Montana Department of
ENVIRONMENTAL QUALITY

Flint Creek Planning Area Sediment and Metals TMDLs and Framework Water Quality Improvement Plan



October 2012

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Suggested citation: Montana DEQ. 2012. Flint Creek Planning Area Sediment and Metals TMDLs and Framework Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality.

ACKNOWLEDGEMENTS

DEQ would like to acknowledge multiple entities for their contributions in the development of the TMDLs contained in this document. Specifically, the Granite Conservation District provided support throughout the Flint TMDL planning process by assisting with the coordination of technical and advisory stakeholder meetings, administering contracts for the completion of source assessments, and via public outreach and education.

Various versions of sections or components of this document were presented or sent to stakeholders for review and input. Stakeholders include landowners, livestock and agriculture producers, private businesses, and local, state, and federal agency personnel and represent interests from the US Forest Service, NRCS, Granite County, the city of Philipsburg, MT Fish, Wildlife, & Parks, among others. In particular, Dick Hoehn of the city of Philipsburg provided significant data and technical assistance; and Gerald Mueller from the Granite Headwaters Watershed Group was indispensible for his assistance coordinating meetings, facilitating information sharing, and bringing understanding between government and stakeholders.

Steve Cook, a previous water quality planner with DEQ, and Eric Sivers, a current water quality planner provided planning support for these TMDLs and were also vital members of the field crews that collected data for this project. We would like to thank Carrie Greeley, an administrative assistant for the Watershed Management Section of DEQ, for her time and efforts formatting this document.

Lastly, consultants often provide significant contributions with data collection, source assessment, and reporting. In the Flint watershed, multiple consultants were used for data collection during the course of this project. Water & Environmental Technologies specifically provided assistance with data collection, analysis and the accompanying documentation listed as **Attachments A and B**, *Analysis of Base Parameter and Erosion Inventory Data for Sediment TMDL Development within the Flint Creek TPA*; *Flint Creek Watershed Assessment Upland Sediment Assessment and Modeling and BMP Effectiveness and Percent Reduction Potential,* respectively.

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ACRONYM LIST

Acronym	Definition
AFO	Animal Feeding Operation
AML	Abandoned Mine Lands
ARARS	Applicable or Relevant and Appropriate Requirements and Standards
ARCO	Atlantic Richfield Company
ARM	Administrative Rules of Montana
ARARS	Applicable or Relevant and Appropriate Requirements and Standards
AWRA	American Water Resources Association
BDNF	Beaverhead Deerlodge National Forest
BEHI	Bank Erosion Hazard Index
BLM	Bureau of Land Management (federal)
BMP	Best Management Practices
BUD	Beneficial Use Determination
CAFO	Concentrated (or Confined) Animal Feed Operations
CALA	Controlled Allocation of Liability Act
CECRA	[Montana] Comprehensive Environmental Cleanup and Responsibility Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CNMP	Comprehensive Nutrient Management Plans
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation
EPA	Environmental Protection Agency (US)
FWP	Fish, Wildlife, and Parks (Montana)
FWS	Fish & Wildlife Service (US)
GIS	Geographic Information System
GWIC	Groundwater Information Center
INFISH	Inland Native Fish Strategy
IR	Integrated Report
LA	Load Allocation
LWD	Large Woody Debris
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MFWP	Montana Fish, Wildlife and Parks
MMI	Multi-Metric Index
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MSU	Montana State University
MWCB	Mine Waste Cleanup Bureau (DEQ)
NBS	Near Bank Stress
NF	North Fork
NLCD	National Land Cover Dataset
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List

Acronym	Definition
NPS	Nonpoint Source
NRCS	National Resources Conservation Service
NRDP	Natural Resource Damage Program
NRIS	Natural Resource Information System (Montana)
PEL	Probable Effects Levels
PFC	Proper Functioning Condition
PIBO	PACFISH/INFISH Biological Opinion
RIT/RDGP	Resource Indemnity Trust/Reclamation and Development Grants Program
RP	Responsible Party
SAP	Sampling and Analysis Plan
SDWIS	Safe Drinking Water Information System
SF	South Fork
SILC	(Montana's) Satellite Imagery land Cover
SMCRA	Surface Mining Control & Reclamation Act
SMZ	Streamside Management Zone
SOP	Standard Operating Procedure
SSURGO	Soil Survey Geographic database
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
TSS	Total Suspended Solids
UCFRB	Upper Clark Fork River Basin Grant Program
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	US Fish and Wildlife Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VCRA	Voluntary Cleanup and Redevelopment Act
VFS	Vegetated Filter Strips
WLA	Wasteload Allocation
WRP	Watershed Restoration Plan
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This document presents a Total Maximum Daily Load (TMDL) and framework water quality improvement plan for 11 impaired streams or stream segments in the Flint Creek TMDL Planning Area (TPA) (see **Figure A-1** found in **Appendix A**). The document contains a total of 47 TMDLs.

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 Flint Creek TPA encompasses an area of approximately 500 square miles in western Montana, and lies almost entirely in Granite County with a small portion in Deer Lodge County. The Flint Creek watershed originates in the Flint Creek Mountains to the east, the Pintlar Mountains to the south, and the Sapphire and John Long Mountains to the west. Flint Creek drains from Georgetown Lake and bisects two large agricultural valleys, the Philipsburg Valley and the Drummond Valley, which are separated by a narrow bedrock canyon. Flow in Flint Creek is seasonally augmented from a trans-basin diversion in the East Fork of Rock Creek. Approximately 2,200 residents reside within the Flint Creek TPA, with Philipsburg (pop. 911) and Drummond (pop. 315) as the largest towns. Other population centers include Maxville and Hall. Land ownership in the Flint Creek TPA is primarily private and U.S. Forest Service (Beaverhead-Deer Lodge National Forest), with a small amount of land managed by Bureau of Land Management (BLM) or the State of Montana. Private lands are located predominantly in the lower areas where wide, low-gradient valleys are conducive to agriculture and development.

Today, the economy of the Flint Creek watershed is dominated by agriculture and tourism supported through the areas rich recreational opportunities, although historically the Flint Creek watershed has also seen extensive mining activity, and forested lands were harvested for timber. Many roads were built in conjunction with these activities. Currently, forest lands in the Flint Creek TPA are used for recreational purposes as well as some resource extraction. Most of the historic road system is maintained to some degree to supply access for recreation, resource extraction and fire suppression. Other roads are either decommissioned or left in place. Private lands are predominantly agricultural and rural, with some residential areas. Several tracts of land that were historically grazed or farmed are now subdivided into smaller parcels and have been developed into residential units.

DEQ determined that 11 streams or stream segments do not meet the applicable water quality standards. The scope of the TMDLs in this document addresses problems with sediment and metals (see **Table ES-1**). Although DEQ recognizes that there are other pollutant listings for this TPA, this document addresses only sediment and metals. Other pollutant listings will be addressed in future documents.

Sediment was identified as impairing aquatic life and coldwater fishes in the upper segment of Flint Creek, Barnes Creek, Douglas Creek (near Philipsburg), and Smart Creek. Sediment is affecting beneficial uses in these streams by altering aquatic insect communities, reducing fish spawning success and altering habitat, and increasing turbidity. In addition, turbidity was listed as a cause of impairment affecting aquatic life and coldwater fishes, primary contact recreation, and industrial use in the lower segment of Flint Creek, which is addressed in this document via a sediment TMDL. Water quality

restoration goals for sediment were established on the basis of fine sediment levels in trout spawning areas and aquatic insect habitat, stream morphology and available in-stream habitat as it relates to the effects of sediment, and the stability of streambanks. DEQ believes that once these water quality goals are met, all water uses currently affected by sediment will be restored.

Sediment loads are quantified for natural background conditions and for the following sources: bank erosion, hillslope erosion, and roads. The most significant sources vary by watershed but impacts from agricultural land uses (hay fields, grazing, etc) and forest roads tend to be the most prominent, along with natural erosion. The Flint Creek TPA watershed sediment TMDLs indicate that reductions in sediment loads ranging from 44% to 59% will satisfy the water quality restoration goals.

Recommended strategies for achieving the sediment reduction goals are also presented in this plan. They include best management practices (BMPs) for building and maintaining roads, for harvesting timber, and for agricultural practices. 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.

Metals were identified as impairing one or more of the following beneficial uses: aquatic life and coldwater fishes, drinking water, agricultural, and primary contact recreation in both segments of Flint Creek, Barnes Creek, Boulder Creek, Camp Creek, Douglas Creek (near Philipsburg), North Fork Douglas Creek, Fred Burr Creek, Royal Gold Creek, Smart Creek, and South Fork Lower Willow Creek. Metals such as Antimony, Arsenic, Cadmium, Copper, Iron, Lead, Mercury and Zinc are affecting beneficial uses in these streams by occurring in concentrations that exceed state water quality standards. Water quality restoration goals for these metals were established based on the state water quality standards for each respective metal.

Metals loads are quantified for natural background conditions and for sources such as abandoned mines, mine tailings, adits, and contaminated sediments. The most significant sources vary by watershed but are mostly related to the remnants of historic mining practices, as well as some natural sources.

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, 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.

Although most water quality improvements are based on voluntary measures that address diffuse sources, federal law calls for permit requirements for *point sources* to be consistent with the assumptions and requirements of wasteload allocations (WLAs) on streams where TMDLs have been developed and approved by EPA. The Flint Creek TPA has permitted dischargers requiring the incorporation of WLAs into permit conditions on Flint Creek, South Fork Lower Willow Creek and Smart Creek.

A flexible approach to most nonpoint source TMDL implementation activities may be necessary as more knowledge is gained through implementation and future monitoring. The 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 ES-1. List of Impaired Waterbodies and their Impaired Uses in the Flint Creek TPA with Completed Sediment and Metals TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
Upper Flint Creek, Georgetown Lake to Boulder Creek confluence	Sediment	Sediment	Aquatic Life
	Arsenic	Metals	Aquatic Life; Drinking Water
	Copper	Metals	Aquatic Life
	Lead	Metals	Aquatic Life; Drinking Water
	Mercury	Metals	Aquatic Life; Drinking Water
Lower Flint Creek, Boulder Creek to mouth (Clark Fork River)	Sediment	Sediment	Aquatic Life; Primary Contact Recreation
	Arsenic	Metals	Aquatic Life; Drinking Water
	Copper	Metals	Aquatic Life
	Iron	Metals	Aquatic Life
	Lead	Metals	Aquatic Life; Drinking Water
Barnes Creek, headwaters to mouth (Flint Creek)	Sediment	Sediment	Aquatic Life; Primary Contact Recreation
	Iron	Metals	Agricultural; Aquatic Life; Drinking Water
Boulder Creek, headwaters to mouth (Flint Creek)	Arsenic	Metals	Aquatic Life
	Lead	Metals	Aquatic Life
	Mercury	Metals	Aquatic Life; Drinking Water
	Zinc	Metals	Aquatic Life
Camp Creek, headwaters to mouth (Flint Creek)	Arsenic	Metals	Aquatic Life; Primary Contact Recreation
	Cadmium	Metals	Aquatic Life
	Copper	Metals	Aquatic Life; Primary Contact Recreation
	Lead	Metals	Aquatic Life; Primary Contact Recreation
	Zinc	Metals	Aquatic Life; Primary Contact Recreation
Douglas Creek (near Philipsburg), headwaters to mouth (Flint Creek)	Sediment	Sediment	Aquatic Life
	Arsenic	Metals	Agricultural; Aquatic Life; Drinking Water
	Cadmium	Metals	Agricultural; Aquatic Life; Drinking Water
	Copper	Metals	Agricultural; Aquatic Life
	Iron	Metals	Agricultural; Aquatic Life
	Lead	Metals	Agricultural; Aquatic Life; Drinking Water
	Mercury	Metals	Agricultural; Aquatic Life; Drinking Water
	Zinc	Metals	Agricultural; Aquatic Life
North Fork Douglas Creek, headwaters to mouth (Douglas Creek)	Cadmium	Metals	Aquatic Life; Drinking Water
	Copper	Metals	Agriculture; Aquatic Life
	Lead	Metals	Aquatic Life
	Zinc	Metals	Aquatic Life; Drinking Water
Fred Burr Creek, Fred Burr Lake to mouth (Flint Creek)	Arsenic	Metals	Aquatic Life; Drinking Water
	Lead	Metals	Aquatic Life
	Mercury	Metals	Aquatic Life; Drinking Water
Royal Gold Creek, headwaters to mouth (Boulder Creek)	Copper	Metals	Aquatic Life
	Lead	Metals	Aquatic Life
Smart Creek, headwaters to mouth (Flint Creek)	Sediment	Sediment	Aquatic Life
	Arsenic	Metals	Drinking Water
	Iron	Metals	Aquatic Life

Table ES-1. List of Impaired Waterbodies and their Impaired Uses in the Flint Creek TPA with Completed Sediment and Metals TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
South Fork Lower Willow Creek, headwaters to mouth (Lower Willow Creek)	Antimony	Metals	Drinking Water
	Arsenic	Metals	Aquatic Life; Drinking Water
	Cadmium	Metals	Aquatic Life
	Copper	Metals	Aquatic Life
	Lead	Metals	Aquatic Life
	Mercury	Metals	Aquatic Life; Drinking Water

1.0 INTRODUCTION

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for sediment and metals problems in the Flint Creek TMDL Planning Area (TPA). This document also presents a general framework for resolving these problems. **Figure A-1**, found in **Appendix A**, shows a map of waterbodies in the Flint Creek TPA with sediment and metals pollutant listings.

1.1 BACKGROUND

In 1972, the U.S. Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act (CWA). The CWA's goal is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The CWA requires each state to designate uses of their waters and to develop water quality standards to protect those uses. Each state must monitor their waters to track if they are supporting their designated uses.

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

- fish and aquatic life
- wildlife
- recreation
- agriculture
- industry
- drinking water

Each waterbody has a set of standards associated with the applicable designated uses from the above list. 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 waters. 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, which require a TMDL. TMDLs are not *required* for non-pollutant causes of impairment. **Table A-1** in **Appendix A** identifies impaired waters for the Flint Creek TPA from Montana's 2012 303(d) List, as well as non-pollutant impairment causes included in Montana's "2012 Water Quality Integrated Report." **Table A-1** provides the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal CWA require the development of total maximum daily loads for all impaired waterbodies when water quality is impaired by a pollutant. A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards.

Developing TMDLs and water quality improvement strategies includes the following components, which are further defined in **Section 4.0**:

- Determining measurable target values to help evaluate the waterbody's condition in relation to the applicable water quality standards

- Quantifying the magnitude of pollutant contribution from their sources
- Determining the TMDL for each pollutant based on the allowable loading limits for each waterbody-pollutant combination
- Allocating the total allowable load (TMDL) into individual loads for each source

In Montana, restoration strategies and monitoring recommendations are also incorporated in TMDL documents to help facilitate TMDL implementation.

Basically, developing a TMDL for an impaired waterbody is a problem-solving exercise: The problem is excess pollutant loading that impairs a designated use. The solution is developed by identifying the total acceptable pollutant load (the TMDL), identifying all the significant pollutant-contributing sources, and identifying where pollutant loading reductions should be applied to achieve the acceptable load.

1.2 WATER QUALITY IMPAIRMENTS AND TMDLS ADDRESSED BY THIS DOCUMENT

Table 1-1 below lists all of the impairment causes from the "2010 Water Quality Integrated Report" (IR) that are addressed in this document (also see **Appendix A, Figure A-1**). Each pollutant impairment falls within a TMDL pollutant category (e.g., sediment or metals), and this document is organized by those categories.

New data assessed during this project identified new metals impairment causes for six waterbodies. These impairment causes are identified in **Table 1-1** and noted as not being on the 2012 303(d) List (within the integrated report) or within the most recent 2012 IR, currently at the draft stage of development. Instead, these will be documented within the DEQ assessment files and incorporated into the 2014 IR.

This document contains 47 TMDLs (**Table 1-1**). There are several non-pollutant types of impairment that are also addressed in this document. The overlap between the pollutant TMDLs and non-pollutant impairment causes is discussed in **Section 7**. **Section 8** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

Although DEQ recognizes that there are other pollutant listings for the Flint Creek TPA without completed TMDLs (**Appendix A, Table A-1**), this document only addresses those identified in **Table 1-1**. 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. **Table A-1** in **Appendix A** includes impairment causes that will be addressed by future TMDLs, as well as pollutant and non-pollutant impairment causes that need to be addressed by future planning and TMDL development efforts.

Table 1-1. Water Quality Impairment Causes for the Flint Creek TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 Integrated Report*
Upper Flint Creek, Georgetown Lake to Boulder Creek confluence	MT76E003_011	Sedimentation / Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Alteration in streamside or littoral vegetation covers	Not Applicable: Non-Pollutant	Addressed via Sediment TMDL in this document	Yes
		Antimony	Metals	No TMDL developed; updated 303(d) listing status pending	Yes
		Arsenic	Metals	Arsenic TMDL contained in this document	Yes
		Cadmium	Metals	No TMDL developed; updated 303(d) listing status pending	Yes
		Copper	Metals	Copper TMDL contained in this document	Yes
		Iron	Metals	Future monitoring needed	No
		Lead	Metals	Lead TMDL contained in this document	Yes
		Low Flow Alterations	Not Applicable: Non-Pollutant	Partially addressed via recommendations in **Sections 7**, **8**, & **9**	Yes
		Mercury	Metals	Mercury TMDL contained in this document	Yes
Lower Flint Creek, Boulder Creek to mouth (Clark Fork River)	MT76E003_012	Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	No
		Alteration in streamside or littoral vegetation covers	Not Applicable: Non-Pollutant	Addressed via Sediment TMDL in this document	Yes
		Arsenic	Metals	Arsenic TMDL contained in this document	Yes
		Cadmium	Metals	No TMDL developed; updated 303(d) listing status pending	Yes
		Copper	Metals	Copper TMDL contained in this document	Yes
		Iron	Metals	Iron TMDL contained in this document	Yes
		Lead	Metals	Lead TMDL contained in this document	Yes
		Turbidity	Sediment	Addressed via Sediment TMDL in this document	Yes
Barnes Creek, headwaters to mouth (Flint Creek)	MT76E003_070	Iron	Metals	Iron TMDL contained in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes

Table 1-1. Water Quality Impairment Causes for the Flint Creek TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 Integrated Report*
Boulder Creek, headwaters to mouth (Flint Creek)	MT76E003_060	Arsenic	Metals	Arsenic TMDL contained in this document	Yes
		Cadmium	Metals	Future monitoring recommended	No
		Copper	Metals	Future monitoring recommended	No
		Lead	Metals	Lead TMDL contained in this document	Yes
		Mercury	Metals	Mercury TMDL contained in this document	Yes
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Addressed via recommendations in **Sections 7**, **8**, & **9**	Yes
		Zinc	Metals	Zinc TMDL contained in this document	Yes
Camp Creek, headwaters to mouth (Flint Creek)	MT76E003_130	Alteration in streamside or littoral vegetation covers	Not Applicable: Non-Pollutant	Addressed via recommendations in **Sections 7**, **8**, & **9**	Yes
		Arsenic	Metals	Arsenic TMDL contained in this document	Yes
		Cadmium	Metals	Cadmium TMDL contained in this document	No
		Copper	Metals	Copper TMDL contained in this document	Yes
		Fish Passage Barrier	Not Applicable: Non-Pollutant	Addressed via recommendations in **Sections 7**, **8**, & **9**	Yes
		Lead	Metals	Lead TMDL contained in this document	Yes
		Zinc	Metals	Zinc TMDL contained in this document	Yes
Douglas Creek (Hall), confluence of Middle and South Forks to mouth (Flint Creek), T9N R13W S10	MT76E003_020	Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Addressed via recommendations in **Sections 7**, **8**, & **9**	Yes
		Cadmium	Metals	Future monitoring recommended	No
		Iron	Metals	Future monitoring recommended	No

Table 1-1. Water Quality Impairment Causes for the Flint Creek TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 Integrated Report*
Douglas Creek (Philipsburg), headwaters to where stream ends, T7N R14W S25	MT76E003_100	Arsenic	Metals	Arsenic TMDL contained in this document	Yes
		Cadmium	Metals	Cadmium TMDL contained in this document	Yes
		Copper	Metals	Copper TMDL contained in this document	Yes
		Iron	Metals	Iron TMDL contained in this document	Yes
		Lead	Metals	Lead TMDL contained in this document	Yes
		Mercury	Metals	Mercury TMDL contained in this document	Yes
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Addressed via Sediment TMDL	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Zinc	Metals	Zinc TMDL contained in this document	Yes
North Fork Douglas Creek, headwaters to mouth (Douglas Creek)	MT76E003_030	Alteration in streamside or littoral vegetation covers	Not Applicable: Non-Pollutant	Addressed via recommendations in **Sections 7**, **8**, & **9**	Yes
		Arsenic	Metals	No TMDL developed; updated 303(d) listing status pending	Yes
		Cadmium	Metals	Cadmium TMDL contained in this document	Yes
		Copper	Metals	Copper TMDL contained in this document	Yes
		Lead	Metals	Lead TMDL contained in this document	No
		Sulfates	Metals	No TMDL developed; updated 303(d) listing status pending	Yes
		Zinc	Metals	Zinc TMDL contained in this document	Yes
Fred Burr Creek, Fred Burr Lake to mouth (Flint Creek)	MT76E003_040	Alteration in streamside or littoral vegetation covers	Not Applicable: Non-Pollutant	Addressed via recommendations in **Sections 7**, **8**, & **9**	Yes
		Arsenic	Metals	Arsenic TMDL contained in this document	Yes
		Copper	Metals	Future monitoring needed	No
		Lead	Metals	Lead TMDL contained in this document	Yes
		Mercury	Metals	Mercury TMDL contained in this document	Yes
		Zinc	Metals	Future monitoring needed	No
Royal Gold Creek, headwaters to mouth (Boulder Creek)	MT76E003_140	Copper	Metals	Copper TMDL contained in this document	No
		Lead	Metals	Lead TMDL contained in this document	No

Table 1-1. Water Quality Impairment Causes for the Flint Creek TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 Integrated Report*
Smart Creek, headwaters to mouth (Flint Creek), T9N R13W S21	MT76E003_110	Alteration in streamside or littoral vegetation covers	Not Applicable: Non-Pollutant	Addressed via Sediment TMDL	Yes
		Arsenic	Metals	Arsenic TMDL contained in this document	No
		Iron	Metals	Iron TMDL contained in this document	No
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
South Fork Lower Willow Creek, headwaters to mouth (Lower Willow Creek)	MT76E003_050	Arsenic	Metals	Arsenic TMDL contained in this document	No
		Antimony	Metals	Antimony TMDL contained in this document	No
		Cadmium	Metals	Cadmium TMDL contained in this document	No
		Copper	Metals	Copper TMDL contained in this document	Yes
		Lead	Metals	Lead TMDL contained in this document	Yes
		Mercury	Metals	Mercury TMDL contained in this document	Yes
Princeton Gulch, headwaters to mouth (Boulder Creek)	MT76E003_090	Physical Substrate Habitat Alterations	Not Applicable: Non-Pollutant	Addressed via recommendations in **Sections 7**, **8**, & **9**	Yes

1.3 DOCUMENT LAYOUT

This document addresses all of the required components of a TMDL and includes an implementation and monitoring strategy. The TMDL components are summarized within the main body of the document. Additional technical details are contained in the appendices and attachments. In addition to this introductory section, this document includes:

Section 2.0 Flint Creek Watershed 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 Flint Creek watershed.

Section 4.0 Defining TMDLs and Their Components
Defines the components of TMDLs and how each is developed.

Sections 5.0 – 6.0 Sediment and Metals TMDL Components (sequentially):
Each section includes (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.

Section 7.0 Other Identified Issues or Concerns:
Describes other problems that could potentially be contributing to water quality impairment and how the TMDLs in the plan might address some of these concerns. This section also provides recommendations for combating these problems.

Section 8.0 Framework Water Quality Restoration Strategy:
Discusses water quality restoration objectives and presents a framework for implementing a strategy to meet the identified objectives and TMDLs.

Section 9.0 Monitoring Strategy and Adaptive Management:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the Flint Creek Planning Area Sediment and Metals TMDLs and Framework Water Quality Improvement Plan.

Section 10.0 Stakeholder and Public Participation:
Describes other agencies and stakeholder groups who were involved with the development of the plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 FLINT CREEK WATERSHED DESCRIPTION

This section includes a summary of the physical characteristics and social profile of the Flint Creek watershed.

2.1 PHYSICAL CHARACTERISTICS

The following information describes the physical characteristics of the Flint Creek watershed.

2.1.1 Location

The Flint Creek TMDL planning area (TPA) is located in the Pend Oreille River Basin (Accounting Unit 170102) of western Montana, as shown on **Figure A-2** in **Appendix A**. The TPA is located within the Middle Rockies Level III Ecoregion. Four Level IV Ecoregions are mapped within the TPA (Woods et al., 2002). These include: Flint Creek – Anaconda Mountains (17am), Alpine (17h), Deer Lodge – Philipsburg – Avon Grassy Intermontane Hills and Valleys (17ak) and Rattlesnake – Blackfoot – South Swan – Northern Garnet – Sapphire Mountains (17x) (**Appendix A**, **Figure A-3**). The majority of the TPA is within Granite County, with a minor percentage (near Georgetown Lake) in Deerlodge County.

The TPA is bounded by the Flint Creek Range to the east, the Anaconda Range to the south, and the John Long Mountains to the west. The total area is 318,537 acres, or approximately 498 square miles.

Topography

Elevations in the TPA range from approximately 1,200 to 2,700 meters (3,900 - 9,000 feet) above mean sea level (**Appendix A**, **Figure A-4**). The highest point in the watershed is Twin Peaks, at 9,067 feet. The lowest point is in the Drummond valley where Flint Creek drains into the Clark Fork River.

The TPA includes two basins: the Philipsburg Valley and the Drummond Valley. The valleys are separated by a narrow canyon. The canyon is confined by Henderson Mountain, a promontory of the John Long Mountains that abuts the Flint Creek Range north of Philipsburg. The Philipsburg Valley ranges from 5,000 - 6,000 feet above sea level, and the Drummond Valley from 4,000 - 4,600 feet above sea level.

2.1.2 Climate

Climate in the area is typical of mid-elevation intermontane valleys in western Montana. Voeller and Warren (1997) described the climate as “modified continental”, characterized by low overnight temperatures. The local climate is milder in the lower elevation Drummond Valley than in the Philipsburg Valley.

Precipitation is most abundant in May and June. Philipsburg receives an annual average of 14.8 inches of moisture, compared to 11.8 reported at Drummond. The mountains may exceed 40 inches average annual moisture (Voeller and Waren, 1997). See **Tables 2-1** and **2-2** for climate summaries; **Figure A-5** in **Appendix A** shows the distribution of average annual precipitation.

Climate Stations

Climate data for the TPA is based upon the stations at Philipsburg and Drummond (although the latter is located outside the TPA). The USDA Natural Resources Conservation Service (NRCS) operates three SNOTEL snowpack monitoring stations within the TPA: Black Pine, Combination and Peterson Meadows.

Figure A-5 in **Appendix A** shows the locations of the NOAA and SNOTEL stations, in addition to average annual precipitation. The precipitation data is mapped by Oregon State University's PRISM Group, based on the records from NOAA stations (PRISM Group, 2004). Climate data is provided by the Western Regional Climate Center, operated by the Desert Research Institute of Reno, Nevada.

Table 2-1. Monthly Climate Summary: Drummond

Drummond Aviation, Montana (242500) Period of Record : 6/ 1/1963 to 4/30/2012

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ave. Max. Temp (F)	31.8	38.2	47.9	57.8	66.7	74.4	84.7	83.6	72.8	58.9	41.4	31.3	57.5
Ave. Min. Temp. (F)	12.3	15.6	21.8	27.8	34.8	42.0	45.0	43.5	36.3	28.4	20.0	12.2	28.3
Ave Tot. Precip. (in.)	0.85	0.57	0.76	0.99	1.76	2.00	1.10	1.18	1.12	0.82	0.76	0.84	12.75
Ave.. Snowfall (in.)	8.0	5.3	6.0	3.9	1.8	0.3	0.0	0.1	0.6	1.2	5.4	7.9	40.5
Ave Snow Depth (in.)	3	2	1	0	0	0	0	0	0	0	1	2	1
Drummond FAA Airport, Montana (242511) Period of Record : 11/1/1928 to 5/31/1963													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave. Max. Temp (F)	28.2	34.0	42.1	55.9	64.6	71.1	82.3	80.7	69.4	57.1	40.9	32.8	54.9
Ave. Min. Temp. (F)	5.9	11.1	18.2	26.5	34.1	40.1	43.8	42.0	34.4	26.7	17.5	12.1	26.0
Ave Tot. Precip. (in.)	0.61	0.55	0.67	0.78	1.59	1.87	1.00	0.86	0.91	0.80	0.67	0.58	10.89
Ave.. Snowfall (in.)	6.7	7.3	5.3	2.2	0.7	0.0	0.0	0.0	0.3	1.4	4.9	5.8	34.7
Ave Snow Depth (in.)	3	4	2	0	0	0	0	0	0	0	1	2	1

Table 2-2. Monthly Climate Summary: Philipsburg

Philipsburg Ranger Station, Montana (246472) Period of Record : 10/13/1955 to 4/30/2012

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ave. Max. Temp (F)	33.2	37.4	44.3	53.0	62.2	70.4	80.2	79.8	69.8	58.0	41.9	33.9	55.3
Ave. Min. Temp. (F)	13.6	16.0	20.5	26.3	33.0	39.6	42.6	41.3	34.4	28.1	20.3	14.4	27.5
Ave Tot. Precip. (in.)	0.64	0.47	0.85	1.36	2.26	2.49	1.25	1.51	1.31	1.08	0.72	0.64	14.5
Ave. Snowfall (in.)	8.9	5.4	7.2	4.4	1.3	0.0	0.0	0.0	0.2	1.2	5.0	5.6	39.3
Ave Snow Depth (in.)	3	3	1	0	0	0	0	0	0	0	1	2	1
Philipsburg, Montana (246470) Period of Record : 9/16/1903 to 10/12/1955													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave. Max. Temp (F)	30.8	35.2	42.2	53.7	61.6	69.3	80.5	79.2	68.7	57.4	43.5	33.9	54.7
Ave. Min. Temp. (F)	11.7	14.6	19.8	27.0	33.3	39.1	43.8	41.9	35.5	28.9	21.5	15.5	27.7
Ave Tot. Precip. (in.)	0.81	0.78	1.03	1.30	2.15	2.82	1.34	1.03	1.40	1.00	0.81	0.68	15.17
Ave. Snowfall (in.)	9.7	9.6	11.4	8.8	5.9	1.5	0.0	0.2	1.2	4.0	8.0	8.2	68.6
Ave Snow Depth (in.)	3	3	1	0	0	0	0	0	0	0	1	2	1

2.1.3 Hydrology

2.1.3.1 Surface Water

Flint Creek drains from Georgetown Lake to the Clark Fork River near Drummond, a distance of approximately 36 miles. Flint Creek hydrography is illustrated on **Figure A-6** in **Appendix A**.

Flint Creek has three significant tributaries: Fred Burr Creek, Boulder Creek and Lower Willow Creek. Fred Burr Creek enters Flint Creek in the Philipsburg Valley, while Boulder and Lower Willow Creeks join Flint Creek in the Drummond Valley. Interbasin diversion to Trout Creek (described below) has significantly increased flow in that tributary, which drains into Flint Creek in the Philipsburg Valley. Flow in Flint Creek can also be augmented by inter-basin diversion from Silver Lake to Georgetown Lake. The Silver Lake – Georgetown Lake diversion can be reversed (Kendy and Tresch, 1996). Flow from Silver Lake drains to Warm Springs Creek, which meets the Clark Fork River in the Deer Lodge valley.

One hundred forty five lakes are present in the TPA (Montana Department of Natural Resources and Conservation, 2007). Of these, only 22 are large enough to be named. The largest are reservoirs (described below). The other named lakes are generally tarns present in the higher portions of the Flint Creek range, particularly in the upper Boulder Creek watershed.

Impoundments

Two impoundments are located within the watershed: Georgetown Lake (31,000 acre-feet) and Lower Willow Creek Reservoir (4,800 acre-feet). Georgetown Lake was created for hydroelectric power in 1900 by flooding Georgetown Flat (Montana Department of Environmental Quality, 1998). A third impoundment, the East Fork Rock Creek Reservoir (16,000 acre-feet), is within the adjacent Rock Creek watershed but stores water for agricultural use within the Flint Creek watershed. Water from this reservoir is diverted to the Flint Creek basin via the Flint Creek Main Canal, built in 1938. This canal drains to Trout Creek, a tributary of Flint Creek (Voeller and Waren, 1997).

Stream Gauging Stations

The United States Geological Survey (USGS) and DNRC maintain(ed) 11 gauging stations within the watershed (**Table 2-3**). Recent funding limitations have reduced the gauging network in this watershed. The Flint Creek near Drummond station was deactivated in 2004. The Flint Creek at Maxville and Boulder Creek at Maxville stations were converted to seasonal operations in November 2006. The USGS stations are situated on stream, while the DNRC stations are situated on canals and diversions to measure irrigation withdrawals. The USGS gauging stations are shown on **Figure A-6** in **Appendix A**.

Table 2-3. Stream Gages

Name	Number	Drainage Area	Agency	Period of Record
Flint Creek near Southern Cross	12325500	53 miles^2	USGS	1940-
Flint Creek Main Canal below Headgate	76E 02000	—	DNRC	1961-1980, 1982-
Flint Creek Main Canal below County Bridge	76GJ02089	—	DNRC	1961-1980, 1982-
Marshal Canal below Headgate	76GJ04000	—	DNRC	1961-1980, 1982-
Trout Creek below Marshal Canal Diversion	76GJ05000	—	DNRC	1961-1980, 1982-
Fred Burr Creek near Philipsburg	12327100	15.7 miles^2	USGS	1994-1996
Flint Creek at Maxville	12329500	208 miles^2	USGS	1942-
Boulder Creek at Maxville	12330000	71 miles^2	USGS	1940-
Allendale Canal below Headgate	76GJ08000	—	DNRC	1961-
Allendale Canal above Tail End	76GJ08080	—	DNRC	1961-1985, 1987-
Flint Creek near Drummond	12331500	490 miles^2	USGS	1991-2002, 2003-2004

Streamflow

Streamflow data is based on records from the USGS stream gages described above, and is available on the Internet from the USGS (2007). Flows in Flint Creek and its tributaries vary considerably over a calendar year. Hydrographs from stations at Flint Creek near Southern Cross (2007-2011), Flint Creek at Maxville (2007-2011), Boulder Creek at Maxville (2007-2011), Fred Burr Creek near Philipsburg (1994-1996), and Flint Creek near Drummond (2007-2011) are attached in **Appendix B**. Due to data gaps as described above, the date ranges for each hydrograph are not identical.

In the tributaries, peak discharges statistically occur in June, with a steadily declining flow to September, and then a slight increase in flow occurring in the fall; after which flows decline again gradually to a low flow condition through much of the winter until spring runoff. These patterns may in part relate to

irrigation practices, with the flows declining steadily through summer as water is used to irrigate hayfields, and then, when fall comes the slight increase, or bump, in the hydrograph may illustrate the discontinuing of irrigation and/or irrigation returns at this time.

The hydrographs from Flint Creek exhibit a slightly different pattern, with a decline from peak flow being much more gradual and even plateauing through some summer months. These somewhat unusual extended high flows and prolonged decline of the hydrograph may reflect the dam management of water releases from Georgetown Lake, coupled with the influence of irrigation practices in the valley.

Annual peak discharge at Flint Creek near Southern Cross occurs over a wider range of dates than at the other gauging stations. Annual peak discharges were recorded in all months except January, March and April. The maximum peak discharge occurred on June 15, 2008 at 192 cfs. 2011 peak discharge occurred on July 4, at 177 cfs. USGS statistics show that the average low flow (over 68 years) is roughly 15 cfs.

The four highest recorded discharges at Flint Creek near Maxville probably represent rain-on-snow events. These discharges were 1,680 cfs (March 28, 1943); 1,280 cfs (April 17, 1948); 1,040 cfs (February 9, 1996); and 900 cfs (February 24, 1986). The maximum peak discharge in 2011 was 567 cfs on June 8.The lowest annual peak discharge measured at this station was 159 cfs (May 30, 1992). Peak annual discharge was measured prior to May 1 in 20 of the 57 years on record. Peak annual discharges were recorded 9 times in March, 5 times in February, 3 times in January and 3 times in April. The lowest flow recorded in 2011 was on October 29 (25 cfs), although USGS statistics report that the average low flow (based on 70 years) is 53 cfs.

Peak annual discharge in Boulder Creek (measured at Maxville) has ranged from 117 cfs (May 25, 1977) to 1,580 cfs (June 8, 2011). All annual peak discharges measured from Boulder Creek have occurred in May or June, with the exception of April 30, 1987. The lowest daily average flow measured was 2.8 cfs on October 13, 1991. The lowest daily average in 2011 was 20, on December 31.

Voeller and Waren (1997) summarized the average total annual discharge of Flint Creek and its tributary streams. Spring Creek, at the head of the Philipsburg Valley, contributes approximately 2,500 acre-feet annually (one acre-foot equals 43,560 cubic feet). Trout Creek has a natural average flow of 3,000 acre-feet annually, but this is considerably increased by the East Fork Rock Creek diversion. Fred Burr Creek's annual average flow is roughly 7,000 acre-feet. Total flow from the Philipsburg Valley via Flint Creek is roughly 70,800 acre-feet annually, as measured by the stream gage at Maxville. Average annual runoff from the Boulder Creek drainage is 32,900 acre-feet. Smart Creek and Douglas Creek contribute average annual flows of 3,500 acre-feet and 4,500 acre-feet, respectively. Lower Willow Creek Reservoir stores 4,800 acre-feet of spring runoff for later agricultural use. Barnes Creek contributes an average 3,500 acre-feet annually.

Rodeo Ground Spring, located near Drummond, flows directly into the Clark Fork River. The spring exists due to Flint Creek return flows (Voeller and Waren, 1997).

The Flint Creek near Drummond (12331500) stream gage does not record total basin outflow. Flood irrigation diversions that enter the Clark Fork River as springs or return flow bypass this stream gage. Voeller and Waren (1997) estimated that the total basin outflow was underrepresented by 35 cubic feet per second (cfs) from July 1 through September 30, and by 20 cfs in all other months.

2.1.3.2 Groundwater

Hydrogeology

Two distinct basins comprise the TPA. Groundwater flow within these valleys is typical of intermontane basins. Groundwater flows towards the center of the basin from the head and sides, and then down valley along the central axis.

The hydrogeology of the lower portion of the TPA is described in Kendy and Tresch (1996), in discussion of the Upper Clark Fork River basin. The Montana Department of Natural Resources Conservation (DNRC) completed a study on irrigation return flow in the Flint Creek watershed (Voeller and Waren, 1997). This report describes the geology, hydrogeology and hydrology of the Philipsburg and Drummond valleys in considerable detail.

While the bedrock surrounding the valleys hosts groundwater, Voeller and Waren studied only the valley aquifers and assumed that the bedrock-sediment interfaces at the valley margins are flow barriers. This is valid for the purposes of their study, and the average groundwater flow velocity in the bedrock is probably several orders of magnitude lower than in the valley fill sediments. However, carbonate and siliciclastic sedimentary rocks in the mountains may have zones of significant permeability. The hydrologic role of the structural geology (faults and folds) is uncertain. Faults may act as flow conduits or flow barriers. No studies of the bedrock hydrogeology were identified.
Natural recharge occurs from infiltration of precipitation, stream loss and flow out of the adjacent bedrock aquifers. Flood irrigation is a major source of recharge to the valley aquifers, particularly on the benches that flank the modern floodplain.

The canyon between the Philipsburg and Drummond Valleys is presumed to act as a groundwater bottleneck. Voeller and Waren (1997) assumed that all water leaving the Philipsburg basin does so as surface water in Flint Creek (and therefore measurable at the Flint Creek at Maxville stream gage). They made no mention of hyporheic water in streambed sediments, which would presumably represent a marginal increase in the total basin discharge.

Groundwater Quality

The Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center (GWIC) program monitors and samples a statewide network of wells (Montana Bureau of Mines and Geology, 2007). Additionally, the GWIC program is engaged in a statewide characterization of aquifers and groundwater resources, by region. The TPA is in Region 5, the Upper Clark Fork River basin.

As of January 2007, the GWIC database reports 1,111 wells within the TPA (Montana Department of Natural Resources and Conservation, 2007). Water quality data is available for 42 of those wells. Of these wells, 24 are in the Philipsburg Valley, and 18 are in the Drummond Valley. The locations of these data points are shown on **Figure A-7** in **Appendix A**.

The water quality data include general physical parameters: temperature, pH and specific conductance, in addition to inorganic chemistry (common ions, metals and trace elements). MBMG does not analyze groundwater samples for organic compounds. Groundwater quality data is available from the GWIC database. Data from groundwater sampling sites within the Flint Creek watershed have also been retrieved and included with the DEQ TMDL development files.

A review of GWIC data reports for agricultural chemical monitoring programs did not yield any data points for Granite County.

There are 15 public water supplies within the TPA. The majority of these are small transient, non-community systems (*i.e.* that serve a dynamic population of more than 25 persons daily) located around Georgetown Lake. The Town of Philipsburg uses surface water; all other public water supplies in the TPA utilize groundwater. Water quality data is available from these utilities via the SDWIS State database (Water Quality Bureau, Environmental Sciences Division, Montana State Department of Health and Environmental Sciences, 2007), although the data reflect the finished water provided to users, not raw water at the source.

2.1.4 Geology and Soils

Figure A-8 in **Appendix A** provides an overview of the geology, based on the most recent geologic map of the Butte 1° x 2° quadrangle (Lewis, 1998). Description of the geology is derived from more recent, larger-scale mapping projects. The geology of selected areas of the TPA has been described and mapped in detail by Portner and Hendrix (2005) and Lonn *et al*. (2003). The geology of the Flint Creek area is complex, and has been subjected to considerable reinterpretation in recent years. Much of the recent debate is beyond the scope of this characterization. In summary, recognition of the Anaconda metamorphic core complex (O'Neill et al., 2002), led to the interpretation that the major folds and faults of the Flint Creek Range were produced by extensional and compressional forces.

In general, the TPA encompasses fault-bounded valleys and the bedrock mountains that surround them. At the eastern edge of the Philipsburg Valley, the Philipsburg-Georgetown Thrust defines the eastern edge of a structural unit formerly called the Sapphire Block (no longer considered an intact body), which extends west to the Bitterroot detachment fault (Lonn et al., 2003). This structural unit was also been referred to as the Western Structural Block.

Bedrock

The 'Sapphire Block' includes the John Long Mountains, which separate the Flint Creek and Rock Creek watersheds. Like the Sapphire Mountains, the John Long Mountains are composed of Middle Proterozoic (~1.5 billion years old) Belt Supergroup rocks. These rocks are interpreted as passive margin deposits, and the dominant lithologies are siltstone, sandstone and limestone (and their metamorphic equivalents). Volcanics of Tertiary age are also present, including the Rock Creek volcanic field (in the adjacent watershed), a rhyolitic flow believed to be the source of the eponymous sapphires. These rocks are less resistant than the granitic rocks in surrounding mountain ranges, giving the Sapphire and John Long ranges their subdued topography and lower elevations.

The Flint Creek Range is composed of folded and faulted sedimentary rocks ranging in age from Cambrian (540 million years ago) through Cretaceous (65 million years ago), with overthrusts of Belt Supergroup rocks mapped in places. Cretaceous rocks are the most extensive sedimentary rocks; Portner and Hendrix (2005) report that the Cretaceous section in the northern Flint Creek range is one of the thickest in Montana. The Cretaceous sediments are predominantly fine-grained rocks such as siltstones and shales.

This package of sedimentary rocks has been intruded by several generations of Cretaceous and Tertiary igneous rocks. The range is cored by the Philipsburg pluton, a body of resistant Cretaceous granodiorite that holds up the higher peaks. Metamorphism and hydrothermal activity associated with these rocks produced ores that made Philipsburg a significant silver mining district. Pleistocene glaciation sculpted the Flint Creek range, producing the rugged alpine geomorphology.

Basin Sediments

In the Northern Rockies, the Tertiary is generally characterized as a time of basin filling, followed by renewed uplift, stream erosion and downcutting in the Quaternary. The basins are filled with several thousand feet of Tertiary basin-fill sediments, with a veneer of overlying Quaternary deposits. Stalker and Sherriff (2004) estimate the Tertiary rocks reach a maximum of 4,000 feet thick in the center of the Flint Creek basin (Drummond Valley). Large-scale mapping of the unconsolidated sediments is not available, although cross-sections were prepared by Voeller and Waren (1997). Quaternary sediments include fluvial, colluvial, glacial and proglacial deposits. The lower portion of the Drummond Valley was inundated by Glacial Lake Missoula, and lacustrine sediments are likely.

Voeller and Waren (1997) reported that the upper several hundred feet of basin sediments are dominated by shale and clay. Coarse-grained sediments are limited, generally occurring as alluvium or gravel caps on benches.

The benches above the modern alluvial valley are generally capped by a coarsening-upward sequence of 15-20 feet of sandy or gravelly sediment. In their review of well logs across the watershed, Voeller and Waren (1997) identified a common sequence of shale at depth, commonly overlain by up to 100 feet of clay, with silty sand, gravel and cobble deposits at the surface. A bouldery debris-flow deposit (Beaty, 1961) just north of the [Boulder Creek] canyon mouth is up to 50 feet thick, and hosts a gravel pit (Voeller and Waren, 1997).

Glacial History

The glacial history of the watershed is presumably similar to that of the rest of the Central and Northern Rockies, although no detailed studies were identified. While evidence of earlier glaciations (before 150,000 years ago) is not well-preserved, there is widespread evidence for two recent episodes of significant glacial activity. The earlier (Bull Lake) is generally dated to ~130,000 years ago, and the later (Pinedale) to 23,000 – 16,000 years ago (Chadwick et al., 1997; Pierce et al., 1976). The dates are general; alpine glacial activity varied somewhat according to elevation and other local variables. Each period of glaciation included multiple advances and retreats.

In the absence of detailed Quaternary mapping, discussion of the glacial history is based on aerial photograph interpretation. Bull Lake -aged features are subdued and indistinct, due to their long exposure to weathering. Pinedale -aged features are much easier to identify. The Fred Burr drainage displays distinctive glacial morphology. The valley is a classic U-shaped glacial trough, and a prominent terminal moraine is present just beyond the valley's mouth. A broad sheet of glacial outwash extends northwestward towards Flint Creek. Fred Burr Creek has incised this deposit.

The Fred Burr glacier is the only valley glacier that extended to the basin floor, and this is the only moraine mapped in the TPA by Alden (1953). The Boulder Creek valley and several of its tributaries were also glaciated, but the (Pinedale-aged) glacier terminated near Princeton Gulch, and did not reach the Drummond Valley. Beaty (1961) reports "stranded lateral moraines from an earlier glaciation" along the walls of the canyon as far as its mouth, but notes that the canyon morphology is inconsistent with recent glaciation.

Soils

The USGS Water Resources Division (Schwartz and Alexander, 1995) created a dataset of hydrology-relevant soil attributes, based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil

database. The STATSGO data is intended for small-scale (watershed or larger) mapping, and is too general to be used at scales larger than 1:250,000. It is important to realize, therefore, that each soil unit in the STATSGO data may include up to 21 soil components. Soil analysis at a larger scale should use NRCS SSURGO data. The soil attributes considered in this characterization are erodibility and slope. Soil erodibility is based on the Universal Soil Loss Equation (USLE) K-factor (Wischmeier and Smith, 1978). 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 A-9 (Appendix A)**, with soil units assigned to the following ranges: low (0.0-0.2), moderate-low (0.2-0.29) and moderate-high (0.3-0.4). Values of >0.4 are considered highly susceptible to erosion. No values greater than 0.4 are mapped in the TPA.

Several patterns are apparent in the distribution of mapped K-factors. The low and moderate-to-low susceptibility soils correspond to timbered uplands, and moderate-to-high susceptibility soils are confined to the valleys. Moderate-to-high susceptibility soils coincide with areas where Tertiary sediments are mapped, and the Quaternary alluvial valleys incised into these deposits generally have moderate-to-low susceptibility. The majority of the low-susceptibility soils coincide with the granitic rocks of the Philipsburg pluton. A smaller area of low K-factor soils occurs in a band at the southwestern margin of the Drummond Valley, against the foot of the John Long Mountains. The geology of this area is mapped as Tertiary sediments (**Appendix A**, **Figure A-9**). These may correspond to gravelly fanglomerate deposits; available geologic maps are of insufficient resolution to differentiate these deposits from the other Tertiary deposits.

The majority of the soil units within the watershed are mapped with slopes ranging from 21°-34°. The alluvium alongside Flint Creek in the Philipsburg valley has a slope of 1.2°. Much of the Drummond Valley (corresponding to the gravel benches) has slopes of 1.2°-21°.

A map of soil slope is provided on **Figure A-10 (Appendix A)**.

2.2 ECOLOGICAL PROFILE

The following information describes the ecological profile of the Flint Creek watershed.

2.2.1 Vegetation

The primary cover in the uplands is conifer forest. Conifers are dominated by Lodgepole pine, giving way to Douglas fir at lower elevations. The valleys are characterized by grassland and irrigated agricultural land, with minor shrublands. Landcover is shown on **Figures A-11 and A-12** in **Appendix A**. Data sources include the University of Montana's Satellite Imagery land Cover (SILC) project (University of Montana, 2002), and USGS National Land Cover Dataset (NLCD) mapping (Montana State Library, 1992).

2.2.2 Aquatic Life

Native fish species present in the TPA include: bull trout, westslope cutthroat trout, mountain whitefish, largescale sucker and longnose sucker. Native redside shiner are present in Georgetown and Echo lakes. Bull trout and westslope cutthroat trout are designated "Species of Concern" by Montana Department of Fish, Wildlife and Parks (FWP). Bull trout are further listed as "threatened" by the US Fish and Wildlife Service (US FWS). Reaches of Flint and Fred Burr Creeks have been designated as critical habitat for bull trout (50 CFR Part 17 (2005)).

As mapped by FWP, bull trout and western cutthroat trout inhabit different portions of the Flint Creek watershed. Bull trout are mapped along the full length of Flint Creek, and in its tributaries of Marshall Creek and Boulder Creek. A small (0.05 mile) length of Fred Burr Creek is mapped with bull trout. Bull trout are not mapped in any tributaries of Boulder Creek. Bull trout are not present in Lower Willow Creek or its tributaries. Westslope cutthroat trout are not present in Flint Creek, but are mapped in its tributary drainages, and in the tributaries of Lower Willow Creek and Boulder Creek.

Introduced species are also present, including: brook, rainbow and brown trout, and kokanee salmon. Additionally, Yellowstone cutthroat trout are reported in Middle Altoona and Lower Boulder Lakes, seemingly beyond their native range.

Data on fish species distribution is collected, maintained and provided by FWP (2006). Fish species distribution is shown on **Figure A-13 (Appendix A)** and tabulated in **Appendix B**.

2.2.3 Fires

One significant burn is mapped within the TPA (University of Montana, 2002), stretching from South Fork Lower Willow Creek to Smart Creek (**Appendix A**, **Figure A-14**). Aerial photographs taken in July 2005 reveal that vegetation is returning to this area. Abundant roads suggest that this area experienced a timber harvest either pre- or post-fire.

The United States Forest Service (USFS) remote sensing applications center provides data on fire locations from 2001 to the present (**Appendix A**, **Figure A-14**). No fires from 2001 or 2002 are mapped within the TPA (U.S. Forest Service, 2006). Isolated fires are mapped from 2003 to 2006, mostly on the western flanks of the Flint Creek range. These are difficult to identify as burned areas on aerial photographs. In general, the TPA has not experienced significant burns in recent years.

2.3 SOCIAL PROFILE

The following information describes the social profile of the Flint Creek watershed.

2.3.1 Population

An estimated 1,951 persons lived within the TPA in 2000. This is an increase of 16% from an estimated 1,682 in 1990. Population estimates are derived from census data (United States Census Bureau, 2000), with spatial analysis of census blocks performed by NRIS' thematic mapper (Montana Department of Natural Resources and Conservation, 2007). The denser populations are located along Montana Highway 1, which links Georgetown Lake with the towns of Philipsburg, Maxville, Hall and Drummond.

2.3.2 Transportation Networks

Roads

The principal transportation route in the TPA is Montana Highway 1. Highway 1 connects Anaconda to Drummond, via Georgetown Lake and Philipsburg. An estimated 613 miles of paved roadways were present in 2000 (Montana Department of Natural Resources and Conservation, 2007). The network of unpaved roads on public and private lands will be further characterized as part of the source assessment.

Railroads

No active railways are present in the TPA. Montana Rail Link maintains 32 miles of railroad rights-of-way in the TPA (Montana Department of Natural Resources and Conservation, 2007). During the peak years of mining and milling, a rail line connected Philipsburg to Drummond, with a spur extending up Douglas Creek.

2.3.3 Land Ownership

Slightly more than one-half of the TPA is under private ownership. The dominant landholder is the USFS, which administers 42.5% of the TPA (**Table 2-4**). There is a distinct pattern of ownership, with private land concentrated in the basins and USFS land concentrated in the uplands (**Appendix A**, **Figure A-15**).

Table 2-4. Land Ownership

Owner	Acres	Square Miles	% of Total
Private	165,387	258.4	51.9%
US Forest Service	135,334	211.5	42.5%
US Bureau of Land Management	8,538	13.3	2.7%
State Trust Land	5,764	9.0	1.8%
Other State Land	333	0.5	0.1%
Water	3,180	5.0	1.0%
Total	318,537	497.7	—

2.3.4 Land Use

Land use within the TPA is dominated by forest and agriculture. Agriculture in the valley is primarily related to the cattle industry: irrigated hay and dry grazing (**Table 2-5**). Information on land use is based on the National Land Cover Dataset (NLCD), from mapping completed by the USGS circa 1992. Land use categories are based on a combination of observed existing land use and existing land cover vegetation analysis. The data is at 1:250,000 scale. Census trends from 1990 to 2000 (described above) suggest that the percentage of residential use has probably increased, but aerial photographs from 2005 show that the watershed is still relatively sparsely populated. Agricultural land use is illustrated on **Figure A-16 (Appendix A)**. Potential sources of human impacts (abandoned mines, livestock feeding areas, and MPDES-permitted discharge sites) are illustrated on **Figure A-17 (Appendix A)**.

Table 2-5. Land Use

Land Use	Acres	Square Miles	% of Total
Evergreen Forest	170,033	265.7	53.4%
Mixed Rangeland	72,183	112.8	22.7%
Crop/Pasture	38,119	59.6	12.0%
Brush Rangeland	14,125	22.1	4.4%
Grass Rangeland	7,500	11.7	2.4%
Deciduous Forest	5,748	9.0	1.8%
Exposed Rock	3,832	6.0	1.2%
Reservoir	2,816	4.4	0.88%
Mixed Forest	1,836	2.9	0.58%
Residential	743	1.2	0.23%
Mine/Quarry	657	1.0	0.21%
Lake	229	0.4	0.072%
Wetland (Existing Woody and/or Emergent Herbaceous Wetland Vegetation)	142	0.2	0.045%

Table 2-5. Land Use

Land Use	Acres	Square Miles	% of Total
Mixed Urban	128	0.2	0.040%
Transportation/Utilities	93	0.1	0.029%
Other Urban	63	0.1	0.020%
Other Agriculture	54	0.1	0.017%
Commercial	51	0.1	0.016%

Information on agricultural land use can be obtained from Department of Revenue data. Nearly 16,000 acres of irrigated land is reported in the TPA. Voeller and Waren (1997) found that a detailed survey of irrigated acreage in a 1959 report prepared by the State Engineer's Office (now DNRC) was still relevant in the mid-1990s. According to this data, 8,200 acres are irrigated in the Philipsburg Valley, and 17,000 acres in the Drummond Valley. Despite the age of the data, these numbers are probably more realistic than the Department of Revenue data, which assigns an agricultural use only if more than 50% of a given parcel is so used. Irrigation infrastructure includes interbasin diversions and impoundments as described above in **Section 2.1.3**.

Mining

The Flint Creek TPA was the scene of considerable mining activity. Like many other mining districts, much of the metal production began with gold placers. Lode mines, particularly silver, and eventually tungsten, manganese and phosphate, came to be of particular importance. The Philipsburg district was a major silver producer, and the hills east of Philipsburg exhibit the highest density of abandoned mine sites (Water Quality Bureau, Environmental Sciences Division, Montana State Department of Health and Environmental Sciences, 2007). MBMG completed an environmental survey of 119 abandoned mining sites in the Flint Creek and Rock Creek watersheds in the mid-1990s (Metesh et al., 1995). The study was limited to sites on Deer Lodge National Forest property.

Milling was performed at many locations within the TPA, both in Philipsburg and at many of the now abandoned mining camps. Waste rock and tailings are still present in many locations. DEQ Remediation Division data on abandoned mine locations are plotted on **Figure A-17 (Appendix A)**. No active mines are present as of early 2007, according to DEQ Environmental Management Bureau files.

Livestock Operations

The Montana Pollution Discharge Elimination System (MPDES) does not include any regulated concentrated animal feeding operations (CAFOs) within the Flint Creek watershed. From interpretation of aerial photographs, DEQ identified 12 denuded areas that are probable livestock operations (**Appendix A**, **Figure A-17**). Four of these locations are directly adjacent to surface waterbodies. DEQ Water Protection Bureau personnel have yet to determine whether any of these sites meet the definitions of a CAFO.

Wastewater

One municipal wastewater system is located within the TPA. The town of Philipsburg is sewered, and the wastewater lagoons are located northwest of town, adjacent to Flint Creek. This discharge location is shown on **Figure A-17 (Appendix A)**.

Septic system density is estimated from the 2000 census block data, based on the assumption that one septic tank and drainfield is installed for each 2.5 persons (Montana Department of Natural Resources and Conservation, 2007). Septic system density is classified as low (<50 per square mile), moderate (51-

300 per square mile) or high (>300 per square mile). Nearly all of the TPA is mapped as low septic system density, with very limited areas of moderate (347 acres) and high (2 acres) density. The moderate density locations are found primarily around Georgetown Lake, outside Philipsburg, and in and around Maxville. The high density areas are limited to two ~1 acre areas south and east of Georgetown Lake. Septic system density is illustrated on **Figure A-17 (Appendix A)**.

3.0 MONTANA WATER QUALITY STANDARDS

The federal Clean Water Act provides for the restoration and maintenance of the chemical, physical, and biological integrity of the nation'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 include four main parts:

1. Stream classifications and designated uses
2. Numeric and narrative water quality criteria designed to protect designated uses
3. Nondegradation provisions for existing high-quality waters
4. Prohibitions of practices that degrade water quality

Those components that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards that apply to the Flint Creek TPA streams can be found **Appendix C**.

3.1 FLINT CREEK TPA STREAM CLASSIFICATIONS AND DESIGNATED BENEFICIAL USES

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. All streams identified in this document within the Flint Creek watershed are classified as B-1, which specifies that the water must be maintained suitable to support all of the following uses:

- 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
- Agricultural and industrial waters supply

While some of the waterbodies might not actually be used for a designated use (e.g., drinking water supply), their 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 C**.

Twelve waterbodies or waterbody segments in the Flint Creek TPA are listed in the "2012 Water Quality Integrated Report" as not supporting or partially supporting one or more designated uses (**Table 3-1**). In the course of investigations related to the development of this document, Douglas Creek (Hall), and Princeton Gulch were found to be currently supporting their designated uses, whereas Royal Gold Creek, which was not previously assessed, was found to be "not supporting" due to Copper and Lead impairments. Waterbodies that are "not supporting" or "partially supporting" a designated use are impaired and require a TMDL. When TMDLs are written, they are written to protect all designated uses for a waterbody and not just those identified as being not or partially supported. DEQ describes impairment as either partially supporting or not supporting, based on assessment results. Not supporting is applied to not meeting a drinking water standard, and is also applied to conditions where the assessment results indicate a severe level of impairment of aquatic life or coldwater fishery. A non-supporting level of impairment does not equate to complete elimination of the use. Detailed information about Montana's use support categories can be found in **Appendix A** of Montana's Water

Quality Integrated Report (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2010).

Table 3-1. Impaired Waterbodies and their Designated Use Support Status on the "2012 Water Quality Integrated Report" in the Flint Creek TPA

Waterbody & Location Description	Waterbody ID	Use Class	Agriculture	Aquatic Life	Drinking Water	Primary Contact Recreation
Upper Flint Creek, Georgetown Lake to Boulder Creek	MT76E003_011	B-1	F	N	N	P
Lower Flint Creek, Boulder Creek to mouth (Clark Fork River)	MT76E003_012	B-1	F	N	N	P
Barnes Creek, headwaters to mouth (Flint Creek)	MT76E003_070	B-1	P	P	P	P
Boulder Creek, headwaters to mouth (Flint Creek)	MT76E003_060	B-1	F	P	N	X
Camp Creek, headwaters to mouth (Flint Creek)	MT76E003_130	B-1	F	N	F	N
Douglas Creek (Hall), confluence of Middle and South Forks to mouth (Flint Creek), T9N R13W S10	MT76E003_020	B-1	F	P	X	F
Douglas Creek (Philipsburg), headwaters to where stream ends, T7N R14W S25	MT76E003_100	B-1	P	N	N	P
North Fork Douglas Creek, headwaters to mouth (Douglas Creek)	MT76E003_030	B-1	P	N	N	X
Fred Burr Creek, Fred Burr Lake to mouth (Flint Creek)	MT76E003_040	B-1	F	N	N	F
Smart Creek, headwaters to mouth (Flint Creek), T9N R13W S21	MT76E003_110	B-1	F	P	F	F
South Fork Lower Willow Creek, headwaters to mouth (Lower Willow Creek)	MT76E003_050	B-1	F	N	N	X
Princeton Gulch, headwaters to mouth (Boulder Creek)	MT76E003_090	B-1	F	P	X	X

3.2 FLINT CREEK TPA WATER QUALITY STANDARDS

In addition to the use classifications described above, Montana's water quality standards include numeric and narrative criteria that protect the designated uses. Numeric criteria define the allowable concentrations of specific pollutants so as not to impair designated uses. Narrative criteria are more "free from" descriptions, or statements, of unacceptable conditions. **Appendix C** defines both the numeric and narrative water quality criteria for the Flint Creek TPA. For the sediment and metals TMDL development in the Flint Creek TPA the narrative standards are applicable to sediment impairments, and numeric standards are applicable to metals impairments.

Numeric standards apply to pollutants that are known to have adverse effects on human health or aquatic life (e.g., metals, organic chemicals, and other toxic constituents). Human health standards are

set at levels that protect against long-term (lifelong) exposure, as well as short-term exposure through direct contact such as swimming. Numeric standards for aquatic life include chronic and acute values. Chronic aquatic life standards prevent long-term, low level exposure to pollutants. Acute aquatic life standards protect from short-term exposure to pollutants. Chronic standards are usually more stringent than acute standards.

Narrative standards are developed when there is insufficient information to develop specific numeric standards. Narrative standards describe either the allowable condition or an allowable increase of a pollutant above "naturally occurring" conditions. DEQ uses the naturally occurring condition, called a "reference condition," to determine whether or not narrative standards are being met (see **Appendix C**).

Reference defines the condition a waterbody could attain if all reasonable land, soil, and water conservation practices were put in place. Reasonable land, soil, and water conservation practices usually include, but are not limited to, best management practices (BMPs).

The specific water quality standards that apply to the Flint Creek TPA are summarized in **Appendix C**.

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.

- Pollutant sources are generally defined as two categories: point sources and nonpoint sources. Point sources are discernible, confined and discrete conveyances, such as pipes, ditches, wells, containers, or concentrated animal feeding operations, from which pollutants are being, or may be, discharged. Some sources such as return flows from irrigated agriculture are not included in this definition. All other pollutant loading sources are considered nonpoint sources. Nonpoint sources are diffuse and are typically associated with runoff, streambank erosion, most agricultural activities, atmospheric deposition, and groundwater seepage. Natural background loading is a type of nonpoint source.

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, where:

ΣWLA is the sum of the wasteload allocation(s) (point sources)
ΣLA is the sum of the load allocation(s) (nonpoint sources)

TMDL development must include a margin of safety (MOS), which can be explicitly incorporated into the above equation. Alternatively, the MOS can be implicit in the TMDL. 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., pollutant loading or use protection).

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.

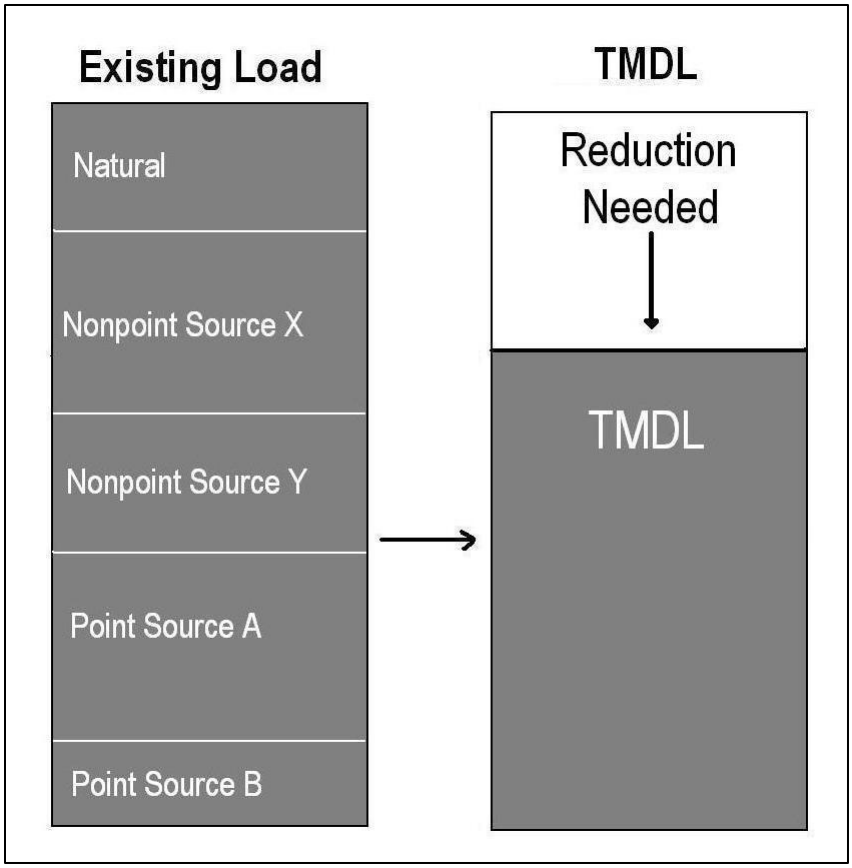


Figure 4-1. Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

TMDL water quality targets are a translation of the applicable numeric or narrative water quality standard(s) for each pollutant. 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 waterbody-specific interpretation of the narrative standard(s).

Water quality targets are typically developed for multiple parameters that link directly to the impaired beneficial use(s) and applicable water quality standard(s). Therefore, the targets provide a benchmark by which to evaluate attainment of water quality standards. Furthermore, 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

All significant pollutant sources, including natural background loading, are quantified 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 must include 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.

A pollutant load is usually quantified for each point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Nonpoint sources are quantified by source categories

(e.g., unpaved roads) and/or by land uses (e.g., grazing or forestry). These source categories and land uses can be divided further by ownership, such as federal, state, or private. Alternatively, most, or all, pollutant sources in a sub-watershed or source area can be combined for quantification purposes.

Because all potentially significant sources of the water quality problems must be evaluated, source assessments are conducted on a watershed scale. The source quantification approach may produce reasonably accurate estimates or gross allotments, depending on the data available and the techniques used for predicting the loading (40 CFR Section 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.

4.3 ESTABLISHING THE TOTAL ALLOWABLE LOAD

Identifying the TMDL requires a determination of the total allowable load over the appropriate time period necessary to comply with the applicable water quality standard(s). Although "TMDL" implies "daily load," determining a daily loading 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.

If 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 same approach can be applied when a numeric target is developed to interpret a narrative standard.

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. In addition to basic technical and environmental analysis, DEQ also considers economic and social costs and benefits when developing allocations. The allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices and other reasonable conservation practices.

Under the current regulatory framework (40 CFR 130.2) for developing TMDLs, flexibility is allowed in allocations in that "TMDLs can be expressed in terms of either mass per time, toxicity, or other

appropriate measure." Allocations are typically expressed as a number, a percent reduction (from the current load), or as a surrogate measure (e.g., a percent increase in canopy density for temperature TMDLs).

Figure 4-2 illustrates how TMDLs are allocated to different sources using WLAs for point sources and LAs for natural and nonpoint sources. Although some flexibility in allocations is possible, the sum of all allocations must meet the water quality standards in all segments of the waterbody.

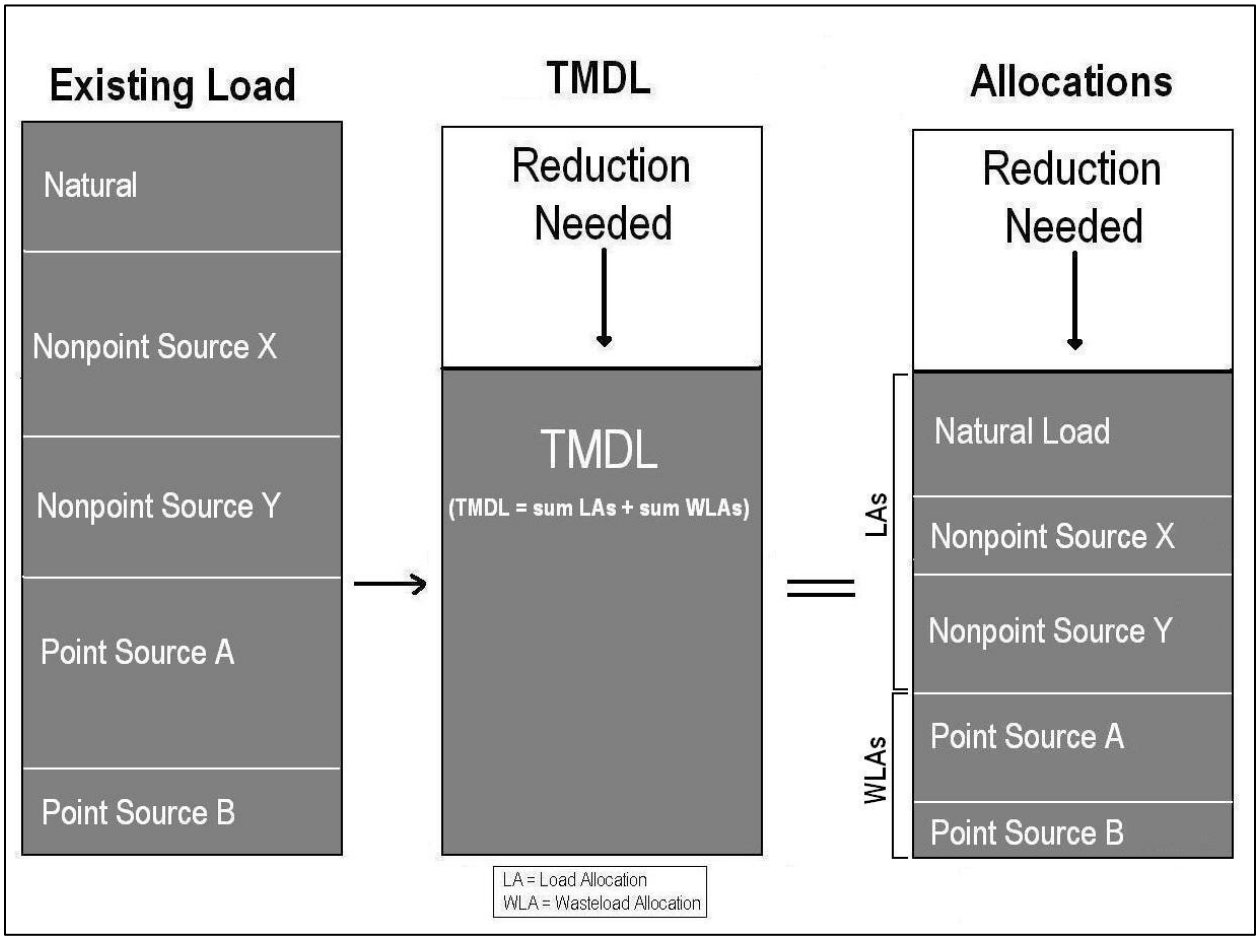


Figure 4-2. Schematic Diagram of a TMDL and its Allocations

Incorporating an MOS is required when developing TMDLs. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to support beneficial uses. 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 (U.S. Environmental Protection Agency, 1999).

For TMDLs with waters impaired by both nonpoint sources and MPDES permitted point sources, the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in situations where the point source wasteload allocation (WLA) is based on an assumption that nonpoint source load reductions will occur. In such situations (where nonpoint source load allocations (LAs) are made more stringent so that WLAs can be made less stringent), reasonable assurances that water quality standards will be achieved is needed because WLAs for permitted point

sources are implemented via incorporation into associated enforceable MPDES permits while LA implementation relies primarily on voluntary measures.

For all TMDLs (whether a combination of WLAs and LAs or only LAs), DEQ develops LAs based on a feasible scenario of nonpoint source load reductions with the LAs always set at levels that will result in achievement of the applicable water quality standard(s). To help facilitate successful implementation of LAs, this TMDL document includes strategies for implementation and monitoring, as well as details on DEQ's adaptive management approach. Although implementation of the nonpoint source controls necessary to meet the LAs is mostly via a voluntary program defined within Montana's Nonpoint Source Plan, Montana State Law requires TMDL implementation reviews, thus addressing an important component of adaptive management.

For TMDLs in this document where there is a combination of nonpoint source LAs and one or more permitted point source WLAs discharging into an impaired stream reach, the WLAs are not based on the LAs. Instead, DEQ sets the WLAs and LAs at levels necessary to achieve water quality standards throughout the watershed. Under these conditions, the LAs are developed independently of the WLA such that they would satisfy the TMDL target concentration within the stream reach immediately above the point source. In order to ensure that the water quality standard or target concentration is achieved below the point source discharge, the WLA is based on the point source's discharge concentration set equal to the standard or target concentration for each TMDL pollutant.

5.0 SEDIMENT TMDL COMPONENTS

This portion of the document focuses on sediment as an identified cause of water quality impairment in the Flint Creek TPA. It includes: 1) the mechanisms by which sediment can impair beneficial uses, 2) the specific stream segments of concern, 3) the presently available data pertaining to sediment impairment characterization in the watershed, including target development and a comparison of existing water quality to targets, 4) quantification of the various contributing sources of sediment based on recent data and studies, and 5) identification of and justification for the sediment TMDLs and the TMDL allocations.

The term sediment is used in this document to refer collectively to several closely-related factors associated with the sediment pollutant, including suspended sediment, turbidity, or alterations to habitat or channel shape and characters that may affect sediment delivery and transport, and sediment deposition on the stream bottom.

5.1 MECHANISMS OF EFFECTS OF EXCESS SEDIMENT TO BENEFICIAL USES

Sediment is a naturally occurring component of healthy and stable stream and lake ecosystems. Erosion through natural processes such as wind, water, or ice constantly supplies our waters with some amounts of sediment. Regular flooding allows sediment deposition to build floodplain soils and point bars, and it prevents excess scour of the stream channel. 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 human causes create excessive sediment loads from bank erosion or other sources on the landscape, it may alter channel form and function. These alterations may affect fish and other aquatic life by increasing turbidity and causing excess sediment to accumulate in critical aquatic habitat areas not naturally characterized by high levels of fine sediment.

More specifically, sediment may block light and cause a decline in primary production, and it may also interfere with fish and macroinvertebrate survival and reproduction. Fine sediment deposition reduces availability of suitable spawning habitat for salmonid fishes and can smother eggs or hatchlings. 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 where sediment aggrades 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 instance, high concentrations of suspended sediment in streams can also cause water to appear murky and discolored, negatively impacting recreational use, and excessive sediment can increase filtration costs for water treatment facilities that provide safe drinking water.

5.2 STREAM SEGMENTS OF CONCERN

A total of five waterbody segments in the Flint Creek TPA appeared on the 2012 Montana 303(d) List due to sediment impairments (**Table 5-1**). These include: Barnes Creek, Douglas Creek (near Philipsburg), Flint Creek (two segments), and Smart Creek. As shown in **Table 5-1**, many of the waterbodies with sediment impairments are also listed for habitat alterations, which are non-pollutant causes of impairment frequently associated with sediment. TMDLs are developed for pollutants, but

implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some non-pollutant impairment causes.

Table 5-1. Waterbody segments in the Flint Creek TPA with sediment related pollutant and pollution listings on the 2012 303(d) List

Waterbody ID	Stream Segment	2012 Probable Causes of Impairment
MT76E003_070	**BARNES CREEK**, headwaters to mouth (Flint Creek)	**Sedimentation/siltation**
MT76E003_100	**DOUGLAS CREEK,** headwaters to where stream ends (T7N R14W S25)	**Sedimentation/siltation,** *Physical substrate habitat alterations*
MT76E003_011	**FLINT CREEK**, Georgetown Lake to confluence with Boulder Creek	**Sedimentation/siltation**, *Alteration in streamside or littoral vegetation covers*
MT76E003_012	**FLINT CREEK,** Boulder Creek to mouth (Clark Fork River)	**Turbidity*,** *Alteration in streamside or littoral vegetation covers*
MT76E003_110	**SMART CREEK**, headwaters to the mouth (Flint Creek), T9N R13W S21	**Sedimentation/siltation**, *Alteration in streamside or littoral vegetation covers*

*Turbidity is a pollutant that falls within the Sediment pollutant category
Pollution listings are presented in *italics*

At the time of the 2009 field investigation, additional Flint Creek TPA streams were included for data collection and analysis as a result of their appearance on the state's list of impaired waters for non-pollutant impairment causes frequently associated with sediment. This inclusion of additional sites within the Flint Creek TPA helped provide the foundation for target development, and give a broader representation of sediment issues throughout the watershed. Additional streams included in the analysis for this report are listed in **Table 5-2**. Data for these additional streams is included in **Attachment A**.

Data from these streams were reviewed relative to sediment targets but none indicated an overwhelming link to excess sediment. Therefore, a full analysis of data for the streams in **Table 5-2** is not included within **Section 5.0** and no TMDLs were developed for these streams. However, because of the strong link between habitat and sediment impairments and the fact that all sediment sources to Flint Creek must be considered, the sediment reduction strategies discussed for the TMDL streams are also applicable to the streams in **Table 5-2** as well as other streams in the Flint Creek watershed.

Table 5-2. Additional waterbody segments in the Flint Creek TPA included for TMDL related investigation

Waterbody ID	Stream Segment	Previous Probable Causes of Impairment Listings
MT76E003_060	**BOULDER CREEK,** headwaters to mouth (Flint Creek)	*Physical substrate habitat alterations*
MT76E003_020	**DOUGLAS CREEK,** confluence of Middle and South Forks to mouth (Flint Creek) T9N R13W S10	*Physical substrate habitat alterations*
MT76E003_040	**FRED BURR CREEK,** Fred Burr Lake to mouth (Flint Creek)	*Alteration in streamside or littoral vegetative covers*
	LOWER WILLOW CREEK*	
	TROUT CREEK*	

Pollution listings are presented in *italics*
**Previously unassessed and do not currently have waterbody IDs or impairment determinations assigned to them*

5.3 INFORMATION SOURCES AND ASSESSMENT METHODS TO CHARACTERIZE SEDIMENT CONDITIONS

For TMDL development, information sources and assessment methods fall within two general categories. The first category, discussed within this section and **Section 5.4**, is focused on characterizing overall stream health with focus on sediment and related water quality conditions. The second category, discussed within **Section 5.5**, is focused on quantifying sources of sediment loading within the watershed.

5.3.1 Summary of Information Sources

To characterize sediment conditions for TMDL development purposes, a sediment data compilation was completed and additional monitoring was performed during 2009. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets.

- DEQ Assessment Files
- DEQ 2009 Sediment and Habitat Assessments
- Relevant Local and Regional Reference Data

5.3.2 DEQ Assessment Files

The DEQ assessment files contain information used to make the existing sediment impairment determinations. The files include a summary of physical, biological, and habitat data collected by DEQ on most waterbodies between 2003 and 2008 as well as other historical information collected or obtained by DEQ. The files also include information on sediment water quality characterization and potentially significant sources of sediment, as well as information on non-pollutant impairment determinations and associated rationale.

5.3.3 DEQ's 2009 Sediment and Habitat Assessments

Field measurements of channel morphology and riparian and instream habitat parameters were collected in 2009 from 24 reaches on 9 waterbodies to aid in TMDL development. (Detailed locations and further information included in **Attachment A**.)

Initially, all streams of interest underwent an aerial assessment by which reaches were characterized by four main attributes: stream order, valley gradient, valley confinement, and ecoregion. These four attributes represent main factors influencing stream morphology, which in turn influence sediment transport and deposition. These four attributes are also assumed to be unaffected by human influence.

The next step in the aerial assessment involved identification of near-stream land uses since land management practices can have a significant influence on stream morphology and sediment characteristics. The resulting product was a stratification of streams into reaches that allow for comparisons among those reaches of the same natural morphological characteristics, while also indicating stream reaches where land management practices may further influence stream morphology. The stream stratification, along with field reconnaissance, provided the basis for selecting the above-referenced monitoring reaches. Stream stratification results are included with the TMDL development files at DEQ.

Monitoring reaches were chosen with the goal of being representative of various reach characteristics, land use categories, and anthropogenic influence. However, there was a preference to ensure sampling of some reaches where anthropogenic influences would likely be apparent since it is a primary goal of

sediment TMDL development to characterize sediment impairment conditions. Thus, it is not a random sampling design intended to sample stream reaches representing all potential impairment and non-impairment conditions. Instead, it is a targeted sampling design that aims to assess a representative subset of reach types while ensuring that reaches within each [sediment] 303(d) listed waterbody with potential impairment conditions are incorporated into the overall evaluation. Typically, the effects of excess sediment are most apparent in low gradient, unconfined streams larger than 1st order (i.e. having at least one tributary); therefore, this stream type was the focus of the field effort. Although the TMDL development process necessitates this targeted sampling design, it is acknowledged that this approach results in less certainty regarding conditions in 1st order streams and higher gradient reaches, and that conditions within sampled reaches are not necessarily representative of conditions throughout the entire stream.

The field parameters assessed in 2009 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. Although the sampling areas are frequently referred to as "sites" within this document, to help increase sample sizes and capture variability within assessed streams, they were actually sampling reaches ranging from 500 to 2000 feet (depending on the channel bankfull width) that were broken into five cells. Generally, channel morphology and fine sediment measures were performed in three of the cells, and stream habitat, riparian, and bank erosion measures were performed in all cells. Field parameters are briefly described in **Section 5.4**, and summaries of all field data are contained in the 2009 monitoring summary report (**Attachment A**).

5.3.4 Relevant Local and Regional Reference Data

Relevant local and regional reference data was reviewed from Beaverhead Deerlodge National Forest (BDNF) reference sites, sites of the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) from the Pintler Ranger District in the BDNF, and results from an 2008/2009 FWP fish habitat study. The PIBO reference dataset includes USFS and BLM sites throughout the Pacific Northwest, but to increase the comparability of the data to conditions in the Flint Creek watershed, only data collected within the Pintler Ranger District were evaluated. Discussion on how reference data is used for target development and comparison of conditions is described in **Appendices C** and **D**. Locations of reference data sites is included in **Figure A-23** in **Appendix A**.

5.4 WATER QUALITY TARGETS

5.4.1 Targets

In order to determine the relative impact of sediment on a stream's beneficial uses, multiple parameters related to stream habitat and morphology are used. These parameters provide a quantitative translation of a narrative standard. The values for these parameters are referred to as targets and they represent the in-stream conditions that would likely be found when all TMDL allocations are met. Usually, not one single water quality target is sufficient for determining the condition of a stream; however, when viewed in combination measures of in-stream siltation, habitat features that demonstrate the effects of sediment, and biological response to increased sediment provide a good representation of impact from sediment. The degree to which one or more targets are exceeded should be taken into account, and the combination of target analysis, qualitative observations, and sound, scientific professional judgment is crucial when assessing stream condition.

In developing these targets, consideration must be made to account for natural variation throughout the river. Specifically, some reaches have a natural tendency for storage of sediment and others are prone to sediment transport. In addition, stream size and power factor into the response of a stream to increased sediment. Therefore, targets may be broken into sub-categories, such that they can be applied appropriately.

The water quality targets presented in this section (**Table 5-3**) are based on the best science and information available at the time this document was written. However, targets may be assessed during future TMDL reviews for their appropriateness and can be modified if new information provides a better understanding of reference conditions. A brief description and justification of the target parameters used in the analysis is included in the sections that follow, and rationale and development of target values is included in **Appendix D**.

Table 5-3. Flint Creek TPA Morphology, Substrate, and Habitat Targets

TARGET PARAMETER	TARGET VALUE
Morphology	
Width/Depth Ratio	
Streams 3rd order or less	≤20
Streams 4th order or greater	≤28
Entrenchment	Literature values based on Rosgen stream type
Substrate Composition	
Wolman Riffle Pebble Count, % <2mm	≤7
Wolman Riffle Pebble Count, % <6mm	≤14
Pool Tail Grid Pebble Count, % <6mm	≤15
Pool Habitat	
Pool Frequency (#/mile)	
Bankfull Width <20 feet	≥95
Bankfull Width 20-39 feet	≥70
Bankfull Width >40 feet	≥50
Residual Pool Depth (feet)	
Bankfull Width <20 feet	≥0.9
Bankfull Width 20-39 feet	≥1.4
Bankfull Width >40 feet	≥1.7
Riparian Indicators	
Large Instream Wood (#/mile)	
Bankfull Width <20 feet	≥500
Bankfull Width 20-39 feet	≥250
Bankfull Width >40 feet	≥150
Percent Streamside Shrub Cover	≥70%
Percent Streamside Bare Ground	0%
Biological Indicators	
O/E Model value	≥ 0.80

5.4.1.1 Morphology

Parameters related to stream morphology describe channel shape and dimension, and thereby indicate the ability of the stream to store and transport sediment. Stream gradient and valley confinement are two significant controlling factors that determine stream form and function, however alterations to the landscape, and sediment input beyond naturally occurring amounts can affect stream morphology. Numerous scientific studies have found trends and common relationships between channel dimensions

in properly functioning stream systems and those with a sediment imbalance. Two of those relationships are used as targets in the Flint Creek TPA and are described below.

Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio are fundamental aspects of channel morphology; each provides a measure of channel stability and indicates a stream's ability to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (i.e., riffles, pools, and near-bank zones). Changes in both the width/depth ratio and entrenchment ratio can be used to indicate change in the relative balance between the sediment load and the transport capacity of the stream channel. As the width/depth ratio increases, streams become wider and shallower, suggesting an excess coarse sediment load (MacDonald et al., 1991). As sediment accumulates, the depth of the stream channel decreases, which is compensated for by an increase in channel width as the stream attempts to regain a balance between sediment load and transport capacity. Conversely, a decrease in the entrenchment ratio signifies a loss of access to the floodplain. Low entrenchment ratios signify that stream energy is concentrated in-channel during flood events rather than dissipating energy to the floodplain. Accelerated bank erosion and an increased sediment supply often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Knighton, 1998; Rosgen, 1996; Rowe et al., 2003).

5.4.1.2 Substrate Composition

Percent surface fines provide a good measure of the siltation occurring in a river system and serve as an indicator of the ability of stream bottom habitat to support aquatic life. Although it is difficult to correlate percent surface fines with sediment loads in mass per time directly, the Clean Water Act allows "other applicable measures" for the development of TMDL water quality restoration plans. Percent surface fine measures have been used successfully in other sediment TMDLs in western Montana to address stream bottom deposits, siltation, and aquatic life uses.

Percent Fines <2mm

Surface fine sediment measured using the Wolman (1954) pebble count method can indicate excessive sediment loading. Studies have shown that increased substrate fine materials less than 2mm can adversely affect embryo development success by limiting the amount of oxygen needed for development (Meehan, 1991). In addition, as described in the Flathead Headwaters TMDL (Montana Department of Environmental Quality, 2004), work completed in the Boise National Forest in Idaho showed a strong correlation between the health of macroinvertebrate communities and percent surface fine particles less than two millimeters.

Percent Fines <6mm

As with surface fine sediment smaller than 2mm diameter, an accumulation of surface fine sediment less than 6mm diameter may also indicate excess sedimentation, and may have detrimental impacts on aquatic habitat. Size distribution of substrate material in the streambed is also indicative of habitat quality for salmonid spawning and egg development. Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of material less than 6.35 mm and the emergence success of westslope cutthroat trout and bull trout.

5.4.1.3 Pool Features

Pools are stream features characterized by slow moving, deep sections of the stream. These important components aid the balance between flow and sediment load by reducing stream velocity and storing

water and sediment. The measure and comparison of pool features can have direct links to sediment load increases and its affect on stream form and function, as well as biological integrity. Pool features play an important role for aquatic life and fisheries by providing refuge from warm water, high velocity, and terrestrial predators. However, when sediment loads are excessive, pool habitat quality and frequency is often diminished as pools fill with sediment. When this happens, velocities increase, stream channels widen, and sediment is transported to other areas of the stream where it may be deposited into areas that have an additional impact on fisheries and aquatic life.

Residual Pool Depth

Residual pool depth, defined as the difference between the maximum depth and the tail crest depth, is a discharge-independent measure of pool depth and an indicator of pool habitat quality. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes and high flow periods (Baigun, 2003; Bonneau and Scarnecchia, 1998; Nielson et al., 1994). Similar to channel morphology measurements, residual pool depth integrates the effects of several stressors; pool depth can be decreased as a result of filling with excess sediment (fine or coarse), a reduction in channel obstructions (such as large woody debris), and changes in channel form and stability (Bauer and Ralph, 1999). A reduction in pool depth from channel aggradation may not only alter surface flow during the critical low flow periods, but may also harm fish by altering habitat, food availability, and productivity (May and Lee, 2004; Sullivan and Watzin, 2010). Residual pool depth is typically greater in larger systems. During DEQ sampling in 2009, pools were defined as depressions in the streambed bounded by a “head crest” at the upstream end and “tail crest” at the downstream end with a maximum depth that was 1.5 times the pool-tail depth (Kershner et al., 2004).

