Typically, failing systems exhibit obvious evidence of failure by surface ponding or routing of effluent, and these symptoms are quickly identifiable by the owner of the system in most circumstances. Because a failing or malfunctioning septic system is easily identifiable, repairs are likely done in a timely manner, limiting the risk of *E. coli* contamination to nearby surface or groundwater. While no information is available regarding failing septic systems in the Red Rock watershed, the number of failing septic systems is likely very low and is not expected to be a significant contributor of *E. coli*.

Domestic Pets and Recreational Use

Domestic pets such as dogs and recreational livestock are common in the Red Rock watershed and have the potential to contribute *E. coli*. It is assumed that contributions from pets and recreational livestock within the residential and recreational areas are insignificant because the number of pets and recreational livestock is low compared to the number of cattle, the largest contributing sources of *E. coli*. Given the lower number of pets and recreational livestock and the resulting lower volume of excrement this source is not expected to be a significant contributor of *E. coli* to the Red Rock River or its tributaries.

Re-suspension of *E. coli* in substrate sediments as a result of recreational usage or general disturbance (fishing, swimming, stream crossing, domestic pets, etc.) may contribute to instream *E. coli* loads during the summer recreation season. A study conducted in Oak Creek, Arizona, found that water quality violations occurred when high levels of fecal coliform were found in the sediment (Cabrill et al., 1999).

The largest potential contributor of *E. coli* in this category includes recreational stock, which may be maintained by individuals and businesses. Limited information regarding the specific contribution from recreational activities in the Red Rock watershed is available. However, this source is not expected to be a significant contributor of *E. coli* to the Red Rock and its tributaries.

7.6.2. Medicine Lodge Creek Source Assessment

E. coli inputs to Medicine Lodge Creek come from non-point sources. The primary sources of *E. coli* are those that occur naturally and those that are human caused (agricultural land use). There are no permitted point sources in the Medicine Lodge Creek watershed.

Medicine Lodge Creek occurs in the lower portion of the Red Rock watershed and is a tributary to Horse Prairie Creek. Land use in the watershed is approximately 63% shrubland, 17.5% forested, 8% grass land and pasture, 7.5% wetlands and miscellaneous open space, and 4 % recently disturbed ground or other human land use. Throughout Montana, these land use types are commonly utilized for grazing. Grazing land use in Medicine Lodge Creek is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 7-4**). The US Forest Service (USFS) has approximately 64,125 acres of land in federally managed grazing allotments and the Bureau of Land Management (BLM) has approximately 89,063 acres. Cropland in the Medicine Lodge Creek watershed is widespread and consists primarily of irrigated and dryland hay and pastureland (grass and alfalfa) and dryland small grain (winter wheat and barley) production (U.S. Department of Agriculture, National Agricultural Statistics Service, 2019 https://nassgeodata.gmu.edu/CropScape).

To consider a septic system as a source, it would need to be failing, and produce an effluent stream capable of reaching a nearby surface water. For this to occur, a septic system would need to be in close enough proximity to a surface water to receive overland flow from the failing system. There are no identified septic systems in the Medicine Lodge Creek watershed that are with 100 feet of Medicine Lodge Creek. One hundred feet is a conservative estimate of distance that an effluent stream could (without infiltrating in into surface soils or becoming diluted by other means) be expected to persist and reach a nearby surface water. **Figure 7-4** shows the location of known septic systems in the watershed and their proximity to the Medicine Lodge Creek.

The Medicine Lodge Creek was sampled six times at two locations (M01MEDLC02, and M01MEDLC05). One sample was collected from each site on July 11, 12 and 14 of 2017. On all sampling events, at all locations, *E. coli* concentrations exceeded the summer water quality target of 252 cfu/mL (**Table 7-4**). In general, *E. coli* concentrations are highest at the monitoring location furthest upstream (M01HRSPC02) and decrease at the location downstream (M01HRSPC03). As there are 2 monitoring locations, it is difficult to come to a concise conclusion about *E. coli* contributing sources. Higher *E. coli* concentrations upstream indicate that there might be more abundant sources further upstream in the watershed. The decrease in concentrations can be attributed to dilution from tributaries downstream of M01DECLC02. There are a number of cattle operations in the Medicine Lodge Creek watershed. The lower segment of the creek also becomes braided, and there are a number of ditches crossing agricultural land. These features allow for more opportunity for manure to come in contact with surface waters. This, along with a high volume of cattle present, provide means for *E. coli* to be deposited and conveyed to Medicine Lodge Creek.

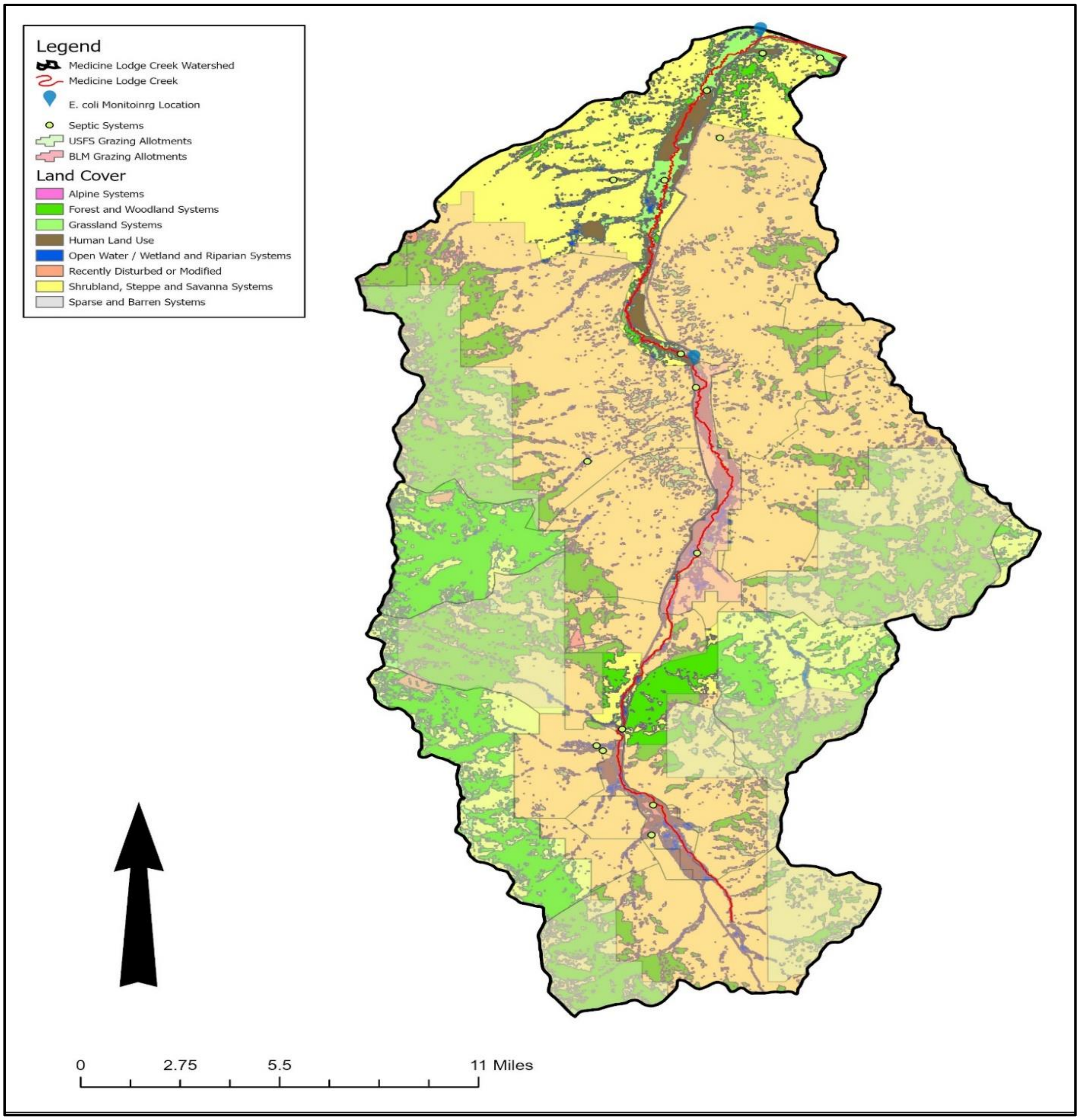

Figure 7-4. Water Quality Monitoring Sites and E. coli Sources in the Medicine Lodge Creek Watershed

7.6.3 Horse Prairie Creek Source Assessment

E. coli inputs to Horse Prairie Creek come from non-point sources. The primary sources of *E. coli* are those that occur naturally and those that are human caused (agricultural land use). There are no permitted point sources in the Horse Prairie Creek watershed.

Horse Prairie Creek occurs in the lower portion of the Red Rock watershed and is a tributary to Clark Canyon Reservoir. Land use in the watershed is approximately 37% shrubland, 32% grass land and pasture, 30% forested and 1% wetlands and miscellaneous open space. Throughout Montana these land use types are commonly utilized for grazing. Grazing land use in the Horse Prairie Creek is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 7-5**). The USFS has approximately 187,944 acres of land in federally managed grazing allotments and the BLM has approximately 208,691 acres. Cropland in the Horse Prairie Creek watershed is widespread and consists primarily of irrigated and dryland hay and pastureland (grass and alfalfa) and dryland small grain (winter wheat, spring wheat and barley) production (U.S. Department of Agriculture, National Agricultural Statistics Service, 2019 https://nassgeodata.gmu.edu/CropScape).

To consider a septic system as a source, it would need to be failing, and produce an effluent stream capable of reaching a nearby surface water. For this to occur, a septic system would need to be in close enough proximity to a surface water to receive overland flow from the failing system. There are no identified septic systems in the Horse Prairie Creek watershed that are with 100 feet of Horse Prairie Creek. One hundred feet is a conservative estimate of distance an effluent stream could (without infiltrating in into surface soils or becoming diluted by other means) be expected to persist and reach a nearby surface water. **Figure 7-5** shows the location of known septic systems in the watershed and their proximity to the Horse Prairie Creek.

The Horse Prairie Creek was sampled nine times at three locations (M01HRSPC02, M01HRSPC03 and M01HRSPC01) on July 11, 12 and 14 of 2017. Except for one sample, all *E. coli* concentrations exceeded the summer water quality target of 252 cfu/mL. *E. coli* concentrations are elevated at the monitoring location furthest upstream (M01HRSPC01), decrease dramatically at the next monitoring location downstream (M01HRSPC02), and, with the exception of one sample, increase again at the next downstream monitoring location (M01HRSPC03). This indicates that sources are present throughout the watershed and are likely most abundant in the upper section. The decrease in *E. coli* concentrations from the uppermost monitoring location to the middle monitoring location is likely a result of dilution from incoming tributaries. There are a number of cattle operations in throughout the Horse Prairie Creek watershed. This creek also becomes braided through the lower segment, and there are a number of ditches providing return flows. These attributes along with a high volume of cattle present provide means for *E. coli* to be deposited and conveyed to Horse Prairie Creek.

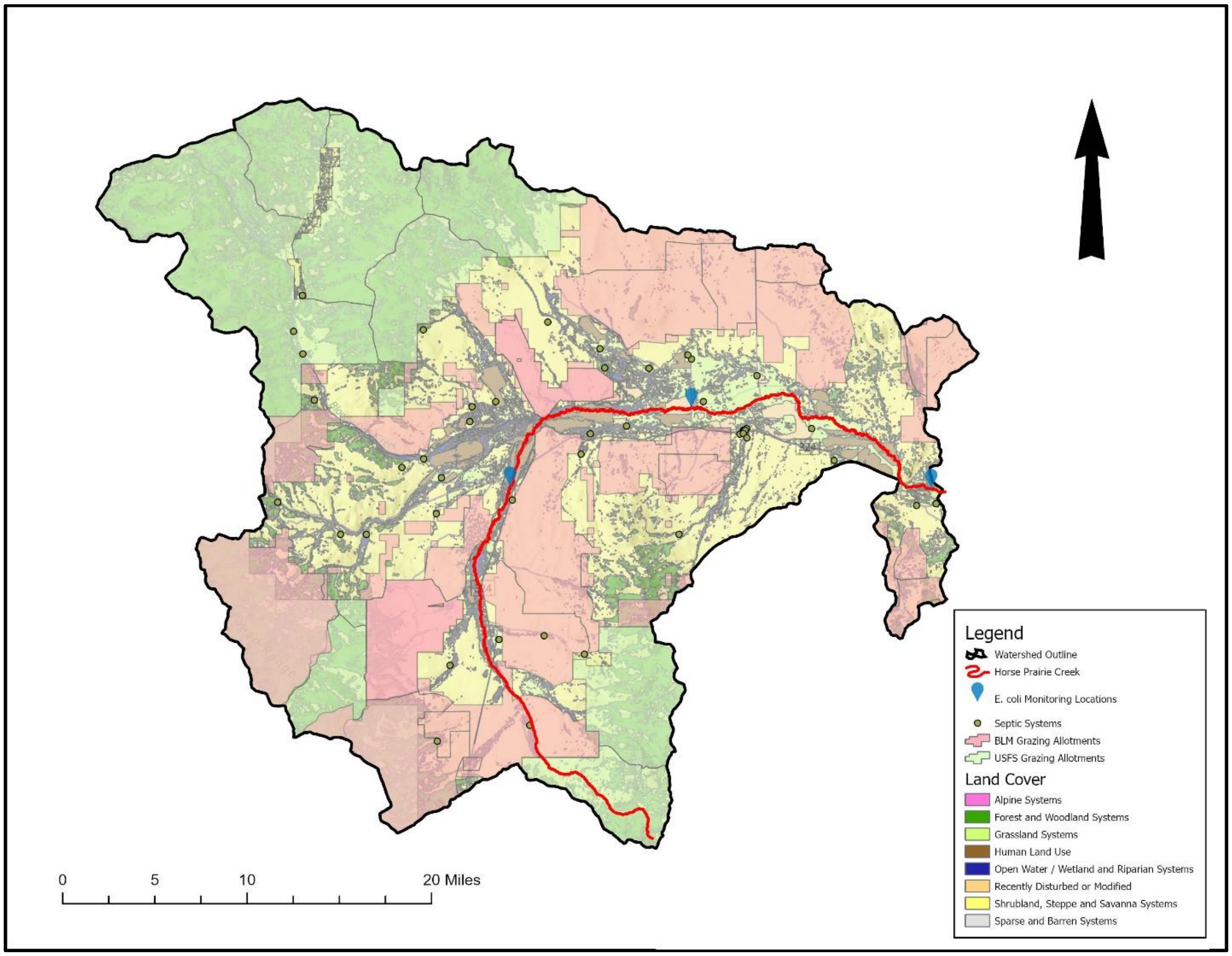

Figure 7-5. Water Quality Monitoring Sites and E. coli Sources in the Horse Prairie Creek Watershed

7.6.4 Peet Creek Source Assessment

E. coli inputs to Peet Creek come from a number of non-point sources. The primary sources of *E. coli* are limited to those that occur naturally and those that are human caused (agricultural land use). There are no permitted point sources in the Peet Creek watershed.

Peet Creek occurs in the upper portion of the Red Rock watershed, and is a direct tributary to Red Rock River just upstream of the Lima Reservoir. Land use in the watershed is approximately 62% shrubland, 20% forested, 10% wetlands/riparian and miscellaneous open space and 8% grass land and pasture. Throughout Montana these land use types are commonly utilized for grazing. Grazing land use in Peet Creek is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 7-6**). The BLM has approximately 10,366 acres. There are no USFS grazing allotments in this watershed. Cropland in the Peet Creek watershed is widespread and consists primarily of irrigated and dryland hay and pastureland (grass and alfalfa) (U.S. Department of Agriculture, National Agricultural Statistics Service, 2019 https://nassgeodata.gmu.edu/CropScape).

To consider a septic system as a source, it would need to be failing, and produce an effluent stream capable of reaching a nearby surface water. For this to occur, a septic system would need to be in close

enough proximity to a surface water to receive overland flow from the failing system. There are no identified septic systems in the Peet Creek watershed that are with 100 feet of Peet Creek.
The Peet Creek was sampled a total of eight times at one locations (M01PEETC03). Samples were collected between July 10 and August 18, 2017. As there is only one sampling location, inferences about sources in the watershed are difficult to make. *E. coli* concentrations at five out of the seven sampling events exceeded the summer water quality target of 252 cfu/mL. In general *E. coli* concentrations tended to be higher later in the summer (8/14/2017, 8/16/2017 and 8/17/2017). There are a number of Federal grazing allotments and private cattle operations in the Peet Creek watershed that are likely acting as contributing sources.

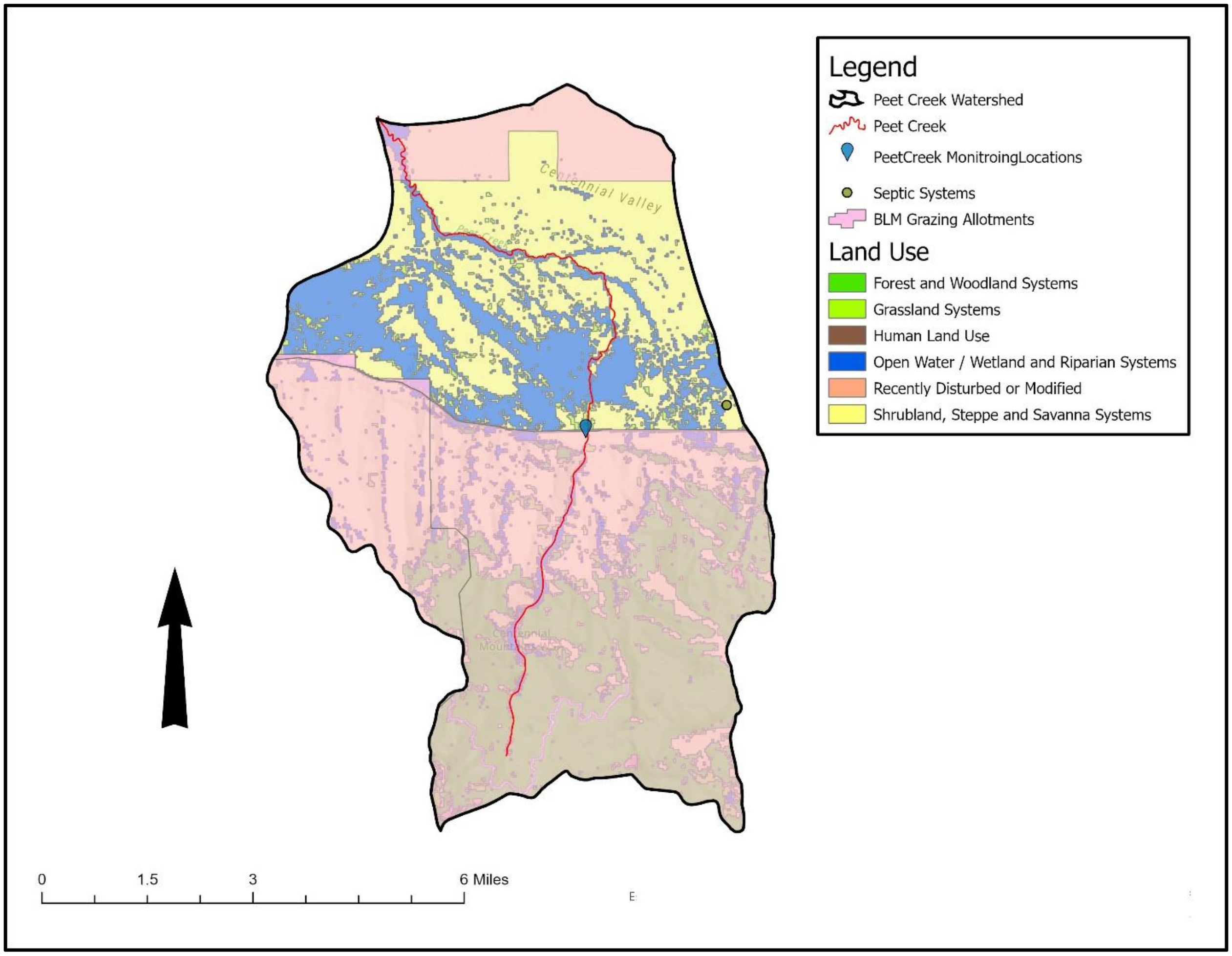

Figure 7-6. Water Quality Monitoring Site and E. coli Sources in the Peet Creek Watershed

7.6.5 Red Rock River Source Assessment

E. coli inputs to Red Rock River come from non-point sources. The primary sources of *E. coli* are those that occur naturally and those that are human caused (agricultural land use). There are no permitted point sources in the Red Rock River watershed.

The impaired segment of the Red Rock River occurs in the upper portion of the Red Rock watershed and is a tributary to Lima Reservoir. Land use in the watershed is approximately 64% shrubland, 19% forested, 12% wetlands, 2.5% grass/pasture and about 2.5 % of what is considered open water. Throughout Montana these land use types are commonly utilized for grazing. Grazing land use in Red

Rock River is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 7-7**). The USFS has approximately 21,027 acres of land in federally managed grazing allotments and the BLM has approximately 2109,832 acres. Cropland in this portion of the Red Rock River watershed is widespread and consists primarily of irrigated and dryland hay and pastureland (grass and alfalfa) and dryland small grain (winter wheat and barley) production (U.S. Department of Agriculture, National Agricultural Statistics Service, 2019 https://nassgeodata.gmu.edu/CropScape).

To consider a septic system as a source, it would need to be failing, and produce an effluent stream capable of reaching a nearby surface water. For this to occur, a septic system would need to be in close enough proximity to a surface water to receive overland flow from the failing system. There are no identified septic systems in the Red Rock River watershed that are with 100 feet of The Red Rock River. The Red Rock River was sampled a total of eleven times at three locations (M01RDRKR01, M01RDRKR05 and M01RDRKR07) from mid-July to mid-August of 2017.

E. coli concentrations only exceeded the summer water quality target of 252 cfu/100mL at the upstream most monitoring location (M01RDRKR01). These exceedances occurred on 7/17/2017, 8/162/17 and 8/17/2017. *E. coli* concentrations are highest at M01RDRKR01 and decrease in a downstream direction, with average concentration of 50 cfu/100ml at M01RDRKR05 and 1.3 cfu/100ml at M01RDRKR07. Higher *E. coli* concentration at M01RDRKR01 indicate that there are likely more abundant sources further upstream in the watershed. The decrease in concentrations in the downstream direction can be attributed to dilution from tributaries downstream of M01RDRKR01. There are a number of cattle operations in the Red Rock River watershed and grazing allotments throughout the watershed.

Another potential source of *E. coli* loading is that which occurs naturally from wildlife. Monitoring location M01RDRKR01 is at the outlet of Lower Red Rock Lake. The Red Rock Lakes National Wildlife refuge is renowned for the waterfowl and other wildlife that frequent this area.

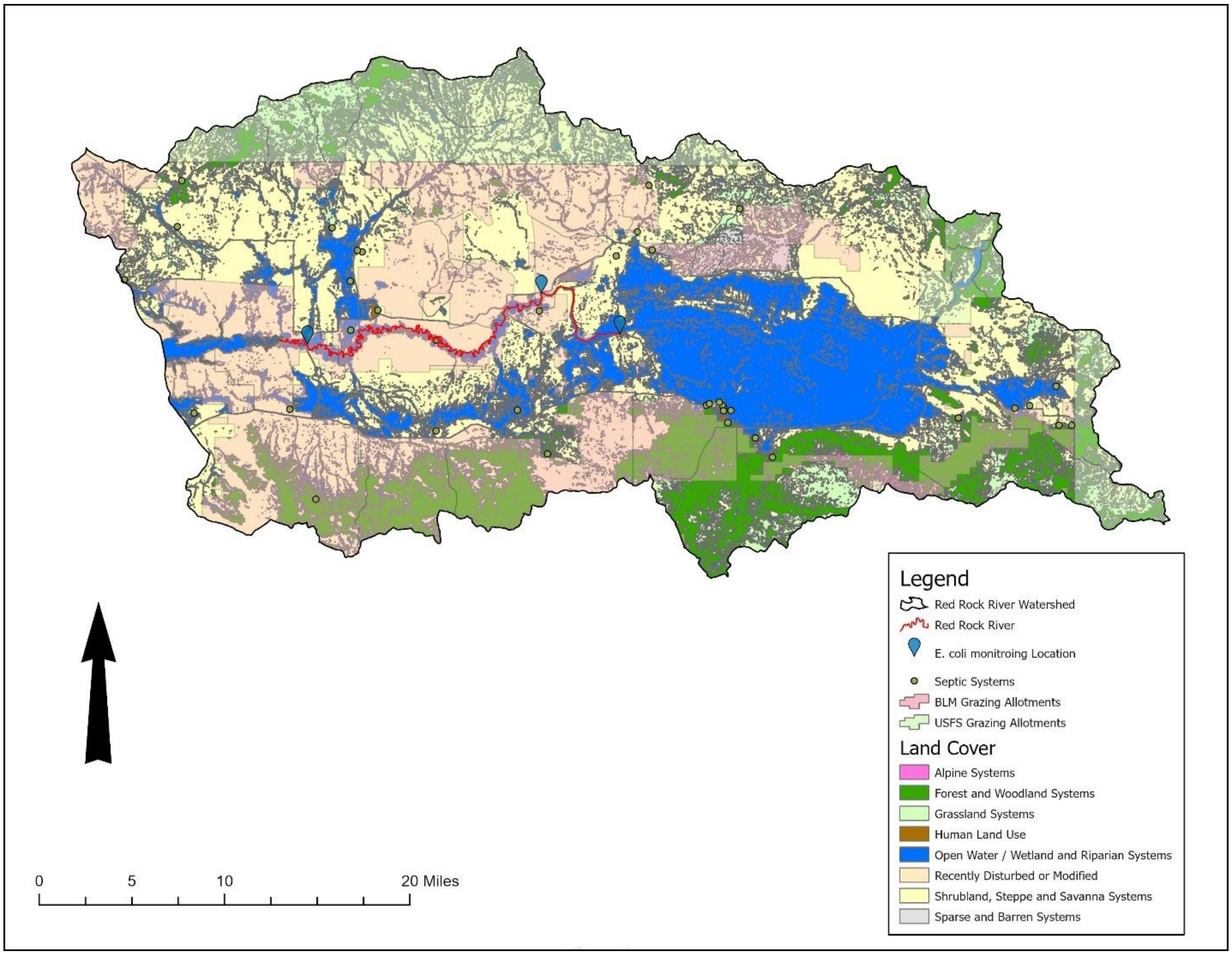

Figure 7-7. Water Quality Monitoring Sites and E. coli Sources in the Red Rock River

7.7 Approach to TMDL Allocations

As discussed in **Section 4.0**, the *E. coli* TMDL consists of the sum of all load allocations to individual sources and source categories (**Table 7-9**). Because there are nonpoint sources of *E. coli* throughout the watershed, Load Allocations (LAs) will be established. The TMDL is broken into a load allocation to natural background (*LA*) and a composite load allocation to all human-caused nonpoint sources (*COMP* LA_H) as seen in **Equation 7-2**.

Equation 7-2*: TMDL = LA_{NB} + COMP LA_H*

TMDL = *Total maximum daily load*

LA_{NB} = *Load allocation to natural background sources (Mcfu/day)*

COMP LA_H = Composite *load allocation to human-caused nonpoint sources (Mcfu/day)*

Under most circumstances, DEQ provides an implicit margin of safety (MOS) by using assumptions known to be conservative and are discussed in depth in **Section 7.9**. Where an implicit MOS is applied, the MOS in the TMDL equation is equal to zero and not necessarily included in the equation.

Table 7-9. *E. coli* Source Categories and Descriptions for the Red Rock Watershed

Source Category	Source Descriptions
Natural Background	• Wild animal excrement
Nonpoint Sources (Diffuse sources)	• Agriculture (manure applied or deposited) • Leaking septic and sewer systems • Domestic animal excrement

7.7.1 Natural Background Allocation

There are no *E. coli* reference sites in the Red Rock watershed. Therefore, load allocations for natural background are based on median *E. coli* concentrations from sites within Montana that have similar land use characteristics as those found in the Red Rock watershed (**Table 7-8**). These sites were chosen to represent stream conditions in the Red Rock watershed where human activities may be present but do not negatively harm stream use. Natural background loads are calculated by multiplying the median reference concentration (19.6 cfu/100mL) by the streamflow. The natural background load allocation is calculated as follows (**Equation 7-3**):

Equation 7-3: $LA_{NB} = (X)\,(Y)\,(2.44\ X10^{7})/1{,}000{,}000$

LA_{NB} = Load allocation to natural background (Mcfu/day)
X = Natural background concentration (19.6 cfu/100mL)
Y = Streamflow in cubic feet per second (cfs)
$2.44\ X10^{7}$ = Conversion factor

7.7.2 Human-Caused Source Allocation

The composite load allocation to human-caused nonpoint sources (COMP LA_H) is calculated as the difference between the allowable daily load (TMDL) and the sum of all the remaining load allocations (LA_{NB}). An example of this can be seen in **Equation 7-4**:

Equation 7-4: $Comp\ LA_H = TMDL - LA_{NB}$

TMDL = Total maximum daily load (Mcfu/day)
COMP LA_H = Composite load to human-caused nonpoint sources (Mcfu/day)
LA_{NB} = Load allocation to natural background (Mcfu/day)

7.7.3 Total Existing (Above Target) Load

To estimate a total existing load for the purpose of estimating a required load reduction, the following equation will be used:

Equation 7-5: **Total Existing Load (Mcfu/day) = $((X)\,(Y)\,(2.44\ X10^{7}))/1{,}000{,}000$**

X = Above Target E. coli concentration (cfu/100mL)
Y = streamflow in cubic feet per second (cfs)
$2.44\ X10^{7}$ = conversion factor

The existing load resulting from **Equation 7-5** (**X**) is unique to each waterbody, and is dependent on the available for that waterbody. The geometric mean of target exceedances is used to calculate the existing load as these concentrations are greater than the target and when incorporated into the above equation indicate the TMDL is being exceeded and load reductions are necessary. For all the waterbodies receiving TMDLs for *E. coli* there was enough data to calculate a geometric mean of target exceedance.

7.8 TMDL Allocations For the Red Rock Watershed

This section presents the TMDL, source allocations, and estimated reductions necessary to meet water quality targets for *E. coli* in the Red Rock TMDL Planning Area. An *E. coli* TMDL has been developed for those waterbodies listed in **Table 7-7**.

It is important to acknowledge that different water quality targets and subsequent allocations are applicable at separate times of the year. The TMDLs explained in the following sections are based on the summer (April 1 through October 31) *E. coli* limit (126 cfu/100mL). The example loading estimates and load allocations in the following sections are established for the summertime period, when contact recreation (swimming, fishing, etc.) is most likely to occur. TMDLs for the winter months (November 1 through March 31) should be based on the winter *E. coli* limit (630 cfu/100mL). The example TMDLs are based on water quality data and flow conditions measured in each of the impaired waterbodies.

It is also important to note that seasonal flow data were collected during sampling efforts not directly associated with *E. coli* sampling, rather flow was collected during nutrient sampling. Loading estimates are conservative and should be protective of the beneficial use during other times of the year as well, given the nonpoint source or diffuse nature of the *E. coli* loading.