Pool Frequency

Pool frequency is another indicator of sediment loading that relates to changes in channel geometry and is an important component of a stream’s ability to support the fishery beneficial use (Muhlfeld and Bennett, 2001). Sediment may limit pool habitat by filling in pools with fines. Alternatively, aggradation of larger particles may exceed the stream’s capacity to scour pools, thereby reducing the prevalence of this critical habitat feature. Pool frequency generally decreases as stream size (i.e. watershed area) increases.

5.4.2 Supporting Information/Supplemental Water Quality Parameters

Although the following categories are not a direct measure of sediment, they do provide insight into the overall riparian quality. Riparian condition is often associated with factors that may be leading to increased sediment loads and the reduction of in-stream habitat.

During the 2009 DEQ sediment and habitat data collection, a riparian assessment method (ie, Greenline) (Montana Department of Environmental Quality, 2010) was used to conduct a coarse survey of the riparian corridor and its general vegetation composition. The results are used here to infer riparian corridor health and bank stability. In addition, large woody debris counts were conducted and results were tallied to develop targets.

Understory Shrub Cover along Green Line

Riparian shrub cover is one of the most important influences on streambank stability. Removal of riparian shrubs can dramatically increase streambank erosion and increase channel width/depth ratios. Shrubs stabilize streambanks by holding soil and armoring lower banks with their roots, and reduce scouring energy of water by slowing flows with their branches.

Good riparian shrub cover is also important for fish habitat. Riparian shrubs provide shade, reducing solar inputs and increases in water temperature. The dense network of fibrous roots of riparian shrubs allows streambanks to remain intact while creating important fish habitat in the form of overhanging banks and lateral scour pools. Overhanging branches of riparian shrubs provide important cover for aquatic species. In addition, riparian shrubs provide critical inputs of food for fish and their feed species. Terrestrial insects falling from riparian shrubs provide one main food source for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are an important food source for fish.

Bare Ground along Green Line

Percent bare ground is an important indicator of erosion potential, as well as an indicator of land management influences on riparian habitat. Bare ground was noted in the greenline inventory in cases where recent ground disturbance was observed, leaving bare soil exposed. Bare ground is often caused by trampling from livestock or wildlife, fallen trees, recent bank failure, new sediment deposits from overland or overbank flow, or severe disturbance in the riparian area, such as from past mining, road-building, or fire. Ground cover on streambanks is important to prevent sediment recruitment to stream channels. Sediment can wash in from unprotected areas due to snowmelt, storm runoff, or flooding. Bare areas are also much more susceptible to erosion from hoof shear. Most stream reaches have a small amount of naturally-occurring bare ground. As conditions are highly variable, this measurement is most useful when compared to reference values from best available conditions within the study area or literature values.

Large Woody Debris

Large woody debris in the form of branches, trunks, rootwad, and other manner of downed wood within the active stream channel is a vital component of most western Montana stream ecosystems. Large wood in the channel provides multiple benefits for fish and other aquatic life by creating cover and habitat, encouraging scour resulting in pool development and sediment transport, and being a component in the overall foodweb for the various lifeforms in and around the stream. In addition, large woody debris may also be an indicator of riparian community health and maturity, which also has impacts on the overall form and function of a stream ecosystem.

Although large woody debris does not, by itself, suggest impairment from sediment, because of the common linkages that large woody debris has on stream health, it is commonly reviewed in combination with other sediment parameters to provide a better picture of the overall issues affecting a stream. Large woody debris discussion within the context of this document is used for that purpose and is not suggested as a target value per say; but simply to provide a stronger weight of evidence when discussing the condition of streams in the Flint Creek TPA.

Macroinvertebrates

Siltation exerts a direct influence on benthic macroinvertebrates assemblages by filling in spaces between gravel and by limiting attachment sites. Macroinvertebrate assemblages respond predictably to siltation with a shift in natural or expected taxa to a prevalence of sediment tolerant taxa over those that require clean gravel substrates. Macroinvertebrate bioassessment scores are an assessment of the macroinvertebrate assemblage at a site, and DEQ uses one bioassessment methodology to evaluate stream condition and aquatic life beneficial-use support. Aquatic insect assemblages may be altered as a result of different stressors such as nutrients, metals, flow, and temperature, and the biological index values must be considered along with other parameters that are more closely linked to sediment.

The macroinvertebrate assessment tool used by DEQ is the Observed/Expected model (O/E). The rationale and methodology for the index is presented in the DEQ Benthic Macroinvertebrate Standard Operating Procedure (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2006). The O/E model compares the taxa that are expected at a site under a variety of environmental conditions with the actual taxa that were found when the site was sampled and is expressed as a ratio of the Observed/Expected taxa (O/E value). The O/E community shift point for all Montana streams is any O/E value < 0.80. Therefore, an O/E score of ≥ 0.80 is established as a sediment target in the Flint Creek TPA.

An index score greater than the threshold value is desirable, and the result of each sampling event is evaluated separately. Because index scores may be affected by other pollutants or forms of pollution such as habitat disturbance, they will be evaluated in consideration of more direct indicators of excess sediment. In other words, not meeting the biological target does not automatically equate to sediment impairment. Additionally, because the macroinvertebrate sample frequency and spatial coverage is typically low for each watershed and because of the extent of research showing the harm of excess sediment to aquatic life, meeting the biological target does not necessarily indicate a waterbody is fully supporting its aquatic life beneficial use. For this reason, measures that indicate an imbalance in sediment supply and/or transport capacity, such as the targets presented in this document, are also used for TMDL development determinations.

5.4.3 Comparison of Listed Waters to Targets (by stream segment)

5.4.3.1 Barnes Creek, headwaters to the mouth (Flint Creek); MT76E003_070

Three reaches were evaluated by the DEQ during the 2009 field effort (**Table 5-4** and **5-5**). Each of the reaches are 3rd order, unconfined, and within a low gradient valley (less than 2%). Percent fines data were well above target values for each parameter in each reach. Residual pool depths did not meet the target in each of the three reaches, and pool numbers were low in BARN 11-01 and BARN 13-03. In addition, percent shrub cover was well below expected values for BARN 11-01 and BARN 13-01, particularly in the latter, suggesting anthropogenic influence on the riparian corridor. This inference from the data is confirmed in the field notes. The low shrub cover percent in 13-01 may also have a direct relationship to the significantly low large wood numbers in that reach.

Table 5-4. Barnes Creek Morphology and Pool Data (Water & Environmental Technologies, PC, 2010)

Reach	Ecoregion	Reach Type	Expected Rosgen	Bankfull Width	Width/ Depth	Entrench-ment	Residual Pool Depth	Pools #/mile
BARN 11-01	17ak	3-U-0	C	12.9	**23.0**	4.1	**0.5**	**48**
BARN 13-01	17ak	3-U-0	E	6.5	6.9	23.5	**0.7**	116
BARN 13-03	17ak	3-U-0	E	9.1	9.3	**2.1**	**0.7**	**63**

Values in **BOLD** indicate an exceedance of the target value.

Table 5-5. Barnes Creek Substrate and Riparian Condition Data (Water & Environmental Technologies, PC, 2010)

Reach	Wolman Pebble Count		Grid Toss in Pool Tails	Greenline Shrubs	Greenline Bare Ground	Large Wood #/mile
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
BARN 11-01	**29**	**45**	**62**	**41**	**16**	581
BARN 13-01	**16**	**33**	**25**	**13**	0	**32**
BARN 13-03	**17**	**26**	**41**	**57**	0	502

Values in **BOLD** indicate an exceedance of the target value.

Field notes from the 2009 field assessment describe the conditions of the DEQ Barnes Creek reaches further:

- BARN 11-01 field notes documented heavy grazing impacts and overall poor condition of the site. This is witnessed in the exaggerated width/depth ratio when compared to the two other Barnes reaches, the excessive fines, and the amount of bare ground and lack of shrub cover witnessed in the reach.

- BARN 13-01 also describes heavy grazing impact however not to the extent of BARN 11-01. Bank erosion through this reach appears to be highly attributed to hoof shear.

- BARN 13-03 field notes describe more stable bank conditions in this reach, with willows providing a major influence on bank stability and pool formation.

DEQ Assessment files, otherwise known as (SCD/BUD files) provide data and information used during the assessment process which led to the impairment determination. The most recent assessment record for Barnes Creek was conducted in 2006. A brief summary review of that information provides the following description:

The drainage is dominated by hayfields and pastures, with forest covering only the upper 20%. In the middle of the watershed, Barnes Creek was dominated by glides, not riffles, with a U-shaped channel, few meanders and mostly silt/sand bottom. Bank vegetation was primarily grasses with a few willows present in the riparian corridor. Closer to the mouth, the substrate was predominantly silt with some gravels in the riffles. Riffle development was marginal. Erosion was occurring in some areas; vegetation consisted mainly of grasses and cropland with little to no woody vegetation present. Cattle had access to the stream. Water quality at the upper site may have been impaired as the biotic index value (4.25) was elevated compared to expectations for a montane stream, and stoneflies were absent from the sample. Stony substrate habitats could have been compromised by sediment deposition, and monotonous instream habitats were likely. No sensitive taxa were collected at the lower site, and the biotic index value (6.32) was substantially elevated, indicating a much more tolerant assemblage than expected.

As a result of the 2009 field data and the assessment file summary a TMDL for sediment on Barnes Creek is well justified and will be developed.

5.4.3.2 Douglas Creek, headwaters to where the stream ends (T17N, R14, S25); MT76E003_100

Only one site on Douglas Creek was evaluated by DEQ during the 2009 field effort (**Table 5-6** and **5-7**). Access issues prohibited further investigation of sites above the town of Philipsburg. The one reach that was accessible occurred in town, not far from the mouth of the creek. Douglas Creek at this location is a small, 2nd order stream with a valley slope between 2 and 4%. Despite this reach being slightly higher gradient, which would tend to flush fine sediment accumulation to areas of lower gradient, percent fines values still well exceeded the target values. Residual pool depths did not meet target values either. In addition, low percent shrub cover and lack of large wood indicate disturbance to the riparian corridor that may further influence sediment input and habitat quality.

Table 5-6. Douglas Creek Morphology and Pool Data (Water & Environmental Technologies, PC, 2010)

Reach	Ecoregion	Reach Type	Expected Rosgen	Bankfull Width	Width/ Depth	Entrench-ment	Residual Pool Depth	Pools #/mile
DOUS 19-02	17ak	2-U-2	E	4.2	4.1	5.7	**0.6**	180

Values in **BOLD** indicate an exceedance of the target value.

Table 5-7. Douglas Creek Substrate and Riparian Condition Data (Water & Environmental Technologies, PC, 2010)

Reach	Wolman Pebble Count		Grid Toss in Pool Tails	Greenline Shrubs	Greenline Bare Ground	Large Wood #/mile
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
DOUS 19-02	**39**	**64**	NA	**35**	0	**211**

Values in **BOLD** indicate an exceedance of the target value.

Field notes from the 2009 field assessment describe the conditions of the DEQ Douglas Creek reaches further:

- Douglas Creek is dramatically altered by channelization in this reach. The stream occurs in an urban setting, and in general, no woody vegetation occurs beyond 5' of the channel. The channel is frequently bordered by dense manicured grasses.

DEQ Assessment files, otherwise known as (SCD/BUD files) provide data and information used during the assessment process which led to the impairment determination. The most recent assessment record for Douglas Creek was conducted in 1999. A brief summary review of that information provides the following description:

Limited data existed for the high headwaters of this stream; however the midreach section (1-3 miles above the mouth) was listed as severely impaired. The Stream has been extensively mined and large tailings piles compose much of the streambanks. Poor SMZ management during logging has left stream channel in poor condition and the stream is channelized through town.

Although actual quantifiable data is limited on this stream, descriptions of the condition of the stream in combination with the data from DOUS 19-02 indicate significant sediment sources and accumulation of that sediment within the stream channel. As a result, a TMDL will be developed for Douglas Creek.

5.4.3.3 Flint Creek, Georgetown Lake to the confluence with Boulder Creek; MT76E003_011

Four sites were evaluated in the upper segment of Flint Creek (**Table 5-8** and **5-9**). The upper most reach, FLIN 06-01 is a second order stream in a higher gradient valley (2-4%). Residual pool depths are slightly below target values and pool numbers are considerably beneath the target of ≥70, however percent fines values are not elevated. Large wood is meeting the target. Reach FLIN 09-02 occurs in a low gradient section of Flint Creek and is 3rd order in size. The width/depth value for this reach is well above the target of ≤20 indicating overwidening of the stream, and the number of pools per mile is quite low as well. Fine substrate percentages are all within the target range. Shrub cover is diminished however. Reaches FLIN 11-01 and FLIN 11-04 are 4th order streams. FLIN 11-01 is slightly below the target for residual pool depth however based on the bankfull width this reach is right between the two target categories and therefore may not have as issue with this parameter. Pool numbers are considerably diminished however. Percent fines results in two of the three categories are slightly exceeding the target values, with percent fines results in the <6mm Wolman pebble count just under the target value. Percent shrub cover is almost entirely absent, with some bare ground noted as well. Large wood per mile is also almost nonexistent through this reach. FLIN 11-04 has low residual pool depths but all other target parameters appear to be within the target ranges or just straddling the target value.

Table 5-8. (Upper) Flint Creek Morphology and Pool Data (Water & Environmental Technologies, PC, 2010)

Reach	Ecoregion	Reach Type	Expected Rosgen	Bankfull Width	Width/Depth	Entrenchment	Residual Pool Depth	Pools #/mile
FLIN 06-01	17am	2-U-2	B	23.1	15	8.8	**1.2**	**21**
FLIN 09-02	17ak	3-U-0	C	34.5	**34**	6.1	1.6	**32**
FLIN 11-01	17am	4-U-0	C	40.0	20.5	4.2	**1.4**	**21**
FLIN 11-04	17am	4-U-0	C	52.0	25.3	**2.1**	**1.1**	100

Values in **BOLD** indicate an exceedance of the target value.

Table 5-9. (Upper) Flint Creek Substrate and Riparian Condition Data (Water & Environmental Technologies, PC, 2010)

Reach	Wolman Pebble Count		Grid Toss in Pool Tails	Greenline Shrubs	Greenline Bare Ground	Large Wood #/mile
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
FLIN 06-01	1	3	1	97	0	438
FLIN 09-02	7	12	1	**37**	0	280
FLIN 11-01	**12**	14	**16**	**3**	**3**	**11**
FLIN 11-04	**8**	12	10	94	0	**148**

Values in **BOLD** indicate an exceedance of the target value.

Field notes from the 2009 field assessment describe the conditions of the DEQ Flint Creek reaches further:

- FLIN 06-01 occurs just downstream of the old power station and within a public campground. Significant and widespread channel alterations exist due to the road, campground, old dam, and other remnants of historic structures at this site. River-left actively was eroding, particularly

where encroachment from road is directly adjacent to the creek. Bank vegetation was comprised of primarily non-native grasses and weeds.

- Riparian grazing, a road crossing, irrigation, and adjacent dirt road all influence Flint Creek at FLIN 09-02. Few quality pools present. Substrate dominated by large cobble but appear embedded. Eroding banks are generally low profile and contribute low to moderate amounts of erosion. Where erosion occurs it appears to be largely influenced by lack of good riparian.

- FLIN 11-01 is confined on two sides by the railroad and highway. Ice scour is reportedly common in this reach. There is evidence of past grazing, although currently grazing appears minimal. High sinuosity and low channel slope indicate that this stream may have been an E channel at one time, but high width/depth ratios currently identify this reach as more similar to a C channel. The site has poor riffle development with long lateral scour pools on outside meander bends. Stream bed is embedded with fine substrate. Channel has signs of instability and many long eroding banks, primarily on outside meander bends. Banks comprised of mostly fine, unconsolidated material. There is no overstory or understory present throughout this reach and no large woody in the channel.

- A railroad, residences, and evidence of mining all occur along Flint Creek reach FLIN 11-04, although they don't appear to be having an immediate impact on the site itself. A steep C type stream type, few well-developed pools are present but there are many small step pools. Pool tails do not appear to have much fine accumulation. Overall, the riparian area appears to have good diversity. Site has minimal streambank erosion, mostly naturally influenced.

DEQ Assessment files provide data and information used during the assessment process which led to the impairment determination. The most recent assessment record for the upper segment of Flint Creek was conducted in 1999. A brief summary review of that information provides the following description:

For assessment investigation, the stream has been segmented into three separate reaches: headwaters (below Georgetown Lake dam), midreach (above and below Marshall Creek influence), and the lower reach in the canyon area above confluence with Boulder Creek. Some minor impact, specifically bank erosion, is noted in the headwaters reach. Midreach is described as having severe impairment. The entire reach is grazed and bank and riparian degredation is common. The lower reach has also been classified as having severe impairment, also displaying common bank erosion and riparian degredation as a result of grazing.

In addition to the DEQ information, the FWP conducted an assessment of fish populations and riparian habitat in tributaries of the Upper Clark Fork Basin (Lindstrom et al., 2008). Flint Creek was included in that study. Of four sites assessed on Flint Creek, the upper three roughly correspond with DEQ sites FLIN 06-01, FLIN 09-02, and FLIN 11-01. Description of the riparian assessments at the upper three sites is as follows:

- Below the dam at river mile 41.2, Flint Creek received a riparian assessment score of 61/70 (87%). The controlled flows out of Georgetown Lake are believed to have prevented deep pools from scouring in this reach, which limited the diversity of the habitat. Noxious weeds such as spotted knapweed (*Centaurea biebersteinii*) were also abundant, likely due to disturbance of the high use of campground located in this reach.

- At the site located at river mile 35.5, Flint Creek received a relatively low riparian assessment score 41/68 (60%). At this site, riparian grazing by cattle appeared to be the primary land use impacting the stream. Some of the direct negative impacts included heavy browse on all of the riparian vegetation by cattle and relatively little willow regeneration. Cattle hoof shear and associated bank instability were also observed. Overall, the impacts of riparian grazing were bank instability, channel overwidening, low densities of LWD [Large Woody Debris], and reduced stream shading. These impacts were particularly evident for a pasture found lower in the electrofishing reach in which past stock densities appeared to have been higher than in the upstream pasture. Despite these deficiencies, the fish habitat was still rated as good in this reach because of the presence of many deep pools, undercut banks, and some LWD.

- At river mile 23.4, Flint Creek received a riparian assessment score of 49/68 (72%). Cattle utilization of this site was high; however more riparian vegetation remained intact at this site than at the site located at river mile 35.5. Some shortcomings of this site were bank erosion from cattle hoof shear and the resulting increased fine sediment in the creek, as well as the abundance of noxious and disturbance-induced plants. Fish habitat was rated good because of the presence of deep pools and undercut banks.

Despite the limited exceedance of target values, the additional information regarding adjacent land use and obvious controllable sources of sediment justify the development of a TMDL for this stream segment.

5.4.3.4 Flint Creek, Boulder Creek to the mouth (Clark Fork River); MT76E003_012

Four sites were evaluated in the lower Flint Creek segment (**Table 5-10** and **5-11**). The upper most reach, FLIN 17-01, is located in a higher gradient valley (2-4%); all other reaches are low gradient (0-2%). The upper most three sites are 4th order streams, however the stream order increases to 5th order in the lowest reach in the watershed, FLIN 19-01. Width/depth ratios are not meeting or very near the target value at all four sites. Residual pool depths are low in FLIN 17-01 and FLIN 18-05, and pools per mile are low in the lower three reaches. Percent fines are meeting the targets for all parameters in all sites. Riparian condition appears fine in the upper two reaches. Shrub cover in FLIN 18-05 is slightly under the target value, and shrub cover in FLIN 19-01 is extremely below the target at a mere 4%. Large wood is also deficient in this reach, which may partly be related to the lack of riparian vegetation.

Table 5-10. (Lower) Flint Creek Morphology and Pool Data (Water & Environmental Technologies, PC, 2010)

Reach	Ecoregion	Reach Type	Expected Rosgen	Bankfull Width	Width/ Depth	Entrench-ment	Residual Pool Depth	Pools #/mile
FLIN 17-01	17ak	4-U-2	C	62.9	**34.2**	2.0	**0.8**	79
FLIN 18-02	17ak	4-U-0	B	57.0	27.6	**1.9**	**1.8**	**37**
FLIN 18-05	17ak	4-U-0	B	49.2	**28.8**	3.1	**1.3**	**26**
FLIN 19-01	17ak	5-U-0	C	50.8	**31.2**	3.5	2.2	**26**

Values in **BOLD** indicate an exceedance of the target value.

Table 5-11. (Lower) Flint Creek Substrate and Riparian Condition Data (Water & Environmental Technologies, PC, 2010)

Reach	Wolman Pebble Count		Grid Toss in Pool Tails	Greenline Shrubs	Greenline Bare Ground	Large Wood #/mile
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
FLIN 17-01	3	5	4	76	0	164
FLIN 18-02	7	14	7	92	0	306
FLIN 18-05	3	6	2	**60**	0	190
FLIN 19-01	4	9	3	**4**	**3**	**58**

Values in **BOLD** indicate an exceedance of the target value.

Field notes from the 2009 field assessment describe the conditions of the DEQ Flint Creek reaches further:

- No obvious human impacts were noted within the stream channel at site FLIN 17-01. Agricultural practices occur on both sides of the river however riparian fencing is present to protect the riparian area and streambanks. No actively eroding banks noted, and the riparian condition is good with multiple grasses, alder understory, and mature cottonwood overstory. Substrate is dominated by boulders and cobble and riffle features dominate, with infrequent pools. Cell 2 is entrenched and appears to be actively downcutting.

- FLIN 18-02 is adjacent to agricultural lands (hay fields) with a narrow riparian buffer, although grazing impacts appear minor. An irrigation ditch does exist with associated riprap along the bank. Minimal streambank erosion however; some slowly eroding banks but most well armored and with dense root mass. Reach is riffle dominated with minimal pools. Pools present only as a results of large boulders or woody debris.

- FLIN 18-05 is also adjacent to agricultural land but does have riparian fencing throughout the reach and good riparian vegetation. There is some evidence of historical grazing but site appears to be recovering well. Most erosion appears to be natural or recovering from the historic grazing and agricultural practices. This site has good riffle development and the substrate is dominated by gravel and cobble, although some embeddedness is apparent in places.

- The lowest reach, FLIN 19-01, has evidence of historic and recent hay/pasture use. Riparian fencing occurs on only one side of the stream. Reach doesn't appear to be heavily grazed recently, however hoof shear evident in places, and little riparian vegetation to help stabilize banks. Long stretches of actively eroding banks on meander bends; one section has approximately 80'-100' of rip rap where fence is falling into the stream. There is decent pool habitat throughout the reach but not much woody debris. Good riffle development with some point bars. Substrate consists mainly of large gravel and cobble, and does not appear as embedded as in upper reaches.

DEQ Assessment files provide data and information used during the assessment process which led to the impairment determination. The most recent assessment record for the lower segment of Flint Creek was conducted in 2003. A brief summary review of that information provides the following description:

For the assessment investigation, the lower segment was separated into three sections. The section directly below the confluence with Boulder Creek is described as having minor impairment, although sediment is still a problem. Midreach (near the Douglas Creek confluence) is categorized as having minor-moderate impairment, with bank instability and remnants of hydraulic mining. The final reach, near the mouth, is described as having severe impairment, in part, due to bank instability from grazing and riparian degradation. In addition, turbidity is noted as being over 200 times the ntu level of similar reference streams.

In addition to the DEQ information, the FWP conducted an assessment of fish populations and riparian habitat in tributaries of the Upper Clark Fork Basin (Lindstrom et al., 2008). Flint Creek was included in that study. Of four sites assessed on Flint Creek, one occurred in this segment of concern. Description of the riparian assessments for this site is as follows:

- At river mile 12.1, Flint Creek received a riparian assessment score of 39/70 (56%). Habitat was limited by a lack of pools, with a majority of the pools being formed by boulder pockets. Riparian vegetation was insufficient on many of the banks despite a mature overstory of cottonwoods located in the floodplain. Despite this lack of woody riparian vegetation, the width to depth ratio in this reach of Flint Creek appeared appropriate which is likely due to the large substrate found in this reach and the resilient nature of this B_c channel type.

Data and descriptions of the lower segment of Flint Creek seem to correlate between information sources. Upper portions have minimal to no apparent impact from sediment, however the lower portion (near the mouth) has noticeable impacts from adjacent land use and sediment input and therefore a sediment TMDL will be pursued.

5.4.3.5 Smart Creek, headwaters to the mouth (Flint Creek); MT76E003_110

Four locations on Smart Creek were evaluated during the 2009 DEQ field effort (**Table 5-12** and **5-13**). All four sites are 2nd order streams, the uppermost occurring in a slightly higher gradient reach (2-4%) than the other reaches which are of low gradient (0-2%). Reaches SMAR 18-01-01 and SMAR 18-01-02 occur directly adjacent to one another. These two reaches were split by a fence line, with the upper reach (SMAR 18-01-02) occurring in a well vegetated, protected riparian area, and the lower reach (SMAR 18-01-01) displaying obvious recent and recurring cattle grazing and open access to the stream. These two reaches were sampled to see if the differences in the resultant data would illustrate the dramatic differences in land use. Width/depth ratios are within the target range, except for reach 18-01-01 (where cattle grazing has had a large impact on streamside vegetation and bank stability). Residual pool depths are not meeting the target value in any of the four reaches, and pool numbers are either meeting the target values, or slightly under the target. Percent shrub cover is limited however throughout all four reaches, particularly in SMAR 21-01. In addition, 8% of SMAR 18-01-01 is bare ground, which is a direct result of the cattle access to the stream at this point. Large wood is also lacking in two of the reaches.

Table 5-12. Smart Creek Morphology and Pool Data (Water & Environmental Technologies, PC, 2010)

Reach	Ecoregion	Reach Type	Expected Rosgen	Bankfull Width	Width/ Depth	Entrench-ment	Residual Pool Depth	Pools #/mile
SMAR 13-01	17am	2-U-2	B	8.9	15.6	2.0	**0.6**	**100**
SMAR 18-01-01	17ak	2-U-0	B	13.8	**21.6**	10.6	**0.7**	116
SMAR 18-01-02	17ak	2-U-0	B	8.4	11.5	**2.0**	**0.6**	137
SMAR 21-01	17ak	2-U-0	E	6.9	10.7	**1.7**	**0.6**	**90**

Values in **BOLD** indicate an exceedance of the target value.

Table 5-13. Smart Creek Substrate and Riparian Condition Data (Water & Environmental Technologies, PC, 2010)

Reach	Wolman Pebble Count		Grid Toss in Pool Tails	Greenline Shrubs	Greenline Bare Ground	Large Wood #/mile
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
SMAR 13-01	4	9	3	**30**	0	**195**
SMAR 18-01-01	7	13	**21**	**43**	**8**	634
SMAR 18-01-02	7	14	14	**49**	0	803
SMAR 21-01	**9**	**18**	**16**	**4**	0	**58**

Values in **BOLD** indicate an exceedance of the target value.

Field notes from the 2009 field assessment describe the conditions of the DEQ Smart Creek reaches further:

- A road parallels the stream for much of reach SMAR 13-01, however road impacts appear minor. Grazing from cattle within the riparian is obvious by the denuded vegetation and invasive weeds are present throughout. Past mining and logging is known to have occurred in the upper watershed of Smart Creek. SMAR 13-01 has moderate entrenchment and appears to be downcutting. Substrate composed of small gravels. The best pools formed by sloughing vegetation and woody debris. Many tall eroding banks, the erosion exacerbated by the fine soil bank composition and poor vegetation (little root mass and depth; very limited good quality woody vegetation). Improvements to riparian vegetation in this reach would be very beneficial to reducing sediment.

- SMAR 18-01-01 is extensively grazed with lots of hummocking and hoof shear to the banks. Stream channel is overwidened in many places and shows evidence of aggradation. Poorly developed pools through this reach; pool tails often trampled by cattle. Spawning gravel potential existed in some pool tails, but many had a high percentage of fines, apparently as a result of the eroding banks and heavy grazing. Existing woody debris is poor quality and provides little habitat. Streambank erosion is fairly limited as the banks are low profile, but all noticeable erosion is caused by hoof shear and cattle grazing. Vegetation is grazed very short. Some grasses and sedges established on slumped banks, the understory mostly alder with a few sparse conifers.

- SMAR 18-01-02 occurs directly upstream of SMAR 18-01-01. In contrast however, SMAR 18-01-02 is protected by riparian fencing. There is some evidence of past grazing in this reach, but effects are minor and the current fence protection is allowing for good recovery. This reach resembles a B stream channel, although the low width depth ratios are reminiscent of an E channel in places. SMAR 18-01-02 has well developed pools and riffles, and good small gravel substrate for spawning, however pool depths are somewhat shallow. Streambanks are well vegetated and provide very limited sediment contribution. There is good diversity of riparian vegetation and functional woody debris in the channel.

- SMAR 21-01 has a headgate at the top of the reach, which may be contributing to some overwidening in the channel. In addition, there is evidence of past grazing, but the reach does not appear recently grazed at the time of investigation. Sheep and llama are present just downstream. The stream is crossed by numerous small bridges to accommodate pivot wheels. Eroding banks prevalent throughout the reach with whole sections of bank are slumping into the

channel. The reach has small gravel substrate, poor riffle-pool development, and resembles an entrenched step-pool system in some places as a result of the slumping banks and active downcutting. Limited large wood creating backwater affects where it does occur. Landowner describes ice scour occurring during periods of thaw. Dense grasses are the predominant streamside vegetation, with some sedges on the slumped areas within the channel but little other vegetation present.

DEQ Assessment files, otherwise known as (SCD/BUD files) provide data and information used during the assessment process which led to the impairment determination. The most recent assessment record for Smart Creek was conducted in 2006. A brief summary review of that information provides the following description:

The Smart Creek drainage is approximately 60% National Forest, 30% private land, and 10% BLM, with the majority of private land concentrated near the mouth of the stream. The upper watershed burned in the Combination fire of 1988 and was logged. There was heavy utilization by livestock in the past, and several former mines in the watershed. The upper reach had good fish habitat, the channel was not embedded, and banks were relatively stable with a few outside bends eroding. The riparian zone was generally in good condition with alders and fir present, but some age classes missing due to grazing. Noxious weeds were present including Canada thistle, houndstongue and knapweed. The lower reach had trampled and eroded banks, and the channel was moderately embedded. There was evidence of serious overgrazing, with no brush or shrubs, only a few dying trees, and no other riparian vegetation evident – in some places, not even grass. A landowner says the area has been grazed for 145 years, and until 16 years ago, the stream had ample willows. After the 1988 fire, a severe flood occurred, washing gravels downstream, and, according to a local landowner, killing the willows that used to grow by the stream. Smart Creek was designated a fisheries resource of substantial value by Montana Fish, Wildlife and Parks (MFWP). At the upper site, evidence of probable water quality impairment could be discerned in the taxonomic composition of the macroivertebrate sample collected there. It seems unlikely that periodic dewatering, scouring sediment pulses, or thermal extremes occurred here recently, since the semivoltine riffle beetles in 3 genera were so abundant. The functional mix was dominated by scrapers, suggesting that riparian shading may have been limited. Water quality impairment was suggested at the lower site, where only 2 mayfly taxa were collected and the biotic index value (5.30) indicated that the assemblage was more tolerant than expected for a foothill stream. Low richness among the caddisflies and “clingers” strongly suggest that sediment deposition limited access to stony substrate habitats in this reach. Stoneflies were represented by a single genus; unstable streambanks, altered channel morphology, or disrupted riparian vegetation may be implicated. The Low Valley MMI and RIVPACS results for both sites indicated that the macroinvertebrate communities were moderately impaired. Although the percentage of fine sediment was high at both sites, this is most likely due to the fact that the stream is still recovering from a severe flood event.

In addition to the DEQ information, the FWP conducted an assessment of fish populations and riparian habitat in tributaries of the Upper Clark Fork Basin (Liermann et al., 2009). Smart Creek was included in that study. Description of the riparian assessments at for this site is as follows:

- The main land use observed in the drainage is cattle grazing with grazing allotments existing on federal lands in the drainage. Two sections were electrofished on Smart Creek in August 2008. In both sections, westslope cutthroat trout were the sole fish species captured. At the upper site located at river mile 5.7, Smart Creek was classified as a C channel and woody riparian vegetation consisted of willows, alder, and cottonwoods. At this site, cattle grazing was quite heavy and cattle hoof shear was observed throughout the reach. Bank erosion was common in

the reach and the channel appeared to be slightly overwidened. Both the density and recruitment of woody riparian vegetation in the reach appeared to be low and browse on the adult woody vegetation was heavy. However, this reach still maintained some quality pool habitat and fish densities were quite high, so the fish habitat was still rated as "good". At the lower site (river mile 3.0), Smart Creek was classified as a C channel type and the woody riparian vegetation observed at this site was primarily alders and spruce. The width to depth ratio at this site appeared reasonable however bank erosion was observed throughout the reach. Woody riparian vegetation was relatively abundant at this site, however, the diversity of woody species was low with only alder and spruce observed. Past grazing impacts were evident in the reach, although it appeared that the reach had not been grazed in 2008 at the time of the survey. Noxious weeds and disturbance-induced plants were common, likely indicative of past grazing in this reach. Fish habitat in the reach was classified as "good" due to the low width to depth ratio and abundant pool habitat, but the pools in the reach appeared to be relatively shallow and fine sediment was also common.

Data and qualitative descriptions of Smart Creek justify the development of a sediment TMDL.

5.4.4 TMDL Development Summary

Based upon the results of **5.4.3**, the following streams will be included for TMDL development for sediment (**Table 5-14**). Sediment sources and estimates of sediment loads from those sources are investigated in **Section 5.5**, and the TMDLs and allocations of sediment load are presented in **Section 5.6**.

Table 5-14. Flint Creek TPA waterbodies included in sediment TMDL development

Waterbody ID	Stream Segment	2012 Probable Causes of Impairment
MT76E003_070	**BARNES CREEK,** headwaters to mouth (Flint Creek)	**Sedimentation/Siltation**
MT76E003_100	**DOUGLAS CREEK**, headwaters to where stream ends (T7N R14W S25)	**Sedimentation/Siltation,** *Physical substrate habitat alterations*
MT76E003_011	**FLINT CREEK**, Georgetown Lake to confluence with Boulder Creek	**Sedimentation/Siltation**, *Alteration in streamside or littoral vegetation covers*
MT76E003_012	**FLINT CREEK**, Boulder Creek to mouth (Clark Fork River)	**Turbidity***, *Alteration in streamside or littoral vegetation covers*
MT76E003_110	**SMART CREEK**, headwaters to the mouth (Flint Creek), T9N R13W S21	**Sedimentation/Siltation**, *Alteration in streamside or littoral vegetation covers*

*Turbidity is a pollutant that falls within the Sediment pollutant category.
Pollution listings are presented in *italics*

5.5 SOURCE QUANTIFICATION FOR ALL WATERBODIES

When developing TMDLs, sediment loads must be quantified for each significant source category, and where appropriate, strategies for reducing those loads from human caused sources must be developed such that streams meet all applicable water quality standards. Sources are described in two broad ways: point sources and nonpoint sources. Point sources are a specific and discrete source of a pollutant, such as the end of a wastewater discharge pipe or municipal stormwater drain. Point sources are addressed through permit requirements and addressed in the TMDL via wasteload allocations (WLAs). Two permitted sediment point sources are present in the Flint Creek TPA (Philipsburg's wastewater treatment plant and Black Pine Mine). Nonpoint sources are sources of pollutants that come from diffuse locations across the landscape and are often cumulative in their effects. Examples of nonpoint

source pollution include bank erosion, the leaching of nutrients or agricultural chemicals into groundwater from farm fields, or increased surface runoff and the associated pollutants runoff carries from timber harvest. Nonpoint source pollution is addressed in the TMDL via load allocations (LAs). Three major nonpoint source categories of sediment have been identified in the Flint Creek TPA (bank erosion, sediment from unpaved roads, and hillslope erosion). This section describes the methodology, rationale, and assumptions in sediment source load quantification and load reduction that is used as the basis for TMDLs in the Flint Creek TPA.

5.5.1 Bank Erosion

Rivers and streams are dynamic, ever changing systems that are constantly seeking equilibrium with their surrounding environment. The size, force, and shape of these flowing waters fluctuate throughout the seasons, and over the years. Streams tend to shift across the landscape, cutting new channels either slowly or subtly, or quickly and dramatically. Sediment from eroding banks may alter channel shape, alter the erosive properties of the stream itself, prohibit or encourage aquatic life and fisheries, and affect water chemistry and quality.

Bank erosion as a result of these shifts in direction and energy is a natural and necessary function of an active stream channel. However, in some cases bank erosion can be exacerbated or accelerated by human activities that result in altered bank stability or stream morphology. In investigating bank erosion as one source of the total watershed sediment load to derive the TMDL, methods were used to quantify sediment loads from eroding banks, identify the cause and effects of the eroding banks and therefore differentiate between existing and desired conditions (under all applicable land, water, and soil best management practices).

5.5.1.1 Quantifying Pollutant Sources

In 2009, a field study was conducted throughout the Flint Creek watershed that investigated the sediment and habitat conditions in selected reaches. In preparation for that study, an aerial assessment and GIS exercise organized streams into representative reaches based on naturally occurring geomorphic constraints. The reaches were further categorized by the apparent influences of land use, land cover, and human activities. Study sites were chosen to represent the variability in natural and human influences throughout the watershed. The data collected is the basis for quantifying loads from individual banks and their associated conditions. The extrapolated bank erosion load was used as a component of the Total Maximum Daily Load for sediment.

5.5.1.2 Bank Erosion Assessment

For each monitoring reach selected in the aerial photo assessment, measurements were collected to calculate the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS), in accordance with the Watershed Assessment of River Stability and Sediment Supply guidelines (Rosgen, 2006). BEHI evaluates the susceptibility to erosion from multiple erosional processes. The process integrates multiple variables that relate to “combined” erosional processes leading to annual erosion rates. Erosion risk is then established for a variety of BEHI variables and is eventually used to establish corresponding streambank erosion rates (Rosgen, 1996).

In addition to the recorded BEHI and NBS information, each bank was categorized as either actively/visually eroding or slowly eroding/vegetated. Individual banks were also assigned percent influence contributing to the erosion of the bank and distributed among natural and anthropogenic causes such as transportation, grazing, timber harvest, etc. Reaches with less than 25% of the influence

attributed to human activity were classified as "naturally influenced" reaches. Once a sediment load was generated for each analyzed bank in a given site, the sum of the bank loads was calculated to derive the total load for the sampled site.

5.5.1.3 Bank Erosion Sediment Loads

In order to determine sediment loads from bank erosion, results from the field study (results are presented in **Attachment A**) were used to develop reasonable estimates to represent the total sediment loads from bank erosion for each watershed.

In the Flint Creek TPA, the sediment load for each eroding bank in a sampled reach was calculated, and then the total sediment load for that reach was summed. Sampled reaches were sorted by their influence category (natural or human) and reach type (a reach type is defined by its combination of stream order, valley slope, and valley confinement), and the average sediment loads (tons/1000') from these representative groupings determined. To estimate a total bank erosion load for each stream of interest, the average sediment load from the reach types were applied to their respective reaches. For those reach types without a derived average sediment load, the average sediment load from the most appropriate comparable reach type was applied. Actual loads from sampled reaches were applied to those individual reaches where sampled data exists. **Table 5-15** presents the average existing sediment load by reach type.

Table 5-15. Average Bank Erosion Sediment Load by Reach Type

Reach Type (valley gradient – stream order – valley confinement)[^]	Number of Sampled Reaches	Sampled Reaches	Existing Average Bank Erosion Sediment Load per 1000 feet (tons/year)
0-1-C; 0-1-U; 2-1-U; (valley gradients >4)	2[*]	BOUL 16-01; FLIN 17-01	0.6
0-2-C; 0-2-U	5	DOUN 08-02; FRED 29-02; SMAR 18-01-01; SMAR 18-01-02; SMAR 21-01	17.9
0-3-U	6	BARN 11-01; BARN 13-01; BARN 13-03; BOUL 21-02; FLIN 09-02; TROU 09-03	7.0
0-4-U	5	FLIN 11-01; FLIN 11-04; FLIN 18-02; FLIN 18-05; LOWI 02-05	18.0
0-5-U	1	FLIN 19-01	23.9
2-2-C; 2-2-U	4	DOUN 07-01; DOUS 19-02; FLIN 06-01; SMAR 13-01	20.4
2-3-U	2	BOUL 16-01; TROU 10-01	4.0
2-4-U	1	FLIN 17-01	0.8

[^]Reach Type presented as Valley Slope-Stream Order-Valley Confinement. Valley Slope Categories: 0 = 0-2%; 2 = 2-4%, 4 = 4-10%, 10 = >10%. Valley Confinement Categories: U = Unconfined (>150 feet wide); C = Confined (<150 feet wide)

[*]For reaches with a stream order of one, or a valley gradient greater than 4%, a sediment load of 0.6 tons/year was applied. This value was derived from the average load of naturally influenced reaches occurring in valley gradients of 2-4% (Two reaches: BOUL 16-01 and FLIN 17-01). It is assumed that the loads from 1st order reaches, and higher gradients are generally minimal, as the associated terrain is often less influenced by human activity and the low stream orders are small headwater streams with less erosive power.

5.5.1.4 Establishing the Total Allowable Load

Once the existing bank erosion sediment load was derived, an allowable (desired) load was established to determine the target conditions and allocation of sediment reductions.

It is difficult to precisely quantify total sediment loads from bank erosion without assessing the entire length of streambanks. However, quantitative data coupled with qualitative information from the sample reaches provides a good basis to estimate the total load and potential for sediment load reduction.

During the field effort, each eroding bank encountered was classified as actively eroding or slowly eroding. Actively eroding banks are those banks that appear to be an obvious active, and possibly chronic, sediment source. Slowly eroding banks are those banks where some erosion processes appear to be occurring, but vegetation and bank material provide stability and greatly reduce the rate of erosion. Slowly eroding banks are generally expected to occur under most natural conditions, in most environments.

Eroding banks measured in the field were also classified by those sources that appear to be influencing erosion. Determinations were made for each bank based on the witnessed adjacent or upstream activities/sources of instability and best professional judgment. Banks were collectively reviewed for each reach, and a classification of natural or human influence was given to each reach based on overall percentage of influence. Reaches with less than 25% human influence were deemed natural. Eight of the twenty-four reaches in the Flint Creek TPA were classified as naturally influenced.

To determine the total allowable load, analysis was conducted on the naturally influenced reaches. For each naturally influenced reach, the percent of the reach length that was eroding was reviewed for actively eroding banks, slowly eroding banks, and total eroding banks. The averages of these percentages for all naturally influenced reaches were then calculated to be 1.3% actively eroding and 5.8% slowly eroding, for a total of 7.1% of the stream reach length with eroding banks. In contrast, the average for human influenced reaches was 9.1% active and 4.9% slowly, for a total of 14.0% of the stream length with eroding banks. It is assumed that the averages of percent eroding banks for naturally influenced reaches provides a reasonable expectation for streams under natural conditions, including those streams with all reasonable land, soil, and water conservation practices.

A comparison between average total load of natural and human influenced reaches finds 3.6 tons/year/1000’ reach for natural reaches, in contrast to 19.0 tons/year/1000’ for human influenced reaches. This provides further illustration of the apparent difference between the sediment loads of natural and human influenced reaches. However, this is simply an average of all human or natural reaches. The rate of erosion and subsequent load for each bank, and each reach, is presumed to be affected by those characteristics of the reach type (stream order, valley gradient, and valley confinement), and therefore the extrapolation of existing loads are based on the variations of loading among reach types.

As a result, a simple equation was derived to determine a reasonable load per reach type, based on the results of the percent reach length of eroding banks witnessed in natural and human influenced reaches. For each reach type, the percent of actively eroding banks relative to the total percent eroding banks in naturally influenced reaches (1.3/7.1=0.18) was multiplied by the average load for that reach type; this represents the percent length of actively eroding banks and associated load that would be expected under natural or full application of BMP conditions. Similarly, the average load for slowly eroding banks in each reach type was also multiplied by the percent of stream length containing slowly eroding banks in naturally influenced reaches (5.8/7.1=0.82). The sum of the actively eroding load and slowly eroding loads, based on the percent length of eroding bank types in naturally influenced reaches, serves as the

extrapolated load (per reach type) to determine the total allowable load from bank erosion. Extrapolated bank erosion loads, by stream, are presented in **Table 5-16**.

Desired load = (average active load per reach type * 0.18) + (average slowly eroding load per reach type * 0.82)

Example: Desired Load Reach Type 0-4-U = (15.5 * 0.18) + (2.5 * 0.82) = 4.9 tons/year/1000'

Table 5-16. Extrapolated Bank Erosion Loads and Reductions

Stream	Existing Bank Erosion Load	Desired Bank Erosion Load	Percent Reduction
Barnes Creek	408.6	185.8	55%
Boulder Creek	302.0	193.9	36%
Douglas Creek (Hall)	398.1	172.4	57%
Douglas Creek (Philipsburg)	132.0	73.6	44%
Flint Creek (upper)	2306.8	596.5	74%
Flint Creek (lower)	1467.1	389.7	73%
Fred Burr Creek	599.9	216.8	64%
Lower Willow Creek	692.1	232.7	66%
Smart Creek	952.6	374.6	61%
Trout Creek	508.9	229.3	55%

5.5.1.5 Allocations and achievement

The desired sediment load is a gross estimate based on limited data. As such, the quantified load is not as significant for management and TMDL achievement purposes as the potential percent reduction. Since the desired load is based on analysis of natural and human influenced bank erosion, it is assumed that this is a reasonable estimate for what is achievable. The percent reduction allocation encompasses all adjacent land use categories and land management practices, and expects land owners to manage their properties with all applicable and reasonable land, water, and soil conservation practices to protect, improve, and restore stable and healthy streambanks and riparian corridors. Reasonable land, water, and conservation practices in this context may include limiting riparian livestock grazing durations to reduce effect on riparian vegetation, directing livestock to designed water gaps or off-site watering locations, establishing a specific riparian corridor with free from human-related activity, or re-establishment of key riparian vegetation. It is acknowledged that recovery of stable banks and improvement of riparian vegetation communities may take many decades to achieve. It is encouraged that, in addition to managing current activities with all reasonable land, soil, and water conservation practices, management decisions to promote floodplain functionality and native vegetation establishment throughout the riparian corridor will be reviewed and implemented wherever and whenever possible.

Although it is difficult to discern between bank erosion influenced from current or historic human practices and bank erosion as a result of natural processes using aerial photography and GIS methodology, it is possible to identify potential present-day influencing factors with these methods. Through the stratification process used during the assessment method, adjacent land use and potential current influences on bank erosion was noted for each reach. Simple breakouts of the apparent percent influence of major land use types allows a general, but useful, overlook of those activities that may be affecting bank erosion. This data can be used to help assist land managers with prioritizing areas to expedite sediment load reductions and eventually achieve the TMDL. Rough estimates of potential influence at the watershed scale are presented in **Table 5-17** below.

It is acknowledged that the developed sediment loads and the method by which to attribute anthropogenic and historic influence are estimates based on aerial photography, best professional judgment, and limited access to on-the-ground reaches. The assignment of bank erosion loads to the various land uses is not definitive; however it does provide helpful guidance for directing focus and efforts at reducing the loads from those causes which are likely having the biggest impacts on the investigated streams. Ultimately, it is the responsibility of local land owners and managers to identify the causes of bank erosion, and adopt practices to reduce bank erosion where ever practicable and possible. Complete TMDLs and allocations are presented in **Section 5.6**.

Table 5-17. Percent Adjacent Land Use With Potential Influence on Bank Erosion (as identified through GIS/aerial imagery)

Watershed	Natural	Tranport.	Grazing	Mining	Forestry	Irrigation	Other*
Barnes	27	6	31			27	9
Boulder	57	25	1	4	2		11
Douglas (N)	10	49	12	3	8	17	
Douglas (S)	28	45		20	6		1
Flint	6	24	20	1		45	4
Flint	2	9	23			56	10
Fred Burr	55	12	1	3	7	11	12
L. Willow	10	7	29			53	1
Smart	37	26	23		4	9	1
Trout	7	3	28			54	8

* 'Other' typically refers to adjacent land use that appears to be obviously related to past human activity, but an activity that is not as easily discernable due to the length of time that has elapsed. For example, historic placer mining and historic timber harvest may be designated as 'Other' based on judgment regarding how long ago the activity occurred, and the likelihood that the activity will occur again at that location in the future.

5.5.1.6 Assumptions and Considerations

- The annual streambank erosion rates used to develop the sediment loading numbers were based on Rosgen BEHI studies developed using Colorado USDA Forest Service data for streams found in sedimentary and/or metamorphic geology. While the geologies between the Rosgen research sites and the Flint Creek TPA are not identical, they are similar enough in character to warrant their application.
- The bank erosion data collected during the 2009 field effort is representative of conditions throughout the Flint Creek watershed.
- The assignment of influence to the eroding banks, and distinction between natural and human caused bank erosion is based on best professional judgment by qualified and experienced field personnel.
- The application of percent length of eroding bank in naturally influenced stream reaches, and the differences between actively eroding and slowly eroding banks provides a reasonable expectation for achievable conditions under natural and/or properly managed conditions.
- Specific quantification of the load reductions estimated here is not as significant as the complete application of best management practices in each of the watersheds of interest. With application of all reasonable land, soil, and water conservation practices it is expected that the allocation will be achieved.

- The land use percentages identified in **Table 5-17** are general and may not be entirely accurate. They are intended to provide a starting point for further investigation and activity to address bank erosion by land use planners and watershed managers.

5.5.2 Sediment from Roads

Roads located near stream channels can impact stream function through a degradation of riparian vegetation, channel encroachment, and sediment loading. The degree of impact is determined by a number of factors including road type, construction specifications, drainage, soil type, topography, precipitation, and the use of Best Management Practices (BMPs). In the Flint Creek watershed, sediment from roads has been identified as one of three major source categories potentially affecting sediment loads in impaired tributary streams.

In the summer of 2010, DEQ conducted a study of road systems in the Flint Creek TMDL planning area (TPA) to estimate sediment contributions and potential load reductions from unpaved roads. Data was collected from randomly selected road crossings and parallel segments and entered into a soil erosion model (WEPP:Roads) to quantify the amount of sediment produced at each location. The model was used to quantify loads from both existing conditions and potential BMP conditions. Results from assessed road features were then extrapolated to non-assessed features based on ownership, road-type, and precipitation characteristics. The following subsections present summary information regarding the road assessment and load calculations. Expanded details of this assessment are provided in **Appendix E**.

5.5.2.1 Quantifying Sediment From Roads

Computer models are often used to simulate road surface erosion response to the hydrology and climate for a given area. These models take into account weather, road condition, road shape, road orientation, topography, buffering vegetation, and other factors. Most models require a certain amount of specific field information as input parameters to derive loads from discrete locations; however, in large areas of study, representative conditions from a subset of locations may be modeled, and the results extrapolated to the remaining roads.

In 2010, DEQ used GIS to identify crossings and parallel segments in the road network, and classified them relative to the subwatersheds of interest, land ownership, precipitation zone and road type. Then, a total of 38 unpaved crossings and 8 parallel segments were measured in the field to provide a subset of data related to these road attributes. General results of the GIS assessment are presented in **Table 5-18**.

Assessment of data from the field evaluation was conducted using the WEPP:Road forest road erosion prediction model (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model (Flanagan and Livingston, 1995), developed by the USDA Forest Service and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The model predicts sediment yields based on soil, climate, ground cover, and topographic conditions. Specifically, the following model input data was collected in the field: soil type, percent rock, road surface, road design, traffic level, and specific road topographic values (road grade, road length, road width, fill grade, fill length, buffer grade, and buffer length). In addition, supplemental data was collected on vegetation condition of the buffer, evidence of erosion from the road system, and potential for best management practice implementation.

Table 5-18. Road Statistics for Streams in the Flint Creek TPA

Watershed	Watershed Area (mi^2)	Stream Miles	Road Miles	Road Density (mi/mi^2)	Number of Crossings	Unpaved Parallel Road Length w/in 150 feet of streams (mi)
Barnes Creek	21.33	37.6	36.36	1.70	29	1.62
Boulder Creek	70.64	67.7	148.55	2.10	74	6.96
Douglas Creek (North)	14.68	20.6	51.24	3.49	34	7.13
Douglas Creek (South)	6.43	7.8	27.60	4.29	21	2.34
Fred Burr Creek	15.75	14.2	25.15	1.60	9	0.91
Lower Flint Creek	24.41	92.3	115.24	4.72	79	10.40
Middle Flint Creek	35.26	94.3	199.53	5.66	112	10.77
Upper Flint Creek	69.85	62.0	203.34	2.91	86	12.12
Smart Creek	77.32	27.0	97.46	1.26	72	10.48
Trout Creek	14.11	42.3	63.44	4.50	41	3.49
Lower Willow Creek	76.03	27.2	19.11	0.25	20	0.96
North Fork Willow Creek	30.4	40.5	62.36	2.05	38	5.54
South Fork Lower Willow Creek	40.21	51.3	98.55	2.45	52	4.30

5.5.2.2 Sediment from Road Crossings

Often, the majority of sediment loading from roads occurs at road crossings. Intersections of road and stream are natural drainage locations and often have limited capacity for buffering or diverting sediment laden runoff from the road. The contributing sediment load at road crossings is a function of the road length and condition adjacent to the crossing, and other physical and hydrologic characteristics of the immediate area. Addressing road/stream crossings and their contributing sediment load is an important component to managing the sediment load from road networks.

Each site was individually modeled and the results were organized based on the ecoregion, land ownership, road type and associated climate station. The combination of these characteristics is defined as a road category. Loads for the measured sites were then averaged by road category.

Sediment loads for the Flint Creek TPA road crossings were then extrapolated by multiplying the average sediment load for each road category by the total number of road crossings within that category. In those instances where no representative sites were sampled within a particular road category, the average load for **all** sites of a given road surface and climate station was applied. A total of 711 road crossings were identified in the Flint Creek TPA. Of these, 44 crossings were paved and therefore determined to not contribute road related sediment. (**Table E-3** in **Appendix E** presents the extrapolated loads.)

Of the 55 road crossings visited during the field assessment, 17 of them were determined to be “false stream crossings”. False stream crossings are those crossings that, upon investigation, do not appear to contribute any sediment load because of a lack of a defined waterway or conveyance of sediment load to a stream, or errors in GIS analysis. It can be assumed therefore, that not all of the road crossings identified through the GIS analysis contribute sediment. In order to account for this, and thereby provide a more accurate representation of the sediment loads after extrapolation, a reduction factor was calculated using the difference between “true crossings” to “false crossings” as observed in the field. As described in **Section 3.0**, 31% of the sites encountered in the field were determined to be false crossings. That percentage was then considered the reduction factor. The reduction factor was applied

to the total calculated loads for each watershed. Sediment loads from road crossings per watershed are presented in **Table 5-19**.

Table 5-19. Estimated Sediment Loads for Road Crossings, by Watershed

Watershed	Number Crossings	Estimated Total Load (lb/year)	Estimated Total Load (tons/year)	Total Load with 31% Reduction Factor (tons/year)
Barnes Creek	29	5,202	2.60	1.79
Boulder Creek	74	17,474	8.74	6.03
Douglas Creek (North)	34	7,145	3.57	2.46
Douglas Creek (South)	21	3,184	1.59	1.10
Fred Burr Creek	9	1,468	0.73	0.50
Lower Flint Creek	79	13,151	6.58	4.54
Middle Flint Creek	112	22,086	11.04	7.62
Upper Flint Creek	86	16,699	8.35	5.76
Smart Creek	72	16,793	8.40	5.80
Trout Creek	41	4,411	2.21	1.52
Lower Willow Creek	20	2,931	1.47	1.01
North Fork Willow Creek	38	5,892	2.95	2.04
South Fork Lower Willow Creek	52	7,976	3.99	2.75
Total	667	124,412	62.22	42.92

5.5.2.3 Sediment from Parallel Segments

Sediment contributed from road/stream crossings addresses discrete locations in a watershed where the road and stream intersect. However, road sediment from those parallel sections of road which may not have a direct entry point to the stream channel must also be considered and included with the overall sediment load quantification.

In the Flint Creek TPA, parallel road segments were also investigated to calculate sediment contribution from roads. Parallel road segments were modeled with WEPP:Roads to calculate the amount of sediment from roads that are within a distance of 150 feet of the stream. Eight parallel segments were measured in the field. For modeling purposes, contributing road lengths were given a maximum contributing length of 1000'. The calculated load for each parallel segment was converted to an annual load per mile of road length. In this case, since the number of sampled parallel road segments was too few to allow to effectively discern differences between road type, climate station, or ownership, a general average sediment load for parallel road segments was determined.

The average load per mile was then multiplied by the total miles of parallel road segments in each watershed (as was identified during the GIS analysis) and an estimate of sediment load from parallel segments was determined for each watershed. Due to time and resource constraints, data collected for parallel segments during the road assessment came from a smaller representative sample of sites. Therefore, the same reduction factor that was used with road crossings (31%) was used for parallel segments based on the assumption that the same general analysis error and geographic features present throughout the watershed apply to the parallel segments as do the road crossings. Sediment loads from parallel segments per watershed are presented in **Table 5-20**.

Table 5-20. Estimated Sediment Loads for Parallel Segments, by Watershed

Watershed	Miles of Gravel Road	Miles of Native Road	Total Road Miles	Estimated Total Load (tons/year)	Total Load 31% RF (tons/year)
Barnes Creek	0.88	0.74	1.62	1.55	1.07
Boulder Creek	3.86	3.10	6.96	6.66	4.60
Douglas Creek (North)	5.57	1.56	7.13	6.82	4.71
Douglas Creek (South)	1.32	1.02	2.34	2.24	1.56
Fred Burr Creek	0.16	0.75	0.91	0.87	0.60
Lower Flint Creek	3.03	7.37	10.40	9.94	6.86
Middle Flint Creek	5.70	5.07	10.77	10.30	7.11
Upper Flint Creek	3.18	8.94	12.12	11.59	8.00
Smart Creek	4.55	5.93	10.48	10.02	6.91
Trout Creek	1.64	1.85	3.49	3.34	2.30
Lower Willow Creek	0.66	0.30	0.96	0.92	0.63
North Fork Willow Creek	1.72	3.82	5.54	5.30	3.66
South Fork Lower Willow Creek	1.00	3.30	4.30	4.11	2.84
Total	33.27	43.76	77.02	73.65	50.85

5.5.2.4 Establishing the Total Allowable Load

The sum of the loads from road crossings and parallel segments is an estimate of the existing sediment load from the road networks in the Flint Creek TPA. To determine the reductions necessary to achieve a desired condition, or total allowable load from roads, data for each of the measured sites was rerun in WEPP:Roads, with changes to represent the implementation of BMPs. BMP modifications were based on photographs and notes, taken during data collection, of potential improvements that could be made specific to each investigated site. Potential improvements include improving road surface type, reducing the contributing length of road to the crossing through installation of waterbars or additional drainage features, and improvement of roadside vegetation for filtering purposes. As in calculating the existing loads, sites were then grouped according to road type, ownership, and precipitation zone; averages developed for road categories; and values extrapolated throughout the watersheds **Table 5-21**. **Table 5-21** also provides a normalized load (load/1000 acres) to illustrate relative degree of loading between watersheds.

Table 5-21. Estimated Sediment Loads From Roads With Application of BMPs, by Watershed

Watershed	Acres	Crossings Load	Parallel Load	Total Load	Percent Reduction	Load/1000 acres
Barnes Creek	13,649	0.39	0.23	0.62	78%	0.05
Boulder Creek	45,207	0.70	0.99	1.69	84%	0.04
Douglas Creek (North)	9393	0.28	1.01	1.29	82%	0.14
Douglas Creek (South)	4118	0.31	0.33	0.64	76%	0.16
Fred Burr Creek	10,082	0.15	0.13	0.28	75%	0.03
Lower Flint Creek	49,485	0.97	1.48	2.45	79%	0.05
Middle Flint Creek	48,657	1.32	1.53	2.85	81%	0.06
Upper Flint Creek	44,707	1.09	1.72	2.81	80%	0.06
Smart Creek	15,626	0.88	1.49	2.37	81%	0.15
Trout Creek	22,565	0.64	0.50	1.14	70%	0.05
Lower Willow Creek	9032	0.26	0.14	0.40	76%	0.04
N. F. Willow Creek	19,453	0.38	0.79	1.17	79%	0.06

Table 5-21. Estimated Sediment Loads From Roads With Application of BMPs, by Watershed

Watershed	Acres	Crossings Load	Parallel Load	Total Load	Percent Reduction	Load/1000 acres
S. F. Willow Creek	25,731	0.43	0.61	1.04	81%	0.04

5.5.2.5 Determining Allocations

Allocations for the reduction of sediment from roads in the Flint Creek TPA are presented as general percent reduction by watershed. It is expected that the maintenance of roads and ultimate achievement of the desired load is the responsibility of those individuals or entities who control and manage the roads. An illustration of road crossing ownership throughout the Flint Creek TPA is provided in **Table 5-22**. The true ownership, and therefore responsibility of maintenance, identified in **Table 5-22** is not confirmed, however the table provides an indication of the distribution of ownership by which to direct initial management activity priorities and investigations.

Table 5-22. Road Crossings By Ownership Based on Available GIS Information, By Watershed

Watershed	BLM	USFS	State of Montana	Private	Unattributed
Barnes Creek	-	2	-	26	1
Boulder Creek	1	69	-	4	-
Douglas Creek (North)	-	22	-	12	-
Douglas Creek (South)	1	-	-	19	1
Fred Burr Creek	-	-	-	9	-
Lower Flint Creek	-	14	3	62	-
Middle Flint Creek	10	31	-	70	1
Upper Flint Creek	-	47	-	35	4
Smart Creek	3	42	-	27	-
Trout Creek	-	-	9	32	-
Lower Willow Creek	-	-	-	20	-
North Fork Willow Creek	-	11	-	27	-
South Fork Lower Willow Creek	-	29	-	23	-

* Road crossings as identified through initial GIS analysis and does not account for 30% reduction due to "false-crossings". Crossings were identified based on adjacent land ownership; it is acknowledged that road ownership may not always equate to adjacent land ownership and therefore the ownership attribution may not be entirely accurate.

The management practices to achieve load reductions may be accomplished through a variety of measures; such as the installation of structural BMPs (drive through dips, culvert drains, settling basins, silt fence, etc), road surface improvement, reduction in road traffic levels (seasonal or permanent road closures), and timely road maintenance to reduce surface rutting. It is recognized that in reality, in some cases the majority of the sediment load may come from only a few discrete locations within a watershed, or some watersheds may currently have some or all of their roads addressed with appropriate BMPs and the allocations may already have been met. It is expected however, that the derived sediment load and expected reductions in this document serve as a starting point for road management investigations, and a guideline for where to begin additional studies to improve and refine these estimates. Complete TMDLs and allocations are presented in **Section 5.6**.

5.5.2.6 Assumptions and Considerations

- The sites assessed are representative of conditions throughout the Flint Creek TPA.

- The BMP reductions as simulated in WEPP represent the likely achievable reductions in sediment load that can be gained from BMP application throughout the watershed.
- Approximately 31% of the initially identified crossings and parallel segments either do not exist or do not contribute a quantifiable load to the streams of interest.
- BMPs may have already have been implemented on roads but have not been accounted for in the GIS information used in this analysis and therefore the reductions necessary by land owner may be less than described in this document.

5.5.3 Upland Sediment

Upland sediment is sediment that occurs across the landscape and is influenced by land use and/or vegetative cover. Sediment from the landscape may be entirely natural, or it may be increased by human activities such as timber harvest practices, farming or grazing practices, or clearing of land for development. When human activities increase levels of sediment, nutrients, metals, etc to levels that affect beneficial uses (**Section 3.0**), it may be described as a form of pollution. The term "nonpoint source pollution" is described as pollution that originates over many varied and diffuse sources, as opposed to pollution delivered directly from a specific point or outlet, such as an end of pipe or chimney stack. Typically, nonpoint source pollution is carried to streams and lakes through erosion via surface water (in the form of rainfall or snowmelt), groundwater, or wind. It is often difficult to accurately quantify pollutant loads from the landscape when so much variability may exist across a watershed with regard to weather, vegetation, land use practices, soil types, geology, riparian condition, etc. However, while many complex processes are intertwined that determine a pollutant load, models can be employed to represent the landscape and simulate natural processes to reasonably estimate sediment loads, identify where on the landscape the loads are coming from, and intimate how those loads could be reduced. In the Flint Creek watershed, a Universal Soil Loss Equation (USLE) model was used to quantify sediment loads from various land cover/land use types.

5.5.3.1 Quantifying Sediment from Upland Sources Using USLE

Upland sediment loading due to hillslope erosion was modeled using a GIS application of the USLE model. A sediment delivery ratio was incorporated in USLE to better simulate the relationship between downslope travel distance and ultimate delivery to the stream. In addition, riparian zone health was also accounted for in quantifying sediment loads from upland sources, since riparian zone health is susceptible to anthropogenic impacts and thus to land management decisions, and the effectiveness of healthy riparian zones as sediment filters has been quantified in the literature. This model provided an assessment of existing sediment loading from upland sources, an assessment of potential sediment loading through the application of BMPs and riparian improvement.

USLE uses five main factors by which to estimate soil erosion: R * K* LS * C * P, where:

R = rainfall/intensity
K = erodibility
LS = length/slope
C = vegetation cover
P = field practices

ArcGIS and available data sources were used to develop the appropriate USLE factor values to estimate upland sediment loading. Typically, the ability to modify change to vegetation cover or field practices are the only real ways to simulate landscape or land management alterations using USLE. As the P-Factor (field practices) generally relates to specific agricultural plots and at a scale much less than the

watershed-scales DEQ deals with, the C-Factor is the main variable to represent existing conditions and the potential for improvement. The C-factor integrates a number of variables that influence erosion, including vegetative cover, plant litter, soil surface, and land management. Three primary variables are considered when determining the C-factor, including (1) canopy cover effects, (2) effects of low-growing vegetal cover, and (3) rooting structure. For the Flint Creek TPA, the 2001 National Land Cover Dataset, NRCS C-factor tables, and the assistance and input of local NRCS and USFS employees served as the basis for establishing the C-factors.

The riparian corridor quality assessment, used to modify sediment delivery to the stream, is based on the stream reach stratification results described earlier. Riparian corridors are referred to as having low (marginal/limited), moderate (some good, some marginal), or high (majority adequate for aquatic resources) quality and the buffering capacity of the riparian corridor is based on the percent condition for each stream of interest. The following subsections provide a summary of the upland sediment modeling efforts in the Flint Creek TPA. Expanded details of this effort are documented in the report, Flint Creek Watershed Sediment Assessment: Upland Sediment Assessment Modeling and BMP Effectiveness and Percent Reduction Potential, (Water & Environmental Technologies, P.C., 2010) and is included here as **Attachment B**.

5.5.3.2 Establishing the Total Allowable Load

From the model output, an average annual sediment load delivered to the stream is determined for each subwatershed, (or listed stream watershed). This sediment load represents the best estimation of current conditions (land use, land cover, riparian condition) and resultant sediment from upland sources.

To determine the total allowable load from upland sources, land use/land cover categories are modified (through an alteration to the C-Factor, or vegetative condition) and riparian condition categories improved to represent those changes on the landscape, and the USLE model is run again. The resultant sediment loads represent a desired condition where all reasonable land, soil, and water conservation practices are employed.

For the purposes of this assessment, only a few land use categories were modified. These include mixed forest, shrub/scrub, grasslands/herbaceous, pasture/hay, and cultivated crops. For example, ground and canopy cover percentages for shrub/scrub and grassland/herbaceous land would increase 10% with the reduction of grazing pressure, while ground cover percentages for mixed forest would increase 5%. Ground cover percentages for pasture/hay and cultivated cropland would increase 10% and 20%, respectively, with the implementation of BMP practices designed to reduce erosion, such as conservation tillage or crop stripping. It is assumed that in the Flint Creek TPA, these land use categories have real potential for improvement and are often not meeting all applicable land, soil, and water conservation practices. The sediment contributions from the other land uses in the Flint Creek TPA are presumed to be either negligible, or with little potential for altering the current management to reduce existing sediment loads. In addition, riparian corridor buffering efficiency was altered to reflect an increase from moderate quality riparian health to high quality and from areas with low quality riparian health to an improved moderate quality. (The riparian improvement scenario is based on a very broad assumption that there is some level of riparian improvement capable from areas designated as low or moderate. It is acknowledged however that there are certainly areas where the riparian corridor is at its potential, despite the fact that they may not appear to be high quality when reviewed through aerial photos. When developing implementation plans for a given watershed, a more thorough investigation of

riparian condition should be conducted to identify where riparian improvement is possible, and to what degree.) Results are presented in **Table 5-23**.

Table 5-23. Upland Modeling Results

Watershed	Existing Condition (tons/year)	Land use/Land Cover BMP Implementation (tons/year)	Percent Change From Existing	Land Use/Land Cover BMPs and Riparian Improvement (tons/year)	Percent Change From Existing Condition
Barnes Creek	605	491	19%	265	56%
Boulder Creek	494	452	8%	279	44%
Douglas Creek (north)	535	446	17%	244	54%
Douglas Creek (P'burg)	58	50	13%	34	42%
Fred Burr Creek	61	57	8%	36	41%
Georgetown Lake	146	129	12%	74	49%
Lower Flint Creek	2276	1842	19%	948	58%
Lower Willow Creek	1121	900	20%	467	58%
Middle Flint Creek	3195	2592	19%	1334	58%
Princeton Gulch	124	110	11%	62	50%
Smart Creek	685	558	18%	305	55%
Trout Creek	1555	1224	21%	612	61%
Upper Flint Creek	179	147	18%	76	58%
Upper Willow Creek	2554	2098	18%	1212	53%

5.5.3.3 Determining Allocations

The upland sediment loads are estimations based on the land uses, land cover types, riparian conditions, and potential for improvements that exist within a watershed. The difference between the modeled existing condition and the modeled desired condition provides the amount of sediment that must be reduced to achieve acceptable sediment loads from upland sources. Because it is difficult to discretely quantify the sediment loads at the watershed scale, the percent reduction serves to best describe the degree of sediment load reduction necessary for each watershed. This value is then incorporated into each TMDL calculation. In the Flint Creek TPA, although a general percent reduction value is provided for the major source types, land use/land cover types and the associated percent reductions are provided to assist with future planning and prioritization or management activities. These values are provided in **Table 3-1** of **Attachment B**.

5.5.3.4 Assumptions and Considerations

As with any modeling effort, and especially when modeling at a watershed scale, there are a number of assumptions that must be accepted. For the Flint Creek TPA, the following points serve as some of the more significant considerations:

- The input variables used in the USLE calculations are representative of their respective land use conditions.
- The land management practices (grazing duration, hay cutting, etc) for certain land use categories that define the vegetative cover are relatively consistent and representative of practices throughout the watershed.
- The riparian condition as estimated through the aerial assessment is representative of on-the-ground conditions.
- The improvement scenarios to riparian condition and land management are reasonable and achievable.

- The USLE model provides an appropriate level of detail and is sufficiently accurate for developing upland sediment loads for TMDL purposes.
- The data sources used are reasonable and appropriate to characterize the watershed and parameterize the model.

5.6 TMDL AND ALLOCATIONS (BY STREAM)

The sediment TMDLs for all streams and stream segments presented below are expressed as a yearly load, and a percent reduction in the total yearly sediment loading achieved by applying the load allocation reductions identified in the associated tables. These reductions address both coarse and fine sediment loading to ensure full protection of beneficial uses. The allocations are based on information provided from the source assessment analyses used within this document, and a determination that these approximate source load reductions for each stream or segment of interest, and its contributing tributaries, will cumulatively account for the total percent reduction needed to meet the TMDL, and is achievable by addressing the major human caused sources described in this section. The sediment load allocations and associated rationale behind the allocations are described in **Section 5.5** and **Attachments A and B, and Appendix E**. Due to the uncertainty and assumptions associated with the methods used to determine sediment loads, the specific annual loads should not necessarily be recognized as an exact quantification. However the percent reductions presented offer a valuable and more conceivable goal for watershed restoration planning purposes and an accurate representation of the *degree* of sediment reduction that would result from the implementation of this plan. As required by EPA, TMDLs must also be expressed as actual daily loads. Information on interpreting these values into "daily" sediment loads is presented in **Appendix F**.

Sediment from upland erosion in the following tables is represented as the sum of upland sediment load from each of the categorized land uses within that watershed. These land uses, by default, incorporate sediment loads influenced by both anthropogenic activities and natural loads. However, within the context of TMDL development and Montana state law, we can interpret the natural load to be the load that results when all reasonable land, soil, and water conservation practices are applied, which in this case, also equates to the sediment load allocation.

A TMDL is determined by the sum of the Wasteload Allocation (WLA), Load Allocation (LA), and Margin of Safety (MOS). Wasteload Allocations are derived for specific point sources, often which require local, state, or federal permits that put limits on the amount of a particular pollutant that a nearby waterbody can receive. There are two permits in the Flint Creek watershed requiring a WLA: one on Smart Creek associated with the Black Pine Mine, and one on the upper segment of Flint Creek associated with the wastewater treatment plant for the town of Philipsburg. These permits and WLA's are discussed in detail in their respective sections below. There are no WLA's for Barnes Creek, Douglas Creek, and the lower segment of Flint Creek.

In addition to the TMDLs and allocations presented below, a sub-section is included for each stream entitled "Implications for Implementation". These sections are provided to give additional information or suggestions on broad categories to begin efforts to address TMDLs. More detailed descriptions of specific implementation strategies and management practices are included in **Section 8.0**, however these descriptions to do not identify specific locations within any of the watersheds; only practices that may be used to address pollutants in the Flint watershed. As with any TMDL document, the analysis and resultant determinations contained herein are meant as the first steps toward achieving water quality goals. It is up to local land owners and resource managers to build upon the foundation of the TMDL and

develop the proper strategies to address pollutants and meet water quality standards in the most appropriate, efficient and effective ways possible.

5.6.1 Barnes Creek

TMDL and allocations for Barnes Creek are presented in **Table 5-24**. Current estimated loads are presented as gross estimates which include natural and anthropogenic related loads. Sediment load allocations are estimated loads that are expected under all reasonable land, soil, and water conservation practices and natural conditions.

Table 5-24. Barnes Creek Sediment TMDL

Sources	Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion	409	186	55%
Roads	3	1	79%
Upland Load	605	265	56%
Total Sediment Load	1017	452	56%

The loads presented in **Table 5-24** above provide only general estimations of current loads and reductions needed from the three major source types in order to achieve the TMDL. For consistency in presentation, sediment loads have been rounded to the nearest ton/year. However, percent reduction values are based on the actual values determined through the source assessments (**Section 5.5**). Information from the source assessments and reach stratification provides insight into how and where to begin continued investigation and action to prioritize efforts to affect change and reduce sediment.

Implications for Implementation

An aerial assessment conducted on Barnes Creek during the stratification effort further characterizes the near stream conditions. Although only a qualitative observation, riparian condition was deemed 15% good, and 85% fair. Riparian vegetation composition was observed to be 15% mature coniferous, 31% shrubs, and 54% grasses. Typically riparian areas observed to be dominated by grasses often reflect less stable banks and higher sediment loads from bank erosion. These conditions also often reflect agricultural practices that may be limiting riparian health and condition. Adjacent land use was described as 14% forest, 40% range, 34% hay/pasture, and 12% rural residential. Aerial assessment attribution to bank influence identified 67% to grazing, irrigation, and other related human influence. Only 27% of the stream appeared to be without significant human influence, and roads made up the final 6%.

According to the loads in **Table 5-24**, roads in the Barnes watershed make up a relatively minor contribution to the overall sediment input to the stream. Of 29 identified crossings, 26 (90%) were designated as private or country roads. Although the load from roads is minor in comparison to other sources, a full inventory of Barnes roads and crossing conditions should be conducted to identify the most in need of improvement. Once identified, outreach should be developed to work with those responsible for road maintenance to reduce sediment loads and keep the load from roads to a minimum.

Upland loads in the Barnes watershed were identified as 45% grassland/herbaceous, 20% shrub/scrub, and 6% pasture/hay, for a total of 71% of land designated as having a potential for management improvement. According to the USLE model results, management changes alone through the

improvement of vegetative cover could yield a 20% decrease in sediment. When coupled with riparian improvement, the predicted result is a 57% sediment load reduction from upland sources.

In summary, the Barnes watershed sediment loads appear to be most influenced by land management related to grazing and other agricultural practices, and the loss of riparian vegetation that is likely associated with those practices. As illustrated in the adjacent land use, almost a third of the watershed has range or hay/pasture. This watershed could see significant improvement through riparian restoration efforts, as well as review of upland land management practices, and changes where appropriate.

5.6.2 Douglas Creek (Philipsburg)

TMDL and allocations for Douglas Creek are presented in **Table 5-25**. Current estimated loads are presented as gross estimates which include natural and anthropogenic related loads. Sediment load allocations are estimated loads that are expected under all reasonable land, soil, and water conservation practices and natural conditions.

Table 5-25. Douglas Creek Sediment TMDL

Sources	Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion	132	74	44%
Roads	3	1	78%
Upland Load	58	34	41%
Total Sediment Load	193	109	44%

The loads presented in **Table 5-25** above provide only general estimations of current loads and reductions needed from the three major source types in order to achieve the TMDL. For consistency in presentation, sediment loads have been rounded to the nearest ton/year. However, percent reduction values are based on the actual values determined through the source assessments (**Section 5.5**). Information from the source assessments and reach stratification provides insight into how and where to begin continued investigation and action to prioritize efforts to affect change and reduce sediment.

Implications for Implementation

Aerial assessment on Douglas Creek conducted during the stratification further characterizes the near stream conditions. Although only a qualitative observation, riparian condition was designated as 15% good, 34% fair, and 51% poor. In addition, the riparian vegetation composition identified 30% as mature conifers, 16% shrubs, 3% grass, and over half identified as bare. Bare in this context refers to closely cropped vegetation or manicured lawns through the town of Philipsburg, in addition to the loss of riparian from mining practices and related disturbances upstream in the watershed. Attribution to bank erosion influence conducted during the aerial assessment identifies 20% to mining, 45% to transportation, 6% to forestry, and 28% natural. Review of adjacent land use describes 28% as forest, 24% as mine related, 25% as urban, and 13% roads. Limited access and road conditions limited visual observations on the upper watershed at the time of the field data collection, however the instability of banks and potential sediment load related to bare banks is probably a greater threat in the upper watershed due to the general terrain and steeper stream gradients there; as opposed to the lower section where the stream is essentially ditched and armored, inhibiting its ability to develop a natural morphology. The transportation influence on bank erosion refers to roads that impede or confine the channel, and therefore may exacerbate stream velocities and power resulting in increased erosion. As Douglas Creek has an unpaved road paralleling the stream through much of the upper watershed, and

roads paralleling the stream throughout lower Douglas Creek, the 45% attribution to transportation seems reasonable.

Despite the high influence roads appear to have on channel form and stability, the sediment load from roads themselves is minimal in relation to the loads derived from bank erosion and upland sources. Nevertheless, these roads, particularly because of their proximity to Douglas Creek for much of its length, are a significant factor. Of 21 road crossings, 19 appear to occur on private or county roads. Much of that road length is in the upper watershed and as private road, may not be under the same standards of operation and maintenance. A full inventory of Douglas Creek roads and crossings should be conducted, especially above town, to identify the most in need of improvement and work with those responsible for road maintenance to reduce sediment loads and keep the load from roads to a minimum.

Upland land use in the Douglas Creek watershed was identified as 83% evergreen forest, 9% shrub/scrub, with small percentages of grassland, pasture, crop, and developed land. As a result, sediment loads derived using USLE could only be reduced by 14% through management improvements alone, with a maximum of 43% when coupled with riparian improvement.

In summary, Douglas Creek sediment loads appear to be most influenced by the present and historic practices related to mining and resource extraction in the upper watershed. Road development along the stream, and mining that occurred adjacent to and within the riparian corridor has disturbed and destabilized the banks, removed vegetation that would otherwise serve as a buffer or filter, and created direct conduits of sediment to the stream via the roads. However, the upper watershed is not the only source of sediment. In addition, the historic development of Philipsburg altered Douglas Creek's channel form and flow path and denuded much of the lower watershed's riparian vegetation. Years of manipulation and adaptation to the lower watershed's development has left the stream relatively stable here, however focus should be placed on improving riparian vegetation where appropriate, and investigating the road system to eliminate or reduce as many sediment paths to the stream as possible (the road source assessment focus on unpaved roads, where most of the roads through town are paved, and therefore their contribution unaccounted for). In the upper watershed, investigation and improvement of road conditions, and restablishment of riparian vegetation, particularly in known mine areas, should be a priority.

5.6.3 Flint Creek (Upper - Georgetown Lake to confluence with Boulder Creek)

Loads presented in **Table 5-26** include the sediment loads from all major contributing watersheds that flow into the upper segment of Flint Creek. These include Georgetown Lake, Trout Creek, Fred Burr Creek, and Douglas Creek (near Philipsburg), and the middle Flint watershed (from Fred Burr Creek to Boulder Creek). Current bank erosion and upland sediment loads include natural and human caused loads; load allocations for these two sources express the sediment load that can be expected with implementation of all reasonable land, soil, water conservation practices. The difference between the two is considered the controllable load, i.e., the human caused load.

Wasteload Allocation

Philipsburg's domestic wastewater treatment plant is a MPDES permitted point source authorized under permit #MT0031500. The plant is a two-cell facultative lagoon with no disinfection and a continuous discharge. It was built in 1961 and upgraded in the early 1990s. The plant discharges directly to Flint Creek via a single outfall location (at the end of ditch) and has a 300 foot mixing zone. With a maximum

design flow of 0.16 million gallons per day (mgd), the WWTP serves 520 hookups (over 900 citizens) from the Town of Philipsburg (Houston Engineering, 2011).

The WLA for the Philipsburg treatment plant is based on the current load limit in its permit. This can be calculated using the facility design capacity of 0.160 mgd (0.25 cfs) and the 30-day average TSS permit concentration limit of 45 mg/l. This equates to 60 lbs/day, or 11.0 tons/year. Although the 7-day average value can be as high as 65 mg/l, the 30-day average TSS concentration of 45 mg/l provides a more representative account for calculating the acceptable yearly load.

The effect from this allowable permit discharge can be evaluated by calculating the potential increase in TSS loading within Flint Creek from the Philipsburg WWTP at design capacity. Flint Creek data from sampling completed by DEQ near the town of Philipsburg during 2007-2009 can be used to represent typical low flow conditions. Using a flow of 66.2 cfs (which is the lowest cfs recorded in the vicinity by DEQ during August) and an average TSS value for August measurements of about 9.9 mg/l; if the Philipsburg WWTP was discharging at design capacity (0.25 cfs) with a TSS concentration of 65 mg/l into Flint Creek when Flint Creek was flowing at 66.2 cfs, the result would be an increase in TSS concentration in Flint Creek from approximately 9.9 mg/l to 10.1 mg/l. Under this scenario, a 0.2 mg/l increase represents an acceptably low level that is not expected to cause harm to aquatic life nor is it expected to result in aesthetic concerns.

Based on the analysis above, it is concluded that the 11.0 tons/year load based on the existing permit is an acceptable value to use as the WLA for the Philipsburg wastewater treatment facility. This is also supported by the fact that the sediment TMDL focuses on inorganic material from watershed erosion processes, whereas the TSS load from the Philipsburg wastewater treatment facility is mainly organic material. The WLA applies to the upper segment of Flint Creek.

In addition to the concentration limitations on TSS described in the permit, the permit also called for a 65% removal requirement for TSS; whereby the arithmetic mean of the TSS for effluent samples collected in a period of 30 consecutive days shall not exceed 35% of the arithmetic mean of the values for influent samples collected at approximately the same times during the same period. This and any other conditions of the permit must still be met in addition to the WLA.

Table 5-26. Flint Creek (Upper) Sediment TMDL

Sources	Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion	3548	1116	69%
Roads	36	5	86%
Upland Load	5194	2166	58%
WLA – Philipsburg WWTP	11	11	0%
Total Sediment Load	8689	3299	62%

The loads presented in **Table 5-26** above provide only general estimations of current loads and reductions needed from the three major source types in order to achieve the TMDL. For consistency in presentation, sediment loads have been rounded to the nearest ton/year. However, percent reduction values are based on the actual values determined through the source assessments (**Section 5.5**). Information from the source assessments and reach stratification provides insight into how and where to begin continued investigation and action to prioritize efforts to affect change and reduce sediment.

Implications for Implementation

An aerial assessment conducted on upper Flint Creek during the stratification effort further characterizes the near stream conditions. Although only a qualitative observation, riparian condition was deemed 94% fair, and 6% poor. Riparian vegetation composition was observed to be 3% mature coniferous, 10% shrubs, 81% grasses, and 6% bare. Typically riparian areas observed to be dominated by grasses often reflect less stable banks and higher sediment loads from bank erosion. These conditions also often reflect agricultural practices that may be limiting riparian health and condition. Adjacent land use was described as 83% hay/pasture, with 7% as road, 2% as rural residential, 1% mining, and 8% as forest. 64% of possible influence on bank erosion in the upper Flint Creek mainstem was attributed to grazing and/or irrigation practices. Another 24% was attributed to the influence from roads. The remaining influence was presumed to be small percentages of mining or other human influences, and some naturally occurring bank erosion.

According to the loads in **Table 5-26**, roads in the upper Flint Creek watershed make up a relatively minor contribution to the overall sediment input to the stream. Of 198 identified crossings, 105 (53%) were designated as private or county roads, and 78 (39%) were within USFS property. The remaining road ownership was identified as BLM (5%) or unattributed (3%). Although the load from roads is minor in comparison to other sources, the analysis does indicate a potential for substantial improvement in sediment loads from roads. Reducing the loads from this source may improve discrete areas near and downstream of some of these sites, which may have a significant impact on fisheries or aquatic life as a whole. A full inventory of upper Flint Creek roads and crossing conditions should be conducted to identify those most in need of improvement. Once identified, outreach should be developed to work with those responsible for road maintenance to reduce sediment loads and keep the load from roads to a minimum.

Upland loads in the upper Flint watershed were identified as 17% grassland/herbaceous, 19% shrub/scrub, 6% pasture/hay, and 6% cultivated crops for a total of 48% of land designated as having a potential for management improvement. According to the USLE model results, management changes alone through the improvement of vegetative cover could yield a 20% decrease in sediment. When coupled with riparian improvement, the predicted result is a 59% sediment load reduction from upland sources.

It should be noted that the descriptions of stratification results, road, and upland load statistics are for the Flint Creek mainstem which includes some of its smaller contributing tributaries. The above summaries *do not* include Trout Creek, Douglas Creek (Philipsburg), or Fred Burr Creek. However these streams and their associated loads do factor into the TMDL and allocation calculations presented in **Table 5-26**. Immediate management activities to reduce sediment should focus on the Flint Creek mainstem and adjacent lands. Information above suggests that the predominance of agriculture and lack of good riparian quality should put focus on agricultural practices related to grazing and hay production and overall riparian condition. More detailed investigations of management practices and riparian health should be conducted to help prioritize areas where work can be done. Information related to Douglas Creek is described in detail in **Section 5.6.2**. Fred Burr Creek is a relatively low contributor of sediment in the context of the upper Flint Creek watershed, however roads in the Fred Burr watershed may be an issue and in general, road conditions and BMP implementation should be considered here as well. Trout Creek is dominated by agricultural land and when normalized by acreage, the estimated Trout Creek watershed sediment load is over 110 tons/1000 acres, more than any other watershed in the upper Flint Creek, including the upper Flint Creek valley watershed (which has an estimated contribution of 91 tons/1000 acres). Therefore, review of management practices and riparian condition

in the upper Flint Creek watershed should include Trout Creek, although Trout Creek has not undergone full assessment and is not identified as impaired in this document.

5.6.4 Flint Creek (Lower – Boulder Creek to mouth)

Loads presented in **Table 5-27** include the sediment loads from all major contributing watersheds that flow into the lower segment of Flint Creek. These include Barnes Creek, Boulder Creek, Douglas Creek (near Hall), lower Willow Creek, and Smart Creek (Loads from upper Willow Creek were not included in **Table 5-27** calculations because they deposit in a reservoir that separates the two segments. It is assumed that these loads are trapped within the reservoir and do not contribute to the sediment load in lower Willow Creek.) Current bank erosion and upland sediment loads include natural and human caused loads; load allocations express the sediment load that can be expected under natural conditions, and/or implementation of all reasonable land, soil, water conservation practices. The difference between the two is the percent reduction in sediment load and is considered the controllable load, i.e., the human caused load.

Table 5-27. Flint Creek (Lower) Sediment TMDL

Sources	Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion	4221	1563	63%
Roads	46	9	80%
Upland Load	5840	2570	56%
Upper Flint Loads*	8689	3299	62%
Total Sediment Load	18808	7427	61%

*From **Table 5-26**

The loads presented in **Table 5-27** above provide only general estimations of current loads and reductions needed from the three major source types in order to achieve the TMDL. For consistency in presentation, sediment loads have been rounded to the nearest ton/year. However, percent reduction values are based on the actual values determined through the source assessments (**Section 5.5**). Information from the source assessments and reach stratification provides insight into how and where to begin continued investigation and action to prioritize efforts to affect change and reduce sediment.