7.8.1 Medicine Lodge Creek (MT41A003_010) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for Medicine Lodge Creek. There are no point sources in the Medicine Lodge Creek watershed, therefore there are no wasteload allocations (WLA) calculated in this TMDL. Additionally, this section provides *E. coli* loading estimates for natural and human-caused source categories, and estimates reductions necessary to meet *E. coli* water quality targets.

Estimating TMDL and Allocations

The total existing load is used to estimate load reductions by comparing it to the allowable load (TMDL) and computing a required percent reduction to meet the TMDL. No load reductions are given for natural background allocations; therefore, all necessary load reductions apply to the nonpoint sources within the watershed.

E. coli TMDLs vary by flow. The following is an example *E. coli* TMDL for Medicine Lodge Creek, calculated with the "summer" *E. coli* standard (126 cfu/100mL) and median flow rate of 5.0 cfs. This median flow rate was derived from measured flow values at all sites on Medicine Lodge Creek during 2017 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The Medicine Lodge TMDL for *E. coli* is based on **Equation 7-1** and is presented below.

TMDL = ((126 cfu/100mL) (5.0 cfs) (2.44 x10^{7}))/1,000,000 = 15,356 Mcfu/day

Equation 7-3 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 5.0 cfs and a median background concentration of 19.6 cfu/100mL (**Section 7.6.1.1**), this allocation is as follows:

LA_{NB} = ((19.6 cfu/100mL) (5.0 cfs) (2.44 X 10^{7}))/1,000,000 = 2,389 Mcfu/day

The portion of the total existing load attributed to human-caused sources is determined by subtracting out the background load (2,388 Mcfu/day) from the TMDL (15,356 Mcfu/day). Using **Equation 7-4**, the human-caused *E. coli* load allocation (**COMP LA_H**) at a flow rate of 5.0 cfs can be calculated as follows:

COMP LA_H = (15,356 Mcfu/day) – (2,388 Mcfu/day) = 12,968 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 5.0 cfs is based on **Equation 7-5**. This equation uses the geometric mean of *E. coli* target exceedance values (1,447 cfu/100mL). The geometric mean of *E. coli* data collected during 2017 sampling efforts is considered a conservative estimate of *E. coli* concentrations in Medicine Lodge Creek and is appropriate for use in calculating the existing load.

Total Existing Load = ((1,447 cfu/100mL) (5.0 cfs) (2.44 X10^7))/1,000,000 = 176,317 Mcfu/day

Table 7-10 contains the results for the example *E. coli* TMDL, based on a median summer flow rate of 5.0 cfs, along with the LAs to natural background and human caused sources for this same flow. It is important to note that the TMDL and the associated allocations calculated below only apply at the flow of 5.0 cfs. The Medicine Lodge Creek *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 7-10. Medicine Lodge Creek *E. coli* TMDL and Load Allocation at a Median Flow of 5.0 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
5.0	15,356	2,389	12,968

Based on the existing conditions in Medicine Lodge Creek (data presented in **Table 7-3**), the percent load reductions required to meet the TMDL range from about 0 to 91 percent. This reduction is calculated by comparing the geometric mean of target exceedances (1,447 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

Based on the median summer flow of 5.0 cfs, and the geometric mean of target value exceedances, the current loading to Medicine Lodge Creek is greater than the TMDL. Under these conditions, a 93% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

7.8.2 Horse Prairie Creek (MT41A003_090) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for Horse Prairie Creek. There are no point sources in the Horse Prairie Creek watershed, therefore there are no WLAs calculated in this TMDL. Additionally, this section provides *E. coli* loading estimates for natural and human-caused source categories, and estimates reductions necessary to meet water quality targets.

Estimating TMDL and Allocations

The total existing load is used to estimate load reductions by comparing it to the allowable load (TMDL) and computing a required percent reduction to meet the TMDL. No load reductions are given for natural background allocations; therefore, all necessary load reductions apply to the nonpoint sources within the watershed.

The following is an example *E. coli* TMDL for Horse Prairie Creek, calculated with the "summer" *E. coli* standard (126 cfu/100mL) and median flow rate of 44.5 cfs. This median flow rate was derived from measured flow values at all sites on Horse Prairie Creek during 2017 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The Horse Prairie TMDL for *E. coli* is based on **Equation 7-1** and an example is presented below.

TMDL = ((126 cfu/100mL) (44.5 cfs) (2.44 x10^7))/1,000,000 = 136,695 Mcfu/day

Equation 7-3 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 44.5 cfs and a median background concentration of 19.6 cfu/100mL (**Section 7.6.1.1**) this allocation is as follows:

LA_{NB} = ((19.6 cfu/100mL) (44.5 cfs) (2.44 X 10^7))/1,000,000 = 21,264 Mcfu/day

The portion of the total existing load attributed to human-caused sources is determined by subtracting out the background load (21,264 Mcfu/day) from the TMDL (136,695 Mcfu/day). Using **Equation 7-4**, the human-caused *E. coli* load allocation (**COMP LA_H**) at a flow rate of 44.5 cfs can be calculated as follows:

COMP LA_H = (136,695 Mcfu/day) – (21,264 Mcfu/day) = 115,432 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 44.5 cfs is based on **Equation 7-5**. This equation uses the geometric mean of *E. coli* target exceedance values (698cfu/100ml). The geometric mean of *E. coli* data collected during 2017 sampling efforts is considered a conservative estimate of *E. coli* concentrations in Horse Prairie Creek and is appropriate for use in calculating the existing load.

Total Existing Load = ((698cfu/100mL) (44.5 cfs) (2.44 X10^7))/1,000,000 = 757,746 Mcfu/day

Table 7-11 contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 44.5 cfs, along with the LAs to natural background and human caused sources for this same flow. It is important to note that the TMDL and the associated allocations calculated below only apply at the flow of 44.5 cfs. The Horse Prairie Creek *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 7-11. Horse Prairie Creek *E. coli* TMDL and Load Allocation at a Median Flow of 44.5 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
44.5	136,695	21,264	115,432

Based on the existing conditions in Horse Prairie Creek (data presented in **Table 7-4**), the percent load reductions required to meet the TMDL range from about 0 to 82 percent. This reduction is calculated by comparing the geometric mean of target exceedances (698 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

Based on the median summer flow of 44.5 cfs, and the geometric mean of target value exceedances, the current loading to Horse Prairie Creek is greater than the TMDL. Under these conditions, a 92% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

7.8.3 Peet Creek (MT41A004_090) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for Peet Creek. There are no point sources in the Peet Creek watershed, therefore there are no WLAs calculated in this TMDL. Additionally, this section provides *E. coli* loading estimates for natural and human-caused source categories, and estimates reductions necessary to meet water quality targets.

Estimating TMDL and Allocations

The total existing load is used to estimate load reductions by comparing it to the allowable load (TMDL) and computing a required percent reduction to meet the TMDL. No load reductions are given for natural background allocations; therefore, all necessary load reductions apply to the nonpoint sources within the watershed.

The following an example *E. coli* TMDL for Peet Creek calculated with the "summer" *E. coli* standard (126 cfu/100mL) and median flow rate of 1.6 cfs. This median flow rate was derived from measured flow values at all sites on Peet Creek during 2017 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The Peet Creek TMDL for *E. coli* is based on **Equation 7-1** and is presented below.

TMDL = ((126 cfu/100mL) (1.6 cfs) (2.44 x10^7))/1,000,000 = 5,042 Mcfu/day

Equation 7-3 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 1.6 cfs and a median background concentration of 19.6 cfu/100mL (**Section 7.6.1.1**) this allocation is as follows:

LA_{NB} = ((19.6 cfu/100mL) (1.6 cfs) (2.44 X 10^7))/1,000,000 = 784 Mcfu/day

The portion of the total existing load attributed to human-caused sources is determined by subtracting out the background load (784 Mcfu/day) from the TMDL (5,042 Mcfu/day). Using **Equation 7-4**, the human-caused *E. coli* load allocation (**COMP LA_H**) at a flow rate of 1.6 cfs can be calculated as follows:

COMP LA_H = (5,042 Mcfu/day) – (784 Mcfu/day) = 4,258 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 1.6 cfs is based on **Equation 7-5**. This equation uses the Geometric mean of *E. coli* target exceedance values (712 cfu/100ml). The geometric mean of *E. coli* data collected during 2017 sampling efforts is considered a conservative estimate of *E. coli* concentrations in Peet Creek and is appropriate for use in calculating the existing load.

Total Existing Load = ((712 cfu/100mL) (1.6 cfs) (2.44 X10^7))/1,000,000 = 28,507 Mcfu/day

Table 7-12 contains the results for the example *E. coli* TMDL expressed at a median summer flow rate of 1.6 cfs, along with the LAs to natural background and human caused sources for this same flow. It is important to note that the TMDL and the associated allocations calculated below only apply at the flow of 1.6 cfs. The Peet Creek *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 7-12. Peet Creek *E. coli* TMDL and Load Allocation at a Median Flow of 1.6 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
1.6	5,042	784	4,258

Based on the existing conditions in Peet Creek (data presented in **Table 7-5**), the percent load reductions required to meet the TMDL range from about 0 to 82 percent. This reduction is calculated by comparing the geometric mean of target exceedances (712 cfu/100mL) to the “summer” *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

Based on the median summer flow of 1.6 cfs, and the geometric mean of target value exceedances, the current loading to Peet Creek is greater than the TMDL. Under these conditions, an 87 percent reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

7.8.4 Red Rock River (MT41A001_020) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for the Red Rock River. There are no point sources in the Red Rock River watershed, therefore there are no WLAs calculated in this TMDL. Additionally, this section provides *E. coli* loading estimates for natural and human-caused source categories, and estimates reductions necessary to meet water quality targets.

Estimating TMDL and Allocations

The total existing load is used to estimate load reductions by comparing it to the allowable load (TMDL) and computing a required percent reduction to meet the TMDL. No load reductions are given for natural background allocations; therefore, all necessary load reductions apply to the nonpoint sources within the watershed.

The following is an example *E. coli* TMDL for the Red Rock River calculated with the "summer" *E. coli* standard (126 cfu/100mL) and median flow rate of 163.3 cfs. This median flow rate was derived from measured flow values at all sites on the Red Rock River during 2017 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The Red Rock River TMDL for *E. coli* is based on **Equation 7-1** and an example is presented below.

TMDL = ((126 cfu/100mL) (163.3 cfs) (2.44 x10^{7}))/1,000,000 = 501,972 Mcfu/day

Equation 7-3 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 163.3 cfs and a median background concentration of 19.6 cfu/100 mL (**Section 7.6.1.1**) this allocation is as follows:

LA_{NB} = ((19.6 cfu/100mL) (163.3 cfs) (2.44 X 10^{7}))/1,000,000 = 78,084 Mcfu/day

The portion of the total existing load attributed to human-caused sources is determined by subtracting the background load (78,084 Mcfu/day) from the TMDL (501,972 Mcfu/day). Using **Equation 7-4**, the human-caused *E. coli* load allocation (**COMP LA_H**) at a flow rate of 163.3 cfs can be calculated as follows:

COMP LA_H = (501,972 Mcfu/day) – (78,084 Mcfu/day) = 423,888 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 163.3 cfs is based on **Equation 7-5**. This equation uses the geometric mean of *E. coli* target exceedance values (296.7 cfu/100mL). The geometric mean of *E. coli* data collected during 2017 sampling efforts is considered a conservative estimate of *E. coli* concentrations in the Red Rock River and is appropriate for use in calculating the existing load.

Total Existing Load = ((296.7 cfu/100mL) (163.3 cfs) (2.44 X10^{7}))/1,000,000 = 1,181,874 Mcfu/day

Table 7-13 contains the results for the example *E. coli* TMDL expressed at a median summer flow rate of 163.3 cfs, along with the LAs to natural background and human caused sources for this same flow. It is important to note that the TMDL and the associated allocations calculated below only apply at the flow of 163.3 cfs. The Red Rock River *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 7-13. The Red Rock River *E. coli* TMDL and Load Allocation at a Median Flow of 163.3 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_{H}) (Mcfu/day)
163.3	501,972	78,084	423,888

Based on the existing conditions in the Red Rock River (data presented in **Table 7-6**), the percent load reductions required to meet the TMDL range from about 0 to 57 percent. This reduction is calculated by comparing the geometric mean of target exceedances (296.7 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

Based on the median summer flow of 163.3 cfs, and the geometric mean of target value exceedances, the current loading to the Red Rock River is greater than the TMDL. Under these conditions, a 62 percent reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

7.9 Seasonality, Critical Conditions and Margin of Safety

TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), wasteload allocations (WLAs), and load allocations (LAs). TMDL development must also incorporate a margin of safety (MOS) to account for uncertainties between pollutant sources and the quality of the receiving waterbody, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and MOS in the Red Rock TMDL Planning Area *E. coli* TMDL development process.

7.9.1 Seasonality and Critical Conditions

Addressing seasonal variations is an important and required component of TMDL development and throughout this plan, seasonality is an integral consideration. Water quality is recognized to have seasonal cycles. Specific examples of how seasonality has been addressed within this document include:

- Different water quality targets and subsequent allocations are applicable for two separate periods: the summer period (April 1 through October 31) where water temperatures are more conducive to bacterial colony growth, and the winter period (November 1 through March 31) where water temperatures suppress bacterial colony growth.
- *E. coli* data used to determine compliance with targets and to establish allowable loads were collected during the summer period to coincide with applicable *E. coli* targets and the time of highest recreational use. Data were collected for the summer period because *E. coli* targets are more restrictive during this period and therefore by meeting the summer period *E. coli* targets, it is assumed that the winter period *E. coli* targets will also be met.
- Flow values used in calculating the *E. coli* TMDLs and allocations in **Section 7.8** were collected within the summer period during nutrient sampling efforts and are considered representative of conditions during which the summer period *E. coli* targets apply.

TMDLs must take into account critical conditions for steam flow, loading, and water quality parameters as part of analysis of loading capacity (40 C.F.R. §130.7(c)(1)). In developing a TMDL, the critical condition can be thought of as the "worst case" scenario of environmental conditions in the waterbody, a condition where the pollutant loading is greatest, but the waterbody continues to meet water quality standards. Critical conditions can be thought of as the combination of environmental factors (e.g., stream flow, air temperature, etc.) that result in the attainment of standards with a low frequency of occurrence.

During wet weather periods, *E. coli* concentrations in surface waters tend to be higher than during dry periods, and often exceed the numeric targets. Therefore, wet weather conditions can be considered a critical condition for bacteria levels. However, during the summer, low-flow period there is much more exposure to pathogenic indicator bacteria through recreation. Therefore, summer recreation periods can also be considered a critical period. Since both wet and dry periods are critical conditions, TMDL targets are constant across these conditions and only vary according to the seasonally-dependent standards displayed in **Table 7-2**.

7.9.2 Margin of Safety

A margin of safety (MOS) is a required component of TMDL development. The MOS accounts for the uncertainty about the pollutant loads and the quality of the receiving water and is intended to protect beneficial uses in the face of this uncertainty. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (EPA 2001). This plan addresses MOS implicitly in a variety of ways:

- The geometric mean *E. coli* value was used to calculate TMDLs and load allocations. Using a geometric mean provides a margin of safety by ensuring that allowable daily load allocations do not result in the exceedance of water quality targets.
- The median value of natural background concentrations was used to establish a natural background concentration for load allocation purposes. This is a conservative approach and provides an additional MOS for human-caused *E. coli* loads during most conditions. This is because the application of a higher natural background load allocation equates to a higher percent load reduction from human-caused sources needed to meet the TMDL.
- TMDLs and allocations were presented in this document using the geometric mean targets, which require a lower *E. coli* concentration to meet the target (126 cfu/100mL) than the 10% exceedance target of 252 cfu/100mL. It is assumed that meeting the geometric mean target under most circumstances equates to meeting the 10% exceedance target.
- Bacterial decay rates were not factored in while developing the TMDL, therefore adding an implicit margin of safety to the TMDL.
- Seasonality (discussed above) and variability in *E. coli* loading is considered in target development, monitoring design, and source assessment.
- An adaptive management approach (discussed in **Section 7.10**) is recommended to evaluate target attainment and allow for refinement of load allocations, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development over time.

7.10 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, source assessments, loading estimates, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. However, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. The process of adaptive management is predicated on the premise that TMDL targets, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood. Uncertainty is inherent in assessing *E. coli* sources and needed reductions. The main sources of uncertainty are summarized below.

7.10.1 Water Quality Conditions

E. coli water quality data in the Red Rock watershed was sufficient to make impairment determinations. However, there were instances where data used for source assessment purposes could be strengthened (Example: Peet Creek). Additional water quality monitoring may be necessary to help better identify sources and their impacts on water quality. Future monitoring efforts should help reduce the uncertainty regarding data representativeness, improve the understanding of the effectiveness of Best Management Practice (BMP) implementation, and increase the understanding of the load reductions needed to meet the TMDL.

It was also assumed that background concentrations (**Section 7.6.1.1**) are less than the target values, and based on sample data, this appears to be true. However, it is possible that target values may be naturally exceeded during certain times or at certain locations in the watershed. Future monitoring should help reduce uncertainty regarding background *E. coli* concentrations.

7.10.2 Source Assessment

Source characterization and assessment to determine the major *E. coli* sources was conducted by using monitoring data collected in 2017, which represents the most recent data available for determining existing conditions. Source characterization and assessment also utilized aerial photos, Geographic Information System (GIS) analysis, field work, and literature reviews. That being said, uncertainties in source assessment can occur from misinterpretation of aerial photos, and by referencing data that does not reflect the current condition of the waterbody, using outdated GIS data, field data that may not be representative of the overall condition of the waterbody, and literature that was developed for areas outside of the Red Rock watershed.

Sources of pollutants or the level of contribution from those sources may have changed since data collection in 2017. Therefore, there is some uncertainty that the data used is reflective of the current conditions in the Red Rock watershed. BMP implementation efforts may have taken place since the collection of this data. In the absence of more recent data, an assumption was made that the data used are representative of current conditions. Data collected accurately characterize individual site at the time of sample collection, but there is some uncertainty as to whether that site is representative of the overall waterbody condition. To address this, monitoring site locations and sample collection times were selected to generate the most representative samples.

When using aerial photography and GIS data, uncertainty may occur through the misinterpretation of aerial photos and using GIS data that may be inaccurate or outdated. To reduce uncertainty, multiple years of aerial photos were analyzed and only GIS data containing complete metadata and generated from reliable sources were used for source assessment.

7.10.3 Loading Estimates

Loading estimates are based on currently available data and are only representative of the pollutant load at the time of data analysis. It is important to recognize that pollutant loads are not static and can therefore be different than the loads reported in this document. This brings some uncertainty into load reductions, as achieving the load reductions stated in this document may or may not result in meeting in-stream water quality targets. To determine the existing *E. coli* loads, the geometric mean of target exceedance values was used. This reflects an existing load only when exceedances are occurring. Future additional water quality monitoring may be able to identify when the TMDL is being met and when or where the TMDL is met or exceeded. This information can help guide BMP implementation efforts by identifying the most significant *E. coli* sources. Adaptive management can address uncertainties related to loading estimates through the re-evaluation of water quality conditions as BMPs are installed, land uses change, or pollutant sources and their contribution levels change.

8.0 Public Participation and Public Comments

Stakeholder and public involvement is a component of total maximum daily load (TMDL) planning required by Montana state law which directs the Department of Environmental Quality (DEQ) to consult with a watershed advisory group and local conservation districts during the TMDL development process. Technical advisors, stakeholders, state and federal agencies, interest groups, and the public were solicited to participate in differing capacities throughout the TMDL development process for this project in the Red Rock TMDL Planning Area.

8.1 Participants and Their Roles

Throughout completion of the sediment and temperature TMDLs in this document, DEQ worked to keep stakeholders apprised of project status and solicited input from a TMDL watershed advisory group. A description of the participants and their roles in the development of the TMDLs in this document is contained below.

Montana Department of Environmental Quality
The Montana Water Quality Act (75-5-703, Montana Code Annotated (MCA)) directs DEQ to develop all necessary TMDLs. DEQ provided resources toward completion of these TMDLs in terms of staff, funding, internal planning, data collection, technical assessments, document development, and stakeholder communication and coordination. DEQ works with other state and federal agencies to gather data and conduct technical assessments.

United States Environmental Protection Agency
EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act. Section 303(d) of the Clean Water Act directs states to develop TMDLs (see **Section 1.1**), and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program and is responsible for reviewing and evaluating TMDLs to see that they meet all federal requirements.

Local Conservation Districts
DEQ consulted with the Beaverhead Conservation District and associated Beaverhead Watershed Committee during development of the TMDLs in this document, which included opportunities to provide comment during the various stages of TMDL development and an opportunity for participation in the watershed advisory group described below.

Red Rock TMDL Planning Area Watershed Advisory Group
The Red Rock TMDL Planning Area TMDL Watershed Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Red Rock River watershed, and representatives of applicable interest groups. All members were solicited to participate and work with DEQ in an advisory capacity per Montana state law. DEQ requested participation from the interest groups defined in 75-5-704 MCA including livestock-oriented and farming-oriented agriculture representatives; conservation groups; watershed groups; state and federal land management agencies; and representatives of fishing, recreation, and tourism interests.

Advisory group involvement was voluntary, and the level of involvement was at the discretion of the individual members. Members had the opportunity to attend meetings organized by DEQ for soliciting feedback on project planning. Draft documents, project status updates, and meeting agendas and presentations were made available both via e-mail and through DEQ's wiki for water quality planning projects (http://mtwaterqualityprojects.pbworks.com/). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including a two-week review and comment period for a draft version of the metals, sediment, and *E. coli* TMDLs prior to the public comment period.

8.2 Response to Public Comments

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

The public comment period for this document was initiated on July 28, 2021 and closed on August 18, 2021. A virtual public informational meeting was held August 10, 2021 at 5:00 p.m. via Zoom. At the meeting, DEQ provided an overview of the TMDL document, answered questions, and solicited input and comment on the document. The public comment period and public meeting were announced in a July 28, 2021 press release from DEQ which was published on DEQ's website and was distributed to multiple media outlets across Montana. A public notice advertising the public comment period and public meeting was published in the Dillon Tribune, the Montana Standard and Dillonite Daily. Additionally, the announcement was distributed to the project's TMDL watershed advisory group, the Statewide TMDL Advisory Group, and other additional contacts via e-mail.

Formal comments were received and summarized below, along with DEQ's response to this comment. DEQ evaluates comments and related information to ensure no critical information was excluded from the document.
Paste Comments and Responses here.

PART 3
WATER QUALITY IMPROVEMENT RECOMMENDATIONS

Glossary of Water Quality Terminology

Term	Definition or Description
Anthropogenic	Human-caused, or human-influenced. Water quality pollution originating from human activity.
Aquatic Life	Fish and aquatic bugs (macroinvertebrates)
Beneficial Use(s)	Beneficial uses, or designated uses, are simply the ways that we use water, and are the uses of water that we protect with water quality standards. They may include support of drinking water, recreation, fish and aquatic life, agricultural uses, and industrial uses. All surface waters in Montana are classified with, or assigned, a group of beneficial uses they must support, based on the potential of the waterbody to support those uses.
Best Management Practice (BMP)	Appropriate management practices designed and implemented for a specific purpose and include management methods as well as actual physical structures. In the case of water quality, BMPs are practices designed to protect or improve the physical, chemical, or biological characteristics of surface water and groundwater resources.
Buffer	Also referred to as a "riparian buffer" or "buffer strip." In the context of this document, a buffer is a strip of vegetation that filters pollutants from entering the water. It can also be defined as the distance between a waterbody and the adjacent uplands, which includes the riparian area/zone.
Floodplain	Floodplains are the areas adjacent to streams, and sometimes to lakes and reservoirs, which are subject to periodic flooding. Often, they are defined by whether they would be inundated during a flood with a given probability of occurrence, such as a 100-year flood, which has a 1% chance of happening in any given year.
Habitat, Instream or Aquatic	Fish habitat within a waterbody (stream channel, lake, or reservoir).
Habitat, Streamside or Riparian	Wildlife habitat adjacent to a waterbody (stream channel, lake, or reservoir) and within the riparian zone.
Hummocking	Formation of grass mounds in a knob-like shape due to livestock access to soft ground in the riparian area or in a wetland. The mounds of grass or wetland vegetation are typically surrounded by bare soil.
Impaired	An unhealthy water or waterbody for which water quality data shows that the waterbody is failing to achieve compliance with applicable water quality standards and is not fully supporting one or more of its designated beneficial uses. DEQ maintains a list of impaired waters.
Nonpoint Source Pollution	Polluted runoff that comes from a variety of land-use activities. Common nonpoint source pollutants include sediment (dirt), nutrients (nitrogen and phosphorus), water temperature changes, metals, pesticides, pathogens, and salinity (salt). Nonpoint source pollution is the largest contributor of water quality problems in Montana, when compared to point sources of pollution in the state.

Term	Definition or Description
Non-Pollutant	Non-pollutants are human-induced alterations in the health of a water and have a harmful effect on any living thing that drinks or uses or lives in the water. For example, a human-induced alteration is the removal of streamside vegetation that results in the alteration of aquatic and wildlife habitat in and along the stream, which may subsequently increase stream temperatures and negatively affect the shape of the stream channel.
Point Source Pollution	Water pollution that requires a permit, usually from a single, traceable location. Note that agricultural stormwater discharges and return flows from irrigated agriculture are considered nonpoint sources and do not require a permit.
Pollutant	A pollutant is any substance that is introduced into a water, naturally or by human activities, that adversely affects the water quality. Common water pollutants include nutrients (nitrogen and phosphorus), sediment (dirt), pathogens, temperature, and metals (e.g., aluminum, arsenic, cadmium, copper, iron, lead, nickel, mercury, zinc).
Residual Pool Depth	A pool is defined as a depression in the streambed that is concave in profile. The “residual” pool is identified by visualizing the shape of the pool and evaluating where standing water would remain if all the flowing water were drained from the stream. The residual pool is defined as the portion of the pool that is deeper than the riffle crest forming the downstream end of the pool, and is calculated by subtracting the maximum depth at the riffle crest from the maximum pool depth.
Riparian	Riparian areas are typically vegetated zones along a waterbody and are usually transitional areas between the waterbody and upland habitat. Riparian areas have one or both of the following characteristics: • Distinctly different vegetative species than adjacent areas • Species similar to adjacent areas but exhibiting more vigorous or robust growth forms
Stakeholder	A person or entity with a direct interest in, or concern with, this project, usually local to the Red Rock River watershed.
Stormwater	Snowmelt and rainfall that does not infiltrate into the ground and runs off the land; also referred to as runoff or overland flow.
Total Maximum Daily Load (TMDL)	The maximum amount of a pollutant that a stream or waterbody can receive and still meet water quality standards. Think of it as a pollution diet or pollution budget. **Section 4.0** in Part 1 of this document further defines a TMDL and the TMDL development process.
Upland	Land outside of the riparian zone, usually higher than, or elevated above, the riparian.

Term	**Definition or Description**
Waterbody	A water; a stream, creek, river, lake, or reservoir. Also referred to as an assessment unit for water quality impairment assessments/determinations, which can be the full length, or partial segment of the length or area, of a waterbody.
Watershed	A geographic area drained by a river or stream; also referred to as a drainage basin, which is any area of land where precipitation collects and drains into a common outlet, such as into a river, bay, or other body of water.
Wetland	Wetlands are transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water. Wetlands are typically defined as those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils.
Width/Depth Ratio	A number calculated by dividing the width of a stream channel by the depth of the stream channel, which is measured along what is called a cross-section or transect.

9.0 NON-POLLUTANT IMPAIRMENTS

This section discusses non-pollutant impairments in the Red Rock TMDL Planning Area (TPA). This section is included for informational purposes to help with development of overall watershed management goals and objectives and prioritization of restoration projects in the Red Rock TPA.

9.1 NON-POLLUTANT IMPAIRMENTS

A waterbody may be on Montana's list of impaired waters, but does not require a TMDL if it is not impaired for a pollutant, such as sediment, temperature, a nutrient, or metal. Non-pollutant causes of impairment such as "alteration in stream-side or littoral vegetative covers" do not require a TMDL. Non-pollutant causes of impairment are often associated with a pollutant cause of impairment; however, in some cases, non-pollutant impairments are causing a deleterious effect on beneficial uses without a clearly defined quantitative measurement or direct linkage to a pollutant.

The Montana Department of Environmental Quality (DEQ) recognizes that non-pollutant impairments can limit a waterbody's ability to fully support all beneficial uses and these impairment causes are important to consider when improving water quality conditions in both individual streams, and the Red Rock TMDL Planning Area as a whole. **Table 9-1** shows the non-pollutant impairments for waterbodies in the Red Rock TPA on Montana's 2020 list of impaired waters. They are summarized in this section to increase awareness of the non-pollutant impairment definitions and typical sources, and should be considered during planning of watershed-scale restoration efforts.

It is important to note that water quality issues are not limited to waterbodies that have identified pollutant and non-pollutant impairments. In some cases, streams have not yet been reviewed through DEQ's water quality assessment process and do not appear on Montana's list of impaired waters even though they may not be fully supporting all their beneficial uses.

Table 9.1 Waterbody segments with Non-Pollutant Impairments in the 2020 Water Quality Integrated Report.

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Addressed by a TMDL in this Document
Bean Creek, Headwaters to mouth (Red Rock River)	MT41A004_140	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
		Flow regime modification	YES (Sediment TMDL)
Big Sheep Creek, Headwaters to mouth (Red Rock River)	MT41A003_150	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
		Flow regime modification	YES (Sediment TMDL)

Table 9.1 Waterbody segments with Non-Pollutant Impairments in the 2020 Water Quality Integrated Report.

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Addressed by a TMDL in this Document
Cabin Creek, headwaters to mouth (Big Sheep Creek)	MT41A003_030	Alteration in streamside or littoral vegetative covers	NO (No Sediment TMDL)
Clark Canyon Reservoir	MT41A002_010	Flow regime modification	No
Corral Creek, Headwaters to mouth (Red Rock Creek)	MT41A004_040	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
Fish Creek, Headwaters to mouth (Metzel Creek)	MT41A004_030	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
Hell Roaring Creek, headwaters to mouth (Red Rock Creek)	MT41A004_060	Alternation in streamside or littoral vegetative covers	NO (No Sediment TMDL)
Horse Prairie Creek, Headwaters to mouth (Clark Canyon Reservoir)	MT41A003_090	Flow regime modification	YES (Sediment TMDL)
Jones Creek, Headwaters to mouth (Winslow Creek)	MT41A004_130	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
		Flow regime modification	YES (Sediment TMDL)
Little Sheep Creek, Headwaters to mouth (Red Rock River)	MT41A003_160	Habitat Alterations	NO (No Sediment TMDL)
		Alteration in streamside or littoral vegetative covers	NO (No Sediment TMDL)
Long Creek, Headwaters to mouth (Red Rock River)	MT41A004_070	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
		Flow regime modification	YES (Sediment TMDL)

Table 9.1 Waterbody segments with Non-Pollutant Impairments in the 2020 Water Quality Integrated Report.