Implications for Implementation

An aerial assessment conducted on lower Flint Creek during the stratification effort further characterizes the near stream conditions. Although only a qualitative observation, riparian condition was deemed 98% fair, and 2% poor. Riparian vegetation composition was observed to be 37% shrubs, 62% grasses, and 1% bare. Typically riparian areas observed to be dominated by grasses often reflect less stable banks and higher sediment loads from bank erosion. These conditions also often reflect agricultural practices that may be limiting riparian health and condition. Adjacent land use was described as 83% hay/pasture, with 8% described as range, and 9% as rural residential. 80% of possible influence on bank erosion on the mainstem of lower Flint Creek was attributed to grazing and/or irrigation practices. Another 9% was attributed to the influence from roads. The remaining influence was presumed to be small percentages of mining or other human influences, and some naturally occurring bank erosion.

According to the loads in **Table 5-27**, roads in the lower Flint Creek watershed make up a relatively minor contribution to the overall sediment input to the stream. Of 79 identified crossings, 62 (78%) were designated as private or county roads, and 14 (18%) were within USFS property. The remaining 4%

of road ownership was identified as occurring within State of Montana property. Although the load from roads is minor in comparison to other sources, the analysis does indicate a potential for substantial improvement in sediment loads from roads. Reducing the loads from this source may improve discrete areas near and downstream of some of these sites, which may have a significant impact on fisheries or aquatic life as a whole. A full inventory of lower Flint Creek roads and crossing conditions should be conducted to identify those most in need of improvement. Once identified, outreach should be developed to work with those responsible for road maintenance to reduce sediment loads and keep the load from roads to a minimum.

Upland loads in the lower Flint watershed were identified as 34% grassland/herbaceous, 18% shrub/scrub, 14% pasture/hay, and 17% cultivated crops for a total of 83% of land designated as having a potential for management improvement. According to the USLE model results, management changes alone through the improvement of vegetative cover could yield a 22% decrease in sediment. When coupled with riparian improvement, the predicted result is a 60% sediment load reduction from upland sources.

It should be noted that the descriptions of stratification results, road, and upland load statistics are for the mainstem of lower Flint Creek which includes some of its smaller contributing tributaries. The above summaries *do not* include Barnes Creek, Boulder Creek, Smart Creek, Douglas Creek (Hall), or Willow Creek. However these streams and their associated loads do factor into the TMDL and allocation calculations presented in **Table 5-27**. Immediate management activities to reduce sediment should focus on the Flint Creek mainstem and adjacent lands. Some of the statistics above (98% fair riparian condition, 83% hay/pasture adjacent land, 83% land use with management improvement potential) suggests that focus should be put on agricultural practices related to grazing and hay production and overall riparian condition. More detailed investigations of management practices and riparian health to help prioritize areas where work can be done should be conducted. Information related to Barnes Creek and Smart Creek are described in detail in **Sections 5.6.1** and **5.6.5** respectively. Estimates of sediment loads normalized by watershed acres consistently show a load of over just over 100 tons of sediment per 1000 acres for all of the major watersheds contributing to the lower Flint Creek, except for Boulder Creek, which has an estimated load of roughly 25 tons/1000 acres.

The sediment-related impairment listing for lower Flint Creek is identified as turbidity. This listing is based on data from a 2001 report which showed turbidity levels over 200 times that of similar streams at the time of that sampling event (April 3, 2001). Other information in the assessment file identifies significant sources of sediment from bank erosion, siltation, and riparian degradation. Although sediment does not appear specifically as a cause of impairment for the lower Flint Creek segment, analysis of recent data and supporting information within the original assessment file shows that sediment is indeed a problem in lower Flint Creek and the cause of the elevated turbidity due to increases in suspended sediment in the water column. Therefore a sediment TMDL is the justified approach to address turbidity. In developing the sediment TMDL, it is assumed that water quality problems such as turbidity or alteration in streamside littoral vegetative covers are also addressed since satisfying the sediment TMDL targets and sediment allocations will result in conditions where turbidity levels and streamside littoral vegetative covers are consistent with reference or naturally occurring conditions.

5.6.5 Smart Creek

TMDL and allocations for Smart Creek are presented in **Table 5-28**. Current estimated loads are presented as gross estimates which include natural and anthropogenic related loads. Sediment load allocations are estimated loads that are expected under all reasonable land, soil, and water conservation practices and natural conditions.

Wasteload Allocation

MPDES permit MTR300080 has been issued for Storm Water Discharges Associated with Mining and Oil and Gas Activities related to the ASARCO LLC Black Pine Mine, currently under the ownership of Montana Environmental Trust Group, LLC. Within that permit, two outfalls from the Combination Mine (Outfall 001, Outfall 003) were identified as discharging to an unnamed tributary to Smart Creek.

According to the General Permit For Storm Water Discharges Associated With Mining and With Oil and Gas Activities (Permit Number MTR300000) the following effluent limitations apply:

A. There shall be no discharge of process wastewater pollutants to surface waters.
B. A discharge of stormwater associated with mining or with oil and gas activity may occur based on water generated only through rainfall precipitation and snowmelt.
C. No discharge of stormwater associated with mining or with oil and gas activity shall cause or contribute to a violation of water quality standards.
D. Discharges of stormwater containing pollutants associated with mining or with oil and gas activity covered under this General Permit will be controlled through the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP). Best Management Practices (BMPs) identified in the SWPPP must help eliminate or minimize the discharge of pollutants to surface waters.
E. New or increased stormwater discharges associated with mining or with oil and gas activity on or after April 29, 1993 shall not cause degradation as described in ARM 17.30.715(3) and 75-5-301(5)(c), MCA.

The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges from the facility. In addition, this SWPPP describes general practices used to reduce pollutants in stormwater discharges. According to the Black Pine Mine SWPPP, (ASARCO, LLC, 2011), the mine has been inactive and on standby status since the early 1990s. Therefore, there are no on-going operational activities that would contribute to stormwater runoff or stormwater pollution. However, recently completed and future reclamation-related construction activities have the potential to produce stormwater pollution sources; stormwater sampling data at the Combination Mine from sampling events on 4/12/06 and 3/30/07 returned Total Suspended Solids results of 19 mg/l, 764 mg/l, 2670 mg/l, 2870 mg/l. These results illustrate the elevated suspended solids that may occur from this site; although these same reclamation activities and stormwater BMPs have the potential to reduce sediment loading rates to Smart Creek through the eventual establishment of vegetative cover over previously disturbed areas.

According to **Attachment B** (Monitoring Parameter Benchmark Concentrations) within the general stormwater permit, the benchmark value for TSS is 100 mg/l. The SWPPP for the Black Pine Mine (Combination Mine site) provides information pertaining to site conditions. Based on this information, an area of approximately 12 acres drains the facility to Smart Creek. The annual average precipitation for this site is approximately 21 inches (PRISM data). Given the 12 acres of disturbed area, 21 inches of precipitation, and using the condition of the benchmark value (100 mg/l), the maximum allowable

annual sediment load from this site would equate to approximately 2.8 tons/year. The WLA is provided because it is a requirement for permitted point sources (of the pollutant category of concern) but is not intended to add load limits to the permit; it is assumed that the WLA will be met by adherence to the General Permit requirements (MTR300000), which include a Stormwater Pollution Prevention Plan (SWPPP) with numerous BMPs and site stabilization before a permit can be terminated.

Table 5-28. Smart Creek Sediment TMDL

Sources	Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion	953	375	61%
Roads	13	2	81%
Upland Load	685	305	55%
WLA - Black Pine Mine	2.8	2.8	0%
Total Sediment Load	1654	685	59%

The loads presented in **Table 5-28** above provide only general estimations of current loads and reductions needed from the three major source types in order to achieve the TMDL. For consistency in presentation, sediment loads have been rounded to the nearest ton/year. However, percent reduction values are based on the actual values determined through the source assessments (**Section 5.5**). Information from the source assessments and reach stratification provides insight into how and where to begin continued investigation and action to prioritize efforts to affect change and reduce sediment.

Implications for Implementation

Aerial assessment on Smart Creek conducted during the stratification further characterizes the near stream conditions. Although only a qualitative observation, riparian condition was designated as 17% good and 83% fair. Riparian vegetation composition was classified as 51% mature conifers, 13% shrubs, and 36% grass. Adjacent land use is identified as 43% forest, 24% range, and 32% road. In viewing the aerial photos, influence on bank erosion was deemed to be 37% natural, 26% transportation, 23% grazing, with small contributions from forestry, irrigation and other agricultural related influences.

The percentages described above illustrate the fact that this watershed is split between forest in the upper watershed, and agriculture and cattle grazing in the lower, with grazing extending up into the forest as well. A road parallels the stream closely for much of its length and influences the stream, and this is reflected in the adjacent land use and attribution to bank erosion.

Although sediment loads from roads are relatively minor in comparison to the loads derived from bank erosion and upland loads, they are still a significant source, particularly in a watershed like Smart Creek where road and stream are within such close proximity for much of the stream length. A total of 72 crossings were identified through GIS analysis in the watershed, with 42 (58%) occurring on USFS land, 27 (38%) as private, and the remaining 3 on BLM land.

Land types in the Smart Creek watershed were identified as 11% grassland/herbaceous, 26% shrub/scrub, 1% pasture/hay, and 1% cultivated crops for a total of 39% of land designated as having a potential for management improvement; the remaining land use is identified as forest. According to the USLE model results, management changes alone through the improvement of vegetative cover could yield a 19% decrease in sediment. When coupled with riparian improvement, the predicted result is a 56% sediment load reduction from upland sources.

5.7 SEASONALITY AND MARGIN OF SAFETY

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions, 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 margin of safety in the Flint Creek TPA tributary sediment TMDL development process.

5.7.1 Seasonality

All TMDL documents must consider the seasonal applicability of water quality standards as well as the seasonal variability of pollutant loads to the stream. Seasonality was addressed in several ways as described below.

- The applicable narrative water quality standards (**Appendix C**) are not seasonally dependant, although low flow conditions provide the best ability to measure harm to use based on the selected target parameters. The low flow or base flow condition represents the most practical time period for assessing substrate and habitat conditions, and also represents a time period when high fine sediment in riffles or pool tails will likely influence fish and aquatic life. Therefore, meeting targets during this time frame represents an adequate approach for determining standards attainment.
- The substrate and habitat target parameters within each stream are measured during summer or autumn low flow conditions consistent with the time of year when reference stream measurements are conducted. This time period also represents an opportunity to assess effects of the annual snow runoff and early spring rains, which is the typical time frame for sediment loading to occur.
- The DEQ sampling protocol for macroinvertebrates identifies a specific time period for collecting samples based on macroinvertebrate life cycles. This time period coincides with the low flow or base flow condition.
- All assessment modeling approaches are standard approaches that specifically incorporate the yearly hydrologic cycle specific to the Flint Creek watershed. The resulting loads are expressed as average yearly loading rates to fully assess loading throughout the year.
- Allocations are based on average yearly loading and the preferred TMDL expression is as an average yearly load reduction, consistent with the assessment methods.

5.7.2 Margin of Safety

Natural systems are inherently complex. Any approach used to quantify or define the relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty or error. To compensate for this uncertainty and ensure water quality standards are attained, a margin of safety is required as a component of each TMDL. 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 (U.S. Environmental Protection Agency, 1999). This plan incorporates an implicit MOS in a variety of ways:

- By using multiple targets to help verify beneficial-use support determinations and assess standards attainment after TMDL implementation. Conservative assumptions were used during target development (see **Section 5.4.1**).

- By using supplemental indicators, including biological indicators, to help verify beneficial-use support determinations and assess standards attainment after TMDL implementation. Conservative assumptions were used during supplemental indicator development (see **Section 5.4.1**).
- By using standards, targets, and TMDLs that address both coarse and fine sediment delivery.
- By using supplemental indicators that act as an early warning method to identify pollutant-loading threats, which may not otherwise be identified, if targets are not met. Conservative assumptions were used for the source assessment process, including erosion rates, sediment delivery ratio, and BMP effectiveness (see **Appendix E, and Attachments A and B**).
- By considering seasonality (discussed above).
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed below and in **Sections 8 and 9**).
- By using naturally occurring sediment loads as described in ARM 17.30.602(17) (see **Appendix C**) to establish the TMDLs and allocations. This includes an allocation process that addresses all known human sediment causing activities, not just the significant sources.

5.7.3 Uncertainty and Adaptive Management

A degree of uncertainty is inherent in any study of watershed processes. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainty through adaptive management is a key component of TMDL implementation. The process of adaptive management is predicated on the premise that TMDLs, allocations and their supporting analyses are not static, but are processes that can be subject to periodic modification or adjustment as new information and relationships are better understood. Within the Flint Creek TPA, adaptive management for sediment TMDLs relies on continued monitoring of water quality and stream habitat conditions, continued assessment of impacts from human activities and natural conditions, and continued assessment of how beneficial uses, (particularly aquatic life), respond to changes in water quality and stream habitat conditions.

As noted in **Section 5.7.2**, adaptive management represents an important component of the implicit margin of safety. This document provides a framework to satisfy the MOS by including sections focused on TMDL implementation, monitoring and adaptive management (**Sections 8.0** and **9.0**). Furthermore, state law (ARM 75-5-703), requires monitoring to gauge progress toward meeting water quality standards and satisfying TMDL requirements. These TMDL implementation monitoring reviews represent an important component of adaptive management in Montana.

Perhaps the most significant uncertainties within this document involve the accuracy and representativeness of 1) field data and target development and 2) the accuracy and representativeness of the source assessments and associated load reductions. These uncertainties and approaches used to reduce uncertainty are discussed in following subsections.

5.7.3.1 Sediment and Habitat Data Collection and Target Development

Some of the uncertainties regarding accuracy and representativeness of the data and information used to characterize existing water quality conditions and develop water quality targets are discussed below.

Data Collection

The stream sampling approach used to characterize water quality is described within **Attachment A**. To control sampling variability and improve accuracy, the sampling was done by trained environmental professionals using a standard DEQ procedure developed for the purpose of sediment TMDL development (Montana Department of Environmental Quality, 2011). This procedure defines specific methods for each parameter, including sampling location and frequency to ensure proper representation and applicability of results. Prior to any sampling, a sampling and analysis plan (SAP) was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP, and was based on a stratification process described in **Attachment A**. The stratification work ensured that each stream included one or more sample sites representing a location where excess sediment loading or altered stream habitat could affect fish or aquatic life.

Even with the applied quality controls, a level of uncertainty regarding overall accuracy of collected data will exist. There is uncertainty regarding whether or not the appropriate sites were assessed and whether or not an adequate number of sites were evaluated for each stream. Also, there is the uncertainty of the representativeness of collecting data from one sampling season. These uncertainties are difficult to quantify and even more difficult to eliminate given resource limitations and occasional stream access problems.

Target Development

DEQ evaluated several data sets to ensure that the most representative information and most representative statistic was used to develop each target parameter consistent with the reference approach framework outlined in **Appendix D**. Using reference data is the preferred approach for target setting, however, some uncertainty is introduced because of differing protocols between the available reference data and DEQ data for the Flint Creek TPA. These differences were acknowledged within the target development discussion and taken into consideration during target setting. For each target parameter, DEQ stratified the Flint Creek watershed sample results and target data into similar categories, such as stream width or Rosgen stream type, to ensure that the target exceedance evaluations were based on appropriate comparison characteristics.

The established targets are meant to apply under median conditions of natural background and natural disturbance. It is recognized that under some natural conditions such as a large fire or flood event, it may be impossible to satisfy one or more of the targets until the stream and/or watershed recovers from the natural event. The goal, under these conditions, is to ensure that management activities are undertaken in a way that the achievement of targets is not significantly delayed in comparison to the natural recovery time. Also, human activity should not significantly increase the extent of water quality impacts from natural events. For example, extreme flood events can cause a naturally high level of sediment loading that could be significantly increased from a large number of road crossing or culvert failures.

Because sediment target values are based on statistical data percentiles, DEQ recognizes that it may be impossible to meet all targets for some streams even under normal levels of disturbance. On the other hand, some target values may underestimate the potential of a given stream and it may be appropriate to apply more protective targets upon further evaluation during adaptive management. It is important to recognize that the adaptive management approach provides the flexibility to refine targets as necessary to ensure protection of the resource and to adapt to new information concerning target achievability.

5.7.3.2 Source Assessments and Load Reduction Analyses

Each assessment method introduces uncertainties regarding the accuracy and representativeness of the sediment load estimates and percent load reduction analyses. For each source assessment, assumptions must be made to evaluate sediment loading and potential reductions at the watershed scale, and because of these uncertainties, conclusions may not be representative of existing conditions and achievable reductions at all locations within the watershed. Uncertainties are discussed independently for the three major source categories of bank erosion, upland erosion, and unpaved road crossings.

Bank Erosion

Bank erosion loads were initially quantified using the DEQ protocols (Montana Department of Environmental Quality, 2011) and the standard BEHI methodology as defined within **Attachment A**. Prior to any sampling, a SAP was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP, and was based on a stratification process described in **Attachment A**. The results were then extrapolated across the Flint Creek watershed as defined in **Attachment A** to provide an estimate of the relative bank erosion loading from various streams and associated stream reaches. Based on this process, the relative contribution from human versus natural sources as well as the potential for reduction with the implementation of riparian BMPs was estimated and used for TMDL allocations. Stratifying and assessing each unique reach type was not practical, therefore adding to uncertainty associated with the load extrapolation results.

There is additional uncertainty regarding the amount of bank erosion linked to human activities and the specific human sources, as well as the ability to reduce the human related bank erosion levels. This uncertainty is largely associated with historic disturbances, which are extremely difficult to identify the level to which they are still affecting streambank erosion, how much is associated with human sources, and what the dominant human sources are. Even if difficult to quantify, the linkages between human activity such as riparian clearing and bank erosion, are well established and these linkages clearly exist at different locations throughout the Flint Creek watershed. Evaluating bank erosion levels, particularly where best management practices have been applied along streams, is an important part of adaptive management that can help define the level of human-caused bank erosion as well as the relative impact that bank erosion has on water quality throughout the Flint Creek watershed.

Upland Erosion

A professional modeler determined upland erosion loads by applying a landscape soil loss equation (USLE) as defined in **Attachment B**. As with any model, there will be uncertainty in the model input parameters including uncertainties regarding land use, land cover and assumptions regarding existing levels of BMP application. For example, only one vegetative condition was assigned per land cover type (i.e., cannot reflect land management practices that change vegetative cover from one season to another), so an average condition is used for each scenario in the model.

The upland erosion model integrates sediment delivery based on riparian health, with riparian health evaluations linked to the stream stratification work discussed above. The potential to reduce sediment loading was based on modest land cover improvements to reduce the generation of eroded sediment particles in combination with riparian improvements. The uncertainty regarding existing erosion prevention land management practices and their ability to reduce erosion represents a level of uncertainty. Also, because the model is not spatial, the riparian health improvement was simulated through broad assumptions in riparian condition and filtering capacity, which are applied to the loads at

the watershed scale. Although some uncertainty is introduced by simulating riparian improvements in this manner, the exercise was performed using the results of the model so that the pollutant removal capacity of the riparian areas could be simulated, and because the buffering capacity of riparian areas is used as a BMP for sediment TMDLs. Even with these uncertainties, the ability to reduce upland sediment erosion and delivery to nearby waterbodies is well documented in literature, the riparian buffer widths used are based on literature values, and the estimated reductions are consistent with literature values for riparian buffers.

Roads

The road sediment load was linked to unpaved road crossings and parallel segments. As described in **Appendix E**, the road sediment load was estimated via a standardized simple yearly model (WEPP:Roads). This model relies on a few basic input parameters that are easily measured in the field, as well as inclusion of precipitation data from local weather stations. A total of 38 crossings and 8 parallel segments were randomly selected for evaluation, representing about 5% of the total population of road crossings, and a much smaller percentage (1.5%) of parallel segments. The results from the 46 sites were extrapolated to the whole population of roads, stratified by climate station, road type, ownership, and ecoregion. The reduction potential for all road crossings was also based on data collected from the 46 sites taking into consideration existing BMP conditions. Random selection of the stratified sites was intended to capture a representative subset of the roads for existing conditions and level of BMP implementation, but some uncertainty is introduced because of the small sample size relative to the total number of road crossings. While an additional area of uncertainty, although the representation of parallel segments is small, modeling related to other TMDL projects has shown loading from parallel roads to be much smaller compared to crossings, and that based on field observations and model results in the Flint this appears to hold true.

SECTION 6.0 METALS TMDL COMPONENTS

This portion of the document focuses on metals as a cause of water quality impairments in the Flint Creek TMDL Planning Area. It addresses:

- Metals beneficial use impacts
- Stream segments of concern
- Water quality data and information sources
- Water quality targets and comparison to existing conditions for each impaired stream
- Metals sources
- Metals water quality data
- Evaluation of target attainment for individual metals parameters
- Metals total maximum daily loads and allocations
- Seasonality and margin of safety

6.1 MECHANISM OF EFFECTS OF EXCESS METALS TO BENEFICIAL USES

Waterbodies with metals concentrations exceeding the aquatic life and/or human health standards can impair support of numerous beneficial uses including aquatic life, drinking water, and agriculture. Within aquatic ecosystems, elevated concentrations of heavy metals can have a toxic, carcinogenic, or bioconcentrating effect on biota. Likewise, humans and wildlife can suffer acute and chronic effects from consuming water or fish with elevated metals concentrations. Because elevated metals concentrations can be toxic to plants and animals, high metals concentrations in irrigation or stock water may affect agricultural uses. The metals TMDLs provided are based upon protecting the most sensitive use a particular metal and thus protect all other uses. Depending upon the metal of concern, human health standards and aquatic life standards are the most sensitive use for the metals of concern in this document.

6.2 STREAM SEGMENTS OF CONCERN

A total of nine waterbody segments in the Flint TMDL Planning Area were listed as impaired due to metals-related causes on the 2012 Montana 303(d) List (**Table 6-1**). Additionally, Smart Creek and Royal Gold Creek were identified as needing metals TMDL for certain metals during source assessment for the Flint Creek. Eleven streams segments are provided TMDLs in this document. Because Douglas Creek near Hall is between metals listed waterbodies it was also considered for TMDL development but data was not conclusive and follow up monitoring may be needed for this stream. All 2012 303(d) listings are included in **Table 1-1** and the beneficial-use support status of listed segments are presented in **Table 3-1**. Metals-related listings include antimony, arsenic, cadmium, chromium, copper, iron, lead, mercury, and zinc. Sulfate is also listed as a cause of impairment in North Fork Douglas Creek. The sulfates are related to mining sources in North Fork Douglas Creek, and therefore this listing is addressed in conjunction with metals impairments.

Table 6-1. Metal and Sulfate Impairment Causes for the Flint TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Document Resolution	Included in 2012 Integrated Report*
Upper Flint Creek Georgetown Lake to Boulder Creek confluence	MT76E003_011	Antimony	No TMDL Needed	Yes
		Arsenic	TMDL Completed	Yes
		Copper	TMDL Completed	Yes
		Cadmium	No TMDL Needed	Yes
		Lead	TMDL Completed	Yes
		Iron	Future Monitoring	No
		Mercury	TMDL Completed	Yes
Lower Flint Creek, Boulder Creek to mouth (Clark Fork R.)	MT76E003_012	Arsenic	TMDL Completed	Yes
		Cadmium	No TMDL Needed	Yes
		Copper	TMDL Completed	Yes
		Iron	TMDL Completed	Yes
		Lead	TMDL Completed	Yes
Barnes Creek, headwaters to mouth (Flint Cr.)	MT76E003_070	Iron	TMDL Completed	Yes
Boulder Creek, headwaters to mouth (Flint Cr.)	MT76E003_060	Arsenic	TMDL Completed	Yes
		Lead	TMDL Completed	Yes
		Mercury	TMDL Completed	Yes
		Zinc	TMDL Completed	Yes
		Copper	Future Monitoring	No
		Cadmium	Future Monitoring	No
Camp Creek, headwaters to mouth (Flint Cr.)	MT76E003_130	Arsenic	TMDL Completed	Yes
		Copper	TMDL Completed	Yes
		Cadmium	TMDL Completed	No
		Lead	TMDL Completed	Yes
		Zinc	TMDL Completed	Yes
Douglas Creek (Near Philipsburg), headwaters to mouth (Flint Cr.)	MT76E003_100	Arsenic	TMDL Completed	Yes
		Cadmium	TMDL Completed	Yes
		Copper	TMDL Completed	Yes
		Iron	TMDL Completed	Yes
		Lead	TMDL Completed	Yes
		Mercury	TMDL Completed	Yes
		Zinc	TMDL Completed	Yes
Douglas Creek (near Hall) Confluence of Middle and South Forks to mouth (Flint Creek) T9N, R13W	MT76E003_020	Cadmium	Future Monitoring	No
		Iron	Future Monitoring	No
North Fork Douglas Creek, Headwaters to mouth(Douglas Creek)	MT76E003_030	Arsenic	No TMDL Needed	Yes
		Cadmium	TMDL Completed	Yes
		Copper	TMDL Completed	Yes
		Zinc	TMDL Completed	Yes
		Lead	TMDL Completed	No
		Sulfates	No TMDL Needed	Yes

Table 6-1. Metal and Sulfate Impairment Causes for the Flint TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Document Resolution	Included in 2012 Integrated Report*
Fred Burr Creek, Fred Burr Lake to mouth (Flint Cr.)	MT76E003_040	Arsenic	TMDL Completed	Yes
		Lead	TMDL Completed	Yes
		Mercury	TMDL Completed	Yes
		Copper	Future Monitoring	No
		Zinc	Future Monitoring	No
Royal Gold Creek (Headwaters to Mouth – Boulder River)	MT76E003_140	Cadmium	Future Monitoring	No
		Copper	TMDL Completed	No
		Lead	TMDL Completed	No
		Zinc	Future Monitoring	No
Smart Creek, headwaters to mouth (Flint Creek)	MT76E003_110	Arsenic	TMDL Completed	No
		Iron	TMDL Completed	No
South Fork Lower Willow Creek, headwaters to mouth (Lower Willow Creek)	MT76E003_050	Copper	TMDL Completed	Yes
		Lead	TMDL Completed	Yes
		Mercury	TMDL Completed	Yes
		Arsenic	TMDL Completed	No
		Antimony	TMDL Completed	No
		Cadmium	TMDL Completed	No

*Impairment causes not in the "2012 Water Quality Integrated Report" were recently identified and will be included in a future Integrated Report.

6.3 WATER QUALITY DATA AND INFORMATION SOURCES

Anthropogenic metals sources and associated water quality impacts in the Flint TMDL Planning Area are primarily the result of legacy mining impacts from abandoned and inactive hardrock and placer mines in the region. Predominant metals sources are those associated with historic mining activities and include metals derived from adits and seeps, metals-laden floodplain deposits, waste rock and tailings, and other ubiquitous sources associated with abandoned and inactive mining operations. Two sites are currently regulated by MPDES permits. The majority of existing data used in this report was obtained from the Montana DEQ Abandoned Mines Program, Montana Bureau of Mines and Geology, Montana DEQ permit compliance database, University of Montana, and Montana DEQ TMDL water quality sampling from 2007-2009.

Data used to assist in source characterization, target evaluation, loading analysis, and development of load allocations is derived from the aforementioned water quality investigations. Due to the availability and quality of recent data, unless specified otherwise, data from 2001 to present was considered in water quality analysis. In some cases where recent significant cleanup action has occurred, data previous to the cleanup action was not considered in analyses, and is discussed in the appropriate waterbody evaluation section. Data summaries for relevant water quality and sediment quality parameters are provided in **Section 6.4** for each metals impaired waterbody segment.

6.4 WATER QUALITY TARGETS AND COMPARISON TO EXISTING DATA

Water quality data described in **Section 6.3** was compiled and evaluated for attainment of water quality targets. **Section 6.4** presents the evaluation framework, metals water quality targets used in the evaluation, and metals targets attainment evaluations for each impaired waterbody given in **Table 6-1**.

6.4.1 Metals 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. Evaluation of metals sources.

   Sources of metals in a watershed are both natural and anthropogenic. TMDLs are developed for waterbodies that are not meeting water standards, at least in part, due to human caused sources. Consequently, metals-impaired streams must demonstrate existence of significant anthropogenic metals sources to be appropriate candidates for TMDL development.

2. 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 (narrative and numeric) or represent a water quality condition that is unimpaired for the pollutant of concern. Metals water quality targets are presented in **Section 6.4.2**.

3. 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, a TMDL is developed. If recent data indicates no impairment, the data is incorporated into 303(d) list files and the cause is removed from the list. If there are no recent target exceedances, but there is insufficient data to fully evaluate all seasonal flow conditions, then TMDL development may not be pursued within this document and further monitoring is recommended. TMDL determination is based on the assumption that natural levels of metals are below the chronic water quality criteria for aquatic life, and that single water quality samples represent a 96-hour average water quality condition.

6.4.2 Metals Water Quality Targets

Water quality targets for metals-related impairments in the Flint TMDL Planning Area consist of metals water quality targets, sediment quality targets and salinity targets. Metals water quality targets are based on numeric acute and chronic metals water quality criteria for the protection of aquatic life as defined in DEQ Circular, DEQ-7, while sediment quality targets are based on narrative criteria for toxins in sediment (**Appendix C**). Sulfate targets are based on general prohibitions and classification standards for B-1 waters given in **Appendix C.**

6.4.2.1 Metals Water Quality Criteria

For metals with numeric criteria, the most protective established state numeric water quality criteria as defined in Montana DEQ Circular DEQ-7 (Montana Department of Environmental Quality, 2008) is adopted as the water quality target. Numeric criteria apply to both human health and aquatic life protection. The numeric aquatic life criteria for most metals are dependent upon water hardness values: usually, as the hardness increases, the water quality criteria for a specific metal increase. Water quality

criteria (acute and chronic aquatic life[1], human health HHC[2]) for each parameter of concern at a water hardness of 25 mg/L and 100mg/L are shown in **Table 6-2**. Acute and chronic toxicity aquatic life criteria are designed to protect aquatic life uses, while the human health standard is designed to protect drinking water uses.

If more than 10% of the samples exceed aquatic life standards, then a TMDL will be completed. If the exceedance rate is equal to or less than 10%, then a TMDL will not be written. In this case the TMDL document may recommend further monitoring if metals were found at low frequency. There are two exceptions to the 10% exceedance rate decisions: a) if **twice** the **acute** standard is exceeded in a sample, then the attainment decision is to list or to remain listed regardless of the percent exceedance by the data set or the data set size. b) If the 10% exceedance rate threshold is surpassed but no human caused metals sources are found in the drainage, then scientists and management will convene for a case by case review. When assessing recent data, no standard exceedances are allowed when assessing for human health. If any recently collected samples exceed human health criteria, the TMDL will be completed.

Table 6-2. Metals numeric water quality targets applicable to the Flint TMDL Planning Area

Metal of Concern	Aquatic Life Criteria (ug/L) at 25 mg/L Hardness		Aquatic Life Criteria (ug/L) at 100 mg/L Hardness		Human Health Criteria
	Acute	Chronic	Acute	Chronic	
Arsenic, TR*	340	150	340	150	10
Cadmium, TR	0.52	0.10	2.13	0.27	5
Copper, TR	3.79	2.85	14.00	9.33	1,300
Iron, TR	---	1,000	---	1,000	
Mercury, TR	1.70	0.91	1.70	0.91	0.05
Lead, TR	13.98	0.54	81.65	3.18	15
Antimony, TR	---	---	---	---	5.6
Zinc, TR	37.02	37.02	119.82	119.82	2,000

*TR = total recoverable

6.4.2.2 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 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 (see **Appendix C**) 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".*

The National Oceanic and Atmospheric Administration (NOAA) has developed Screening Quick Reference Tables for stream sediment quality, and provides concentration guidelines for metals in freshwater sediments. Screening criteria concentrations come from a variety of studies and investigations, and are expressed in Probable Effects Levels (PEL). PELs represent the sediment

[1] No surface or ground water concentration shall exceed these values more than once in three years, or alternatively, a similar exceedance rate. Any single acute exceedance greater than two times the criteria justifies a TMDL.

[2] No surface or ground water shall exceed these values.

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).

Table 6-3 contains the PEL values (in parts per million) for parameters of concern in the Flint TMDL Planning Area.

Table 6-3. Screening level criteria for sediment metals concentrations

Metal of Concern	PEL (mg/kg)
Antimony	--
Arsenic	17.0
Cadmium	3.53
Copper	197
Iron	4% content
Lead	91.3
Mercury	0.486
Nickel	36.0
Silver	--
Zinc	315

PELs provide a screening tool that may assist in identification of toxic metals concentrations in stream sediments, and can be used to assist in impairment determinations and metals source assessment where water chemistry data is limited. PEL values are therefore adopted as supplemental targets that are used to evaluate whether streams are *"free from substances…that will…create concentrations or combinations of materials that are toxic or harmful to aquatic life"* **(Appendix C).** Where in-stream water quality data exceeds water quality targets, sediment quality data provide supporting information, but are not necessary to verify impairment. Where water quality data is limited or does not show exceedances of water quality targets, sediment quality data may demonstrate impairment due to high levels of metals toxicity in stream sediments.

6.4.2.3 Sulfate Criteria

A recent review of sulfate aquatic toxicity studies indicates sulfate toxicity is related to overall hardness (**Appendix C**). Using toxicity studies from 9 different species and a typical reference hardness range sometimes dipping into the lowest hardness category (25-50 mg/L) for sulfate toxicity effects, a target criteria of 129 ug/L sulfates is used for comparing sulfate data. Human drinking water and agricultural uses are generally higher than the targets that will be used to protect aquatic life which apply in the Flint Creek Watershed. A random 10% exceedance rate is allowed when comparing data to the chronic sulfate target.

6.4.3 Metals Target Attainment Evaluation

For each waterbody segment listed on the 2012 303(d) List for metals (**Table 6-1**), recent water quality and sediment data is evaluated relative to the water quality targets to make a TMDL development determination. Many current metals impairment listings are based on data collected by the DEQ Abandoned Mines Bureau in 1993 and 1994. For all impaired streams in the Flint TPA, substantial data has been collected since this initial effort, and the new data (mostly from 2007-2009) forms the basis for the metals target attainment evaluations below. Montana's 2014 "Integrated Water Quality Report" will reflect an update of impairment decisions using the 2007-2009 metals data.

6.4.3.1 Barnes Creek (MT76E003_070)

Barnes Creek originates at mid range elevations along the northwestern edge of the Flint Range. Forest composes about 15% of the watershed and the remainder is native rangeland and irrigated hay pastures. Barnes Creek flows into Flint Creek between Hall and Drummond. A livestock confinement area is located on Barnes Creek near where it enters the Flint Creek Valley. Only one known abandoned mine is located in the watershed, it is located high on the divide between Dunkleberg Creek and Barnes Creek Watersheds. Summit Mine produced small amounts of silver and lead (**Appendix A, Figure A-18**). Yet, it is far from a stream and there is no adit discharge. Iron is the only metal of concern found during this TMDL project and the only metal identified as a cause of impairment on the 2012 303(d) List.

Of 16 water samples collected from Barnes Creek, exceedance of iron chronic aquatic life criteria is 81% (**Table 6-4**). Four groundwater samples from the area are all well below iron levels found in the stream. Because no known iron deposits and no known significant mining sources are present, the TMDL will focus on controlling erosion. Iron is likely associated with soil erosion from the landscape. A single sample of stream sediment was collected in 2007 near the confluence with Flint Creek. The sample contained 11,200 mg/kg iron. Iron and TSS loading are correlated, indicating iron is primarily associated with sediment (**Figure 6-1**).

Table 6-4. Barnes Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Iron
# Samples	16
Min	150
Max	6420
Median	2061
# Acute Exceedances	NA
Acute Exceedance Rate	NA
# Chronic Exceedances	12
Chronic Exceedance Rate	81%
# Human Health Exceedances	NA
Human Health Exceedance Rate	NA

*all units in ug/L, Total Recoverable fraction

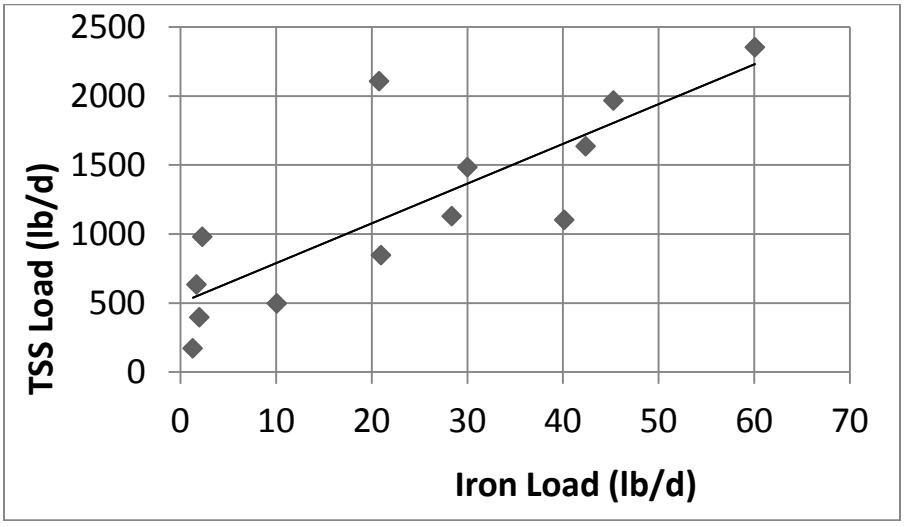


Figure 6-1. Iron and TSS loading in Barnes Creek.

Only one known mine is located in the watershed, it is located above the headwaters sample location (**Appendix A**, **Figure A-18**). In Barnes Creek, Iron and TSS levels are the highest downstream of Gaskill Creek confluence and remain elevated in the lower reaches of the stream (**Figure 6-2**). An inter-basin water transfer from Douglas Creek may also contribute to erosion, iron, and streamflow within Gaskill Creek. Limited iron data available for Douglas Creek indicate iron may be slightly elevated in water diverted from Douglas Creek watershed. Median iron concentrations in Douglas Creek were 230 ug/L while the median iron condition in Barnes Creek was 1715 ug/L. Therefore, it appears that most of the iron is being generated in Barnes Creek watershed in or near the Gaskill Creek area, although data suggests there are also sources above Gaskill Creek. The Gaskill Creek source area could be caused by erosion from irrigation water transport or from infiltration and reemergence of irrigation water in iron rich soils and geology.

An iron TMDL is provided, but controlling iron concentrations in Barnes Creek should focus on reduction of upland, road, irrigation network, and streambank erosion rates. It appears that iron is not derived from mining, but from soils and erosion in the watershed. Sediment sources are reviewed and sediment allocations are provided in the Barnes Creek sediment TMDL (**Section 5.6.1**).

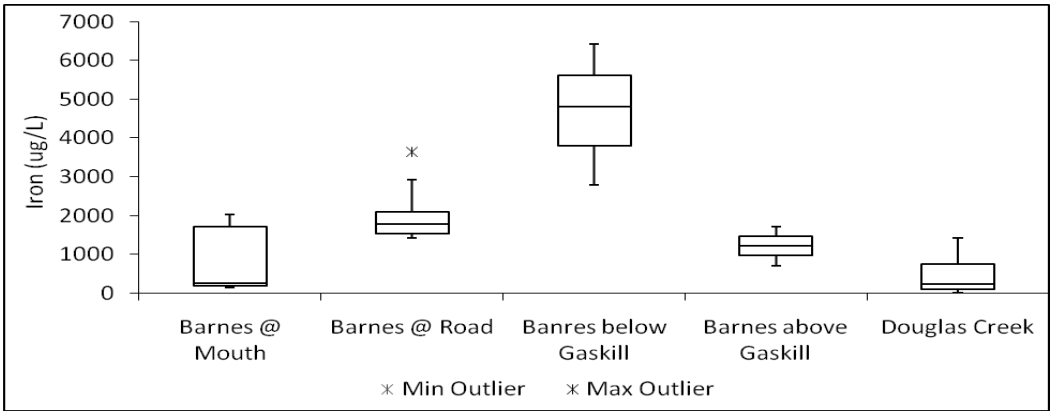


Figure 6-2. Iron concentrations at Barnes Creek sites and in Douglas Creek.

6.4.3.2 Boulder Creek (MT76E003_070)

Boulder Creek drains a large area of the Flint Range (**Appendix A, Figure A-18**). Most of the watershed is composed of mid to high elevation conifer forest. Boulder Creek enters Flint Creek at Maxville and is a significant contributor of water to Flint Creek (**Appendix A**, **Figure A-18**). Boulder Creek is on the 2012 303(d) List as being impaired for metals: arsenic, lead, zinc and mercury. Data compilation, collection and analysis indicate arsenic, lead, zinc and mercury TMDLs are necessary.

Metals Sources

Anthropogenic metals sources in the Boulder Creek watershed are comprised primarily of abandoned mining activity from the Maxville District. Many abandoned mines, waste piles, and mills have been identified in Boulder Creek's watershed. Three of these are identified in Montana's list of priority abandoned mine cleanup sites. Waste rock and tailings, by-products of mining and milling processes, are present in the valley bottoms in various locations. Also, numerous mine adits discharge to the local streams either directly or through groundwater flow.

Mining-related metals sources in these areas have been documented through a variety of investigations in support of mine site investigation and remediation activities, and sampling studies have documented

heavy metal impacts from pervasive mining waste affecting soil, groundwater, surface water and stream sediments. Most of this limited mine reclamation related sampling was completed in the early 1990s. Additional stream water quality and adit sampling was completed from 2007-2009 by DEQ in support of this TMDL effort (**Table 6-5**). **Figure A-19** (**Appendix A)** shows the spatial extent of historic mining activity and mine wastes in the watershed.

Available Water Quality Data

Metals water quality and sediment data were used to evaluate attainment of water quality targets. Due to the availability of recently-collected water quality data in the watershed, data used for this evaluation was comprised of recent 2007-2009 synoptic high and low flow sampling data collected by Montana DEQ for the TMDL project, except for mercury. Mercury samples were collected by Montana Bureau of Mines and Geology and Montana DEQ's abandoned mines program in the late 1990s. **Figure A-19** (**Appendix A)** shows the location of these sampling stations on Boulder Creek and its tributaries. Data collected along Boulder Creek was used to evaluate attainment of metals water quality targets **(Table 6-5** and **6-6**).

Table 6-5. Boulder Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Copper	Lead	Zinc	Mercury
# Samples	22	30	30	29	9
Min	<1	<0.5	<0.5	<3	<0.02
Max	2	3.2	46	56	0.10
Median	<1	<0.5	<0.5	<5	0.10
# Acute Exceedances	0	0	6	0	0
Acute Exceedance Rate	0%	0%	20%	0	0%
# Chronic Exceedances	0	1	11	1	0
Chronic Exceedance Rate	0%	3%	37%	3%	0%
# Human Health Exceedances	0	0	0	0	5
Chronic Exceedance Rate	0%	0%	0%	0%	55%

Table 6-6. Boulder Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Copper	Lead	Zinc
# Samples	4	4	4	4
Min	24	76	114	537
Max	62	2110	289	20200
Median	35	92	225	649
PEL Value	17	197	91	315
# Samples>PEL	4	1	4	4
PEL Exceedance Rate	100%	25%	100%	100%
Max PEL Exceedance Magnitude	360%	1071%	317%	6412%

*All units in mg/kg dry weight

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Arsenic

Boulder Creek is listed as impaired for arsenic on the 2012 303(d) List. This listing was originally based upon older sampling results from the late 1970s and a sample from 1990. Recent data collection, from 2007-2009 indicated no samples exceeded the human health criteria. Yet, all arsenic concentrations in stream sediments were higher than sediment targets with one sample at 3.6 times the sediment target threshold. Arsenic appears to harm aquatic life via sediment toxicity. Since mining sources are prevalent

and need cleanup for other metals, arsenic sediment concentrations should be reduced by mining reclamation activities. Therefore, an arsenic TMDL is provided for Boulder Creek.

Cadmium

Boulder Creek is not currently listed for cadmium. During the initial TMDL monitoring event which collected full metals analysis, cadmium was found in the sediment and therefore DEQ continued to collect water samples during 2007-2009 along the length of Boulder Creek (**Appendix B**). No water samples were above the water quality standards yet cadmium concentrations in 75% of stream sediment samples exceeded PEL values established as supplemental indicators of impairment. Because cadmium is not listed and no cadmium water column targets were exceeded, no TMDL will be provided at this time. Cadmium should continue to be monitored if metals sampling occurs in this watershed associated with mine cleanup activities.

Copper

Boulder Creek is not currently listed for copper. During the initial TMDL monitoring event which collected full metals analysis, sediment copper levels were found above the PEL, therefore copper monitoring continued during the TMDL monitoring. Of 30 water quality samples collected from 2007-2009 along the length of Boulder Creek, only 1 exceeded the chronic aquatic life criteria (a 3% exceedance rate). Copper concentrations in only one out of four stream sediment samples exceeded PEL value established as supplemental indicators of impairment. Therefore, a copper TMDL will not be provided at this time because aquatic life threshold exceedance rates were less than 10%. Copper should be included in the metals monitoring suite when future monitoring occurs.

Lead

Boulder Creek is listed as impaired for lead on the 2012 303(d) List. Evaluation of data collected since the initial impairment listing verifies this impairment listing. Of 30 samples collected from 2007-2009 along the length of the stream, six exceeded the acute aquatic life criteria (a 20% exceedance rate) and 11 (37%) exceeded the chronic aquatic life criteria. Likewise lead concentrations in all stream sediment samples exceeded sediment PEL values. Consequently, lead target exceedances are confirmed and a lead TMDL is provided for Boulder Creek.

Zinc

Boulder Creek is listed as impaired for zinc on the 2012 303(d) List. Of 29 samples collected from 2007-2009 along the length of the stream, one exceeded the chronic aquatic life criteria (a 3% exceedance rate) and no samples exceeded the acute aquatic life criteria. All four sediment samples exceeded zinc PEL values with the highest sediment concentration at 64 times the PEL. Zinc likely exerts toxicity to aquatic life and fish via contact with the sediment or interstitial water. Additionally, sources of zinc are documented in the TMDL source assessment monitoring and include: Bluebird and Mountain Lion mine adit discharges, Nonpareil waste rock and Royal Gold Mill tailings in Royal Gold Creek. Target exceedances are confirmed and a zinc TMDL is provided for Boulder Creek.

Mercury

Boulder Creek is listed as impaired for mercury on the 2012 303(d) List. Water quality data collected during the early 1990s, indicated ten (71%) out of 14 samples exceeded the human health criteria and two samples (14%) exceeded chronic aquatic life standards. Mercury appears to impact human health and likely impacts aquatic life. A mercury TMDL will be provided.

6.4.3.2 Camp Creek (MT76E003_130)

Camp Creek is about 3miles in length and extends from its headwaters to Philipsburg. It flows under Phillipsburg and reemerges from buried pipe east of MT HWY 1 and then flows into an irrigation canal or Flint Creek depending upon the season (**Appendix A**, **Figure A-20**). Camp Creek is on the 2012 303(d) List as being impaired for metals: Arsenic, copper, lead, and zinc. TMDLs will be written for arsenic, cadmium, copper, lead and zinc.

Metals Sources

Human caused metals sources in the Camp Creek watershed are comprised primarily of abandoned or inactive mines. A number of abandoned mines and mills in the district have adit-discharges or large volumes of tailings, waste rock and mine spoils which are directly impacting Camp Creek (**Appendix A**, **Figure A-20**). Some of the larger abandoned mine adits, mills, and spoil piles include: True Fissure, Scratch All, Thomas McKay, Minerals Processing Mill and others. Forty known mine, mill, or waste sites are identified in the Montana Bureau of Mines and Geology abandoned mine inventory. Additionally, a cyanide heap leach pad is present in the headwaters area above the ghost town of Tower. This pad was run under a small miners exclusion from state regulations and began to flow over the pad liner during 2011 due to inactivity at the site. The small miners exclusion status for this cyanide heap leach pad was closed due to inactivity and non-renewal of the exclusion status.

Data from Camp Creek was used to evaluate attainment of metals water quality targets. Data included 19 water quality samples and three stream sediment samples collected from several stations along the length of Camp Creek during 2007 to 2009. A summary of relevant water quality and sediment data is provided in **Table 6-7** and **6-8**.

Table 6-7. Camp Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper**	Lead	Zinc
# Samples	19	15	19	19	19
Min	5	<0.1	<1.0	<0.5	<10
Max	16	3.51	16	40.5	2110
Median	7	0.2	2	2.5	50
# Acute Exceedances	0	0	1	1	3
Acute Exceedance Rate	0%	0%	5%	5%	16%
# Chronic Exceedances	0	3	1	3	3
Chronic Exceedance Rate	0%	20%	5%	16%	16%
# Human Health Exceedances	4	0	0	3	1
Human Exceedance Rate	21%	0%	0%	16%	5%

*all units in ug/L, Total Recoverable fraction

** See text for further discussion about copper spatial considerations.

Table 6-8. Camp Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper	Lead	Zinc
# Samples	3	3	3	3	3
Min	34.3	2.46	61.8	189	646
Max	246	10.4	247	800	4940
Median	189	9.88	72.8	750	4410
PEL Value	17	3.5	197	91	315
# Samples>PEL	3	2	1	3	3
PEL Exceedance Rate	100%	66%	33%	100%	100%

*All units in mg/kg dry weight

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Arsenic

Camp Creek is listed as impaired for arsenic on the 2012 303(d) List based primarily on data collected by the DEQ's Abandoned Mines Bureau in 1993 and 1994. Four of 19 recent water quality samples exceeded the human health criteria for arsenic, and 100% of stream sediment samples exceeded PEL targets for arsenic. Due to human health criteria exceedances and high levels of arsenic in stream sediments, an arsenic TMDL is developed for Camp Creek.

Cadmium

Camp Creek was not listed as impaired for cadmium on the 2012 303(d) List. Evaluation of data collected since the initial impairment listing verifies that cadmium likely exerts toxicity upon aquatic life and fish. Of 15 samples collected since 2007 along the length of Camp Creek, no concentrations exceeded the acute aquatic life criteria and three samples exceeded the chronic aquatic life criteria. Likewise cadmium concentrations in two out of three sediment samples collected greatly exceeded PEL values established as indicators of impairment. Consequently, cadmium target exceedances are confirmed and a cadmium TMDL is developed for Camp Creek. The 303(d) listing status for cadmium will be formally evaluated by DEQ in the future.

Copper

Camp Creek is listed as impaired for copper on the 2012 303(d) List, and the copper listing is based primarily on sediment chemistry data collected by the DEQ during 2005. For purposes of this evaluation, two reaches of this segment are used. An upper and lower reach were used to segregate data due to different sources of metals. Sites 3 and 4 are located in the upper reach (**Appendix A**). When looking at data from these sites, the copper acute aquatic life exceedance rate is 10% in this upper reach. Likewise a sediment copper concentration exceeded the PEL value established as a sediment quality target. Consequently, copper target exceedances are confirmed near mine sources and a copper TMDL is developed for Camp Creek.

Lead

Camp Creek is listed as impaired for lead on the 2012 303(d) List, and is based primarily on sediment metal contamination found during a 2005 sampling event. Evaluation of data collected since the initial impairment listing verifies lead problems. Of 19 samples collected since 2007, one exceeded the acute aquatic life criteria, three (15%) exceeded the chronic aquatic life criteria and human health standards. Likewise lead concentration in all stream sediment samples greatly exceeded PEL values established as indicators of potential aquatic life impairment. Consequently, lead target exceedances are confirmed and a lead TMDL is developed for Camp Creek.

Zinc

Camp Creek is listed as impaired for zinc on the 2012 303(d) List; the listing is based primarily on sediment zinc data collected by the DEQ during 2005. Evaluation of data collected since the initial impairment listing verifies this impairment listing. Of 19 samples collected since 2007, three (15%) exceeded the acute and chronic aquatic life criteria and one sample exceeds the human health standard. Likewise zinc concentration in all stream sediment samples greatly exceeded PEL values established as supplemental indicators of impairment. Due to exceedances of all applicable zinc targets, a zinc TMDL is developed for Camp Creek.

6.4.3.3 Douglas Creek (near Philipsburg) MT76E003_100

Douglas Creek originates in the Flint Range and flows east about six miles to its confluence with Flint Creek (**Appendix A**, **Figure A-20**). Douglas Creek is on the 2012 303(d) List as being impaired for metals: arsenic, cadmium, copper, iron, lead, mercury and zinc. TMDLs will be completed for each of these metals.

Metals Sources

Human caused metals sources in the Douglas Creek watershed are comprised primarily of abandoned mining and milling activities. Although, the Contact Mill currently has a MPDES groundwater permit, which is not to be confused with a NPDES permit. Major mining activity occurred in the District in the late 19th century through the early 20th century. Large scale mining ceased in the 1940's but mines operated sporadically and intermittently since then. The major abandoned mining influences are Granite Mountain and Bimetalic mines near the ghost town of Granite, along with Wagner, Little Gem, Trout and Algonquin mines in the Frost Creek watershed. The associated wasterock and mill tailings from these and other local mines are now deposited along the Douglas Creek valley (**Appendix A**, **Figure A-20**). EPA recently reported results from Superfund Program preliminary site investigation monitoring that further characterizes sources of metals in the watershed (United States Environmental Protection Agency and Hogan, 2010). This effort is investigating this area to determine if it should be included on a National Priority List (NPL) or 'Superfund' site.

Metals water quality and sediment data were used to evaluate attainment of water quality targets. Data used for this evaluation consisted of recent (2007 to 2009) synoptic high and low flow sampling data. Sediment metals data from 1993-2007 is used. **Figure A-20** (**Appendix A**) shows the location of these sampling stations and abandoned mine sources on Douglas Creek and its tributaries. A summary of relevant water quality and sediment data is given in **Table 6-9** and **6-10**.

Table 6-9. Douglas Creek (near Philipsburg) Metals Water Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper	Iron	Lead	Mercury	Zinc
# Samples	13	11	13	13	13	3	13
Min	<3	<0.08	<1	40	<0.5	0.11	<10
Max	155	2.77	12	1,950	40.2	0.25	1970
Median	56	0.27	2	430	0.70	0.17	180
# Acute Exceedances	0	1	1	NA	1	0	8
Acute Exceedance Rate	0%	9%	8%	NA	0%	0%	62%
# Chronic Exceedances	8	8	3	2	5	0	8
Chronic Exceedance Rate	62%	73%	23%	15%	38%	0%	62%
# Human Health Exceedance	8	0	0	NA	3	3	1
Human Health Exceedance Rate	62%	0%	0%	NA	23%	100%	8%

*all units in ug/L, Total Recoverable fraction

Table 6-10. Douglas Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper	Iron	Lead	Mercury	Zinc
# Samples	7	7	5	4	5	5	7
Min	<1	<0.2	<5	12,300	<5	2.32	<5
Max	4,860	9.98	253	60,900	535	22.5	5,680
Median	1,770	3.3	95.1	15,950	403	3.84	672
PEL Value	17	3.53	197	40,000	91	0.486	315
# Samples>PEL	6	2	1	1	4	5	6

Table 6-10. Douglas Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper	Iron	Lead	Mercury	Zinc
PEL Exceedance Rate	86%	29%	20%	25%	80%	100%	86%

*All units in mg/kg dry weight

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Arsenic

Douglas Creek is listed as impaired for arsenic on the 2012 303(d) List based primarily on data collected by the DEQ's Abandoned Mines Bureau in 1993 and 1994. Eight of 13 recent (2007-2009) water quality samples exceeded the human health criteria for arsenic, and 100% of stream sediment samples exceeded PEL targets for arsenic which were downstream of human sources. The only site with arsenic sediment and water concentrations below the target concentrations was above known mining sources. Due to human health criteria exceedances, known human caused sources, and high levels of arsenic in stream sediments, an arsenic TMDL is developed for Douglas Creek.

Cadmium

Douglas Creek is listed as impaired for cadmium on the 2012 303(d) List based primarily on data collected by the DEQ's Abandoned Mines Bureau in 1993 and 1994. Evaluation of data collected since the initial impairment listing verifies that cadmium conditions negatively affect aquatic life. Of 13 samples collected since 2007 along the length of Douglas Creek, 1 (9%) exceeded the acute aquatic life criteria, and 8 (73%) exceeded the chronic aquatic life criteria. Also, cadmium concentration in two of seven stream sediment samples collected exceed PEL values established as sediment targets. Consequently, cadmium target exceedances are confirmed and a cadmium TMDL is developed for Douglas Creek.

Copper

Douglas Creek is listed as impaired for copper on the 2012 303(d) List, which is based primarily on data collected by the DEQ's Abandoned Mines Bureau in 1993 and 1994. Evaluation of data collected since the initial impairment listing verifies a copper problem. Of 13 samples collected since 2007 along the length of Douglas Creek, 1 (8%) exceeded the acute aquatic life criteria and 3 (23%) exceeded the chronic aquatic life criteria. Likewise copper concentrations in 1 of 5 stream sediment samples exceeded PEL values established as a sediment target. Consequently, copper target exceedances are confirmed and a copper TMDL is developed for Douglas Creek.

Iron

Douglas Creek is listed as impaired for iron on the 2012 303(d) List, and is based primarily on data collected by the DEQ's Abandoned Mines Bureau in 1993 and 1994. Evaluation of data collected since the initial impairment listing verifies this decision. Of 13 samples collected since 2007 along the length of Douglas Creek, two (15%) exceeded the acute aquatic life criteria and one was almost double the criteria. Iron concentrations in one of five stream sediment samples exceeded toxicity guidance values which were based upon 4% iron content. Consequently, iron target exceedances are confirmed and an iron TMDL is developed for Douglas Creek.

Lead

Douglas Creek is listed as impaired for lead on the 2012 303(d) List, and is based primarily on data collected by the DEQ's Abandoned Mines Bureau in 1993 and 1994. Evaluation of data collected since the initial impairment listing verifies this decision. Of 13 samples collected since 2007 along the length of

Douglas Creek, one sample exceeded the acute aquatic life criteria but was less than double this value and 5 (38%) exceeded the chronic aquatic life criteria. Likewise lead concentration in all four stream sediment samples downstream of sources greatly exceeded PEL values established as sediment targets. Consequently, lead target exceedances are confirmed and a lead TMDL is developed for Douglas Creek.

Mercury

Douglas Creek is listed as impaired for mercury on the 2012 303(d) List, and is based primarily on data collected by the DEQ's Abandoned Mines Bureau in 1993 and 1994. Evaluation of this data indicates a mercury problem. Of 3 samples, there were no acute or chronic aquatic life criteria exceedances but human health criteria were exceeded in all samples. Likewise, mercury concentrations in all 5 stream sediment samples collected greatly exceeded PEL values established as sediment targets. Due to exceedances of human health standards and high levels of mercury in stream sediments, a mercury TMDL is developed for Douglas Creek.

Zinc

Douglas Creek is listed as impaired for zinc on the 2012 303(d) List, and is based primarily on data collected by the DEQ's Abandoned Mines Bureau in 1993 and 1994. Evaluation of data collected since the initial impairment listing verifies zinc contamination. Of 12 samples, 8 (62%) exceeded the acute aquatic life criteria. Likewise, zinc concentrations in all 6 stream sediment samples collected from downstream of source areas greatly exceeded PEL values established as sediment targets. Due to exceedances of acute aquatic life criteria, a zinc TMDL is developed for Douglas Creek.

6.4.3.4 Douglas Creek (near Hall) MT76E003_020

Douglas Creek is originates in the Flint Range and flows east to its confluence with Flint Creek (**Appendix A**, **Figure A-18 and A-19**). Douglas Creek currently is not listed for any metals related impairment causes on the 2012 303(d) List. Monitoring occurred because North Fork Douglas Creek, a tributary to Douglas Creek, and Flint Creek (a downstream waterbody) were both listed for metals impairment. Limited data was collected and indicates potential cadmium and iron problems. Available data is not definitive about metals impairment because exceedance rates are low and sample sizes are low. Future monitoring should occur on this stream, especially downstream of the North Fork confluence. Alternatively, it appears most metals loading comes from the North Fork of Douglas Creek and metals TMDLs will be completed for this tributary. If abandoned mine sources in the North Fork of Douglas Creek are cleaned up, metal loading to Douglas Creek will be lowered. No TMDLs will be completed for Douglas Creek near Hall at this time. Future metals monitoring of this waterbody should be pursued if water quality monitoring occurs in the vicinity.

6.4.3.5 North Fork Douglas Creek (near Hall) MT76E003_030

North Fork Douglas Creek originates in the Flint Range and flows southeast about three miles to its confluence with Douglas Creek (**Appendix A**, **Figure A-18**). North Fork Douglas Creek is on the 2012 303(d) List as being impaired for metals: arsenic, cadmium, copper, zinc and sulfates. TMDLs will be completed for each of these metals except for arsenic. Additionally, a lead TMDL will be completed. Sulfate conditions do not likely inhibit aquatic life and a sulfate TMDL will not be pursued.

Metals Sources

Human caused metals sources in the NF Douglas Creek watershed are comprised of abandoned or inactive mines. A number of abandoned mines and mills in the district have adit-discharges or large volumes of tailings, waste rock and mine spoils which are directly impacting NF Douglas Creek

(**Appendix A**, **Figure A-18**). Some of the larger abandoned mine adits, mills, and spoil piles include: Homestake, Kirkindal/Koski, Shamrock and Wasa mines. Most of these are located in the headwaters area; the stream originates from a highly contaminated adit.

Data from NF Douglas Creek was used to evaluate attainment of metals water quality targets. Data included 15 water quality samples and two stream sediment samples collected from several stations along the length of NF Douglas Creek from 2007 to 2009. Sulfate samples consist of 13 collections over five monitoring events. A summary of relevant water quality and sediment data is given in **Table 6-11** and **6-12**.

Table 6-11. North Fork Douglas Creek (by Hall) Metals Water Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper	Lead	Zinc	Sulfate
# Samples	15	12	15	15	15	13
Min	<3	1.42	2.00	<0.5	132	19
Max	10.00	107	646.00	8.30	9880	180
Median	<3.00	7.81	18.00	<0.5	1070	30
# Acute Exceedances	0	8	6	0	13	NA
Acute Exceedance Rate	0%	67%	40%	0%	87%	NA
# Chronic Exceedances	0	12	8	2	13	1
Chronic Exceedance Rate	0%	100%	53%	13%	87%	7%
# Human Health Exceedance	0	0	0	0	0	NA
Human Health Exceedance Rate	0%	0%	0%	0%	0%	NA

Table 6-12. North Fork Douglas Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper	Lead	Zinc	Mercury	Zinc
# Samples	2	4	4	4	4	5	7
Min	15.5	3.43	124	32.1	308	2.32	<5
Max	29.2	54.4	973	221	8720	22.5	5,680
Median	22.35	13.7	498.5	83	2188	3.84	672
PEL Value	17	3.5	197	91	315	0.486	315
# Samples>PEL	1	4	2	2	3	5	6
PEL Exceedance Rate	50%	100%	50%	50%	75%	100%	86%

*All units in mg/kg dry weight

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Sulfate

North Fork Douglas Creek is listed as impaired for sulfate on the 2012 303(d) List, and is based primarily on data collected by the DEQ's Abandoned Mines Bureau in 1993 and 1994. Evaluation of available data and review of new sulfate toxicity studies conducted since the initial impairment listing disputes this decision. Of 13 samples collected since 2007 along the length of Douglas Creek, one (7%) exceeded the chronic aquatic life criteria. Consequently, sulfate target exceedances are below the allowed exceedance rate threshold of 10% for chronic toxicity and a sulfate TMDL is not needed for NF Douglas Creek. The 303(d) listing status of this stream will be updated to reflect the new sulfate data.

Arsenic

North Fork Douglas Creek is listed as impaired for arsenic on the 2012 303(d) List based primarily on 1970s data. No recent (1990-2009) water quality samples exceeded the human health criteria for

arsenic but one sample was at the standard. Arsenic sediment concentrations were slightly elevated at a site just downstream of Wasa Mine. An arsenic TMDL will not be developed for NF Douglas Creek, although future metals monitoring in the stream should include arsenic analysis to track conditions. The listing status of this stream will be updated to reflect the new arsenic data.

Cadmium

North Fork Douglas Creek is listed as impaired for cadmium on the 2012 303(d) List based primarily on data collected in the late 1970s. Evaluation of data collected since the initial impairment listing verifies that cadmium conditions negatively affect aquatic life. Of 15 water samples collected since 2007 along the length of NF Douglas Creek, 8 (67%) exceeded the acute aquatic life criteria, and all exceeded the chronic aquatic life criteria. Also, cadmium concentration in all stream sediment samples collected exceed PEL values established as sediment targets. Consequently, cadmium target exceedances are confirmed and a cadmium TMDL is developed for NF Douglas Creek.

Copper

North Fork Douglas Creek is listed as impaired for copper on the 2012 303(d) List, which is based primarily on data collected in the late 1970s. Evaluation of data collected since the initial impairment listing verifies a copper problem. Of 15 water samples collected since 2007 along the length of NF Douglas Creek, 6 (40%) exceeded the acute aquatic life criteria and 8 (53%) exceeded the chronic aquatic life criteria. Also, copper concentrations in 2 of 4 stream sediment samples exceeded PEL values established as a sediment target. Consequently, copper target exceedances are confirmed and a copper TMDL is developed for NF Douglas Creek.

Lead

North Fork Douglas Creek is not currently listed as impaired for lead on the 2012 303(d) List. Evaluation of new data collected during the TMDL project verifies lead conditions are likely to affect aquatic life. Of 15 water samples collected since 2007 along the length of NF Douglas Creek, two (13%) exceeded the chronic aquatic life criteria. Likewise, lead concentration in two of four stream sediment samples exceeded PEL values established as sediment targets. Consequently, lead target exceedances are confirmed and a lead TMDL is developed for NF Douglas Creek. The 303(d) listing status for lead will be formally evaluated by DEQ in the future.

Zinc

North Fork Douglas Creek is listed as impaired for zinc on the 2012 303(d) List, and is based primarily on data collected in the late 1970s. Evaluation of data collected since the initial impairment listing verifies zinc conditions are likely to affect aquatic life. Of 15 samples, 13 (87%) exceeded the acute aquatic life criteria. Likewise, zinc concentration in 3 of 4 stream sediment samples collected from downstream of source areas exceeded PEL values established as sediment targets. Due to target exceedances, a zinc TMDL is developed for NF Douglas Creek.

6.4.3.6 Fred Burr Creek MT76E003_040

Fred Burr Creek originates in the Flint Range and flows east about 10 miles to its confluence with Flint Creek (**Appendix A**, **Figure A-20**). The town of Phillipsburg draws drinking water from Fred Burr Reservoir near the headwaters. Fred Burr Creek is on the 2012 303(d) List as being impaired for metals: arsenic, lead and mercury. TMDLs will be completed for each of these metals.

The only known human caused metals source in the Fred Burr Creek watershed is an abandoned mill site, Rumsey Mill (**Appendix A, Figure A-20**). The mill used a pan amalgamation method of ore

extraction which employed large quantities of mercury to isolate silver. A landowner of the site developed the stream bottom area for fish and wildlife ponds and potential subdivision in the later half of the 1990s without permits or proper government review. The land developer did not comply with state and federal investigation and was eventually sent to jail. The EPA CERCLA program published an ecological risk assessment of the Rumsey site in 1999 after the developer moved mine tailings, mechanically altered Fred Burr Creek, created ponds within tailings areas, and disturbed contaminated soils.

Data from Fred Burr Creek was used to evaluate attainment of metals water quality targets. Data includes 11 water quality samples and two stream sediment samples collected from several stations along the length of Fred Burr Creek from 2007 to 2009. EPA CERCLA data and Montana DEQ enforcement action data from the late 1990s is also used for the mercury and sediment metals summaries. A summary of relevant water quality and sediment data is provided in **Table 6-13** and **6-14**.

Table 6-13. Fred Burr Metals Water Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Lead	Mercury
# Samples	11	11	10
Min	<1.00	<0.50	<0.02
Max	85.00	8.20	10.60
Median	14.00	-0.50	0.46
# Acute Exceedances	0	0	0
Acute Exceedance Rate	0%	0%	0%
# Chronic Exceedances	0	5	5
Chronic Exceedance Rate	0%	45%	50%
# Human Health Exceedance	6	0	6
Human Health Exceedance Rate	55%	0%	60%

Table 6-14. Fred Burr Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Lead	Mercury
# Samples	7	7	6
Min	8.4	4.6	<0.060
Max	3270	674	6.5
Median	69.4	45.6	3.550
PEL Value	17	91.3	0.486
# Samples>PEL	6	2	4
PEL Exceedance Rate	86%	29%	67%

*All units in mg/kg dry weight

Table 6-15. Fred Burr Creek Mercury Fish Tissue Concentrations (1974)

	Mercury (ug/g)
# Samples	33
Min	<0.010
Max	0.670
Median	0.270

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Arsenic

Fred Burr Creek is listed as impaired for arsenic on the 2012 303(d) List based primarily on 1990s data. Evaluation of data collected since the initial impairment listing verifies this decision. Of 11 water samples collected since 2007 along the length of Fred Burr Creek, six (55%) samples exceeded the human health standard. Likewise, arsenic concentrations in six stream sediment samples exceed PEL values established as sediment targets. Consequently, arsenic target exceedances are confirmed and a arsenic TMDL is developed for Fred Burr Creek.

Lead

Fred Burr Creek is listed as impaired for lead on the 2012 303(d) List, and is based primarily on data collected in the late 1990s. Evaluation of data collected since the initial impairment listing verifies this decision. Of 11 water samples collected since 2007 along the length of Fred Burr Creek, five (45%) samples exceeded the chronic aquatic life criteria. Likewise, lead concentration in two stream sediment samples greatly exceeded PEL values established as sediment targets. Consequently, lead target exceedances are confirmed and a lead TMDL is developed for Fred Burr Creek.

Mercury

Fred Burr Creek is listed as impaired for mercury on the 2012 303(d) List, and is based primarily on data collected in the late 1970s and late 1990s. Evaluation of this data verifies mercury contamination. Of 10 stream water samples, five (50%) exceeded the chronic aquatic life criteria and six (60%) exceeded the human health standard. Likewise, mercury concentration in 4 of 6 stream sediment samples collected exceed PEL values established as sediment targets. Results from a 1974 University of Montana fish tissue analysis are quite dated but add evidence there is a mercury problem (**Table 6-15**). Due to exceedances of chronic aquatic life criteria and human health standards, a mercury TMDL is developed for Fred Burr Creek.

Zinc and Copper

Fred Burr Creek is not currently listed for zinc or copper. Fred Burr Creek zinc and copper conditions were monitored during this project to inform source assessment efforts for Flint Creek. Results indicate that Rumsey Mill area is a source of these metals. Only one copper water quality monitoring result (<10%) was above the chronic aquatic life standard threshold while no zinc water quality results were above the any standard threshold. Both zinc and copper were found in sediment samples at slightly above the PEL. The results do not clearly indicate if these metals are affecting aquatic life. Zinc and copper should be considered during future metals monitoring efforts of the area to assure they stay at or below current levels.

6.4.3.7 Princeton Gulch MT76E003_090

Princeton Gulch originates in the Flint Range and flows southwest about four miles to its confluence with Boulder Creek (**Appendix A, Figure A-19**). Princeton Gulch is not currently listed for any metals on the 2012 303(d) List. It was included in source assessment monitoring for the Boulder Creek metals TMDLs because of mining sources. Cadmium monitoring should continue in this watershed when metal monitoring occurs in this area as there was one out of seven samples that exceeded the chronic aquatic life standard threshold. More data is needed to determine impairment.

Human caused metals sources in the Princeton Gulch watershed are comprised of abandoned or inactive mines. Although there are no priority abandoned mines, mills or spoil piles in Princeton Gulch,

there are a number of abandoned mines in the watershed. (**Appendix A, Figure A-19**). These include: Moonlight, Mountain lion, East Mountain lion, upper mountain lion, Princeton, Sunset, Thursday-Friday, and Mayward mines.

6.4.3.8 Royal Gold Creek MT76E003_140

Royal Gold Creek originates in the Flint Range and flows southeast about three miles to its confluence with Boulder Creek (**Appendix A**, **Figure A-19**). Royal Gold Creek is not currently on the 2012 303(d) List as being impaired for metals. It was included in source assessment monitoring for the Boulder Creek metals TMDLs because of mining sources. Cadmium and zinc data indicate there may be a problem, yet too little evidence exists to make an assessment if these metals exert toxicity to fish and aquatic life. Yet, enough evidence exists to support the need for copper and lead TMDLs for Royal Gold Creek.

Metals Sources

Human caused metals sources in the Royal Gold Creek watershed are comprised of abandoned or inactive mines. A number of abandoned mines and mills in the district have adit-discharges or large volumes of tailings, waste rock and mine spoils which affect water quality in Royal Gold Creek (**Appendix A, Figure A-19**). Some of the larger abandoned mine adits, mills, and spoil piles include: Starlight (little queen), Royal Gold mill tailings, Port Royal, Sunday, and others.

Recent TMDL source assessment data for Boulder Creek was used to evaluate attainment of metals water quality targets in Royal Gold Creek. Data included 4 water quality samples and one stream sediment sample collected from several stations along the length of Royal Gold Creek from 2007 to 2009. A summary of relevant water quality data is given in **Table 6-16**. These metals were found to be above water quality standards: non-reported metals were below standards.

Table 6-16. Royal Gold Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Cadmium	Copper	Lead	Zinc
# Samples	4	4	4	4
Min	<0.08	2	0.9	20
Max	0.19	9	9.4	50
Median	0.06	4	4.5	25.00
# Acute Exceedances	0	2	2	0
Acute Exceedance Rate	25%	50%	50%	0%
# Chronic Exceedances	1	2	4	1
Chronic Exceedance Rate	25%	50%	100%	25%
# Human Health Exceedance	0	0	0	0
Human Health Exceedance Rate	0%	0%	0%	0%

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

<u>Cadmium</u>

Royal Gold Creek is not currently identified as impaired for cadmium on the 2012 303(d) List. Of 4 water samples collected since 2007 along the length of the stream, no samples exceeded the acute and one (25%) exceed chronic aquatic life criteria. Cadmium data indicate there may be a problem, yet too little evidence exists to make an assessment if these metals exert toxicity to fish and aquatic life. Cadmium sampling should continue in this watershed.

Copper
Royal Gold Creek is not currently identified as impaired for copper on the 2012 303(d) List. Evaluation of TMDL source assessment data collected during 2007-2009 indicate Royal Gold Creek is in need of a copper TMDL. Of 4 water samples collected since 2007 along the length of the stream, two (50%) exceeded both the acute and chronic aquatic life criteria. Consequently, copper target exceedances are confirmed and a copper TMDL is developed for Royal Gold Creek. The 303(d) listing status for copper will be formally evaluated by DEQ in the future.

Lead
Royal Gold Creek is not currently identified as impaired for lead on the 2012 303(d) List. Evaluation of TMDL source assessment data collected during 2007-2009 indicate Royal Gold Creek is in need of a lead TMDL. Of 4 water samples collected since 2007 along the length of the stream, two (50%) exceeded the acute and all (100%) exceed the chronic aquatic life criteria. Consequently, lead target exceedances are confirmed and a lead TMDL is developed for Royal Gold Creek. The 303(d) listing status for will be formally evaluated by DEQ in the future.

Zinc
Royal Gold Creek is not currently identified as impaired for zinc on the 2012 303(d) List. Of 4 water samples collected since 2007 along the length of the stream, no samples exceeded the acute and one (25%) exceed chronic aquatic life criteria. Cadmium data indicate there may be a problem, yet too little evidence exists to make an assessment if these metals exert toxicity to fish and aquatic life. Zinc sampling should continue in this watershed.

6.4.3.9 Smart Creek MT76E003_110

Smart Creek originates in the John Long Mountains and flows northeast about 11 miles to its confluence with Flint Creek (**Appendix A, Figure A-21**). Smart Creek is not currently on the 2012 303(d) List as being impaired for any metals. This stream was included in source assessment monitoring for the Flint Creek metals TMDLs because of abandoned mining sources present in the watershed. Arsenic and iron levels warrant TMDLs for Smart Creek.

Future 303(d) assessment should include copper, zinc and cadmium monitoring in the upper reach of the segment. A limited amount of data associated with Black Pine Mine indicate there may be copper, zinc and cadmium levels in a tributary to Smart Creek which could limit fish and aquatic life growth in the upper reaches of Smart Creek. Data collected by the confluence of Flint Creek did not indicate any exceedances of copper, zinc and cadmium standards. Further zinc and cadmium data collection should continue with the Black Pine Mine reclamation efforts.

Metals Sources
Human caused metals sources in the Smart Creek watershed are comprised mostly of abandoned or inactive mines. A number of abandoned mines and mills in the district have tailings, waste rock and mine spoils which are directly impacting Smart Creek (**Appendix A, Figure A-21**). Some of the larger abandoned mine adits, mills, and spoil piles include: Black Pine, Sunrise/Queen Mill, Douglas Mine/Mill and other various small shafts and placer mines. Montana received settlement funds for cleanup of Black Pine Mine and DEQ recently began investigations to base the site cleanup upon.

Recent TMDL source assessment data for Flint Creek was used to evaluate attainment of metals water quality targets in Smart Creek. Data included seven water quality samples and one stream sediment sample collected during 2007 to 2009 from a single site on Smart Creek near the confluence with Flint

Creek. A summary of relevant water quality data is given in **Table 6-17**. Relevant sediment data is summarized in text.

Table 6-17. Smart Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Iron
# Samples	7	7
Min	4.00	20
Max	19	2190
Median	12	330
# Acute Exceedances	0	2
Acute Exceedance Rate	0%	29%
# Chronic Exceedances	0	NA
Chronic Exceedance Rate	0%	NA
# Human Health Exceedance	4	0
Human Health Exceedance Rate	57%	0%

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Arsenic

Smart Creek is not currently identified as impaired for arsenic on the 2012 303(d) List. Evaluation of TMDL source assessment data collected during 2007-2009 indicate Smart Creek is in need of an arsenic TMDL. Of seven water samples collected since 2007 along the length of the stream, four (57%) exceeded human health standards. Consequently, arsenic target exceedances are confirmed and an arsenic TMDL is developed for Smart Creek. The 303(d) listing status for arsenic will be formally evaluated by DEQ in the future.

Iron

Smart Creek is not currently identified as impaired for iron on the 2012 303(d) List. Evaluation of TMDL source assessment data collected during 2007-2009 indicate Smart Creek is in need of a iron TMDL. Of seven water samples collected since 2007 along the length of the stream, two (29%) exceeded the acute aquatic life criteria. Consequently, iron target exceedances are confirmed and an iron TMDL is developed for Smart Creek. The 303(d) listing status for iron will be formally evaluated by DEQ in the future.

6.4.3.10 South Fork Lower Willow Creek MT76E003_050

South Fork Lower Willow Creek originates in the John Long Mountains and flows north about thirteen miles to its terminus at Willow Creek Reservoir (**Appendix A, Figure A-21**). South Fork Lower Willow Creek is on the 2012 303(d) List as being impaired for metals: copper, lead and mercury. TMDLs will be completed for each of these listed metals and also for arsenic, cadmium and antimony.

Metals Sources

Human caused metals sources in the South Fork Lower Willow Creek watershed are comprised of abandoned or inactive mines. A number of abandoned mines and mills in the district have large volumes of tailings, waste rock and mine spoils which are directly impacting South Fork Lower Willow Creek (**Appendix A, Figure A-21**). The larger abandoned mine adits, mills, and spoil piles include: Combination, Combination II and Black Pine Mine. Most of these are located in the headwaters area.

Data from South Fork Lower Willow Creek was used to evaluate attainment of metals water quality targets. Data included 15 water quality samples and two stream sediment samples collected from several stations along the length of South Fork Lower Willow Creek from 2007 to 2009. A summary of relevant water quality data is given in **Table 6-18**. Sediment metals analysis indicate mine waste has migrated along the whole segment of South Fork Lower Willow Creek during past floods.

Table 6-18. South Fork Lower Willow Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Antimony	Arsenic	Cadmium	Copper	Mercury	Lead
# Samples	25	25	20	25	7	25
Min	5	3	0.08	<1	0.04	0.5
Max	21	35	0.21	48	0.13	39.7
Median	8	4	0.12	17	0.10	2.7
# Acute Exceedances	0	0	0	21	0	21
Acute Exceedance Rate	0%	0%	0%	84%	0%	84%
# Chronic Exceedances	0	8	13	21	0	2
Chronic Exceedance Rate	0%	32%	65%	84%	0%	8%
# Human Health Exceedance	11	3	0	0	5	2
Human Health Exceedance Rate	44%	12%	0%	0%	71%	8%

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Antimony

South Fork Lower Willow Creek is not listed as impaired for antimony on the 2012 303(d) List. Evaluation of data collected since the initial impairment listing verifies that antimony conditions may negatively affect human health. Of 25 water samples collected since 2007 along the length of South Fork Lower Willow Creek, 11 (44%) exceeded the human health standard. Consequently, antimony target exceedances are confirmed and an antimony TMDL is developed for South Fork Lower Willow Creek. The 303(d) listing status for antimony will be formally evaluated by DEQ in the future.

Arsenic

South Fork Lower Willow Creek is not listed as impaired for arsenic on the 2012 303(d) List. Evaluation of data collected since the initial impairment listing verifies that arsenic conditions may negatively affect human health. Of 25 water samples collected since 2007 along the length of South Fork Lower Willow Creek, 8 (32%) exceeded the chronic aquatic life criteria, and three (12%) exceeded the human health standard. Also, arsenic concentrations in both stream sediment samples collected greatly exceed PEL values established as sediment targets. Consequently, arsenic target exceedances are confirmed and an arsenic TMDL is developed for South Fork Lower Willow Creek. The 303(d) listing status for arsenic will be formally evaluated by DEQ in the future.

Cadmium

South Fork Lower Willow Creek is not listed as impaired for cadmium on the 2012 303(d) List. Evaluation of data collected since the initial impairment listing verifies that cadmium conditions negatively affect aquatic life. Of 25 water samples collected since 2007 along the length of South Fork Lower Willow Creek, 6 (24%) exceeded the acute aquatic life criteria, and 18 (72%) exceeded the chronic aquatic life criteria. Also, cadmium concentrations in both stream sediment samples collected greatly exceed PEL values established as sediment targets. Consequently, cadmium target exceedances are confirmed and a

cadmium TMDL is developed for South Fork Lower Willow Creek. The 303(d) listing status for cadmium will be formally evaluated by DEQ in the future.

Copper

South Fork Lower Willow Creek is listed as impaired for copper on the 2012 303(d) List, which is based primarily on historic data. Evaluation of data collected since the initial impairment listing verifies a copper problem. Of 25 water samples collected since 2007 along the length of South Fork Lower Willow Creek, 21 (84%) exceeded the acute and chronic aquatic life criteria. Also, copper concentrations in both stream sediment samples greatly exceeded PEL values established as a sediment target. Consequently, copper target exceedances are confirmed and a copper TMDL is developed for South Fork Lower Willow Creek.

Lead

South Fork Lower Willow Creek is listed as impaired for lead on the 2012 303(d) List, and is based primarily on historic data. Evaluation of data collected since the initial impairment listing verifies this decision. Of 25 water samples collected since 2007 along the length of South Fork Lower Willow Creek, 21 (84%) exceeded the chronic aquatic life criteria. Two (8%) samples exceeded acute aquatic life and human health standards. Likewise, lead concentrations in both stream sediment samples exceeded PEL values established as sediment targets. Consequently, lead target exceedances are confirmed and a lead TMDL is developed for South Fork Lower Willow Creek.

Mercury

South Fork Lower Willow Creek is listed as impaired for mercury on the 2012 303(d) List, and is based primarily on data collected in the early 1990s. Evaluation of this data verifies mercury contamination. Of seven samples, five (71%) exceeded the human health standard. Likewise, mercury concentration in 6 of 7 stream sediment samples greatly exceeded PEL values established as sediment targets. The greatest PEL exceedance was 107 times the PEL. Due to exceedances of human health standards and high sediment concentrations, and known human sources, a mercury TMDL is developed for South Fork Lower Willow Creek.

6.4.3.11 Upper Flint Creek MT76E003_011

Flint Creek flows out of Georgetown Lake toward the north. The upper segment of Flint Creek flows past Philipsburg and ends at the Boulder Creek confluence near Maxville (**Appendix A, Figure A-22**). The lower segment of Flint Creek continues to the Clark Fork River. Upper Flint Creek is on the 2012 303(d) List as being impaired for metals: antimony, arsenic, cadmium, copper, lead and mercury. TMDLs will be completed for each of these metals except antimony and cadmium.

Metals Sources

Human caused metals sources in the Upper Flint Creek watershed are comprised of abandoned or inactive mines. A number of abandoned mines and mills in the district have adit-discharges or large volumes of tailings, most of these are located on tributaries, although a couple sites of interest are located directly on Flint Creek (**Appendix A, Figure A-22**). Londonderry adit is located near Flint Creek upstream of Maxville, and an old mill site is located near Flint Creek downstream of Philipsburg. An active MPDES groundwater permitted milling facility is located in the Douglas Creek (near Philipsburg) area. Most of the historic and abandoned mining sources are located near Philipsburg or Maxville although there was historic mining activity in other areas of the watershed including the North Fork Flint Creek. Additionally, Philipsburg's WWTP effluent and storm sewer systems appear to provide some metals loading.

Data from Upper Flint Creek was used to evaluate attainment of metals water quality targets. Data included 20-34 water quality samples depending upon the metal, and five stream sediment samples collected from several locations along the length of Upper Flint Creek. Most of this data ranges from 2007 to 2009. Mercury data is the exception; all mercury data was collected during the 1970s. A summary of relevant water quality, sediment, and fish tissue data is provided in **Table 6-19** through **6-21**.

Table 6-19. Upper Flint Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Antimony	Arsenic	Cadmium	Copper	Lead	Mercury
# Samples	34	28	20	31	28	10
Min	0	<3	<0.08	<1	<0.5	<0.01
Max	0	46	0.09	13	37	1.3
Median	0	11.5	<0.08	2	3.6	0.4
# Acute Exceedances	0	0	0	2	0	0
Acute Exceedance Rate	0	0%	0%	6%	0%	0%
# Chronic Exceedances	0	0	0	2	12	0
Chronic Exceedance Rate	0%	0%	0%	6%	43%	0%
# Human Health Exceedance	0	14	0	0	2	5
Human Health Exceedance Rate	0%	50%	0%	0%	7%	50%

Table 6-20. Upper Flint Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper	Lead	Mercury
# Samples	5	5	5	5	No Data
Min	87.3	-0.5	25.7	77.3	
Max	415	4.29	763	493	
Median	228	2.04	91.5	324	
PEL Value	17	3.5	197	91	
# Samples>PEL	5	1	1	4	
PEL Exceedance Rate	100%	20%	20%	80%	

*All units in mg/kg dry weight
**No PEL for Antimony

Table 6-21. Upper Flint Creek Mercury Fish Tissue Concentrations (1974)

	Mercury (ug/g)
# Samples	16
Min	<0.01
Max	0.22
Median	0.06

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Antimony

Upper Flint Creek is listed as impaired for antimony on the 2012 303(d) List based primarily on 1991-1992 data. Evaluation of data collected from 2007-2009 disputes this decision. Of 34 water samples collected since 2007 along the length of Flint Creek, no samples exceeded the human health or aquatic life standards. Antimony concentrations in stream sediment are irrelevant because there are no PEL values established as sediment targets due to antimony's low toxicity to aquatic animals. As a result,

antimony conditions are blow standards and a TMDL will not be pursued for upper Flint Creek. The 303(d) listing status for antimony will be formally evaluated by DEQ in the future.

Arsenic

Upper Flint Creek is listed as impaired for arsenic on the 2012 303(d) List based primarily on 1990s data. Evaluation of data collected since the initial impairment listing verifies this decision. Of 28 water samples collected since 2007 along the length of Flint Creek, 14 (50%) samples exceeded the human health standard. Likewise, arsenic concentrations in five stream sediment samples exceed PEL values established as sediment targets. Consequently, arsenic target exceedances are confirmed and an arsenic TMDL is developed for upper Flint Creek.

Lead

Upper Flint Creek is listed as impaired for lead on the 2012 303(d) List, and is based primarily on data collected in the late 1990s. Evaluation of data collected since the initial impairment listing verifies this decision. Of 28 water samples collected since 2007 along the length of Upper Flint Creek, 12 (43%) samples exceeded the chronic and two (6%) exceed acute aquatic life criteria. Likewise, lead concentration in four of five stream sediment samples exceeded PEL values established as sediment targets. Consequently, lead target exceedances are confirmed, human sources are present, and a lead TMDL is developed for Upper Flint Creek.

Cadmium

Upper Flint Creek is listed as impaired for cadmium on the 2012 303(d) List, and is based primarily on data collected in the late 1990s. Evaluation of data collected since the initial impairment does not support this decision. Of 20 water samples collected since 2007 along the length of Upper Flint Creek, no samples exceeded the chronic or acute aquatic life criteria. No human health standards are exceeded. Consequently, a cadmium TMDL is not needed for Upper Flint Creek. The 303(d) listing status will be formally evaluated by DEQ in the future.

Copper

Upper Flint Creek is listed as impaired for copper on the 2012 303(d) List, and is based primarily on data collected in the late 1990s, most of the 1990s data was collected near Maxville area in association with a Londonderry Adit investigation. Evaluation of data collected since the initial impairment listing verifies two acute and chronic exceedances out of 31 samples (6%). Yet, both of these samples were collected downstream of Londonderry Adit. A copper concentration in one of five stream sediment samples exceeded PEL values established as sediment targets. Consequently, copper target exceedances are confirmed near a mining area at the lower end of this river segment, human sources are present, and a copper TMDL is developed for Upper Flint Creek.

Mercury

Upper Flint Creek is listed as impaired for mercury on the 2012 303(d) List, and is based primarily on data collected in the late 1970s. Evaluation of this data along with data collected by MBMG and DEQs PAM program during 1992-1995 near Maxville, verifies mercury contamination. Of ten stream water samples, five (50%) exceeded the human health standard. Results from a 1974 University of Montana fish tissue analysis add evidence that mercury levels are elevated (**Table 6-15**). Due to exceedances of human health standards, a mercury TMDL is developed for Upper Flint Creek.