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Addressed by a TMDL in this Document
Lower Red Rock Lake	MT41A005_020	Flow regime modification	NO
Medicine Lodge Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_010	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
		Flow regime modification	YES (Sediment TMDL)
Muddy Creek, Confluence Sourdough and Wilson Creek to mouth (Big Sheep Creek)	MT41A003_020	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
O'Dell Creek, Headwaters to mouth (Lower Red Rock Lake)	MT41A004_080	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
Peet Creek, Headwaters to mouth (Red Rock River)	MT41A004_090	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
		Flow regime modification	YES (Sediment TMDL)
Price Creek, Headwaters to mouth (Red Rock River)	MT41A004_010	Flow regime modification	YES (Sediment TMDL)
Red Rock River (Lima Dam to Clark Canyon Reservoir)	MT41A001_010	Habitat alterations	NO
		Flow regime modification	NO
		Alteration in streamside or littoral vegetative covers	NO
Red Rock River (Lower Red Rock Lake to Lima Dam)	MT41A001_020	Alteration in streamside or littoral vegetative covers	NO

Table 9.1 Waterbody segments with Non-Pollutant Impairments in the 2020 Water Quality Integrated Report.

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause	Addressed by a TMDL in this Document
Sage Creek, Headwaters to mouth (Red Rock River)	MT41A003_140	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
Selway Creek, Headwaters to mouth (Bloody Dick Creek)	MT41A003_110	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
Tom Creek, Headwaters to mouth (Upper Red Rock Lake)	MT41A004_100	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
		Flow regime modification	YES (Sediment TMDL)
Trail Creek, Headwaters to mouth (Horse Prairie Creek)	MT41A003_080	Alteration in streamside or littoral vegetative covers	YES (Sediment TMDL)
Upper Red Rock Lake	MT41A005_030	Flow regime modification	NO

9.2 Non-Pollutant Impairment Cause Descriptions

Non-pollutants are often used as a probable cause of impairment when available data at the time of a water quality assessment do not provide a direct, quantifiable linkage to a specific pollutant. In some cases, the pollutant and non-pollutant categories are linked and appear together in the list of impairment causes for a waterbody; however, a non-pollutant impairment cause may appear independently of a pollutant cause. The following discussion provides some rationale for the application of the identified non-pollutant causes to a waterbody, and thereby provides additional insight into possible factors in need of additional investigation and potential restoration.

Alteration in Stream-side or Littoral Vegetative Covers

"Alteration in stream-side or littoral vegetative covers" refers to circumstances where practices along the stream channel have altered or removed riparian vegetation and subsequently affected channel geomorphology and/or stream temperature. Such instances may be riparian vegetation removal for a road or utility corridor, or overgrazing by livestock along the stream. As a result of altering the streamside vegetation, destabilized banks from loss of vegetative root mass could lead to over-widened stream channel conditions, elevated sediment and/or nutrient loads, and the resultant lack of canopy cover can lead to increased water temperatures.

Physical Substrate Habitat Alterations and Other Anthropogenic Substrate Alterations

"Physical substrate habitat alterations" generally describe cases where the stream channel has been physically altered or manipulated, such as straightening of the channel or human-influenced channel downcutting, resulting in a reduction of morphological complexity and loss of habitat (riffles and pools) for fish and aquatic life. For example, this may occur when a stream channel has been straightened to accommodate roads, agricultural fields, or placer mine operations. "Other anthropogenic substrate alterations" (human-caused modifications) may include channel alterations due to new infrastructure such as highways, roads, and bridges; and construction of dams or impoundments.

Flow Regime Modification

Flow modification refers to a change in the flow characteristics of a waterbody relative to natural conditions. An impairment listing caused by flow regime modification could be associated with changes in runoff and streamflow due to activities such as urban development, road construction, and timber harvest. Changes in runoff are commonly linked to elevated peak flows, which can also cause excess sedimentation by increasing streambank erosion and channel scour. Road crossings, particularly where culverts are undersized or inadequately maintained, can also alter flows by causing water to back-up upstream of the culvert.

Streams can also be listed as impaired for flow regime modification when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses designated for that system. This could result in dry channels or extreme low flow conditions unsupportive of fish and aquatic life. Low flow conditions absorb thermal radiation more readily and increase stream temperatures, which in turn creates dissolved oxygen conditions too low to support some species of fish.

It should be noted that while Montana law requires monitoring and assessment to identify impaired waterbodies (75-5-702, Montana Code Annotated (MCA)) and to subsequently develop TMDLs for these waterbodies (75-5-703, MCA), the law also states that these requirements may not be construed to divest, impair, or diminish any legally-recognized water right (75-5-705, MCA). The identification of flow regime modification as a probable cause of impairment, related to probable sources of agriculture and irrigated crop production, should not be construed to divest, impair, or diminish a water right. Instead, it should be considered an opportunity to characterize the impacts of flow alterations, and pursue solutions that can result in improved streamflows during critical periods, while at the same time ensuring no harm to water rights. It is up to local users, agencies, and entities to voluntarily improve instream flows through water and land management, which may include irrigation efficiency improvements and/or instream water leases that result in reduced amounts of water diverted from streams.

9.3 Monitoring and Best Management Practices for Non-Pollutant Affected Streams

Table 9-1 above indicates whether the non-pollutant impairment causes are addressed by a sediment TMDL in this document. It is likely that meeting the sediment TMDL targets (**Sections 6.4**) will also equate to addressing the habitat and flow regime modification impairment conditions in the streams listed in the table above. For streams with habitat alteration or flow regime modification impairments that do not have a sediment TMDL, meeting the sediment targets applied to streams of similar size will likely equate to addressing the habitat impairment condition for each stream.

Streams with non-pollutant impairments should be considered when developing watershed management goals and plans and when prioritizing restoration projects. Additional sediment and/or temperature information should be collected where data is insufficient for pollutant impairment determinations and the linkage between probable cause, non-pollutant listing, and effects to the beneficial uses is not well defined. The monitoring and restoration strategies that follow in **Sections 10.0** and **11.0** are presented to address both pollutant and non-pollutant issues for streams in the Red Rock TMDL Planning Area with TMDLs in this document, and they are equally applicable to streams listed for the above non-pollutant impairment causes. The strategies also apply to the entire Red Rock River watershed.

10.0 Water Quality Improvement Plan

There are many approaches to implementing a total maximum daily load (TMDL) and improving water quality, often with the majority of approaches linked to voluntary measures by landowners (including homeowners), particularly those located along an impaired stream or a tributary to an impaired stream. Landowners may independently choose to implement conservation measures (i.e., best management practices (BMPs)) with or without technical assistance offered by a variety of agency and other professionals (see **Section 10.2**), and with or without financial assistance offered via many available water quality improvement programs (see **Section 10.7**).

Equally important toward improving water quality is the continuation and maintenance of those land management activities that may already be incorporating conservation practices or other approaches toward limiting sediment loading and increases in water temperature, as well as limiting instream and streamside habitat alterations. **Section 10** discusses applicable BMPs.

While certain land uses and human activities are identified as sources and causes of water quality impairment, this document does not advocate for the removal of land and water uses to achieve the water quality restoration objectives discussed in this document. Changes to current and future land management practices that will improve and maintain water quality are instead the intended goal.

10.1 Purpose of this Water Quality Improvement Plan and Support It Provides for Watershed Restoration Plan Development

This section provides an overall strategy and specific on-the-ground measures designed to restore water quality beneficial uses and attain water quality standards in the Red Rock TMDL Planning Area. This strategy includes general measures for reducing loading from identified nonpoint sources of pollutants (i.e., pollution that originates from a diffuse area, such as an agricultural field or an unpaved road adjacent to a stream).

To help promote and achieve water quality improvements linked to a TMDL document, the Montana Department of Environmental Quality (DEQ) endorses and provides technical support toward a collaborative watershed approach that involves development of what is called a “watershed restoration plan” (WRP). While this document section does not serve as a watershed restoration plan, it should assist local stakeholders in developing a WRP, which is a locally-developed plan providing more specific restoration goals for the Red Rock TMDL Planning Area, and the WRP may encompass broader goals than the water quality improvement information outlined in this document. The intent of a WRP for the Red Rock is to serve as a locally organized “road map” for watershed activities, prioritizing types of projects, sequences of projects, and funding sources towards achieving local watershed goals. Within the WRP, local stakeholders identify and prioritize streams, tasks, resources, and schedules for applying best management practices. A WRP is intended to be a living document that can be revised based on new information related to restoration effectiveness, monitoring results, and stakeholder priorities.

The U.S. Environmental Protection Agency’s nine minimum elements for a WRP are summarized here:

1. Identification of the causes and sources of pollutants
2. Estimated load reductions expected, based on implemented management measures
3. Description of needed nonpoint source management measures
4. Estimate of the amounts of technical and financial assistance needed

5. An information/education component
6. Schedule for implementing the nonpoint source management measures
7. Description of interim, measurable milestones
8. Set of criteria that can be used to determine whether loading reductions are being achieved over time
9. A monitoring component to evaluate effectiveness of the implementation efforts over time

10.2 Role of DEQ, Other Agencies, and Stakeholders

DEQ does not implement TMDL pollutant-reduction projects for nonpoint source activities, but may provide technical and financial assistance for stakeholders interested in improving their water quality. Successful implementation of TMDL pollutant-reduction projects requires collaboration among private landowners, land management agencies, and other stakeholders. DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help support water quality improvement and pollution prevention projects, and help identify other sources of funding.

Because most nonpoint source reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers work collaboratively with local and state agencies to achieve water quality restoration goals and to meet TMDL targets and load reductions. In addition to DEQ, specific stakeholders and agencies that will likely be vital to restoration efforts for streams discussed in this document include:

- Beaverhead Conservation District
- Madison Conservation District
- Beaverhead Watershed Committee
- Centennial Valley Association
- Nature Conservancy
- U.S. Environmental Protection Agency (EPA)
- U.S. Forest Service (USFS)
- Bureau of Land Management
- Natural Resources and Conservation Service (NRCS)
- U.S. Fish & Wildlife Service (USFWS)
- Montana Department of Natural Resources and Conservation (DNRC)
- Montana Fish, Wildlife and Parks (FWP)
- Montana Department of Transportation
- Montana Bureau of Mines and Geology
- Trout Unlimited
- Local City and County Representatives

Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include:

- Montana Water Center (at Montana State University)
- University of Montana Watershed Health Clinic
- Montana Aquatic Resources Services
- Montana State University Extension Water Quality Program

10.3 Water Quality Restoration Objective

The water quality restoration objective for the Red Rock TMDL Planning Area is to reduce pollutant loads, as identified throughout this document, to meet the water quality standards and TMDL targets for full recovery of beneficial uses for all impaired streams. Meeting the TMDLs provided in this document will help achieve this objective for all identified pollutant-impaired streams. The TMDLs can be achieved through proper implementation of best management practices and using the appropriate technology to treat wastewater (both private and municipal). However, this section focuses on BMPs for nonpoint sources.

10.4 Restoration Approaches by Pollutant

TMDLs were completed for 10 segments for metals (with 14 pollutant-waterbody combinations), 18 segments for metals, and four waterbody segments for *E. coli*. Other streams in the planning area may be in need of restoration or pollutant reduction, but insufficient information about them precludes TMDL development at this time. The following sub-sections describe some generalized recommendations for implementing projects to achieve the TMDLs. Details specific to each stream, and therefore which of the following strategies may be most appropriate, are found within **Sections 5.0, 6.0, and 7.0**.

Many of the BMPs in relation to sediment reduction involve what is often referred to as soft, or passive, approaches. These include situations where impacts along a stream are often reduced due to changes in grazing management, or other activities to reduce erosion, and nature is allowed to 'run her course' over time via establishment of healthy riparian vegetation and other conditions that improve water quality and overall stream function. These are often the most practical and least expensive approaches, although full recovery can take years. In some situations, it can be advantageous to take a more aggressive or active approach which can be as simple as planting willows along the stream to help hold banks together, versus waiting for willows to naturally repopulate. In more extreme cases, particularly where channel form and function have been significantly altered and passive approaches could take decades, an active approach could involve reconfiguring a whole reach of a stream along with creation of stream meander patterns and planting of willows or other appropriate riparian vegetation.

10.4.1 Metals Restoration Approach

Metal mining is the principal human-caused source of excess metals loading in the project area. In some cases, more active restoration approaches may be needed, such as large-scale removal or containment of metals-contaminated sediment. In other cases, sources of metals may be related to more diffuse surface disturbance of sediment from previous small mining operations. Reducing surface disturbance in these areas by maintaining or restoring vegetation will either help maintain low metals concentrations or reduce metal concentrations. In addition, for some segments, metals concentrations may be exceeded during low flow water withdrawals. Maintaining adequate stream flow may be all that is needed for the reduction of water quality standards in some cases. Additional monitoring could be used to further describe sources of metals and identify potential solutions.

10.4.2 Sediment Restoration Approach

The goal of the sediment restoration strategy is to limit the availability, transport, and delivery of excess sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport. Monitoring data used to develop targets and determine impairments are described in **Section 6.0** and in **Appendix D**, Sediment and Habitat Data Collection Methods. Sediment restoration activities on impaired stream segments will help reduce the amount of fine sediment, reduce width/depth ratio, increase residual pool depths, increase pool frequency, increase riparian understory shrub cover, reduce impacts of human-caused sediment sources, and restore appropriate macroinvertebrate assemblages. These are indicators of successful restoration activities targeted toward sediment reduction and need to be considered together and within the context of stream potential in comparison to appropriate reference sites. For example, pool frequency tends to decline as stream size increases; therefore, indicators for these parameters will vary. General targets for these indicators are summarized in **Table 6-2**.

Streamside riparian and wetland vegetation restoration and long-term management are crucial to achieving the sediment TMDLs. Native streamside riparian and wetland vegetation provides root mass, which hold streambanks together. Suitable root mass density ultimately slows bank erosion. Riparian and wetland vegetation filter pollutants from upland runoff. Therefore, improving riparian and wetland vegetation will decrease streambank erosion by improving streambank stability and will also reduce pollutant delivery from upland sources. Suspended sediment is also deposited more effectively in healthy riparian zones and wetland areas during flooding because water velocities slow in these areas enough for excess sediment to settle out. Restoration recommendations involve the promotion of riparian and wetland recovery through improved grazing and land management (including the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas), application of timber harvest best management practices, floodplain and streambank stabilization, revegetation efforts, and instream channel and habitat restoration where necessary. Appropriate BMPs will differ by location and are recommended to be included and prioritized as part of a comprehensive watershed scale plan (e.g., a WRP).

In addition to restoring riparian buffers, upland practices such as using cover crops and implementing conservation tillage can reduce upland erosion. Grazing management plans may be developed to identify and minimize areas where upland erosion is contributing significant amounts of sediment.

In areas where stormwater is accelerating sediment loading to streams, the sediment restoration strategy will be achieved by BMPs that promote infiltration of runoff and lessen its volume and the timing of delivery to surface water. Although the watershed is currently dominated by open space, smart growth and low impact development are two closely related planning strategies that help reduce stormwater volume, slow its transport to surface waterbodies, and improve groundwater recharge.

Although unpaved roads may be a small source of sediment at the watershed scale, sediment derived from roads may cause significant localized impact in some stream reaches. Restoration approaches for unpaved roads near streams primarily include measures that divert water to ditches before it enters the stream. The diverted water should be routed through natural healthy vegetation, which will act as filter zones for the sediment laden runoff before it enters streams. In addition, routine maintenance of unpaved roads (particularly near stream crossings) and proper sizing and maintenance of culverts, regardless of road use status, are crucial components to limiting sediment production from roads.

Mining was not specifically discussed in the sediment source assessment, but waste materials can be a component of upland and in-channel sediment loading. The goal of the sediment restoration strategy is to limit the input of sediment to stream channels from abandoned mine sites and other mining-related sources. Goals and objectives for future restoration work include the following:

- Prevent waste rock and tailings materials/sediments from migrating into adjacent surface waters, to the extent practicable.