6.4.3.12 Lower Flint Creek MT76E003_012

The lower segment of Flint Creek continues from the confluence of the Boulder River to the Clark Fork River (**Appendix A, Figure A-22**). Lower Flint Creek is on the 2012 303(d) List as being impaired for metals: arsenic, cadmium, copper, lead and iron. TMDLs will be completed for each of these metals except for cadmium. Minimal data indicates mercury should be monitored in the future although this segment is not currently listed for this pollutant.

Metals Sources

Human caused metals sources in the Flint Creek watershed are comprised of abandoned or inactive mines. A number of abandoned mines and mills in the district have adit-discharges or large volumes of tailings. Most of the mining areas are located on tributaries or areas adjacent to Flint Creek above Maxville (**Appendix A, Figure A-22**). Londonderry adit is located near Flint Creek upstream of Maxville, and an old mill site is located near Flint Creek downstream of Philipsburg. An active MPDES groundwater permitted milling facility is located in the Douglas Creek (near Philipsburg) area. Most of the historic and abandoned mining sources are located near Philipsburg or Maxville, or in Smart, Willow, and Boulder Creek Watersheds. Additionally, Philipsburg's WWTP effluent and stormsewer system appear to provide some metals loading.

The 303(d) metals listings are based upon USGS and other temporally dispersed data from 1971-2003. More recent data from the Flint Creek TMDL project was used to evaluate attainment of metals water quality targets. Data included 16-19 water quality samples depending upon the metal, and five stream sediment samples collected from several locations along the length of Lower Flint Creek. Most of this data ranges from 2007 to 2009. Historic data was reviewed and also supports conclusions made from the recent review of TMDL project data. A summary of relevant water quality and sediment data is provided in **Table 6-22** and **6-23**.

Table 6-22. Lower Flint Creek Metals Water Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper	Iron	Lead
# Samples	19	12	19	19	19
Min	6	<0.08	1	50	0.5
Max	28	0.19	10	1250	28.3
Median	13	<0.08	3	340	5.7
# Acute Exceedances	0	0	0	NA	0
Acute Exceedance Rate	0%	0%	0%	NA	0%
# Chronic Exceedances	0	0	7	3	11
Chronic Exceedance Rate	0%	0%	37%	16%	58%
# Human Health Exceedance	14	0	0	NA	2
Human Health Exceedance Rate	74%	0%	0%	NA	11%

Table 6-23. Lower Flint Creek Metals Sediment Quality Data Summary and Target Exceedances

Parameter*	Arsenic	Cadmium	Copper	Iron	Lead
# Samples	4	4	4	4	4
Min	66.9	2.03	44	9610	122
Max	415	4.29	143	11500	493
Median	239.5	2.655	83.4	10425	283
PEL Value	17	3.5	197	4%	91
# Samples>PEL	4	1	0	0	4
PEL Exceedance Rate	100%	25%	0%	0%	100%

*All units in mg/kg dry weight

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Arsenic

Lower Flint Creek is listed as impaired for arsenic on the 2012 303(d) List based primarily on 1990s and earlier data. Evaluation of data collected since the initial impairment listing verifies this decision. Of 19 water samples collected since 2007 along the length of Flint Creek, 14 (74%) samples exceeded the human health standard. Likewise, arsenic concentrations in all four stream sediment samples exceed PEL values established as sediment targets. Consequently, arsenic target exceedances are confirmed and an arsenic TMDL is developed for lower Flint Creek.

Cadmium

Lower Flint Creek is listed as impaired for cadmium on the 2012 303(d) List, and is based primarily on data collected in the late 1990s and early 2000s. Evaluation of data collected since the initial impairment listing contradicts the listing based on older data. Of 12 water samples collected since 2007 along the length of Lower Flint Creek, no samples exceeded the chronic or acute aquatic life criteria. Cadmium concentration in one of four stream sediment samples exceeded PEL values established as secondary sediment targets. Consequently, a cadmium TMDL is not needed for Lower Flint Creek but future metals monitoring should verify static or improving cadmium conditions. The 303(d) listing status for cadmium will be formally evaluated by DEQ in the future.

Copper

Lower Flint Creek is listed as impaired for copper on the 2012 303(d) List, and is based primarily on data collected in the late 1990s and early 2000s. Evaluation of data collected since the initial impairment listing verifies a copper problem. Seven chronic exceedances out of 19 samples (37%) were detected. No copper concentrations in stream sediment samples exceeded PEL values established as sediment targets. Copper target exceedances are confirmed, human sources are present, and a copper TMDL is developed for Lower Flint Creek.

Iron

Lower Flint Creek is listed as impaired for iron on the 2012 303(d) List, and is based primarily on data collected in the late 1990 and early 2000s. Evaluation of data collected since the initial impairment listing verifies an iron problem. Three chronic aquatic life exceedances out of 19 (16%) samples were detected. No iron concentrations in stream sediment samples exceeded values established as sediment targets. Iron target exceedances are confirmed, human sources are present, and an iron TMDL is developed for Lower Flint Creek.

Lead

A USGS report indicates Flint Creek contributes 17% of the Clark Fork River's lead load at Turah Bridge based upon early 1990s data. Lower Flint Creek is listed as impaired for lead on the 2012 303(d) List, and is based primarily on data collected in the late 1990s and early 2000s. Evaluation of data collected since the initial impairment listing verifies this decision. Of 19 water samples collected since 2007 along the length of Lower Flint Creek, 11 (16%) samples exceed the chronic aquatic life criteria and two exceed human health standards. Likewise, lead concentration in all four stream sediment samples exceeded PEL values established as sediment targets. Consequently, lead target exceedances are confirmed, human sources are present, and a lead TMDL is developed for Lower Flint Creek.

Mercury

Lower Flint Creek is not currently listed as impaired by mercury on the 2012 303(d) List. Recent fish and aquatic insect tissue analysis indicates a potential mercury water quality problem. Montana FWP has provided a fish consumption advisory for Flint Creek. MSU research indicates high levels of mercury in aquatic insects. Future water quality and sediment metals monitoring in this area should include mercury for analysis in Lower Flint Creek.

6.4.4 Metals Target Attainment Evaluation and TMDL Development Summary

Nine individual stream segments were listed as impaired for metals-related impairments in the Flint Creek TMDL Planning Area. Review of metals target exceedances verified most metals impairments on the 2012 303(d) List, however target exceedances could not be verified for listed metals on some stream segments. Likewise, several streams exhibited target exceedances for metals that do not appear on the 2012 303(d) List. Metals TMDLs will be completed for two streams not currently identified as impaired for metals. Metals TMDLs for 11 stream segments will be provided in **Section 6.5**. Data from this project will be incorporated into the 303(d) list for their inclusion in a future Integrated Water Quality Report for Montana. **Table 6-1** presents a summary of existing metals impairment causes and metals for which target exceedances were confirmed and for which TMDLs are prepared.

A total of 42 metals TMDLs are identified in this document. TMDLs and allocations for these segments and metals are provided in the following section. Although elevated levels of sulfate are present in North Fork Douglas from historic mining activity, this TMDL was not pursued because sulfates are not at levels likely to cause harm to the most sensitive uses.

6.5 METALS TMDLS AND ALLOCATIONS

6.5.1 Metals TMDLs

As summarized in **Table 5-23**, metals total maximum daily loads are presented herein for impaired waterbodies in the Flint TMDL Planning Area. A Total Maximum Daily Load (TMDL) is a calculation of the maximum pollutant load a waterbody can receive while maintaining water quality standards. The total maximum daily load is based on the most stringent applicable water quality criteria provided in **Section 6.4.2.1**, the 25th percentile of seasonal water hardness if applicable, and the stream flow. With most metals, the chronic aquatic life criteria, which depend upon hardness, will be used to calculate the TMDL. Under high hardness conditions however, the human health criteria for lead may apply). In the case of arsenic and mercury, the human health criteria will be used for the basis of the TMDLs, as it is the most stringent standard. Where aquatic life criteria are variable based on hardness, TMDLs at a water hardness of 25 mg/L and 400 mg/L are shown. TMDLs based on human health criteria are included in the graphs where appropriate.

Because stream flow and hardness vary seasonally, the TMDL is expressed not as a static value, but as an equation. The TMDL under a specific flow condition is calculated using the following formula:

TMDL = (X) (Y) (k)

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

The TMDL equation and curves apply to all metals TMDLs within this document and provide a graphical reference for illustrating TMDLs for applicable metals under variable flow and hardness conditions. If a TMDL is based upon the chronic aquatic life standard, the lowest applicable metals water quality target is based upon a 25th percentile hardness value for a seasonal data set. Metals TMDLs will apply to any point along the continuum of the waterbody, with some exceptions for mixing zones, and therefore protect uses along the entire stream.

6.5.2 Metals Allocations

Metals TMDLs are allocated to point (wasteload) and nonpoint (load) sources. The TMDL is comprised of the sum of all significant point and nonpoint metals sources (natural and anthropogenic), plus a margin of safety that accounts for uncertainties in loading and receiving water analyses. In addition to metals load allocations, the TMDL must also take into account the seasonal variability of metals loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses.

These elements are combined in the following equation:

TMDL = ∑WLA + ∑LA + MOS

WLA = Wasteload Allocation or the portion of the TMDL allocated to metals point sources.
LA = Load Allocation or the portion of the TMDL allocated to nonpoint metals sources and natural background
MOS = Margin of Safety or an accounting of uncertainty about the relationship between metals loads and receiving water quality.

Within the Flint TMDL Planning Area, significant metals sources are primarily those derived from historic and abandoned mining activity over the past one hundred and fifty years. Mining sources are prevalent at several locations throughout the affected watersheds. An in-depth assessment of metals sources is not conducted herein. Rather, loading estimates from these known sources are provided using data and information gleaned from aforementioned investigations, and form the basis for metals load allocations and load reductions necessary to meet water quality criteria. Aside from metals sources associated with mining activity and municipal sources, other sources of metals are not believed to be a significant source contributing to water quality impairment and appear to be within naturally-occurring concentrations.

Metals source load allocations are provided for the following source categories:

- Naturally occurring metals sources
- Abandoned mining sources
- Permitted NPDES point-source discharges

Naturally occurring metals sources

Naturally occurring sources will be provided a load allocation (LA) in lbs/day based on naturally occurring metals concentrations and streamflow. Naturally occurring metals sources occur naturally within a watershed. As defined in ARM 17.30.602, naturally occurring sources also include *"those sources from developed areas where all reasonable land, soil and water conservation practices have been applied."* Within the Flint Creek TMDL Planning Area, naturally-occurring metals concentrations are established by using in-stream data upstream of mining sources or from locally unimpacted watersheds where metals sources are limited to those associated with natural background and low-level development.

Within the Flint Creek TMDL Planning Area, naturally-occurring metals concentrations were estimated from 14-16 samples collected in the watershed in areas representing naturally occurring conditions for metals during both high and low flow conditions. All samples were taken upstream of developed mining lands and represent water quality conditions where "all reasonable land and soil water conservation practices have been applied." From this data set, the 75th percentile metals concentration was chosen as an estimation of naturally-occurring metals concentration. In many cases, non-detects were recorded for most metals; for purposes of data analysis half the lowest detection limit was substituted for the result value. **Table 6-24** shows estimates of naturally occurring metals concentration in the Flint Creek TMDL Planning Area. Because local reference data was not available, a statewide data set was used for mercury using only recently collected, ultra low level detection limits. These metal concentrations are used to calculate load allocations to naturally occurring metals sources for impaired waterbodies.

Table 6-24. Naturally occurring metals concentrations in the Flint TMDL Planning Area

Metal	Number of Samples	Concentration (ug/L)
Arsenic	16	1.5
Antimony	16	1.5
Cadmium	16	0.04
Copper	16	0.5
Iron	14	330
Lead	16	0.25
Mercury	168 (statewide)	0.0025
Zinc	16	5.0

Abandoned mining sources

Abandoned mining sources include a variety of discrete sources associated with historic abandoned mining activity and are typically categorized as adits, seeps, tailings piles, floodplain deposits, and other associated mining waste. Given the pervasive nature of abandoned mining activity in most of the affected watersheds, the sum of all abandoned mining sources contributing to a waterbody segment are treated as a composite non-permitted point source, and a composite wasteload allocation is provided for these non-permitted point sources. Composite wasteloads to abandoned mining sources are calculated as the difference between the TMDL and the load allocation to naturally occurring sources plus any wasteloads to permitted discharges.

Permitted NPDES point-source discharges

MPDES discharges permitted by the DEQ are also provided a wasteload allocation. One individual municipal wastewater MPDES permit exists within the Flint TMDL Planning Area: Permit MT0031500 (Town of Philipsburg). The permitted facility is a lagoon system that discharges to Flint Creek. Also, a permitted mining related stormwater permit is active for the Black Pine Mine area as the State of Montana begins a cleanup process after settlement with ASARCO. As the two NPDES point-sources in the watershed with reasonable potential for metals loading, both permitted sources will be provided wasteload allocations. The wasteload allocation under a specific discharge flow is calculated using the following formula:

$$\mathbf{WLA_{NPDES} = (X)\ (Y)\ (k)}$$

WLA= Wasteload Allocation to NPDES- permitted discharges in pounds per day

X= lowest applicable metals water quality target in ug/L for a specific in-stream hardness value

Y= wastewater treatment plant discharge flow (not design flow) in gallons per day

k = conversion factor of 0.00834

Essentially the WLA is based on meeting the lowest applicable metals standard concentration within the discharger's effluent. This approach is consistent with the reasonable assurance approach defined within **Section 4.4.**

The example wasteload allocation numbers provided in tables within the following sections should not strictly be used for permit writing because they are only applicable to a given set of flow and point source discharge conditions. In an effort to coordinate potential permit based WLAs to the TMDL derived WLAs, DEQ found that both efforts provided similar outcomes for providing wasteload allocations even though they are based upon different processes.

6.5.3 Allocations by Waterbody Segment

In the sections that follow, a loading summary and source load allocations are provided for each pollutant-waterbody combination for which a TMDL is prepared (see **Table 5-23**). Loading summaries are based on the sample data used for evaluation of metals targets in **Section 5.4.3**. For each metal, water quality sample data are used to calculate metals loading estimates and the required percent load reduction to achieve the TMDL for each metal during high flow and low flow conditions. 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.

The example loads provided for existing conditions, TMDLs, LAs, and WLAs provided for both high flow and low flow conditions are based upon the following assumptions:

1. The 25th percentile of in-stream seasonal hardness results are used for determining hardness based standards and associated TMDLs, LAs, and WLAs.
2. TMDL examples use seasonal average stream flow condition as basis for TMDL load examples. Permits may need to use 7Q10 or other statistics for deriving numeric WLAs consistent with the WLA equations given in this TMDL.
3. Existing condition load summaries use the 90th percentile of the data set to compare to TMDLs based upon chronic aquatic life standard thresholds. This compares to a 10% random exceedance rate, which is allowed for under DEQ duration and frequency considerations of chronic aquatic life thresholds.
4. Existing condition load summaries use the maximum concentration of a data set to compare to TMDLs based upon human health standards. This compares to a condition where no exceedances of these thresholds should occur within recent data sets (<10 years old).
5. The existing condition and TMDL examples provided in the following metals TMDL sections are located at the most contaminated location that was monitored for each metal.

6.5.3.1 Barnes Creek MT41U002_010

There are no known mining related iron sources in Barnes Creek watershed. There are also no permitted point-sources in the watershed. Iron load allocations consist of a composite load allocation to agricultural sources that increase soil erosion or potentially leach iron from soils due to irrigation, and a load allocation to naturally-occurring iron sources. A margin of safety (MOS) is implicit in this allocation approach, through a variety of conservative assumptions (see **Section 6.6**). The iron TMDL for Barnes Creek is therefore the sum of the LA to agricultural sources and the LA to naturally-occurring sources:

$TMDL_{Barnes} = LA_{nat} + LA_{ag}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed

LA_{ag} = Composite load allocation to all agricultural sources in the watershed

Table 6-25 summarizes metals TMDLs and load allocations for Barnes Creek. Percent reduction values are the necessary load reduction to meet the TMDL and water quality standards. The Barnes Creek sediment TMDL has detailed allocations for sediment sources in the watershed (**Section 5.6.1**). Sediment sources in Barnes Creek watershed are mutual with the iron sources. It appears that iron is mostly derived from erosion within the watershed.

Table 6-25. Barnes Creek: Metals TMDLs and Allocation Example

Metal	Flow	TMDL	LA_{nat}	LA_{ag}	Existing Load	Percent Reduction
Iron	High flow	11.1	3.67	7.47	49.6	77.6%
	Low flow	9.11	3.00	6.11	42.8	78.7%

Example TMDL calculations based upon: Hardness = irrelevant, Discharge: HF = 2.1cfs, LF = 1.7cfs
*loads reported in lb/day

TMDL and allocation examples provided in **Table 6-25** are calculated from iron and flow data collected from the middle reach of Barnes Creek between Gaskill Creek and county road 512. This area has the highest iron concentrations. Gaskill Creek area appears to be a large source of iron and suspended sediment. Irrigation removes take water, suspended sediment and iron from Barnes Creek at the road and groundwater continues to dilute iron and suspended sediment conditions below the road. Significant reductions are necessary during both high and low flow to meet the iron TMDL and water quality targets. This is because even at low flow, Barnes Creek is turbid.

6.5.3.2 Boulder Creek (MT76E003_070)

Abandoned mine sources in the Boulder Creek watershed are responsible for significant metals loading to the creek. Abandoned mills, lodes, and placer mining in the watershed are generally pervasive. Three priority abandoned mines are located in and near Royal Gold Creek, a tributary to Boulder Creek. Significant metal sources may include: Bluebird Mine, Mountain Lion Mine, Starlight Mine, Swamp Gulch Mill, Brooklyn Mill, Port Royal Tailings, NonPareil and potentially others. As there are no permitted point-sources in the watershed, metals load allocations consist of a composite wasteload allocation to abandoned mining sources and a load allocation to naturally-occurring metals sources. Also, metals TMDLs will be completed for Princeton Gulch and Royal Gold Creek, both tributaries to Boulder Creek. A margin of safety (MOS) is implicitly applied through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for Boulder Creek are therefore the sum of the WLA to abandoned mines and the LA to naturally-occurring sources:

$TMDL_{Boulder} = LA_{nat} + WLA_{abmine}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed
WLA_{abmine} = Composite wasteload allocation to all abandoned mining sources in the watershed

Example metals TMDLs and allocations for Boulder Creek are calculated at the confluence with Flint Creek for typical high and low flow water quality conditions. The TMDL, LA and WLAs are equations provided in **Section 6.5.1 and 6.5.2**. **Table 6-26** provides an example of metals TMDLs and load allocations for Boulder Creek. Percent reduction values are the necessary load reduction to meet the TMDL.

Table 6-26. Boulder Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	WLA_{abmine}	Existing Load	Percent Reduction
Arsenic	High flow	15.7	2.37	13.35	4.71	NA*
	Low flow	1.41	0.212	1.20	0.282	NA*
Lead	High flow	1.27	0.393	0.873	3.61	65.0%
	Low flow	0.349	0.0353	0.313	0.0353	NA
Mercury	High flow	0.0705	0.00393	0.0670	0.109951	28.6%
	Low flow	0.00785	0.000353	0.00749	0.0141	50%
Zinc	High flow	75.4	7.85	67.6	15.7	NA%*
	Low flow	14.2	0.705	13.6	7.85	NA%*

Example TMDL calculations based upon: Hardness = HF = 34, LF = 82, Discharge: HF = 292.5cfs, LF = 26.3cfs
*loads reported in lb/day

Lead and mercury appear as the most pervasive metals in Boulder Creek, usually during high flow, springtime conditions. Arsenic and zinc appear to mostly be transported via sediment and likely exert toxicity to benthic fish and aquatic life. Because there may be cumulative interactions between toxicity of these metals, and the abandoned mine sources are the same as other metals, TMDLs are provided for arsenic and zinc. Sediment metals levels will likely be reduced if mining reclamation reduces influence of mine waste piles on water quality in this watershed.

6.5.3.3 Camp Creek (MT76E003_130)

Abandoned mine sources in the Camp Creek watershed are responsible for significant metals loading to the creek. Abandoned mills, waste piles, lodes, and placer mining in the watershed are generally pervasive. The stream originates slightly downstream from a cyanide heap leach pad which has a grandfathered small miners exclusion. During 2011, the lined pad began to overflow. Just downstream, a number of priority abandoned mine sites affect water quality. The stream enters a canyon between the abandoned mine sites and the town of Philipsburg, yet due to historic mining, the stream almost completely infiltrates into loosely compacted mine waste and soils and then it reemerges above the town of Philipsburg. Camp Creek then flows into Philipsburg's storm runoff system and reemerges near MT HWY 1. Abandoned mine influences also occur within Philipsburg city limits where spoils from Hope Mill are scattered. Significant metal sources likely include: Trout, True Fissure, Thomas McKay, Scratch All, Hope Mill, and Hobo T. Hayes mines, with a possibility of many other historic mining sources that could contribute metals. EPA recently reported results from Superfund Program preliminary site investigation monitoring that further characterizes sources of metals in the Camp Creek watershed (United States Environmental Protection Agency and Hogan, 2010).

As there are no permitted point-sources in the watershed, metals load allocations consist of a composite wasteload allocation to abandoned mining sources and a load allocation to naturally-occurring metals sources. As a side note, metals are likely infiltrating into Philipsburg wastewater collection system from groundwater in the area. Metals also appear to be infiltrating from groundwater into the city stormwater collection system and ultimately into Camp Creek. A margin of safety (MOS) is implicitly applied through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for Camp Creek are therefore the sum of the WLA to abandoned mines and the LA to naturally-occurring sources:

$TMDL_{Camp} = LA_{nat} + WLA_{abmine}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed

WLA_{abmine} = Composite wasteload allocation to all abandoned mining sources in the watershed

The TMDL, LA and WLAs are equations provided in **Section 6.5.1 and 6.5.2**. The example metals TMDLs and allocations for Camp Creek are calculated for the area above Philipsburg for typical high and low flow water quality conditions because this area had the highest metals contamination. **Table 6-27** provides an example of metals TMDLs and load allocations for Camp Creek. Percent reduction values are the necessary load reduction to meet the TMDL.

Table 6-27. Camp Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	WLA_{abmine}	Existing Load	Percent Reduction
Arsenic	High flow	0.0171	0.00257	0.0146	0.0274	37.5%
	Low flow	0.0143	0.00215	0.0122	0.0186	23.1%
Cadmium	High flow	0.000265	0.0000685	0.000196	0.00511	94.8%
	Low flow	0.000383	0.0000573	0.000326	0.00185	79.2%
Copper	High flow	0.00838	0.000857	0.00753	0.00358	NA
	Low flow	0.0153	0.000716	0.0146	0.0212	60.5%
Lead	High flow	0.00787	0.00162	0.00625	0.207	96.2%
	Low flow	0.00447	0.000358	0.00412	0.00580	22.8%
Zinc	High flow	0.409	0.0323	0.376	2.33	82.4%
	Low flow	0.170	0.00716	0.162	1.63	89.6%

Example TMDL calculations based upon: Hardness = HF = 47, LF = 98, Discharge: HF = 1.2cfs, LF = 0.27cfs
*loads reported in lb/day

In Camp Creek above Philipsburg, most metals loads are above TMDLs during both high and low flow conditions. This is understandable given the extent of mining-related soil and water quality contamination in the upper Camp Creek watershed. Metals conditions generally continue to be problematic near and below Philipsburg, but are not as pervasive.

6.5.3.4 Douglas Creek (near Philipsburg) MT76E003_100

Human caused metals sources in Douglas Creek watershed are comprised primarily of abandoned mining activity. Montana's abandoned mine cleanup program has identified eight priority abandoned mines in the watershed. A couple of these are near the ghost town of Granite: BiMetalic/Old Red and Granite Mountain. Others are located in or near Frost Creek, a tributary to Douglas Creek: Algonquin, Little Gem, Trout, Wegnar #2. Still others are located on the Douglas Creek valley bottom: Douglas Creek waste areas and extensive waste from Bi-Metallic Mill (**Appendix A, Figure A-18**). The Granite Drain, a drain system under the mines near Granite, and an associated aqueduct, moves metal laden water from most of the shafts under Granite Mountain to Douglas Creek near the lowest Douglas Creek Waste area.

Contact Mill continues to operate sporadically, yet does not discharge to Douglas Creek or its tributaries. Groundwater monitoring near this operation will occur beginning 2011 to assure this potential source meets conditions in adherence to the combined WLA. The facility has two tailings impoundments, one of which is located in Douglas Creek watershed. Montana DEQ identifies that the ponds are not lined and likely discharge to groundwater, while the operators contend the ponds have self sealed through metals processing activities.

Remedial investigation of the watershed was initiated during the summer of 2011 under the EPA Superfund program. Extensive investigation of mine waste location and characterization is underway through this process. EPA recently reported results from Superfund Program preliminary site

investigation monitoring that further characterizes sources of metals in the Douglas Creek watershed (United States Environmental Protection Agency and Hogan, 2010).

State efforts of mine waste cleanup activities include a 2000 Montana DEQ completed a reclamation project on both of the Douglas Creek Tailings piles by placing them in lined repositories and covering them with a geomembrane. This effort also moved the stream to flow around the repositories. Historic Bi-Metallic Mill tailings cover an area of about 600,000 sf and may have been partially reclaimed in the 1980s as a condition of the original Contact Mill MPDES groundwater discharge permit. Little information can be found about this reclamation effort. The stream enters a wooden flume for diversion around a portion of the Bi-Metallic Mill tailings.

As there are no NPDES permitted point-sources, metals load allocations consist of a composite wasteload allocation to abandoned mining sources and a load allocation to naturally-occurring metals sources. A margin of safety (MOS) is implicit in this allocation scheme, through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for upper Douglas Creek are therefore the sum of the WLA to abandoned mines and the LA to naturally-occurring sources:

$TMDL_{Douglas} = LA_{nat} + WLA_{abmine}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed

WLA_{abmine} = Composite wasteload allocation to all abandoned mining sources in the watershed

The TMDL, LA and WLAs are equations provided in **Section 6.5.1 and 6.5.2. Table 6-28** provides examples of metals TMDLs and load allocations for Douglas Creek, calculated from a location just upstream of the abandoned Bi-Metallic Mill because this site had the highest metals contamination.

Table 6-28. Douglas Creek (near Philipsburg): Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	WLA_{abmine}	Existing Load	Percent Reduction
Arsenic	High flow	0.222	0.0333	0.189	2.65	91.6%
	Low flow	0.0987	0.0148	0.0839	1.53	93.5%
Cadmium	High flow	0.00650	0.000889	0.00561	0.0453	85.7%
	Low flow	0.00149	0.000347	0.00114	0.0143	89.6%
Copper	High flow	0.227	0.0111	0.216	0.187	NA
	Low flow	0.0478	0.00434	0.0435	0.0971	50.8%
Iron	High flow	22.2	7.24	14.9	30.2	26.4%
	Low flow	9.95	3.26	6.69	10.1	2.53%
Lead	High flow	0.0808	0.00516	0.0752	0.183	55.9%
	Low flow	0.0126	0.00217	0.0104	0.314	96.0%
Mercury*	High flow	0.00111	0.0000556	0.00106	0.00556	80%
	Low flow	0.000434	0.0000217	0.000412	0.00217	80%
Zinc	High flow	0.227	0.0111	0.216	0.187	NA
	Low flow	0.0478	0.00434	0.0435	0.0971	50.8%

Example TMDL calculations based upon: Hardness: HF = 54, LF = 111, Discharge: HF = 4.14cfs, LF = 1.84cfs
*For the mercury example TMDL and WLAs, the chemistry samples were collected on different dates than discharge samples.
*all loads reported in lb/day

In Douglas Creek just upstream of the Bi-Metallic Mill, most metals loads are above TMDLs during both high and low flow conditions. This is understandable given the extent of mining-related soil and water quality contamination in the watershed. It appears that the Granite Drain is a very large source of most

metals in this watershed even though its contribution of discharge ranges from 5-20% of the water when compared to monitoring sites in the lower watershed (**Table 6-29**). Metals conditions generally continue to be problematic near and below Philipsburg. As stated earlier, the EPA superfund program is assessing metal sources in the watershed, and results could be used for further prioritization of reclamation activities.

Table 6-29. Load contribution of metals from Granite Drain to Lower Douglas Creek just upstream of the abandoned Bi-Metallic Mill

	Arsenic	Cadmium	Copper	Lead	Iron	Zinc
Low Flow	47%	26%	10%	0.35%	84%	142%
High Flow	27%	5%	2%	0.67%	15%	10%

*all loads reported in lb/day

6.5.3.5 North Fork Douglas Creek – near Hall (MT76E003_130)

Abandoned mine sources in the North Fork Douglas Creek watershed are responsible for significant metals loading to the creek. Abandoned mills, waste piles, lodes, and placer mining in the headwaters are extensive. The stream originates from an adit with very high metals concentrations and collects more water in an area with extensive mine waste and other adits. As the stream continues down-gradient, water quality only slightly improves as few abandoned mine sources are present in any other areas of the watershed (**Appendix A, Figure A-18**). A margin of safety (MOS) is implicitly applied through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for North Fork Douglas Creek are therefore the sum of the WLA to abandoned mines and the LA to naturally-occurring sources:

$TMDL_{NFDC} = LA_{nat} + WLA_{abmine}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed

WLA_{abmine} = Composite wasteload allocation to all abandoned mining sources in the watershed

The TMDL, LA and WLAs are equations provided in **Section 6.5.1 and 6.5.2**. The example metals TMDLs and allocations for North Fork Douglas Creek are calculated for the headwaters area for typical high and low flow water quality conditions because this area had the highest metals contamination. **Table 6-30** provides an example of metals TMDLs and load allocations for North Fork Douglas Creek. Percent reduction values are the necessary load reduction to meet the TMDL.

Table 6-30. North Fork Douglas Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	WLA_{abmine}	Existing Load	Percent Reduction
Cadmium	High flow	0.00262	0.000404	0.00221	0.719	99.6%
	Low flow	0.00141	0.000195	0.00122	0.167	99.2%
Copper	High flow	0.0896	0.00505	0.0846	3.80	97.6%
	Low flow	0.0493	0.00243	0.0468	0.160	69.1%
Lead	High flow	0.0298	0.00253	0.0273	0.0535	44.3%
	Low flow	0.0175	0.00122	0.0163	0.00355	NA
Zinc	High flow	1.15	0.0505	1.10	65.6	98.2%
	Low flow	0.632	0.0243	0.607	16.1	96.1%

Example TMDL calculations based upon: Hardness: HF =94, LF = 110, Discharge: HF = 1.88cfs, LF = 0.90cfs
*all loads reported in lb/day

In North Fork Douglas Creek most metals loads are above TMDLs during both high and low flow conditions. This is understandable given the extent of mining-related soil and water quality

contamination in the upper reaches of North Fork Douglas Creek headwaters. Metals conditions generally continue to be problematic along the whole stream.

6.5.3.6 Fred Burr Creek (MT76E003_040)

An abandoned mill in the middle reach of Fred Burr Creek is the primary source of metals loads to the creek (**Appendix A, Figure A-20**). The DEQ abandoned mine program assessed metal sources on this property during the 1990s. EPA recently reported results from Superfund Program preliminary site investigation monitoring that further characterizes sources of metals in the Fred Burr Creek watershed (United States Environmental Protection Agency and Hogan, 2010).

The WLA for abandoned mining activities in the watershed can almost entirely be applied to this site. A margin of safety (MOS) is implicitly applied through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for Fred Burr Creek are therefore the sum of the WLA to abandoned mines and the LA to naturally-occurring sources:

$TMDL_{FBC} = LA_{nat} + WLA_{abmine}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed

WLA_{abmine} = Composite wasteload allocation to all abandoned mining sources in the watershed

The TMDL, LA and WLAs are equations provided in **Section 6.5.1 and 6.5.2**. The example metals TMDLs and allocations for Fred Burr Creek are calculated using data from a site near the confluence with Flint Creek for typical high and low flow water quality conditions. This area had the highest metals contamination. **Table 6-31** provides an example of metals TMDLs and load allocations for Fred Burr Creek. Percent reduction values are the necessary load reduction to meet the TMDL.

Table 6-31. Fred Burr Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	WLA_{abmine}	Existing Load	Percent Reduction
Arsenic	High flow	4.46	0.669	3.79	11.6	61.5%
	Low flow	0.104	0.0156	0.0882	0.882	88.2%
Lead	High flow	0.243	0.112	0.132	3.56	93.2%
	Low flow	0.00566	0.00260	0.00306	0.00976	42.0%
Mercury	High flow	0.0223	0.00112	0.0212	4.73	99.5%
	Low flow	0.000519	0.0000260	0.000493	.00332	84.3%

Example TMDL calculations based upon: Hardness: HF =25 LF = 25, Discharge: HF = 83.1cfs, LF = 1.9cfs
*all loads reported in lb/day

In Fred Bur Creek, a limited number of metals are in need of TMDLs because human caused sources are from milling activity, not metals extraction from the earth. Metals problems occur at both high and low flow conditions and originate from Rumsey Mill site and associated sediment contamination along the stream.

6.5.3.7 Royal Gold Creek (MT76E003_040)

Royal Gold Mill tailings are the largest source of metal loading in Royal Gold Creek (**Appendix A, Figure A-20**). The WLA for abandoned mining activities in the watershed can almost entirely be applied to this site. A margin of safety (MOS) is implicitly applied through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for Royal Gold Creek are therefore the sum of the WLA to abandoned mines and the LA to naturally-occurring sources:

$TMDL_{RGC} = LA_{nat} + WLA_{abmine}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed

WLA_{abmine} = Composite wasteload allocation to all abandoned mining sources in the watershed

The TMDL, LA and WLAs are equations provided in **Section 6.5.1 and 6.5.2**. The example metals TMDLs and allocations for Royal Gold Creek are calculated using data from a site near the confluence with Boulder Creek for typical high and low flow water quality conditions. **Table 6-32** provides an example of metals TMDLs and load allocations for Royal Gold Creek. Percent reduction values are the necessary load reduction to meet the TMDL.

Table 6-32. Royal Gold Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	WLA_{abmine}	Existing Load	Percent Reduction
Copper	High flow	0.1455	0.0255	0.120	0.444	67.2%
	Low flow	0.0218	0.00382	0.0180	0.0153	NA
Lead	High flow	0.0278	0.0128	0.0150	0.444	93.7%
	Low flow	0.00417	0.00191	0.00226	0.0153	72.7%

Example TMDL calculations based upon: Hardness: HF =94, LF = 110, Discharge: HF = 1.88cfs, LF = 0.90cfs
*all loads reported in lb/day

In Royal Gold Creek, a limited number of samples were collected, copper and lead very apparently need load reductions to meet standards and are in need of TMDLs because human caused sources are from milling and mining activity. Other metals should be included in any further sampling in this watershed.

6.5.3.8 Smart Creek (MT76E003_110)

The Black Pine Mine is located in the headwaters of Smart Creek. Montana DEQ is beginning a cleanup effort for this mine after a settlement agreement with ASARCO; preliminary investigations are currently underway. There is a mining related stormwater permit for the Black Pine mine area. Also, a hardrock mine permit is in place for the Black Pine mine, yet no water quality discharge permit, other than the stormwater permit, is associated with this mine. Other various abandoned mines are scattered across the watershed including one priority abandoned mine (**Appendix A, Figure A-21**). A margin of safety (MOS) is implicitly applied through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for Smart Creek are therefore the sum of the WLA to abandoned mines plus the Black Pine Mine stormwater WLA and the LA to naturally-occurring sources:

$TMDL_{Smart} = LA_{nat} + WLA_{abmine} + WLA_{BPMsw}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed

WLA_{abmine} = Composite wasteload allocation to all abandoned mining sources in the watershed

WLA_{BPsw} = Wasteload allocation to Black Pine Mine stormwater

The TMDL, LA and WLAs equations are provided in **Section 6.5.1 and 6.5.2**. The example metals TMDLs for Smart Creek are calculated using data from a site near the confluence with Flint Creek for typical high and low flow water quality conditions. This location was the only monitoring site assessed during this TMDL project because it was originally included as a source assessment location for the Flint Creek TMDL. Metals problems were found in Smart Creek, therefore TMDLs are prepared but with less source assessment data than other streams in the TPA. **Table 6-33** provides an example of metals TMDLs and load allocations for Smart Creek. Percent reduction values are the necessary load reduction to meet the TMDL.

Black Pine mine shafts contain acid mine drainage which is likely seeping into adjacent groundwater and emerging in local springs. Local seeps and springs are being pumped back into the mine shafts to contain metals contamination. DEQ is currently investigating a cleanup strategy for this source. An environmental trust group holds a hardrock permit for this area, yet no industrial wastewater NPDES discharge permit is associated with this source. Since no active mining is occurring, there is no industrial process wastewater NPDES discharge permit, and a cleanup effort is underway, this area will be combined with all other areas of abandoned mines for a composite WLA to all abandoned mines in the watershed. Although, the NPDES stormwater permitted area is provided an individual WLA. The combined abandoned mine WLA approach assumes that water quality standards are met in Smart Creek down gradient of the Black Pine Mine area.

Wasteload Allocation

MPDES permit MTR300080 has been issued for Storm Water Discharges Associated with Mining and Oil and Gas Activities related to the ASARCO LLC Black Pine Mine, currently under the ownership of Montana Environmental Trust Group, LLC. Within that permit, two outfalls from the Combination Mine (Outfall 001, Outfall 003) were identified as discharging to an unnamed tributary to Smart Creek.

According to the General Permit For Storm Water Discharges Associated With Mining and With Oil and Gas Activities (Permit Number MTR300000) the following effluent limitations apply:

A. There shall be no discharge of process wastewater pollutants to surface waters.
B. A discharge of storm water associated with mining or with oil and gas activity may occur based on water generated only through rainfall precipitation and snowmelt.
C. No discharge of storm water associated with mining or with oil and gas activity shall cause or contribute to a violation of water quality standards.
D. Discharges of storm water containing pollutants associated with mining or with oil and gas activity covered under this General Permit will be controlled through the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP). Best Management Practices (BMPs) identified in the SWPPP must help eliminate or minimize the discharge of pollutants to surface waters.
E. New or increased storm water discharges associated with mining or with oil and gas activity on or after April 29, 1993 shall not cause degradation as described in ARM 17.30.715(3) and 75-5-301(5)(c), MCA.

The arsenic drinking water and the iron chronic aquatic life standards are used for the basis of a stormwater wasteload allocation. Because the permit indicates no runoff may contribute to water quality standards exceedances, the permitting process should meet the WLA for the TMDL. The State of Montana is currently planning a mine waste cleanup for this source area. Runoff conditions during the cleanup may exceed water quality standards even with all reasonable stormwater practices in place. Therefore, the WLA to permit MTR300080 should not be applied until after the mine waste cleanup is completed according to consent decree Case No. 05-21207 of the Southern District of the Texas Corus Christy Bankruptcy Court.

Table 6-33 provides estimates of the WLAs for this area. An equation provided in **Section 6.5.2** provides the actual WLA. The assumptions behind the example WLA in **Table 6-33** include a 1 inch rainfall event with 100% runoff from the twelve acres of barren land from this site draining to the unnamed tributary of Smart Creek. In reality, detention basins are present but a rainstorm of a larger magnitude may occur. The WLA assumes average daily runoff conditions meet arsenic and iron standards. An implementation approach for meeting wasteload allocations is provided in **Section 8.5.7**.

Table 6-33. Smart Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	WLA_{BPsw}	WLA_{abmine}	Existing Load	Percent Reduction
Arsenic	High flow	0.288	0.0433	0.0272	0.218	0.548	47.4%
	Low flow	0.255	0.0383	0.0272	0.190	0.357	28.6%
Iron	High flow	28.8	9.52	2.72	16.6	61.7	52.8%
	Low flow	25.5	8.42	2.72	14.4	9.31	NA

Example TMDL calculations based upon: Hardness: irrelevant, Discharge: HF = 5.4cfs, LF = 4.8cfs
*all loads reported in lb/day

Permit data indicates that zinc, copper, iron and arsenic samples should be collected in Smart Creek downstream of the unnamed tributaries influenced by Black Pine Mine. If standards cannot be met in this area after remediation is completed and time is provided for remediation activities to take effect, site specific standards may be needed. Yet, the goal of the cleanup should consider meeting existing water quality standards.

6.5.3.9 South Fork Lower Willow Creek (MT76E003_050)

The predominant source of metals in South Fork Lower Willow Creek is Black Pine Mine and associated tailings from mills that processed ore from this mine (**Appendix A, Figure A-21**). Other small scattered abandoned mines are present throughout the watershed. Now, contaminated sediments originating from these sources are present throughout most of South Fork Lower Willow Creek. There is a mining related stormwater permit for the Black Pine mine area. A margin of safety (MOS) is implicitly applied through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for South Fork Lower Willow Creek are therefore the sum of the WLA to abandoned mines plus the Black Pine Mine stormwater WLA and the LA to naturally-occurring sources:

$TMDL_{SFLWC} = LA_{nat} + WLA_{abmine} + WLA_{StormBPM}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed
WLA_{abmine} = Composite wasteload allocation to all abandoned mining sources in the watershed
$WLA_{StormBPM}$ = Wasteload allocation to Black Pine Mine stormwater

The TMDL, LA and WLAs are equations provided in **Sections 6.5.1 and 6.5.2**. The example metals TMDLs and allocations for SF Lower Willow Creek are calculated using data from a site near the confluence with Willow Creek Reservoir for typical high and low flow water quality conditions. This area had the highest metals contamination. **Table 6-34** provides an example of metals TMDLs and load allocations for South Fork Lower Willow Creek. Percent reduction values are the necessary load reduction to meet the TMDL.

Black Pine mine shafts contain acid mine drainage which is likely seeping into adjacent groundwater and emerging in local springs. Local seeps and springs are being pumped back into the mine shafts to contain metals contamination. DEQ is currently investigating a cleanup strategy for this source. An environmental trust group holds a hardrock permit for this area, yet no industrial wastewater NPDES discharge permit is associated with this source. Since no active mining is occurring, there is no industrial process wastewater NPDES discharge permit, and a cleanup effort is underway, this area will be combined with all other areas of abandoned mines for a composite WLA to all abandoned mines in the watershed. Although, the NPDES stormwater permitted area associated with Black Pine Mine is provided an individual WLA. The combined abandoned mine WLA approach assumes that water quality standards are met along all reaches of South Fork Lower Willow Creek.

Wasteload Allocation

MPDES permit MTR300080 has been issued for Storm Water Discharges Associated with Mining and Oil and Gas Activities related to the ASARCO LLC Black Pine Mine, currently under the ownership of Montana Environmental Trust Group, LLC. Within that permit, one outfall from the Tim Smith Drainage (Outfall 002) is identified as discharging to a tributary of South Fork Lower Willow Creek.

According to the General Permit For Storm Water Discharges Associated With Mining and With Oil and Gas Activities (Permit Number MTR300000) the following effluent limitations apply:

A. There shall be no discharge of process wastewater pollutants to surface waters.
B. A discharge of storm water associated with mining or with oil and gas activity may occur based on water generated only through rainfall precipitation and snowmelt.
C. No discharge of storm water associated with mining or with oil and gas activity shall cause or contribute to a violation of water quality standards.
D. Discharges of storm water containing pollutants associated with mining or with oil and gas activity covered under this General Permit will be controlled through the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP). Best Management Practices (BMPs) identified in the SWPPP must help eliminate or minimize the discharge of pollutants to surface waters.
E. New or increased storm water discharges associated with mining or with oil and gas activity on or after April 29, 1993 shall not cause degradation as described in ARM 17.30.715(3) and 75-5-301(5)(c), MCA.

The arsenic and mercury drinking water and the iron, antimony, cadmium, copper and lead chronic aquatic life standards are used for the basis of a stormwater wasteload allocation. There has been no observed runoff from the 1.98 acres of disturbed area in the Tim Smith drainage (outfall 02), therefore no data exists for this location. Because the permit indicates no runoff may contribute to water quality standards exceedances, the permitting process should meet the WLA for the TMDL. The State of Montana is currently planning a mine waste cleanup action for this source area. Runoff conditions during the cleanup may exceed water quality standards even with all reasonable stormwater practices in place. Therefore, the WLA to permit MTR300080 should not be applied until after the mine waste cleanup is completed according to consent decree Case No. 05-21207 of the Southern District of the Texas Corpus Christy Bankruptcy Court.

Table 6-34 provides estimates of the WLAs for the stormwater permit area. An equation provided in S**ection 6.5.2** provides the actual WLA. The assumptions behind the example WLA in **Table 6-34** include a 1 inch rainfall event with 100% runoff from the 1.98 acres of barren land from this site draining to Tim Smith Gulch, a tributary of South Fork Lower Willow Creek. The WLA assumes average daily runoff conditions meet the most restrictive metals standards. An implementation approach for meeting wasteload allocations is provided in **Section 8.5.7**.

Table 6-34. South Fork Lower Willow Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	$WLA_{StormBPM}$	WLA_{abmine}	Existing Load	Percent Reduction
Arsenic	High flow	4.16	0.625	0.00449	3.53	3.33	NA
	Low flow	0.061	0.00900	0.00449	0.0475	0.212	71.4%

Table 6-34. South Fork Lower Willow Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	$WLA_{StormBPM}$	WLA_{abmine}	Existing Load	Percent Reduction
Antimony	High flow	2.33	0.625	0.00251	1.70	8.75	73.3%
	Low flow	0.0340	0.00900	0.00251	0.0225	0.103	67.1%
Cadmium	High flow	0.0403	0.0166	0.0000449	0.0237	0.0566	28.7%
	Low flow	0.0007	0.000200	0.0000449	0.000451	0.000900	36.2%
Copper	High flow	1.188	0.208	0.00128	0.979	18.5	93.6%
	Low flow	0.017	0.003	0.00128	0.0127	0.181	90.4%
Lead	High flow	0.227	0.104	0.000244	0.123	14.6	98.44%
	Low flow	0.003	0.00100	0.000244	0.00176	0.0460	92.87%
Mercury	High flow	0.0197	0.00112	0.0000224	0.0186	0.0333	61.5%
	Low flow	0.000303	0.0000151	0.0000224	0.000265	.000789	37.5%

Example TMDL calculations based upon: Hardness: HF =25, LF = 25 , Discharge: HF = 77.6cfs, LF = 1.13cfs
*all loads reported in lb/day

In South Fork Lower Willow Creek at its confluence with Willow Creek Reservoir, all metals loads are above TMDLs during both high and low flow conditions except for arsenic. Arsenic appears to be problematic only during low flow conditions. This is understandable given the extent of mining-related soil and water quality contamination in the watershed. Metals conditions generally continue to be problematic along most of the stream. As stated earlier, the DEQ remediation program is assessing metal sources associated with Black Pine Mine and results could be used for further prioritization of reclamation activities.

6.5.3.10 Upper Flint Creek (MT76E003_011)

Human caused metals sources in the Upper Flint Creek watershed (above Boulder Creek) are comprised primarily of abandoned mines and mills around Philipsburg in Camp, Douglas and Fred Burr creek watersheds (**Appendix A, Figure A-22)**. Also, another large source appears to come from abandoned mines near Maxwell. Other abandoned mines are scattered across the landscape yet are smaller sources. The contact mill continues operation periodically yet does not have a surface water effluent. Although the city of Philipsburg contributes very small loads compared to other sources, current wastewater effluent conditions contribute to copper, mercury and lead water quality standard exceedances.

The town of Philipsburg operates a permitted wastewater treatment lagoon facility that discharges to Flint Creek (MPDES Permit No. MT0031500) for which metals wasteload allocations are provided. Wasteload allocations to permitted discharges in the Planning Area are calculated using the formula in **Section 6.5.2** and the chronic aquatic life standard for copper and lead along with the arsenic and mercury human health standard are applied in this case. The example numeric Philipsburg WLAs provided in **Table 6-35** are estimated using effluent discharge data from 2007-2010 and the lowest standard threshold for each metal. An implementation approach for meeting wasteload allocations is provided in **Section 8.5.7**.

Metals load allocations consist of a composite wasteload allocation to abandoned mining sources, a wasteload allocation to the city of Philipsburg wastewater treatment facility, and a load allocation to naturally-occurring metals sources. A margin of safety (MOS) is implicit in this allocation scheme, through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for upper Flint Creek are therefore the sum of the two wasteload allocations and the load allocation to naturally-occurring sources:

$TMDL_{UFlint} = LA_{nat} + WLA_{abmine} + WLA_{Pburg}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed

WLA_{abmine} = Composite wasteload allocation to all non-permitted abandoned mining sources in the watershed

WLA_{Pburg} = Wasteload allocation to City of Philipsburg permitted wastewater treatment facility

Because water hardness, flows and metals concentrations are variable throughout the seasons, the example loads and TMDLs presented herein represent loading conditions calculated from high and low flow sampling events. Actual TMDLs and allocations are variable equations presented in **Sections 6.5.1 and 6.5.2** and are dependent upon streamflow and water quality conditions. **Table 6-35** provides example metals TMDLs and load allocations for upper Flint Creek, calculated based on flows and metals concentrations measured at the downstream end of the segment. The Philipsburg WLA examples are based upon end of pipe concentrations that would meet human health or chronic aquatic life standards end of the pipe.

Table 6-35. Upper Flint Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	WLA_{abmine}	WLA_{Pberg}	Existing Load	Percent Reduction
Arsenic	High flow	13.6	2.042	11.6	0.00942	62.62	78.3%
	Low flow	9.40	1.41	7.98	0.00767	15.036	37.5%
Copper	High flow	9.33	0.681	8.65	0.0065	17.56	46.8%
	Low flow	6.08	0.470	5.60	0.005	3.57	NA
Lead	High flow	2.74	0.340	2.40	0.00189	49.7	94.5%
	Low flow	3.91	0.235	3.67	0.00315	7.55	48.2%
Mercury	High flow	0.0681	0.0034	0.0647	0.0000471	0.681	90%
	Low flow	0.0470	0.00235	0.0446	0.0000384	1.22	96%

Example TMDL calculations based upon: Hardness: HF = 69.8, LF = 124 , Discharge: HF = 253cfs, LF = 175cfs
*all loads reported in lb/day

Variable metals load reductions are needed for Upper Flint Creek depending upon the metal and season. This is understandable given the variable extent and location of mining-related soil and water quality contamination in the watershed. If loads from abandoned mines in Douglas, Fred Burr, Camp Creek and near Philipsburg and Maxville are reduced to conditions that meet standards along with minor load reductions of copper, mercury and lead from the Philipsburg WWTP, TMDLs would likely be met. Metals conditions are generally high beginning near Fred Burr Creek Confluence and continue to the lower end of the segment.

6.5.3.11 Lower Flint Creek (MT76E003_012)

Human caused metals sources in the Flint Creek watershed are comprised of abandoned mines and mills around Philipsburg in Camp, Douglas and Fred Burr creeks, Londonderry Mine, Black Pine Mine, and abandoned mines and mills in Smart, Douglas, Lower Willow Creek and Boulder Creek Watersheds (**Appendix A, Figure A-22**). Erosion from agriculture, grazing and irrigation systems may be a significant source of iron in the lower Flint Creek Valley, Lower Willow Creek, and Barnes Creek. Other abandoned mines are scattered across the landscape yet are smaller sources. The contact mill continues operation periodically yet does not have a surface water effluent. Although the city of Philipsburg contributes very small loads compared to other sources, current wastewater effluent conditions contribute to copper and lead water quality standard exceedances.

The town of Philipsburg operates a permitted wastewater treatment lagoon facility that discharges to Upper Flint Creek (MPDES Permit No. MT0031500) for which metals wasteload allocations are provided. Wasteload allocations to permitted discharges in the Planning Area are calculated using the formula in **Section 6.5.2** and the chronic aquatic life standard for iron, copper, and lead along with the arsenic human health standard are applied in this case. Because iron conditions in Philipsburg's effluent do not have reasonable potential for contribution to iron impairment and loading from this source is less than 0.5 % of the TMDL, iron monitoring beyond one yearly sample is not necessary for TMDL implementation and TMDL WLA tracking purposes. The example numeric Philipsburg WLAs provided in **Table 6-36** are estimated using effluent discharge data from 2007-2010 and the lowest standard threshold for each metal. An implementation approach for meeting wasteload allocations is provided in **Section 8.5.7**.

Metals load allocations consist of a composite wasteload allocation to abandoned or diffuse mining sources, a wasteload allocation to the city of Philipsburg wastewater treatment facility, a wasteload allocation to Black Pine Mine Stormwater Runoff, and a load allocation to naturally-occurring metals sources. A margin of safety (MOS) is implicit in this allocation scheme, through a variety of conservative assumptions (see **Section 6.6**). Metals TMDLs for Lower Flint Creek are therefore the sum of the two wasteload allocations and the load allocation to naturally-occurring sources:

$TMDL_{LFlint} = LA_{nat} + WLA_{abmine} + WLA_{Pberg} + WLA_{BPMsw}$

LA_{nat} = Load allocation to naturally occurring sources in the watershed

WLA_{abmine} = Composite wasteload allocation to all non-permitted abandoned mining sources in the watershed

WLA_{Pberg} = Wasteload allocation to City of Philipsburg permitted wastewater treatment facility

$WLA_{BPMsw=\ Black}$ Pine Mine stormwater wasteload allocation

Because water hardness, flows and metals concentrations are variable throughout the seasons, the example loads and TMDLs presented herein represent loading conditions calculated from high and low flow sampling events. Actual TMDLs and allocations are variable equations presented in **Sections 6.5.1 and 6.5.2** and are dependent upon streamflow and water quality conditions. **Table 6-36** provides example metals TMDLs and load allocations for Lower Flint Creek, calculated based on flows and metals concentrations measured at the downstream end of the segment. The Philipsburg WLA examples are based upon end of pipe concentrations that would meet human health or chronic aquatic life standards end of the pipe.

Table 6-36. Lower Flint Creek: Metals TMDLs and Allocation Examples

Metal	Flow	TMDL	LA_{nat}	WLA_{abmine}	WLA_{BPMsw}	WLA_{Pberg}	Existing Load	Percent Reduction
Arsenic	High	26.0	3.90	22.1	0.0375	0.00942	72.9	64.3%
	Low	3.21	0.481	2.68	0.0375	0.00767	3.53	9.1%
Copper	High	15.7	1.30	14.4	0.00273	0.0065	24.7	36.5%
	Low	2.15	0.160	1.98	0.00273	0.0050	0.834	NA
Iron	High	2,602	859	1,739	3.17	0.942	2,960	12.1%
	Low	321	106	211	3.17	0.767	102	NA
Lead	High	4.32	0.650	3.64	0.0274	0.00189	69.5	93.8%
	Low	1.42	0.0800	1.31	0.0274	0.00315	1.56	9.0%

Example TMDL calculations based upon: Hardness: HF =60, LF = 130 , Discharge: HF = 485cfs, LF = 59.8cfs
*all loads reported in lb/day

Variable metals load reductions are needed for the lower segment of Flint Creek depending upon the metal and season. This is understandable given the variable extent and location of mining-related soil and water quality contamination in the watershed. If loads from abandoned mines in Camp, Douglas and Fred Burr creeks, Londonderry Mine, Black Pine Mine, and abandoned mines and mills in Smart, Douglas, Lower Willow Creek and Boulder Creek watersheds are reduced to conditions that meet standards along with minor load reductions of copper, mercury and lead from the Philipsburg WWTP, TMDLs would likely be met. Metals conditions are generally high along the whole segment.

6.6 SEASONALITY AND MARGIN OF SAFETY

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process 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 a margin of safety in the Flint TPA metal TMDL development process.

6.6.1 Seasonality

Seasonality addresses the need to ensure year round beneficial-use support. Seasonality was considered for assessing loading conditions and for developing water quality targets, TMDLs, and allocation schemes. For metals TMDLs, seasonality is critical due to varying metals loading pathways and varying water hardness during high and low flow conditions. Loading pathways associated with overland flow and erosion of metals-contaminated soils and wastes tend to be the major cause of elevated metals concentrations during high flows, with the highest concentrations and metals loading typically occurring during the rising limb of the hydrograph. Loading pathways associated with groundwater transport and/or adit discharges tend to be the major cause of elevated metals concentrations during low or base flow conditions. Hardness tends to be lower during higher flow conditions, thus leading to lower water quality standards for some metals during the runoff season. Seasonality is addressed in this document as follows:

- Metals concentrations and loading conditions are evaluated for both high flow and low flow conditions.
- Metals TMDLs incorporate stream flow as part of the TMDL equation.
- Metals targets apply year round, with monitoring criteria for target attainment developed to address seasonal water quality extremes associated with loading and hardness variations.
- Example targets, TMDLs and load reduction needs are developed for high and low flow conditions.

6.6.2 Margin of Safety

The margin of safety is to ensure that TMDLs and allocations are sufficient to sustain conditions that will support beneficial uses. All metals TMDLs incorporate an implicit MOS in several ways. The implicit margin of safety is applied by using conservative assumptions throughout the TMDL development process and is addressed by the following:

- Target attainment, refinement of load 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.

- Chronic aquatic life criteria were used to calculate a daily load limit rather than a 96-hour load limit
- Sediment metals concentration criteria were used as secondary indicators.

6.7 UNCERTAINTY AND ADAPTIVE MANAGEMENT

Uncertainties in the accuracy of field data, applicable target values, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. Uncertainties, assumptions, and considerations are addressed throughout this document and point to the need to refine analysis, conduct further monitoring, and address unknowns in order to develop better understanding of impairment conditions and the processes that affect impairment. This process of adaptive management is predicated on the premise that TMDLs, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood.

The adaptive management process allows for continual feedback on the progress of restoration activities and status of beneficial uses. It provides the flexibility to refine targets as necessary to ensure protection of the resource or to adapt to new information concerning target achievability. For instance, as a result of additional monitoring and source refinement additional WLAs may be necessary for abandoned mines that are found to be discrete sources and the allocations and margin of safety may be modified. Components may be changed to improve ways of achieving and measuring success. A remediation and monitoring framework is closely linked to the adaptive management process, and is addressed in **Section 8.0**.

The water quality targets and associated metals TMDLs developed for the Flint TPAs are based on future attainment of water quality standards. In order to achieve attainment, all significant sources of metal loading must be addressed via all reasonable land, soil, and water conservation practices. It is recognized however, that in spite of all reasonable efforts, attainment of water quality targets may not be possible due to the potential presence of unalterable human-caused sources. For this reason, an adaptive management approach is adopted for all metals targets described within this document. Under this adaptive management approach, all metals identified in this plan as requiring TMDLs will ultimately fall into one of the three categories identified below:

- Implementation of remediation and restoration activities resulting in full attainment of restoration targets for all parameters;
- Implementation of remediation and restoration activities fails to result in target attainment due to underperformance or ineffectiveness of restoration actions. Under this scenario the waterbody remains impaired and will require further restoration efforts associated with the pollutants of concern. The target may or may not be modified based on additional information, but conditions still exist that require additional pollutant load reductions to support beneficial uses and meet applicable water quality standards. This scenario would require some form of additional, refocused restoration work.
- Implementation of restoration activities fails to result in target attainment, but target attainment is deemed unachievable even though all applicable monitoring and restoration activities have been completed. 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 could either reflect the existing conditions at the time or the anticipated future conditions associated with the restoration work that has been performed.

The DEQ Remediation Division, EPA Superfund Program, and/or DEQ Standards Program personnel will lead this effort within DEQ to make determinations concerning the appropriateness of specific mine cleanup activities relative to expectations for mining cleanup efforts for any impairment condition associated with mining impacts. This includes consideration of appropriate evaluation of cleanup options, actual cleanup planning and design, as well as the appropriate performance and maintenance of the cleanup activities. Where NPDES permitted point sources are involved, the DEQ Permitting Program will also be involved. Determinations on the performance of all aspects of restoration activities, or lack thereof, will then be used along with available in-stream data to evaluate the appropriateness of any given target and beneficial-use support. Reclamation activities and monitoring conducted by other parties, including but not limited to the USFS and EPA, should be incorporated into the process as well. The information will also help determine any further cleanup/load reduction needs for any applicable waterbody and will ultimately help determine the success of water quality restoration.

It is acknowledged that construction or maintenance activities related to restoration, construction/maintenance, and future development may result in short term increase in surface water metals concentrations. For any activities that occur within the stream or floodplain, all appropriate permits should be obtained before commencement of the activity. Federal and State permits necessary to conduct work within a stream or stream corridor are intended to protect the resource and reduce, if not completely eliminate, pollutant loading or degradation from the permitted activity. The permit requirements typically have mechanisms that allow for some short term impacts to the resource, as long as all appropriate measures are taken to reduce impact to the least amount possible.

7.0 OTHER IDENTIFIED ISSUES OR CONCERNS

7.1 NON-POLLUTANT LISTINGS

Water quality issues are not limited simply to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the assessment process and do not appear on the 303(d) list. In other cases, streams in the Flint Creek TPA may appear on the 303(d) list but may not always require TMDL development for a pollutant, but do have non-pollutant listings such as "alteration in streamside or littoral vegetation covers" that could be linked to a pollutant. These habitat related non-pollutant causes are often associated with sediment issues, or potential sediment issues, or may be having a deleterious effect on a beneficial use without a clearly defined quantitative measurement or direct linkage to a pollutant to describe that impact. Nevertheless, the issues associated with these streams are still important to consider when attempting to improve water quality conditions in individual streams, and the Flint Creek watershed as a whole. In some cases, pollutant and *non-pollutant* causes are listed for waterbody, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the non-pollutant listings. **Table 7-1** presents the *non-pollutant* listings in the Flint Creek TPA, and notes those streams listed that do not have any associated pollutant listings.

Table 7-1. Waterbody segments in the Flint Creek TPA with non-pollutant listings related to the 2012 303(d) List pollutants of concern addressed in this document

Waterbody ID	Stream Segment	2012 Probable Causes of Impairment
MT76E003_060	**Boulder Creek*,** headwaters to the mouth (Flint Creek)	*Physical substrate habitat alterations*
MT76E003_130	**Camp Creek*,** headwaters to terminus, T7N R14W S25	*Alteration in streamside or littoral vegetation covers; Fish-passage barrier*
MT76E003_020	**Douglas Creek*,** confluence of Middle and South Fork to the mouth (Flint Creek), T9N R13W S10	*Physical substrate habitat alterations*
MT76E003_100	**Douglas Creek,** headwaters to where stream ends, T7N R14W S25	*Physical substrate habitat alterations*
MT76E003_011	**Flint Creek,** Georgetown Lake to confluence with Boulder Creek	*Alteration in streamside or littoral vegetation covers; Low flow alterations*
MT76E003_012	**Flint Creek,** Boulder Creek to mouth (Clark Fork River)	*Alteration in streamside or littoral vegetation covers*
MT76E003_040	**Fred Burr Creek*,** Fred Burr Lake to mouth (Flint Creek)	*Alteration in streamside or littoral vegetation covers*
MT76E003_030	**North Fork Douglas Creek*,** headwaters to mouth (Middle Fork Douglas Creek)	*Alteration in streamside or littoral vegetation covers*
MT76E003_090	**Princeton Gulch*,** headwaters to mouth (Boulder Creek)	*Physical substrate habitat alterations*
MT76E003_110	**Smart Creek,** headwaters to mouth (Flint Creek), T9N R13W S21	*Alteration in streamside or littoral vegetation covers*

* Streams listed for *non-pollutants* only, and have no associated sediment pollutant listings.

7.2 NON-POLLUTANT CAUSES OF IMPAIRMENT DESCRIPTIONS

Non-pollutant listings are often used as a probable cause of impairment when available data at the time of assessment does not necessarily provide a direct quantifiable linkage to a specific pollutant; however non-pollutant sources or indicators do indicate impairment. In some cases the pollutant and non-pollutant categories are linked and appear together in the cause listings; however a non-pollutant category may appear independent of a pollutant listing. 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 or remediation.

Alteration in Streamside or Littoral Vegetation Covers

Alteration in streamside or littoral vegetation 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 overwidened stream channel conditions, elevated sediment loads, and the resultant lack of canopy cover can lead to increased water temperatures.

In cases where a sediment TMDL has been developed for a stream that also has alteration in streamside or littoral vegetation covers listed as a cause, the recommendations and allocations described within the TMDL will usually address the alteration cause as well. For those streams that are only listed for an alteration cause and have no sediment TMDL, the targets and implementation recommendations for TMDL streams in the watershed provide the general guidance to address habitat alterations.

Physical Substrate Habitat Alterations

Physical substrate habitat alterations generally describe cases where the stream channel has been physically altered or manipulated, such as through the straightening of the channel or from anthropogenically 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 through placer mine operations.

In cases where a sediment TMDL has been developed for a stream that also has physical substrate habitat alterations listed as a cause, the recommendations and allocations described within the TMDL will usually address the alteration cause as well. For those streams that are only listed for an alteration cause and have no sediment TMDL, the targets and implementation recommendations for TMDL streams in the watershed provide the general guidance to address habitat alterations.

Fish Passage Barrier

Fish passage barriers, in the context of a probable cause of impairment, refer to those barriers created by humans that impede the movement of fish within their natural habitat and range. Barriers such as dams, diversion structures, or mis-sized or improperly installed culverts that prohibit fish passage to or from areas critical to the various life stages of fish can be deemed a cause of impairment to the Fishes beneficial use. Exceptions to this include the reasonable operation of dams that have been constructed prior to July 1, 1971, which are defined as ‘natural’ under MCA 75-5-306(2) (reasonable operations as evaluated by Montana DEQ). In addition, fish passage barriers installed or maintained as a management strategy by resource professionals may be exempted as well. For instance, a fish passage barrier that

prohibits an undesirable fish species from intermingling with a desired species (such as a native population of westslope cutthroat) when the result of their intermingling would negatively affect the desired species would be an acceptable method for protecting a beneficial use. These cases are only acceptable when developed solely or in conjunction with ecosystem or fish management professionals.

In the context of Camp Creek, the fish passage barrier cause was assigned due to extreme habitat alterations in the watershed resulting in areas where the creek goes dry or subsurface. In this instance, addressing habitat alterations in Camp Creek via the recommendations within this document for sediment and habitat impairment should also address the fish passage barrier cause.

Low Flow Alterations

Streams are typically listed for low flow alterations when irrigation withdrawal management or dam operations lead to base flows that are too low to support all the beneficial uses designated for that stream. This could result in dry channels or extreme low flow conditions that do not support fish and aquatic life. It could also result in lower flow conditions which 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 states that TMDLs cannot impact Montana water rights and thereby affect the allowable flows at various times of the year, the identification of low flow alterations as a probable source of impairment does not violate state or federal regulations or guidance related to stream assessment and water quality impairment determination. Subsequent to the identification of low flow alterations as a probable cause of impairment, it is up to local users, agencies, and entities to investigate water management options, and improve flows through water and land management if possible.

7.3 MONITORING AND BMPS FOR POLLUTION AFFECTED STREAMS

Streams listed for *non-pollutant* as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect additional information where data is minimal and the linkage between probable cause, non-pollutant listing, and affects to the beneficial uses are not well defined. As part of Flint Creek watershed TMDL development, some of the streams listed in **Table 7-1** were included in sediment and habitat investigations. In some cases the data collected was not enough to warrant TMDL development, but still may have warrant future monitoring or implementation. Information from that data collection effort is included in **Attachment A** and includes data for Boulder Creek, Douglas Creek (near Hall), Fred Burr Creek, North Fork Douglas Creek, and Trout Creek, in addition to the TMDL addressed streams. The restoration and monitoring strategies that follow in **Sections 8** and **9** are presented to address pollutant and issues for the Flint Creek TPA, are equally applicable to streams listed for the above non-pollutant categories.

8.0 FRAMEWORK WATER QUALITY RESTORATION STRATEGY

8.1 SUMMARY OF RESTORATION STRATEGY

This section provides a framework strategy for water quality restoration in the Flint Creek watershed, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document. This section identifies which activities will contribute the most reduction in pollutants for each TMDL.

This section should assist stakeholders in developing a more detailed adaptive Watershed Restoration Plan (WRP) in the future. The locally-developed WRP will likely provide more detailed information about restoration goals and spatial considerations within the watershed. The WRP may also encompass broader goals than the focused water quality restoration strategy outlined in this document. The intent of the WRP is to serve as a locally organized "road map" for watershed activities, sequences of projects, prioritizing types of projects, and funding sources towards achieving local watershed goals, including water quality improvements. Within this plan, the local stakeholders would identify and prioritize streams, tasks, resources, and schedules for applying Best Management Practices (BMPs). As restoration experiences and results are assessed through watershed monitoring, this strategy could be adapted and revised by stakeholders based on new information and ongoing improvements.

8.2 ROLE OF DEQ, OTHER AGENCIES, AND STAKEHOLDERS

The DEQ does not implement TMDL pollutant reduction projects for nonpoint source activities, but can provide technical and financial assistance for stakeholders interested in improving their water quality. The DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help fund water quality improvement and pollution prevention projects, and can 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 continue to work collaboratively with local and state agencies to achieve water quality restoration which will progress toward meeting water TMDL targets and load reductions. Specific stakeholders and agencies that have been, and will likely continue to be, vital to restoration efforts include the Granite Conservation District, USFS, USFWS, NRCS, DNRC, FWP, EPA, and DEQ. Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include Granite Headwaters Watershed Group, Montana Water Trust, Montana Water Center, University of Montana Watershed Health Clinic, Clark Fork Coalition, Watershed Restoration Coalition of the Upper Clark Fork, Montana Bureau of Mines and Geology, Montana Aquatic Resources Services (MARS), and MSU Extension Water Quality Program.

8.3 WATERSHED RESTORATION GOALS

This TMDL document provides information to achieve the following water quality goals:

- Provide technical guidance for full recovery of aquatic life beneficial uses to all impaired streams within the Flint Creek TPA by improving pollutant and non-pollutant related water quality conditions. This technical guidance is provided by the TMDL components in the document which include:
    - water quality targets,

  - pollutant source assessments, and
  - general restoration guidance which should meet the TMDL allocations.
- Assess watershed restoration activities to address significant pollutant sources.

A WRP is a locally-derived plan that can be more dynamic and detailed than the TMDL document. It can be refined as activities progress and address more goals than those included in this TMDL document. The following elements may be included in a stakeholder-derived WRP in the future:

- Design for implementing restoration projects to protect water conditions so that all streams and aquatic resources in the watershed maintain good water quality with an emphasis on waters with TMDLs completed.
- More detailed cost/benefit analysis and spatial considerations for water quality improvement projects.
- An approach for future BMP installment and efficiency results tracking.
- Strategies for stakeholder outreach to inform and educate about restoration approaches, benefits and funding assistance.
- Inclusion of other various watershed health goals and local watershed issues (such as weed control initiatives, wetland restoration, etc).

Specific water quality goals for the various pollutants are detailed in **Sections 5 and 6.** These goals include water quality and habitat targets as a measure for long-term effectiveness monitoring. These targets specify satisfactory conditions to ensure protection and/or recovery of beneficial uses of waterbodies in the Flint Creek TPA. It is presumed that the meeting of all water quality and habitat targets will signal the achievement of water quality goals for a given stream. **Section 9** identifies a general monitoring strategy and recommendations designed to track post-implementation water quality conditions and measure restoration successes.

8.4 Overview of Management Recommendations

TMDLs were completed for 5 waterbody segments for sediments, and 11 waterbody segments for metals. Other streams in the watershed may be in need of restoration or pollutant reduction, but insufficient information about them precludes TMDL formation at this time. The following sub-sections describe some generalized recommendations for implementing projects to achieve the TMDL. Details specific to each stream, and therefore which of the following strategies may be most appropriate, are found within **Section 5**.

8.4.1 Sediment Restoration Approach

Streamside riparian and wetland vegetation restoration and long term riparian area and wetland management are vital restoration practices that must be implemented across the watershed to achieve 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 filters pollutants from upland runoff. Therefore, improving riparian and wetland vegetation will decrease bank erosion by improving streambank stability and will also reduce pollutant delivery from upland sources. Sediment is also deposited more heavily in healthy riparian zones and wetland areas during flooding because water velocities slow in these areas enough for excess sediment to settle out.

Riparian and wetland disturbance has occurred throughout the Flint Creek TPA as a result of many influencing factors. Riparian timber harvest and the conversion of forest and valley bottoms for

agriculture, livestock production, and residential development have all had varying degrees of impact, depending on the drainage. 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, and floodplain and streambank stabilization and revegetation efforts where necessary. In general, natural recovery of disturbed systems is preferred however it is acknowledged that existing conditions may not readily allow for unassisted recovery in some areas where disturbance has occurred. Active vegetation planting and bank or stream channel reshaping may increase costs, but may be a reasonable and relatively cost effective restoration approach, depending on the site. When stream channel restoration work is needed because of altered stream channels, cost increases and projects should be assessed on a case by case basis. The implementation of BMPs should aim to prevent the availability, transport, and delivery of a pollutant through the most natural or natural-like means possible. Appropriate BMPs will differ by location and are recommended to be included and prioritized as part of a comprehensive watershed scale plan (e.g. WRP).

Although 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 should be to divert water off of roads and 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. Sediment loads from culvert failure and culvert caused scour were not assessed by the TMDL source assessment, but should be considered in road sediment restoration approaches.

Assistance from resource professionals from various local, state, and federal agencies or non-profit groups is widely available in the Flint Creek TPA. In particular, the Granite Conservation District in Philipsburg and the NRCS are two resources that are valuable aids for assisting with investigating, developing, and implementing measures to improve conditions in the Flint Creek watershed.

8.4.2 Metals Restoration Approach

This section outlines strategies for addressing metals loading sources in need of restoration activities within the Flint Creek TPA. The restoration strategies focus on regulatory mechanisms and/or programs applicable to the controllable source types present within the watershed; which, for the most part, are associated with historic mining and mining legacy issues. Potential metals loading sources associated with abandoned mines include discharging mine adits and mine waste materials on-site and in-channel. The goal of the metals restoration plan is to limit the input of metals to stream channels from priority abandoned mine sites and other identified sources of metals impairments. For most of the mining-related sources, additional analysis will likely be required to identify site specific metals delivery pathways and to develop mitigation plans.

Because Superfund/CERCLA clean-up goals do not always correspond to Montana water quality standards, additional remediation may be necessary to meet metals TMDLs. However, after all planned remediation work is complete, effectiveness and trends monitoring should be conducted to determine if additional measures are needed to meet the TMDLs and to assess if target attainment may not be achievable for all metals.

Goals and objectives for future restoration work include the following:

- Prevent soluble metal contaminants or metals contaminated solid materials in the waste rock and tailings materials/sediments from migrating into adjacent surface waters to the extent practicable.
- Reduce or eliminate concentrated runoff and discharges that generate sediment and/or heavy metals contamination to adjacent surface waters and groundwater to the extent practical.
- Identify, prioritize, and select response and restoration actions based on a comprehensive source assessment and streamlined risk analysis of areas affected by historical mining.

8.4.3 Pollution Restoration Approach

Although TMDL development is not required for pollution listings, they are frequently linked to pollutants, and addressing pollution sources is an important component of TMDL implementation. Pollution listings within the Flint Creek TPA are described in **Section 7**. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Therefore, if restoration goals within the Flint Creek TPA are not also addressing pollution impairments, additional pollution-related BMP implementation should be considered.

8.5 RESTORATION APPROACHES BY SOURCE

Generalized management recommendations are outlined below for the major sources of human caused pollutant loads in the Flint Creek TPA: grazing, upland sources, riparian and wetland vegetation removal, irrigation, and roads. Applying BMPs are the core of the sediment reduction strategy, but are only part of a watershed restoration strategy. 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 sediment sources. In these cases, BMPs are usually identified as a first effort and an adaptive management approach will be used to determine if further restoration approaches are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process. Monitoring recommendations are outlined in **Section 9.0**.

8.5.1 Agriculture Sources

Reduction of sediment from upland agricultural sources can be done 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 Flint Creek watersheds 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 stripcropping (although currently there is very little cropping activity that occurs in the Flint Creek watershed). 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 NPS Management Plan (Montana Department of Environmental Quality, 2012).

An additional benefit of reducing sediment input to the stream is a decrease in sediment-bound nutrients. Although this document focuses only on sediment and metals, nutrient TMDLs will be completed for the Flint Creek watershed in the future. Reductions in sediment loads may help address some nutrient related problems. Nutrient management considers the amount, source, placement, form,

and timing of plant nutrients and soil amendments. Conservation plans should include the following information (NRCS MT 590-1):

- Field maps and soil maps
- Planned crop rotation or sequence
- Results of soil, water, plant, and organic materials sample analysis
- Realistic expected yields
- Sources of all nutrients to be applied
- A detailed nutrient budget
- Nutrient rates, form, timing, and application method to meet crop demands and soil quality concerns
- Location of designated sensitive areas
- Guidelines for operation and maintenance

8.5.3.1 Grazing

Development of riparian grazing management plans should be a goal for any landowner in the watershed who operates livestock and does not currently have such plans. Private land owners 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 necessary eliminate all grazing in riparian corridors. Nevertheless, in some areas, a more restrictive management strategy may be necessary for a period of time in order to accelerate re-establishment of a riparian community with the most desirable species composition and structure.

Every livestock grazing operation should have a grazing management plan. The plan should at least include the following elements:

- 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

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 to prevent ‘loafing’ in riparian areas
- 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

The following resources may be able to help you prevent pollution and maximize productivity from your grazing operation:

- USDA, Natural Resources Conservation Service. You can find your local USDA Agricultural Service Center listed in your phone directory or on the internet at www.nrcs.usda.gov
- Montana State University Extension Service www.extn.msu.montana.edu
- DEQ Watershed Protection Section, Nonpoint Source Program www.deq.mt.gov/wqinfo/nonpoint/NonpointSourceProgram

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 Flint Creek watershed are providing off-site watering sources, limiting livestock access to streams and stabilizing the stream at access points, planting woody vegetation along streambanks, and establishing riparian buffers. Although bank revegetation is a preferred BMP, in some instances bank stabilization may be necessary prior to planting vegetation.

8.5.3.2 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. 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 (United States Department of Agriculture, Natural Resources Conservation Service, 2005). This strategy encouraged owners of AFOs of any size or 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). CAFOs 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, 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 to 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 (United States Department of Agriculture, Natural Resources Conservation Service, 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. Studies have shown benefits in red meat and milk production of 10 to 20 percent by livestock and dairy animals when good quality drinking water is substituted for contaminated surface water.

Opportunities for financial and technical assistance (including CNMP development) in achieving voluntary AFO and CAFO compliance may be available from conservation districts, NRCS field offices, or the Montana DEQ Watershed Protection Section (among other sources). Further information on CAFO discharge permitting may be obtained from the DEQ website at:
www.deq.mt.gov/wqinfo/mpdes/cafo.mcpx

8.5.3.3 Irrigation

Flow alteration 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, especially nutrients, metals and heat. Flow reduction may increase water temperature, allow sediment 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; Schmidt and Potyondy, 2004). Restoration targets and 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 State law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana's water quality law (MCA 75-5-705).

Irrigation management is a critical component of attaining both cold water fishery conservation and TMDL goals. Management practices for irrigation efficiency in the Flint Creek watershed should investigate reducing the amount of stream water diverted during July and August, while still maintaining healthy crops. It may also be desirable to investigate irrigation practices earlier in the year that promote groundwater return during July, August, and September. Understanding irrigation water, groundwater and surface water interactions is an important part of understanding how irrigation practices will affect streamflow during specific seasons.

Many of the irrigation practices in western Montana are based in flood irrigation methods. In some cases, head gates and ditches leak, which can decrease the amount of water in diversion flows. The following recommended activities could 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) to increase ditch conveyance efficiency.

Future studies could investigate irrigation water return flow timeframes from specific areas along the Flint Creek watershed. 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.

8.5.2 Forestry and Timber Harvest

Currently, active timber harvest is not significantly affecting sediment loads in the Flint Creek TPA, but harvesting will likely continue in the future within the Beaverhead-Deer Lodge National Forest, and on private land. Future harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (Montana State University, Extension Service, 2001) and the Montana SMZ Law (77-

5-301 through 307 MCA). The Montana Forestry BMPs cover timber harvesting and site preparation, 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 can be applied to numerous land management activities (i.e. timber harvest for personal use, agriculture, development). Prior to harvesting on private land, landowners or operators are required to notify the Montana DNRC. The 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.

Timber harvest should not increase the peak water yield by more than 10 percent of historic conditions. If a natural disturbance, such as a forest fire, increases peak water yield, the increase should be accounted for as part of timber harvest management.

8.5.3 Riparian Corridors and Wetlands

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 of passive BMPs that allow riparian and wetland vegetation to recover at natural rates is typically the most cost-effective approach, active restoration (i.e. 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. In addition to providing shade (and possible reduced water temperature) and cover for aquatic species, riparian and wetland plantings can develop root masses that penetrate deep into the soils, increasing bank resilience to erosion. All areas that are actively restored with vegetation should have a reasonable approach to protecting the invested effort from future degradation from livestock or hay production.

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.

- Harvest and transplant locally available sod mats with an existing dense root mass which provide immediate promotion of bank stability and filtering nutrients and sediments.
- 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.
- 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.
- 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 noted above, it should be noted that in some cases wetland act as areas of shallow subsurface groundwater recharge and/or storage areas, and can have added links to the issues discussed in **Section 8.5.3.3**. 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.

8.5.4 Unpaved Roads

The road sediment reductions in this document represent a gross estimation of the sediment load that would remain once road BMPs were applied, assuming no current BMPs are in place. In general, a road with associated BMPs assumes contributing road treads, cutslopes, and fillslopes were reduced to 100 feet (from each side of a crossing). 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 100ft 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 NPS Management Plan (Montana Department of Environmental Quality, 2007). Examples include:

- Providing adequate ditch relief up-grade of stream crossings.
- Constructing waterbars, where appropriate, and up-grade of stream crossings.
- Use rolling dips on downhill grades with an embankment on one side to direct flow to the ditch.
- Inslope roads along steep banks with the use of cross slopes and cross culverts.
- Outslope low traffic roads on gently sloping terrain with the use of a cross slope.
- Use 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.
- Prevent disturbance to vulnerable slopes.
- Use 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.

8.5.4.1 Culverts

Although culverts were not part of the source assessment, they can be large sources of sediment, and should be included in the restoration strategy. A field survey should be conducted and combined with local knowledge to prioritize culverts for restoration. As culverts fail, they should be replaced with culverts that pass a 100 year flood on fish bearing streams and at least 25 year events on non fish bearing streams. Culverts should be installed at grade with the streambed, and inlets and outlets should be vegetated and armored. Some road crossings may not pose a feasible situation for size upgrades because of road bed configuration; in those circumstances, the largest size culvert feasible should be used.

Another consideration for culvert upgrades will be to provide fish passage. During the assessment and prioritization of culverts, additional crossings should be assessed for streams where fish passage is a concern. Each 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 FWP can aid in

determining if a fish passage barrier should be mitigated, and, if so, they should be involved in culvert design. If funding is available, culverts should be prioritized and replaced prior to failure.

8.5.5 Bank Hardening/Riprap/Revetment/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 is necessary in some instances, it generally redirects channel energy and exacerbates erosion in other places. Bank armoring should be limited to areas with a demonstrated threat to infrastructure. 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 land use planning initiatives.

Bank stabilization using natural channel design techniques can provide both bank stability and 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 fillslopes and/or embankments, reducing near-bank shear stress, and enhancing aquatic habitat and lateral channel margin complexity.

8.5.6 Mining

Because restoration of metals sources that are not also associated with sediment are typically implemented under state and federal programs, this section will discuss general restoration programs and funding mechanisms that may be applicable to the metals sources instead of specific BMPs. The need for further characterization of impairment conditions and loading sources is addressed through the framework monitoring plan in **Section 9.0**. 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 considered most applicable to the Flint Creek watershed include:

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- The State of Montana Mine Waste Cleanup Bureau's 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)

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA (a.k.a. Superfund) is a Federal law that addresses cleanup on sites, such as historic mining areas, where there has been a hazardous substance release or threat of release. Sites are prioritized on the National Priority List (NPL) using a hazard ranking system with significant focus on human health. Under CERCLA, the potentially responsible party or parties must pay for all remediation efforts based upon the application of a strict, joint and several liability approaches whereby any existing or historical land owner can be held liable for restoration costs. Where viable landowners are not available to fund cleanup, funding can be provided under Superfund authority. Federal agencies can be delegated Superfund authority, but cannot access funding from Superfund. Cleanup actions under CERCLA must be based on professionally developed plans and can be categorized as either Removal or Remedial.

Removal actions can be used to address the immediate need to stabilize or remove a threat where an emergency exists. Removal actions can also be non-time critical. Once removal activities are completed, a site can then undergo Remedial Actions or may end up being scored low enough from a risk perspective that it no longer qualifies to be on the NPL for Remedial Action. Under these conditions the site is released back to the state for a "no further action" determination. At this point there may still be a need for additional cleanup since there may still be significant environmental threats or impacts, although the threats or impacts are not significant enough to justify Remedial Action under CERCLA. Any remaining threats or impacts would tend to be associated with wildlife, aquatic life, or aesthetic impacts to the environment or aesthetic impacts to drinking water supplies versus threats or impacts to human health. A site could, therefore, still be a concern from a water quality restoration perspective, even after CERCLA removal activities have been completed.

Remedial actions may or may not be associated with or subsequent to removal activities. A remedial action involves cleanup efforts whereby Applicable or Relevant and Appropriate Requirements and Standards (ARARS), which include state water quality standards, are satisfied. Once ARARS are satisfied, then a site can receive a "no further action" determination.

Currently the EPA superfund program is conducting a site investigation near Philipsburg Montana in the Douglas Creek drainage. During 2011, a sampling effort was conducted to further characterize metals sources and threats to human life. Depending on the results and analysis, future removal actions or remediation actions may be pursued.

Montana Mine Waste Cleanup Bureau Abandoned Mine Reclamation Program (AML)

The Mine Waste Cleanup Bureau (MWCB), which is part of the DEQ Remediation Division, is responsible for reclamation of historical mining disturbances associated with abandoned mines in Montana. The MWCB abandoned mine reclamation program is funded through the Surface Mining Control and Reclamation Act of 1977 (SMCRA) with SMCRA funds distributed to states by the federal government. In order to be eligible for SMCRA funding, a site must have been mined or affected by mining processes, and abandoned or inadequately reclaimed, prior to August 3, 1977 for private lands, August 28, 1974 for Forest Service administered lands, and prior to 1980 for lands administered by the U.S. Bureau of Reclamation. Furthermore, there must be no party (owner, operator, other) who may be responsible for reclamation requirements, and the site must not be located within an area designated for remedial action under the federal Superfund program or certain other programs. Priority abandoned mines within the Flint Creek TPA are presented in **Table 8-1**. In addition to the priority abandoned mines cleanup, the Mine Waste Cleanup Bureau (MWCB) is also responsible for cleanup of Black Pine Mine area through a consent decree between ASARCO and the State of Montana.

Table 8-1 Priority Abandoned Mines in the Flint Creek Watershed

Site Name	Mining District	Primary Drainage	Secondary Drainage	Priority AM Rank
Trout	Philipsburg	Cliff Gulch	-	4
Bi-Metallic/Old Red	Philipsburg	Flint Creek	Douglas Creek	6
Scratch All	Philipsburg	Camp Creek	-	7
Granite Mountain	Philipsburg	Flint Creek	Douglas Creek	10
Algonquin	Philipsburg	Douglas Creek	Frost Creek	16
Douglas Creek	Philipsburg	Douglas Creek	-	17
True Fissure	Philipsburg	Douglas Creek	Camp Creek	20

Table 8-1 Priority Abandoned Mines in the Flint Creek Watershed

Site Name	Mining District	Primary Drainage	Secondary Drainage	Priority AM Rank
Little Gem	Philipsburg	Camp Creek	Cliff Gulch	31
Nonpareil	South Boulder	Flint Creek	Boulder Creek	32
Millers Mine	Frog Pond	Copper Creek	Lutz Creek	73
Port Royal Mill Tailings	South Boulder	Flint Creek	Royal Gold Creek/Boulder Creek	84
Sunrise/Queen Millsite	Combination	Flint Creek	Henderson Creek	110
Combination Mine		Flint Creek	S.F. Lower Willow Creek	
Wasa	Philipsburg	Douglas Creek	N.F. Douglas Creek	
Maxville Tailings/Londonderry	Philipsburg	Flint Creek	Boulder Creek	
Rumsey	Philipsburg	Flint Creek	Fred Burr Creek	
Wenger #2	Philipsburg	Camp Creek	Cliff Gulch	
Brooklyn	Philipsburg	Flint Creek	Boulder Creek	
Combination II	Combination	Flint Creek	S.F. Lower Willow Creek	

Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA)

Reclamation of historic mining-related disturbances administered by the State of Montana and not addressed under SMCRA, are typically addressed through the DEQ State Superfund or CECRA program. The CECRA program maintains a list of facilities potentially requiring response actions based on the confirmed release or substantial threat of a release of a hazardous or deleterious substance that may pose an imminent and substantial threat to public health, safety or welfare or the environment (ARM 17.55.108). Listed facilities are prioritized as maximum, high, medium, or low priority or in operation and maintenance status based on the potential threat posed. Currently, there are two sites on the CECRA priority list within the Flint Creek watershed; Granite Timber Co (near Philipsburg) and Sluice Gulch Leaking Mine Adit (near Philipsburg).

CECRA also encourages the implementation of voluntary cleanup activities under the Voluntary Cleanup and Redevelopment Act (VCRA), and the Controlled Allocation and Redevelopment Act (CALA). It is possible that any historic mining-related metals loading sources identified in the watershed in the future could be added to the CECRA list and addressed through CECRA, with or without the VCRA and/or CALA process. A site can be added to the CECRA list at DEQ's initiative, or in response to a written request made by any person to the department containing the required information.

Other Programs

In addition to the programs discussed above, other funding may be available for water quality restoration activities. These sources include the following:

- Upper Clark Fork River Basin Grant Program (UCFRB)
- Resource Indemnity Trust/Reclamation and Development Grants Program (RIT/RDGP)
- EPA Section 319 Nonpoint Source Grant Program

UCFRB

The State of Montana was awarded monies through a series settlement agreements signed between 1999 and 2008 against the Atlantic Richfield Company (ARCO) as a result the extensive mining-related damages to natural resources within the Upper Clark Fork watershed. The Natural Resource Damage Program (NRDP), which is part of the Montana Department of Justice, filed the lawsuit and administers a grant process as a way to disperse the settlement funds. Government agencies and private

entities/individuals are eligible for the grant funding, and UCFRB is a unique opportunity for remediation in the Upper Clark Fork TPA because funding must be applied within the Upper Clark Fork watershed.