- Reduce or eliminate concentrated runoff and discharges that transport sediment to adjacent surface waters, to the extent practicable.
- Identify, prioritize, and select response and restoration actions of areas affected by historical mining, based on a comprehensive source assessment and risk analysis.

10.4.3 E. coli Restoration Approach

E. coli inputs to the waterbodies of the Red Rock watershed come from nonpoint sources. Human caused nonpoint sources of *E. coli* in the Red Rock watershed consist primarily of agriculture (pasture, rangeland, and manure applied on cropland). Naturally occurring sources and those other sources that are human caused (subsurface wastewater disposal, domestic pets, recreation etc.) can also contribute *E. coli* to waterways General recommendations for the management of grazing management and septic systems and other sources of human caused *E. coli* loading to Red Rock are outlined in **Section 7.6.2**.

10.4.4 Non-Pollutant Restoration Approach

Although TMDL development is not required for non-pollutant causes of impairment, they are frequently linked to pollutants, and addressing non-pollutant causes is an important component of TMDL implementation. Non-pollutant impairment causes within the Red Rock TMDL Planning Area include alteration in streamside or littoral vegetative covers, physical substrate habitat alterations, other anthropogenic substrate alterations, and flow regime modification, and are described in **Section 9.0**. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Although flow modifications have the most direct link with temperature, adequate flow is also critical for downstream sediment transport and improving the assimilative capacity of streams for sediment and nutrient inputs, and diluting *E. coli* loads. Therefore, if restoration goals within the Red Rock TMDL Planning Area are not also addressing non-pollutant impairments, additional non-pollutant related BMP implementation should be considered.

10.5 Restoration Approaches by Source

General management recommendations are outlined below for the major sources of human-caused pollutant loads in the Red Rock TMDL Planning Area: mining, agricultural sources, riparian and wetland vegetation removal, bank hardening, unpaved roads, and forestry and timber harvest. Restoration activities may also address other current pollution-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key pollutant sources. In these cases, BMPs are usually identified as a first effort and further monitoring and evaluation of activities and outcomes, as part of an adaptive management approach, will be used to determine if further restoration approaches are necessary to achieve water quality standards. Monitoring is an important part of the restoration process, and monitoring recommendations are outlined in **Section 10**.

10.5.1 Mining

The Red Rock River watershed and Montana more broadly, have a legacy of mining that continues today. Mining activities may have impacts that extend beyond increased metal concentrations in the water. Channel alteration, riparian degradation, and runoff and erosion associated with mining can lead to sediment, habitat, nutrient, and temperature impacts.

A number of state and federal regulatory programs have been developed over the years to address water quality problems stemming from historic mines, associated disturbances, and metal refining impacts. Some regulatory programs and approaches that may be applicable to the Red Rock TMDL Planning Area include:

- The Montana Abandoned Mine Lands (AML) Reclamation Program
- The Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA), which incorporates additional cleanup options under the Controlled Allocation of Liability Act (CALA) and the Voluntary Cleanup and Redevelopment Act (VCRA).

In some area of the Red Rock Watershed, past mining occurred but is not well documented or is diffuse across the landscape. Depending on the source, reduced erosion or increased baseflows may also significantly decrease metals concentrations by reducing sediment-bound metals to the stream and diluting metals concentrations.

10.5.1.1 The Surface Mining Control and Reclamation Act (SMCRA)
DEQ's Abandoned Mines Lands program is responsible for reclamation of abandoned mines in Montana. The AML reclamation program is funded through the Surface Mining Control and Reclamation Act of 1977 (SMCRA). SMCRA funding is collected as a per ton fee on coal production that is then distributed to states by the federal Office of Surface Mining Reclamation and Enforcement. Funding eligibility is based on land ownership and date of mining disturbance. Eligible abandoned coal mine sites have a priority for reclamation construction funding over eligible non-coal sites. Areas within federal Superfund sites and areas where there is a reclamation obligation under state or federal laws are not eligible for expenditures from the abandoned mine reclamation program. **Table 5-1** lists the priority abandoned mines within the Red Rock TMDL Planning Area. Additional information about each mine can be found on DEQ's AMLs website at: https://deq.mt.gov/Land/abandonedmines/priority

10.5.2 Agriculture Sources
Agriculture contributes sediment and *E. coli*, as well as sediment-bound metals, to waterways. Reduction of pollutants from upland agricultural sources can be accomplished by limiting the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil and runoff before it enters a waterbody. The main BMP recommendations for the Red Rock TMDL Planning Area are riparian buffers, wetland restoration, and vegetated filter strips, where appropriate. These methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept pollutants. Filter strips and buffers are even more effective for reducing upland agricultural-related sediment when used in conjunction with BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, and strip-cropping. Additional BMP information, design standards and effectiveness, and details on the suggested BMPs can be obtained from your local USDA Agricultural Service Center and in Montana's Nonpoint Source Management Plan (DEQ 2017).

An additional benefit of reducing sediment input to the stream is a decrease in sediment-bound nutrients. Reductions in sediment loads may help address some nutrient-related problems. Nutrient management plans can be developed that consider the amount, source, placement, form, and timing of plant nutrients and soil amendments. (United States Department of Agriculture, Natural Resources Conservation Service, 2019).

10.5.1.1 Grazing
Grazing has the potential to increase sediment loads. Metals can also be increased when soil is disturbed. Finally, *E. coli* and nutrients can increase when animals are concentrated in an area.

Development of riparian grazing management plans should be a goal for any landowner who operates livestock and does not currently have such plans. Private landowners may be assisted by state, county, federal, and local conservation groups to establish and implement appropriate grazing management plans. Note that riparian grazing management does not necessarily eliminate all grazing in riparian corridors. In some areas however, a more limited management strategy may be necessary for a period of time in order to accelerate reestablishment of a riparian community with the most desirable species composition and structure.

Every livestock grazing operation should have a grazing management plan. The NRCS Prescribed Grazing Conservation Practice Standard (Code 528) recommends the plan include the following elements (Natural Resource Conservation Service, 2010):

- A map of the operation showing fields, riparian and wetland areas, winter feeding areas, water sources, animal shelters, etc.
- The number and type of livestock
- Realistic estimates of forage needs and forage availability
- The size and productivity of each grazing unit (pasture/field/allotment)
- The duration and time of grazing
- Practices that will prevent overgrazing and allow for appropriate regrowth
- Practices that will protect riparian and wetland areas and associated water quality
- Procedures for monitoring forage use on an ongoing basis
- Development plan for off-site watering areas

Reducing grazing pressure in riparian and wetland areas and improving forage stand health are the two keys to preventing nonpoint source pollution from grazing. Grazing operations should use some or all of the following practices:

- Minimizing or preventing livestock grazing in riparian and wetland areas
- Providing off-stream watering facilities or using low-impact water gaps to prevent 'loafing' in wet areas
- Managing riparian pastures separately from upland pastures
- Installing salt licks, feeding stations, and shelter fences in areas that prevent 'loafing' in riparian areas and help distribute animals
- Replanting trodden down banks and riparian and wetland areas with native vegetation (this should always be coupled with a reduction in grazing pressure)
- Rotational grazing or intensive pasture management that takes season, frequency, and duration into consideration

The following resources provide guidance to help prevent pollution and maximize productivity from grazing operations:

- USDA, Natural Resources Conservation Service
  (find your local USDA Agricultural Service Center listed in your phone directory or at www.nrcs.usda.gov)
- Montana State University Extension Service (www.musextension.org)
- DEQ Watershed Protection Section, Nonpoint Source Program: Nonpoint Source Management Plan
  (https://deq.mt.gov/files/Water/WPB/Nonpoint/Publications/Annual%20Reports/2017NPSManagementPlanFinal.pdf)

The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian and wetland vegetation and minimize disturbance of the streambank and channel. The primary recommended BMPs for the Red Rock TMDL Planning Area are limiting livestock access to streams and stabilizing the stream at access points, providing off-site watering sources when and where appropriate, planting native stabilizing vegetation along streambanks, and establishing and maintaining riparian buffers. Although bank revegetation is a preferred BMP, in some instances bank stabilization may be necessary prior to planting vegetation.

10.5.1.2 Animal Feeding Operations

Animal feeding operations (AFOs) can pose a number of risks to water quality and public health if the animal manure and wastewater they generate contaminates nearby waters by contributing pathogens (*E.coli*) and nutrients. To minimize water quality and public health concerns from AFOs and land applications of animal waste, the USDA and EPA released the Unified National Strategy for AFOs in 1999 (USDA and U.S. EPA, 1999). This strategy encouraged owners of AFOs of any size of number of animals to voluntarily develop and implement site-specific Comprehensive Nutrient Management Plans (CNMPs). A CNMP is a written document detailing manure storage and handling systems, surface runoff control measures, mortality management, chemical handling, manure application rates, schedules to meet crop nutrient needs, land management practices, and other options for manure disposal.

An AFO that meets certain specified criteria is referred to as a Concentrated Animal Feeding Operation (CAFO), and may be required to obtain a Montana Pollution Discharge Elimination System (MPDES) permit as a point source. Montana's AFO compliance strategy is based on federal law and has voluntary, as well as regulatory components. If voluntary efforts can eliminate discharges to state waters, in some cases no direct regulation is necessary through a permit.

Operators of AFOs may take advantage of effective, low cost practices to reduce potential runoff to state waters. In addition to water quality benefits, these practices may help increase property values and operation productivity. Properly installed vegetative filter strips, in conjunction with other practices to reduce wasteloads and runoff volume, are very effective at trapping and detaining sediment and reducing transport of nutrients and pathogens to surface waters, with removal rates approaching 90 percent (USDA, NRCS 2005). Other options may include clean water diversions, roof gutters, berms, sediment traps, fencing, structures for temporary manure storage, shaping, and grading. Animal health and productivity also benefit when clean, alternative water sources are installed to prevent contamination of surface water.

Opportunities for financial and technical assistance (including comprehensive nutrient management plan development) in achieving voluntary AFO and CAFO compliance are available from conservation districts, NRCS field offices, or the Montana DEQ Watershed Protection Section. Further information may be obtained from the DEQ website at: http://deq.mt.gov/Water/permits.

Montana's nonpoint source pollution control strategies for addressing AFOs are summarized in the bullets below:

- Work with producers to prevent nonpoint source pollution from AFOs
- Promote use of State Revolving Fund for implementing AFO BMPs
- Collaborate with Montana State University (MSU) Extension Service, NRCS, and agriculture organizations in providing resources and training in whole farm planning to farmers, ranchers, conservation districts, watershed groups and other resource agencies

- Encourage inspectors to refer farmers and ranchers with potential nonpoint source discharges to DEQ watershed protection staff for assistance with locating funding sources and grant opportunities for BMPs that meet their needs (this is in addition to funds available through NRCS and the Farm Bill)
- Develop early intervention of education and outreach programs for small farms and ranches that have potential to discharge nonpoint source pollutants from animal management activities. This includes assistance from the DEQ Permitting Division, as well as external entities such as DNRC, local watershed groups, conservation districts, and MSU Extension.

10.5.1.3 Water Management and Irrigation

Flow modification and dewatering are commonly considered water quantity rather than water quality issues. However, changes to streamflow can have a profound effect on the ability of a stream to attenuate pollutants, including nutrients, *E. coli*, metals, and heat. Flow reduction may increase water temperature, allow pollutants to accumulate in stream channels, reduce available habitat for fish and other aquatic life, and may cause the channel to respond by changing in size, morphology, meander pattern, rate of migration, bed elevation, bed material composition, floodplain morphology, and streamside vegetation if flood flows are reduced (Andrews and Nankervis, 1995. Implementation strategies recognize the need for specific flow regimes, and may suggest flow-related improvements as a means to achieve full support of beneficial uses. However, local coordination and planning are especially important for flow management because Montana state law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana's water quality law (75-5-705, Montana Code Annotated).

Irrigation management is a critical component of attaining both coldwater fishery conservation and TMDL goals. Understanding irrigation water, groundwater, and surface water interactions is an important part of understanding how irrigation practices will affect streamflow during specific seasons. Improvements should focus on how to reduce the amount of stream water diverted during July and August, while still maintaining healthy crops or forage. It may also be desirable to investigate irrigation practices earlier in the year that promote groundwater return during July and August, and September.

Some irrigation practices in western Montana are based on flood irrigation methods. Occasionally head gates and ditches leak, which can decrease the amount of water in diversion flows. The following recommended activities could potentially result in notable water savings:

- Install upgraded head gates for more exact control of diversion flow and to minimize leakage when not in operation
- Develop more efficient means to supply water to livestock
- Determine necessary diversion flows and timeframes that would reduce over watering and improve forage quality and production
- Where appropriate, redesign or reconfigure irrigation systems
- Upgrade ditches (including possible lining, if appropriate) to increase ditch conveyance efficiency

Some water from spring and early summer flood irrigation likely returns as cool groundwater to the streams during the heat of the summer. These critical areas could be identified so that they can be preserved as flood irrigation areas. Other irrigated areas which do not contribute to summer groundwater returns to the river should be identified as areas where year-round irrigation efficiencies could be more beneficial than seasonal management practices. Winter baseflow should also be considered during these investigations.

10.5.1.4 Small Acreages

Throughout Montana, the number of small acreages is growing rapidly, and many small acreage owners own horses or cattle. Animals grazing on small acreages can lead to overgrazing and a shortage of grass cover, leaving the soil subject to erosion and runoff to surface waters. This erosion can contribute to increased sediment, sediment-bound metals, and nutrients in streams. General BMP recommendations for small acreage lots with animals include creating drylots, developing a rotational grazing system, and maintaining healthy riparian buffers. Small acreage owners should collaborate with MSU Extension Service, NRCS, conservation districts and agriculture organizations to develop management plans for their lots. Further information may be obtained from the Montana Nonpoint Source Management Plan (DEQ, 2017) or the MSU extension website at: http://animalrangeextension.montana.edu/range/small-acreages.html

10.5.1.5 Cropland

The primary strategy of the recommended cropland BMPs is to reduce sediment inputs. The major factors involved in decreasing sediment loads are reducing the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil before it enters waterbodies. The main BMP recommendations for the Red Rock TMDL Planning Area are vegetated filter strips and riparian buffers. Both methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept sediment. Effectiveness is typically about 70% for the filter strips (Arora 1996) and 50% for the buffers (Liu 2008). Filter strips and buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, strip cropping, and precision farming. Filter strips along streams should be composed of natural vegetative communities. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's Nonpoint Source Management Plan (DEQ 2017).

10.5.3 Riparian Areas, Wetlands, and Floodplains

Healthy and functioning riparian areas, wetlands, and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. The performance of these functions is dependent on the connectivity of riparian areas, wetlands, and floodplains to both the stream channel and upland areas. Human activities affecting the quality of these transitional habitats or their connectivity can alter their performance and greatly affect the transport of water, sediments, and contaminants (e.g., channelization, increased stream power, bank erosion, and habitat loss or degradation). Therefore, restoring, maintaining, and protecting riparian areas, wetlands, and floodplains within the watershed should be a priority of TMDL implementation in the Red Rock TMDL Planning Area.

Reduction of riparian and wetland vegetative cover by various land management activities is a principal cause of water quality and habitat degradation in watersheds throughout Montana. Although implementation and maintenance of passive BMPs that allow riparian and wetland vegetation to recover at natural rates is typically the most cost-effective approach, active restoration (e.g., plantings) may be necessary in some instances. The primary advantage of riparian and wetland plantings is that installation can be accomplished with minimum impact to the stream channel, existing vegetation, and private property. Weed management should also be a dynamic component of managing riparian areas.