Several types of projects are eligible for funding but those most applicable to TMDL implementation are *restoration projects* and *monitoring and research project*s. UCFRB is an annual program and has a slightly different application process for grants under $25,000 than for those over $25,000. Certain areas that are still being investigated as part of the Superfund sites are not eligible for funding.

RIT/RDGP
The RIT/RDGP is an annual program that can provide up to $300,000 to address environmental related issues. This money can be applied to sites included on the Mine Waste Cleanup Bureau's Abandoned Mine Lands (AML) priority list, but of low enough priority where cleanup under AML is uncertain. RIT/RDGP program funds can also be used for conducting site assessment/ characterization activities such as identifying specific sources of water quality impairment.

Section 319 funding
Section 319 grant funds are typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects. Individual contracts under the yearly grant typically range from $20,000 to $150,000, with a 25 percent or more match requirement. RIT/RDGP and 319 projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

8.5.7 Metals WLAs

A phased implementation approach for reaching WLAs for metals is provided. The stormwater WLAs should be met after Black Pine Mine remediation process is complete.

Copper and lead WLAs for the city of Philipsburg shall follow the following phased approach:

1. The existing WWTP copper and lead loads represent less than ½ of a percent of the allowable copper and lead loads (i.e., less than ½ percent of the TMDL). The WWTP is not a significant source of copper or lead.
2. Impairment conditions only exist in the receiving water (Flint Creek) during high flow conditions. During lower and baseflow conditions, there is assimilative capacity and the WWTP discharge does not contribute to impairment.
3. The elevated copper and lead loads originate from root deterrent treatment, leaching from pipes and from infiltration of contaminated groundwater into the WWTP collection system.
4. The extent of achievable remediation is unknown within the upstream tributaries and within Flint Creek. Adaptive management, as it relates to future copper and lead target concentrations, could result in site specific standards or some other modification to the copper and/or lead targets. This type of modification would change the current basis for setting the WLA. Therefore, the final WWTP copper and lead treatment determinations should be based on a watershed – scale remediation plan that evaluates all contributing sources, natural background conditions, and achievable in-stream concentrations after implementing all reasonable remediation and restoration activities.

The Mercury WLA for the city of Philipsburg shall follow the following phased approach:

1. Collect and analyze ultra low detection limit mercury samples in coordination with DEQ in the effluent and upstream of the effluent.

2. Collaborate with DEQ to determine increased certainly associated with sampling indicates a mercury problem in the effluent or in Flint Creek.
3. Follow the phased approach for copper and lead WLAs provided in this section.

For the phased metals WLA implementation, the city of Philipsburg has 20 years to achieve the WLA at levels consistent with discharge flow times the TMDL target concentration. During that time period, the WLA is to be capped at existing load and the WWTP facility must provide quarterly water quality and flow data for Flint Creek above and below the WWTP discharge, with focus on ensuring that yearly high flow sampling is included.

The WLA can be modified prior to the end of the 20 year period if a comprehensive remediation plan is developed and implemented to create assimilative capacity (dilution) within Flint Creek and/or site-specific standards are adopted.

9.0 MONITORING STRATEGY AND ADAPTIVE MANAGEMENT

9.1 INTRODUCTION

The monitoring strategies discussed in this section are an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. Water quality targets and allocations presented in this document are based on available data at the time of analysis, however the scale of the watershed coupled with constraints on time and resources often result in compromises that must be made that include estimations, extrapolation, and a level of uncertainty. The margin of safety (MOS) 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 (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 and specific 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 aforementioned goals. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on stakeholder priorities for restoration and funding opportunities.

9.2 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach is recommended to control costs and meet the water quality standards to support all beneficial uses. This approach works in cooperation with the monitoring strategy, and as new information is collected, it allows for adjustments to restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary.

9.3 FUTURE MONITORING GUIDANCE

The objectives for future monitoring in the Flint Creek watershed include: 1) strengthen the spatial understanding of sources for future restoration work, which will also strengthen source assessment analysis for future TMDL review, 2) gather additional data to supplement target analysis, better characterize existing conditions, and improve or refine assumptions made in TMDL development, 3) gather consistent information among agencies and watershed groups that is comparable to targets and allows for common threads in discussion and analysis, 4) expand the understanding of streams throughout the Flint Creek beyond those where TMDL have been developed and address issues if necessary, and 5) track restoration projects as they are implemented and assess their effectiveness.

9.3.1 Strengthening Source Assessment

In the Flint Creek TPA, the identification of sources was conducted largely through watershed field tours, aerial assessment, the incorporation of GIS information, available data and literature review, with limited field verification and on-the-ground analysis. In many cases, assumptions were made based on overall TPA conditions and extrapolated throughout the watershed. As a result, the level of detail often

does not provide specific areas by which to focus restoration efforts, only broad source categories to reduce sediment loads from in each of the discussed subwatersheds. Strategies for strengthening source assessments for each of the pollutants may include:

Sediment
Field surveys of road and road crossing to identify specific contributing road crossings, their associated loads, and prioritize those road segments/crossings of most concern.

Review of land use practices specific to subwatersheds of concern to determine where the greatest potential for improvement and likelihood of sediment reduction can occur for the identified major land use categories.

More thorough examinations of bank erosion conditions and investigation of related contributing factors for each subwatershed of concern through site visits and subwatershed scale BEHI assessments. Additionally, the development of bank erosion retreat rates specific to the Flint Creek TPA would provide a more accurate quantification of sediment loading from bank erosion. Bank retreat rates can be determined by installing bank pins at different positions on the streambank at several transects across a range of landscapes and stability ratings. Bank erosion is documented after high flows and throughout the year for several years to capture retreat rates under a range of flow conditions.

Metals
Because of both limited data and the complexity of sources, many of the TMDL allocations to mining sources are combined into composite allocations. In watersheds with composite WLAs to unpermitted point sources and in watersheds with composite LAs to diffuse mining-related sources that also include some abandoned mines or mining wastes, follow up monitoring should focus on defining the contribution from abandoned mines and other discrete mining sources.

Although many of the mines in the DEQ and/or MBMG databases have been visited to determine the location and condition of abandoned mines, in most cases the load contribution from individual abandoned mines is not well known. Additionally, there may be discrete abandoned mine sources that are contributing to exceedances of metals targets that are not identified in either of the State databases. As additional information becomes available regarding contributions from abandoned mines, TMDLs may be modified via adaptive management to split composite WLAs into separate WLAs and/or to develop WLAs for discrete mining sources in watersheds dominated by nonpoint source loading that currently have a composite LA. Additionally, if certain sites are known to contribute a large portion of metals loads, a higher level of soil and water monitoring will almost always be needed to guide site specific cleanup plans.

Although there is well documented mercury contamination within the watershed, there is a level of uncertainty associated with the mercury TMDLs that should be strengthened. Lower level mercury analysis using clean sampling techniques should be conducted across the Flint Creek Watershed. This is especially stressed in respect to Philipsburg WWTP effluent and upper Flint Creek. The mercury data used to assess existing effluent conditions and upstream conditions is less certain than desirable. New data collection may prove Philipsburg is meeting their Mercury WLA.

9.3.2 Increase Available Data

While the Flint Creek watershed has been the recipient of significant remediation and restoration activities, data is still often limited depending on the stream and pollutant of interest. 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.

Sediment

For sediment investigation in the Flint Creek, each of the streams of interest were stratified into unique reaches based on physical characteristics and anthropogenic influence. A total of 25 sites were sampled throughout the watershed, however this equates to only a small percentage of the total number of stratified reaches, and even less on a stream by stream basis. Sampling additional monitoring locations to represent some of the various reach categories that occur would provide additional data to assess existing conditions, and provide more specific information on a per stream basis as well as the TPA as a whole, by which to assess reach by reach comparisons and the potential influencing factors and resultant outcomes that exist throughout the watershed.

Metals

In general, Mercury TMDLs are based upon smaller data sets than other metals. Low level mercury sampling should occur in Flint Creek and all major tributaries to better define mercury sources and impairment conditions. Water chemistry mercury sampling should include a coordinated sampling of fish tissue.

9.3.3 Consistent Data Collection and Methodologies

Data has been collected throughout the Flint Creek watershed for many years and by many different agencies and entities, however the type and quality of information is often variable. Where ever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals.

The Montana Department of Environmental Quality (DEQ) is the lead agency for developing and conducting impairment status monitoring. However, other agencies or entities may work closely with DEQ to provide compatible data if interest arises. Impairment determinations are conducted by the state but can use data collected from other sources. The information in this section provides general guidance for future impairment status monitoring and effectiveness tracking.

It is important to note that monitoring recommendations are based on TMDL related efforts to protect beneficial uses in a manner consistent with Montana's water quality standards. Other regulatory programs with water quality protection responsibilities may impose additional requirements to ensure full compliance with all appropriate local, State and Federal laws. For example, reclamation of a mining related source of metals under CERCLA and CECRA typically requires source-specific sampling requirements, which cannot be defined at this time, to determine the extent of and the risk posed by contamination, and to evaluate the success of specific remedial actions.

Sediment

Sediment and habitat assessment protocols consistent with DEQ field methodologies and that serve as the basis for sediment targets and assessment within this TMDL should be conducted whenever

possible. Current protocols are identified within Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments (Montana Department of Environmental Quality, 2010). 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, when collecting sediment and habitat data in the Flint Creek watershed 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
- Pool Assessment; Count and Residual Pool Depth Measurements
- Greenline Assessment; NRCS methodology

Additional information will undoubtedly be useful and assist DEQ with TMDL effectiveness monitoring in the future. Macroinvertebrate studies, McNeil core sediment samples, and fish population surveys and redd counts are examples of additional useful information used in impairment status monitoring and TMDL effectiveness monitoring which were not developed as targets but reviewed where available during the development of this TMDL.

Metals

Standards attainment monitoring should include analysis of a suite of total recoverable metals (e.g. As, Cu, Cd, Pb, Zn), sediment samples, hardness, pH, discharge and TSS for all pollutant-waterbody combinations. As a result of water and sediment data collected during TMDL development, TMDLs were developed for several metals that were not on the 2012 303(d) List, and TMDLs were not developed for some listed metals because recent data did not exceed water quality targets and/or anthropogenic sources were not identified. Based on the data evaluations within this document (**Section 6.0**), several metals have been identified as recommendations for future monitoring.

9.3.4 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 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 bank 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 begin throughout the watershed, pre and post monitoring so as to understand the change that follows will be necessary to track the effectiveness of specific given practices or implementation projects. The following recommendations are categorized by the type of restoration practice to which they apply.

9.3.4.1 Road BMPs

Monitoring road sediment delivery is necessary to determine if BMPs are effective, to determine which are most effective, and to determine which practices or sites require modification to achieve water quality goals. Effectiveness monitoring should be initiated before implementing BMPs at treatment sites.

Monitoring actual sediment routing is difficult or prohibitively expensive. It is likely that budget constraints will influence the number of monitored sites. Once specific restoration projects are identified, a detailed monitoring study design should be developed. To overcome environmental variances, monitoring at specific locations should continue for a period of two to three years after BMPs are initiated.

Specific types of monitoring for separate issues and improvements are listed in **Table 9-1**.

Table 9-1. Monitoring Recommendations for Road BMPs

Road Issue from Section 8.0 (Restoration)	Restoration Recommendation	Monitoring Recommendation	Recommended Methodology
Ditch Relief Combined with Stream Crossings	Re-engineer & rebuild roads to completely disconnect stream sloped ditches from stream crossings. Techniques may include: • Ditch relief culverts • Rolling dips • Water Bars • Outsloped roads • Catch basins • Raised road grade near stream crossing	• Place silt trap directly upslope of tributary crossing to determine mass of sediment routed to that point. • Rapid inventory to document improvements and condition.	• Sediment yield monitoring based on existing literature/USFS methods. • Revised Washington Forest Practices Board methodology.
Ditch Relief Culverts	• Consider eliminating stream sloped ditches and outsloping the road or provide rolling dips. • When maintaining/ cleaning ditch, do not disturb toe of cutslope. • Install culverts with proper slope and angle following Montana road BMPs. • Armor culvert outlets. • Construct stable catch basins. • Vegetate cutslopes above ditch. • Increase vegetation or install slash filters. • Provide infiltration galleries where culvert outlets are near a stream.	• Rapid inventory to document improvements and condition. • Silt traps below any ditch relief culvert outlets close to stream.	• Revised Washington Forest Practices Board methodology. • Sediment yield monitoring based on existing literature/USFS methods.
Stream Crossings	• Place culverts at streambed grade and at base of road fill. • Armor and/or vegetate inlets and outlets. • Use proper length and diameter of culvert to allow for flood flows and to extend beyond road fill.	• Repeat road crossing inventory after implementation. • Fish passage and culvert condition inventory.	• Revised Washington Forest Practices Board methodology. • Montana State (DNRC) culvert inventory methods.

Table 9-1. Monitoring Recommendations for Road BMPs

Road Issue from Section 8.0 (Restoration)	Restoration Recommendation	Monitoring Recommendation	Recommended Methodology
Road Maintenance	• Avoid casting graded materials down the fillslope & grade soil to center of road, compact to re-crown. • Avoid removing toe of cutslope. • In some cases graded soil may have to be removed or road may have to be moved.	• Repeat road inventory after implementation. • Monitor streambed fine sediment (grid or McNeil core) and sediment routing to stream (silt traps) below specific problem areas.	• Revised Washington Forest Practices Board methodology. • Standard sediment monitoring methods in literature.
Oversteepened Slopes/ General Water Management	• Where possible outslope road and eliminate inboard ditch. • Place rolling dips and other water diverting techniques to improve drainage following Montana road BMPs. • Avoid other disturbance to road, such as poor maintenance practices and grazing.	• Rapid inventory to document improvements and condition.	• Revised Washington Forest Practices Board methodology.

9.3.4.2 Agricultural BMPs

Grazing BMPs reduce grazing pressure along streambanks, riparian and wetland areas. Implementing BMPs may improve water quality, create narrower channels and cleaner substrates, and result in recovery of streambank, riparian and wetland vegetation. Effectiveness monitoring for grazing BMPs should be conducted over several years, making sure to start monitoring before BMPs are implemented. If possible, monitoring reaches should be established in pastures keeping the same management as well as in those that have changed. Where grazing management includes moving livestock according to riparian use level guidelines, it is important to monitor changes within the growing season as well as over several years. Monitoring recommendations to determine seasonal and long-term changes resulting from implementing grazing BMPs are outlined below in **Table 9-2**.

Table 9-2. Effectiveness Monitoring Recommendations for Grazing BMPs by Restoration Concern

Recovery Concern	Monitoring Recommendations	Methodology or Source
Seasonal impacts on riparian and wetland area and streambanks	• Seasonal monitoring during grazing season using riparian grazing use indicators. • Streambank alteration. • Riparian browse. • Riparian stubble height at bank and “key area”.	BDNF/BLM riparian standards (Bengeyfield and Svoboda, 1998)
Long-term riparian and wetland area recovery	• Photo points. • PFC/NRCS Riparian Assessment (every 5-10 yrs). • Vegetation Survey (transects perpendicular to stream and spanning immediate floodplain) every 5-10 years. • Strip transects- Daubenmire 20cm x 50cm grid or point line transects • Greenline.	(Harrelson et al., 1994; Bauer and Burton, 1993; United States Department of Agriculture, Natural Resources Conservation Service, 2001)

Table 9-2. Effectiveness Monitoring Recommendations for Grazing BMPs by Restoration Concern

Recovery Concern	Monitoring Recommendations	Methodology or Source
Streambank stability	• Greenline including bare ground, bank stability, woody species regeneration (every 3-5 years)	Modified from Winward (2000)
Channel stability	• Cross-sectional area, with % fines/ embeddedness. • Channel cross-section survey. • Wolman pebble count. • Grid or McNeil core sample. • Bank Erosion Hazard Index.	(Harrelson et al., 1994; Rosgen, 1996)
Aquatic habitat condition	• Aquatic macroinvertebrate sampling. • Pool quality. • R1/R4 aquatic habitat survey. • Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments.	(Hankin and Reeves, 1988; Overton et al., 1997; Water Quality Planning Bureau, Montana Department of Environmental Quality, 2005; Montana Department of Environmental Quality, 2011)
General stream corridor condition	• EMAP/Riparian Assessment (every 5-10 yrs).	(Overton et al., 1997; United States Department of Agriculture, Natural Resources Conservation Service, 2001)

9.3.4.3 Reclamation in Areas Affected by Historic Mining Abandoned Mine Sites

Each reclamation site will have site-specific needs but general recommendations for abandoned mine site remediation effectiveness monitoring are outlined in **Table 9-3**.

Table 9-3. Effectiveness Monitoring Recommendations for Abandoned Mine Site Remediation

Parameter	Monitoring Recommendations
Water quality	Sample for heavy metals, pH, flow and TSS in water column at high and low flow above and below mine site. Collect sediment samples at low flow. Monitoring should be initiated prior to remediation efforts and continue for at least 10 years after site restoration. If possible, monitoring should include biomonitoring (i.e. periphyton and macroinvertebrates) at low flow every 5 years.
Vegetation re-establishment	Greenline survey every 5 years, including bank stability, shrub regeneration, and bare ground. Vegetation transects across floodplain for vegetation community structure and regeneration.

9.3.5 Watershed Wide Analyses

Recommendations for monitoring in the Flint Creek watershed 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 303(d) list 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.

10.0 STAKEHOLDER AND PUBLIC PARTICIPATION

Public and stakeholder involvement is a component of TMDL planning efforts. Stakeholders, included the Granite Headwaters Watershed Group, the Granite Conservation District, the City of Philipsburg, Granite County, USDA Natural Resource Conservation Service, US Environmental Protection Agency, US Forest Service (Beaverhead-Deerlodge National Forest), Montana Fish, Wildlife, and Parks, Montana Department of Natural Resources, the Montana Department of Environmental Quality, as well as private landowners in the watershed. In addition, Technical Advisory Group meetings, and other outreach and education efforts conducted by the DEQ and Granite Headwaters Watershed Group provided opportunities to review and comment on technical documents. Stakeholder review drafts were provided throughout the process to several agency representatives, landowners, conservation district and government representatives, and representatives from conservation and watershed groups. Stakeholder comments, both verbal and written, were accepted and are addressed within the document.

An additional opportunity for public involvement is the public comment period. This public review period was initiated on February 17th, 2012 and extended to April 2nd, 2012. At a public meeting on March 7th in Philipsburg, MT, DEQ provided an overview of the TMDLs for sediment and metals in the Flint Creek Planning Area, made copies of the document available to the public, and solicited public input and comment on the plan. The announcement for that meeting was distributed among the Technical Advisory Group, and advertised in the following newspapers: the Anaconda Leader, The Philipsburg Mail, and The Montana Standard. This section includes DEQ's response to all official public comments received during the public comment period. This final document was updated, based on public input and comment.

10.1 RESPONSE TO PUBLIC COMMENTS

The formal public comment period for the Flint Creek Planning Area Sediment and Metals TMDLs and Framework Water Quality Improvement Plan extended from February 17th to April 2nd, 2012. One package of comments from various stakeholders as part of the Granite Headwaters Watershed Group was submitted to DEQ during the public comment period. Excerpts from the comment letter are provided below. Responses prepared by DEQ follow each of the individual comments and where applicable, the text of the Final document has been modified to address these comments. Original comment letters are held on file at the DEQ and may be viewed upon request.

Granite Headwaters Watershed Group

Comment #1

According to the Draft Plan a number of metal samples found "human health exceedances." The Draft Plan lists by creek the number of and rate of samples labeled as human health exceedances, and we enclose a table which attempts to summarize this information. We are concerned because the draft plan does not explain the significance of the exceedances. Presumably, a human health exceedance translates to human health hazard. We need DEQ's help to understand the nature of the hazard that the metal contamination poses. Also, our reading the Draft Plan indicates that the DEQ does not expect that either local landowners or county or city government would be responsible for cleanuip of the metals contamination caused by historic mining activities. What specific alternatives are available to fund and conduct the mine cleanups? Are they adequate to eliminate the human health hazard? How soon can clean up occur?

Response #1
Metals conditions in a number of streams within the Flint Creek Watershed are at levels that could potentially affect human health if they are used as a drinking water source. The magnitude, duration and frequency of the exceedances in the streams of interest would become a factor in risk management. The sampling for the TMDL project provides limited information to use for leveraging future risk based studies and cleanup based on more detailed study. Also, the magnitude, duration and frequency of exposure (drinking water) would be a major consideration in determining health risk. There is a health risk of using stream water at some locations in the watershed as drinking water sources in locations below mining, milling or waste rock areas. Arsenic and mercury are the predominant pollutants with human health effects found in the Flint Creek Watershed.

Montana's human health standards do consider risk of health problems based on toxicity studies. They are developed using guidance from the EPA which includes:

- National Recommended Water Quality Criteria (NRWQC) [1] developed under Section 304(a) of the CWA; and
- Drinking Water Lifetime Health Advisory (HA) and Maximum Contaminant Levels (MCL) developed under the Safe Drinking WaterAct.[2]

TMDL plans do not explore detailed risk management or comprehensive assessment of cleanup costs. Other environmental restoration programs are intended to investigate more detailed risk and cost management considerations as they collect more thorough and focused environmental data. **Section 8.5.6** identifies primary government agencies that usually deal with mining cleanup. The DEQ TMDL program advises concerned stakeholders to engage the primary programs that administer mine cleanup activities within Montana for collaboration and funding alternatives.

[1]See http://www.epa.gov/waterscience/criteria/wqctable/ .
[2] See http://www.epa.gov/waterscience/criteria/drinking/ .

Comment #2
Executive Summary - 6th paragraph, 1st sentence states that sediment was identified as impairing "industrial" beneficial uses in both segments of Flint Creek. Tables ES-1 and 3.1 show upper Flint Creek as fully supporting industrial uses. Which is correct?

Response #2
Tables ES-1 and 3.1 have the correct listing information. The description in the 6th paragraph of the executive summary has been corrected. It should be noted that because of when the draft report was written, the listing history associated with this document was based on the 2010 Water Quality Integrated Report. Subsequently, there have been changes to the Integrated Report impaired use categories. Aquatic life and Cold Water Fish have been combined as a single "Aquatic Life" category; and Industrial Use no longer appears as an impaired cause because it has been determined that Industrial Use is the least sensitive of the uses and is addressed when dealing with the other beneficial uses. The Final document has been corrected to reference the 2012 Integrated Report.

Comment #3
Page 2-3 to 2-4: Streamflow:

1) *Why not include information on streamflow conditions during the period when data for TMDL was collected (2007-2009). Peak flows for the station at Southern Cross in those years were 168*

cfs (June 10, 2007), 192 cfs (June 15, 2008 and highest recorded peak flow for period of record), and 127 cfs (May 19, 2009). Including a hydrograph from 2005 does not seem particularly useful.

2) *Include some explanation about why the hydrograph at Southern Cross shows sustained high discharge levels in the spring.*
3) *Regarding streamflow in general, were the years the water-quality data was collected normal in terms of streamflow? Wouldn't that be useful information to summarize?*

Response #3

1. Streamflow information was adjusted to include more recent data from 2007-2011 for those gages where data exists. Hydrographs have been updated to include these years and narrative summaries were edited where appropriate.
2. Discussion related to hydrograph trends and observations has been expanded to provide additional discussion that may relate to watershed conditions and response.
3. Discussion in **Section 2.1.3** has been edited where appropriate, however it should be noted that **Section 2.0** is intended to provide a general overview of the character of the watershed. Specifics related to the collected data used in analysis, and events that may have an influence on those results occur in context of the discussions of individual waterbody-pollutant combinations in **Sections 5.0** and **6.0**.

Comment #4

Page 2-5: Groundwater Quality:

1) *First Paragraph: The MBMG groundwater study in the Flint Creek TPA (part of Region 5, Upper Clark Fork River Basin) has been published and is available. It would be useful to reference that report and the link to the web site where report is available for download.*
2) *3rd paragraph: Why not provide a brief summary of the groundwater quality? The Flint Creek TMDL technical advisory committee had questions about whether the groundwater has similar metals issues as the surface water.*

Response #4

The MBMG GWIC database was downloaded and used to inform the metals TMDL project. While the groundwater conditions varied greatly according to localized landuse and geology, the groundwater data was not that useful for informing the metals TMDLs. Additionally, the groundwater data was not usually located near mining areas and therefore didn't help inform how groundwater may be affected by mining activities. This is likely because the sampled wells are mostly drinking sources that would not be located in areas likely contaminated with metals. The groundwater report or GWIC data will likely be cited in the nutrient TMDL efforts in the Flint Creek Watershed.

Comment #5

Page 2-6: Geology

1) *1st paragraph: Summary statement at end of paragraph is incorrect. Both extension and compression contributed to the complex folds and faults in the Flint Creek Range. Recognition of the Anaconda Core Complex was key to understanding that extension, in addition to compression, was important structural history of the area.*
2) *2nd paragraph: Sapphire Block is a term this is still used, but since it extends beyond the boundary of the Philipsburg 30' x 60' map, the term western structural block was used by Lonn and others (2003), for this particular map.*
3) *Basin Sediments: The map by Portner and Hendrix (2005) referenced in the first paragraph is a detailed map of the surficial deposits for part of the lower Flint Creek valley. Also, geology*

section mentions the "boulder debris-flow (Beaty, 1961) just north of the canyon mouth". Identify which canyon (Boulder Creek).

Response #5
DEQ revised this section of the TMDL document to address the comment.

Comment #6
Page 5-4: Relevant Local and Regional Reference Data

1) *It is unclear how the reference data was used in developing the TMDL's. Are there maps that show where USFS reference sites are located?*

Response #6
Appendices C & **D** provide a good description of how DEQ uses reference data. **Section 5.3.4** has been clarified to reference these appendices, better describe what data was used for reference development, and a map was included to identify these locations of reference data.

Comment #7
Page 5-11: Section 5.4.3.3

1) *3rd sentence: States residual pool depths are slightly below target values and pool numbers are considerably beneath the target of >103. Table 5-3 doesn't list any targets as ">103".*
2) *5th sentence: States… "width/depth value for this reach is well above the target of >20. Should that be <20?*

Response #7

1. The appropriate target value for pool numbers for this site, as listed in **Table 5-3**, is ≥70. The text has been corrected in **Section 5.4.3.3** to reflect that value.
2. The appropriate target value for width/depth ratio for this site, as listed in **Table 5-3**, is ≤20. Thank you for highlighting these errors.

Comment #8
Page 5-12: Section 5.4.3.3

1) *2nd full sentence: Regarding FLIN 11-01, states "Percent fines results in each of the three categories are slightly exceeding target values…". According to table 5-8, FLIN 11-01 meets targets for Percent fines < 6mm (Wolman Pebble Count).*
2) *Table 5-9. For FLIN 06-01, for Large Wood #/mile, 438 is in bold (exceedence) yet the target is >250 based on bankfull width of 23.1 feet. It appears to meet the target unless 438 is incorrect.*
3) *In the field notes summary for FLIN 06-01, it states that bank vegetation was primarily non-native grasses and weeds. The observation seems to contradict the amount of large wood listed in Table 5-9.*

Response #8

1. The document text has been corrected to note that percent fines results are slightly exceeding target values in two of the three categories, and slightly below the target for percent fines <6mm as measured via Wolman pebble count.
2. 438 pieces of large wood/mile is the correct value for FLIN 06-01. The correct target value for this site, due to the site's bankfull width of 23.1 feet, is >250. Table 5-9 has been edited to reflect compliance with the target and the text edited accordingly.

3. The statement that bank vegetation was primarily non-native grasses and weeds does seem to contradict both the large wood present at the site, and the Greenline Shrub percent value of 97. However, in review of the site notes, data, and photos, the near bank vegetation (the vegetation that would have significant influence on bank stability through this reach) does appear to be largely composed of less desired, non-native, and weak stabilizing vegetation. The presence of shrubs throughout the reach does exist, but the high percentage witnessed in the greenline value may be in part due to the shrub canopy extending into the area where measurements are being taken, while the trunk of the plants occur somewhat off the bank, hence allowing non-native and grasses to populate the immediate bank areas. This site occurs in an area of significant disturbance and heavy recreational use and non-native weeds and grasses are common in these types of environments. The large wood numbers are surprising given this environment however given the disturbance and instability at the site, it is not surprising that some of the riparian shrubs and trees through this corridor may be more prone to recruitment during larger flow events. In addition, the large wood found at a site may not necessarily be indicative of large wood from the immediate area. FLIN 06-01 occurs at the downstream end of a long, steep section of the stream and wood from upstream areas may be transported to this reach where it accumulates as the gradient lessens and stream power is reduced.

Comment #9

Page 5-24: Section 5.5.1.6 Assumptions and Considerations, First Bullet

1) *Please explain how the geology of NW Wyoming is similar in character to that in the Flint Creek TPA. Be more specific. Northwest Wyoming is a big area, and a large part of the area is dominated by the volcanic rock in Yellowstone which is not similar to major rock types underlying the Flint Creek watershed.*

Response #9

1. The streambank erosion rating curves used in the Flint Creek TPA actually used the Rosgen rating curves based on Colorado USDA Forest Service data for streams found in sedimentary and/or metamorphic geology; the reference of the BEHI studies in northwest Wyoming was in error (although that dataset has been used in previous TMDLs for streams influenced by alpine glaciations and/or areas of volcanism). There are not many rating curves available to represent broad geologic settings, and no sediment rating curves were available to our knowledge specific to the Flint Creek TPA at the time this document was developed. Although Colorado is certainly geographically distant from the Flint Creek TPA, the sedimentary and/or metamorphic geology the Colorado dataset represents is, in a broad sense, appropriate given the predominance of sedimentary and metamorphic geology found in the Flint Creek TPA. These rating curves provide a general estimation of loading rates for the given BEHI Index value and Near-Bank Stress combinations that were encountered in the bank erosion analysis, and subsequently provide a way to estimate sediment loads from bank erosion throughout the watershed. It should be reiterated that the sediment loads derived from eroding banks in this analysis are estimations and should not be taken as an exact quantification of the sediment loads, particularly when extrapolated to the watershed scale; however, the percent reductions that are estimated and provided as part of the TMDL and allocations are considered reasonable expectations given our current information.

Comment #10

Section 6.0 Metals TMDLs Components

1) *A general comment regarding the data presented in this section. It is difficult to get a clear idea of where the areas of greatest concern are located. The tables for each reach give general summary statistics, but all sites along the reach are combined in the table making it difficult to understand what is happening upstream and downstream of the reach. Why not include the water quality data on a map for each site, including the actual measured concentrations and stream flow. It would then be possible to determine what parts of the specific reaches are most impacted.*
2) *It would also be helpful to present more of the metals data as graphs, showing the range of concentrations for each site and including a line showing target values. This would make it easier to prioritize sites-those with a few exceedences just slightly above a target would presumably be lower priority than those greatly exceeding targets.*

Response #10
Thank you for your comment. It is difficult to distill all of the information compiled in a TMDL document into a concise and informative presentation that provides technical details, as well as common language and easily understood messages for a broad range in audience. We will try to keep your comment at the forefront of our minds as we complete TMDL documents in the future.

Comment #11
Page 8-1: Section 8-2

1) *MBMG is another agency that can also provide technical assistance, especially on geology and groundwater resources.*

Response #11
MBMG has been added to the list of potential resources for technical assistance.

Comment #12
Appendix B

1) *The maps included in Appendix A are hard to read. It would be helpful if more landmarks were identified. For example, on the Metals Sampling Location maps, labeling the drainages and some of the side drainages would make it easier to determine where samples were collected.*

Response #12
Thank you for your comment. It is difficult to distill all of the information compiled in a TMDL document for such a large area into a map that is too detailed because the maps become very busy. The TMDL program at DEQ will consider this comment for future TMDL projects.

Comment #13
Appendix D

1) *Page D-4, paragraph above table D-1. There is a statement about similar width to depth targets in prior TMDLs dealing with similarly sized streams (e.g. Prospect Creek, St Regis Creek) as justification for the <28 target for Flint Creek. What specifically is meant by "similarly sized"? Same length? Same flow? This seems a weak justification. Is geology, slope, landuse, etc also similar? Provide data that explains more specifically how they are similar.*
2) *Page D-6, Percent fines in Riffles <6mm section: This section talks about the target being <14, but then also states that <15% is protective of beneficial uses. Is 15% a typo?*
3) *Page D-9, Pool Frequency: The justification for a pool frequency target of 70 for bankfull width 20-39 appears to be based on assumptions rather than science. If the median value is 32, a value*

of 70 is not "somewhat higher". It is higher than any number reported in the table (D-7) for a reach of that width, including the 26 PIBO reaches (11 of which were reference reaches). Further justification for the target value is that the numbers may be skewed lower than expected by the limited number of reaches evaluated. Maybe the two reaches with 79 and 100 pools per miles are outliers. If the limited number of reaches evaluated is a problem, why isn't it a problem for the >40 width, where only six reaches were measured?

Response #13

1) The basis for comparison between these streams is that they are categorized as western Montana streams with stream order size of larger 4th order or smaller 5th order. Bankfull width (in feet) at the sites reviewed for these streams ranges from mid 40s to low 100s depending on the stream, location, and local influences, but the general expected bankfull widths for the sites investigated is around 60 feet. These similarities factor into the width/depth target determination. Specific information regarding the compared watersheds is as follows: Prospect Creek has a mean annual daily discharge of 233 cfs and a drainage area of 182 mi^2; St. Regis has a mean annual daily discharge of 539 cfs and a drainage area of 303 mi^2; and Flint Creek has mean annual daily discharge of 135 cfs and a drainage area of 490 mi^2 (however some of this drainage area is controlled by Georgetown Lake and Upper Willow Creek Dam). There are some differences in the watersheds and their hydrologic regimes, but using the expected bankfull widths as a guide for comparison allows for relationships to be made. Best professional judgment and experience in the field, along with the factors above, suggests that a width/depth target of <28 is appropriate for these types of systems.
2) The text was corrected to state <14% is protective of beneficial uses.
3) When developing targets for the various parameters, statistics based on data collected from good methods and sampling design is a major factor in setting values, however best professional judgment based on years of experience is also incorporated to arrive at a value that, with limited data, seems appropriate for a given site.

   Both experience and available data tell us that typically, as streams increase in size, the number of pools encountered for a given length will decrease. The pools themselves will increase in size and depth, but often, the features that influence these pools (boulders, large wood, meander bends, etc) are less frequent or not large enough to create definable pools (pools being defined as a feature that has a max depth 1.5 times the pool tail crest depth).

   In this case, the PIBO data served as our primary reference for developing appropriate targets. However, because of differences in how pools were counted (PIBO only counts pools greater than 1/2 the wetted width, where as DEQ counts all pools but categorizes them as small: <1/2 wetted width, or large: > 1/2 wetted width) some interpretation must be used rather than a straight analysis of the numbers. The differences between PIBO and DEQ methods suggest that DEQ target values (which count all pools), will be higher than the values of the PIBO data for a given size class.

   The PIBO median value for all the <20 feet bankfull width streams used in this report is 78. The median for the DEQ reaches <20 feet bankfull is 95. Because it is expected that the DEQ numbers would be naturally higher than the PIBO number given the methods used, the target for pools was set at >95. This value is also the median of the DEQ data, of which 10 sites of varying degrees of impact were assessed (therefore making the median a reasonable value to investigate).

The PIBO median value for the 20-39 feet bankfull width streams used in this report is 52. It is expected that under desired conditions the DEQ numbers would be higher as they include both small and large pools, whereas PIBO only includes large pools. A target value of 70 was chosen as a result. In this case, the DEQ data was reviewed, and of the 7 sites that constituted the 20-39 feet bankfull width category, 6 were found to be largely influenced by human influences, and therefore the DEQ dataset was of little value to develop a target to represent a desired condition. The target incorporated best professional judgment that factored in the target value for the <20 feet, and the median of the PIBO data.

For the >40 feet bankfull width category, there were no PIBO sites to reference. The DEQ data was again limited in the number of sites (6); however review of the sites suggested they were not quite as skewed as the 20-39 feet toward the direction of disturbed or highly influenced sites. Therefore, it was expected that an appropriate target value would be above the median of the DEQ data (32), and review of the other target values suggested that 50 pools per mile for streams >40 feet bankfull width may be appropriate. The resulting target values for pools per mile considers the decrease in pool numbers as stream size increases, and used PIBO data as a reference point to help discern what would be expected under desired conditions for the various size classes.

It should be noted here as well, that the strength in the target values is dependent on the available data and resources, and are used to represent desired and achievable conditions. Target values may be revised over time as better information becomes available. The development of target values, and other elements of the TMDL, are greatly improved with discussion and input from other stakeholders and resource professionals who may hold additional data or experience to inform the TMDL development results. The DEQ appreciates the comments received as part of the public review process, but also encourages these discussions to occur throughout the process whenever possible.

Comment #14

2.1.2 Climate

1) *It is not clear why climate summary did not take into account data past 2005.*

Response #14

The watershed characterization report that served as the major reference material for **Section 2.0** was completed in 2005. Generally speaking, the watershed characterizations are often completed at the beginning or in advance of TMDL project development to help the planners and stakeholders put the watershed into context with its environment. These reports are used to provide a broad picture of the general conditions and potential influences that have shaped the watershed over time, and less a description of the specific episodic events. However, due to the watershed characterization being completed well ahead of the completion of this document, DEQ has reviewed some of these sections and updated them to include more recent information. The climate summary has been updated to include information through 2011.

Comment #15

2.1.4 Geology and Soils

1) *Soils – first paragraph, last sentence (page 2-8): "No values greater than 0.4 are mapped in the TPA", this statement is not accurate, there are soils with K factors of 0.43 along Flint Creek (K of*

0.43 is the highest in the watershed). According to the NRCS Physical Soil Properties report for Granite County there are no soils with a K factor of 0.0. However, there are surface layers that have not been evaluated with K factors. NRCS only assigned K factors for soils, a duff/litter layer under a forest/deciduous canopy is not considered a soil but that does not mean it will not erode. Also, a rock outcrop is not a soil so no K factor was assigned.

2) *There is no explanation how K factors (soil erodibility factor) were derived other than in Attachment B 2.1.2 (page 6) where it states "Soils data were summarized and interpolated to 10m (meter?) grid format." What was used, most limiting or most abundant?*

Response #15

1) The soil K-factors are based on the USGS Water Resources Division data set of hydrology-relevant soil attributes (Schwartz and Alexander, 1995), based on the USDA Natural Resource Conservation Service (NRCS) STATSGO soil data base. The soil units in the mapping effort described in **Section 2.1.4** are grouped into ranges to present general soil erodibility conditions at the watershed scale. These ranges and the subsequent presentation in **Figure A-9** does not suggest that there are soils with a K-factor of 0.0, only that the low range is from 0.0-0.2. Furthermore, there may be soils with a K-factor of 0.43 in the Flint that were not mapped because they represent a small percentage of the watershed and may not be discernible given the scale of the map. These areas are undoubtedly captured in the 0.3-0.4 range.
2) Soil erodibility is based on soil type, porosity, and slope among other factors. For specific information on how K-factors are developed see documentation on the Universal Soil Loss Equation (USLE) K-factor from Wischeier and Smith, 1979. For the USLE model used in the Flint Creek analysis, the K-factors were obtained from the NRCS Soil Survey Geographic Database (SSURGO), which is the most detailed level of soil data developed by the National Cooperative Soil Survey. **Figure 2-2** in **Attachment B** presents a range of values from 0.0 – 0.43.

Comment #16

5.5.3 Upland Sediment (page 5-29 to page 5-32)

1) *The Upland Sediment results: particularly Table 5-23 (page 5-31), Attachment B Table 2-1 (page 12), Attachment B Figure 2-4 (page 13), Attachment B Table 3-1 (page 19-22), and Attachment B Table 3-2 (page 23) are significantly flawed. – The acres attributed to "Land Use Type – Cultivated Crops" cannot be substantiated by field investigation, local knowledge, or available data sources. The Philipsburg USDA – NRCS estimated between 1,100 to 1,500 acres of annual crops being tilled in the Flint Creek watershed during 2011. Interviews with local small grain producers estimated a maximum, during any one year, of 2,000 acres of tilled crops in the watershed. Montana 2011 Agricultural Statistics (Issn: 1095-7278, Volume XLVIII, October 2011) for Granite County (Flint Creek watershed and Rock Creek watershed) for small grains estimated 1,200 acres for 2009 and 600 acres for 2010. The Land Use Type – Cultivated Crops acres used for the Universal Soil Loss Equation (USLE) totaled 16,662 acres (Attachment B Table 2-1). After reviewing Attachment B Figure 2-4, a substantial number of these acres may be irrigated meadows that are subsequently hayed and have not been tilled-up in the last 50 years.*
2) *An extreme example can be found in the data from Trout Creek (Attachment B Table 3-1 page 22) where 2,064 acres are attributed to Land Use Type – Cultivated Crops. The subsequent Existing Condition Load (Tons/Year) results from USLE are 1033 tons/year. There are no cultivated annual crops in the Trout Creek sub-watershed.*
3) *Areas denoted as "Land Use Type – Shrub/Scrub" have a similar validation problem as discussed with Cultivated Crops. These areas may have woody species less than 5 meters tall but they also have groundcover of native range species.*

4) *All sediment loads appear to be modeled, no empirical data was found in the document. Without some sampling data to corroborate the USLE model data and the Cultivated Crops classification where no such land exists severely compromises Attachment B – Flint Creek Watershed Sediment Assessment as a valid document.*

Response #16

1) and 2) The USLE model used for the Flint Creek upland sediment load estimations used the 2001 National Land Cover Dataset (NLCD). The 2001 NLCD is a widely used and well respected source of information for determining land cover types at the watershed scale. "The NLCD serves as the definitive Landsat-based, 30-meter resolution, land cover database for the Nation. NLCD provides spatial reference and descriptive data for characteristics of the land surface such as thematic class (for example, urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover. NLCD supports a wide variety of Federal, State, local, and nongovernmental applications that seek to assess ecosystem status and health, understand the spatial patterns of biodiversity, predict effects of climate change, and develop land management policy. NLCD products are created by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of Federal agencies led by the U.S. Geological Survey." (USGS website http://pubs.usgs.gov/fs/2012/3020/) However, because it is based on 2001 land cover, comparisons between 2011 acreage may not be entirely appropriate (although it is presumed that most land cover types in the Flint Creek watershed have changed little over the last decade). It should be noted that the USGS recently released a 2006 version of the NLCD but that was unavailable at the time this assessment took place.

However, your comment regarding the significant discrepancy between locally understood Cultivated Crop acreage and those reported in the 2001 NLCD does bring up a concern regarding the proper delineation of this land cover type in the Flint watershed. In this instance, the land cover type in question is that categorized as Cultivated Crops, which is defined as "Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled." Based on your comment, you suggested the Cultivated Crop category acres used in the model, in actuality, is more likely irrigated hay meadows.

In your review, you cited the Montana 2011 Agricultural Statistics report to illustrate the discrepancy between the USLE numbers and the local knowledge of land cover in the Flint watershed. This was a prudent and informative comparison, however because the NLCD is based on 2001 information the DEQ first reviewed the 2001 edition of the Montana Agricultural Report. For Granite County, in the category of All Crops: Irrigated and Non-irrigated, Harvested Acres 1999-2000, it listed 33,000 irrigated harvested acres, and 2,000 non-irrigated harvested acres in 1999; and 26,700 irrigated harvested acres, and 6,500 non-irrigated harvested acres in 2000. This is a total of 35,000 Crop acres in 1999, and 33,200 in 2000. In the Montana Agricultural report, crops in this category are defined as "wheat, barley, oats, sugar beets, potatoes, and hay". The 2001 NLCD acreage for Cultivated Crops in the Flint watershed was delineated as 16,662 acres. However, when combined with the NLCD land cover category of Pasture/Hay, the total acreage is 31,895.

Further review of the Montana 2001 Agricultural Statistics report, for the category "All Hay", presents a total of 34,000 acres for Granite County. These numbers support your estimates of very low acres of cultivated crop production in comparison to land used for hay production in the Flint watershed. Review of more recent years shows some slight change in Hay acreage but still, very little cultivated crop acreage throughout the Flint Creek watershed.

In light of this information, it was decided to revisit the model numbers and essentially reclassify all land use from Cultivated Crops to Pasture/Hay. NLCD defines Pasture/Hay as "Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle." Time and resource constraints did not allow for a complete re-run of the model itself; however we were able to use some basic computations to reasonably represent this modification. For each watershed, the load per acre rate from the Pasture/Hay land cover class was applied to all Cultivated Crop land cover acres, thereby effectively treating Cultivated Crops as Pasture/Hay and calculating an appropriate load. The same was done for the load per acre rates after BMP application. The new loads were then tallied and the additional percent reductions from riparian improvements were applied to provide the equivalent scenario loads.

Although this method does not account for any true Cultivated Crops that may exist, it is presumed that because the acres of Cultivated Crops are apparently so low, the difference is negligible. While these modifications do have some effect on the sediment loads from upland erosion in each of the watersheds, interestingly, because the relative BMP associated percent reductions are similar between Cultivated Crop and Pasture/Hay land categories, the overall percent reduction of sediment in each watershed was affected by 0-2%, depending on the watershed; and 1% for the Flint watershed as a whole.

Tables in **Section 5.5.3** have been updated with the new values and all TMDLs have been edited to reflect the changes to upland sediment loads. In addition, an errata page has been included with **Attachment B** to describe this modification and details the changes to the report.

3) Shrub/Scrub land cover category is defined as "Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation cover. This class includes tree shrubs, young trees in an early successional stage or trees stunted from environmental conditions." This definition does not preclude the existence of native range species as a percentage of the groundcover within this land classification, nor does the definition exclude land cover that may otherwise colloquially be defined as 'range'. Although the 2001 NLCD appears to have had issues differentiating Cultivated Crop and Pasture/Hay in the Flint Creek watershed, that does not invalidate other land cover delineations.

4) All upland sediment loads for the Flint Creek watershed were modeled using methods and data sources which are widely used by many natural resource agencies and environmental consultants. These methods are heavily peer reviewed and vetted and are commonly regarded as reasonable approaches to estimate sediment loads in watersheds of this scale. The collection of empirical data to corroborate actual sediment loads from specific land use categories would be nice to have, but given the time and resource constraints available to the Department, this was infeasible. In the development of the USLE model for the Flint Creek watershed, experts on the USLE model from the USDA NRCS in Montana were consulted to help define the C-factors (vegetative cover) used to best represent the various land use covers, and vegetative cover changes that may occur after BMP implementation. Apart from the apparent misclassification between Cultivated Crop and Pasture/Hay acreage, there is good confidence that the other land cover classes are reasonably estimated, and the associated sediment loading rates are appropriate.

This comment and the subsequent research and edits made to correct this issue, illustrate an important part of the TMDL development process. The inclusion of a stakeholder group and technical advisory

committee is a component of every TMDL project the Montana DEQ undertakes. This process allows for an exchange of information, and review of data sources and assessment methods, by those who are most invested in the watershed, and those who have the most knowledge regarding the watershed's details. Unfortunately, the participation and involvement from individuals within the watershed are a function of their availability and interest. In this case, the USLE modeling report was available to the stakeholder and technical advisory group in the Flint Creek watershed for over a year before the Flint Creek TMDL Public Review draft report was published. It is understood that many people are very busy with their own work and their personal lives, however ultimately it is review and collaboration from those within the watershed that will determine whether or not the TMDL will be successful. In this case, we are very grateful for the legitimate concerns brought up through this comment, and glad that we had the opportunity to address and correct this issue before the document became final. The DEQ encourages all stakeholders to bring this kind of scrutiny and analytical expertise into the process as early as possible in future TMDLs.

Comment #17

8.4.1 Sediment Restoration Approach (page 8-2)

1) *2nd sentence states: "Native streamside riparian vegetation provides root mass which hold streambanks together." --- Comment: There are also non-native species which are adequate substitutions for native species.*

Response #17

It may be true that some non-native species may have properties that could substitute for a specific function of a native plant, however the Montana DEQ strongly encourages the use of native species whenever possible. Good quality riparian and wetland systems, especially at lower elevations around the state, are becoming increasingly rare due to the displacement of overstory and understory plant communities by non-native species. Some species, such as Russian olive and tamarix, may affect water availability, displace native vegetation, and can be detrimental to other ecosystem processes. Some non-native herbaceous species, such as reed canary grass, orchard grass, smooth brome, and others greatly decrease species diversity in the understory. Native shrubs, sedges, and other species are also often better at bank stabilization than introduced species because the native plants have evolved and adapted to the specific environments and associated complex conditions where they are found. As such, native plants play a significant role not only in bank stabilization, but in the overall ecology of a watershed as well. In addition to sediment stabilization properties, native plants provide diversity of food and structural cover for wildlife. While a given non-native plant may be suitable for bank stabilization due to its dense rooting structure, there are many other factors that should be considered to understand how that plant will respond in a non-native environment; and even then, the response is not always predictable. Because the goal of a TMDL is not simply the reduction of a pollutant, but the eventual achievement of all state standards within a watershed, the use of native plants to restore natural function, and ecological diversity and stability should be pursued whenever possible.

Comment #18

It was clear to me that there was concern about what remediation is mandated, and what is voluntary. And some of the presentation [at the TMDL document Public Meeting] seemed to say that what is voluntary now, may become mandatory later. More information about this would be good. There is a lot of good science here I am sure, but most of those gathered are looking for "what corner does this back me into, or might it back me into in the future?"

The crude way I might handle it if I did not care about losing my job, getting sued or possibly worse, as I understood it, would be:

Ag people, you get a pass. The analysis can show the effect of possible voluntary actions on your part, but nobody is going to make you do anything. You might get subsidies, grants or incentives if you choose to do something, but that is your choice.

Private land owners in general, you get a pass. See Ag people.

Point sources, mainly Philipsburg, this may very well be used to set your discharge limits for future permits.

State and federal land managers, not clear what if anything this will require.

If my statements are inaccurate, then that is feedback on how the message came across. I would like to see crystal clear statements about the above, and if it is not possible to be clear and unambiguous, a succinct statement of the sources of uncertainty.

Response #18
Your statements provide a reasonable and "to the point" summary of the messages conveyed at the meeting, and the overall influence that TMDLs may have in a given watershed.

The TMDL will directly affect permitted dischargers; i.e. the Philipsburg wastewater treatment plant. State law requires that TMDLs be incorporated when developing permit limits.

Some agencies, such as USFS or NRCS, may be obligated to include TMDL considerations into their resource management plans, however would not be required to impose those considerations on private landowners.

Private landowners, including "ag people", are required to comply with any state and federal laws that may be applicable to them and their operations, but the TMDL does NOT impose new regulations or force individuals to engage in actions to meet TMDL allocations. The TMDL provides information that may help guide an individual to improve conditions on their property, which could eventually result in the achievement of TMDLs, but there is NO increased legal obligation to do so. It is true that having TMDLs completed in a watershed may help provide leverage for programs or financial incentives to implement projects on your property that align with TMDL goals, but that is dependent on the project and the programs available in a given year.

During the presentation, the question was raised about whether TMDL requirements will become mandatory for private landowners and sources of nonpoint pollution in the future. As years pass, and politics change, and opinions and information shape the world we live in, we cannot say undeniably that things that are voluntary now, may not be mandatory later (or vice versa). However, it can be said that the development of TMDLs has been a federal requirement since the passing of the Clean Water Act in 1972. And since that time, literally thousands of TMDLs have been developed throughout the United States, and hundreds in Montana alone. The voluntary nature of TMDL implementation for nonpoint sources has not changed in that time, nor have there been any viable efforts or discussions to make TMDL implementation mandatory for private landowners contributing to nonpoint source pollution. So,

to answer the question of "what corner does this back me into", the answer is none now, and none in the foreseeable future.

Comment #19

Arsenic in Douglas Creek. Need to drill down on this. Where is it coming from, and how can it be reduced to an acceptable limit, and again, what is going to be mandatory and what is voluntary regarding work on public and private land required to clean this up.

Response #19

Your statement is appropriate as Arsenic in Douglas Creek near Philipsburg likely creates one of the highest human health concerns in the watershed. Most of the arsenic is derived from the granite drain and other mine waste areas near Douglas Creek. USEPA is assessing the metal sources and conditions within Douglas Creek watershed through the Superfund Technical Assessment and Response Team 3 in Region 8. Preliminary results are available from the Federal Superfund Program. As of now, there is no mandatory cleanup because none of the sources are NPDES permitted in the Douglas Creek Watershed.

Comment #20

General Comment: Lead with A) what is out of bounds; start with the biggest things from the perspective of the common person (like Arsenic!) and B) what needs to happen to bring it under control. The business of how you did the tests and how the limits were established is essential to the document, and be prepared to answer questions about, but it is not the reason why people came to the meeting. What is wrong, and how can it be fixed. That is your story; it should get the front page.

Response #20

Thank you for your comment. It is difficult to distill all of the information compiled in a TMDL document into a concise and informative presentation that provides technical details, as well as common language and easily understood messages for those non-technical members of the audience. DEQ agrees though, that the most basic point to convey is simply what the problem is, and what can be done to fix it. We will try to keep your comment at the forefront of our minds as we conduct more public meetings in the future.

Comment #21

We believe that the flow information to calculate the wasteload allocations (WLA) listed in tables 6-34 and 6-35 for Philipsburg wastewater treatment system (WLApberg) are low. The flow information that was used is from the effluent discharge at the wastewater lagoons. This measuring device is a parshall (sic) flume that is read twice a day each day of the work week and is not necessarily an accurate representation of the total flow that occurs throughout the day. Also the flume is old and the measurements are taken manually which may induce further error. The Town of Philipsburg has since installed a continuous measuring flume on the outfall line from Town (influent flow) and that information is transmitted to a computer at the town shop for record gathering and archiving. Due to the information that we have gathered from this, we feel that the flows you have used for you example calculations are low. When the final calculations are made by you or permitting; the flow data from the continuous measuring flume or a new flow meter at the proposed wastewater treatment plant should be used to ensure accuracy.

Response #21

Thanks for this information. Since these are only examples and DEQ does not have a very robust set of new, more accurate discharge measures, the TMDL WLA examples will not be changed in the document.

However, during future permit renewal efforts the effluent limits should be based upon the most reliable and up to date information.

Comment #22

The statement found in 6.5.3.9, "Actual TMDLs and allocations are variable equations presented in Section 6.5.1 and 6.5.2 are dependent upon streamflow and water quality conditions. Table 6-34 provides example metals TMDLs and load allocations for the upper Flint Creek, calculated based on flows and metals concentrations measured at the downstream end of the segment. The Philipsburg WLA examples are based upon end of pipe concentrations that would meet human health or chronic aquatic life standards end of pipe." should be reiterated in the Lower Flint Creek TMDL section 6.5.3.10 for clarification and understanding that these calculations are only examples. Also in the headers for 6-34 and 6-35 the word ***summary*** *should be replaced with* ***examples****.*

Response #22

The suggested language was added to the final document.

Comment #23

We would like to see the Mercury TMDLs and wasteload allocations implemented as a phased approach after a combined monitoring effort is completed by the Town of Philipsburg and the Montana Department of Environmental Quality. This is due to the high test results found because of lab testing minimum detection limits that are high, and because of questions of how the tests were taken.

Response #23

DEQ will provide a phased implementation approach for meeting the Philipsburg's mercury WLA. The phases will include: 1. Further characterizing mercury levels in the effluent and stream. 2. Identifying a strategy to reduce mercury in the effluent, if needed. 3. Implementing mercury reduction if necessary.

Comment #24

We would like to mention that there are background metals found in our drinking water (copper, lead, arsenic), that meet the drinking water standards but will not meet the limits set in the TMDLs. We are wondering why these metals don't get pulled out of the town's wasteload allocation and get put into the naturally occurring wasteload allocations.

Response #24

Philipsburg's drinking water source has very low metals concentrations. Lead and copper are leaching from the supply system pipes, being introduced as root killer or infiltrating into the collection system from groundwater. These sources are not naturally occurring and can be reduced using conventional mitigation approaches.

Comment #25

The last comment that we would like to make is that the limits for metals, whether from the TMDLs program, or the permitting program, could be very hard to meet, and very expensive for a community the size of Philipsburg. One has to question if the cost is worth the good we can do to clean up Flint Creek when we are such a small part of the problem.

Response #25

DEQ understands that most of the metals load comes from historic mining operations. DEQ also estimates that Philipsburg contributes less than 1% of total metals loads to Flint Creek. Yet, the NPDES

and MPDES systems are implemented to protect against dischargers from contributing to toxicity to aquatic life and humans. Therefore it doesn't allow for a permittee to discharge above standards if there is no assimilative capacity. Also, EPA policy does not allow for WLAs in TMDLs to be more lenient unless there is a firm plan about how unregulated sources will be remediated to achieve assimilative capacity for the WLAs.

Alternatively, DEQ will provide a phased implementation approach for meeting the Philipsburg's copper and lead WLAs. The phases will include:

1. No increases in lead or copper concentrations above current levels for up to 20 years or until abandoned mining sources are remediated and can meet standards upstream of the effluent.
2. If all reasonable remediation occurs upstream and standards are not met in Upper Flint Creek, DEQ will assess if site specific standards are needed and may assess further reductions can be reasonably expected from the Philipsburg WLA at that time.
3. If reasonable remediation occurs upstream and assimilative capacity is provided, the WLA will be revised to reflect assimilative capacity.

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APPENDIX A – MAPS

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Table A-1. 2010* Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Flint Creek TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
Upper Flint Creek, Georgetown Lake to Boulder Creek confluence	MT76E003_011	Sedimentation/ Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Alteration in stream-side or littoral vegetation covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via Sediment TMDL in this document
		Antimony	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	No TMDL developed; updated 303d listing status pending
		Arsenic	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Arsenic TMDL contained in this document
		Cadmium	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	No TMDL developed; updated 303d listing status pending
		Copper	Metals	Aquatic Life, Cold Water Fishery	Copper TMDL contained in this document
		Lead	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Lead TMDL contained in this document
		Low Flow Alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Addressed via recommendations in Sections 7, 8, & 9
		Mercury	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Mercury TMDL contained in this document

Table A-1. 2010* Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Flint Creek TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
Lower Flint Creek, Boulder Creek to mouth (Clark Fork River)	MT76E003_012	Alteration in stream-side or littoral vegetation covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via Sediment TMDL in this document
		Arsenic	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Arsenic TMDL contained in this document
		Cadmium	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	No TMDL developed; updated 303d listing status pending
		Copper	Metals	Aquatic Life, Cold Water Fishery	Copper TMDL contained in this document
		Iron	Metals	Aquatic Life, Cold Water Fishery	Iron TMDL contained in this document
		Lead	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Lead TMDL contained in this document
		Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery	To be addressed in a future document
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery	To be addressed in a future document
		Turbidity	Sediment	Aquatic Life, Cold Water Fishery, Industrial, Primary Contact Recreation	Addressed via Sediment TMDL in this document
Barnes Creek, headwaters to mouth (Flint Creek)	MT76E003_070	Chlorophyll-a	Nutrients	Primary Contact Recreation	To be addressed in a future document
		Iron	Metals	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water	Iron TMDL contained in this document
		Nitrate/Nitrite (Nitrite+Nitrate as N)	Nutrients	Aquatic Life, Cold Water Fishery	To be addressed in a future document
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery	To be addressed in a future document
		Sedimentation/ Siltation	Sediment	Aquatic Life, Cold Water Fishery, Industrial, Primary Contact Recreation	Sediment TMDL contained in this document
		Total Kjehldahl Nitrogen (TKN)	Nutrients	Aquatic Life, Cold Water Fishery	Impairment cause to be replaced with Total Nitrogen on 2012 list; to be addressed in a future document

Table A-1. 2010* Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Flint Creek TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
Boulder Creek, headwaters to mouth (Flint Creek)	MT76E003_060	Arsenic	Metals	Aquatic Life, Cold Water Fishery	Arsenic TMDL contained in this document
		Lead	Metals	Aquatic Life, Cold Water Fishery	Lead TMDL contained in this document
		Mercury	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Mercury TMDL contained in this document
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via recommendations in Sections 7, 8, & 9
		Zinc	Metals	Aquatic Life, Cold Water Fishery	Zinc TMDL contained in this document
Camp Creek, headwaters to mouth (Flint Creek)	MT76E003_130	Alteration in stream-side or littoral vegetation covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via recommendations in Sections 7, 8, & 9
		Arsenic	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Arsenic TMDL contained in this document
		Copper	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Copper TMDL contained in this document
		Fish Passage Barrier	Not Applicable: Non-Pollutant	Cold Water Fishery	Addressed via recommendations in Sections 7, 8, & 9
		Lead	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Lead TMDL contained in this document
		Zinc	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Zinc TMDL contained in this document
Douglas Creek (Hall), confluence of Middle and South Forks to mouth (Flint Creek), T9N R13W S10	MT76E003_020	Nitrogen, Nitrate	Nutrients	Aquatic Life, Cold Water Fishery	To be addressed in a future document
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via recommendations in Sections 7, 8, & 9

Table A-1. 2010* Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Flint Creek TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
Douglas Creek (Philipsburg), headwaters to where stream ends, T7N R14W S25	MT76E003_100	Arsenic	Metals	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water	Arsenic TMDL contained in this document
		Cadmium	Metals	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water	Cadmium TMDL contained in this document
		Cause Unknown	Not Applicable: Non-Pollutant	Primary Contact Recreation	Addressed via recommendations in Sections 7, 8, & 9 and Douglas Creek TMDLs
		Copper	Metals	Agricultural, Aquatic Life, Cold Water Fishery	Copper TMDL contained in this document
		Iron	Metals	Agricultural, Aquatic Life, Cold Water Fishery	Iron TMDL contained in this document
		Lead	Metals	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water	Lead TMDL contained in this document
		Mercury	Metals	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water	Mercury TMDL contained in this document
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via Sediment TMDL
		Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Zinc	Metals	Agricultural, Aquatic Life, Cold Water Fishery	Zinc TMDL contained in this document
North Fork Douglas Creek, headwaters to mouth (Douglas Creek)	MT76E003_030	Alteration in stream-side or littoral vegetation covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via recommendations in Sections 7, 8, & 9
		Arsenic	Metals	Aquatic Life, Cold Water Fishery	No TMDL developed; updated 303d listing status pending
		Cadmium	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Cadmium TMDL contained in this document
		Copper	Metals	Agricultural, Aquatic Life, Cold Water Fishery	Copper TMDL contained in this document
		Sulfates	Metals	Aquatic Life, Cold Water Fishery	No TMDL developed; updated 303d listing status pending
		Zinc	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Zinc TMDL contained in this document

Table A-1. 2010* Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Flint Creek TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
Fred Burr Creek, Fred Burr Lake to mouth (Flint Creek)	MT76E003_040	Alteration in stream-side or littoral vegetation covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via recommendations in Sections 7, 8, & 9
		Arsenic	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Arsenic TMDL contained in this document
		Lead	Metals	Aquatic Life, Cold Water Fishery	Lead TMDL contained in this document
		Mercury	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Mercury TMDL contained in this document
Smart Creek, headwaters to mouth (Flint Creek), T9N R13W S21	MT76E003_110	Alteration in stream-side or littoral vegetation covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via Sediment TMDL
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery	To be addressed in a future document
		Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
South Fork Willow Creek, headwaters to mouth (Lower Willow Creek)	MT76E003_050	Copper	Metals	Aquatic Life, Cold Water Fishery	Copper TMDL contained in this document
		Lead	Metals	Aquatic Life, Cold Water Fishery	Lead TMDL contained in this document
		Mercury	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Mercury TMDL contained in this document
Princeton Gulch, headwaters to mouth (Boulder Creek)	MT76E003_090	Nitrates	Nutrients	Aquatic Life, Cold Water Fishery	To be addressed in a future document
		Physical Substrate Habitat Alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via recommendations in Sections 7, 8, & 9

- Recently approved 2012 Integrated Report impairment listings for the Flint Creek watershed are identical to the 2010 impairment listings

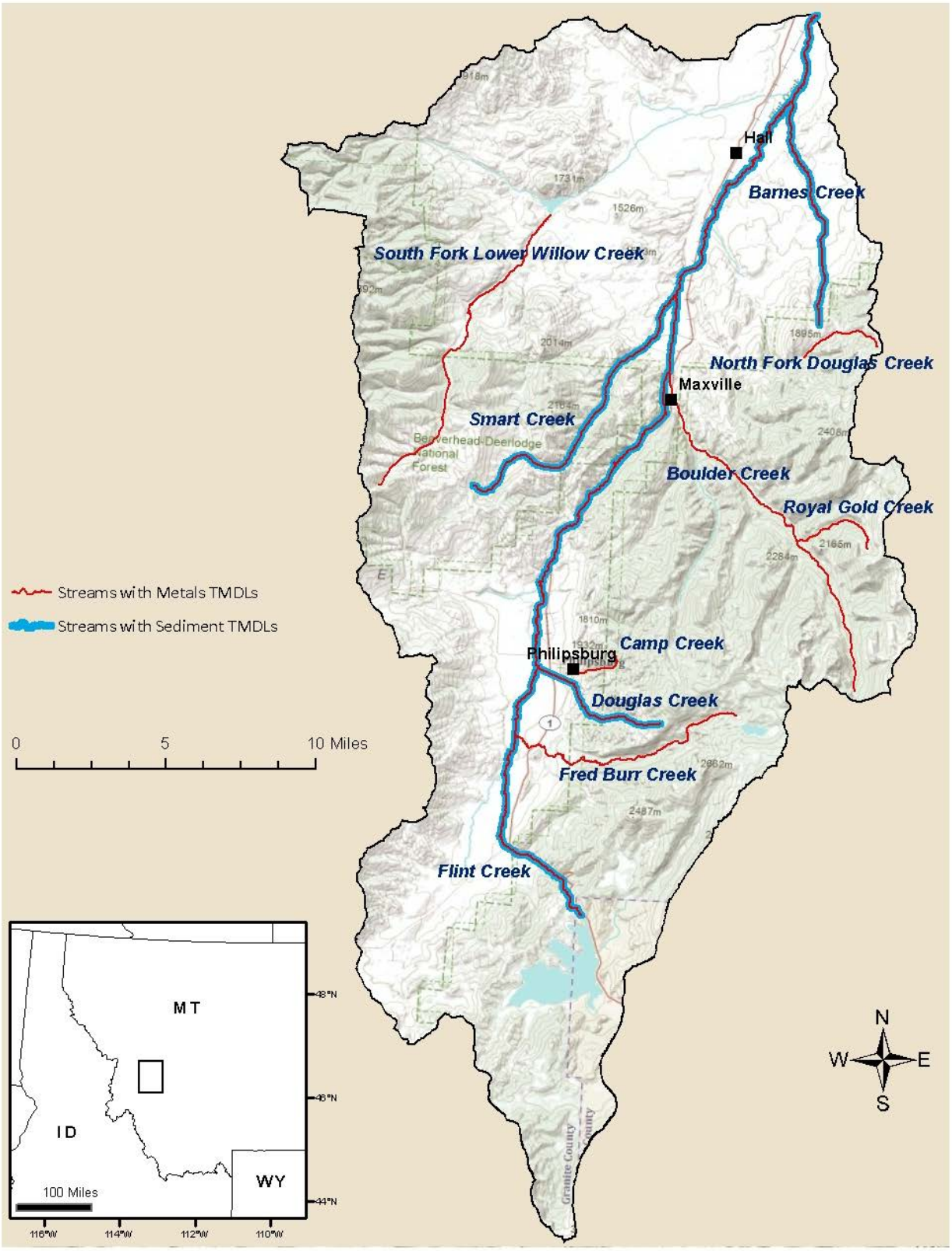


Figure A-1. TMDL Streams

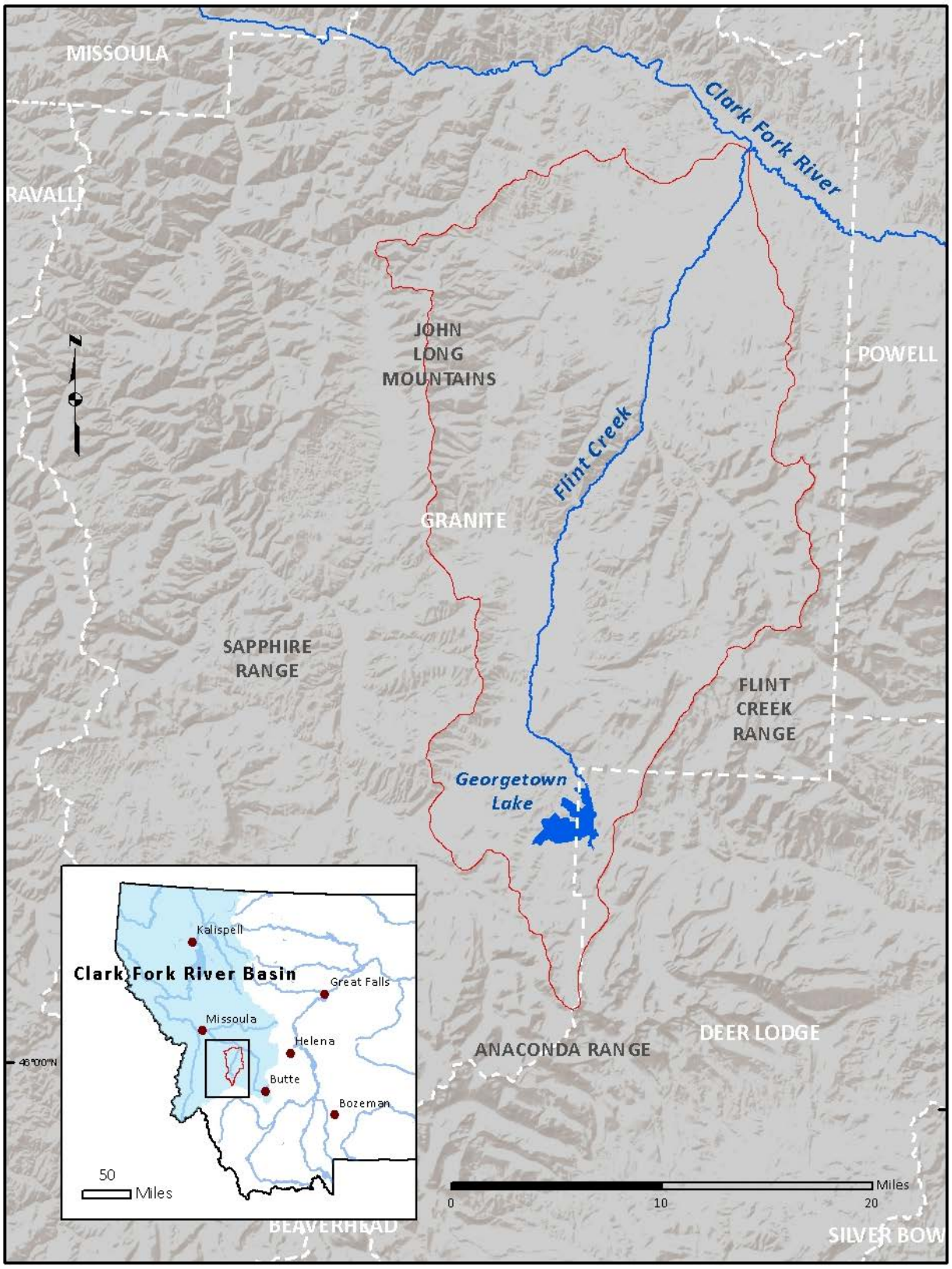


Figure A-2. Location

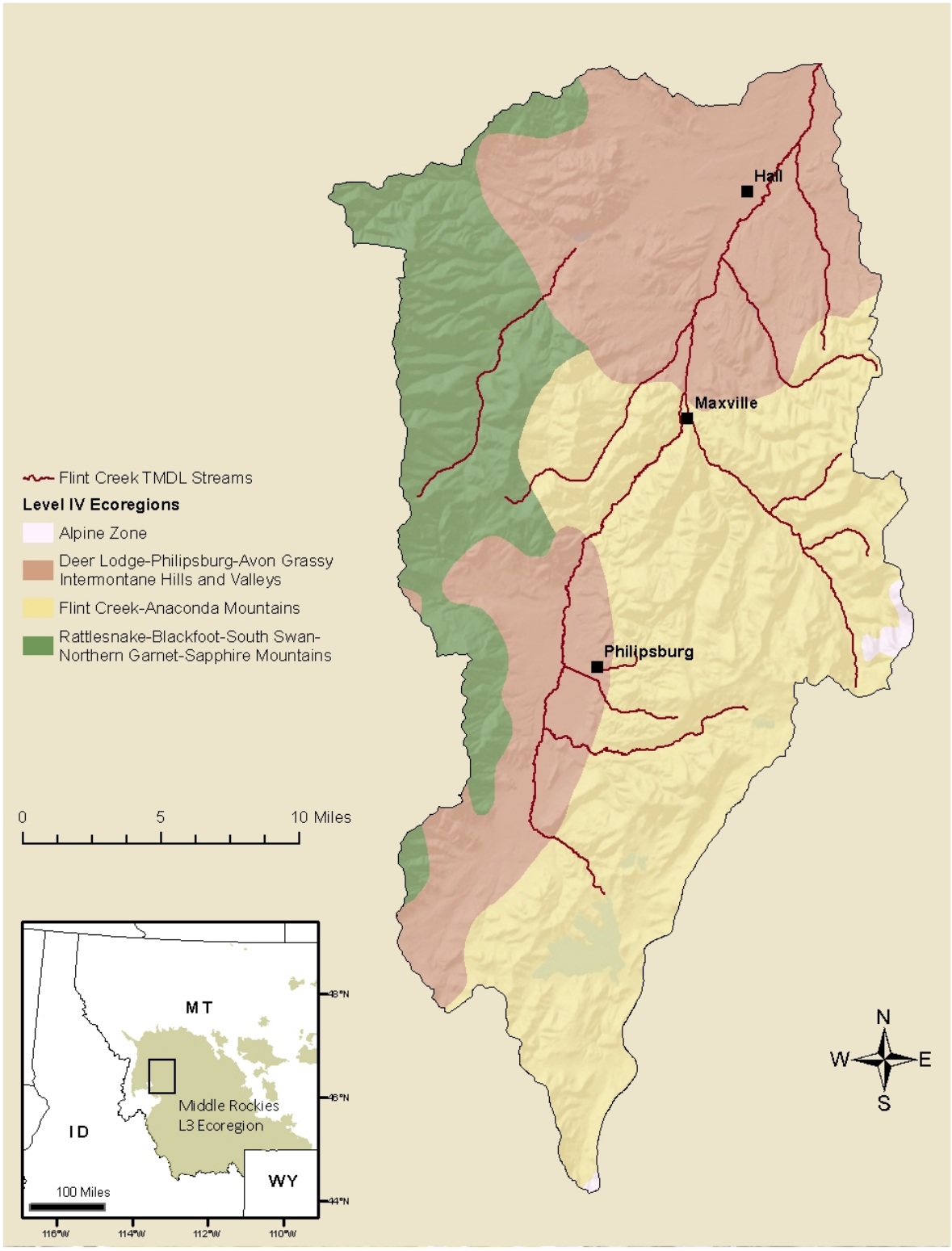


Figure A-3. Ecoregions

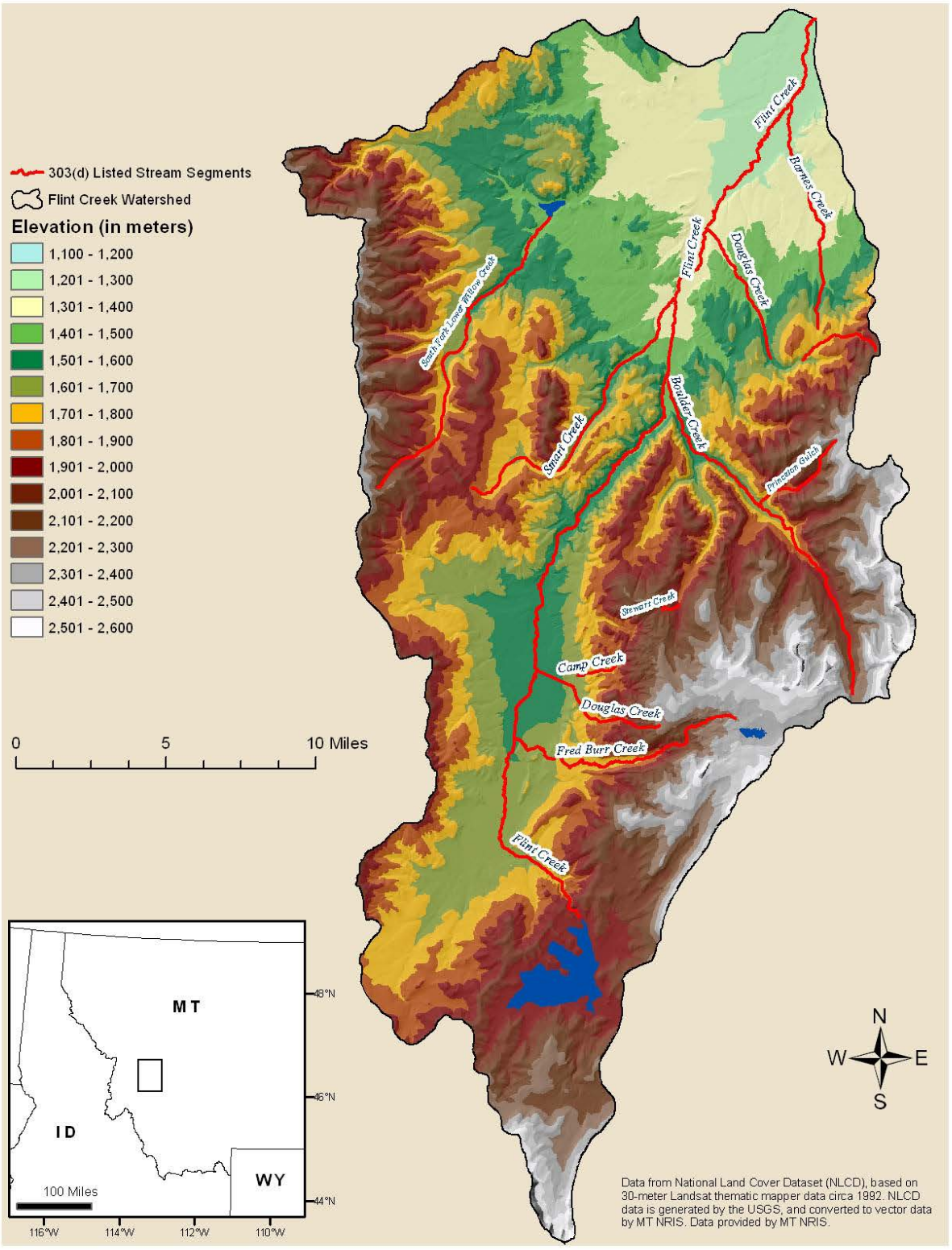


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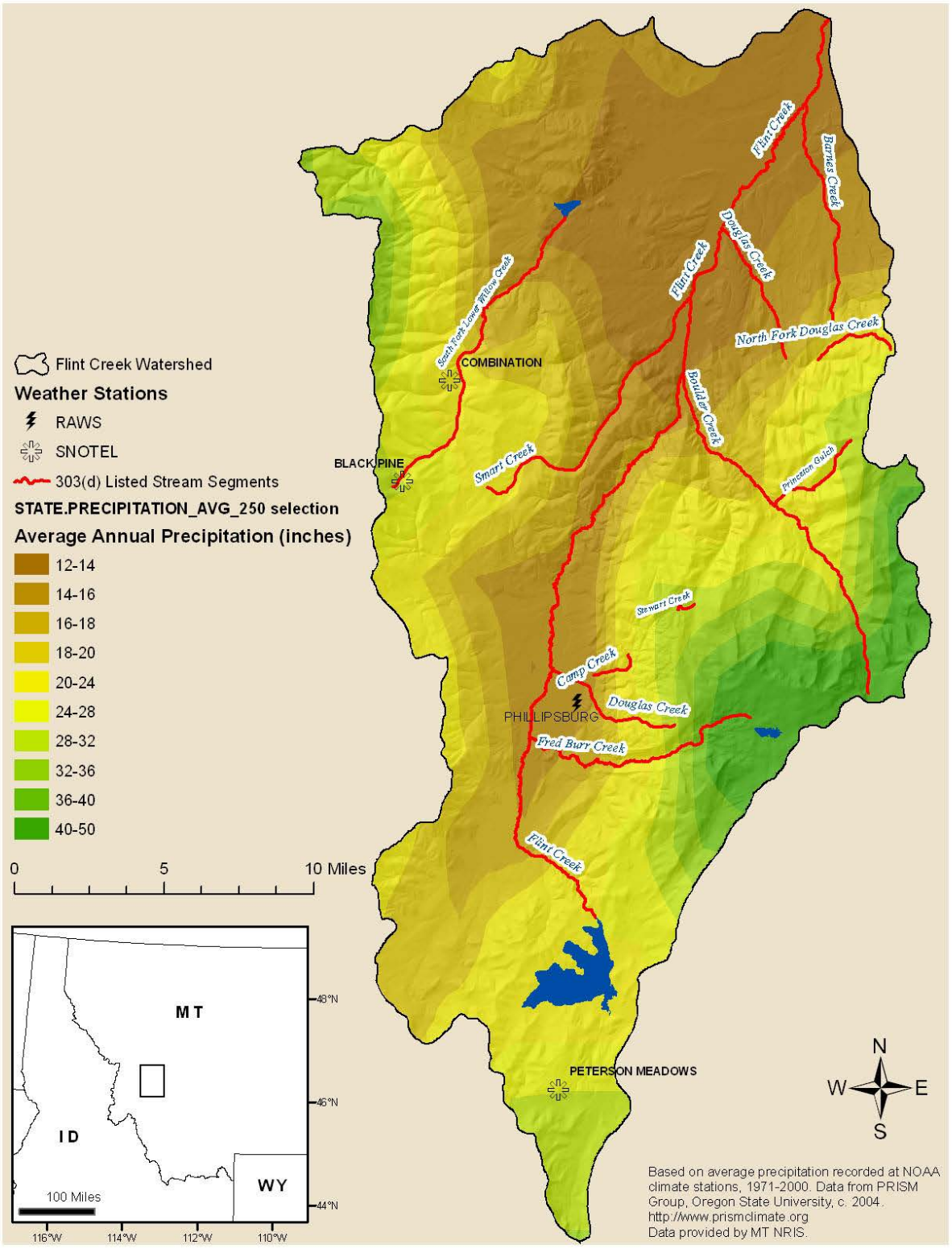


Figure A-5. Precipitation

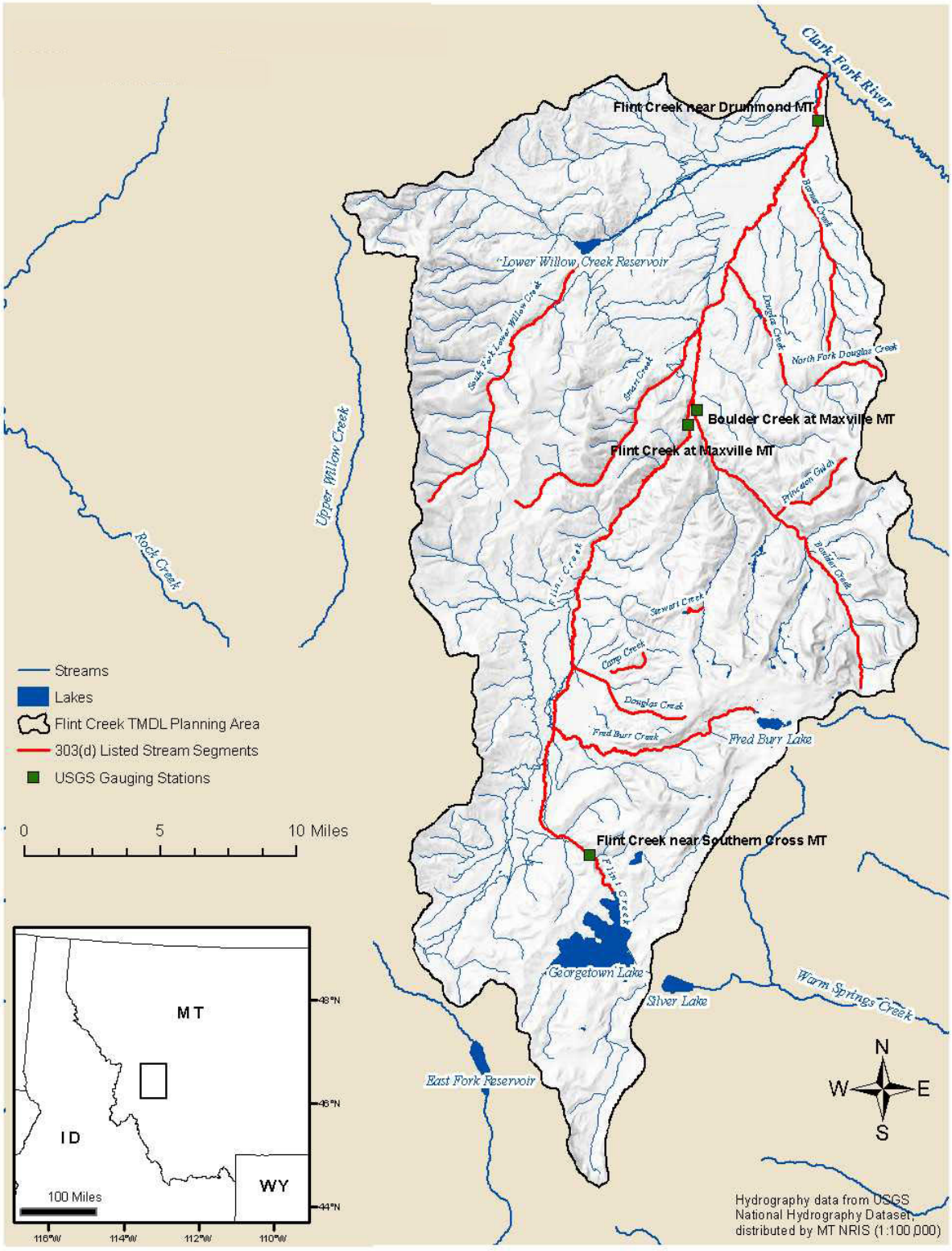


Figure A-6. Hydrography

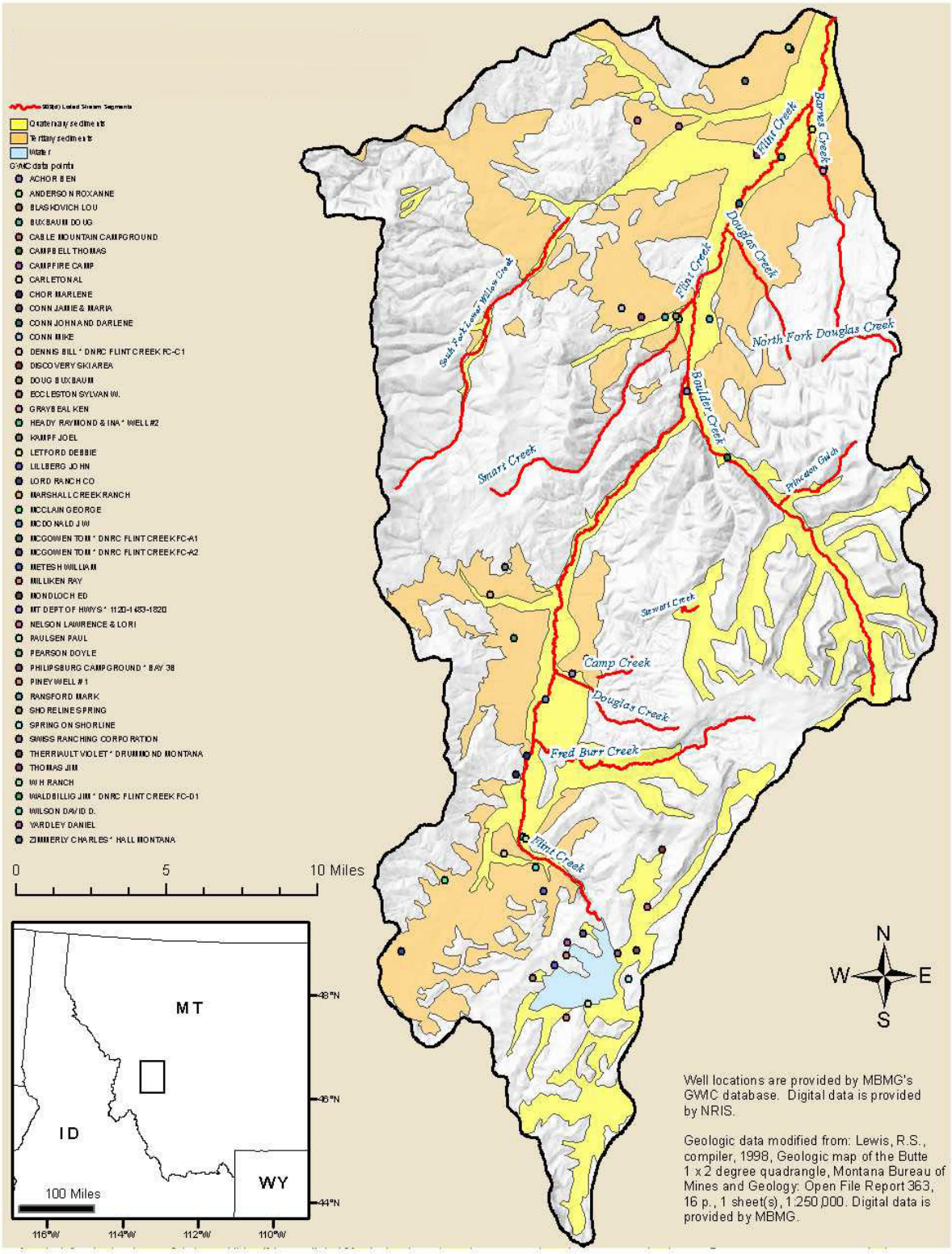


Figure A-7. Groundwater Information Center

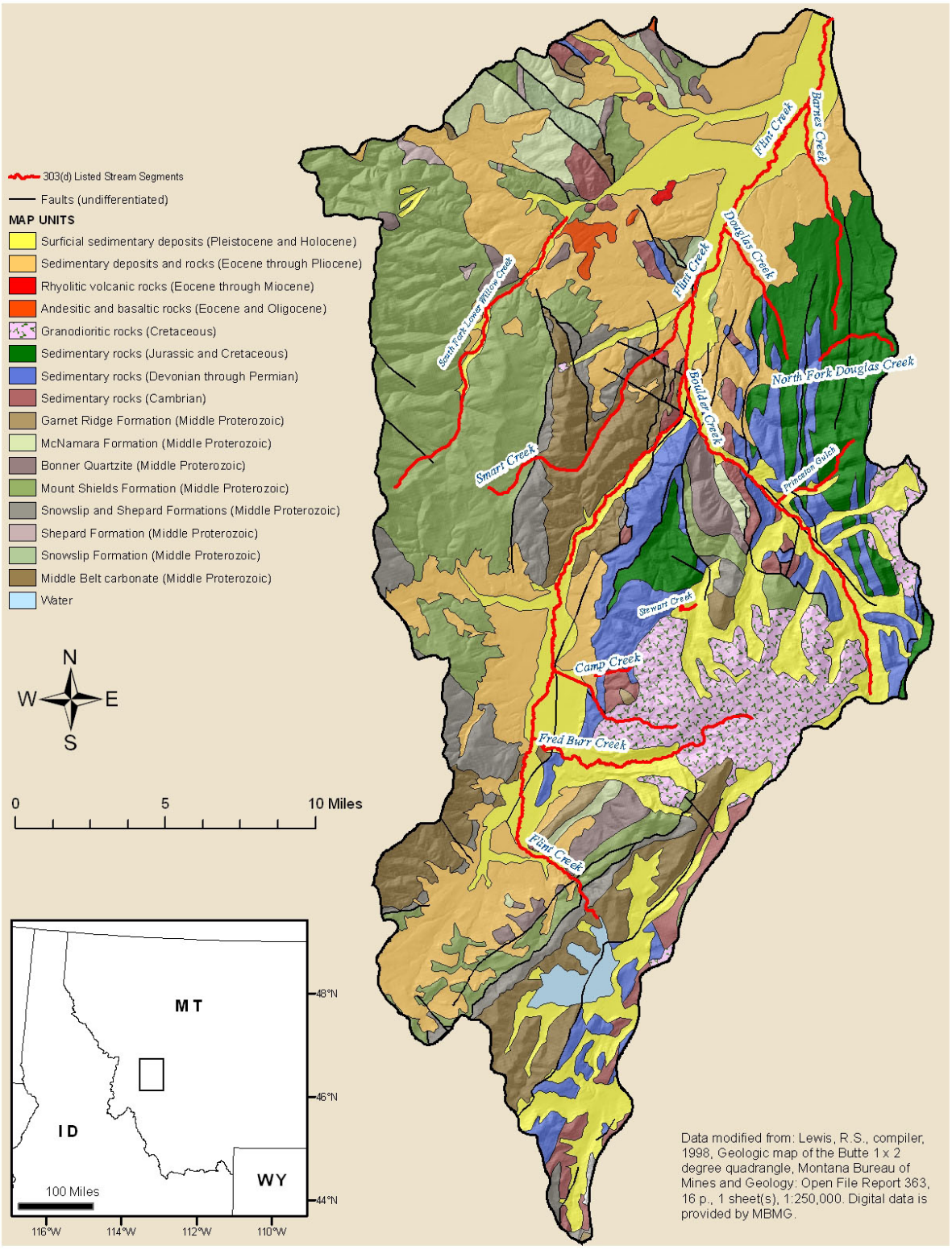


Figure A-8. Geology

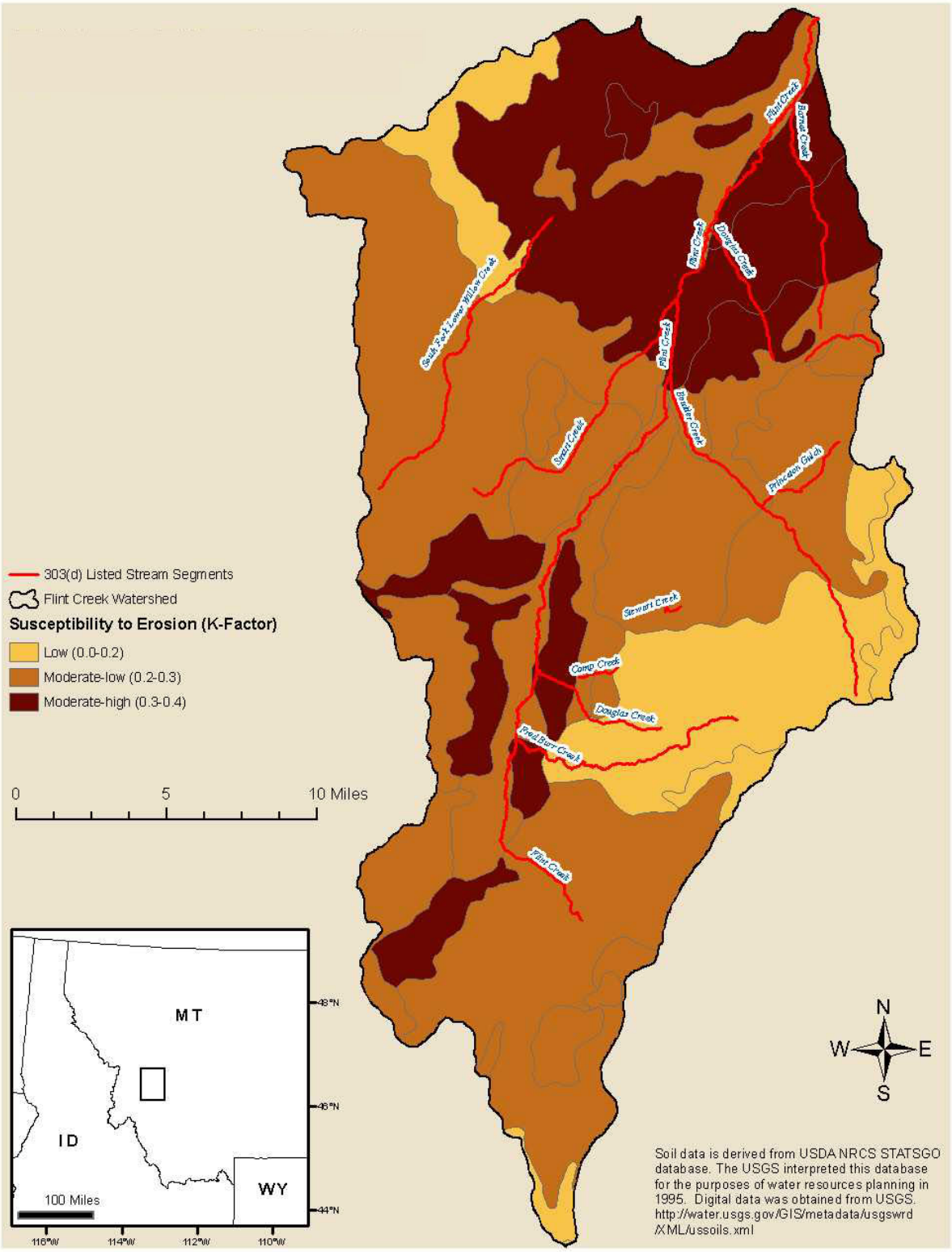


Figure A-9. Soils

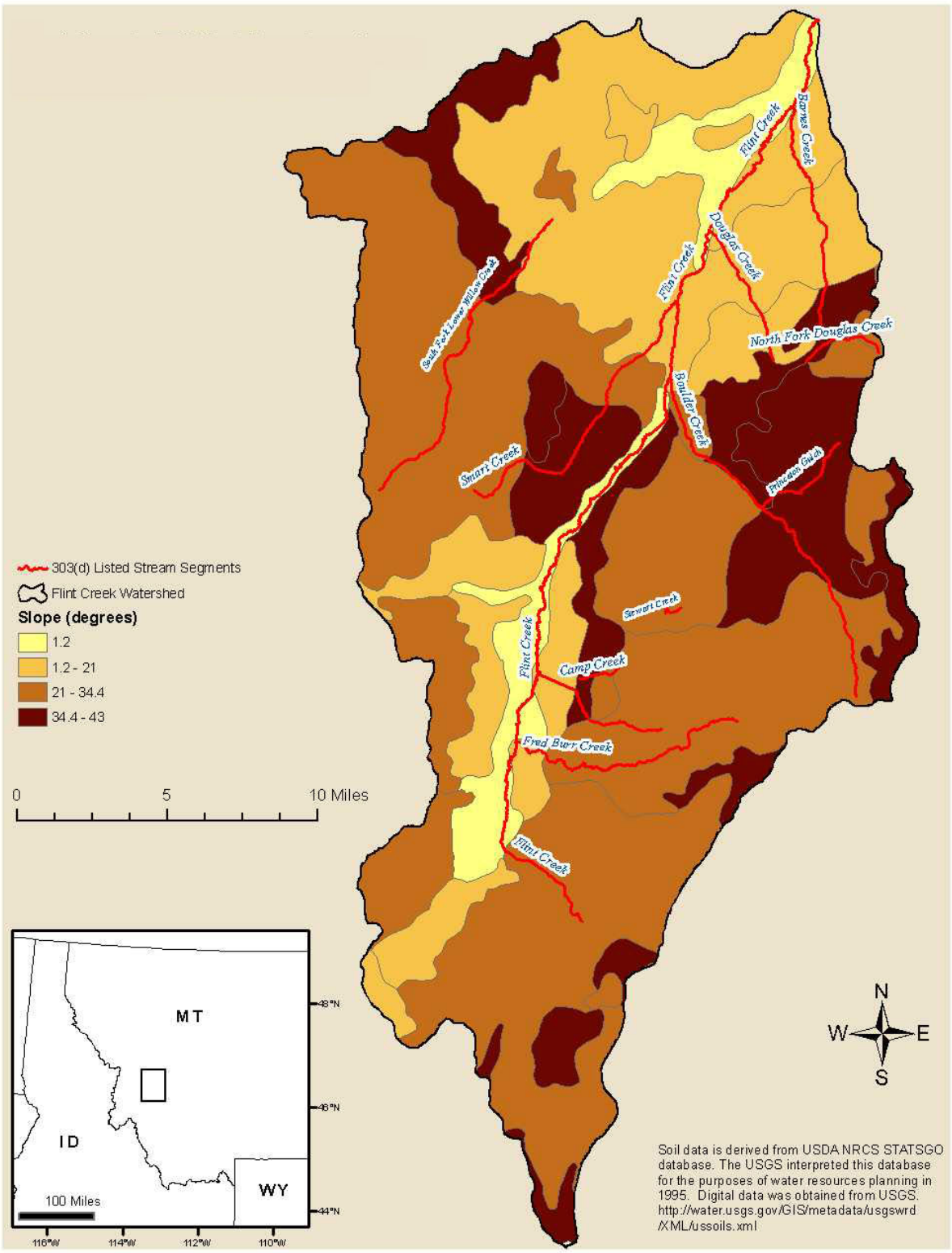


Figure A-10. Slope

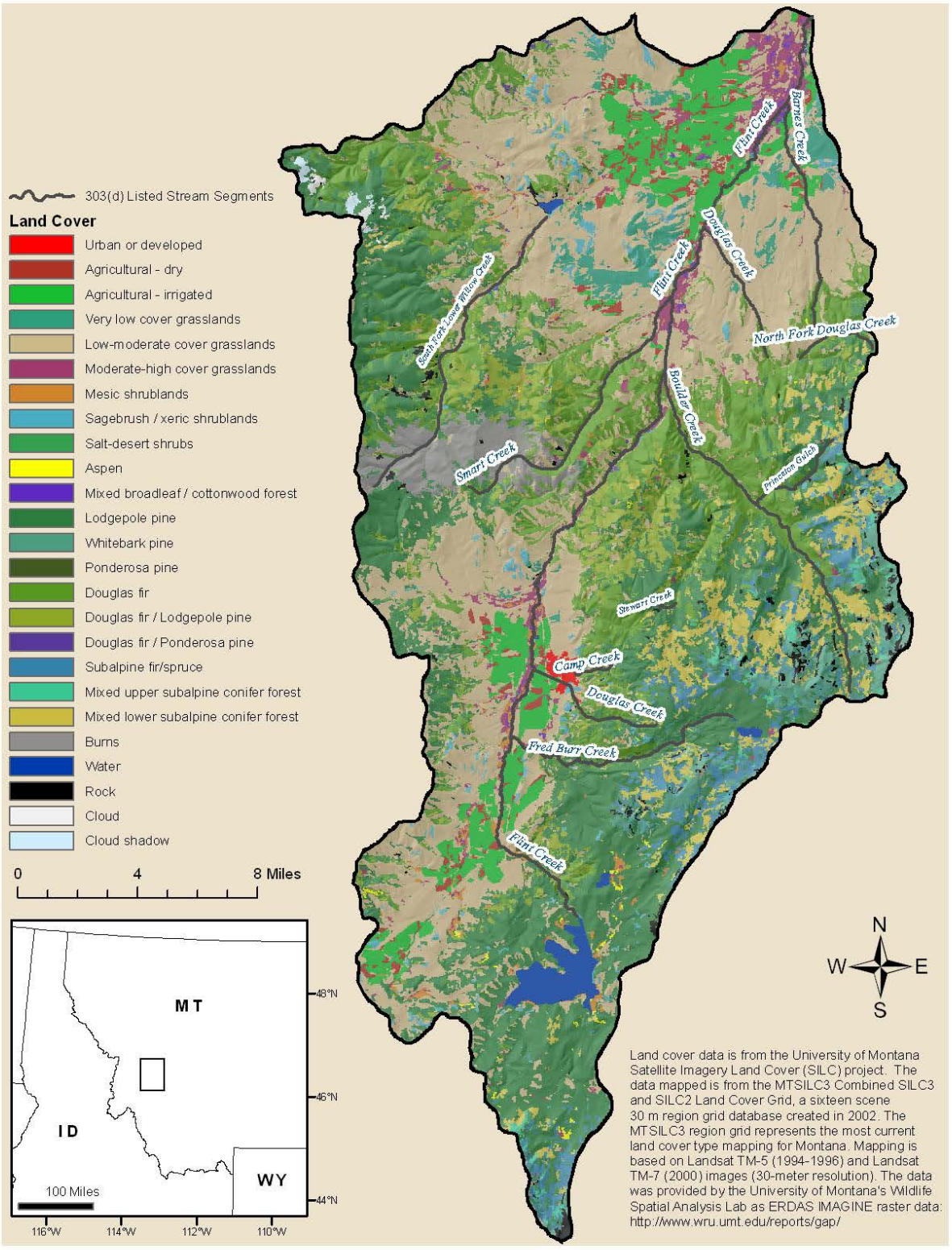


Figure A-11. Satellite Imagery Land Cover

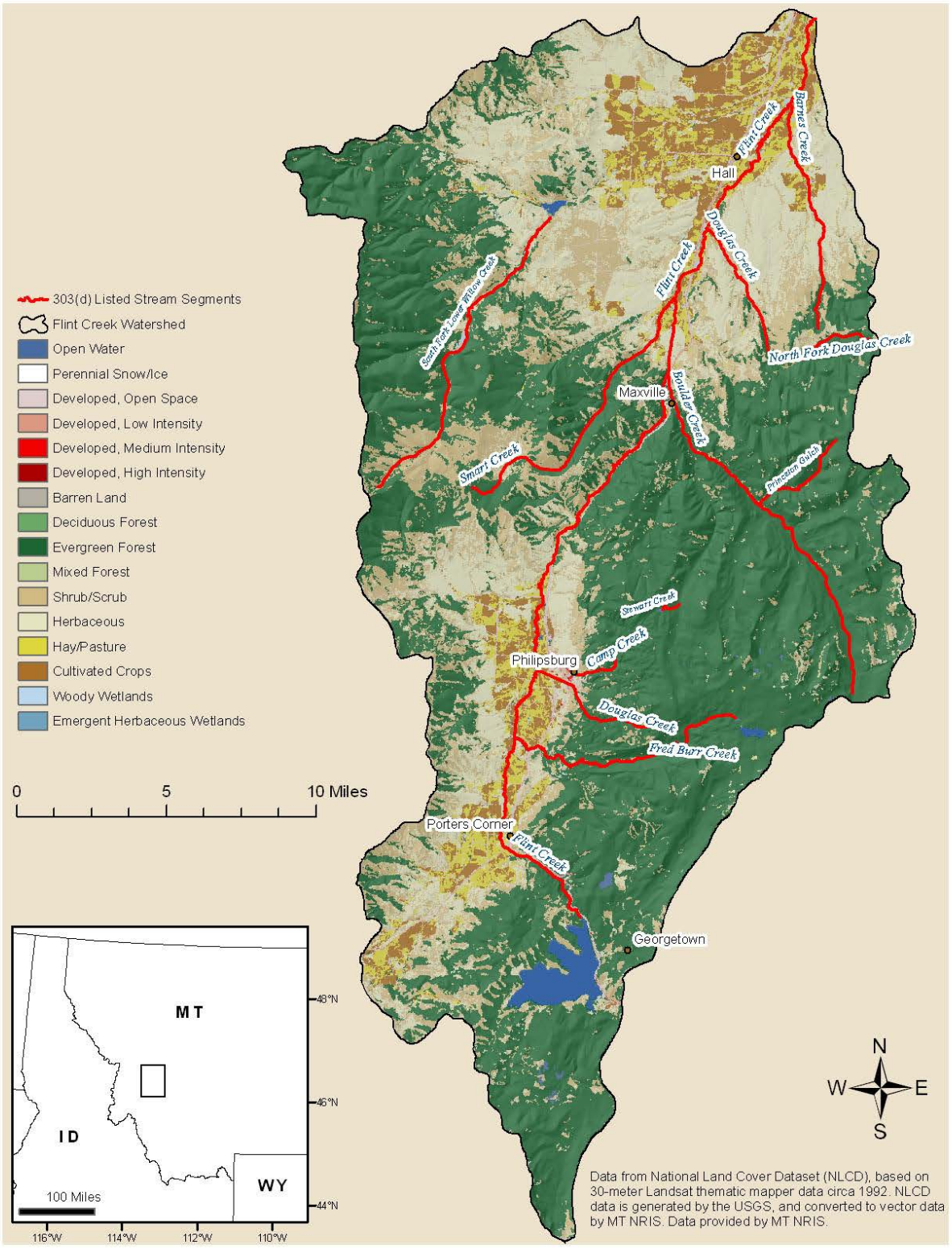


Figure A-12. National Land Cover Dataset

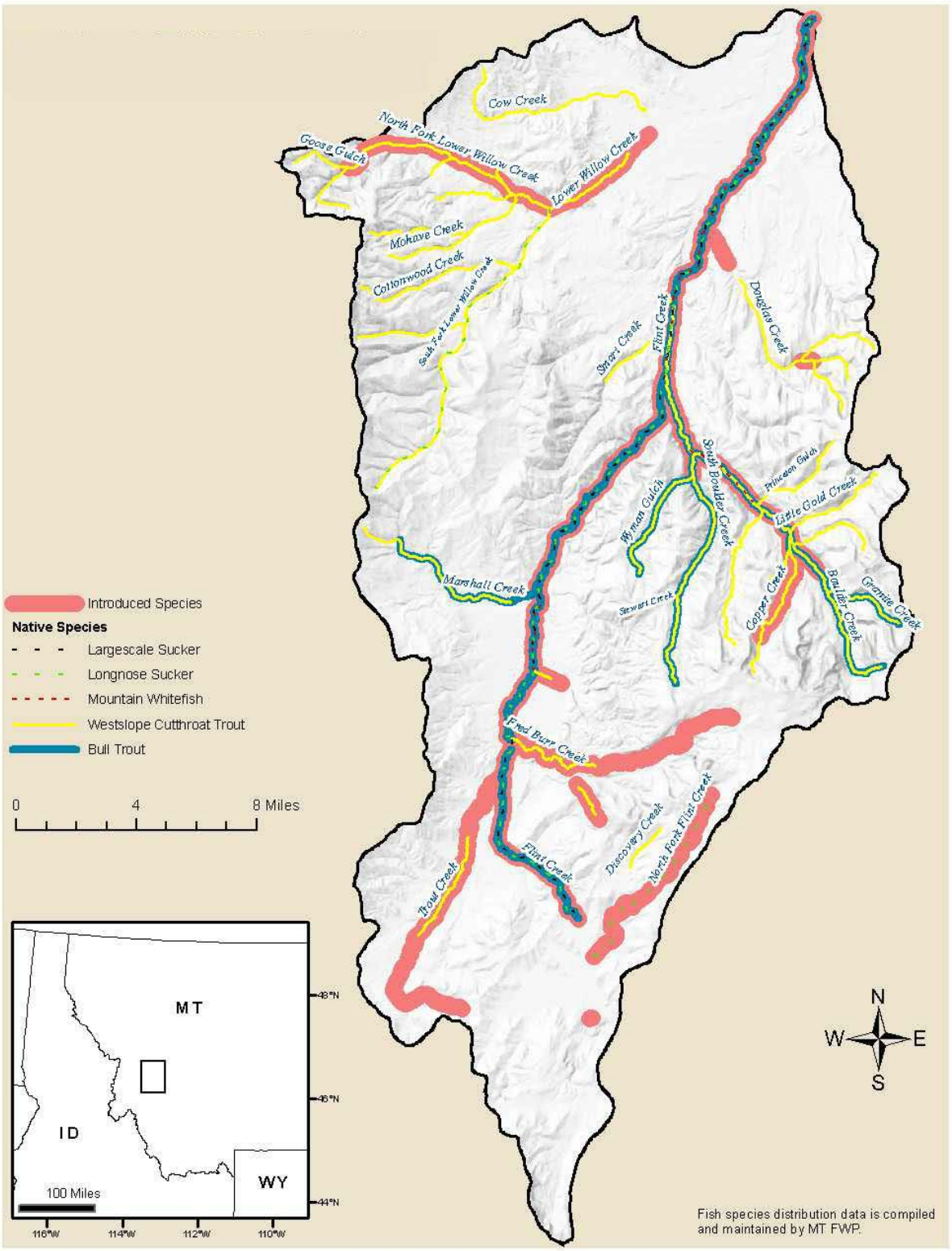


Figure A-13. Fish

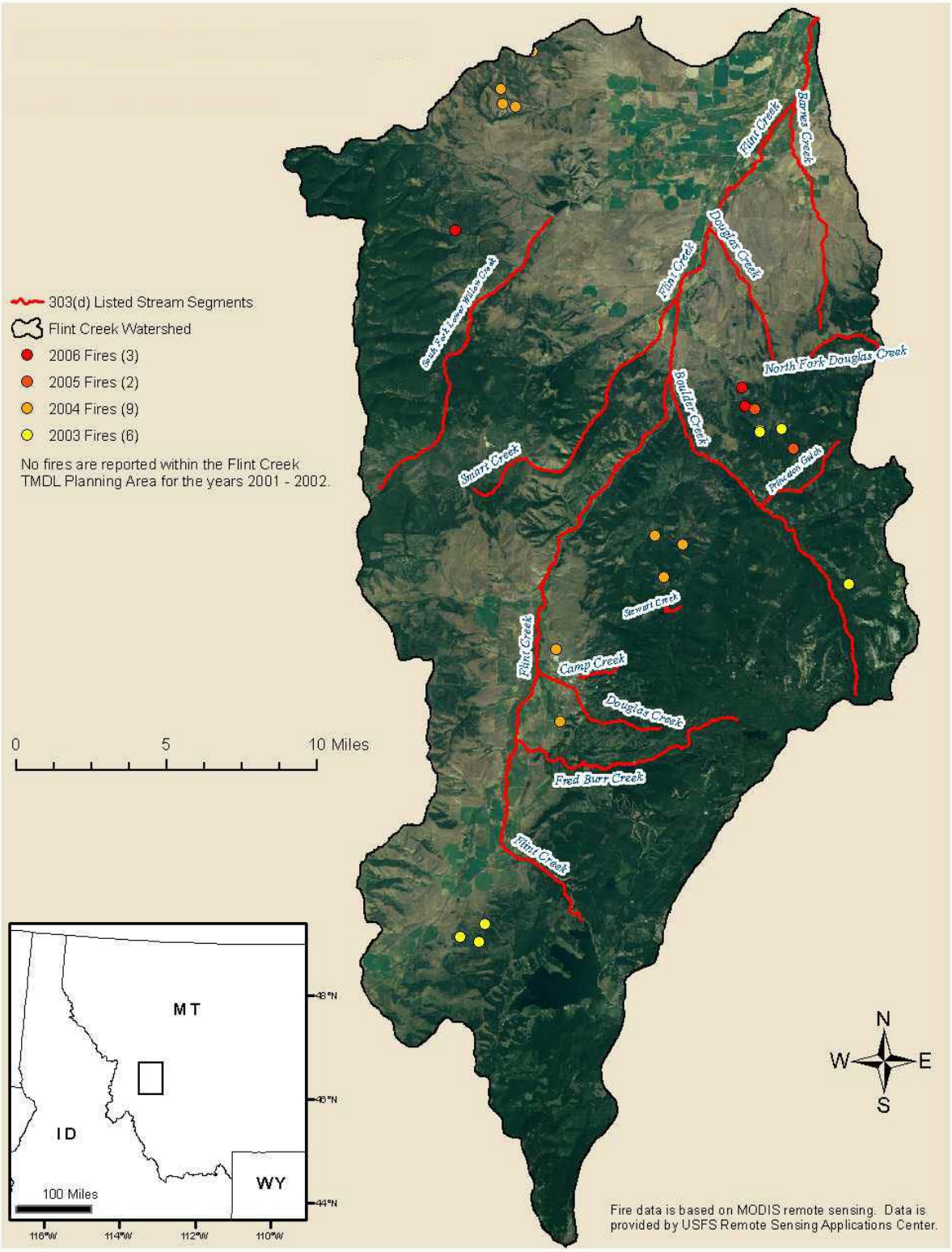


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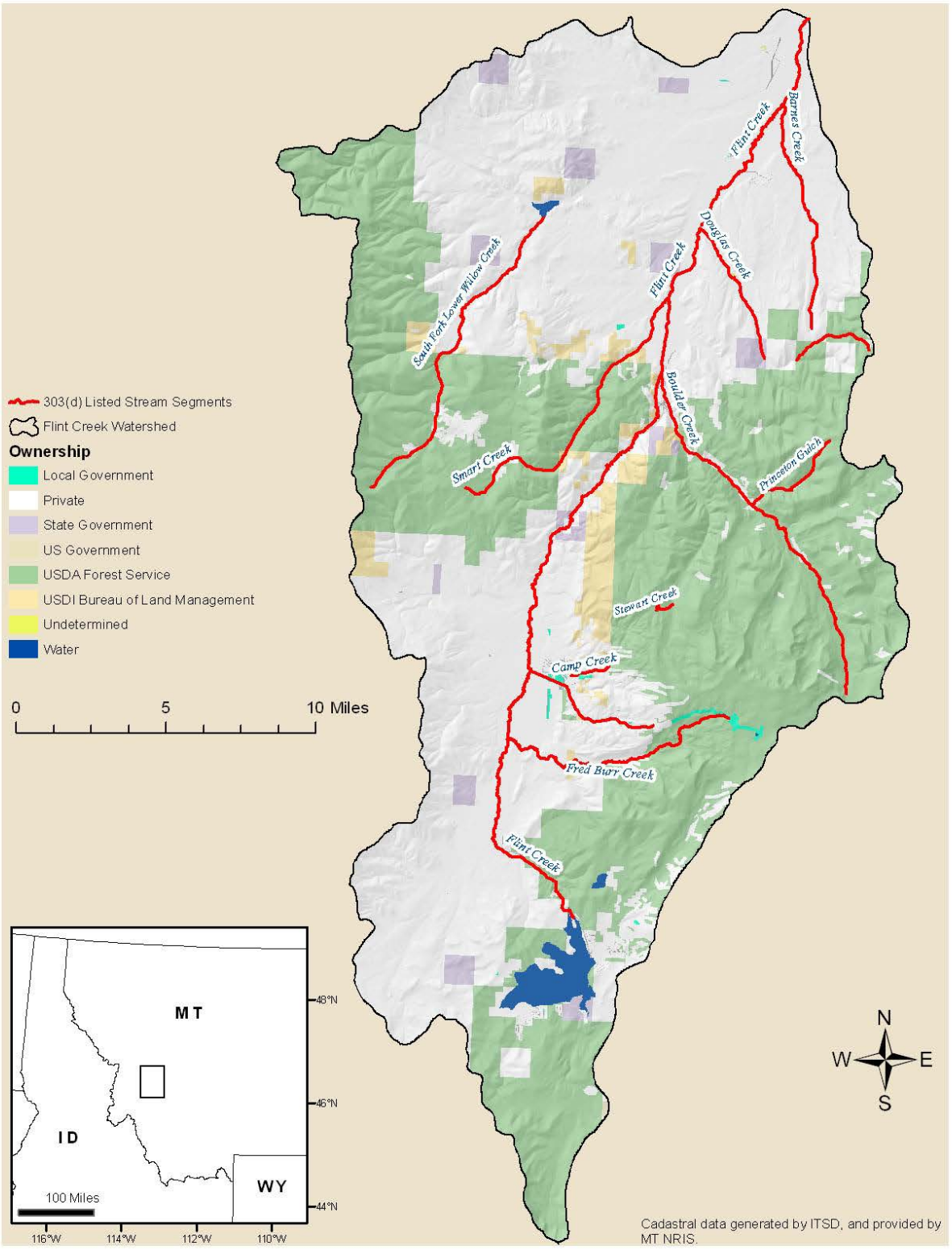


Figure A-15. Ownership

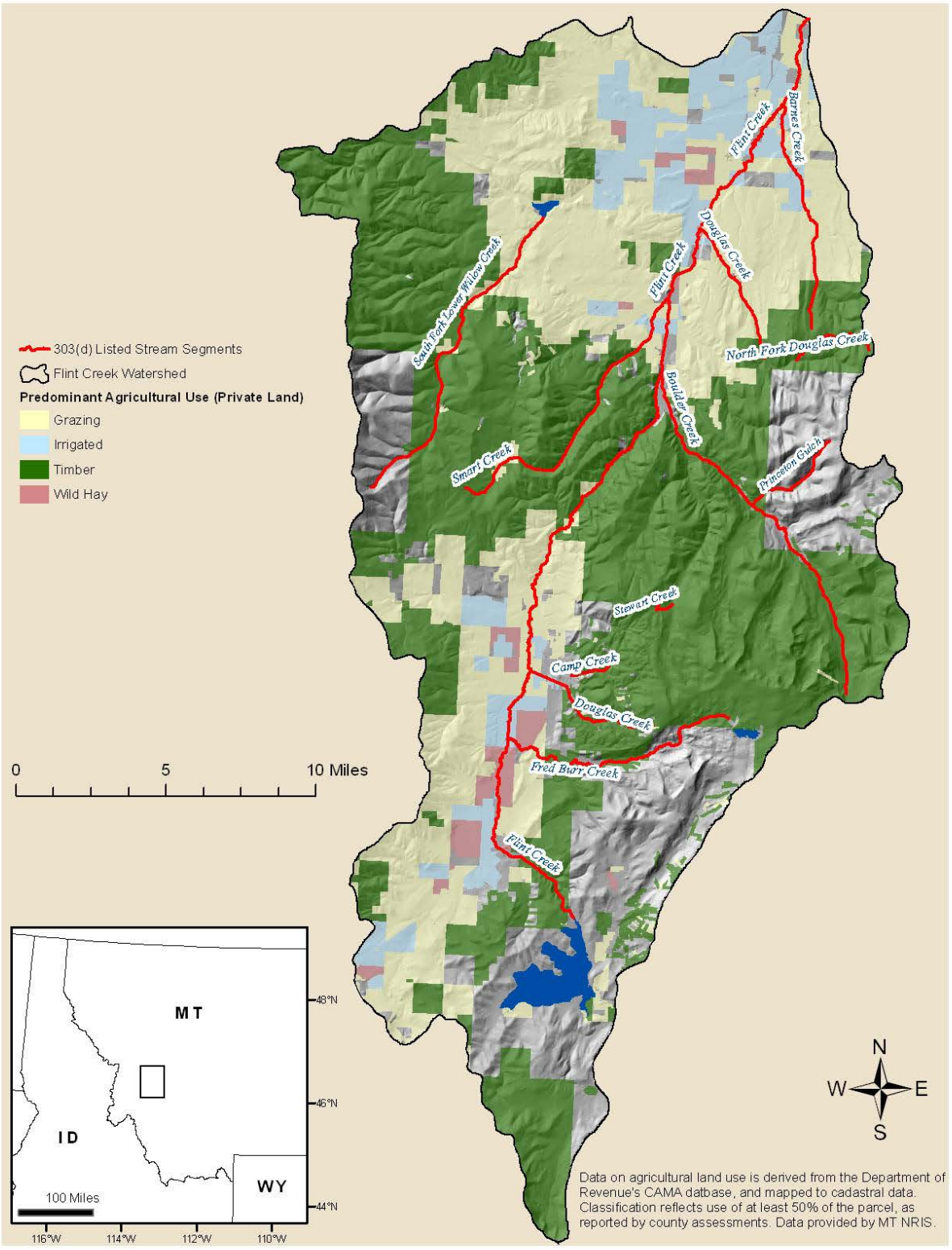


Figure A-16. Agricultural Use

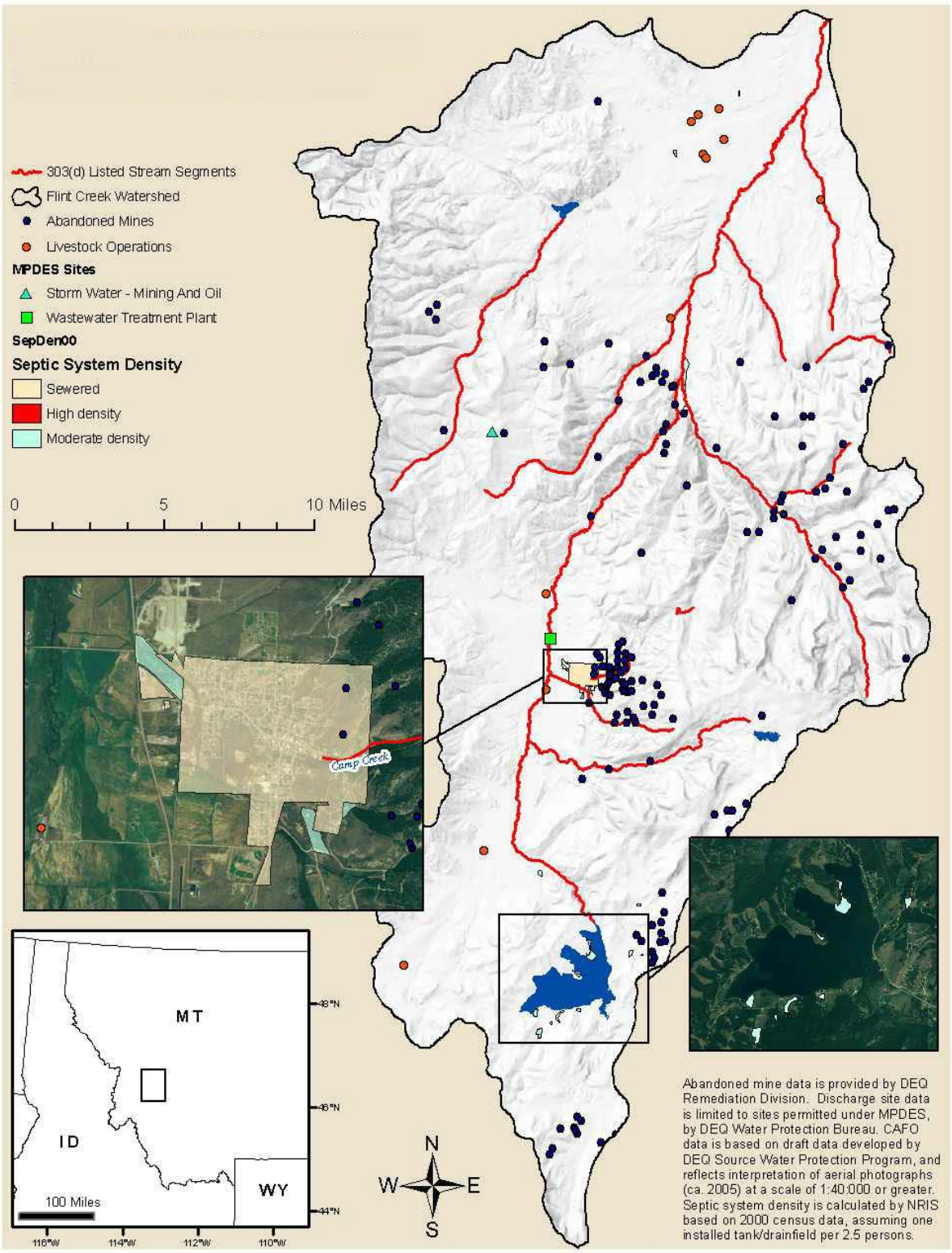


Figure A-17. Discharges

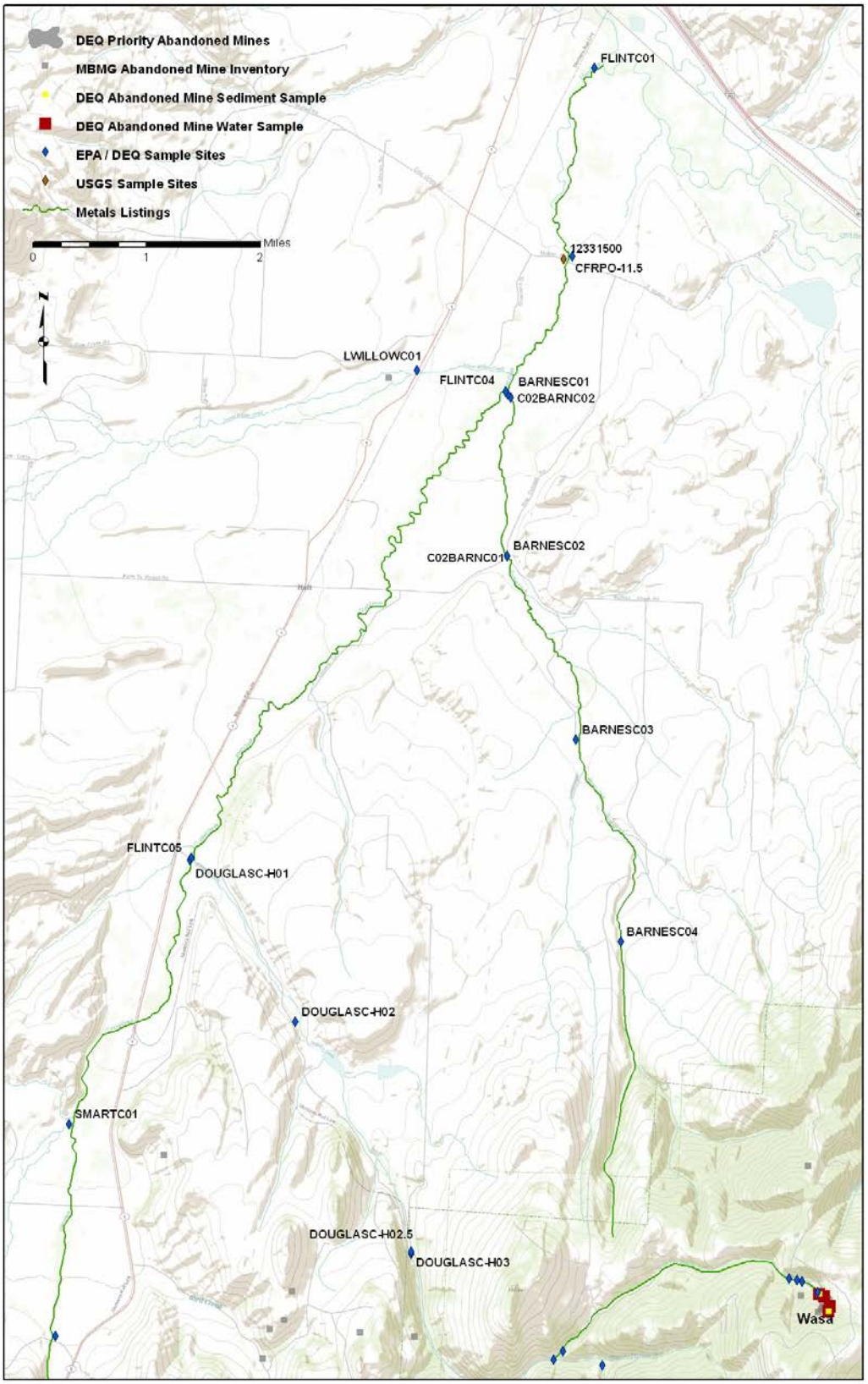


Figure A-18. Metals Sample Locations and Mining Sources in Barnes Creek

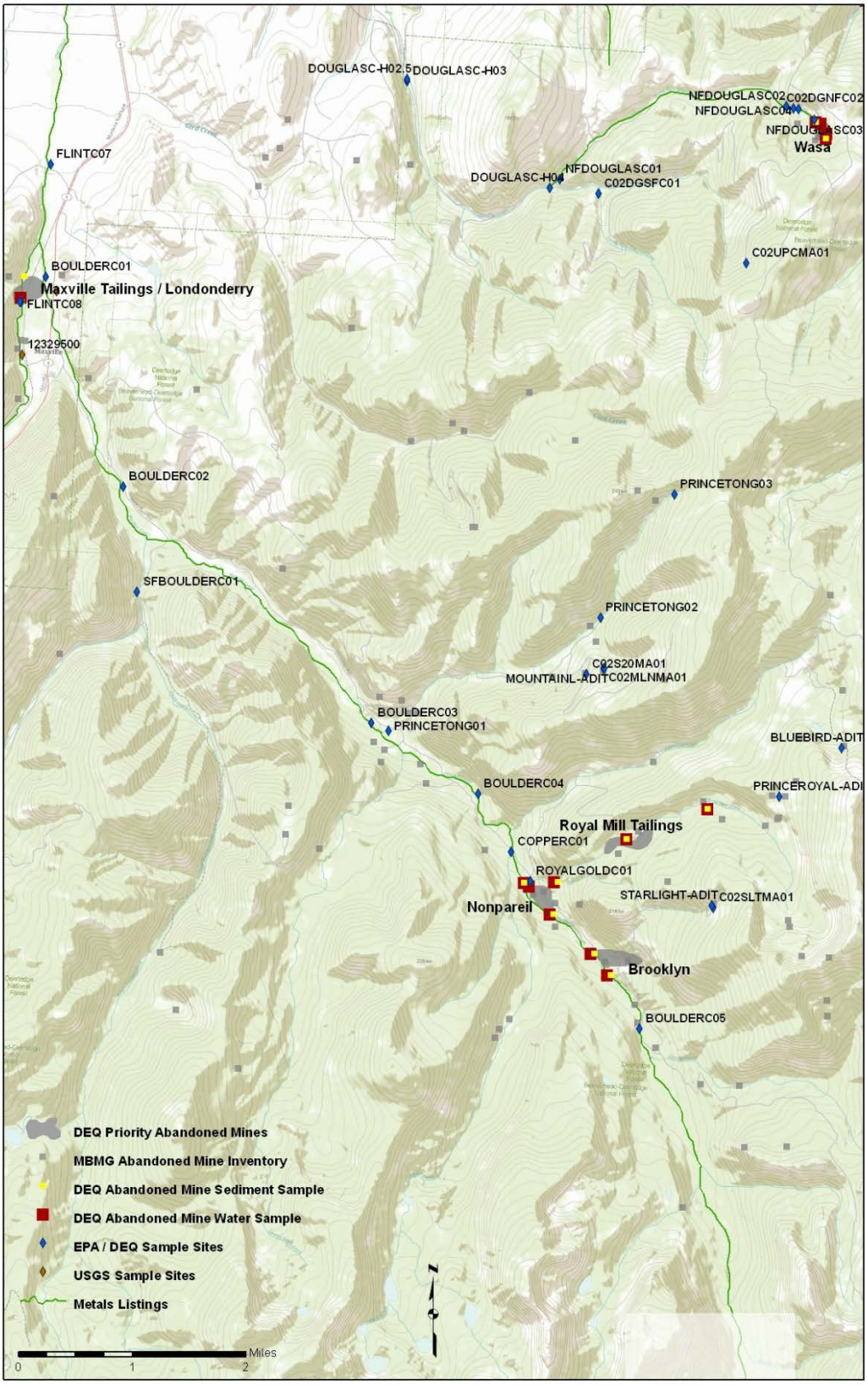


Figure A-19. Metals Sample Locations and Mining Sources in Boulder and Douglas Creeks

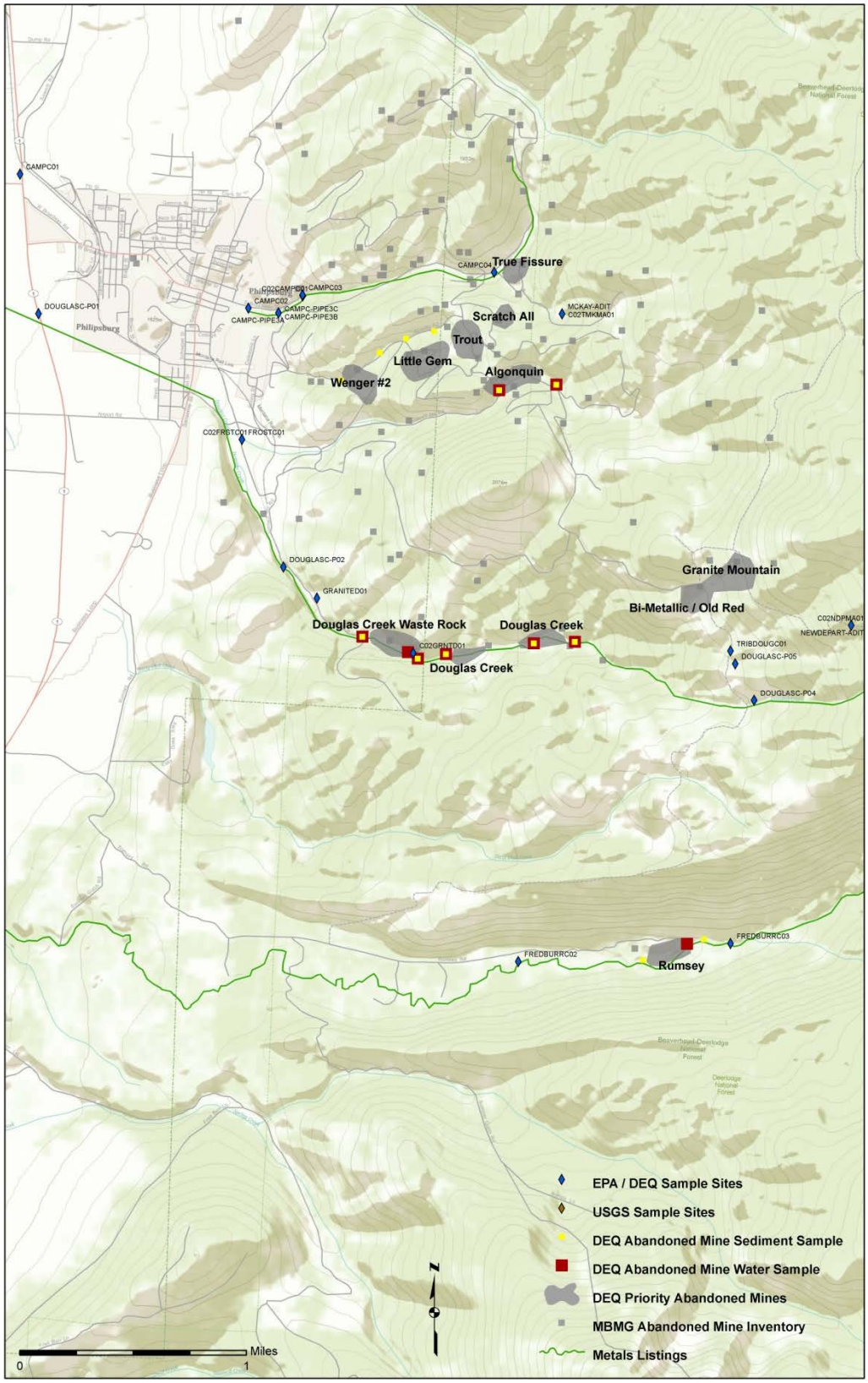


Figure A-20. Metals Sample Locations and Mining Sources near Philipsburg, MT.

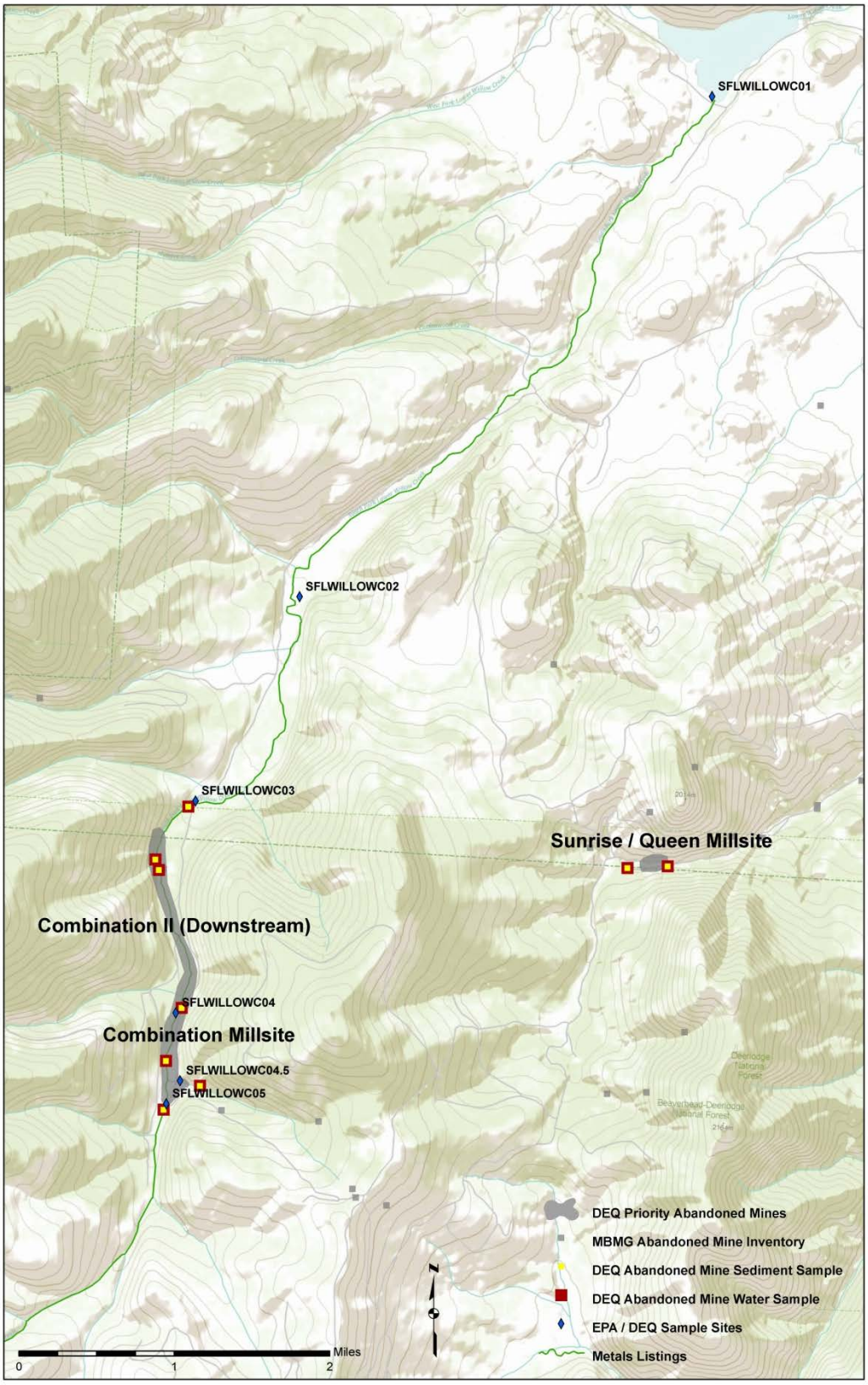


Figure A-21. Metals Sample Locations and Mining Sources in South Fork Lower Willow Creek

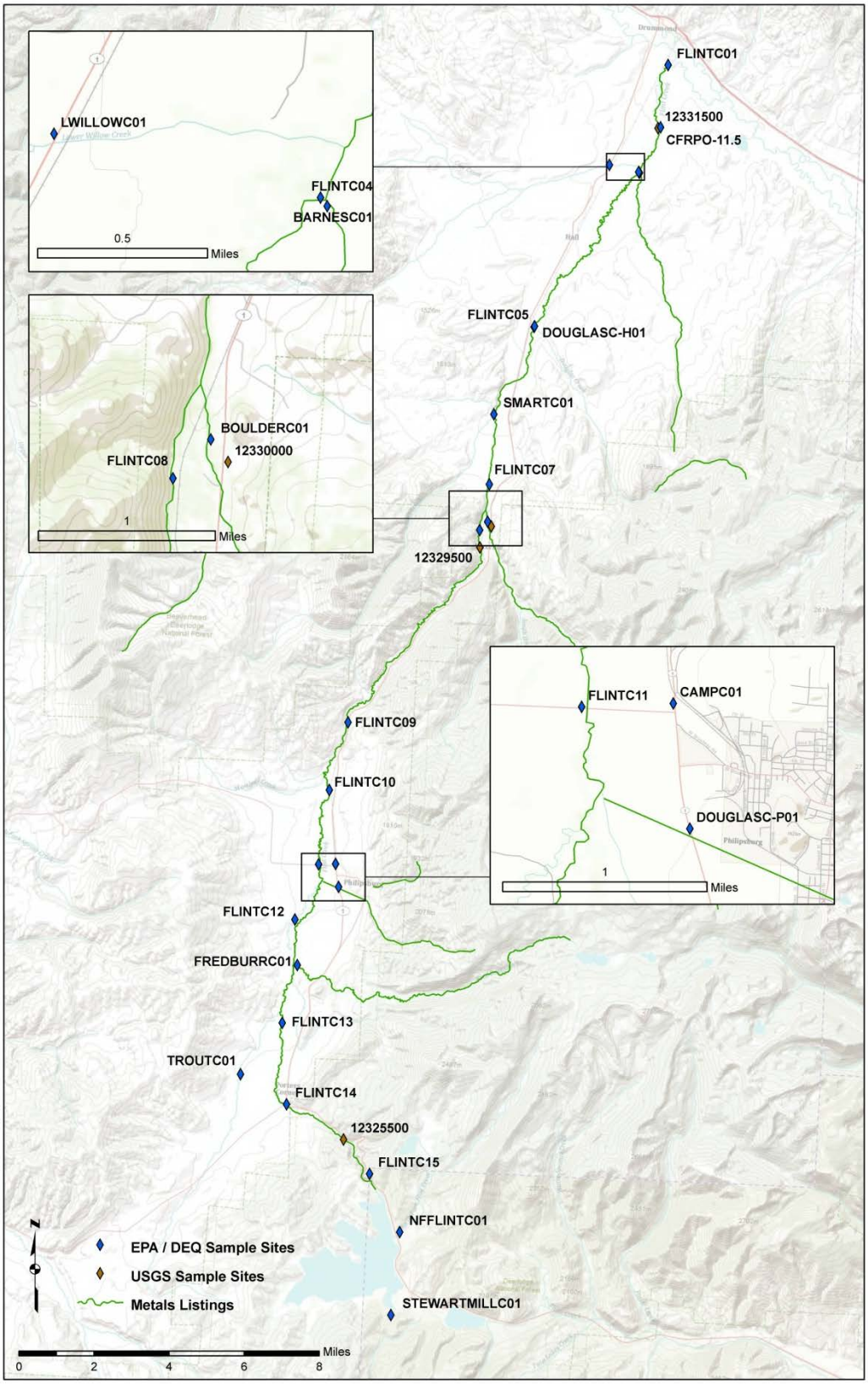


Figure A-22. Metals Sample Locations in Flint Creek and Tributaries

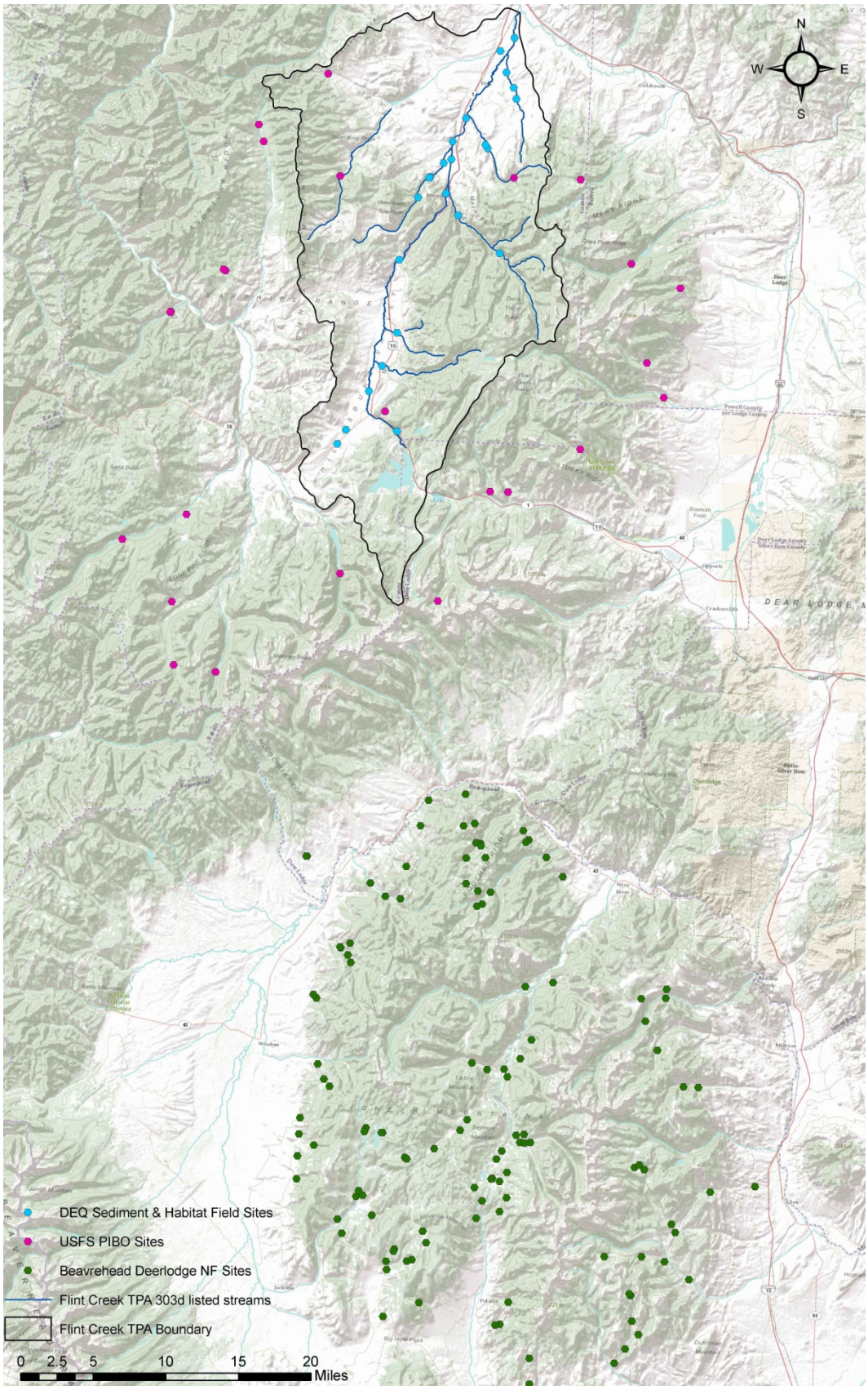


Figure A-23. Data Locations Used for Sediment Target Development

APPENDIX B – DATA

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B1.0 STREAM FLOW DATA

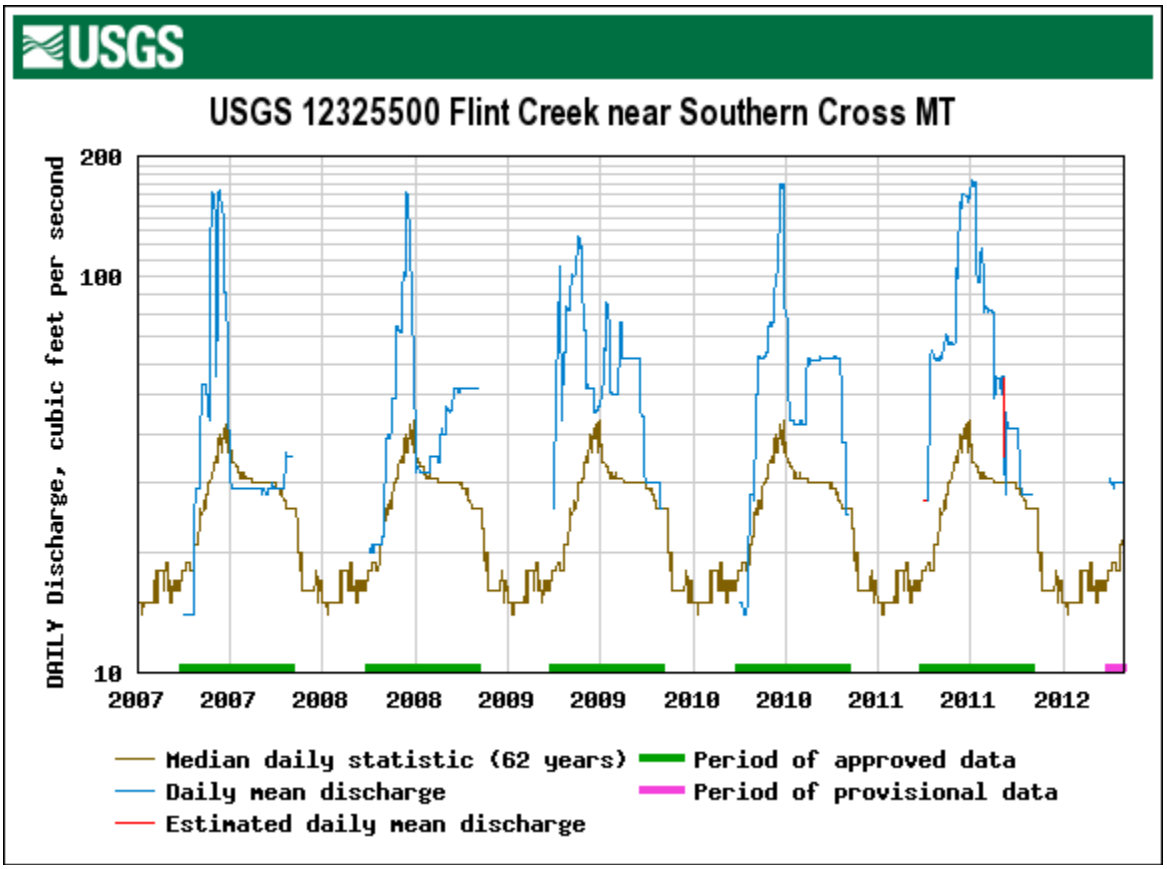


Figure B-1. Stream Flow Data - Flint Creek near Southern Cross, MT

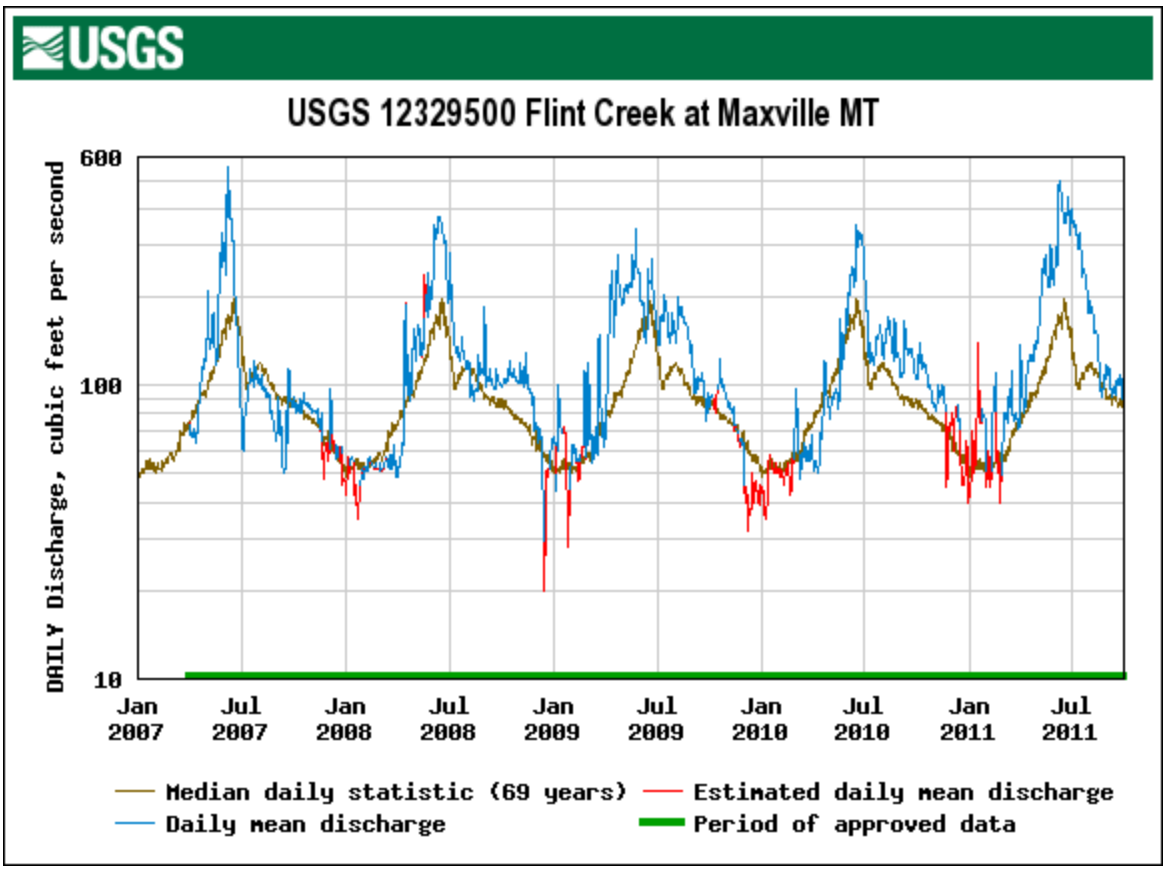


Figure B-2. Stream Flow Data - Flint Creek at Maxville, MT

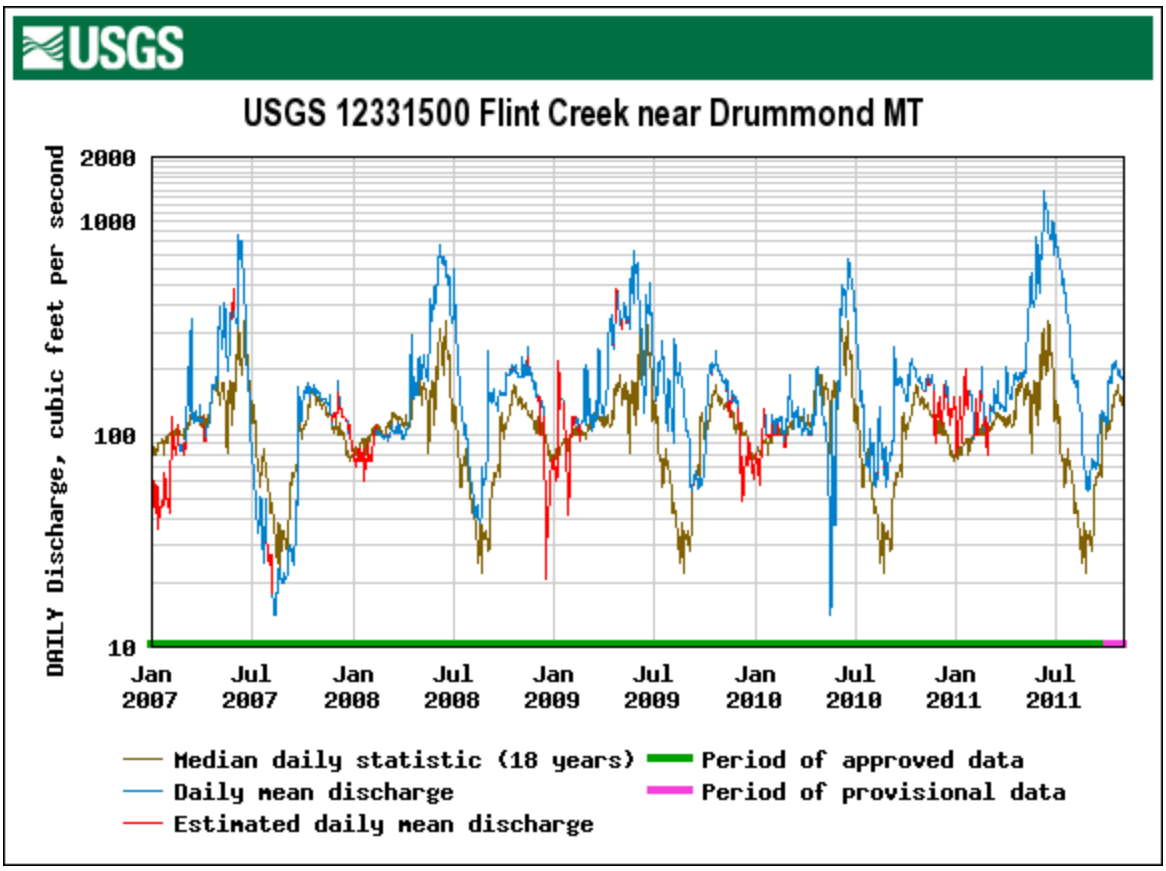


Figure B-3. Stream Flow Data - Flint Creek near Drummond, MT

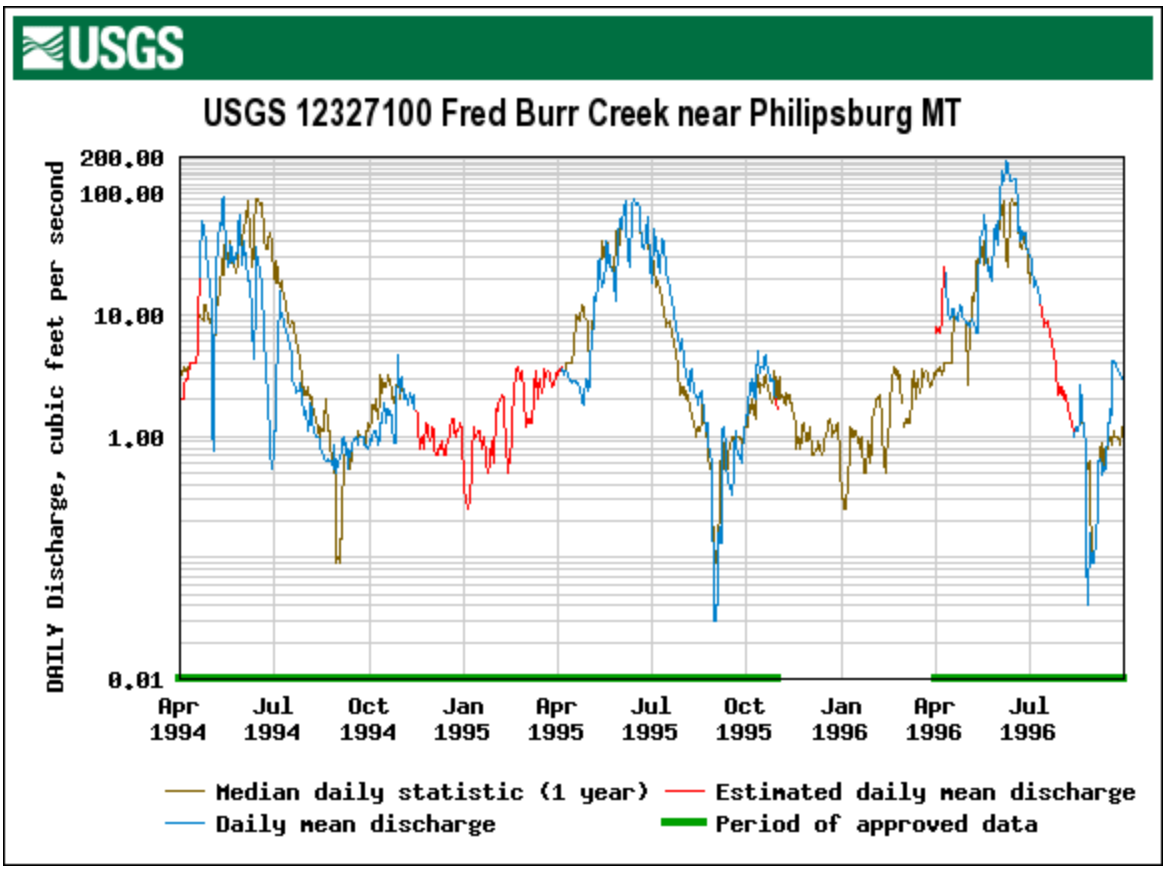


Figure B-4. Stream Flow Data - Fred Burr Creek near Phillipsburg, MT

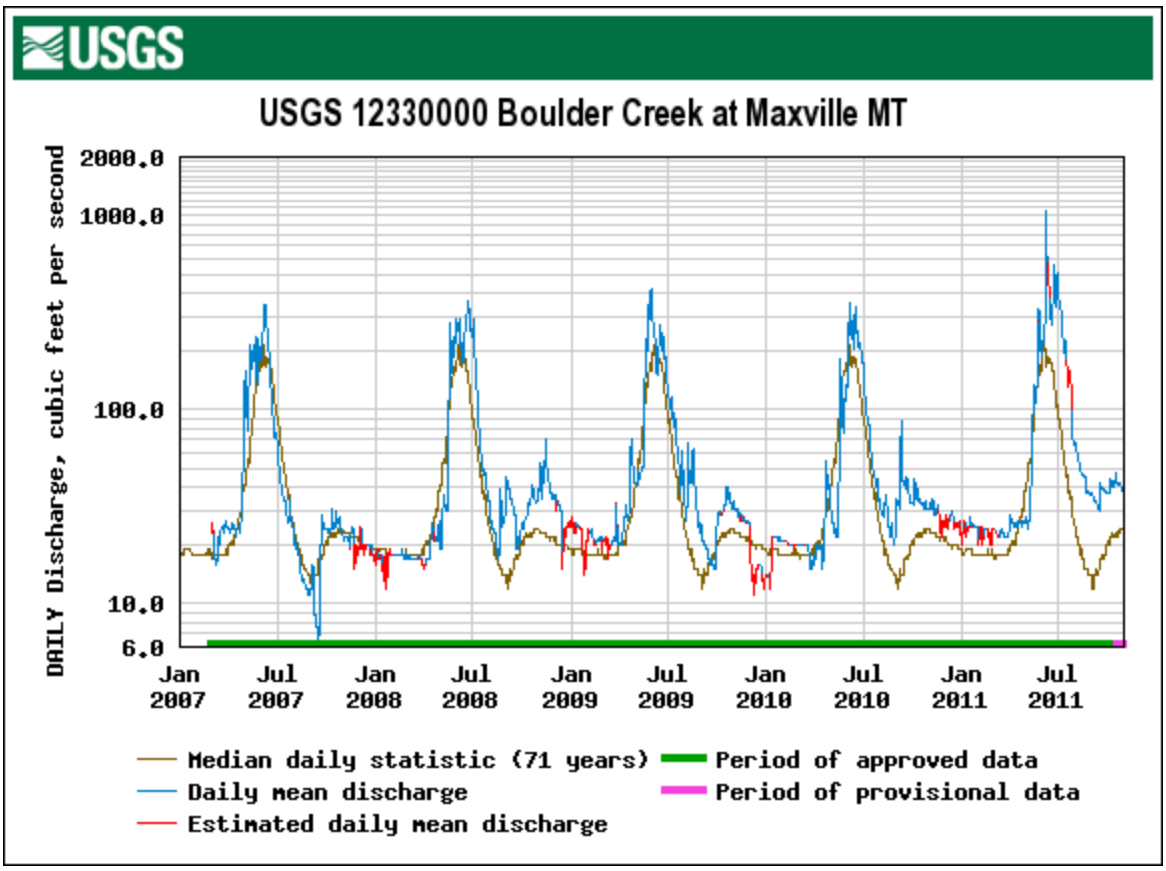


Figure B-5. Stream Flow Data - Boulder Creek at Maxville, MT

B2.0 FISH SPECIES

Table B-1. Fish Species

Waterbody	Species	Abundance	Origin
Boulder Creek	Bull Trout	Rare	Native
	Mountain Whitefish	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Rare	Introduced
	Brown Trout	Common	Introduced
Colter Gulch	Westslope Cutthroat Trout	Unknown	Unknown
	Brook Trout	Unknown	Introduced
Copper Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Abundant	Introduced
Cottonwood Creek	Westslope Cutthroat Trout	Rare	Native
Cow Creek	Westslope Cutthroat Trout	Rare	Native
Discovery Creek	Westslope Cutthroat Trout	Rare	Native
Douglas Creek	Westslope Cutthroat Trout	Unknown	Unknown
	Westslope Cutthroat Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Rare	Introduced
	Brown Trout	Common	Introduced
	Brown Trout	Unknown	Introduced
Flint Creek	Bull Trout	Rare	Native
	Largescale Sucker	Common	Native
	Longnose Sucker	Common	Native
	Mountain Whitefish	Abundant	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Abundant	Introduced
	Rainbow Trout	Abundant	Introduced
Fred Burr Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brown Trout	Unknown	Introduced
	Rainbow Trout	Unknown	Introduced
Goose Gulch	Westslope Cutthroat Trout	Rare	Native
Granite Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
Little Gold Creek	Westslope Cutthroat Trout	Rare	Native
Lower Willow Creek	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Rare	Introduced
Marshall Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
McLean Creek	Westslope Cutthroat Trout	Rare	Native
Middle Fork Douglas Creek	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Unknown	Introduced

Table B-1. Fish Species

Waterbody	Species	Abundance	Origin
Mohave Creek	Westslope Cutthroat Trout	Rare	Native
North Fork Douglas Creek	Westslope Cutthroat Trout	Rare	Native
North Fork Flint Creek	Longnose Sucker	Rare	Native
	Brook Trout	Common	Introduced
	Kokanee	Rare	Introduced
	Rainbow Trout	Rare	Introduced
North Fork Lower Willow Creek	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Rare	Introduced
Princeton Gulch	Westslope Cutthroat Trout	Rare	Native
Royal Gold Creek	Westslope Cutthroat Trout	Rare	Native
Senia Creek	Westslope Cutthroat Trout	Rare	Native
Smart Creek	Westslope Cutthroat Trout	Unknown	Native
South Boulder Creek	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Unknown	Introduced
South Fork Douglas Creek	Westslope Cutthroat Trout	Rare	Native
South Fork Lower Willow Creek	Longnose Sucker	Unknown	Native
	Westslope Cutthroat Trout	Rare	Native
Spring Creek	Westslope Cutthroat Trout	Rare	Native
Stuart Mill Creek	Brook Trout	Abundant	Introduced
	Brown Trout	Unknown	Introduced
	Kokanee	Abundant	Introduced
	Rainbow Trout	Unknown	Introduced
Swamp Gulch Creek	Westslope Cutthroat Trout	Rare	Native
Trout Creek	Westslope Cutthroat Trout	Rare	Native
	Brook Trout	Unknown	Introduced
	Brown Trout	Unknown	Introduced
West Fork Lower Willow Creek	Westslope Cutthroat Trout	Rare	Native
Wyman Gulch	Bull Trout	Rare	Native
	Westslope Cutthroat Trout	Rare	Native

B3.0 METALS DATA

Table B-2. Metals

Station ID	Actvty Date	Latitude	Longitude	Hrdnes mgL	Flow cfs	pH	D_Al ugL	TR_Sb ugL	TR_As ugL	TR_Ba ugL	TR_Cd ugL	TR_Cr ugL	TR_Cu ugL	TR_Fe ugL	TR_Pb ugL	TR_Mg ugL	D_Mg ugL	TR_Mn ugL	TR_Ni_ ugL	TR_Zn ugL	TSS ugL	TR_Ca mgl	D_Ca mgl
3823BA01	8/17/1978	46.589722	-113.1575		3																		
BARNESC01	9/5/2007	46.61124	-113.16065	294	2.37	7.85		<1	8	188	<0.08	<1	<1	180	<0.5		21500	49	<10	4.2	7690		82.4
BARNESC01	9/4/2008	46.61124	-113.16065	183	1.6	7.8		<5	9		<0.08		2	150	0.6		13000	27		<10	<4000		52
BARNESC01	5/28/2009	46.61124	-113.16065	144	3.9	7.64			8		1.01		4	2020	4.2	11000		148		20	78000	40	
BARNESC01	8/26/2009	46.61124	-113.16065	233	6.53	8.44			7		0.08		4	1710	3	18000		87		10	67000	60	
BARNESC02	9/4/2007	46.5906	-113.15941		1.25	7.92								1500							74100		
BARNESC02	5/22/2008	46.5906	-113.15941		2.05	7.8								3640							100000		
BARNESC02	8/19/2008	46.5906	-113.15941		0.17									2000									
BARNESC02	5/28/2009	46.5906	-113.15941	245	2.5	7.62								1560		20000					63000	65	
BARNESC02	8/25/2009	46.5906	-113.15941		2.5	8.52								2110		24000					84000	72	
BARNESC03	5/22/2008	46.5676	-113.1451		1.75	7.35								4810							209000		
BARNESC03	8/19/2008	46.5676	-113.1451		1.02									6420									
BARNESC03	5/28/2009	46.5676	-113.1451	216	2	7.93								2790		18000					138000	58	
BARNESC03	8/25/2009	46.5676	-113.1451	277	2.5	8.2															69000		
BARNESC04	7/10/2008	46.5421	-113.1351											1720									
BARNESC04	8/19/2008	46.5421	-113.1351		0.52									710									
C02BARNC01	7/15/2004	46.59065	-113.15937	212	2.74	8.15	<100	<3	3	105	0.2	<1	3	1410	2.3		17000	130	<20	<10	143000		57
C02BARNC02	7/16/2004	46.61089	-113.16017	232	1.31	8.3	<100	<3	4	114	<0.1	<1	1	240	<0.5		17000	20	<20	<10	9000		64
BLUEBIRD-ADIT	8/18/2009	46.4186	-113.0853	20	0.4	7.66		<3	<3		1.65		19	<30	6.2	<1000		<5	<10	190	<4000	8	
BOULDERC02	8/28/2007	46.44766	-113.22	107	25.7	8.48		<1	2	53	<0.08	<1	<1	20	<0.5		6880	<5	<10	3	<1000		31.6
BOULDERC02	5/22/2008	46.44766	-113.22	40	200	5.56			<3		<0.08		2		1.8	2000			<10	<10		12	
BOULDERC02	8/12/2008	46.44766	-113.22	85	38.9	8.97			<3		<0.08		<1		<0.5		5000		<10	<10	<4000		27
BOULDERC02	5/29/2009	46.44766	-113.22	33	367	7.17			<3		1.81		2		2.7	2000			<10	<10	8000	11	
BOULDERC02	8/20/2009	46.44766	-113.22	82	50	8.15			<3		<0.08		<1		<0.5	5000			<10	<10	<4000	25	
BOULDERC03	8/27/2007	46.41897	-113.17217	98.9	18.3	8.26		<1	2	29	<0.08	<1	<1	10	<0.5		5480	<5	<10	4.9	<1000		30.6
BOULDERC03	5/21/2008	46.41897	-113.17217	32	150	5.54			<3		<0.08		2		1.9	2000			<10	10		10	
BOULDERC03	8/12/2008	46.41897	-113.17217	77	23.6	8.79			<3		<0.08		<1		<0.5		4000		<10	<10	<4000		25
BOULDERC03	6/2/2009	46.41897	-113.17217	35	257	6.83			<3		2.93		1		1.6	2000			<10	<10	<4000	11	
BOULDERC03	8/20/2009	46.41897	-113.17217	76	36	8.04			<3		<0.08		<1		<0.5	4000			<10	<10	<4000	24	
BOULDERC05	5/21/2008	46.3816	-113.1202	29	64.9	5.5			<3		<0.08		1		<0.5	1000			<10	<10		10	
BOULDERC05	8/12/2008	46.3816	-113.1202	79	11.3	8.29			<3		<0.08		<1		<0.5		3000		<10	<10			27
BOULDERC05	5/27/2009	46.3816	-113.1202	39	104	7.18			<3		1.01		<1		<0.5	1000			<10	<10	<4000	13	
BOULDERC05	8/18/2009	46.3816	-113.1202	73	14.2	8.09			<3		<0.08		<1		<0.5	3000			<10	<10	<4000	25	
BOULDERC01	8/30/2007	46.47392	-113.23612	108	10.5	8.45		<1	2	52	<0.08	<1	<1	20	<0.5		7020	<5	<10	3.5	<1000		31.8
BOULDERC01	5/22/2008	46.47392	-113.23612	34	250	6.2		<5	<3		<0.08		3	290	2.2		2000	10	<10	10	7000		10
BOULDERC01	8/13/2008	46.47392	-113.23612	83	22.3			<5	<3		<0.08		<1	<30	<0.5			<5	<10	<10			
BOULDERC01	5/28/2009	46.47392	-113.23612	34	335	7.91					1.63		2	310	2.3	2000		10			8000	11	
BOULDERC01	8/20/2009	46.47392	-113.23612	81	46	7								50		5000						25	
BOULDERC04	8/27/2007	46.41058	-113.15196	92.3	9.19	7.71		<1	2	25	<0.08	<1	<1	10	<0.5		4680	<5	<10	5.7	<1000		29.2
BOULDERC04	5/21/2008	46.41058	-113.15196	27	100	5.38			<3		<0.09		2		1.5	1000			<10	10		9	
BOULDERC04	8/12/2008	46.41058	-113.15196	75	14.7	8.8			<3		<0.08		<1		<0.5		3000		<10	<10	<4000		26
BOULDERC04	5/27/2009	46.41058	-113.15196	29	180	7.01			<3		1.09		2		2.7	1000			<10	<10	<4000	10	