Factors influencing the appropriate riparian and wetland restoration would include severity of degradation, site-potential for various species, and availability of local sources for native transplant materials. In general, riparian and wetland plantings would promote establishment of functioning stands of native species. The following recommended restoration measures would allow for stabilization of the soil, decrease sediment delivery to the stream, and increase absorption of nutrients from overland runoff:

- Harvesting and transplanting locally available sod mats with an existing dense root mass provides immediate promotion of bank stability and filtering nutrients and sediments
- Seeding with native graminoids (grasses and sedges) and forbs is a low-cost activity at locations where lower bank shear stresses would be unlikely to cause erosion
- Transplanting mature native shrubs, particularly willows (*Salix* sp.), provides rapid restoration of instream habitat and water quality through overhead cover and stream shading, as well as uptake of nutrients
- Willow sprigging expedites vegetative recovery, but involves harvest of dormant willow stakes from local sources

Note: Before transplanting *Salix* from one location to another it is important to determine the exact species so that we do not propagate the spread of non-native species. There are several non-native willow species that are similar to our native species and commonly present in Montana watersheds.

In addition to the benefits described above, it should be noted that in some cases, wetlands act as areas of shallow subsurface groundwater recharge and/or storage areas. The captured water via wetlands is then generally discharged to the stream later in the season and contributes to the maintenance of base flows and stream temperatures. Restoring ditched or drained wetlands can have a substantial effect on the quantity, temperature, and timing of water returning to a stream, as well as the pollutant filtering capacity that improved riparian and wetlands provide. Planning guides and informational publications related to wetlands and native plant species in Montana can be found on DEQ's Lakes, Streams, and Wetlands Webpage at https://deq.mt.gov/water/Programs/sw.

10.5.4 Bank Hardening/Riprap/Revetment and Floodplain Development

The use of riprap or other "hard" approaches is not recommended and is not consistent with water quality protection or implementation of this plan. Although it may be necessary in some instances, these "hard" approaches generally redirect channel energy and exacerbate bank erosion in other places. Bank armoring should be limited to areas with a demonstrated infrastructure threat. Where deemed necessary, apply bioengineered bank treatments to induce vegetative reinforcement of the upper bank, reduce stream scouring energy, and provide shading and cover habitat. Limit threats to infrastructure by reducing floodplain development through local land use planning initiatives.

As discussed above, passive riparian restoration is preferable, but in areas where stream channels are unnaturally unstable or streambanks are eroding excessively, additional active restoration approaches, such as channel design, woody debris and log vanes, bank sloping, seeding, and shrub planting may be desired to speed up the rate of recovery. Bank stabilization using natural channel design techniques can provide both bank stability and aquatic habitat potential. The primary recommended structures include natural or "natural-like" structures, such as large woody debris jams. These natural arrays can be constructed to emulate historical debris assemblages that were introduced to the channel by the adjacent cottonwood-dominated riparian community types. When used together, woody debris jams and straight log vanes can benefit the stream and fishery by improving bank stability, reducing bank erosion rates, adding protection to hillslopes and/or embankments, reducing near-bank shear stress, and enhancing aquatic habitat and lateral channel margin complexity.

Initiatives to protect riparian areas and floodplains will help protect property, increase channel stability, and buffer waterbodies from pollutants. However, in areas with a much smaller buffer or where historical vegetation removal and development have shifted the riparian vegetation community and limited its functionality, a tiered approach for restoring stream channels and adjacent riparian vegetation should be considered that prioritizes areas for restoration based on the existing condition and potential for improvement. In non-conifer dominated areas, the restoration goals should focus on restoring natural shrub cover on streambanks.

DEQ encourages the consideration of adopting local zoning or regulations that protect the functions of floodplains and riparian and wetland areas where future growth may occur. Requirements for protecting native vegetation riparian buffers can be an effective mechanism for maintaining or improving stream health. Local outreach activities to inform new residential property owners of the effects of riparian degradation may also prevent such activities from occurring, including providing information on: appropriate fertilizer application rates to lawns and gardens, regular septic system maintenance, preserving existing riparian vegetation, native vegetation for landscaping, maintaining a buffer to protect riparian and wetland areas, and practices to reduce the amount of stormwater originating from developed property. Montana's Nonpoint Source Management Plan contains suggested BMPs to address the effects of residential and urban development, and also contains an appendix of setback regulations that have been adopted by various cities and counties in Montana (DEQ 2017).

10.5.5 Beaver Populations

Historic heavy trapping of beavers throughout Montana has likely had an effect on sediment yields in watersheds in the western areas of the state. Before the removal of beavers, many streams had a series of catchments that moderated flow, with smaller un-incised multiple channels and frequent flooding. Now some of these streams have incised channels and are no longer connected to the floodplain. This results in more bank erosion because high flows scour streambanks to a greater extent instead of flowing onto the floodplain. Beaver ponds capture and store sediment and can result in large reductions in total suspended solids (TSS) concentrations below a beaver impoundment in comparison to TSS concentrations above the beaver impoundment (Bason, 2004). Management of streams should include consideration of beaver habitat in appropriate areas currently lacking the beaver complexes that can trap sediment, reduce peak flows, and increase summer low flows. Allowing for existing and even increased beaver habitat is considered consistent with the sediment TMDL water quality goals.

10.5.6 Unpaved Roads

Unpaved roads contribute sediment (as well as nutrients and other pollutants) to streams in the Red Rock TMDL Planning Area. The road sediment reductions in this document represent a gross estimation of the sediment load that will remain once appropriate road BMPs are applied and maintained at all locations, assuming no current BMPs are in place. In general, a road with associated BMPs assumes contributing road treads, cutslopes, and hillslopes were reduced to 200 feet from each side of a crossing and 500 feet from each parallel road segment. This distance is selected as an example to illustrate the potential for sediment reduction through BMP application and is not a formal goal at every crossing. For example, many roads may easily allow for a smaller contributing length, while others may not be able to meet a 200-foot goal. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana's Nonpoint Source Management Plan (DEQ 217). Examples include:

- Providing adequate ditch relief up-grade of stream crossings
- Constructing waterbars, where appropriate, and up-grade of stream crossings
- Instead of cross pipes, using rolling dips on downhill grades with an embankment on one side to direct flow to the ditch. When installing rolling dips, ensure proper fillslope stability and sediment filtration between the road and nearby streams.
- Insloping roads along steep banks with the use of cross slopes and cross culverts
- Outsloping low traffic roads on gently sloping terrain with the use of a cross slope
- Using ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches
- For maintenance, grade materials to the center of the road and avoid removing the toe of the cutslope
- Preventing disturbance to vulnerable slopes
- Using topography to filter sediments; flat, vegetated areas are more effective sediment filters
- Where possible, limit road access during wet periods when drainage features could be damaged
- Limit new road stream crossings and the length of near-stream parallel segments to the extent practicable

10.5.7 Culverts and Fish Passage

Undersized and improperly installed and maintained culverts can be a substantial source of sediment to streams, and a barrier to fish and other aquatic organisms. There are many factors associated with culvert failure and it is difficult to estimate the true at-risk load. The allocation strategy for culverts is that, regardless of road use status, there should be no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. It is recommended that culverts be assessed so that a priority list may be developed for culvert replacement. As culverts fail, they should be replaced by culverts that pass a 100 year flood on fish-bearing streams and at least 25 year events on non-fish bearing streams. Some road crossings may not pose a feasible situation for upgrades to these sizes because of roadbed configuration; in those circumstances, the largest size culvert feasible should be used. If funding is available, culverts should be prioritized and replaced prior to failure.

Another consideration for culvert upgrades should be fish and aquatic organism passage. Each culvert that is deemed a fish barrier should be assessed individually to determine if it functions as an invasive species and/or native species barrier. These two functions should be weighed against each other to determine if each culvert acting as a fish passage barrier should be mitigated. Montana Fish, Wildlife & Parks can aid in determining if a fish passage barrier should be mitigated, and, if so, can aid in culvert design.

10.5.8 Traction Sand

Severe winter weather and mountainous roads in the Red Rock TMDL Planning Area may require the continued use of relatively large quantities of traction sand. Nevertheless, closer evaluation of and adjustments to existing practices should be done to reduce traction sand loading to streams to the extent practicable. The necessary BMPs may vary throughout the watershed and particularly between state and private roads but may include the following:

- Use a snow blower to directionally place snow and traction sand on cut/hillslopes away from sensitive environments

- Increase the use of chemical deicers and decrease the use of road sand, as long as doing so does not create a safety hazard or cause undue degradation to vegetation and water quality
- Improve maintenance records to better estimate the use of road sand and chemicals, as well as to estimate the amount of sand recovered in sensitive areas
- Continue to fund Montana Department of Transportation research projects that will identify the best designs and procedures for minimizing road sand impacts to adjacent bodies of water and incorporate those findings into additional BMPs
- Street sweeping and sand reclamation
- Identify areas where the buffer could be improved, or structural control measures may be needed
- Improved maintenance of existing BMPs
- Increase availability of traction sand BMP training to both permanent and seasonal MDT employees, as well as private contractors

10.5.9 Forestry and Timber Harvest

Currently, most timber harvests in the Red Rock are salvage or clearcut logging of recently burned areas. Timber harvesting will likely continue in the future within federal lands, and on private land. Therefore, future timber harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (Montana State University Extension Service, 2001) and the Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307, Montana Code Annotated). The Montana Forestry BMPs cover timber harvesting, site preparation, and road building including culvert design, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e., within 50 feet of a waterbody), the riparian protection principles behind the law should be applied to numerous land management activities (e.g., timber harvest for personal use, agriculture, development). Prior to harvesting on private land, landowners or operators are required to notify the Montana Department of Natural Resources and Conservation. DNRC is responsible for assisting landowners with BMPs and monitoring their effectiveness. The Montana Logging Association and DNRC offer regular Forestry BMP training sessions for private landowners.

In addition to the BMPs identified above, effects that timber harvest may have on yearly streamflow levels, such as peak flow, should be considered. Timber harvest plans should evaluate the potential for cumulative effects on water yield and peak flow increases and implement BMPs to reduce sediment and nutrients loading. Finally, noxious weed control should be actively pursued in all harvest areas.

10.6 Relevant Current Restoration Efforts

United States Forest Service-Selway Creek Restoration

The USFS has engaged in numerous restoration efforts on Selway Creek related to unpaved roads surveys and improvements, flood-irrigation practices, fish passage, and grazing management. A concrete fish barrier has been installed to prevent non-native trout movement into Westslope Cutthroat Trout habitat, and future plans include the removal of non-native fish and re-introduction of Westslope Cutthroat Trout.

Candidate Conservation Agreement

A Candidate Conservation Agreement with Assurances is being developed to improve and protection grayling habitat. This is an agreement with the U. S. Fish and Wildlife whereby property owners agree to manage their land to alleviate threats to fluvial arctic grayling. Property owners then receive assurances against additional regulatory requirements should the Arctic grayling be listed under the Endangered Species Act. This project is being implemented by Fish Wildlife and Parks. It is being funded by the USFWS and includes evaluation of riparian habitat and restoration projects including revegetation and implementation of projects to increase flows. Thusfar, the focus has been on Metzel, Long, and Hell Roaring Creeks as well as Red Rock River below the dams.

Bureau of Land Management Surveys

The Bureau of Land Management conducts surveys every five years to evaluate whether streams on BLM lands are properly functioning, and uses this to develop management objectives in the case where they are deemed to be not functioning. In the Red Rock, regular surveys are currently being conducted on Medicine Lodge, Horse Prairie, and Red Rock Creeks.

Centennial Valley Association

The Centennial Valley Association facilitates community-based conservation across this shared landscape by rallying landowners, agencies, and community members together in multiple programs including predator-conflict mitigation, invasive species management, water and drought awareness, and various outreach and educational opportunities. n 2014, the CVA initiated the first season of the Range Rider Program for the summer/fall grazing season. Range riders increase human presence around livestock to deter and prevent predator-livestock conflicts, as well as increase community communication about wildlife presence and activity. The CVA's Invasive Species Management Program works with partners to map and treat noxious weed infestations, as well as increase community literacy of invasive species. In 2019, the CVA formally implemented its Water and Drought Awareness Program. The purpose is to implement a forum on drought awareness, education, and information dissemination, install needed hydrological infrastructure, and provide the community opportunity to improve or implement management decisions for the future of their operations and the landscape. The program analyzes and collects partner and individual data and creates a Water Report for the community bi-weekly in the summer and fall months and monthly in the winter and spring.

10.7 Nonpoint Source Pollution Education

Because most nonpoint source pollution (NPS) is generated by individuals, a key factor in reducing NPS pollution is increasing public awareness through education. Local watershed groups can provide educational opportunities to both children and adults through water quality workshops and informational meetings. Continued education is key to an ongoing understanding of water quality issues in the Red Rock TMDL Planning Area, and to the support for implementation and restorative activities.

10.8 Potential Funding Sources

Prioritization and funding of restoration or water quality improvement projects is integral to maintaining restoration activities and monitoring project successes and failures. Several government agencies and also a few non-governmental organizations fund or can provide assistance with watershed or water quality improvement projects or wetlands restoration projects. Below is a brief summary of potential funding sources and organizations to assist with TMDL implementation. Note that some programs or funding sources summarized below may be discontinued in the future, and new sources of funding could possibly become available. Be sure to inquire with these agencies and organizations for the most current information.

In addition to the information presented below, numerous other funding opportunities exist for addressing nonpoint source pollution. Additional information regarding funding opportunities from state agencies is contained in Montana's Nonpoint Source Management Plan (DEQ 2017) and information regarding additional funding opportunities can be found at https://www.epa.gov/nps/funding-resources-watershed-protection-and-restoration.

Web resources are constantly change. If a link below is no longer accessible, please contact the Water Protection Section at DEQ for assistance.

Section 319 Nonpoint Source Grant Program

DEQ issues a call for proposals every year to award federal Section 319 grant funds administered under the federal Clean Water Act. The primary goal of the 319 program is to restore water quality in waterbodies whose beneficial uses are impaired by nonpoint source pollution and whose water quality does not meet state standards. 319 funds are distributed competitively to support the most effective and highest priority projects. To receive funding, projects must directly implement a DEQ-accepted watershed restoration plan (**Section 10.2**) and funds may only be used for planning and implementing restoration projects. The recommended range for 319 funds per project proposal is $10,000 to $250,000. All funding has a 40% cost share requirement, and projects must be administered through a governmental entity such as a conservation district or county, or a nonprofit organization. For information about past grant awards and how to apply, please visit the DEQ Lakes, Streams, and Wetlands page, and the Nonpoint Source Program: https://deq.mt.gov/water/Programs/sw.

DEQ Volunteer Monitoring Support Program

The DEQ Volunteer Monitoring Support Program provides financial support of up to $4,000 for laboratory sample analysis and shipping costs. The program also provides technical support. Applications are typically due in late winter. Consult the DEQ Lake, Streams, and Wetlands Webpage at https://deq.mt.gov/water/Programs/sw for more information.

Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for projects that focus on habitat restoration to benefit wild and native fish. Anyone ranging from a landowner or community-based group to a state or local agency is eligible to apply. Applications are reviewed annually in December and June. Projects that may be applicable to the Red Rock TMDL Planning Area include restoring streambanks, improving fish passage, and restoring/protecting spawning habitats. For additional information about the program and how to apply, please visit https://fwp.mt.gov/ffip.

Renewable Resource Project Planning Grants

The DNRC administers watershed grants to pay for contracted costs associated with the development of a watershed assessment. Grant are available for a maximum of $75,000 per project. Eligible applicants include conservation districts and irrigation districts, among many others. For additional information about the program and how to apply, please visit: http://dnrc.mt.gov/grants-and-loans.

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is administered by NRCS and offers financial (i.e., incentive payments and cost-share grants) and technical assistance to farmers and ranchers to help plan and implement conservation practices that improve soil, water, air and other natural resources on their land. The program is based on the concept of balancing agricultural production and forest management with environmental quality, and is also used to help producers meet environmental regulations. EQIP offers contracts with a minimum length of one year after project implementation to a maximum of 10 years. Each county receives an annual EQIP allocation and applications are accepted continually during the year; payments may not exceed $300,000 within a six-year period. For additional information about the program and how to apply, please visit http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.