Table B-2. Metals

Station ID	Actvty Date	Latitude	Longitude	Hrdnes mgL	Flow cfs	pH	D_Al ugL	TR_Sb ugL	TR_As ugL	TR_Ba ugL	TR_Cd ugL	TR_Cr ugL	TR_Cu ugL	TR_Fe ugL	TR_Pb ugL	TR_Mg ugL	D_Mg ugL	TR_Mn ugL	TR_Ni_ ugL	TR_Zn ugL	TSS ugL	TR_Ca mgl	D_Ca mgl
BOULDERC04	8/19/2009	46.41058	-113.15196	75	15.5	8			<3		<0.08		<1		<0.5	3000			<10	<10	<4000	25	
COPPERC01	5/21/2008	46.4034	-113.1453	13	50	5.11			<3		<0.08		<1		<0.5	<1000			<10	<10		4	
COPPERC01	8/12/2008	46.4034	-113.1453	40	10	8.62			<3		<0.08		<1		<0.5		2000		<10	<10	<4000		13
COPPERC01	6/2/2009	46.4034	-113.1453	13	58.2	6.94			<3		1.61		<1		<0.5	<1000			<10	<10	<4000	4	
COPPERC01	8/19/2009	46.4034	-113.1453	31	7	7.95			<3		<0.08		<1		<0.5	2000			<10	<10	<4000	9	
C02MLNMA01	6/10/2009	46.4273	-113.1299	110	0.028	8		1	2	9	0.22	<1	3	<10	2.1			<5	<10	19	<1000		
MOUNTAINL-ADIT	8/19/2009	46.4273	-113.1298	104	0.01	8.07							2		0.9	2000				20	<4000	38	
PRINCEROYAL-ADIT	8/18/2009	46.412	-113.0964	13	0.011	8.37		<3	<3		<0.08		2	40	4.7	<1000		9	<10	10	<4000	5	
PRINCETONG02	5/22/2008	46.43376	-113.13091	86	0.28	5.69			4		0.55		2		2.4	4000			<10	10		27	
PRINCETONG01	8/27/2007	46.41806	-113.16892	163	0.19	7.86		<1	3	53	<0.08	<1	<1	30	<0.5		11100	<5	<10	5	3050		47
PRINCETONG01	5/21/2008	46.41806	-113.16892	71	2.56	6.01			<3		<0.08		<1		<0.5		2000			<10	<4000		24
PRINCETONG01	8/20/2008	46.41806	-113.16892	233	0.26				<3		<0.08		<1		1.9		14000			<10	7000		70
PRINCETONG01	5/27/2009	46.41806	-113.16892	74	6.6	7.1					0.99					2000						26	
PRINCETONG01	8/24/2009	46.41806	-113.16892	104	0.6	8.22										4000						36	
ROYALGOLDC01	5/21/2008	46.3998	-113.1415	17	4	4.77			<3		0.19		9		9.4	<1000			<10	50		6	
ROYALGOLDC01	8/12/2008	46.3998	-113.1415	22	1.25	8.38			<3		<0.08		2		0.9		<1000		<10	20	4000		8
ROYALGOLDC01	5/29/2009	46.3998	-113.1415	11	15	6.32			<3		1.14		6		7.8	<1000			<10	30	5000	4	
ROYALGOLDC01	8/19/2009	46.3998	-113.1415	22	1.6	7.81			<3		<0.08		2		1.1	<1000			<10	20	<4000	8	
C02S20MA01	6/10/2009	46.4265	-113.133	63.5	0.04	7.8		<1	<1	22	<0.08	<1	<1	<10	<0.5			<5	<10	2	<1000		
C02SLTMA01	6/10/2009	46.3975	-113.1076	13.9	0.1	8.02		<1	<1	<5	<0.08	<1	<1	20	0.6			<5	<10	6	<1000		
STARLIGHT-ADIT	8/18/2009	46.3977	-113.1079	17	0.1	8.02									<0.5	<1000				<10	<4000	6	
C02CAMPC01	8/17/2005	46.33225	-113.28515		1	8	<100	<3	6	17	<0.1	<1	<1	10	<0.5		20000	11	<20	20	<1000		48
CAMPC03	8/23/2007	46.33231	-113.28517	31	0.73	8.19		<1	10	31	0.23	<1	2	30	2.1		35700	83	<10	95.3	1700		65.3
CAMPC04	8/24/2007	46.33435	-113.26762	92.1	0.1	7.33		<1	13	36	0.16	<1	1	100	4.3		4900	47	<10	160	<1000		28.8
CAMPC01	8/24/2007	46.33915	-113.31172	13.5	2.85	8.32		<1	6	17	<0.08	<1	1	60	1		13400	30	<10	15.7	2000		31.9
CAMPC03	5/20/2008	46.33231	-113.28517	323	0.1	7.83			12		0.8		16		30.9	37000		1310		330		68	
CAMPC-PIPE3A	5/20/2008	46.3311	-113.2873	223	0.05	7.21			10		<0.08		<1		<0.5	22000		<5		20		53	
CAMPC-PIPE3B	5/20/2008	46.3311	-113.2873	256	0.03	6.96			10		0.13		<1		<0.5	26000		<5		20		59	
CAMPC-PIPE3C	5/20/2008	46.3311	-113.2873	251	0.01	6.8			11		<0.08		<1		<0.5	26000		<5		<10		58	
CAMPC02	5/21/2008	46.3313	-113.2901	102	2.67	6.95			5		<0.08		<1		0.5	10000		14		10		25	
CAMPC04	5/21/2008	46.33435	-113.26762	50	0.45	5.57		<5	16		0.67		5		32.8	3000		267		380		15	
CAMPC01	5/21/2008	46.33915	-113.31172	115	3.02	6.77			5		<0.08		3	370	5.3	11000		92		40		28	
CAMPC03	8/11/2008	46.33231	-113.28517	282	0.08	8.5			8		0.22		3		3.8		32000	200		100			60
CAMPC04	8/11/2008	46.33435	-113.26762	70	0.03	8.5			10		<0.08		<1		0.8		3000	7		50			22
CAMPC01	8/11/2008	46.33915	-113.31172	255	1.04	8.37		<5	7		<0.08		<1	30	0.8		24000	20		20			62
CAMPC-PIPE3A	8/11/2008	46.3311	-113.2873	215		7.65			9		0.09		<1		<0.5		21000	<5		20			51
CAMPC-PIPE3B	8/11/2008	46.3311	-113.2873	245		7.75			9		0.14		<1		<0.5		25000	<5		20			56
CAMPC-PIPE3C	8/11/2008	46.3311	-113.2873	221		7.87			11		<0.08		<1		<0.5		22000	<5		<10			52
CAMPC02	5/28/2009	46.3313	-113.2901	267	2.02	8.08			8		1.68		<1		<0.5	27000		7		20	<4000	63	
CAMPC03	5/28/2009	46.33231	-113.28517	299	0.025	8.16			7		1.76		2		2.4	35000		81		80	4000	62	
CAMPC04	5/28/2009	46.33435	-113.26762	38	0.701	7.77			14		3.51		7		40.5	2000		238		760	15000	11	
CAMPC01	5/28/2009	46.33915	-113.31172	103	3.16	8.1		<3	5		1.14		2	140	4.2	10000		41		20	7000	25	
CAMPC-PIPE3A	5/28/2009	46.3311	-113.2873	226	0.22	7.75			9		1.16		<1		<0.5	23000		<5		20	<4000	52	

Table B-2. Metals

Station ID	Actvty Date	Latitude	Longitude	Hrdnes mgL	Flow cfs	pH	D_Al ugL	TR_Sb ugL	TR_As ugL	TR_Ba ugL	TR_Cd ugL	TR_Cr ugL	TR_Cu ugL	TR_Fe ugL	TR_Pb ugL	TR_Mg ugL	D_Mg ugL	TR_Mn ugL	TR_Ni_ ugL	TR_Zn ugL	TSS ugL	TR_Ca mgl	D_Ca mgl
CAMPC-PIPE3B	5/28/2009	46.3311	-113.2873	256	0.12	7.83			9		2.36		<1		<0.5	27000		<5		20	<4000	58	
CAMPC-PIPE3C	5/28/2009	46.3311	-113.2873	249	0.008	8.01			11		0.96		<1		<0.5	26000		<5		<10	<4000	57	
C02TMKMA01	6/9/2009	46.3319	-113.2612	224	0.09	6.9		<1	8	14	21.5	<1	22	1140	0.5			3070	<10	11500	5800		
MCKAY-ADIT	8/19/2009	46.3319	-113.2612	226	0.65	6.85					17		15	940	0.7	10000		2580		9320	10000	73	
CAMPC02	8/19/2009	46.3313	-113.2901	258	1.5	7.67			8		0.12		<1		<0.5	26000		8		20	<4000	60	
CAMPC03	8/19/2009	46.33231	-113.28517	284	0.06	7.65			7		0.2		2		2.5	33000		78		100	<4000	60	
CAMPC04	8/19/2009	46.33435	-113.26762	118	0.6	7.31			5		2.35		2		3.8	6000		26		2110	<4000	38	
CAMPC01	8/19/2009	46.33915	-113.31172	111	1.64	7.66		<3	6		0.12		3	170	3.2	11000		66		30	8000	26	
CAMPC-PIPE3A	8/19/2009	46.3311	-113.2873	216	0.12	7.17			9		0.09		<1		<0.5	22000		<5		10	<4000	50	
CAMPC-PIPE3B	8/19/2009	46.3311	-113.2873	243	0.07	7.17			9		0.16		<1		<0.5	26000		<5		20	<4000	55	
CAMPC-PIPE3C	8/19/2009	46.3311	-113.2873	237	0.022	7.18			11		<0.08		<1		<0.5	25000		<5		<10	<4000	54	
DOUGLASC-H01	8/31/2007	46.54995	-113.21549	157	1.65	8.25		<1	3	66	<0.08	<1	<1	160	<0.5		9050	14	<10	6.3	6200		47.9
DOUGLASC-H01	5/20/2008	46.54995	-113.21549	114	2	6.74		<5	<3		0.17		2	890	1.2		6000	52		20	22000		36
DOUGLASC-H01	8/14/2008	46.54995	-113.21549	130	4.73			<5	4		0.12		<1	300	<0.5			16		10			
C02UPCMA01	6/11/2009	46.4799	-113.1071	60.4	1.3	8.2		<1	1	<5	<0.08	<1	<1	<10	<0.5			<5	<10	<1	<1000		
DOUGLASC-H02.5	8/25/2009	46.5013	-113.1712								0.23		1	70		6000				20		38	
DOUGLASC-H02.5	8/25/2009	46.5013	-113.1712	119	9.9	8.28																	
DOUGLASC-H01	5/28/2009	46.5498	-113.2155	130	9.7				<3				5	1430	1.8	6000		56		50			
DOUGLASC-P02	8/23/2007	46.31489	-113.28572	251	0.73	7.1		5	155	23	2.77	<1	12	1950	<0.5		15800	11200	<10	1970	23100		74.7
DOUGLASC-P04	8/29/2007	46.30782	-113.2418	21.3	0.5	7.74		<1	2	33	<0.08	<1	<1	40	<0.5		1190	<5	<10	0.6	<1000		6.56
DOUGLASC-P04	5/19/2008	46.30782	-113.2418	16	1.2	5.58			<3		<0.08		1	870	0.6	<1000		23		<10		5	
Doug_pberg_5	5/19/2008	46.3109	-113.2442	20	1.05 (f)	5.46			6		<0.08		1	230	0.5	1000		10		10			
DOUGLASC-P02	5/21/2008	46.31489	-113.28572	65	4.3	6.1			119		0.3		8	1080	20.7	4000		1280		200		20	
DOUGLASC-P01	7/8/2008	46.3303	-113.3094	81	3.31	6.8		<5	56		0.23		3	430	11	4000		752		180		26	
DOUGLASC-P02	8/12/2008	46.31489	-113.28572	137	1.33	3.7			72		0.94		2	280	0.7		8000	5430		890			42
DOUGLASC-P04	8/12/2008	46.30782	-113.2418	23	0.005	4.76			<3		<0.08		<1	200	<0.5		1000	18		<10			8
DOUGLASC-P01	6/2/2009	46.3303	-113.3094	51	5.1	7.53		7	83		1.8		12	810	40.2	3000		1160		350	17000	15	
DOUGLASC-P02	6/2/2009	46.31489	-113.28572	57	3.02	7.39			101		1.19		7	560	18.7	3000		952		170	8000	18	
DOUGLASC-P04	6/2/2009	46.30782	-113.2418	14	0.75	7.55			<3		1.01		<1	210	<0.5	<1000		8		<10	<4000	4	
DOUGLASC-P05	6/2/2009	46.3101	-113.2437	15	1.52	7.39			6		1		<1	130	0.5	<1000		6		<10	<4000	4	
C02FRSTC01	6/9/2009	46.3229	-113.2901	38.9	2.97	7.7		1	7	31	0.18	<1	3	260	15.4			216	<10	99	10400		
C02GRNTD01	6/9/2009	46.3098	-113.2734	288	0.38	6.7		4	353	10	1.02	<1	2	2190	0.6			14600	<10	1710	2000		
DOUGLASC-P01	8/18/2009	46.3303	-113.3094	111	2.28	7.53		3	43		0.27		2	320	4.1	7000		1610		340	6000	33	
DOUGLASC-P02	8/18/2009	46.31489	-113.28572	148	1.54	7.36			72		0.6		2	470	0.8	9000		4440		690	<4000	45	
DOUGLASC-P04	8/18/2009	46.30782	-113.2418	25	0.033	7.47			<3		<0.08		<1	300	<0.5	1000		40		<10	<4000	8	
DOUGLASC-P05	8/18/2009	46.3101	-113.2437	24	1	7.1			7		<0.08		<1	<30	<0.5	1000		<5		<10	<4000	7	
GRANITED01	8/18/2009	46.313	-113.2825	367	0.26	6.57		5	513		2.63		7	6090	0.8	21000		19300		2820	13000	112	
FROSTC01	8/19/2009	46.3229	-113.2901	58	0.81	7.52			5				<1		2.6	5000				30	<4000	16	
C02NDPMA01	6/9/2009	46.3129	-113.2332	24.2	0.14	7.6																	
NEWDEPART-ADIT	8/18/2009	46.3129	-113.2332	24	0.25	6.54																	
FLINTC01	9/3/2007	46.65334	-113.1474	273	37	8.64		<1	14	136	<0.08	<1	1	80	0.5		21400	64	<10	3.3	2260		73.9
FLINTC01	5/23/2008	46.65334	-113.1474	89	367	7.27		<5	14		0.11		8	1250	9.9		7000	197	<10	40	49000		24
FLINTC01	9/5/2008	46.65334	-113.1474	179	176	8.08		<5	11		<0.08		2	290	2.8		13000	97		10	7000		49

Table B-2. Metals

Station ID	Actvty Date	Latitude	Longitude	Hrdnes mgL	Flow cfs	pH	D_Al ugL	TR_Sb ugL	TR_As ugL	TR_Ba ugL	TR_Cd ugL	TR_Cr ugL	TR_Cu ugL	TR_Fe ugL	TR_Pb ugL	TR_Mg ugL	D_Mg ugL	TR_Mn ugL	TR_Ni_ ugL	TR_Zn ugL	TSS ugL	TR_Ca mgl	D_Ca mgl
FLINTC01	6/2/2009	46.65334	-113.1474	85	468	7.55			13		1.32		5	860	9.1	6000		164		30	32000	23	
FLINTC01	8/25/2009	46.65334	-113.1474	182	159	7.78			10				3	340	3.4	14000		99		10	15000	49	
FLINTC04	9/5/2007	46.61159	-113.16109		21.3	8.37																	
FLINTC04	7/10/2008	46.61159	-113.16109	107	197	8.41		<5	16		<0.08		4	360	7.3		7000	130		30	15000		31
FLINTC04	9/4/2008	46.61159	-113.16109	152	127	8.37		<5	12		<0.08		3	300	4		11000	105		20	5000		43
FLINTC04	5/28/2009	46.61159	-113.16109	74	483	7.82			15		2.9		5	900	12.4	5000		201		40	37000	21	
FLINTC04	8/26/2009	46.61159	-113.16109	158	66.8	8.62			10				2	270	4.1	12000		105		10	11000	43	
FLINTC05	8/31/2007	46.55023	-113.21521	189	19.7	8.36		<1	10	131	<0.08	<1	1	50	0.7		14400	36	<10	4.6	1870		51.8
FLINTC05	5/20/2008	46.55023	-113.21521	59	399	6.5		<5	28		0.19		10	1190	28.3		4000	323		60	42000		18
FLINTC05	8/14/2008	46.55023	-113.21521	129	52.6			<5	6		<0.08		1	270	1.5			41		10			
FLINTC05	5/28/2009	46.55023	-113.21521	63	570	7.44			16		2.8		5	670	12.5	5000		171		30	25000	17	
FLINTC05	8/25/2009	46.55023	-113.21521	130	107	7.66			11				3	330	5.7	11000		104		20	12000	37	
FLINTC07	9/4/2007	46.48835	-113.23619	150	73.7	8.61		<1	13	116	<0.08	<1	2	170	5		12600	107	<10	15.3	7630		39.4
FLINTC07	5/20/2008	46.48835	-113.23619	41	375	5.83		<5	23		0.16		8	1030	20		3000	250		50	34000		12
FLINTC07	9/3/2008	46.48835	-113.23619	110	149	8.34		<5	12		<0.08		3	330	5.6		8000	91		20	12000		30
FLINTC07	6/3/2009	46.48835	-113.23619	59	465	7.72			14		1.12		4	580	10.4	4000		144		30	17000	16	
FLINTC07	8/25/2009	46.48835	-113.23619	120	179	8.12			11		0.1		3	370	6.4	10000		104		20	14000	31	
FLINTC08	8/28/2007	46.4706	-113.24037	151	100E	8.47		<1	14	122	<0.08	<1	3	160	4.9		13200	104	<10	12.8	7450		38.5
FLINTC08	5/21/2008	46.4706	-113.24037	65	202	6.64		<5	46		<0.08		12	1480	37.3		6000	565		110	64000		17
FLINTC08	8/13/2008	46.4706	-113.24037		88.2																		
FLINTC08	9/4/2008	46.4706	-113.24037	124		8.48		<5	16		<0.08		4	420	7.8		10000	129		20	10000		33
FLINTC08	5/27/2009	46.4706	-113.24037	84	305	7.27			34		1.08		13	1200	29.4	8000		384		90	52000	21	
FLINTC08	8/19/2009	46.4706	-113.24037	123	175	8.33			13				3	460	8.1	11000		142		30	21000	31	
FLINTC15	8/20/2007	46.22021	-113.28443	93.7	32.2	8.67		<1	3	24	<0.08	<1	<1	60	<0.5		10800	23	<10	2.4	<1000		19.7
FLINTC12	8/21/2007	46.31686	-113.33273	139	65.9	8.41		<1	4	113	<0.08	<1	1	130	<0.5		12200	16	<10	2.1	6900		35.5
FLINTC14	8/21/2007	46.2455	-113.33242		12.7	8.02																	
FLINTC11	8/24/2007	46.3386	-113.3211	141	59.8	8.67		<1	9	112	<0.08	<1	1	200	1.9		12400	42	<10	5.4	9200		36
FLINTC09	8/26/2007	46.39398	-113.30857	146	66.2	8.73		<1	12	116	<0.08	<1	2	160	3.3		12700	78	<10	8.5	6620		37.6
FLINTC08	8/28/2007	46.4706	-113.24037	151		8.47		<1	14	122	<0.08	<1	3	160	4.9		13200	104	<10	12.8	7450		38.5
FLINTC10	9/4/2007	46.36751	-113.31714	155	60	8.06		<1	13	120	<0.08	<1	1	190	3.7		13400	79	<10	9.5	7530		39.9
FLINTC13	5/19/2008	46.2768	-113.337	123	46.1	7.94		<5	<3		<0.08		1	230	<0.5		10000	27		<10	<4000		32
FLINTC15	5/19/2008	46.22021	-113.28443	118	47.5	6.95		<5	<3		<0.08		<1	120	<0.5		11000	110		<10	<4000		30
FLINTC10	5/20/2008	46.36751	-113.31714	69	163	6.15		<5	26		<0.08		4	650	11		6000	150		30	22000		18
FLINTC14	5/20/2008	46.2455	-113.33242	114	55.8	6.11		<5	<3		<0.08		<1	200	<0.5		11000	28		<10	4000		28
FLINTC08	5/21/2008	46.4706	-113.24037	65	202	6.64		<5	46		<0.08		12	1480	37.3		6000	565		110	64000		17
FLINTC09	5/21/2008	46.39398	-113.30857	56	163	6.11		<5	24		0.09		5	870	12.9		5000	190		40	24000		15
FLINTC11	5/21/2008	46.3386	-113.3211	61	160	6.12		<5	25		<0.08		3	720	9.2		5000	137		30	22000		16
FLINTC09	8/13/2008	46.39398	-113.30857	120	88			<5	14		<0.08		2	360	6.5			115		20			
FLINTC10	8/13/2008	46.36751	-113.31714	123	81.9			<5	11		<0.08		2	250	3.5			62		10			
FLINTC11	8/13/2008	46.3386	-113.3211	108	81.4			<5	8		<0.08		<1	260	1.5			30		<10			
FLINTC13	8/13/2008	46.2768	-113.337	108	11.8			<5	4		<0.08		<1	100	<0.5			28		20			
FLINTC14	8/13/2008	46.2455	-113.33242	95	24.1			<5	4		<0.08		<1	100	<0.5			37		<10			
FLINTC15	8/18/2008	46.22021	-113.28443	89	34.8			<5	<3		<0.08		<1	70	<0.5			27		5.82			
FLINTC08	9/4/2008	46.4706	-113.24037	124	missing	8.48		<5	16		<0.08		4	420	7.8		10000	129		20	10000		33
FLINTC08	5/27/2009	46.4706	-113.24037	84	305	7.27			34		1.08		13	1200	29.4	8000		384		90	52000	21	

Table B-2. Metals

Station ID	Actvty Date	Latitude	Longitude	Hrdnes mgL	Flow cfs	pH	D_Al ugL	TR_Sb ugL	TR_As ugL	TR_Ba ugL	TR_Cd ugL	TR_Cr ugL	TR_Cu ugL	TR_Fe ugL	TR_Pb ugL	TR_Mg ugL	D_Mg ugL	TR_Mn ugL	TR_Ni_ ugL	TR_Zn ugL	TSS ugL	TR_Ca mgl	D_Ca mgl
FLINTC09	5/28/2009	46.39398	-113.30857	65	253	7.85			21		2.45		3	590	9.7	6000		117		30	23000	17	
FLINTC10	5/28/2009	46.36751	-113.31714	71	273	8.04			23		0.98		4	620	10.3	6000		116		30	22000	18	
FLINTC11	5/28/2009	46.3386	-113.3211	65	226	7.87			20		2.13		3	560	6	6000		62		10	18000	17	
FLINTC13	6/2/2009	46.2768	-113.337	112	42.4	7.91					0.99			220		11000		24			7000	28	
FLINTC14	6/3/2009	46.2455	-113.33242	110	26.5	7.79					2.07			270		10000		31			6000		
FLINTC15	6/3/2009	46.22021	-113.28443	110	53.3	7.56					1.09			120		10000		28				28	
FLINTC08	8/19/2009	46.4706	-113.24037	123	175	8.33			13				3	460	8.1	11000		142		30	21000	31	
FLINTC13	8/24/2009	46.2768	-113.337	118	44.6	7.95							1	150		10000		30			9000	22	
FLINTC14	8/24/2009	46.2455	-113.33242	97	52.3	7.81							1	130		10000		36			5000	22	
FLINTC15	8/24/2009	46.22021	-113.28443	92	60.9	7.78							1	120		10000		43				21	
FLINTC09	8/25/2009	46.39398	-113.30857	118	146	8.1			9				2	320	4.4	10000		84		10	17000	30	
FLINTC10	8/25/2009	46.36751	-113.31714	119	137	8.2			8				2	270	3.5	11000		65		10	14000	30	
FLINTC11	8/25/2009	46.3386	-113.3211	120	135	8.1			5				1	240	1.4	10000		30			14000	31	
TROUTC01	8/23/2007	46.25622	-113.35876	128	41.3	6.98		<1	2	113	<0.08	<1	<1	150	<0.5		11400	23	<10	1.5	8200		32.6
TROUTC01	5/19/2008	46.25622	-113.35876	111	25	7.8		<5	<3		<0.08		<1	340	<0.5		9000	20		<10	10000		29
TROUTC01	8/13/2008	46.25622	-113.35876	118	72.2			<5	<3		<0.08		<1	260	<0.5			23		<10			
TROUTC01	6/2/2009	46.25622	-113.35876		22.6	7.21																	
TROUTC01	8/18/2009	46.25622	-113.35876		64.9	7.77																	
NFFLINTC01	5/19/2008	46.19833	-113.26616	61				<5	<3		<0.08		2	720	<0.5		4000	25		<10	12000		18
NFFLINTC01	5/19/2008	46.19833	-113.26616		32	6.4																	
NFFLINTC01	8/18/2008	46.19833	-113.26616	103	4.98																		
NFFLINTC01	8/20/2007	46.19833	-113.26616		3.78	8.46																	
STEWARTMILLC01	8/20/2007	46.16618	-113.26878		9.4	7.64																	
LONDONADIT01	8/28/2007	46.4706	-113.2406	156				4	1120	235	0.85	<1	29	1910	120		13900	1520	<10	288	182000		39.8
LONDONADIT01	5/27/2009	46.4706	-113.2406	350	0.033	6.41		5	1150		7.51		4	12600	1	35000		1980	30	4830	16000	82	
LONDONADIT01	8/19/2009	46.4706	-113.2406	343	0.027	6.2		7	2110		1.86		<1	21500	0.5	35000		2250	20	2960	24000	80	
FREDBURRC02	8/22/2007	46.29043	-113.26235	26.1	1.64	6.84		<1	8	23	<0.08	<1	<1	80	<0.5		1450	27	<10	4.8	<1000		8.05
FREDBURRC01	8/22/2007	46.2994	-113.33025	65.6	0.27	7.42		<1	85	62	<0.08	<1	1	900	<0.5		3960	186	<10	6.2	1500		19.7
FREDBURRC03	8/23/2007	46.29223	-113.2429	22.1	1.15	6.55		<1	1	19	<0.08	<1	<1	10	<0.5		1170	<5	<10	0.8	<1000		6.91
FREDBURRC02	5/19/2008	46.29043	-113.26235	11	50	5.44			15		<0.08		2	220	1.1	<1000		28		10		4	
FREDBURRC03	5/19/2008	46.29223	-113.2429	21	50	5.35			<3		<0.08		1	150	<0.5	<1000		9		<10		4	
FREDBURRC01	5/19/2008	46.2994	-113.33025	17	71.7	5.36		<5	26		<0.08		3	270	8.2	<1000		50		20		4	
FREDBURRC02	8/12/2008	46.29043	-113.26235	19	2.66	8.41			6		<0.08		<1	70	<0.5		<1000	25		<10			6
FREDBURRC03	8/12/2008	46.29223	-113.2429	17	2	8.22			<3		<0.08		<1	<30	<0.5		<1000	<5		<10			6
FREDBURRC01	8/12/2008	46.2994	-113.33025	21	0.54	8.58		<5	27		<0.08		1	70	1		1000	9		<10			7
FREDBURRC01	6/2/2009	46.2994	-113.33025	9	94.5	7.35		<3	19		0.98 B		2	200	6	<1000		25		20	<4000	3	
FREDBURRC01	8/18/2009	46.2994	-113.33025	18	4.99	7.43		<3	14		<0.08		2	70	0.7	<1000		0.6		<10	<4000	6	
NFDOUGLASC02	8/30/2007	46.5001	-113.10099	167000	0.32	8.25		<1	2	9	7.31	<1	3	20	<0.5		5520	6	<10	971	<1000		58
NFDOUGLASC01	8/30/2007	46.4895	-113.14219	128000	1.13	8.4		<1	3	21	1.46	<1	3	160	<0.5		4110	14	<10	132	8780		44.6
NFDOUGLASC02	5/23/2008	46.5001	-113.10099	95000	1.73	6.22			4		8.23		48		3.3		3000		10	900	27000		33
NFDOUGLASC01	5/23/2008	46.4895	-113.14219	94000	4.57	7.2			6		8.14		53		8.3		3000		20	1070	115000		32
NFDOUGLASC03	5/23/2008	46.4985	-113.0957	145000	0.21	4.7			<3		107		646		<0.5		5000		70	9880	25000		50
NFDOUGLASC02	8/11/2008	46.5001	-113.10099	109000	1.25	8.24			<3		1.9		2		<0.5		3000		<10	250	<4000		39
NFDOUGLASC01	8/11/2008	46.4895	-113.14219	111000	1.35	8.93			<3		1.57		4		0.7		3000		<10	140	<4000		39
NFDOUGLASC03	8/11/2008	46.4985	-113.0957	108000	0.002	6.66			<3		77.8		100		0.8		4000		70	4990	<4000		37

Table B-2. Metals

Station ID	Actvty Date	Latitude	Longitude	Hrdnes mgL	Flow cfs	pH	D_Al ugL	TR_Sb ugL	TR_As ugL	TR_Ba ugL	TR_Cd ugL	TR_Cr ugL	TR_Cu ugL	TR_Fe ugL	TR_Pb ugL	TR_Mg ugL	D_Mg ugL	TR_Mn ugL	TR_Ni_ ugL	TR_Zn ugL	TSS ugL	TR_Ca mgl	D_Ca mgl
NFDOUGLASC02	5/28/2009	46.5001	-113.10099	102	1.1	7.12			<3		24.2		56		0.8	3000			20	2270	5000	35	
NFDOUGLASC03	5/28/2009	46.4985	-113.0957	83	0.6	5.97			<3		47.3		197		<0.5	3000			30	4240	<4000	28	
NFDOUGLASC02	8/24/2009	46.5001	-113.10099		1	7.95			<3		7.48		4		<0.5	5000			<10	1110	<4000	52	
SFLWILLOWC04	9/1/2007	46.46409	-113.39193	20	0.78	7.62		3	2	79	0.12	<1	19	100	0.8		2320	7	<10	7.1	2000		4.19
SFLWILLOWC02	9/1/2007	46.50337	-113.37806	20.9	2.17	7.57		10	5	75	0.16	<1	12	110	2.7		2600	10	<10	20.1	2400		4.08
SFLWILLOWC01	9/1/2007	46.5518	-113.32584	35.5	0.87	8.02		17	35	98	0.12	<1	32	690	8.4		4080	17	<10	9.4	2000		7.51
SFLWILLOWC02	6/9/2008	46.50337	-113.37806	10				<5	<3		0.14		18	480	3.8		1000	7	<10	20			2
SFLWILLOWC01	6/9/2008	46.5518	-113.32584	13				11	6		0.21		30	620	15.9		1000	20	<10	30			3
SFLWILLOWC05	7/8/2008	46.4556	-113.3926	11	2.77	5.82		<5	<3		<0.08		1	170	<0.5	<1000				<10		3	
SFLWILLOWC04.5	7/8/2008	46.4578	-113.3909	15	0.08	5.32		<5	<3		0.11		21	1380	3.4	1000				20		4	
SFLWILLOWC04	7/8/2008	46.46409	-113.39193	18	5.2	5.68		<5	<3		0.15		13	230	1.8	1000				30		5	
SFLWILLOWC03	7/8/2008	46.4839	-113.3907	13	5.13	5.8		5	<3		0.16		17	190	2.2	1000				20		3	
SFLWILLOWC02	7/10/2008	46.50337	-113.37806	20	6.2	8.2		10	5		0.1		20	210	5.5	2000				20		5	
SFLWILLOWC01	7/10/2008	46.5518	-113.32584	19	8.16	7.59		12	8		<0.08		20	240	4.8	2000				10		4	
SFLWILLOWC05	8/11/2008	46.4556	-113.3926	13	1.34	6.25		<5	<3		<0.08		1	100	<0.5		1000			<10			3
SFLWILLOWC04.5	8/11/2008	46.4578	-113.3909	11	0.013	7.26		<5	4		0.11		20	970	3.7		<1000			10			3
SFLWILLOWC04	8/11/2008	46.46409	-113.39193	12	1.8	7.93		<5	<3		0.16		15	100	2.4		1000			20			3
SFLWILLOWC03	8/11/2008	46.4839	-113.3907	12	2.23	8.22		8	4		0.2		18	60	1.8		1000			20			3
SFLWILLOWC02	8/11/2008	46.50337	-113.37806	19	4.09	8.09		11	7		0.12		15	160	4.6		2000			20			4
SFLWILLOWC01	8/11/2008	46.5518	-113.32584	22	1.12	8.17		14	13		<0.08		17	170	2.7		2000			<10			5
SFLWILLOWC05	5/27/2009	46.4556	-113.3926	6	51.6	5.96		<3	<3		1.48		2	170	<0.5	<1000				<10	<4000	1	
SFLWILLOWC04.5	5/27/2009	46.4578	-113.3909	14	3.5	6.31		3	<3		0.89		20	1370	3.1	1000				<10	<4000	3	
SFLWILLOWC04	5/27/2009	46.46409	-113.39193	6	59	5.79		<3	<3		1.94		6	220	1.4	<1000				<10	4000	1	
SFLWILLOWC03	5/27/2009	46.4839	-113.3907	6	79	6.12		8	<3		1.12		20	260	12.9	<1000				<10	<4000	1	
SFLWILLOWC02	5/27/2009	46.50337	-113.37806	8	98.1	6.49		17	7		1.15		40	490	30.8	<1000				20	10000	2	
SFLWILLOWC01	5/27/2009	46.5518	-113.32584	9	147	6.01		21	8		1.25		48	630	39.7	1000				30	23000	2	
SFLWILLOWC05	8/20/2009	46.4556	-113.3926	15	6	8.11		<3	<3		<0.08		1	130	<0.05	2000				<10	<4000	3	
SFLWILLOWC04	8/20/2009	46.46409	-113.39193	13	6	8.17		5	<3		<0.08		16	100	1.6	2000				10	<4000	3	
SFLWILLOWC03	8/20/2009	46.4839	-113.3907	14	8	7.71		9	4		0.1		19	70	2.3	2000				20	<4000	3	
SFLWILLOWC02	8/20/2009	46.50337	-113.37806	21	10	7.73		13	7		<0.08		17	190	6.1	2000				10	<4000	4	
SFLWILLOWC01	8/24/2009	46.5518	-113.32584	26	1.4	7.09		14	11		0.08		21	380	4.6	3000				10	<4000	6	
SFLWILLOWC04.5	8/20/2009	46.4578	-113.3909		dry																		
C02SMRTC02	8/17/2005	46.45355	-113.2907		0.34	8.23	<100	<3	4	149	<0.1	<1	2	20	<0.5		22000	8	<20	<10	<1000		46
C02SMRTC01	8/18/2005	46.49563	-113.24726			8.25	<100	<3	12	112	<0.1	<1	1	60	<0.5		16000	9	<20	<10	3000		50
SMARTC01	9/4/2007	46.51548	-113.2355	276	1.06	7.97		<1	14	149	<0.08	<1	3	330	<0.5		18400	37	<10	3.8	19000		80.2
SMARTC03	5/22/2008	46.45434	-113.28931	54	2.8	6.75											5000				31000		14
SMARTC02	5/22/2008	46.49645	-113.24658	81	5.85	6.87											7000				42000		22
SMARTC01	5/22/2008	46.51548	-113.2355	80	5.44	7.51		<5	7		<0.08		7	2190	1.9		6000	65		20	64000		21
SMARTC01	8/21/2008	46.51548	-113.2355	169	1.1			<5	9		<0.08		2	320	<0.5		15000	9		<10	13000		44
SMARTC01	6/2/2009	46.51548	-113.2355	167	5.3	7.64			19		1.49		6	1470	1.6	11000		91		10	53000	48	
SMARTC01	8/26/2009	46.51548	-113.2355	239	8.4	8.23			14		0.12		3	370		16000		46			14000	69	
SMARTC01	8/26/2009	46.51548	-113.2355																				

APPENDIX C – REGULATORY FRAMEWORK AND REFERENCE CONDITION APPROACH

This appendix presents details about applicable Montana Water Quality Standards (WQS) and the general and statistical methods used for development of reference conditions.

C1.0 TMDL DEVELOPMENT REQUIREMENTS

Waterbodies, or individual waterbody segments where streams have been split into multiple segments, can become impaired from a variety of causes defined as either pollutants or non-pollutants. Pollutants include sediment, temperature or specific types of nutrients or metals. Non-pollutants include flow alterations and different forms of habitat degradation. Section 303 of the Federal CWA and the Montana WQA (Section 75-5-703) require development of TMDLs for impaired waterbodies where one or more pollutants are the cause of impairment within the waterbody segment of interest.

Section 303(d) requires states to submit a list of impaired waterbodies in need of TMDL development to EPA every two years. This list is referred to the 303(d) list, and only includes waterbodies with impairment causes linked to a pollutant as defined under the CWA. The 303(d) list also includes the suspected source(s) of the pollutants of concern such as various land use activities. Prior to 2004, EPA and DEQ defined the 303(d) list as the list of all impaired waterbodies and associated impairment causes (pollutants and non-pollutants), versus just those waters with impairment causes linked to pollutants. Montana integrates the 303(d) list within the 305(b) report, which contains an assessment of Montana's water quality, information on streams impaired by non-pollutants, TMDL development status, and a description of Montana's water quality programs. This 305(b) report is also referred to as the Integrated Water Quality Report.

Under Montana state law, an "impaired waterbody" is defined as a waterbody or stream segment for which sufficient credible data show that the waterbody or stream segment is failing to achieve compliance with applicable WQS (Montana Water Quality Act; Section 75-5-103(11)). State law (MCA 75-5-702) identifies that a sufficient credible data methodology for determining the impairment status of each waterbody is used for consistency; the actual methodology is identified in DEQ's Water Quality Assessment Process and Methods (Montana Department of Environmental Quality, 2006). This methodology was developed via a public process and was incorporated into the EPA-approved 2000 version of the 305(b) report.

A "threatened waterbody" is defined as a waterbody or stream segment for which sufficient credible data and calculated increases in loads show that the waterbody or stream segment is fully supporting its designated uses, but threatened for a particular designated use because of either (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit, the nondegradation provisions, or reasonable land, soil, and water conservation practices or (b) documented adverse pollution trends (Montana WQA; Section 75-5-103(31)). State law and Section 303 of the CWA also require TMDL development for waterbodies threatened by a pollutant cause. There are no threatened waterbodies within the Flint Creek TPA.

A TMDL is a pollutant budget for a waterbody identifying the maximum amount of the pollutant that a waterbody can assimilate without causing applicable WQS to be exceeded. TMDLs are often expressed in terms of an amount, or mass, of a particular pollutant over a particular time period (e.g. pounds of total nitrogen per day). TMDLs can also be expressed in other appropriate measures such as a percent reduction in pollutant loading. TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources and must incorporate a margin of safety and consider influences of seasonality on analysis and compliance with WQS.

To satisfy the Federal CWA and Montana state law, TMDL development will eventually be needed for each waterbody-pollutant combination identified on Montana's 2010 303(d) List of impaired waters in the Flint Creek TPA, unless new data and associated analyses is sufficient to remove a pollutant cause of impairment from one or more waterbodies. State law (Administrative Rules of Montana 75-5-703(8)) also directs Montana DEQ to "...support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for waterbodies that are subject to a TMDL…" This is an important directive that is reflected in the overall TMDL development and implementation strategy within this plan. It is important to note that water quality protection measures are not considered voluntary where such measures are already a requirement under existing federal, state, or local regulations.

C2.0 APPLICABLE WATER QUALITY STANDARDS

Water Quality Standards (WQS's) include the uses designated for a waterbody, the legally enforceable standards that ensure that the uses are supported, and a nondegradation policy that protects the high quality of a waterbody. The ultimate goal of this TMDL document, once implemented, is to ensure that all designated beneficial uses are fully supported and all standards are met. Water quality standards form the basis for the targets described in **Sections 5.0 and 6.0**. This section provides a summary of the applicable water quality standards for sediment and metals. The sediment TMDLs presented in this document also inherently address the additional non-pollutant causes of impairment identified in **Section 1**, **Table 1-1**.

C2.1 CLASSIFICATION AND BENEFICIAL USES

Classification is the assignment (designation) of a single or 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. There are a variety of "uses" of state waters including growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. The Montana Water Quality Act directs the Board of Environmental Review (BER) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (§ 75-5-301(1),MCA) and to adopt standards to protect those uses ((§ 75-5-301(1),MCA).

Montana, unlike many other states, uses a watershed based classification system with some specific exceptions. As a result, *all* waters of the state are classified and have designated uses and supporting standards. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that waterbody must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source

discharges or nonpoint source activities or pollutant discharges may not make the natural conditions worse.

Modification of classifications or standards that would lower a water's classification or a standard (i.e., B-1 to a B-3), or removal of a designated use because of natural conditions can only occur if the water was originally misclassified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet EPA requirements (40 CFR 131.10(g), (h) and (j)). The UAA and findings presented to the BER during rulemaking must prove that the modification is correct and all existing uses are supported. An existing use cannot be removed or made less stringent.

Descriptions of Montana's surface water classifications and designated beneficial uses are presented in **Table C-1**. All waterbodies within the Flint Creek TPA are classified as B-1, except for Georgetown Lake, which is classified as A-1. Georgetown Lake is within the Flint Creek TPA but is listed as "Fully Supporting" all beneficial uses.

Table C-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED CLASSIFICATION:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1 CLASSIFICATION:	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.
B-1 CLASSIFICATION:	Waters classified 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.
B-2 CLASSIFICATION:	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3 CLASSIFICATION:	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1 CLASSIFICATION:	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2 CLASSIFICATION:	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3 CLASSIFICATION:	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply. Degradation which will impact established beneficial uses will not be allowed.
I CLASSIFICATION:	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

C2.2 NUMERIC AND NARRATIVE WATER QUALITY STANDARDS

In addition to the Use Classifications described above, Montana's WQS include numeric and narrative criteria as well as a nondegradation policy.

Numeric surface WQS have been developed for many parameters to protect human health and aquatic life. Most of these standards are contained within the Department Circular WQB-7 (Montana Department of Environmental Quality, 2010). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., lifelong) exposures as well as through direct contact such as swimming.

The numeric aquatic life standards include chronic and acute values that are based on extensive laboratory studies including a wide variety of potentially affected species, a variety of life stages and durations of exposure. Chronic aquatic life standards are protective of long-term exposure to a parameter. The protection afforded by the chronic standards includes detrimental effects to reproduction, early life stage survival and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective of short-term exposures to a parameter and are not to be exceeded.

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface WQS. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a waterbody. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi, and algae.

The standards applicable to the list of pollutants addressed in the Flint Creek TPA are summarized below.

Sediment

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table C2**. The standards applicable to a B-1 classification are used in **Table C-2** and are the same for A-1 classification unless otherwise noted within **Table C-2**. The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a condition in which any increases in sediment above naturally occurring levels are not harmful, detrimental or injurious to beneficial uses (see definitions in **Table C-2**). Naturally occurring levels are evaluated using a reference approach as defined in **Section C-3**.

Table C-2. Applicable Water Quality Standards for Sediment

Rule(s)	Standard or Definition
17.30.623(2) [B-1 classification section number; same language applies for A-1 classification]	No person may violate the following specific water quality standards for waters classified B-1:
17.30.623(2)(f) [B-1 classification section number; same language applies for A-1 classification]	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.623(2)(d) [B-1 classification]	The maximum allowable increase above naturally occurring turbidity five nephelometric turbidity units except at permitted in 75-5-318, MCA. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.622(3)(d) [A-1 classification]	No increase above naturally occurring turbidity or suspended sediment is allowed except at permitted in 75-5-318, MCA. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.637(1 a & d) [this section applies to B-1 and A-1 classifications)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; ….. and (d) create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
17.30.602 (same definitions for A-1 and B-1 classifications)	DEFINITIONS
	"Sediment" means solid material settled from suspension in a liquid; mineral or organic solid material that is being transported or has been moved from its site of origin by air, water, or ice and has come to rest on the earth's surface, either above or below sea level; or inorganic or organic particles originating from weathering, chemical precipitation, or biological activity.
	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.

Turbidity

Turbidity is a measure of light scatter in water. Suspended or colloidal solids like phytoplankton, metal precipitates or clay may cause the light scatter. As identified in **Table C-2**, the allowable change in turbidity (above naturally occurring levels) is 5 nephelometric turbidity units (NTUs) for a B-1 stream, and no increase above naturally occurring for an A-1 stream. The likely direct effects of increased turbidity are on recreation and aesthetics as well as drinking water supplies. Increased turbidity can

indirectly be linked to potential increased concentrations in pathogens, total recoverable metals and total suspended sediment. In some cases it may be a useful surrogate for total suspended solids (TSS) based on a statistical correlation between paired turbidity and TSS data collected during varying flow conditions; preferably a full hydrograph for the stream of interest.

Metals

There are both numeric and narrative water quality standards that can be applied for evaluating metals impairment and setting TMDL targets. The numeric water quality standards are derived from numeric criteria contained within Department Circular DEQ-7. **Table C-3** identifies the numeric criteria for the metals of concern in the Flint TPA. These criteria are the same for waters classified as A-1 and B-1. As aquatic life water quality criteria for many metals is dependent upon water hardness, **Table C-3** presents acute and chronic numeric water quality criteria at water hardness ranging from 25 mg/L to 100 mg/L. Also presented in **Table C-3** are the Human Health Criteria (HHC): note that for mercury and arsenic, the HHC is lower than applicable aquatic life chronic criteria.

Table C-3. Metals Numeric Water Quality Criteria for the Flint TMDL Planning Area

Metal of Concern	Aquatic Life Criteria (ug/L) at 25 mg/L Hardness		Aquatic Life Criteria (ug/L) at 100 mg/L Hardness		HHC
	Acute	Chronic	Acute	Chronic	
Arsenic, TR	340	150	340	150	10
Cadmium, TR	0.52	0.10	2.13	0.27	5
Copper, TR	3.79	2.85	14.00	9.33	1,300
Iron, TR	---	1,000	---	1,000	
Mercury, TR	1.70	0.91	1.70	0.91	0.05
Lead, TR	13.98	0.54	81.65	3.18	15
Antimony, TR	---	---	---	---	6
Zinc, TR	37.02	37.02	119.82	119.82	2,000

In addition to numeric criteria presented above, narrative criteria presented within **Table C-4** also provide protection of beneficial uses. Note that activities or discharges that cause toxic or harmful levels of metals in stream sediment are prohibited via ARM 17.30.637(1)(d). ARM 17.30.623(2)(f) has similar requirements to avoid a nuisance or create undesirable conditions linked to settleable solids. Both criteria can be interpreted to mean that water quality goals should strive toward a condition in which any increases in metals concentration in sediment above naturally occurring levels are not harmful, detrimental or injurious to beneficial uses (see definitions in **Table C-4**).

Development of targets based on the numeric and narrative criteria is presented within **Section 6**. This section also includes an updated evaluation of metals impairment causes by stream segment based on the applicable target values.

Table C-4. Narrative Standards Applicable to Metals Concentrations in Sediment

Rule(s)	Criteria
17.30.623(2) & 17.30.624(2)	No person may violate the following specific water quality standards for waters classified B-1 (B-2 term used for 17.30.624(2)).
17.30.623 (2) (f) & 17.30.624 (2) (f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or

Table C-4. Narrative Standards Applicable to Metals Concentrations in Sediment

Rule(s)	Criteria
	injurious to public health, recreation,
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will.
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.

Sulfate

Sulfate is not considered a metal and there are no numeric criteria for sulfate. The **Table C-4** narrative criteria applied to metals can also be applied for sulfate. Therefore, the sulfate impairment cause and associated target development for North Fork Douglas Creek is addressed via application of the narrative criteria within **Table C-4** and further evaluated within **Section 6**.

C2.3 NONDEGRADATION

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant", or an authorization to degrade must be granted by the Department. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to the waterbody. Although these nondegradation rules are not integrated into TMDL development, they help limit pollutant loading in waters where designated uses are currently satisfied. Some of these waters may be healthy tributaries to waters where a TMDL is developed; thus nondegradation can help implement TMDL related pollutant controls at a watershed scale.

C3.0 REFERENCE CONDITIONS

C3.1 DEQ APPROACH FOR DEFINING A REFERENCE CONDITION

DEQ uses the reference condition to evaluate compliance with many of the narrative WQS. The term "reference condition" is defined as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a waterbody's greatest potential for water quality given historic land use activities. Although sediment water quality targets typically relate most directly to the aquatic life use, the targets are protective of all designated beneficial uses because they are based on the reference approach, which strives for the highest possible condition.

DEQ applies the reference condition approach for making beneficial use-support determinations for certain pollutants (such as sediment) that have specific narrative standards. All classes of waters are subject to the provision that there can be no increase above naturally occurring concentrations of sediment and settleable solids, oils, or floating solids sufficient to create a nuisance or render the water harmful, detrimental, or injurious. These levels depend on site-specific factors, so the reference conditions approach is used.

Montana WQS do not contain specific provisions addressing detrimental modifications of habitat. However, detrimental modifications of habitat may often lead to or result from increases above

naturally occurring concentrations of sediment, etc and therefore the reference condition approach is used to help determine if beneficial uses are supported when habitat modifications are present. The reference approach can also be used to develop riparian and shade target parameters when evaluating temperature.

Waterbodies used to determine reference condition are not necessarily pristine or perfectly suited to giving the best possible support to all possible beneficial uses. Reference condition also does not reflect an effort to turn the clock back to conditions that may have existed before human settlement, but is intended to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology, and other natural physiochemical differences. The intention is to differentiate between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. It attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil, and water conservation practices. DEQ realizes that presettlement water quality conditions usually are not attainable.

Comparison of conditions in a waterbody to reference waterbody conditions must be made during similar season and/or hydrologic conditions for both waters. For example, the Total Suspended Solids (TSS) of a stream at base flow during the summer should not be compared to the TSS of reference condition that would occur during a runoff event in the spring. In addition, a comparison should not be made to the lowest or highest TSS values of a reference site, which represent the outer boundaries of reference conditions. The following methods may be used to determine reference conditions:

Primary Approach

- Comparing conditions in a waterbody to baseline data from minimally impaired waterbodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Evaluating historical data relating to condition of the waterbody in the past.
- Comparing conditions in a waterbody to conditions in another portion of the same waterbody, such as an unimpaired segment of the same stream.

Secondary Approach

- Reviewing literature (e.g. a review of studies of fish populations, etc., that were conducted on similar waterbodies that are least impaired.
- Seeking expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the waterbody's fisheries health or potential).
- Applying quantitative modeling (e.g. applying sediment transport models to determine how much sediment is entering a stream based on land use information, etc.).

DEQ uses the primary approach for determining reference condition if adequate regional or other primary reference data is available, and uses the secondary approach to estimate reference condition when primary approach data is limited or unavailable. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

C3.2 USE OF STATISTICS FOR DEVELOPING REFERENCE VALUES OR RANGES

Reference value development must consider natural variability as well as variability that can occur as part of field measurement techniques. Statistical approaches are commonly used to help incorporate variability. One statistical approach is to compare stream conditions to the mean (average) value of a reference data set to see if the stream condition compares favorably to this value or falls within the range of one standard deviation around the reference mean. The use of these statistical values assumes a normal distribution; whereas, water resources data tend to have a non-normal distribution (Helsel and Hirsch, 1995). For this reason, another approach is to compare stream conditions to the median value of a reference data set to see if the stream condition compares favorably to this value or falls within the range defined by the 25th and 75th percentiles of the reference data. This is a more realistic approach than using one standard deviation since water quality data often include observations considerably higher or lower than most of the data. Very high and low observations can have a misleading impact on the statistical summaries if a normal distribution is incorrectly assumed, whereas statistics based on non-normal distributions are far less influenced by such observations.

Figure C-1 is an example boxplot presentation of the median, 25th and 75th percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include Rosgen stream types, stream size ranges, or geology. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life, then measured values in the potentially impaired stream that fall below the 25th percentile of reference data are not desirable and can be used to indicate impairment. If the parameter being measured is one where high values are undesirable, then measured values above the 75th percentile can be used to indicate impairment.

The use of a non-parametric statistical distribution for interpreting narrative WQS or developing numeric criteria is consistent with EPA guidance for determining nutrient criteria (Buck, et al., 2000) Furthermore, the selection of the applicable 25th or 75th percentile values from a reference data set is consistent with ongoing DEQ guidance development for interpreting narrative WQS where it is determined that there is “good” confidence in the quality of the reference sites and resulting information (Suplee, 2004). If it is determined that there is only a “fair” confidence in the quality of the reference sites, then the 50th percentile or median value should be used, and if it is determined that there is “very high” confidence, then the 90th percentile of the reference data set should be used. Most reference data sets available for water quality restoration planning and related TMDL development, particularly those dealing with sediment and habitat alterations, would tend to be “fair” to “good” quality. This is primarily due to a the limited number of available reference sites/data points available after applying all potentially applicable stratifications on the data, inherent variations in monitoring results among field crews, the potential for variations in field methodologies, and natural yearly variations in stream systems often not accounted for in the data set.

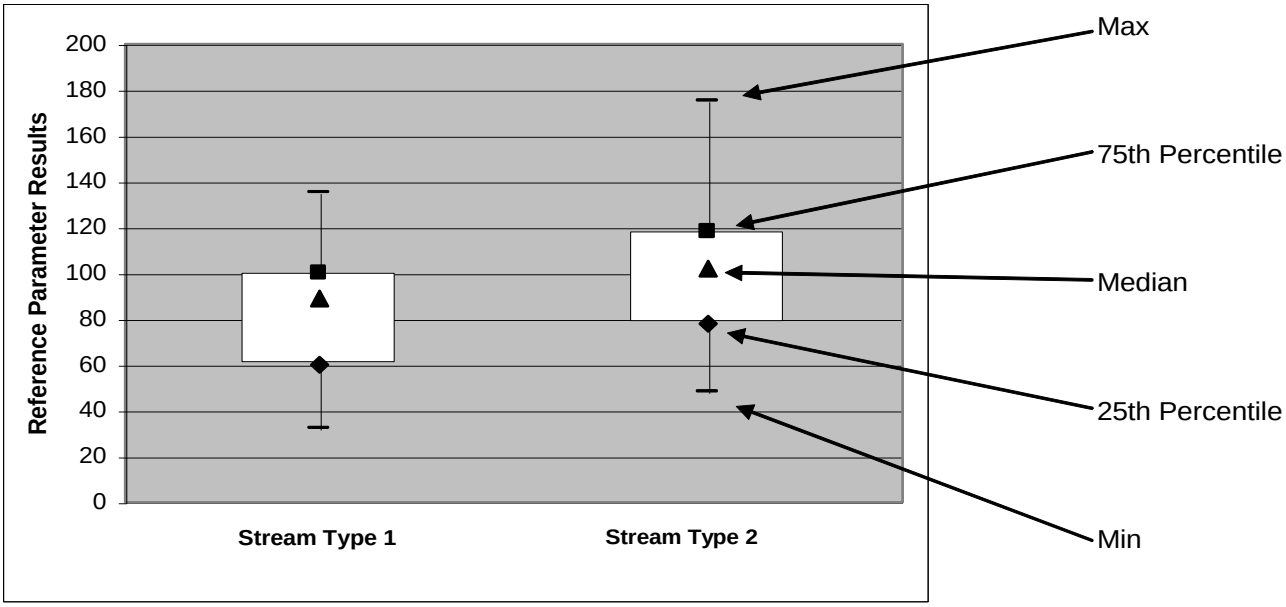


Figure C-1. Boxplot Example for Reference Data.

The above 25th – 75th percentile statistical approach has several considerations:

1. It is a simple approach that is easy to apply and understand.
2. About 25 percent of all streams would naturally fall into the impairment range. Thus, it should not be applied unless there is some linkage to human activities that could lead to the observed conditions. Where applied, it must be noted that the stream's potential may prevent it from achieving the reference range as part of an adaptive management plan.
3. About 25 percent of all streams would naturally have a greater water quality potential than the minimum water quality bar represented by the 25th to 75th percentile range. This may represent a condition where the stream's potential has been significantly underestimated. Adaptive management can also account for these considerations.
4. Obtaining reference data that represents a naturally occurring condition can be difficult, particularly for larger waterbodies with multiple land uses within the drainage. This is because all reasonable land, soil, and water conservation practices may not be in place in many larger waterbodies across the region. Even if these practices are in place, the proposed reference stream may not have fully recovered from past activities, such as riparian harvest, where reasonable land, soil, and water conservation practices were not applied.
5. A stream should not be considered impaired unless there is a relationship between the parameter of concern and the beneficial use such that not meeting the reference range is likely to cause harm or other negative impacts to the beneficial use as described by the WQS in **Table C2-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, coldwater fish, or other beneficial uses, then an impairment determination should not be made based on the particular parameter being evaluated. Relationships that show an impact to the beneficial use can be used to justify impairment based on the above statistical approach.

As identified in (2) and (3) above, there are two types of errors that can occur due to this or similar statistical approaches where a reference range or reference value is developed: (1) A stream could be

considered impaired even though the naturally occurring condition for that stream parameter does not meet the desired reference range or (2) a stream could be considered not impaired for the parameter(s) of concern because the results for a given parameter fall just within the reference range, whereas the naturally occurring condition for that stream parameter represents much higher water quality and beneficial uses could still be negatively impacted. The implications of making either of these errors can be used to modify the above approach, although the approach used will need to be protective of water quality to be consistent with DEQ guidance and WQS (Suplee, 2004). Either way, adaptive management is applied to this water quality plan and associated TMDL development to help address the above considerations.

Where the data does suggest a normal distribution, or reference data is presented in a way that precludes use of non-normal statistics, the above approach can be modified to include the mean plus or minus one standard deviation to provide a similar reference range with all of the same considerations defined above.

Options When Regional Reference Data is Limited or Does Not Exist

In some cases, there is very limited reference data and applying a statistical approach like above is not possible. Under these conditions, the limited information can be used to develop a reference value or range, with the need to note the greater level of uncertainty and perhaps a greater level of future monitoring as part of the adaptive management approach. These conditions can also lead to more reliance on secondary type approaches for reference development.

Another approach would be to develop statistics for a given parameter from all streams within a watershed or region of interest (Buck, et al., 2000). The boxplot distribution of all the data for a given parameter can still be used to help determine potential target values knowing that most or all of the streams being evaluated are either impaired or otherwise have a reasonable probability of having significant water quality impacts. Under these conditions you would still use the median and the 25th or 75th percentiles as potential target values, but you would use the 25th and 75th percentiles in a way that is opposite from how you use the results from a regional reference distribution. This is because you are assuming that, for the parameter being evaluated, as many as 50 percent to 75 percent of the results from the whole data distribution represent questionable water quality. **Figure C-2** is an example statistical distribution where higher values represent better water quality. In **Figure C-2**, the median and 25th percentiles represent potential target values versus the median and 75th percentiles discussed above for regional reference distribution. Whether you use the median, the 25th percentile, or both should be based on an assessment of how impacted all the measured streams are in the watershed. Additional consideration of target achievability is important when using this approach. Also, there may be a need to rely on secondary reference development methods to modify how you apply the target and/or to modify the final target value(s). Your certainty regarding indications of impairment or non-impairment may be lower using this approach, and you may need to rely more on adaptive management as part of TMDL implementation.

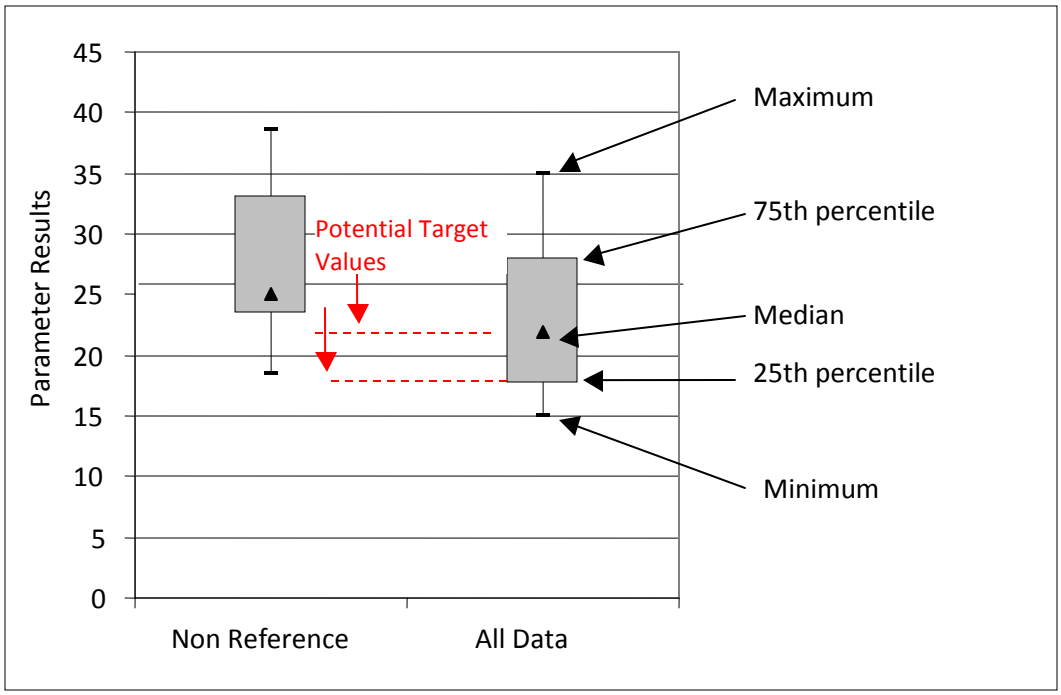


Figure C-2. Boxplot example for the use of all data to set targets.

C4.0 REFERENCES

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APPENDIX D - REFERENCE CONDITIONS AND TARGET VALUE RATIONALE

D1.0 REFERENCE CONDITIONS AND DATA SOURCES

MDEQ applies a reference condition to determine if narrative water quality standards are being achieved. The term "reference condition" is defined as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a waterbody's greatest potential for water quality given historic land use activities.

Waterbodies used to determine reference condition are not necessarily pristine or pre-settlement conditions, or display conditions that meet all possible beneficial uses. A reference condition is intended to differentiate between natural conditions and widespread or significant alterations of biology, chemistry or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. Reference conditions look to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology and other natural physiochemical differences. A reference condition attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil and water conservation practices. MDEQ realizes that pre-settlement water quality conditions usually are not attainable.

The following methods may be used to determine reference conditions:

Primary Approaches

- Regional Approach:
  Compare conditions in a waterbody to baseline data from reference waterbodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Historical Approach:
  Evaluate historical data relating to condition of the waterbody in the past.
- Internal Reference Approach:
  Compare conditions in a waterbody to conditions in another portion of the same waterbody, such as an unimpaired segment of the same stream.

Secondary Approaches

- Literature Approach:
  Review literature (e.g. review of studies of fish populations, etc. that were conducted on similar waterbodies.)
- Professional Judgment Approach:
  Seek expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the waterbody's fisheries health or capability).
- Modeling Approach:
  Apply quantitative modeling (e.g. applying sediment transport models to determine how much sediment is entering a stream based on land use information, etc.).

DEQ prefers to use the primary approach for determining reference condition, particularly where adequate regional reference data are available. Secondary approaches are often necessary to estimate reference condition when there is no regional reference data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent. This is particularly true where the translation of a narrative standard may involve multiple target indicator parameters. Some parameters may have good regional or internal reference information; whereas regional or other primary reference information may be lacking for other parameters. Historical quantitative reference condition information is rarely available; however, historical information can supplement secondary approaches with qualitative data and best professional judgment.

Two main sources of data served as information to help identify reference conditions in the Flint TPA. Target values for the parameters of interest were based on unpublished data from USFS PIBO data collected throughout the Beaverhead Deerlodge National Forest, and from data collected during the 2009 DEQ Flint Creek sediment/habitat field study.

United States Forest Service Pacfish/Infish Biological Opinion (PIBO) data (2010) was reviewed for assistance in developing target values for width to depth ratios, percent fines less than 2mm and 6mm, residual pool depth, pool frequency, and large woody debris frequency. 63 PIBO sites were selected based on data specific to the Pintler Forest District, located in the Beaverhead Deerlodge National Forest, and occurring within or adjacent to the boundaries of the Flint Creek TPA.

PIBO classifies their study reaches as 'reference' or 'managed'. "Watersheds are considered reference if there had been no livestock grazing within the past 30 years, less than 10% of the watershed had undergone timber harvest, there was no evidence of mining in proximity to riparian areas, and road density was less than 0.5km/km2. Managed watersheds included a full complement of management activities, including timber harvest, road building and maintenance, livestock grazing, mining, and recreation" (Kershner, et al., 2004).

2009 DEQ field data was used for the development of all parameter values. Data from 24 sites from the DEQ field effort was collected on listed and non-listed streams throughout the Flint Creek watershed.

2009 DEQ data was categorized by reach results based on a stream stratification procedure. No reference reaches were identified through the stream stratification procedure; however, in the sampling analysis design for the 2009 field data study, sites were chosen to represent the variability among reach type categories and stratification parameters, and therefore include reaches that characterize the range from heavily impacted reaches to "near reference" condition. Although few if any of the reaches represent full application of all reasonable land, soil, and water conservation practices, several sampled reaches reflect the healthy conditions in the study area, with limited land use effects.

D2.0 TARGET VALUE DEVELOPMENT

Target values are often presented for a range of conditions based on stream size, parent geology, or other significant factors that influence stream function and response. For instance, depending on the setting, sediment and habitat conditions in a 5th order stream may vary considerably from those in a 2nd order stream and therefore assessing the respective condition of each against the same target values would be inappropriate for some target parameters. In the Flint Creek TPA, data was sorted and

analyzed based on reach type, level of impact (reference vs. non-reference), stream gradient and stream order; and target values were determined based on the best approach for analysis for a given parameter.

The use of median and percentiles in statistical analysis is often employed when data, such as water quality data, tend to have a non-normal distribution. Also, limited amounts of data can sometimes result in skewed results if using normal distribution statistics. For these reasons, it is more appropriate to use non-normal or non-parametric statistics for setting reference conditions and determining target values for most parameters.

If parameters are used where lower values represent better water quality conditions, then typically the 75th percentile of the reference data set is used as a potential target value. If higher values represent better water quality conditions then the 25th percentile would apply. If a dataset is known to represent a variety of conditions, and not just reference conditions, or where there is less confidence in the data to represent reference conditions, the median may be used. If a dataset is known to largely represent impacted conditions, then the opposite percentiles as mentioned above can be used. E.g. the 25th percentile of an impacted data set may be used to develop a percent fines target value (where lower values represent more desired conditions).

The use of a non-parametric statistical distribution for interpreting narrative water quality standards or developing numeric criteria is consistent with EPA guidance for determining 'water quality' criteria (U.S. Environmental Protection Agency, 1999). Therefore, the selection of the applicable statistics from a data set is consistent with ongoing development of MDEQ and EPA guidance for interpreting narrative water quality standards.

No reference sites were identified from the DEQ data set when developing target values. However the sites that were investigated represented a broad range of conditions, from heavily impacted by anthropogenic activity to desired or near-desired condition. Because of this, generally the median (50th percentile) of the total population of the DEQ data was the primary value of interest. The USFS PIBO data contains both reference and non-reference data. PIBO data sets were reviewed and a target value was determined based on a comparison between the median of total population and quartiles of the reference data sets. The statistics from both the DEQ and PIBO data were then compared and target values determined based on these comparisons, best professional judgment, and relation to commonly accepted literature values.

Information and rationale used to derive target values follow below. Target parameter description and rationale for inclusion is presented in **Section 5.4**.

D2.1 WIDTH DEPTH RATIO

Width to depth ratios provide a metric by which we can assess the form, and therefore, relative function of a given reach. Lower values signify a narrow, deep channel, whereas larger values may indicate unnatural overwidening and shallowing of a reach. Criteria based on Rosgen stream type classification for width to depth ratios gives guidance of <12 for A, G and E stream types, and >12 for F, B and C stream types. While the upper limits are not provided for values >12, data from PIBO and DEQ can be reviewed to provide a range of targets that better represent desired conditions.

For the width/depth parameter, PIBO data was organized and reviewed according to reference sites, and all sites. The 75th percentile of the reference sites served as the focus for evaluating a target value. The median value for all site groupings was also reviewed, as it is assumed that these represent desired width/depths when investigating a variety of conditions encompassing a varying level of impacts to the stream.

Although fewer total reaches were examined in the DEQ study, the DEQ reaches did represent a wider range of stream size and power, and therefore, the width/depth data was broken out by stream order. This was done because it is assumed that as stream orders increase, width/depth ratios for F, B, C stream types will also show a gradual increase. PIBO data, on the other hand, was assumed to come from reaches predominantly 3rd order or less (based on a review of the bankfull widths), but actual stream order information did not accompany the data, and therefore was not segregated as such.

Upon review of the results (**Table D-1**), a width/depth ratio of ≤20 is the target value for 3rd order or less low gradient streams in the Flint Creek TPA. Due to the increasing size and stream power for streams that are 4th order or larger (essentially Flint Creek in the lower portion of the watershed), the width/depth target for these streams have a slightly larger target value of ≤28. As there were only 6 sites that were sampled which were 4th order or larger, best professional judgment and recognition that these sites have been affected by past anthropogenic activities was factored into the determination of ≤28 as a conservative target value. Values used as width to depth targets in prior TMDLs dealing with similarly sized streams (e.g., Prospect Creek, width/depth target of <30; St. Regis, width/depth target of <30) also suggest <28 is appropriate.

Table D-1. Width to Depth Values

	25th Percentile	**Median**	**75th Percentile**
USFS PIBO reference reaches(13)	16	20	21
USFS PIBO all reaches (33)	15	20	23
DEQ Reaches – Segregated by stream order			
2nd (9)	12	15	17
3rd (7)	16	20	24
4th (6)	26	28	29
Target Value	**Low Gradient Streams 3rd order or less***		**≤20**
	Low Gradient Streams 4th order or greater*		**≤28**

*Width to depth of <12 applies to low gradient E channels based on Rosgen stream classification criteria.

D2.2 ENTRENCHMENT

Criteria from Rosgen stream type classification for entrenchment gives guidance of <1.4 for A, F and G streams, 1.4-2.2 for B streams, and >2.2 for C, E streams. These literature values will serve as the target ranges for entrenchment in the Flint Creek TPA as well. Entrenchment values >2.2 are described by Rosgen as slightly entrenched to non-entrenchment as the values increase. The higher the entrenchment value the greater accessibility of streamflow to the floodplain at or greater than bankfull flow. While there is no upper limit to an entrenchment value, entrenchment values in the Flint Creek watershed is not generally expected to exceed 6.0, as observed in the data set (**Table D-2**).

Table D-2. Entrenchment Ratio Values (DEQ 2009 Data)

	High Gradient (>2%)	Low Gradient (<2%)	All Reaches
25th percentile	2.0	2.1	2.0
Median	2.3	3.5	3.1
75th percentile	4.2	6.1	5.5
Target Values	**Rosgen A: <1.4**	**Rosgen B: >1.4 - <2.2**	**Rosgen C,E >2.2**

D2.3 PERCENT FINES ANALYSIS

In developing percent fines targets, differences in the data collection methodology between the PIBO and DEQ datasets does not always allow for direct comparison. DEQ collects percent fine data from both pool tails and riffles. As discussed in **Section 5.4.1.3**, pool tails are important spawning habitat for salmonids, and riffles also serve as spawning habitat for salmonids, as well as important habitat for macroinvertebrate communities. DEQ data is collected from pool tails using the grid toss method, and assesses for those particles less than 6mm. DEQ data is collected from riffles using the Wolman pebble count method, blindly selecting particles using a heel-to-toe process across the riffle, until at least 100 particles are obtained in a riffle, and 400 particles are collected from riffles in a reach.

PIBO data also collects percent fines using a grid toss method in pool tails. PIBO accounts for those particles less than 6mm and less than 2mm. However, PIBO data does not specifically target riffles for Wolman pebble count procedures. Instead, PIBO collects 5 particles from 20 evenly spaced cross sections throughout the reach. The sites where particles are collected may occur in riffles, or they may occur through pools or runs or other habitat features that may be prone to greater fine sediment deposition. Therefore, while PIBO and DEQ pool fines data are comparable, PIBO percent fines (using Wolman methods) provide an overview of conditions representative of the entire reach, where DEQ percent fines is targeted to riffles (and thereby a more focused look at the impact to aquatic life and fisheries). Because of this, the PIBO pebble count data is not comparable to DEQ riffle pebble count data.

It should also be noted that the percent fines targets described below are appropriate for those stream habitats and stream types that best show the effects of sediment accumulation in spawning areas. These targets may not apply to Rosgen E channels, which typically exhibit much higher natural values of percent surface fines. Percent fines in E channel reaches should be evaluated on a case by case basis. Percent fines evaluations should generally occur in 'riffle and pool tails in Rosgen B and C Reach types as these often most clearly illustrate effects from percent fine accumulation.

D2.3 PERCENT FINES IN RIFFLES (WOLMAN METHOD) - <2MM

Percent fines data are sometimes reviewed in relation to the slope of the reach they are taken from. It is expected that in general, higher gradient reaches (slopes greater than 2 percent) act as transport reaches, and the velocity and turbulence within these reaches do not allow for much sediment accumulation in comparison to low gradient reaches. DEQ fines data by gradient is provided here to illustrate that this assumption is supported in the Flint Creek TPA data (**Table D-3**).

No PIBO reference data is available for percent fines <2mm in riffles. For this parameter, the median of the total DEQ data set is used to set the target at <7%. This value is below the minimum-effect sediment levels for sediment-sensitive species (13%) and aquatic macroinvertebrates (10%) as found by Bryce,

Lomnicky, and Kaufmann (2010), and therefore will apply regardless of gradient. Based on the discussion above, it is expected that measured values in high gradient reaches would be lower than the target, and that values in high gradient reaches which are near or above the target value may indicate increased sediment input and potential impacts to low gradient reaches as well.

Table D-3. Wolman Pebble Count Percent Fines Values, <2mm (DEQ 2009 Data)

	25th percentile	Median	75th percentile
DEQ – High Gradient Reaches (7)	2	3	9
DEQ – Low Gradient Reaches (17)	6	8	12
DEQ - All	3	7	11
Target Value			**<7**

D2.4 Percent Fines in Riffles (Wolman method) - <6mm

Due to the differences in percent fines data collection between PIBO and DEQ, the DEQ dataset serves as the sole source of data for developing this target. In review of the data (**Table D-4**), the median values between the "low gradient reaches" and "all reaches" are very similar at 14 and 12, respectively. As expected, the high gradient reaches have percent fines values lower than low gradient reaches. The target value for percent fines <6mm in riffles is $\leq$14.

Table D-4. Wolman Pebble Count Percent Fines Values, <6mm (DEQ 2009 Data)

	25th Percentile	Median	75th Percentile
DEQ – High Gradient Reaches (7)	5	9	14
DEQ – Low Gradient Reaches (17)	12	14	20
DEQ – All (24)	8	12	19
Target Value			**<14**

As discussed in the target narrative for percent surface fines less than 2mm, percent fines data may be reviewed in relation to the slope of the reach they are taken from. It is expected that in general, higher gradient reaches (slopes greater than 2 percent) act as transport reaches, and the velocity and turbulence within these reaches do not allow for much sediment accumulation, in comparison to low gradient reaches. As with percent <2mm data, this assumption is illustrated with the data. Since a target of <15% fines less than 6mm is protective of beneficial uses regardless of the gradient, a single target value was chosen. Care should be taken in reviewing percent fine results in high gradient reaches when values approach the target. It is expected that measured values would be lower than the target, and that values in high gradient reaches which are near or above the target value may indicate increased sediment input and potential impacts to low gradient reaches as well.

D2.5 Percent Fines in Pool Tails (Grid Toss) - <6mm

In the case of percent fine data in pool tails, data exists for both DEQ and PIBO. As a result, a direct comparison between DEQ and PIBO data sets is possible. In general, the PIBO pool tail grid toss results shows consistency between the median values of the non-reference data sets and the 75th percentile of the reference reach data. In fact, the medians for all groupings are lower than the 75th percentile of the PIBO reference reaches. Overall, DEQ pool tail values are slightly lower than PIBO data; however, this may be attributed to subtle differences in identification and selection of which pool tails to measure. In addition, the DEQ results may be affected by the much smaller data set. Despite this, the overall consistency in statistical values between datasets allows for a reasonable target value of <15 percent

surface fines less than 6mm (based on the 75th percentile of PIBO reference data) (**Table D-5**). This value is representative of what can be expected in this watershed under "good" conditions and is protective of beneficial uses.

Table D-5. Pool Tail Percent Fines (Grid Toss) Values, <6mm

	25th Percentile	Median	75th Percentile
PIBO – Reference Reaches (18)	6	10	15
PIBO – All Reaches (52)	6	11	24
DEQ – High Gradient Reaches (6)	3	4	11
DEQ – Low Gradient Reaches (15)	3	11	19
DEQ – All (21*)	3	10	16
* Some reaches did not have pool tails measurements taken.			
Target Value			**<15**

D2.5 RESIDUAL POOL DEPTH

A slightly different approach was taken when developing target values for residual pool depth. In this case, bankfull width information for the study reaches was available for both DEQ and PIBO data (**Table D-6**). Because pool depths are frequently a function of stream size and volume, it was deemed appropriate to segregate sampled reaches by bankfull width, which provides an indication of general stream dimension and power that affects pool size and quality.

For the PIBO data, two categories were broken out based on the sampled reaches; bankfull widths less than 20 feet and bankfull widths between 20-39 feet. DEQ data were split into three categories; bankfull widths less than 20 feet, bankfull widths between 20-39, and bankfull widths larger than 40. Although no statistical analysis was used to develop these breakouts, generally it was considered that <20 feet is the equivalent of 2nd order streams, 20-39 is the equivalent of 3rd order streams, and >39 feet is equivalent to 4th order (or greater) streams. No residual pool depth data existed for bankfull widths larger than 39 feet in the PIBO data.

In the 20-39 feet category of the PIBO data, generally, the reference sites exhibit deeper overall pools than non-reference sites. No reference sites were identified within the DEQ reaches. With this in mind, and presuming the differences between reference and non-reference sites are a constant within stream size, we can use the 20-39 feet category as a guide determine appropriate target values for other size categories.

Although the parameter is the same in the DEQ and PIBO datasets, it should be noted that subtle differences exist in the methodology between the DEQ and PIBO to classify pools. Although both methods identify a pool as having a maximum depth 1.5 times the pool tail depth, PIBO further selects those pools that fall within the path of the thalweg and are 50% or greater of the wetted channel width, whereas DEQ methodology includes all pools throughout the channel. As a result of this, PIBO data is likely to reflect slightly deeper average pool depths than the DEQ data. Targets will be set to apply to DEQ methods.

The DEQ data for residual pool depths in reaches with bankfull widths less than 20 feet exhibits a median value of 0.7 feet. As illustrated in the PIBO 20-39 feet dataset, we can expect something greater

than the median under reference type conditions. The target for bankfull width less than 20 feet is therefore set at > 0.9 feet.

For bankfull widths 20-39 feet, the median of all reaches in the PIBO dataset (1.8 feet) and the 25th percentile of the PIBO reference data (1.8 feet) serve as the benchmarks for setting the target. In comparison, the median value of the DEQ 3rd order data is 1.2 feet. Because PIBO values are somewhat higher than DEQ results due to differing methodology, the target for this bankfull width category is set at 1.4 feet.

For bankfull widths >40 feet, there is no PIBO data available to review. Therefore the DEQ data is assessed with the same assumptions as the other categories and is applied with respect to a presumed difference in reference and non-reference datasets, and ever increasing pool depths as bankfull widths increase. As such, a target value of >1.7 is conservatively set for bankfull widths larger than 40. In the lower section of Flint Creek, where bankfull widths begin to exceed 50', it would be expected that residual pool depths should be somewhat greater than 1.7 feet, however no specific target for bankfull widths >50 is identified here due to the limited data for these sized reaches.

Table D-6. Residual Pool Depth Values

	25th Percentile	**Median**	**75th Percentile**
PIBO - All reaches: Bankfull width			
<20 (28)	0.7	0.9	1.0
20-39 (26)	1.2	1.8	2.2
PIBO - Reference: Bankfull width 20-39 (11)	1.8	1.9	2.1
DEQ – All Reaches – Segregated by bankfull widths			
<20 (10)	0.6	0.7	0.7
20-39 (7)	1.1	1.2	1.4
>40 (6)	1.1	1.3	1.7
			Target Value
<20			**>0.9**
20-39			**>1.4**
>40			**>1.7**

D2.6 POOL FREQUENCY (PER MILE)

Pool frequency tends to be a function of stream size and power; although other factors also contribute to pool formation, such as geology, riparian condition (large woody debris input), and gradient. As streams increase in size, features such as riffles and pools also tend to increase in size, however those components such as boulders and large woody debris that influence pool development becomes less frequent, resulting in larger but fewer pools over a given distance.

Again, some differences in methodology between DEQ and PIBO do not allow for direct comparison of values. Both methods classify a pool as having a maximum pool depth > 1.5 times the pool tail depth. However, PIBO identifies those pools that fall within the path of the thalweg and that are 50% or greater of the wetted channel width; whereas DEQ methodology identifies *all* pools throughout the channel. As a result, PIBO methodology identifies fewer pools than noted according to DEQ methods. With this in

mind, we can review the PIBO data in combination with the DEQ data to derive target values (**Table D-7**). (The targets below apply to DEQ pool quantification methods.)

For streams with a bankfull width <20 feet, the target is set at 95. The median of the DEQ data set is 95. The median of the PIBO data set is 78. It is expected that the PIBO pool numbers would be somewhat higher if DEQ protocols were applied in their data collection and therefore would be likely comparable to the DEQ median.

For streams with a bankfull width between 20 feet and 39 feet, PIBO data exists for both the total population, and for reference streams. The 25th percentile (49) of the PIBO reference data set appears to correspond well with the median (52) of all reaches of the same data set. The median (32) of DEQ data set is considerably less than the PIBO value, despite expectations that the PIBO values would be lower. However, this may be in part due to the limited sites within the DEQ data. In review of the specific reaches that make up the DEQ data set for bankfull widths 20-39, it was determined that 6 of the 7 sampled reaches represent impacted reaches. Because of this, and using the PIBO reference data as an indicator, the target is set at 70.

For streams with a bankfull width equal to or greater than 40 feet, the target is set at 50. No PIBO data is available in this stream size category for comparison. The median value of the DEQ data set (32) provides a reference, but again the limited number of reaches may mislead conclusions. Review of the individual reaches finds two reaches with limited human impact. The number of pools per mile in those two reaches are 79 and 100. Because of this, it appears the median value of the DEQ data set may be skewed lower than what might be expected under good conditions. With this in mind, a target somewhat greater than the median value, and in correspondence with the other bankfull width categories has been chosen.

Flint Creek becomes a 5th order stream toward the bottom of the watershed; however, only one reach of 5th order was sampled within the DEQ dataset. That reach resulted in 26 pools per mile. A conservative estimate therefore for pools per mile in 5th order streams is targeted at >30.

Table D-7. Pool Frequency Values (per mile)

	25th Percentile	**Median**	**75th Percentile**
DEQ - All Reaches – Segregated by bankfull width			
<20 (10)	69	95	116
20-39 (7)	24	32	37
>40 (6)	26	32	69
PIBO Reaches – Segregated by bankfull width			
<20 – All reaches (28)	61	78	116
20-39 – All reaches (26)	43	52	61
20-39 - Reference (11)	49	60	63
Bankfull Width			**Target Value**
<20			**95**
20-39			**70**
>40			**50**

D2.7 Greenline – Percent Shrub

Riparian green line is not used as a direct measurement of sediment itself in the Flint Creek TPA, however it is reviewed as supplemental information due to its relation to bank erosion and therefore an overall gage of stream health and potential sediment production. Shrub cover in particular provides stronger, more stable streamside woody vegetation, and it often provides an indicator of potential bank stability and temperature variability.

As mentioned in earlier target parameter discussions, there are a variety of conditions accounted for in the DEQ dataset, however few of them represent true desired or reference conditions. Although limited in the amount of available data, values were initially organized by their respective reach types to see if there were any obvious differences or similarities based on the physical characteristics of the stream (**Table D-8**). No true discernable variation in values could be determined based on the stream order, gradient, and confinement – but that is also expected since the riparian robustness is generally more a function of the activities on the land rather than the geologic constraints. As a result, the data shows that a target value can be set based on a review of the total dataset, rather than segregating it into specific categories. In reviewing these results, and knowing anthropogenic influence was common throughout the reaches, relying only on the median values in setting a target value may underestimate the potential quality that should be expected. Conversely, relying on the 75th percentile may overestimate what should be expected, particularly in wide open agricultural valleys, where full riparian recovery may not be achievable even under all reasonable land, soil, and water conservation practices. Therefore the target is based on the midline between the median and 75th percentile, and is set at >70.

Table D-8. Greenline Percent Shrub Cover by Reach Type

Reach Type	25th	Median	75th
MR-0-2-U (5)	10	58	75
MR-0-3-U (6)	3	25	75
MR-0-4-U (5)	1	65	91
MR-0-5-U (1)	0	0	10
MR-2-2-U (4)	30	63	93
MR-2-3-U (2)	0	46	98
MR-2-4-U (1)	64	80	85
Total	5	56	84
Target Value			**>70**

D2.8 Greenline – Percent Bare Ground

As described for the Greenline – Percent Shrub Cover, riparian green line is not used as direct target of sediment analysis in the Flint Creek TPA, however it is reviewed as supplemental information because of its relation to potential sediment production and overall gage of stream health. Bare ground along the riparian is the most unstable and most indicative display of streamside sediment sources. Similar to the percent shrub analysis, the statistics for percent bare ground are only used as a relative gage by which to select an appropriate value. In this case, lower percentages of percent bare ground are the expected and desired condition. Based on a review of the available information (**Table D-9**), the Flint Creek TPA would not expect to see any bare ground under most normal conditions. As such, the target for bare ground in conjunction with anthropogenic activities is 0%, however, it is acknowledged that some natural conditions such as talus slopes, recent landslide/avalanche chutes, and wildfire (although not witnessed in this data) may result in a small percentage of bare ground near the bank and therefore, this target is not absolute and will allow for some variance under specific natural conditions.

Table D-9. Greenline Percent Bare Ground by Reach Type

Reach Type	25th	Median	75th
MR-0-2-U (5)	0	0	0
MR-0-3-U (6)	0	0	0
MR-0-4-U (5)	0	0	0
MR-0-5-U (1)	0	0	8
MR-2-2-U (4)	0	0	0
MR-2-3-U (2)	0	0	0
MR-2-4-U (1)	0	0	0
Total	0	0	0
Target Value			**0**

D2.9 LARGE WOODY DEBRIS

Large woody debris is not a direct measure of sediment. However, the quantification of instream large wood is reviewed as supplemental information because of its relation to riparian condition and the associated sediment production that can occur in degraded riparian environments. Large woody debris also has affect on pool formation and habitat creation for both fish and macroinvertebrates and has been shown to be an indicator of overall stream health.

A mature and healthy streamside vegetative community plays a significant role in the numbers of large woody debris found in a stream. This is apparent in reviewing reference with non-reference PIBO data (**Table D-10**). As a result, we can presume that land management and impacts to the riparian community have a significant effect to the amount of large wood in the stream, and thereby the habitat complexity and overall health of the stream.

Large woody debris numbers also relate to stream size and power, in addition to the quality of the riparian condition. Therefore, smaller streams with good riparian health would be more likely to hold pieces of large wood that fall into the stream. As the stream sizes increase, the wider and deeper channels and associated flows mobilize more wood resulting in fewer identified pieces per reach.

Based on the PIBO and DEQ data for bankfull widths less than 20 feet, the target is set at >500 pieces per mile. Although numbers of reference sites in comparison to non-reference sites are few, the data does illustrate a significant difference between reference and non-reference conditions. In addition, the 25th percentile of the PIBO reference data does correspond well with the median of the DEQ data.

For bankfull widths 20-39 feet, the target for large wood per mile is set at >250. Again, there appears to be a good relationship between the 25th percentile of PIBO reference sites and the median of all DEQ sites.

For bankfull widths greater than 40 feet, the target value of >150 pieces per mile is based on the median of the DEQ data. Although there are few reaches within this category, and no reference data to compare to, the general trends in the other bankfull width categories indicate that using the median of the DEQ data is a reasonable approach.

Table D-10. Large Wood Values (per mile)

	25th Percentile	Median	75th Percentile
DEQ – All Reaches – Segregated by bankfull width			
<20 (10)	203	502	620
20-39 (7)	21	248	306
>40 (6)	81	156	183
PIBO Reaches – Segregated by bankfull width			
<20 (36)	9	91	241
<20 reference (6)	500	727	942
<20 managed (30)	0	55	98
20-39 (27)	74	178	283
20-39 reference (11)	274	293	740
20-39 managed (16)	28	99	163
			Target Value
<20			**>500**
20-39			**>250**
>40			**>150**

D3.0 REFERENCES

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Kershner, Jeffrey, Brett Roper, Nicolaas Bouwes, Richard Henderson, and Eric Archer. 2004. An Analysis of Stream Habitat Conditions in Reference and Managed Watersheds on Some Federal Lands Within the Columbia River Basin. *North American Journal of Fisheries Management.* 24: 1363-1375.

U.S. Environmental Protection Agency. 1999. Protocol for Developing Sediment TMDLs. Washington, D.C.: U.S. Environmental Protection Agency. Report EPA 841-B-99-004.

APPENDIX E - UNPAVED ROADS ASSESSMENT: SEDIMENT LOAD ESTIMATIONS AND POTENTIAL REDUCTIONS

E1.0 INTRODUCTION

In the summer of 2010, DEQ conducted a study of road systems in the Flint Creek TMDL planning area (TPA) to estimate sediment contributions and potential load reductions from unpaved roads. Data was collected from randomly selected road crossings and parallel segments and entered into a soil erosion model to quantify the amount of sediment produced at each location. The model was used to quantify loads from both existing conditions and potential BMP conditions. Results from assessed road features were then extrapolated to non-assessed features based on ownership, road-type, and landscape characteristics.

This report describes the analysis and results of the Flint Creek TPA road study. The information from this study will be used in conjunction with other sediment source assessment analyses for inclusion in TMDL development for Flint Creek TPA streams.

E2.0 MODEL

The Water Erosion Prediction Project (WEPP):Roads soil erosion model was used to model the amount of sediment transported from the road to the stream in the Flint Creek TPA. It was developed by an interagency group of scientists including the U.S. Department of Agriculture's Agricultural Research Service (ARS), Forest Service, and Natural Resources Conservation Service; and the U.S. Department of Interior's Bureau of Land Management and Geological Survey (Rocky Mountain Research Station and San Dimas technology and Development Center, 1999). The WEPP:Roads model has been used extensively by the USDA Forest Service for modeling sediment load from national forest roads, and by the Montana DEQ in developing TMDL sediment loads from roads in many TMDL projects.

The Water Erosion Prediction Project (WEPP) model is a soil erosion model based on rill and interrill erosion processes (Lal and Elliot, 1994). Interill erosion is overland flow of detached particles whereas rill erosion is transport of particles by concentrated flow. WEPP provides estimates of soil erosion and sediment yield by considering the specific soil, climate, ground cover, and topographic conditions.

WEPP:Roads is designed to predict runoff and sediment yield from:

- roads
- compacted landings
- compacted skid trails
- compacted foot, cattle, or off-road vehicle trails

WEPP:Road allows the user to specify the characteristics of the road in terms of

- climate
- soil and gravel addition
- local topography

- drain spacing
- road design and surface condition
- ditch condition

WEPP simulates the conditions that impact erosion, which includes the amount of vegetation canopy, the surface residue, and the daily soil water content in a multiple-year run. For each day that has a precipitation event, WEPP determines the type of event (rain or snow), and calculates the infiltration and runoff. If there is runoff, WEPP routes the runoff over the surface, calculating erosion or deposition rates for at least 100 points on the hillslope. It then calculates the average sediment yield from the hillslope (Elliot, et al., 2000). Measured road data from the Flint Creek TPA was entered into the application, and the annual amount of sediment (in pounds) leaving the road buffer was calculated for existing and potential BMP conditions.

There are two distinct landscape types within the Flint Creek watershed, each with different levels of precipitation (broad intermountain valley floor and steep mountainous terrain). Since the amount of sediment loading is directly related to the runoff associated with precipitation, DEQ used two weather stations for running the model on the measured road crossings and parallel road segments. The Drummond Aviation MT weather station, which is located on the valley floor at the lower end of the watershed, was used for all road crossings less than or equal to 16 inches of precipitation. For those crossings in the mountains (precipitation zones greater than 16 inches), DEQ generated a weather station model from a NRCS SNOTEL site (Combination 410). The Combination SNOTEL 410 weather station was added to the WEPP:Road interface with the assistance of David Hall (USDA Forest Service Rocky Mountain Research Station).

E3.0 GIS ANALYSIS AND SAP DEVELOPMENT

DEQ conducted a GIS exercise to identify potential contributing road crossings and parallel segments. Details of the GIS layers used for analysis can be found in the summary report *Road Sediment Assessment & Modeling: Flint Creek TMDL Planning Area 303(D) Listed Tributary Streams – Road GIS Layers & Summary Statistics* (Montana Department of Environmental Quality, 2010).