Montana Partners for Fish and Wildlife
Montana Partners for Fish and Wildlife is a program under the U.S. Fish & Wildlife Service that assists private landowners to restore wetlands and riparian habitat by offering technical and financial assistance. For additional information about the program and to find your local contact for the Red Rock River watershed, please visit https://www.fws.gov/mountain-prairie/refuges/montanaPFW.php.

Wetland Reserve Easements
The NRCS provides technical and financial assistance to private landowners and Indian tribes to restore, enhance, and protect wetlands through permanent easements, 30-year easements, or term easements. Land eligible for these easements includes farmed or converted wetland that can be successfully and cost-effectively restored. For additional information about the program and how to apply, please visit http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/easements/acep/.

Montana Wetland Council
The Montana Wetland Council is an active network of diverse interests that works cooperatively to conserve and restore Montana's wetland and riparian ecosystems. Please visit the DEQ Lakes, Streams, and Wetlands Webpage under "Wetlands" to find dates and locations of upcoming meetings, wetland program contacts, and additional information on potential grants and funding opportunities: https://deq.mt.gov/water/Programs/sw.

Montana Natural Heritage Program
The Montana Natural Heritage Program is a valuable resource for restoration and implementation information, including maps. Wetlands and riparian areas are one of the 14 themes in the Montana Spatial Data Infrastructure. The Montana Wetland and Riparian Mapping Center (found at: http://mtnhp.org/nwi/) is creating a statewide digital wetland and riparian layer as a resource for management, planning, and restoration efforts.

Montana Aquatic Resources Services, Inc.
Montana Aquatic Resources Services, Inc. (MARS) is a nonprofit organization focused on restoring and protecting Montana's rivers, streams and wetlands. MARS identifies and implements stream, lake, and wetland restoration projects, collaborating with private landowners, local watershed groups and conservation districts, state and federal agencies, and tribes. For additional information about the program, please visit http://montanaaquaticresources.org/.

Monitoring Montana Waters
Monitoring Montana Waters, offered through the Flathead Lake Biological Station, provides financial support up to $6,000 to watershed groups for analysis and/or gear. To receive funds, groups must have Sampling and Analysis Plans and Standard Operating Procedures approved by MMW or DEQ. Groups applying for laboratory analyses funding must commit 50% of cost match to be eligible. This cost match may include personnel time, travel, or actual expenses spent. To receive gear funding, groups must provide documentation of a comparable amount (100% of award) of matching funds in dollars. Further information can be found at http://flbs.umt.edu/newflbs/outreach/mmw/mmw-funding/.

11.0 Monitoring for Effectiveness

The monitoring strategies discussed in this section are an important component of watershed restoration, and a requirement of total maximum daily load (TMDL) implementation under the Montana Water Quality Act (75-5-703(7), Montana Code Annotated (MCA)), and the foundation of the adaptive management approach discussed below. Water quality targets and allocations presented in this document are based on available data at the time of analysis. The scale of the watershed analysis, coupled with constraints on time and resources, often result in necessary compromises that include estimations, extrapolation, and a level of uncertainty in TMDLs. The margin of safety (**Section 4.4**) is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities, the amount of reduction of instream pollutants (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate.

The monitoring strategy presented in this section provides a starting point for the development of more detailed planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Monitoring recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans to meet the water quality improvement goals outlined in this document. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on funding opportunities and stakeholder priorities for restoration. Once restoration measures have been implemented for a waterbody with an approved TMDL and given time to take effect, the Department of Environmental Quality (DEQ) will conduct a formal evaluation of the waterbody's impairment status and whether TMDL targets and water quality standards are being met. Based on this evaluation, DEQ will make recommendations on the next steps to take toward meeting water quality goals (**Section 10.2**).

The objectives for future monitoring in the Red Rock TMDL Planning Area include: 1) tracking and monitoring restoration activities and evaluating the effectiveness of individual and cumulative restoration activities, 2) baseline and impairment status monitoring to assess attainment of water quality targets and identify long-term trends in water quality, and 3) refining the source assessments. Each of these objectives is discussed below.

11.1 Adaptive Management and Uncertainty

Adaptive management as discussed throughout this document is a systematic approach for improving resource management by learning from management outcomes, and allows for flexible decision making. There is an inherent amount of uncertainty involved in the TMDL process, including: establishing water quality targets for sediment and temperature, calculating existing pollutant loads and necessary load allocations, and determining effects of BMP implementation. Use of an adaptive management approach based on continued monitoring of project implementation helps manage resource commitments as well as achieve success in meeting the water quality standards and supporting all water quality beneficial uses. This approach further allows for adjustments to restoration goals, TMDLs, and/or allocations, as necessary. For an in-depth look at the adaptive management approach, view the U.S. Department of the Interior's (DOI) technical guide and description of the process at: https://mylearning.nps.gov/libraryresources/adaptive-management-applications-guide/. **Figure 6-1** below is a visual explanation of the iterative process of adaptive management (Williams et al., 2009).

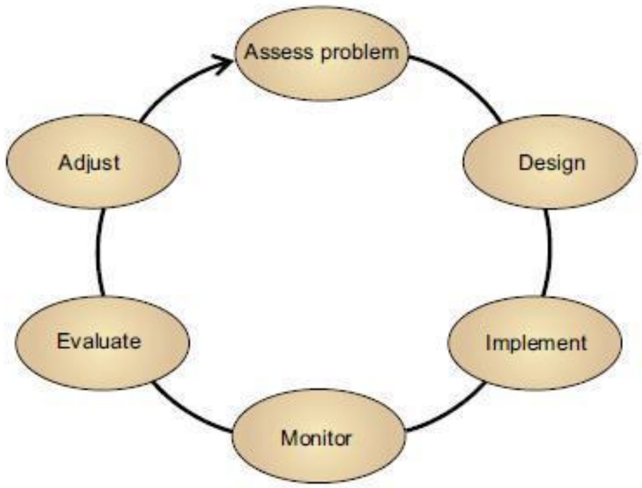

Figure 10-1. Diagram of the Adaptive Management Process

Funding for future implementation and monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on funding opportunities and stakeholder priorities for restoration. The analysis presented in this document assumes that the load reductions proposed for each of the listed streams will enable the streams to meet target conditions and that meeting target conditions will ensure full support of all beneficial uses (and attainment of water quality standards). Much of the monitoring proposed in this section of the document is intended to validate this assumption.

Once restoration measures have been implemented for a waterbody with an approved TMDL and given time to take effect, DEQ will conduct a formal evaluation of the waterbody's impairment status and determine whether TMDL targets and water quality standards are being met. Alternatively, if it looks like greater reductions in loading or improved performance is necessary to meet targets, then updated TMDL(s) and/or allocations will be developed based on achievable reductions via application of reasonable land, soil, and water conservations practices. Additionally, as new stressors are added to the watershed and additional data are collected, new water quality targets may need to be developed or existing targets/allocations may need to be modified.

11.2 Effectiveness Monitoring for Restoration Activities

As restoration activities are implemented, watershed-scale monitoring may be valuable in determining if restoration activities are improving water quality, instream flow, and aquatic habitat and communities. It is important to remember that degradation of aquatic resources happens over many decades and that restoration is often also a long-term process. An efficiently executed long-term monitoring effort is an essential component to any restoration effort.

Due to the natural high variability in water quality conditions, trends in water quality are difficult to define and even more difficult to relate directly to restoration or other changes in management. Improvements in water quality or aquatic habitat from restoration activities will most likely be evident in fine sediment deposition and channel substrate embeddedness, changes in channel cumulative width/depths, improvements in streambank stability and riparian habitat, increases in instream flow, and changes in communities and distribution of fish and other bio-indicators. Specific monitoring methods, priorities, and locations will depend heavily on the type of restoration projects implemented, landscape or other natural setting, the land use influences specific to potential monitoring sites, and budget and time constraints.

As restoration activities continue throughout the watershed, monitoring should be conducted prior to and after project implementation to help evaluate the effectiveness of specific practices or projects. Monitoring activities should be selected such that they directly investigate those subjects and pollutants that the project is intended to effect, and when possible, linked to targets and allocations in the TMDL.

For sediment, which has no numeric standard, and temperature, which was evaluated using a Qual2k water quality modeling approach, loading reductions and BMP effectiveness may be estimated using the approaches used within this document. However, tracking BMP implementation, maintenance, and project-related measurements will likely be most practical for sediment and temperature. For instance, for road improvements, it is not anticipated that post-project sediment loads will be measured. Instead, documentation of the BMP, reduced contributing length, and before and after photos documenting the presence and effectiveness of the BMP will be most appropriate. For installation of riparian fencing, photo point monitoring (before and after photo documentation) of riparian vegetation and streambank conditions, and a measurement such as “greenline” that documents the percentage of bare ground and shrub cover, may be most appropriate.

Evaluating instream parameters used for sediment targets will be one of the tools used to gauge the success of implementation when DEQ conducts a formal assessment, but may not be practical for most projects since the sediment effects within a stream represent cumulative effects from many watershed scale activities and because there is typically a lag time between project implementation and instream improvements (Meals et al., 2010). DEQ TMDL and nonpoint source staff can help local stakeholders determine the most practical and effective monitoring techniques.

If sufficient implementation progress is made within a watershed, DEQ will conduct a TMDL Implementation Evaluation. During this process, DEQ compiles recent data, conducts monitoring (if necessary), may compare data to water quality targets, summarizes BMP implementation that has occurred since TMDL development, and evaluates data to determine if the TMDL is being achieved or if conditions are trending one way or another. If conditions indicate the TMDL is being achieved, the waterbody will be recommended for reassessment and may be removed from the list of impaired waters if assessment results show that water quality standards are being met. If conditions indicate the TMDL is not being achieved, according to Montana State Law (75-5-703(9), MCA), the evaluation must determine if:

- The implementation of a new or improved phase of voluntary reasonable land, soil, and water conservation practices is necessary,
- Water quality is improving, but more time is needed for compliance with water quality standards, or
- Revisions to the TMDL are necessary to achieve applicable water quality standards.

11.3 Impairment Status Monitoring and Strengthening Source Assessment

In addition to effectiveness monitoring, watershed scale monitoring should be conducted to expand knowledge of existing conditions and to provide data that can be used during the TMDL implementation evaluation. Infrequent sampling events at a small number of sampling sites may provide some indication of overall water quality and habitat condition, however regularly scheduled sampling at consistent locations, under a variety of seasonal conditions is the best way to assess overall stream health and monitor change.

Although DEQ is the lead agency for conducting impairment status monitoring, other agencies or entities may collect and provide compatible data. Wherever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent with DEQ methodology to allow for comparison to TMDL targets and track progress toward meeting TMDL goals. The information in this section provides general guidance for future impairment status monitoring.

11.3.1 Metals Monitoring and Data Collection Methodology

The identification of metals sources was conducted largely through tours of the watershed, assessments of aerial photographs, the incorporation of geographic information system information and reviewing and analyzing available data. Limited field-verification of the available data was able to be conducted. In many cases, assumptions were made based on known watershed conditions and extrapolated throughout the planning area. The following actions are recommended:

- Refinement of the sampling approach and locations to better partition pollutant loading from discrete sources within tributaries. This may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling.
- DEQ recommends additional monitoring of all metals parameters in all tributaries of the Red Rock River watershed, as resources allow. Additional monitoring of metals water quality data will yield a better understanding of metals source locations in the watershed.
- A more detailed characterization of historical mining activities and human caused land disturbances directed at defining these sources as area of potential metals loading.
- A more detailed assessment may allow for the verification that abandoned mines that are causing the high metals concentrations, versus natural sources.

It is preferable that sampling follow standardized protocols such as provided by DEQ: https://deq.mt.gov/files/Water/WQPB/QAProgram/Documents/SOP_ChemistrySampling_WQDWQPBFM-02_2019_Final.pdf

11.3.2 Sediment Monitoring and Data Collection Methodology

Each of the sediment streams of interest for this TMDL project was stratified into unique reaches based on physical characteristics and anthropogenic (human) influence. However, the sites assessed in the field represent only a percentage of the total number of stratified reaches. Sampling additional streams, or additional monitoring locations on already-sampled streams, could provide additional data to assess existing conditions, and provide more specific information on a per stream basis as well as the TMDL planning area as a whole.

Sediment and habitat assessment protocols consistent with DEQ field methodologies, and that serve as the basis for sediment targets and assessment within this TMDL document, should be implemented whenever possible. Current protocols are identified within Standard Operating Procedure for Sediment

Beneficial Use Assessment Monitoring: Wadeable Streams in Mountainous and Transitional Ecoregions (Makarowski, 2020). It is acknowledged that various agencies and entities have differing objectives, as well as time and resources available to achieve those objectives. However, when possible, it is recommended that at a minimum the following parameters be collected to allow for comparison to TMDL targets:

- Riffle Cross Section, using Rosgen methodology
- Riffle Pebble Count, using Wolman Pebble Count methodology
- Residual Pool Depth Measurements
- Greenline Assessment, using NRCS methodology

Prior to conducting this type of monitoring, DEQ TMDL and nonpoint source staff should also be contacted to discuss appropriate monitoring techniques and methods.

Additional monitoring information will undoubtedly be useful and assist DEQ with TMDL effectiveness monitoring and impairment status evaluations in the future. Examples of additional useful information may include total suspended solids; identifying percentage of eroding streambanks, human sediment sources, and areas with a high background sediment load; macroinvertebrate studies; McNeil core sediment samples; and fish population surveys and redd counts.

An important part of impairment determination and adaptive management is determining when a stream has fully recovered from past management practices, and where recovery is still occurring from historical improvements in management but recent BMPs were not applied. Ongoing PIBO monitoring can also provide critical insight into the extent of recovery from past practices via comparisons between reference and managed sites.

11.3.3 E.coli Monitoring and Data Collection Methodology

In order to better understand conditions contributing to *E. coli* loading, it is recommended that *E. coli* sampling be continued in areas where elevated *E. coli* concentrations were observed, and to note specific land uses and conditions at the time of sampling that could be contributing to elevated instream concentrations. Additionally, *E. coli* sampling events timeframes could be expanded to include late summer low-flow conditions in order to allow analysis of load contributions during times when water quality is most susceptible to impacts from *E. coli* contributions.

The identification of pollutant sources in the project Area was conducted through a combination of field observations, assessments of aerial photographs and GIS information.

The following monitoring would help improve the understanding of *E. coli* loading in Red Rock watershed:

- Monitoring during both high and low flow conditions. As *E. coli* exceedances occurred during all flow regimes more concerted sampling efforts could be made to collect samples during high and low flow events to get a better understanding of the potential impacts on *E. coli* loads
- Monitoring of *E. coli* in additional segments that were not covered as part of the DEQ assessment
- Additional monitoring of *E. coli* for the tributaries of the Red Rock where there is significant impacts from grazing to riparian areas. Additional monitoring will yield a better understanding of the *E. coli* sources located throughout the watershed.
- A more detailed understanding of grazing and manure management practices within the

watershed.

- Thorough analysis of the number of septic systems in the watershed, their proximity to surface Water, and their state of repair.
- Stream discharge should be measured during all *E. coli* sampling efforts.

11.4 Watershed Wide Analysis

Recommendations for monitoring in the Red Rock TMDL Planning Area should not be confined to only those streams addressed within this document. The water quality targets presented herein are applicable to all streams in the watershed, and the absence of a stream from the state's list of impaired waters does not necessarily imply a stream that fully supports all beneficial uses. Furthermore, as conditions change over time and land management evolves, consistent data collection methods throughout the watershed will allow resource professionals to identify problems as they occur, and to track improvements over time.

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