All road crossings were identified as the intersection of road and stream layers within GIS. Parallel road segments were identified as those road segments adjacent to the stream within 150 feet from the center of the stream.

The identified road crossings (**Figure 2-1**) and parallel road segments (**Figure 2-2**) were then stratified by ecoregion, land ownership and road type. (**Figures 2-1**, **2-2** are located at the end of the report.)The Flint Creek TPA contains the following four ecoregions: 17ak (Deer Lodge-Philipsburg-Avon grassy intermontane hills and valleys; 17am (Flint Creek-Anaconda mountains); 17x (Rattlesnake-Blackfoot-South Swan-Northern Garnet-Sapphire mountains; and 17h (alpine zone). Landownership included BLM, Forest Service, private, Montana state government, and unidentified. Road type included paved, gravel, and native road surfaces.

Due to the large number of identified road features and limited available resources, a random subset of road crossings was selected for field sampling to represent the variety of road crossing conditions in the watershed. Parallel segments were not pre-selected, but chosen in the field en route between sampled road crossing locations.

E4.0 FIELD ASSESSMENT

The following section provides brief information that describes the goals of the field assessment, what data was collected, and success in meeting the goals of the field effort.

E4.1 METHODS

Field assessment occurred during August of 2010. Data was collected from the pre-identified, randomly selected road crossings and along sections of the road that paralleled the stream as chosen in the field. At each site, the data parameters required for WEPP road modeling were recorded. This information includes road design (inslope bare, inslope vegetated, outslope rutted, outslope unrutted); road surface (native, gravel, paved); traffic level (high, low, none); road gradient (percent); road length (feet); road width (feet); fill gradient (percent); fill length (feet); buffer gradient (percent); buffer length (feet); rock fragments (percent); and soil texture (clay loam, silt loam, sandy loam, and loam). In addition, photos were taken along with notes and measurements to be used for the evaluation of potential BMP implementation.

E4.2 RESULTS

Once in the field, DEQ found that some of the GIS identified road crossings occurred at ephemeral streams, topographical depressions, or drainages without perennial streams. In many cases, these sites were found not to contribute a sediment load to the stream of interest and were considered “false stream crossings”. Photos were taken at these sites to document their condition and the rationale for exclusion from the study and then an alternate road crossing was selected based on the nearest non pre-selected site of the same ecoregion, road type and land ownership. In all, 55 road crossings were visited during the field assessment; of these 38 crossings were measured and 17 (31%) were found to be “false crossings”. Similarly, some of the GIS identified parallel road segments were found to be greater than 150 feet from the stream and not contributing a sediment load. Information regarding these locations was noted and alternative sites were chosen.

Additionally, DEQ found in the GIS determined road type did not always equate to field observations. This occurred at several sites where the GIS attribute indicated the road was gravel, but the road type was native. For those locations where discrepancies were found, the road type identified in the field was considered the correct attribute, and the site information was adjusted accordingly.

Two weeks of fieldwork were allocated for collecting road crossing measurements. The goal for the study was to collect information to represent 50 road crossings and 10 parallel road segments (**Table E-1**). Over the course of the fieldwork, false stream crossings, remote locations, and poor road conditions prohibited the full achievement of all 50 sites within the two weeks. 38 road crossings (76% of desired) and 8 parallel road segments (80% of desired) were measured. However, although the goal was not met at the end of the two weeks, DEQ determined that the data collected was acceptable for representing the sediment load for the purposes of this assessment. This decision was based on available resources, with consideration that comparable sampling numbers were used in other TMDL road assessments of similar size.

Table E-1. Flint Creek TPA Roads Fieldwork Completion

	Total in Flint TPA	# Selected for Field Sampling	# Measured	Percent Measured of Selected Sites
Crossings	711	50	38	76
Parallel Segments	510	10	8	80

E5.0 WEPP MODELING RESULTS

This section describes the results of the WEPP:Roads analysis for the measured road crossings and parallel road segments in the Flint Creek watershed. The sediment loads are calculated for each measured site, and then extrapolated to the rest of the road crossings or parallel road segments in the watershed. The extrapolated results are grouped by landownership and subwatershed.

E5.1 ROAD CROSSINGS

Measurements gathered in the field were entered into the model to calculate the existing sediment load from each road crossing. For each site, WEPP:Roads calculates two loads: 1) average annual sediment load coming from the road; and 2) average annual sediment load coming from the buffer. The load coming from the buffer represents the capture of some sediment before it reaches the stream. Buffering capacity is a function of buffer length, slope and vegetation. For the purposes of this analysis, the load from the buffer is the load of concern.

Each site was individually modeled and the results were organized based on the ecoregion, land ownership, road type and associated climate station. The combination of these characteristics is defined as a road category. Loads for the measured sites were then averaged by road category (**Table E-2**).

Table E-2. Modeling Results for Measured Road Crossings

Site #	Land Ownership	Road Type	Load (lbs)	Category Average (lbs)
Drummond Weather Station				
17ak Ecoregion				
37a	BLM	Native	11	11
54a	Private	Native	695	
19a	Private	Native	9	
39	Private	Native	136	
45	Private	Native	40	220
49	Private	Gravel	120	
7a	Private	Gravel	0	
48a	Private	Gravel	185	
47a	Private	Gravel	107	
43a	Private	Gravel	96	
39	Private	Gravel	134	107
17am Ecoregion				
35a	USFS	Native	8	
1a	USFS	Native	1145	577
17x Ecoregion				
41a	Private	Native	344	344
Native Load Average			299	
Gravel Load Average			107	

Table E-2. Modeling Results for Measured Road Crossings

Site #	Land Ownership	Road Type	Load (lbs)	Category Average (lbs)
Combination Weather Station				
17ak Ecoregion				
9	MT State	Native	118	118
5	Private	Native	118	118
6a	Private	Gravel	50	50
17am Ecoregion				
36	Private	Native	138	
8	Private	Native	283	211
16a	BLM	Gravel	721	721
11	Private	Gravel	55	
25	Private	Gravel	161	
14	Private	Gravel	73	96
34	USFS	Gravel	255	
28a	USFS	Gravel	25	
51a	USFS	Gravel	132	
24	USFS	Gravel	441	213
21a	USFS	Native	512	
32a	USFS	Native	16	
52a	USFS	Native	2	
2a	USFS	Native	792	
26	USFS	Native	213	
18a	USFS	Native	9	257
17x Ecoregion				
40a	Private	Native	146	
53a	Private	Native	59	
13a	Private	Native	156	
44a	Private	Native	12	93
22a	USFS	Gravel	65	65
Native Load Average			184	
Gravel Load Average			198	

Total sediment load for the Flint Creek TPA road crossings were then extrapolated by multiplying the average sediment load for each road category by the total number of road crossings within that category (**Table E-3**). In those instances where no representative sites were sampled within a particular road category, the average load for **all** sites of a given road surface and climate station was applied. A total of 711 road crossings were identified in the Flint Creek TPA. Of these, 44 crossings were paved and therefore determined to not contribute road related sediment.

Table E-3. Extrapolation of Modeled Data to All Road Crossings

Drummond Weather Station						
	Gravel			**Native**		
Ownership	**Number**	**Load (lb)**	**Total (lb)**	**Number**	**Load (lb)**	**Total (lb)**
17ak Ecoregion						
BLM	1	[1]107	107	2	11	22
Private	103	107	11,021	64	220	14,080
State				3	[2]299	897
Unidentified	1	[1]107	107	1	[2]299	299

Table E-3. Extrapolation of Modeled Data to All Road Crossings

Drummond Weather Station						
	Gravel			**Native**		
Ownership	**Number**	**Load (lb)**	**Total (lb)**	**Number**	**Load (lb)**	**Total (lb)**
17am Ecoregion						
BLM				2	[2]299	598
USFS	5	[1]107	535	13	577	7501
Private	1	[1]107	107	6	[2]299	1794
17x Ecoregion						
Private	1	[1]107	107	2	344	688
Combination Weather Station						
17ak Ecoregion						
USFS	1	[3]198	198			
Private	30	50	1,500	19	118	2,242
State				2	118	236
Unidentified	1	[3]198	198			
17am Ecoregion						
BLM	7	721	5,047	3	[4]184	552
USFS	66	213	14,058	126	257	32,382
Private	50	96	4800	38	211	8,018
MT				7	[4]184	1,288
Unidentified	3	[3]198	594	1	[4]184	184
17x Ecoregion						
USFS	7	65	455	49	[4]184	9,016
Private	9	[3]198	1,782	43	93	3,999

[1]Average load for gravel (Drummond weather station)
[2]Average load for native (Drummond weather station)
[3]Average load for gravel (Combination weather station)
[4]Average load for native (Combination weather station)

As described in **Section 3.0**, a number of the randomly selected road crossings were determined to be "false stream crossings". It can be assumed therefore, that not all of the road crossings identified through the GIS analysis contribute sediment. In order to account for this, and thereby provide a more accurate representation of the sediment loads after extrapolation, a reduction factor was calculated using the difference between "true crossings" to "false crossings" as observed in the field. As described in Section 3.0, 31% of the sites encountered in the field were determined to be false crossings. That percentage was then considered the reduction factor. The reduction factor was applied to the total calculated loads for each watershed. Sediment loads per watershed are presented in **Table E-4**.

Table E-4. Estimated Sediment Load for all Road Crossings by Subwatershed

Watershed	**Number Crossings**	**Estimated Total Load (lb/year)**	**Estimated Total Load (tons/year)**	**Total Load 31% RF (tons/year)**
Barnes Creek	29	5,202	2.60	1.79
Boulder Creek	74	17,474	8.74	6.03
Douglas Creek (North)	34	7,145	3.57	2.46
Douglas Creek (South)	21	3,184	1.59	1.10
Fred Burr Creek	9	1,468	0.73	0.50
Lower Flint Creek	79	13,151	6.58	4.54
Middle Flint Creek	112	22,086	11.04	7.62
Upper Flint Creek	86	16,699	8.35	5.76

Table E-4. Estimated Sediment Load for all Road Crossings by Subwatershed

Watershed	Number Crossings	Estimated Total Load (lb/year)	Estimated Total Load (tons/year)	Total Load 31% RF (tons/year)
Smart Creek	72	16,793	8.40	5.80
Trout Creek	41	4,411	2.21	1.52
Lower Willow Creek	20	2,931	1.47	1.01
North Fork Willow Creek	38	5,892	2.95	2.04
South Fork Willow Creek	52	7,976	3.99	2.75
Total	**667**	**124,412**	**62.22**	**42.92**

E5.2 PARALLEL ROAD SEGMENTS

Without proper best management practices, uninterrupted parallel road segments can be thousands of feet in length. Particularly in mountainous reaches, the only place for a road is often along the narrow floodplains adjacent to the stream. Close proximity between streams and parallel roads can serve as a conduit for sediment loads to enter the stream, in addition to road/stream intersections.

In the Flint Creek TPA, parallel road segments were also investigated to calculate sediment contribution from roads. Parallel road segments were modeled with WEPP:Roads to calculate the amount of sediment from roads that are within a distance of 150 feet of the stream. Eight parallel segments were measured in the field. For modeling purposes, contributing road lengths were given a maximum contributing length of 1000'. The calculated load for each parallel segment was converted to an annual load per mile of road length. In this case, since the number of sampled parallel road segments was small, and did not allow to discern differences between road type, climate station, or ownership; a general average sediment load for parallel road segments was determined (**Table E-5**).

Table E-5. Modeling Results for Measured Parallel Road Segments

Site Number	Land Ownership	Road Type	Road Length (ft)	Measured Load (lbs/year)	Measured Load (tons/mile)
292-293	Private	Native	1000	883	2.3311
307	Private	Native	574	5	0.0230
327	USFS	Native	279	0	0
3	Private	Gravel	1000	748	1.9747
283	Private	Gravel	1000	253	0.6679
313	USFS	Gravel	492	231	1.2395
315	USFS	Gravel	361	131	0.9585
395	USFS	Gravel	377	65	0.4549
				Average	**0.9562**

The average value was then multiplied by the total miles of parallel road segments in each watershed. As with road crossings, a 31% reduction factor was applied to account for errors in GIS analysis, and an estimate of sediment load from parallel segments was determined for each watershed (**Table E-6**). The same reduction factor that was used with road crossings was used for parallel segments based on the assumption that the geographic occurrence of drainage features (ephemeral streams, swales, depressions) and road networks that do not ultimately connect to the perennial streams of interest corresponds with the findings of the road crossing assessments.

Table E-6. Estimated Sediment Loads for Parallel Segments for Flint Creek TPA Watersheds

Watershed	Number Miles	Number Miles	Total Miles	Estimated Total Load (tons/year)	Total Load 31% RF (tons/year)
	Gravel	Native			
Barnes Creek	0.88	0.74	1.62	1.55	1.07
Boulder Creek	3.86	3.10	6.96	6.66	4.60
Douglas Creek (North)	5.57	1.56	7.13	6.82	4.71
Douglas Creek (South)	1.32	1.02	2.34	2.24	1.56
Fred Burr Creek	0.16	0.75	0.91	0.87	0.60
Lower Flint Creek	3.03	7.37	10.40	9.94	6.86
Middle Flint Creek	5.70	5.07	10.77	10.30	7.11
Upper Flint Creek	3.18	8.94	12.12	11.59	8.00
Smart Creek	4.55	5.93	10.48	10.02	6.91
Trout Creek	1.64	1.85	3.49	3.34	2.30
Lower Willow Creek	0.66	0.30	0.96	0.92	0.63
North Fork Willow Creek	1.72	3.82	5.54	5.30	3.66
South Fork Willow Creek	1.00	3.30	4.30	4.11	2.84
Total	**33.27**	**43.76**	**77.02**	**73.65**	**50.85**

E6.0 BMP RESULTS

This section presents the results of WEPP:Roads analysis with modeled BMP data, and the extrapolation of the BMP sediment loads throughout the watershed. During data collection, photographs and notes were taken at each road crossing and parallel segment to document potential best management practices that could be implemented. Based on these observations, DEQ reran WEPP:Roads for each measured road crossing with modifications to represent the site specific application of BMPs.

E6.1 BMP RESULTS FOR ROAD CROSSINGS

For each sampled road crossing, potential BMPs were documented and the implementation of those BMPs were simulated using WEPP:Roads. As before, calculated loads were then averaged by road category (landownership, road type, and weather station) to provide a value to extrapolate to non-measured crossings (**Table E-7**).

Table E-7. Modeling Results for BMP Scenario of Measured Roads Crossings

Site	Ownership	Road Type	Load (lbs)	Category Average (lbs)
Drummond Weather Station				
17ak Ecoregion				
37a	BLM	Native	4	4
54a	Private	Native	41	
19a	Private	Native	3	
39	Private	Native	99	
45	Private	Native	21	41
49	Private	Gravel	43	
7a	Private	Gravel	0	
48a	Private	Gravel	76	
47a	Private	Gravel	37	
43a	Private	Gravel	13	
39	Private	Gravel	52	36

Table E-7. Modeling Results for BMP Scenario of Measured Roads Crossings

Site	Ownership	Road Type	Load (lbs)	Category Average (lbs)
17am Ecoregion				
35a	USFS	Native	88	
1a	USFS	Native	1	45
17x Ecoregion				
41a	Private	Native	17	17
Native Load Average			34	
Gravel Load Average			36	
Combination Weather Station				
17ak Ecoregion				
9	MT State	Native	13	13
5	Private	Native	81	81
6a	Private	Gravel	44	44
17am Ecoregion				
36	Private	Native	25	
8	Private	Native	125	75
16a	BLM	Gravel	47	47
11	Private	Gravel	8	
24	Private	Gravel	36	
14	Private	Gravel	59	34
34	USFS	Gravel	81	
28a	USFS	Gravel	5	
51a	USFS	Gravel	21	
24	USFS	Gravel	61	42
21a	USFS	Native	4	
32a	USFS	Native	4	
52a	USFS	Native	1	
2a	USFS	Native	11	
26	USFS	Native	57	
18a	USFS	Native	9	14
17x Ecoregion				
40a	Private	Native	16	
53a	Private	Native	13	
13a	Private	Native	4	
44a	Private	Native	7	10
22a	USFS	Gravel	15	15
Native Load Average			26	
Gravel Load Average			36	

For each road category, the corresponding average sediment loads from the BMP scenario results were applied. For those categories where no measured data existed, the average load from ALL crossings of a given road type and climate station was used (**Table E-8**).

Table E-8. Extrapolation of BMP Scenario to All Roads Crossings

Drummond Weather Station						
	Gravel			Native		
Ownership	Number	Load (lb)	Total (lb)	Number	Load (lb)	Total (lb)
17ak Ecoregion						
BLM	1	[1]36	36	2	4	8
Private	103	36	3,708	64	41	2,624
MT	0			3	[2]34	102
Unidentified	1	[1]36	36	1	[2]34	34
17am Ecoregion						
BLM	0			2	[2]34	68
USFS	5	[1]36	108	13	45	585
Private	1	[1]36	36	6	[2]34	204
17x Ecoregion						
Private	1	[1]36	36	2	17	34
Combination Weather Station						
17ak Ecoregion						
USFS	1	[3]36	36	0		
Private	30	44	1,320	19	81	1,539
MT	0			2	13	26
Unidentified	1	[3]36	36	0		
17am Ecoregion						
BLM	7	47	329	3	[4]26	78
USFS	66	42	2,772	126	14	1,764
Private	50	34	1,700	38	75	2,850
MT				7	[4]26	182
Unidentified	3	[3]36	108	1	[4]26	26
17x Ecoregion						
USFS	7	15	105	49	[4]26	1274
Private	9	[3]36	324	43	10	430

[1]Average load for gravel (Drummond weather station)
[2]Average load for native (Drummond weather station)
[3]Average load for gravel (Combination weather station)
[4]Average load for native (Combination weather station)

An estimated total load representing BMP implementation was then derived for each watershed in the Flint Creek TPA. A 31% reduction factor was again applied to account for "false" crossings identified in the GIS analysis (**Table E-9**).

Table E-9. BMP Sediment Load for Road Crossings

Watershed	Number Crossings	BMP Total Load (lb)	BMP Total Load (tons)	Total Load 31% RF (tons)
Barnes Creek	29	1,114	0.56	0.39
Boulder Creek	74	2,017	1.01	0.70
Douglas Creek (North)	34	803	0.40	0.28
Douglas Creek (South)	21	898	0.45	0.31
Fred Burr Creek	9	445	0.22	0.15
Lower Flint Creek	79	2,810	1.41	0.97
Middle Flint Creek	112	3,821	1.91	1.32

Table E-9. BMP Sediment Load for Road Crossings

Watershed	Number Crossings	BMP Total Load (lb)	BMP Total Load (tons)	Total Load 31% RF (tons)
Upper Flint Creek	86	3,150	1.58	1.09
Smart Creek	72	2,549	1.27	0.88
Trout Creek	41	1,866	0.93	0.64
Lower Willow Creek	20	755	0.38	0.26
North Fork Willow Creek	38	1,099	0.55	0.38
South Fork Willow Creek	52	1,263	0.63	0.43
Total	667	22,590	11.3	7.8

E6.2 PARALLEL ROAD SEGMENTS BMP

Sediment loads were modeled for each measured parallel road segment, with all sites reduced to a maximum contributing length of 200 feet. As before, the calculated load for each parallel segment was converted to an annual load per mile of road length, and a general average sediment load for parallel road segments was determined (**Table E-10**).

Table E-10. Modeling Results for BMP Parallel Road Segments

Site Number	Land Ownership	Road Type	Road Length (ft)	Measured Load (lbs/year)	Measured Load (tons/mile)
292-293	Private	Native	200	88	0.2024
307	Private	Native	200	2	0.0092
327	USFS	Native	200	0	0
3	Private	Gravel	200	92	0.1438
283	Private	Gravel	200	51	0.0547
313	USFS	Gravel	200	91	0.4883
315	USFS	Gravel	200	73	0.5341
395	USFS	Gravel	200	31	0.2170
				Average	**0.2062**

The average sediment loading rate from BMP implementation on parallel roads was then applied to the total number of parallel segment miles in each watershed. As before, the 30% reduction factor was incorporated to account for discrepancies between GIS analysis and field observations. (**Table E-11**).

Table E-11. Extrapolation of Modeled BMP Data to Parallel Road Segments by Watershed

Watershed	Miles of Road	Miles of Road	Total Miles	Estimated Total Load (tons/year)	Total Load 31% RF (tons/year)
	Gravel	Native		All	
Barnes Creek	0.88	0.74	1.62	0.33	0.23
Boulder Creek	3.86	3.10	6.96	1.44	0.99
Douglas Creek (North)	5.57	1.56	7.13	1.47	1.01
Douglas Creek (South)	1.32	1.02	2.34	0.48	0.33
Fred Burr Creek	0.16	0.75	0.91	0.19	0.13
Lower Flint Creek	3.03	7.37	10.40	2.14	1.48
Middle Flint Creek	5.70	5.07	10.77	2.22	1.53
Upper Flint Creek	3.18	8.94	12.12	2.50	1.72
Smart Creek	4.55	5.93	10.48	2.16	1.49
Trout Creek	1.64	1.85	3.49	0.72	0.50
Lower Willow Creek	0.66	0.30	0.96	0.20	0.14

Table E-11. Extrapolation of Modeled BMP Data to Parallel Road Segments by Watershed

Watershed	Miles of Road	Miles of Road	Total Miles	Estimated Total Load (tons/year)	Total Load 31% RF (tons/year)
North Fork Willow Creek	1.72	3.82	5.54	1.14	0.79
South Fork Willow Creek	1.00	3.30	4.30	0.89	0.61
Total	**33.27**	**43.76**	**77.02**	**15.88**	**10.95**

E7.0 LOAD REDUCTIONS AND SUMMARY

The analysis of roads in the Flint Creek TPA is an estimate based on data representative of on-the-ground conditions. The results of the GIS analysis and modeling effort provide a reasonable characterization of the sediment loads from roads throughout the Flint Creek watershed. In order to understand the relative impact of these loads, the existing loads have been normalized to provide a watershed by watershed comparison, independent of the watershed area (**Table E-12**). Based on this analysis, Smart Creek, Douglas Creek (North) , and Douglas Creek (South) provide the three largest sediment loads from roads in the Flint Creek TPA.

Table E-12. Existing Load Comparison Among Watersheds

EXISTING LOADS					
Watershed	**Acres**	**Crossings Load**	**Parallel Load**	**Total Load**	**Load/1000 acres**
Barnes Creek	13,649	1.79	1.07	2.86	0.21
Boulder Creek	45,207	6.03	4.60	10.63	0.24
Douglas Creek (North)	9393	2.46	4.71	7.17	0.76
Douglas Creek (South)	4118	1.10	1.56	2.66	0.65
Fred Burr Creek	10,082	0.50	0.60	1.10	0.11
Lower Flint Creek	49,485	4.54	6.86	11.40	0.23
Middle Flint Creek	48,657	7.62	7.11	14.73	0.30
Upper Flint Creek	44,707	5.76	8.00	13.76	0.31
Smart Creek	15,626	5.80	6.91	12.71	0.81
Trout Creek	22,565	1.52	2.30	3.82	0.17
Lower Willow Creek	9032	1.01	0.63	1.64	0.18
N. F. Willow Creek	19,453	2.04	3.66	5.70	0.29
S. F. Willow Creek	25,731	2.75	2.84	5.59	0.22

Sampled locations were modeled first for the existing load, and then again to incorporate changes that could occur given the implementation of potential BMPs. Reductions in sediment loads from road crossings are based on site specific information from each assessed crossing. Parallel road segments were re-modeled to simulate road sections with a maximum contributing distance of 200 feet. At the time of data collection, the field personnel recorded potential improvements in road design or maintenance, which were then later input into the model to simulate the sediment loads if all BMPs were installed. The BMP scenarios allow for the development of an estimate of the potential for improvement and load reduction throughout the watershed. Based on this analysis, on average, a 78% reduction in sediment loading from roads could be achieved throughout the watershed with the application of all appropriate Best Management Practices (**Table E-13**).

Table E-13. Sediment Loads from Roads with Application of All BMPs

BMP LOADS						
Watershed	**Acres**	**Crossings Load**	**Parallel Load**	**Total Load**	**Percent Reduction**	**Load/1000 acres**
Barnes Creek	13,649	0.39	0.23	0.62	78%	0.05
Boulder Creek	45,207	0.70	0.99	1.69	84%	0.04
Douglas Creek (North)	9393	0.28	1.01	1.29	82%	0.14
Douglas Creek (South)	4118	0.31	0.33	0.64	76%	0.16
Fred Burr Creek	10,082	0.15	0.13	0.28	75%	0.03
Lower Flint Creek	49,485	0.97	1.48	2.45	79%	0.05
Middle Flint Creek	48,657	1.32	1.53	2.85	81%	0.06
Upper Flint Creek	44,707	1.09	1.72	2.81	80%	0.06
Smart Creek	15,626	0.88	1.49	2.37	81%	0.15
Trout Creek	22,565	0.64	0.50	1.14	70%	0.05
Lower Willow Creek	9032	0.26	0.14	0.40	76%	0.04
N. F. Willow Creek	19,453	0.38	0.79	1.17	79%	0.06
S. F. Willow Creek	25,731	0.43	0.61	1.04	81%	0.04

In general, a few basic observations regarding the road systems can be made, independent of the model outputs. Roads in the mountains are often responsible for higher sediment loads due to steeper terrain, differences in geology, and higher precipitation. High traffic roads at lower elevations are often maintained year round, whereas less frequented roads (often at higher elevations) receive seasonal or little to no regular maintenance. In addition, the majority of the sediment load often comes from a relatively small percent of all road crossings, as illustrated in **Figure E-1**. With these things in mind, strategies can start to be developed on how to approach reducing sediment load from roads.

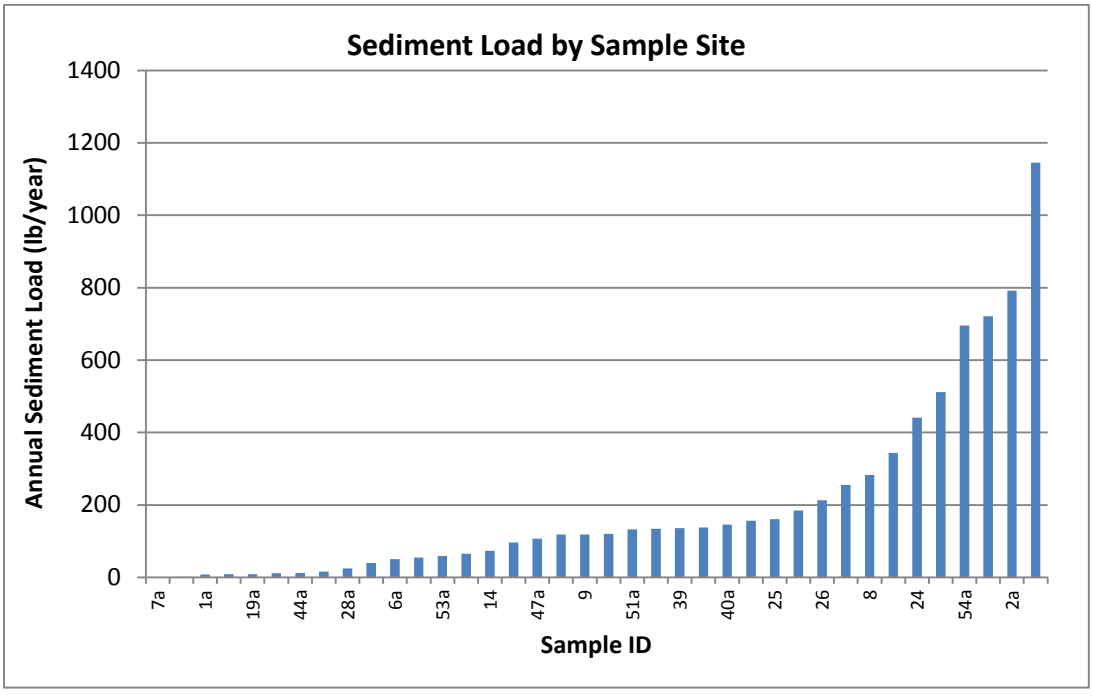


Figure E-1: Sediment Load by Sample Site

Although only a small percentage of sites were assessed, the random sampling design of the project assumes that those sites are representative of the watershed as a whole, and allows for a reasonable representation of what is occurring in the field. As shown in the results, 74% of the road crossings assessed contributed less than 200lbs/year, and only 10% of the road crossings contribute greater than 600 lbs/year. Therefore, it can be assumed that the greatest contribution of sediment loading comes from approximately 25% of the roads, with roughly 10% of the crossings in need of immediate concern. To eventually reduce the sediment load from road systems in the Flint Creek TPA, the best course of action is to identify those individual road crossings and parallel road segments with the largest contribution. The responsibility for determining which road crossings or segments deserve the most immediate attention lies with the owners of the roads in the respective watersheds. Ownership of crossings per watershed is presented in **Table E-14**.

Table E-14. Attributed Ownership of Road Crossings by Watershed

Road Crossings*					
	Attributed Ownership based on available GIS information				
Watershed	**BLM**	**USFS**	**State of Montana**	**Private**	**Unattributed**
Barnes Creek	-	2	-	26	1
Boulder Creek	1	69	-	4	-
Douglas Creek (North)	-	22	-	12	-
Douglas Creek (South)	1	-	-	19	1
Fred Burr Creek	-	-	-	9	-
Lower Flint Creek	-	14	3	62	-
Middle Flint Creek	10	31	-	70	1
Upper Flint Creek	-	47	-	35	4
Smart Creek	3	42	-	27	-
Trout Creek	-	-	9	32	-
Lower Willow Creek	-	-	-	20	-
North Fork Willow Creek	-	11	-	27	-
South Fork Willow Creek	-	29	-	23	-

* Road crossings as identified through initial GIS analysis and does not account for 30% reduction due to "false-crossings". Crossings were identified based on land ownership; it is acknowledged that road ownership may not always equate to adjacent land ownership and therefore the ownership attribution may not be entirely accurate.

The USFS, BLM, and other agencies and organizations have developed extensive documentation and guidelines for managing roads on public lands. BMPs such as dips, crossdrains, graded berms, proper culvert design, road relocation, alteration to road material, and revegetation are options for reducing sediment loads. The main BMPs that were observed in the field included cross drains and dips, and effective road grading. Of the assessed crossings, BMPs were observed on 27 percent of the USFS roads and 24 percent of the private roads, and one of two BLM roads. For the parallel road segments, 75 percent of the segments had some BMPs present. While road BMPs do exist in some in the Flint Creek TPA, the results from this study show there is still significant opportunity for improvement and reduction of sediment loads from roads.

E8.0 REFERENCES

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APPENDIX F – DAILY LOADS

F1.0 OVERVIEW

A percent reduction based on average yearly loading was used as the primary approach for expressing the sediment TMDLs within this document because there is uncertainty associated with loads derived from the source assessment, and using the estimated sediment loads alone creates a rigid perception that the loads are absolutely conclusive. However, in this appendix the TMDL is expressed using daily loads to satisfy an additional EPA required TMDL element. Daily loads should not be considered absolute limits for a given day and may be refined in the future as part of the adaptive management process. The TMDLs may not be feasible at all locations within the watershed but if the allocations are followed, sediment loads are expected to be reduced to a degree that the sediment targets are met and beneficial uses are no longer impaired. It is not expected that daily loads will drive implementation activities.

F2.0 APPROACH

In order to determine a daily load, the means of daily mean values for suspended sediment discharge in tons per day were reviewed from a USGS gage station on the Clark Fork River. The USGS station on the Clark Fork River at Deer Lodge (12324200) was selected to represent the daily variability in sediment loading in the Flint Creek TPA due to its relative proximity to the Flint Creek watershed, and therefore similar climate; its reasonably similar land uses; fairly similar drainage area (Upper Clark Fork watershed to Deer Lodge (excluding the area draining to Warm Springs Ponds) = 618 sq miles, Flint Creek TPA = 500 sq miles) and the fact that it actually had a period of record for annual total suspended sediment, whereas most USGS stations in the region do not have daily sediment data. Although there is some variability in size between the Upper Clark Fork watershed and the Flint Creek TPA, the true size of the streams is of less concern in this case because it is the relationship between sediment load (a function of sediment concentration and flow) and the day of the year that is the primary focus for this analysis. It is assumed that the hydrologic properties and rate of loading on a given day are similar enough to the Flint Creek TPA to discern relative percentages and distribution of an annual load to each day in the calendar year.

The mean of daily mean values for suspended sediment discharge, in tons per day, was calculated based on approximately 26 years of record (October 1, 1984 – September 30, 2010) (**Table F-1**). The mean annual suspended sediment load for USGS gage 12324200, based on a summation of the mean of daily mean values is 9,368 tons per year. Although the suspended sediment load represents a portion of the total load from the source assessment, it provides an approximation of the relationship between sediment and flow in the Upper Clark Fork, which can in turn be used to mirror conditions in the Flint Creek watershed. Using the mean of daily mean sediment loads, a daily percentage relative to the mean annual suspended sediment load was calculated for each day (**Table F-2**). **Figure F-1** visually represents the average daily percentage of the total yearly sediment load for each day of the calendar year.

To conserve resources, this appendix only provides the base data from the USGS stream gage, and the daily percentages of the total annual load. For specific streams, all daily TMDLs may be derived by using

the daily percentages in **Table F-2** and the TMDLs expressed as an average annual load, which are discussed in **Section 5.6**. For instance, the total allowable annual sediment load for Smart Creek is 691 tons. To determine the TMDL for January 1, this value is multiplied by 1.12% which provides a daily load for January 1st for Smart Creek of 7.7 tons. The daily loads are a composite of the allocations, but as allocations are not feasible on a daily basis, they are not contained within this appendix. If desired, daily allocations may be obtained by applying allocations provided in **Section 5.6** to the daily load.

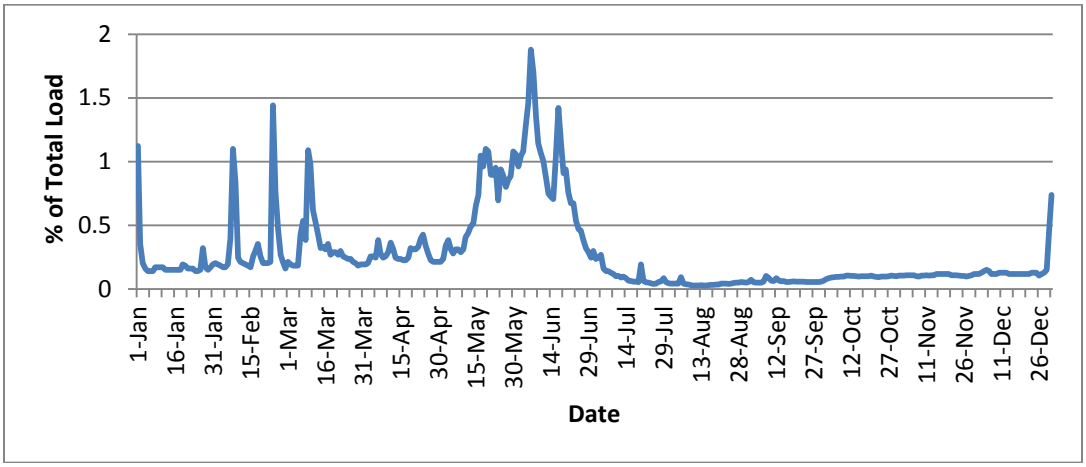


Figure F-1. Average daily percentage of the total yearly sediment load

The percent of total daily sediment loading information from the USGS gage station on the Clark Fork River at Deer Lodge in **Figure F-1** illustrates the fluctuating nature of sediment loads, driven by climate and precipitation, in many western Montana streams. In general, it appears that elevated sediment loading is most closely linked to spring runoff, with occasional sporadic elevated loads, probably as the result of individual runoff events, mostly in winter and early spring, potentially as a result of wet spring snows with rapid melting or rain-on-snow events.

Table F-1. Average Suspended Sediment Discharge, (Calculation Period 1984-10-01 -> 2010-09-30)

Day of	Mean of daily mean values for each day of record in tons/day											
month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	105	19	20	18	20	90	28	3.9	5.1	6	9.7	11
2	33	18	18	19	22	98	22	4	6.7	7.1	9.8	11
3	19	17	17	24	32	101	23	3.9	4.9	7.8	10	12
4	15	16	17	24	36	120	25	3.8	4.5	8.4	10	13
5	13	16	17	23	29	137	15	8.5	4.6	8.7	10	14
6	13	18	40	36	26	176	13	3.8	4.6	8.9	10	13
7	13	37	50	26	29	159	13	3.4	5.4	8.9	9.4	11
8	16	103	36	23	29	127	12	3.1	9.6	9.2	9.2	11
9	16	78	102	24	27	107	11	2.8	8.1	9.1	9.7	11
10	16	23	92	27	29	100	9.4	2.4	6.1	9.7	9.9	12
11	16	20	58	34	38	94	9.6	2.4	5.9	9.8	10	12
12	14	19	49	29	41	82	8.3	2.6	7.9	9.6	9.9	12
13	14	18	40	23	46	70	9	2.7	6.3	9.6	10	12
14	14	17	30	22	48	68	7.8	2.6	5.6	9.4	10	11
15	14	16	31	22	61	66	6.1	2.5	5.7	9.2	11	11
16	14	24	29	21	69	97	5.9	2.8	5	9.4	11	11
17	14	28	33	21	98	133	5.4	3	5	9.3	11	11
18	14	33	25	23	90	108	5.3	3	5.4	9.3	11	11
19	18	24	27	30	103	85	5.1	3.2	5.5	9.3	11	11
20	17	19	27	29	101	88	18	3.3	5.4	9.8	11	11
21	15	19	25	29	84	71	5.9	3.9	5.4	9.2	10	11
22	15	19	28	31	84	63	4.8	4	5.3	8.9	10	11
23	15	20	24	37	89	63	4.5	3.9	5.4	8.7	10	12
24	13	135	23	40	65	50	4.1	3.7	5.2	9	9.9	12
25	13	71	22	32	88	44	3.6	3.8	5.2	9.2	9.6	12
26	14	44	22	26	83	43	4	4.3	5.2	9.1	9.5	9.8
27	30	25	20	21	75	36	5.2	4.7	5	9.4	9.2	11
28	16	20	19	20	80	30	5.5	4.5	5.1	9.7	9.5	12
29	14	15	17	20	83	27	8	5	5.1	9.6	10	14
30	16		18	20	101	23	5.2	4.9	5.3	9.4	11	41
31	18		18		99		4.1	4.5		9.7		69

Table F-2. Suspended Sediment Discharge, Percentage of tons per day based on the annual load

Day of month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1.12	0.20	0.21	0.19	0.21	0.96	0.30	0.04	0.05	0.06	0.10	0.12
2	0.35	0.19	0.19	0.20	0.23	1.05	0.23	0.04	0.07	0.08	0.10	0.12
3	0.20	0.18	0.18	0.26	0.34	1.08	0.25	0.04	0.05	0.08	0.11	0.13
4	0.16	0.17	0.18	0.26	0.38	1.28	0.27	0.04	0.05	0.09	0.11	0.14
5	0.14	0.17	0.18	0.25	0.31	1.46	0.16	0.09	0.05	0.09	0.11	0.15
6	0.14	0.19	0.43	0.38	0.28	1.88	0.14	0.04	0.05	0.10	0.11	0.14
7	0.14	0.39	0.53	0.28	0.31	1.70	0.14	0.04	0.06	0.10	0.10	0.12
8	0.17	1.10	0.38	0.25	0.31	1.36	0.13	0.03	0.10	0.10	0.10	0.12
9	0.17	0.83	1.09	0.26	0.29	1.14	0.12	0.03	0.09	0.10	0.10	0.12
10	0.17	0.25	0.98	0.29	0.31	1.07	0.10	0.03	0.07	0.10	0.11	0.13
11	0.17	0.21	0.62	0.36	0.41	1.00	0.10	0.03	0.06	0.10	0.11	0.13
12	0.15	0.20	0.52	0.31	0.44	0.88	0.09	0.03	0.08	0.10	0.11	0.13
13	0.15	0.19	0.43	0.25	0.49	0.75	0.10	0.03	0.07	0.10	0.11	0.13
14	0.15	0.18	0.32	0.23	0.51	0.73	0.08	0.03	0.06	0.10	0.11	0.12
15	0.15	0.17	0.33	0.23	0.65	0.70	0.07	0.03	0.06	0.10	0.12	0.12
16	0.15	0.26	0.31	0.22	0.74	1.04	0.06	0.03	0.05	0.10	0.12	0.12
17	0.15	0.30	0.35	0.22	1.05	1.42	0.06	0.03	0.05	0.10	0.12	0.12
18	0.15	0.35	0.27	0.25	0.96	1.15	0.06	0.03	0.06	0.10	0.12	0.12
19	0.19	0.26	0.29	0.32	1.10	0.91	0.05	0.03	0.06	0.10	0.12	0.12
20	0.18	0.20	0.29	0.31	1.08	0.94	0.19	0.04	0.06	0.10	0.12	0.12
21	0.16	0.20	0.27	0.31	0.90	0.76	0.06	0.04	0.06	0.10	0.11	0.12
22	0.16	0.20	0.30	0.33	0.90	0.67	0.05	0.04	0.06	0.10	0.11	0.12
23	0.16	0.21	0.26	0.39	0.95	0.67	0.05	0.04	0.06	0.09	0.11	0.13
24	0.14	1.44	0.25	0.43	0.69	0.53	0.04	0.04	0.06	0.10	0.11	0.13
25	0.14	0.76	0.23	0.34	0.94	0.47	0.04	0.04	0.06	0.10	0.10	0.13
26	0.15	0.47	0.23	0.28	0.89	0.46	0.04	0.05	0.06	0.10	0.10	0.10
27	0.32	0.27	0.21	0.22	0.80	0.38	0.06	0.05	0.05	0.10	0.10	0.12
28	0.17	0.21	0.20	0.21	0.85	0.32	0.06	0.05	0.05	0.10	0.10	0.13
29	0.15	0.16	0.18	0.21	0.89	0.29	0.09	0.05	0.05	0.10	0.11	0.15
30	0.17		0.19	0.21	1.08	0.25	0.06	0.05	0.06	0.10	0.12	0.44
31	0.19		0.19		1.06		0.04	0.05		0.10		0.74

ATTACHMENT A – ANALYSIS OF BASE PARAMETER DATA AND EROSION INVENTORY DATA FOR SEDIMENT TMDL DEVELOPMENT WITHIN THE FLINT CREEK TPA

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ANALYSIS OF BASE PARAMETER DATA AND EROSION INVENTORY DATA FOR SEDIMENT TMDL DEVELOPMENT WITHIN THE FLINT CREEK TPA



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February 2010

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1.0 INTRODUCTION

The Flint Creek TMDL Planning Area (TPA) encompasses an area of approximately 500 square miles in southwestern Montana (**Figure 1-1**), and lies almost entirely in Granite County with a small portion in Deer Lodge County. The Flint Creek watershed originates in the Flint Creek Mountains to the east, the Pintlar Mountains to the south, and the Sapphire and John Long Mountains to the west. Flint Creek drains from Georgetown Lake and bisects two large agricultural valleys, the Philipsburg Valley and the Drummond Valley, which are separated by a narrow bedrock canyon. Flow in upper Flint Creek is primarily controlled by the outlet structure at Georgetown Lake, and flow is seasonally augmented from a trans-basin diversion in the East Fork of Rock Creek. Approximately 2,200 residents reside within the Flint Creek TPA, with Philipsburg (pop. 911) and Drummond (pop. 315) as the largest towns. Other population centers include Maxville and Hall. Land ownership in the Flint Creek TPA is primarily private and U.S. Forest Service (Beaverhead-Deer Lodge National Forest), with a small amount of land managed by Bureau of Land Management (BLM) and the State of Montana. Private lands are located predominantly in the lower elevation areas where wide, low-gradient valleys are conducive to agriculture and development.

Today, the economy of the Flint Creek watershed is dominated by agriculture and tourism supported through the areas rich recreational opportunities, although historically the Flint Creek watershed has also seen extensive mining activity, and forested lands were harvested for timber. Many roads were built in conjunction with these activities. Currently, forest lands in the Flint Creek TPA are used for recreational purposes as well as some resource extraction. Most of the historic road system is maintained to some degree to supply access for recreation, resource extraction and fire suppression. Other roads are either decommissioned or left in place. Private lands are predominantly agricultural and rural, with some residential areas. Several tracts of land that were historically grazed or farmed are now subdivided into smaller parcels and have been developed into residential units.

Under Montana law, an impaired water body is defined as a water body for which sufficient and credible data indicates non-compliance with applicable water quality standards (MCA 75-5-103). Section 303 of the Federal Clean Water Act requires states to submit a list of impaired water bodies or stream segments to the U.S. Environmental Protection Agency (EPA) every two years. Prior to 2004, this list was referred to as the "303(d) list", but is now named the "Integrated Report". The Montana Water Quality Act further directs states to develop TMDLs for all water bodies appearing on the 303(d) list as impaired or threatened by "pollutants" (MCA 75-5-703). If sufficient credible data exists to support the sediment impairment determinations for the 1996 listed streams, then sediment TMDLs will be developed. If sufficient data does not exist, then data will be collected to confirm or deny the 1996 listings and TMDLs will be developed for all streams determined to be impaired.

In 2009, Montana Department of Environmental Quality (DEQ) initiated an effort to collect data to support the development of sediment TMDLs for streams within the Flint Creek TPA. The data collection effort involved assessing sediment and habitat conditions within the Flint Creek watershed, as these conditions influence aquatic life beneficial uses. The data collection effort included stream stratification, sampling design, ground surveys, and sediment and habitat

analyses, and is intended to assist DEQ in evaluating the impairment status of tributary streams in the Flint Creek TPA and for developing TMDLs where necessary.

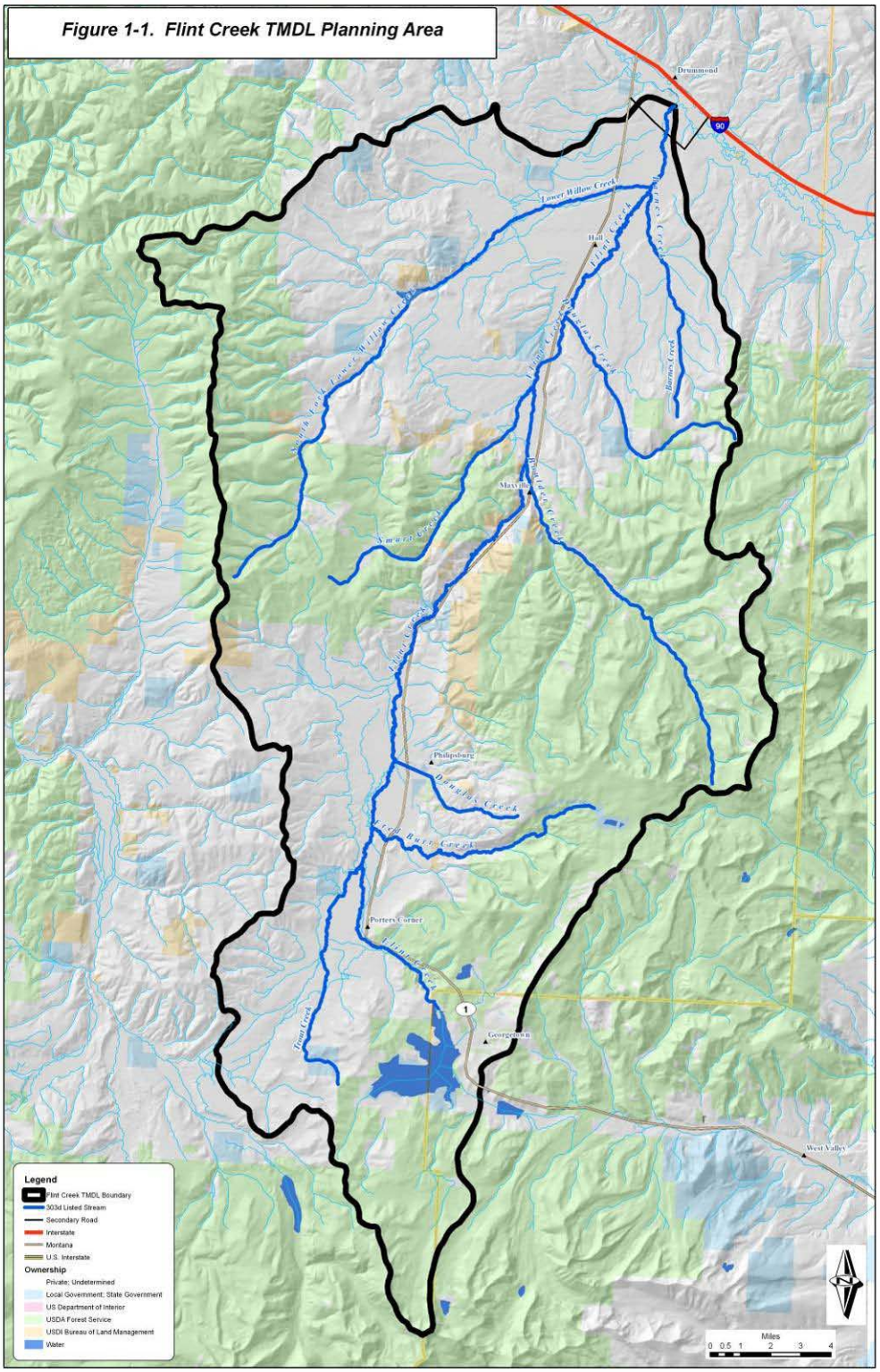


Figure 1-1. Flint Creek TMDL Planning Area.

A total of nine streams in the Flint Creek TPA were included for sediment and habitat assessment: Barnes Creek, Boulder Creek, Douglas Creek North (near Hall), Douglas Creek South (near Philipsburg), Flint Creek, Fred Burr Creek, Flint Creek, Lower Willow Creek, Smart Creek, and Trout Creek. Flint Creek, Smart Creek, Douglas Creek South and Barnes Creek appear on Montana's 2008 Integrated Report for sediment impairment.

A stream stratification process was completed on listed stream segments and is intended to develop water body characterizations that can be applied across watersheds, accounting for localized ecological and hydrologic variations. The stratification enables comparison between observed and expected values for various sediment and habitat parameters, and helps quantify the effects of anthropogenic influences. Stratification for streams in the Flint Creek TPA began by dividing the water bodies into reaches and sub-reaches based on aerial photo interpretation of stream characteristics, landscape conditions, and land-use factors. This preliminary work was completed in summer 2009.

Following the initial primary reach stratification, representative reaches were chosen by DEQ for data collection. A two-day sampling reach reconnaissance was conducted on August 11 and 12, 2009, and field personnel completed full site surveys from September 8-18, 2009. Field personnel visited the selected reaches and recorded bank erosion sites, vegetation, and channel characteristics data. Data were later compiled and analyzed resulting in full descriptions of sediment and habitat conditions for all of the surveyed reaches and the ability to extrapolate to non-surveyed reaches.

2.0 AERIAL ASSESSMENT REACH STRATIFICATION

2.1 Methods

An aerial assessment of streams in the Flint Creek TPA was conducted by Montana DEQ using geographic information systems (GIS) software and 2005 color aerial imagery. Relevant geographic data layers were acquired from the U.S. Geological Survey (USGS), the U.S. Environmental Protection Agency (USEPA) and the Montana State National Resource Information System (NRIS) database. Layers include the following data sets.

- Ecoregion (USEPA)
- Scanned and Rectified Topographic Maps, 1:24,000 and 1:100,000 (USGS)
- National Hydrography Dataset Lakes and Streams (USGS)
- 2005 National Aerial Image Program (NAIP – NRIS)

GIS data layers were used to stratify streams into primary reaches based on stream characteristics, landscape and land-use factors. The stream reach stratification methodology applied in this study is described in *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations* (DEQ 2008a). The reach stratification methodology involves delineating a water body stream segment into stream reaches and sub-reaches. This process was completed for the following stream segments in the Flint Creek TPA: Barnes Creek, Boulder Creek, Douglas Creek North (near Hall), Douglas Creek South (near Philipsburg), Flint Creek, Fred Burr Creek, Lower Willow Creek, Smart Creek, Trout Creek, and Princeton Gulch.

2.2 Stream Reaches

Water body segments are delineated by a water use class designated by the State of Montana, e.g. A-1, B-3, C-3 (Administrative Rules of Montana Title 17 Chapter 30, Sub-Chapter 6). Although a water body segment is the smallest unit for which an impairment determination is made, the stratification approach described in this document initially stratifies individual water body segments into discrete assessment reaches that are delineated by landscape controls such as Ecoregion, Strahler stream order, valley gradient, and valley confinement. The reason for this stratification is that the inherent differences in landscape controls between stream reaches often prevents a direct comparison from being made between the physical attributes of one stream reach to another. By initially stratifying water body segments into stream reaches having similar landscape controls, it is feasible to make comparisons between similar reaches in regards to observed versus expected channel morphology. Likewise, when land use is used as an additional stratification (e.g. grazed vs. non-grazed sub-reaches), sediment and habitat parameters for impaired stream reaches can be more readily compared to reference reaches that meet the same geomorphic stratification criteria.

The aerial photograph reach stratification methodology involves dividing a stream segment into distinct reaches based on four primary watershed characteristics, including Ecoregion, valley gradient, Strahler stream order, and valley confinement. Once stream reaches have been classified by the four watershed characteristics, reaches are further divided based on the

surrounding vegetation and land-use characteristics as observed in the color aerial imagery using GIS. The result is a series of stream reaches and sub-reaches delineated by landscape and land-use factors. Stream reaches with similar landscape factors can then be compared based on the character of surrounding land-use practices.

For ease of labeling, each listed stream in the assessment was assigned an abbreviation based on the stream name. These labels were use in the individual stream reach classification. **Table 2-1** shows the abbreviations developed for each water body.

Table 2-1. Water body naming key.

Water Body	Label Abbreviation
Barnes Creek	BARN
Boulder Creek	BOUL
Douglas Creek (North)	DOUN
Douglas Creek (South)	DOUS
Flint Creek	FLIN
Fred Burr Creek	FRED
Lower Willow Creek	LOWI
Smart Creek	SMAR
Trout Creek	TROU

2.3 Reach Types

Individual stream reaches were delineated by reach type based on four watershed characteristics. For the purposes of this report, a "reach type" is defined as a unique combination of Ecoregion, valley gradient, Strahler stream order, and valley confinement, and is designated using the following naming convention based on the reach type identifiers provided in **Table 2-2**:

Level III Ecoregion – Valley Gradient – Strahler Stream Order – Confinement

Table 2-2. Reach type identifiers.

Watershed Characteristic	Stratification Category	Reach Type Identifier
Level III Ecoregion	Middle Rockies	MR
Valley Gradient	0-2%	0
	2-4%	2
	4-10%	4
	> 10%	10
Strahler Stream Order	first order	1
	second order	2
	third order	3
	fourth order	4
	fifth order	5

Table 2-2. Reach type identifiers.		
Watershed Characteristic	**Stratification Category**	**Reach Type Identifier**
Confinement	confined	C
	unconfined	U

The Flint Creek TPA exists solely within the Middle Rockies Level III Ecoregion (Ecoregion 17), which includes three Level IV Ecoregions within the Flint Creek TPA, including the Flint Creek-Anaconda Mountains (17am), the Deer Lodge-Philipsburg-Avon Grassy Intermontane Hills and Valleys (17ak), and a portion of the Sapphire Mountains (17x). Present reach type combinations for the Flint Creek TPA are provided in **Table 2-3**, including the number of sites monitored of each reach type. Overall, 24 monitoring sites were selected for field evaluation.

Table 2-3. Stratified reach types within the Flint Creek TPA.

Level III Ecoregion	Valley Gradient	Strahler Stream Order	Confine-ment	Reach Type	Number of Reaches	Number of Monitoring Sites
Middle Rockies	<2%	1	C	MR-0-1-C	1	
			U	MR-0-1-U	8	
		2	C	MR-0-2-C	2	
			U	MR-0-2-U	50	5
		3	U	MR-0-3-U	98	6
		4	U	MR-0-4-U	121	5
		5	U	MR-0-5-U	11	1
	2-4%	1	U	MR-2-1-U	15	
		2	C	MR-2-2-C	20	
			U	MR-2-2-U	74	4
		3	U	MR-2-3-U	43	2
		4	U	MR-2-4-U	13	1
	4-10%	1	C	MR-4-1-C	20	
			U	MR-4-1-U	31	
		2	C	MR-4-2-C	16	
			U	MR-4-2-U	40	
		3	U	MR-4-3-U	8	
		4	U	MR-4-4-U	2	
	>10%	1	C	MR-10-1-C	24	
			U	MR-10-1-U	14	
		2	C	MR-10-2-C	6	
			U	MR-10-2-U	14	
				Totals:	**631**	**24**

Table 2-4 shows the assessed water bodies and monitored reaches included within each reach type. A map of monitoring site locations is provided as **Attachment A**.

Table 2-4. Monitoring sites in assessed reach types.

Reach Type	Water body	Monitoring Sites
MR-0-2-U	Douglas Creek (North), Fred Burr Creek, Smart Creek	DOUN 08-02, FRED 29-02, SMAR 21-01, SMAR 18-01-1, SMAR 18-01-2
MR-0-3-U	Barnes Creek, Boulder Creek, Flint Creek, Trout Creek	BARN 11-01, BARN 13-01, BARN 13-03, BOUL 21-02, FLIN 09-02, TROU 09-03
MR-0-4-U	Flint Creek, Lower Willow Creek	FLIN 11-01, FLIN 11-04, FLIN 18-02, FLIN 18-05, LOWI 02-05
MR-0-5-U	Flint Creek	FLIN 19-01
MR-2-2-U	Douglas Creek (North), Douglas Creek (South), Flint Creek, Smart Creek	DOUN 07-01, DOUS 19-02, FLIN 06-01, SMAR 13-01
MR-2-3-U	Boulder Creek	BOUL 16-01, TROU 10-01
MR-2-4-U	Flint Creek	FLIN 17-01

3.0 SEDIMENT AND HABITAT DATASET REVIEW

3.1 Field Methodology

The following sections describe the field methodologies employed during the stream assessments. The methods follow standard DEQ protocols for sediment and habitat assessment as presented in the document *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (DEQ 2008b). For most survey sites, a minimum of 5 team members were present, which were always divided into 3 teams, referred to as the "Greenline", "Longitudinal Profile" or "Long-Pro", and "Cross-Section" teams in this section. The teams worked independently moving upstream through the survey site and in a pre-established order to facilitate accurate data collection and to create the least possible in-stream disturbance. All field data were collected on DEQ standard forms for sediment and habitat assessments, and are summarized and provided in tabular format in **Attachment B**.

3.1.1 Survey Site Delineation

Stream survey sites were delineated beginning at riffle crests at the downstream ends of reaches. Survey sites were measured upstream at pre-determined lengths based on the bankfull width at the selected downstream riffle. Survey lengths of 500 ft were used for bankfull widths less than 10 ft; survey lengths of 1,000 ft were used for bankfull widths between 10 ft and 50 ft; and survey lengths of 1,500 ft were used for bankfull widths greater than 60 ft. Each survey site was divided into 5 equally sized study cells. For each site, the field team leader identified the appropriate downstream riffle crest to begin a reach. Where no riffles were present or the stream was dry, the field team leader identified the appropriate starting point. The GPS location of the downstream and upstream ends of the survey site was recorded on the **Sediment and Habitat Assessment Site Information Form**. Digital photographs were taken at both upstream and downstream ends of the survey site, looking both upstream and downstream. Photo numbers and a brief description were recorded in the **Photo Log**, which is included in **Attachment C**.

3.1.2 Field Determination of Bankfull

All members of the field crew participated in determining the bankfull elevation prior to breaking into their respective teams. Indicators that were used to estimate the bankfull channel elevation included scour lines, changes in vegetation types, tops of point bars, changes in slope, changes in particle size and distribution, stained rocks and inundation features. Multiple locations and indicators were examined, and bankfull elevation estimates and their corresponding indicators were recorded in the **Bankfull Elevation and Slope Assessment Field Form** by the field team leader. Final determination of the appropriate bankfull elevation was determined by the team leader, and informed by the team experience and notes from the field form.

3.1.3 Channel Cross-Sections

The "Cross-Section team" was composed of two members of the assessment crew, who also performed pebble counts, riffle stability index, and riffle grid tosses. Channel cross-section surveys were performed at the first riffle in each cell moving upstream using a line level and a

measuring rod. Channel surveys were recorded in the **Channel Cross-section Field Form**. Cross-sections were surveyed in each cell containing a riffle. In the case that riffles were present in only 1 or 2 cells, but those cells contained multiple riffles, additional cross-sections were performed at the most downstream unmeasured riffle, such that a minimum of three cross-sections were surveyed. If only 1 or 2 riffles were present in the entire reach, all riffle cross-sections were surveyed.

To begin each survey, the Cross-Section team placed a bank pin at the pre-determined bankfull elevation (using bankfull indicators as guides) on the right and left banks. A measuring tape was strung perpendicular to the stream channel at the most well-defined portion of the riffle and tied to the bank pins. Where mid-channel bars or other features were present which prevented a clean line across the channel, the protocol provided in the field methodology document was followed (DEQ 2008b). Bankfull depth measurements were collected to a tenth of a foot across the channel at regular intervals depending on channel width. The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals. From the recorded data, the following information was calculated for each cross-section:

Bankfull channel width = with of the channel measured at bankfull height

Cross-sectional area = the sum of the calculated areas from each measured cross-section cell, this value is estimated in the field and later calculated in a spreadsheet

Mean bankfull depth = cross-section area/bankfull channel width, this value is estimated in the field and later calculated in a spreadsheet

Width/depth ratio = bankfull width / mean bankfull depth

Entrenchment ratio = floodprone width / bankfull width.

The floodprone depth was determined by doubling the maximum channel depth. The floodprone width was then determined by stringing a tape from the bankfull channel margin on both right and left banks until the tape (pulled tight and flat) touched ground at the floodprone elevation. The total floodprone width was calculated by adding the bankfull channel width to the distances on either end of the channel to the floodprone elevation. When dense vegetation or other features prevented a direct line of tape from being strung, best professional judgment was used to determine the floodprone width. GPS coordinates for each cross-section were recorded. Photos were taken upstream and downstream of the cross section from the middle of the channel. A photo was also taken across the channel, showing the tape across the stream.

3.1.4 Channel Bed Morphology

A variety of channel bed morphology features were measured and recorded by the “Long-Pro” team, which usually consisted of two team members, and included the field team leader. The length of the survey site occupied by pools and riffles was identified and recorded in the **Pools, Riffles and Large Woody Debris Field Form.** Beginning from the downstream end of the survey site, the upstream and downstream stations of dominant riffle and pool stream features were recorded. Features were considered dominant when occupying over 50% of the stream

width for riffles and 33% for pools. Pools and riffles were measured from the downstream to upstream end of each feature. Runs and glides were not recorded in the field form. Stream features were identified using standard methods (DEQ 2008b).

3.1.4.1 Residual Pool Depth

At all pools encountered, a residual pool depth measurement was determined. Backwater pools were not measured. Measured pools were recorded at each station (distance in feet) of occurrence beginning at the downstream end (station 0) of the survey site. The depth of the pool tail crest at its deepest point was measured. The maximum depth of each pool was also recorded. The max pool depth minus the pool tail crest depth provides the residual pool depth. In the case of dry channels, readings were taken from channel bed surface to bankfull height. No pool tail crest depth was recorded for dammed pools (see **Section 3.1.4.2**).

3.1.4.2 Pool Habitat Quality

Qualitative assessments of each pool feature were undertaken and recorded in the **Pools, Riffles and Large Woody Debris Field Form** as follows:

1. Pool types were determined to be either Scour (S) or Dammed (D).
2. Pool size was estimated relative to bankfull channel width was recorded as Small (S), Medium (M), or Large (L). Small pools were defined as <1/3 of the bankfull channel width; medium pools were >1/3 and <2/3 of the bankfull channel with; and large pools were determined to be those >2/3 of the bankfull channel width or >20 feet wide.
3. Pool formative features were recorded as lateral scour (LS), plunge (P), boulder (B), or woody debris (W).
4. The primary pool cover type was recorded using the following codes:
   V = Overhanging Vegetation
   D = Depth
   U = Undercut
   B = Boulder
   W = Woody Debris
   N = No apparent cover
5. When undercut banks were present, their depths were measured to a tenth of a foot by inserting a measuring rod horizontally into the undercut bank.

3.1.4.3 Fine Sediment in Depositional Spawning Areas

A measurement of the percent of fine sediment in depositional spawning areas was taken using the grid toss method at the first and second scour pool of each cell. Grid toss readings were focused in those gravels that appeared to be suitable or potentially suitable for trout spawning. Measurements were taken within the "arc" just upstream of the pool tail crest, following the methodology in *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (DEQ 2008b). Three measurements were taken across the channel with specific attention given to measurements in gravels determined to be of appropriate size for salmonid spawning. The presence of spawning gravels was recorded as Yes (Y), No (N) or Unknown (?) at each pool location.

3.1.4.4 Fine Sediment in Riffles

Measurements of fine sediment in riffles were recorded by the Cross-Section team using the same grid toss method as used in pools (**Section 3.1.4.3**). Grid tosses were performed approximately within the right, middle, and left third of the riffle. Grid tosses were performed in the same general location but before the pebble counts (**Section 3.1.4.6**) to avoid disturbances to fine sediments. These measurements were recorded in the **Riffle Pebble Count Field Form.**

3.1.4.5 Woody Debris Quantification

The amount of large woody debris (LWD) was recorded by the Long-Pro team along the entire assessment reach in the **Pools, Riffles and Large Woody Debris Field Form**. Large pieces of woody debris located within the bankfull channel and which were relatively stable as to influence the channel form were counted as either single, aggregate or willow bunch. Further description of these categories is provided in *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (DEQ 2008b).

3.1.4.6 Riffle Pebble Count

A Wolman pebble count (Wolman 1954) was performed by the Cross-Section team at the first riffle encountered in cells 1, 3 and 5 as the team progressed upstream. These data were recorded in the **Riffle Pebble Count Field Form**. Particle sizes were measured along their intermediate length axis (*b-axis*) and results were grouped into size categories. The team progressed from bankfull edge to bankfull edge using the "heel to toe" method, measuring particle size at the tip of the boot at each step. More specific details of the pebble count methodology can be found in the field methods document (DEQ 2008b).

3.1.4.7 Riffle Stability Index

In stream reaches that had well developed point bars downstream of riffles, a riffle stability index (RSI) was performed to determine the average size of the largest recently deposited particles, and to calculate an RSI which evaluates riffle particle stability (Kappesser 2002). For stream reaches in which well developed gravel bars were present, a RSI was determined by first measuring the intermediate axis (*b-axis*) of 15 of the largest recently deposited particles on a depositional bar. This information was recorded in the **Riffle Pebble Count Field Form**. During post-field data processing, the arithmetic mean of the largest recently deposited particles is calculated. This value is then compared to the cumulative particle size distribution of an adjacent riffle, as determined by the Wolman pebble count. The RSI is reported as the cumulative percentile of the particle size classes that are smaller than the arithmetic mean of the largest recently deposited particles. The RSI value generally represents the percent of mobile particles within the riffle that is adjacent to the sampled bar.

3.1.5 Riparian Greenline Assessment

After the entire survey station length was measured by the "Greenline" team member, an assessment of riparian vegetation cover was performed. The reach was walked by the

"Greenline" team member who noted the general vegetation community type of the groundcover, understory and overstory on both banks. Vegetation types were recorded at 10-foot intervals and were entered in the **Riparian Greenline Field Form**.

The *ground cover* vegetation (<1.5 feet tall) was described using the following categories:

W = Wetland vegetation, such as sedges and rushes
G = Grasses or forbs, rose, snowberry (vegetation lacking binding root structure)
B = Bare/disturbed ground
R = Rock, when a large cobble or bolder is encountered
RR = Riprap

The *understory* (1.5 to 15 feet tall) and *overstory* (>15 feet tall) vegetation was described using the following categories:

C = Coniferous
D = Deciduous, riparian shrubs and trees with sufficient rooting mass and depth to provide protection to the streambanks
M = mixed coniferous and deciduous

At 50-foot intervals, riparian buffer width was estimated for both banks by evaluating the belt of riparian vegetation buffering the stream from adjacent land uses. Upon conclusion of the Greenline measurements, the total numbers of each type of vegetation were tallied.

3.1.6 Streambank Erosion Assessment

An assessment of all actively/visually eroding and slowly eroding/undercut/vegetated streambanks was conducted along each survey site. This assessment consisted of the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) estimation which are used to quantify sediment loads from bank erosion. All streambank measurements were recorded in the **Streambank Erosion Field Form** and **Additional Streambank Erosion Measurements Form.** Further information related to the streambank erosion assessment methodology and results is included in **Sections 4.2** and **4.3**.

3.1.7 Water Surface Slope

Where possible, water surface slope measurements were estimated and recorded in the **Elevation & Water Surface Slope Field Form**. Two crew members, usually part of the Cross-Section team, stood distant from each other within direct line-of-sight at the water's surface between two similar stream features, and estimated slope with a clinometer.

3.1.8 Field Notes

At the completion of data collection at each survey site, field notes were collected by the field team leader with inputs from the entire field team. The following four categories contributed to field notes, which served to provide an overall context for the condition of the stream channel relative to surrounding and historical uses:

- Description of human impacts and their severity;

- Description of stream channel conditions;
- Description of streambank erosion conditions; and
- Description of riparian vegetation conditions.

3.1.9 Quality Assurance/Quality Control

Quality assurance and quality control (QA/QC) was achieved through strict adherence to the project's Sampling and Analysis Plan (WET 2009). During each stream assessment, the field team leader and most experienced crew members led the separate teams. Equipment checks were done each morning and field maps were reviewed with drivers before approaching field sites. Field forms were distributed and double-checked before teams left the vehicles to the survey sites. At the conclusion of each stream assessment, all field forms were reviewed for completeness and accuracy. Any questions that arose from field teams were brought to the attention of the field team leader until resolved to the leader's satisfaction.

Despite the best efforts to adhere to the project's Sampling and Analysis Plan (SAP), some deviations did occur while in the field and during data processing. Additionally, parameters used for sediment loading calculations were adjusted during data processing and following review of field photos to better represent actual field conditions. These adjustments and any deviations from the SAP are described in the Quality Assurance/Quality Control Review provided in **Attachment D**.

3.2 Sampling Parameter Descriptions and Summaries by Reach Type

The following sections provide definitions of sampling parameters that were measured at each reach, and basic statistical summaries of data for each parameter organized by reach type. Parameters described in this section include bankfull channel width, width/depth ratio, entrenchment ratio, percent understory shrub cover, percent bare/disturbed ground, riffle pebble count data (% <2 mm and <6 mm, D50), riffle grid toss data (% <6 mm), riffle stability index (RSI), mean pool depth, pool frequency, pool grid toss data (% <6 mm), and large woody debris (LWD) frequency. Data for each individual measurement site were used in the statistical analysis (i.e. data from each of the individual cross sections in one assessment reach were used), and then sample reaches and water bodies were grouped into reach types as shown in **Table 2-3**.

Data provided for each parameter include statistical box plots and data tables organized by each reach type and for the total planning area. The box plots and data tables provide the minimum and maximum observed values, and the 25^{th} (Q1), 50^{th} (median), and 75^{th} (Q3) percentile values. The statistics tables also provide the number of reaches sampled and the number of data cases available for each parameter. Parameters with a limited number of cases (N<4) will appear as a single line on the box plots.

3.2.1 Bankfull Channel Width

Bankfull is a concept used by hydrologists to define a regularly occurring, channel-forming high flow. One of the first generally accepted definitions of bankfull was provided by Dunne and Leopold (1978):

> *"The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels."*

Bankfull channel width is measured at each surveyed cross-section as the width of the channel at bankfull height. In general, bankfull channel width will increase with stream order, although over-widened streams may have an artificially high channel width.

The measured bankfull channel widths are presented in **Figure 3-1** by reach type, and summary statistics are provided in **Table 3-1**. All surveyed cross sections are included in the data generated for each reach type**.**

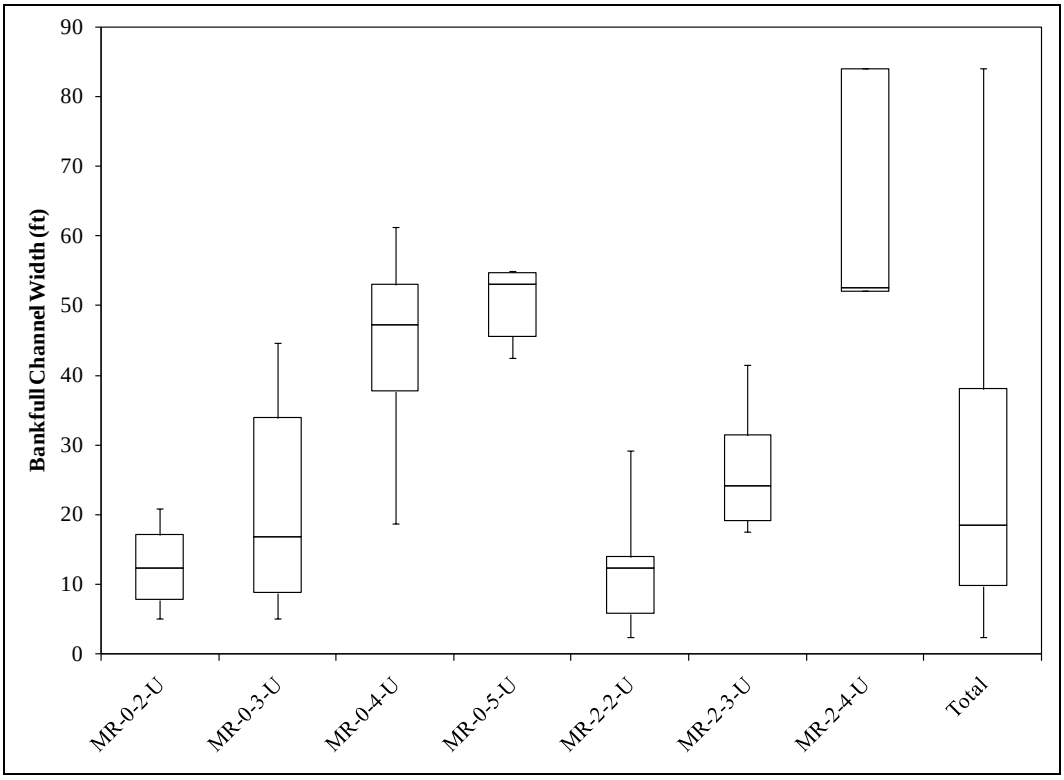


Figure 3-1. Bankfull channel width by reach type.

Table 3-1. Summary statistics of bankfull channel width by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	24	5.1	7.9	12.3	17.1	20.9
MR-0-3-U	6	30	5.2	8.8	16.8	33.9	44.7
MR-0-4-U	5	21	18.8	37.7	47.2	53.1	61.3
MR-0-5-U	1	5	42.5	45.6	53.1	54.8	55.0
MR-2-2-U	4	19	2.5	5.8	12.3	14.0	29.2
MR-2-3-U	2	10	17.6	19.2	24.2	31.4	41.5

Table 3-1. Summary statistics of bankfull channel width by reach type.							
Reach Type	**Reaches**	**Count**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
MR-2-4-U	1	3	52.1	52.1	52.6	84.0	84.0
Total	24	112	2.5	9.9	18.5	38.1	84.0

3.2.2 Width/Depth Ratio

The stream channel width/depth ratio is defined as the channel width at bankfull height divided by the mean bankfull depth (Rosgen 1996). The channel width/depth ratio is one of several standard measurements used to classify stream channels, making it a useful variable for comparing conditions on reaches within the same stream type. A comparison of observed and expected width/depth ratio is a useful indicator of channel over-widening and aggradation, which are often linked to excess streambank erosion or acute or chronic erosion from sources upstream of the study reach. Channels that are over-widened often are associated with excess sediment deposition and streambank erosion, contain shallower, warmer water, and provide fewer deepwater habitat refugia for fish.

The measured width/depth ratios are presented in **Figure 3-2** by reach type, and summary statistics are provided in **Table 3-2**. All surveyed cross sections are included in the data generated for each reach type**.**

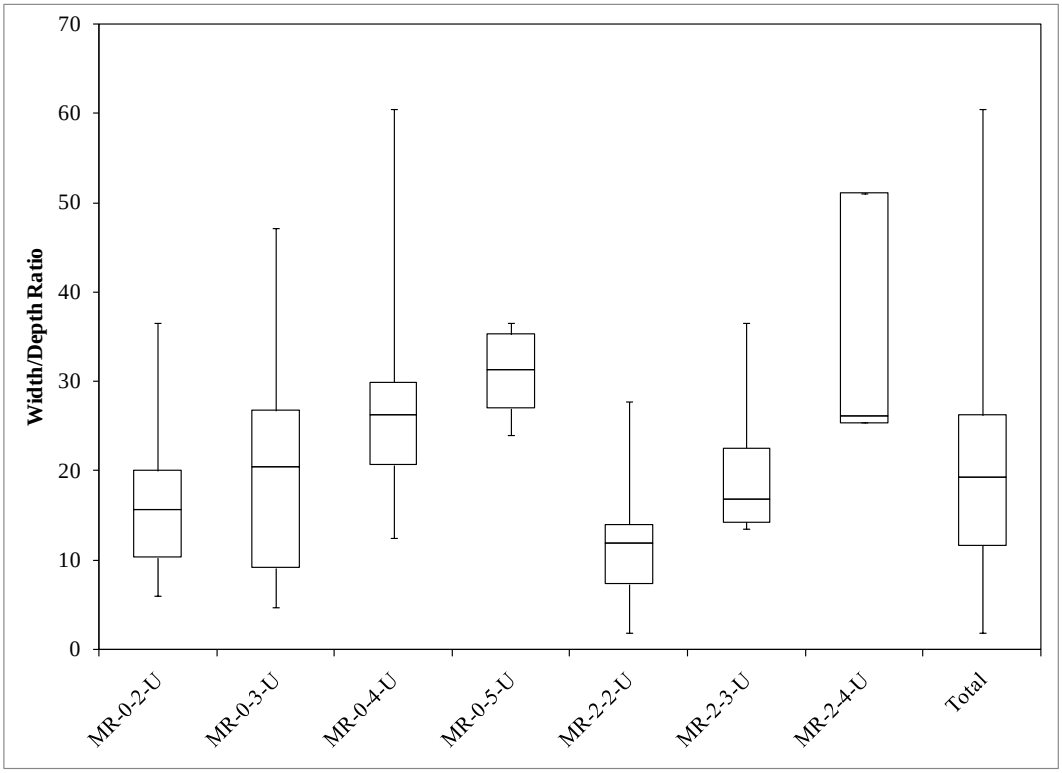


Figure 3-2. Width/depth ratio by reach type.

Table 3-2. Summary statistics of width/depth ratio by reach type.							
Reach Type	**Reaches**	**Count**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
MR-0-2-U	5	24	6.0	10.3	15.7	20.0	36.6
MR-0-3-U	6	30	4.8	9.2	20.5	26.7	47.1
MR-0-4-U	5	21	12.6	20.7	26.3	29.9	60.5
MR-0-5-U	1	5	24.0	27.1	31.3	35.3	36.6
MR-2-2-U	4	19	2.0	7.4	12.0	14.0	27.8
MR-2-3-U	2	10	13.5	14.3	16.9	22.6	36.6
MR-2-4-U	1	3	25.4	25.4	26.1	51.1	51.1
Total	24	112	2.0	11.7	19.3	26.3	60.5

3.2.3 Entrenchment Ratio

Stream entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen 1996). Entrenchment ratio is used to help determine if a stream shows departure from its natural stream type. It is an indicator of stream incision, and therefore indicates how easily a stream can access its floodplain. Streams are often incised due to detrimental land management or may be naturally incised due to landscape characteristics. A stream that is overly entrenched generally is more prone to streambank erosion due to greater energy exerted on the banks during flood events. Greater scouring energy in incised channels results in higher sediment loads derived from eroding banks. If the stream is not actively degrading (down-cutting), the sources of human caused incision may be historical in nature and may not currently be present, although sediment loading may continue to occur. The entrenchment ratio is an important measure of channel condition as it relates to sediment loading and habitat condition, due to the long-lasting impacts of incision and the large potential for sediment loading in incised channels.

The entrenchment ratios by reach type are presented in **Figure 3-3**, and summary statistics are provided in **Table 3-3**. All surveyed cross sections are included in the statistics generated within each reach type**.**

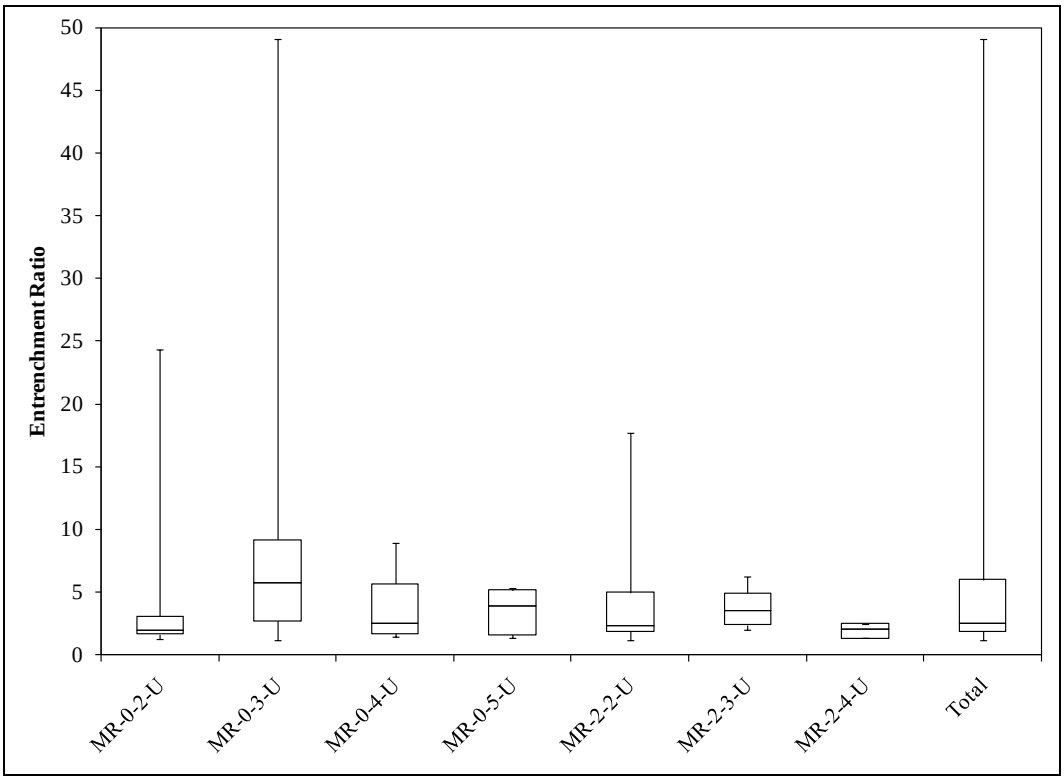


Figure 3-3. Entrenchment ratio by reach type.

Table 3-3. Summary statistics of entrenchment ratio by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	24	1.2	1.7	2.0	3.1	24.3
MR-0-3-U	6	30	1.2	2.7	5.8	9.2	49.1
MR-0-4-U	5	21	1.4	1.7	2.6	5.7	8.9
MR-0-5-U	1	5	1.3	1.6	3.9	5.2	5.3
MR-2-2-U	4	19	1.2	1.9	2.3	5.0	17.7
MR-2-3-U	2	10	2.0	2.4	3.6	5.0	6.2
MR-2-4-U	1	3	1.4	1.4	2.1	2.5	2.5
Total	24	112	1.2	1.9	2.6	6.0	49.1

3.2.4 Riffle Pebble Count: Substrate Fines (% <2 mm)

Clean stream bottom substrates are essential for optimum habitat for many fish and aquatic insect communities. The most obvious forms of degradation occur when critical habitat components such as spawning gravels (Chapman and McLeod 1987) and cobble surfaces are physically covered by fines, thereby decreasing inter-gravel oxygen and reducing or eliminating the quality and quantity of habitat for fish, macroinvertebrates and algae (Lisle 1989, Waters 1995). Chapman and Mcleod found that size of bed material is inversely related to habitat suitability for fish and macroinvertebrates and that excess sediment decreased both density and diversity of aquatic insects. Specific aspects of sediment-invertebrate relationships may be described as

follows: 1) invertebrate abundance is correlated with substrate particle size; 2) fine sediment reduces the abundance of original populations by reducing interstitial habitat normally available in large-particle substrate (gravel, cobbles); and 3) species type, species richness, and diversity all change as particle size of substrate changes from large (gravel, cobbles) to small (sand, silt, clay) (Waters 1995).

The percent of fine sediment in a stream channel provides a measure of the siltation occurring in a river system and is an indicator of stream channel condition. Although it is difficult to correlate percent surface fines with sediment loading directly, the Clean Water Act allows "other applicable measures" for the development of TMDL water quality restoration plans. Percent surface fines have been used successfully in other TMDLs in western Montana addressing sediment related to stream bottom deposits, siltation, and aquatic life uses. Surface fine sediment measured in the Wolman pebble count is one indicator of aquatic habitat condition and can indicate excessive sediment loading. The Wolman pebble count method provides a survey of the particle distribution of the entire channel width, allowing investigators to calculate a percentage of the surface substrate (as frequency of occurrence) composed of fine sediment.

In addition to being a direct measure of impairment to the aquatic macroinvertebrate community, riffle percent surface fines can be used as an indicator of possible impairment condition to cold water fish since the elevated riffle surface fines are likely an indicator of elevated subsurface fines within spawning gravels.

The pebble count measurements for particles <2 mm by reach type are presented in **Figure 3-4**, and summary statistics are provided in **Table 3-4**.

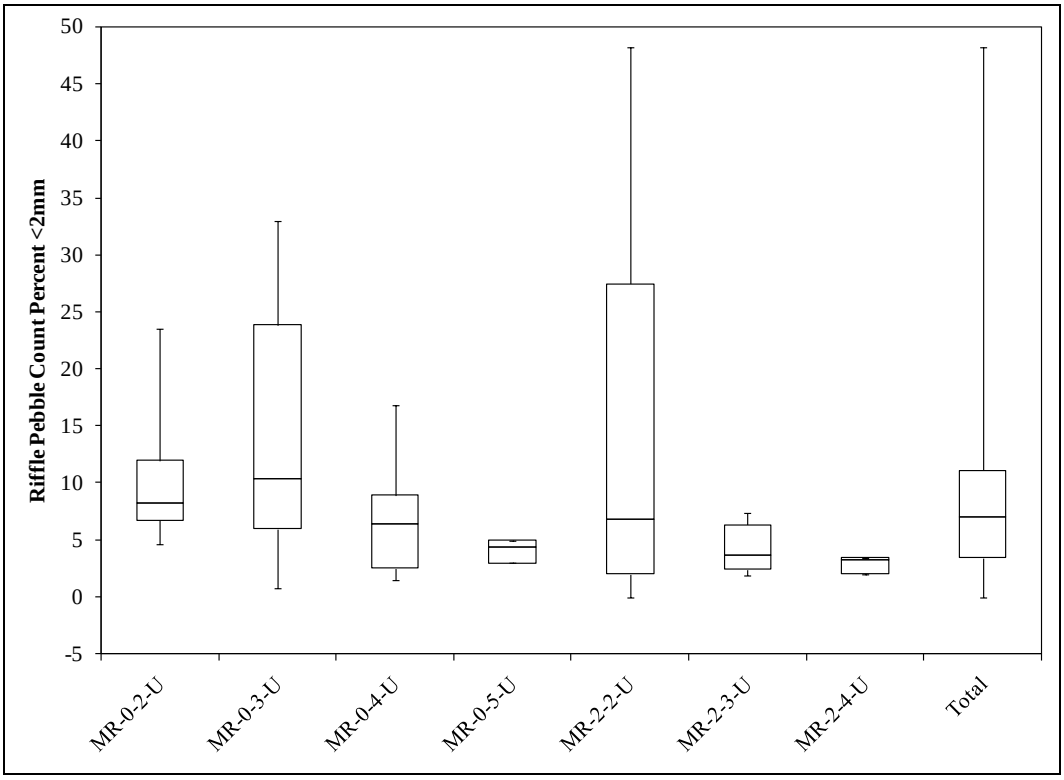


Figure 3-4. Riffle pebble count (% <2 mm) by reach type.

Table 3-4. Summary statistics of riffle pebble count (% <2 mm) by reach type.							
Reach Type	**Reaches**	**Count**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
MR-0-2-U	5	15	4.6	6.7	8.3	12.0	23.5
MR-0-3-U	6	18	0.8	6.0	10.4	23.9	33.0
MR-0-4-U	5	14	1.5	2.5	6.4	8.9	16.8
MR-0-5-U	1	3	3.0	3.0	4.4	5.0	5.0
MR-2-2-U	4	12	0.0	2.0	6.8	27.5	48.2
MR-2-3-U	2	6	1.9	2.4	3.7	6.3	7.3
MR-2-4-U	1	3	2.0	2.0	3.3	3.4	3.4
Total	24	71	0.0	3.4	7.0	11.1	48.2

3.2.5 Riffle Pebble Count: Substrate Fines (% <6 mm)

As with surface fine sediment smaller than 2 mm diameter, an accumulation of surface fine sediment less than 6 mm diameter may also indicate excess sedimentation and has the potential to negatively impact the spawning success of cold water fish. The size distribution of substrate material in the streambed is also indicative of habitat quality for salmonid spawning and incubation. Excess surface fine substrate may have detrimental impacts on aquatic habitat by cementing spawning gravels, thus reducing their accessibility, preventing flushing of toxins in egg beds, reducing oxygen and nutrient delivery to eggs and embryos, and impairing emergence of fry (Meehan 1991). Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of material less than 6.35 mm and the emergence success of westslope cutthroat trout and bull trout.

The pebble count measurements for sediment fines (% <6 mm) by reach type are presented below in **Figure 3-5** and summary statistics are provided in **Table 3-5**.

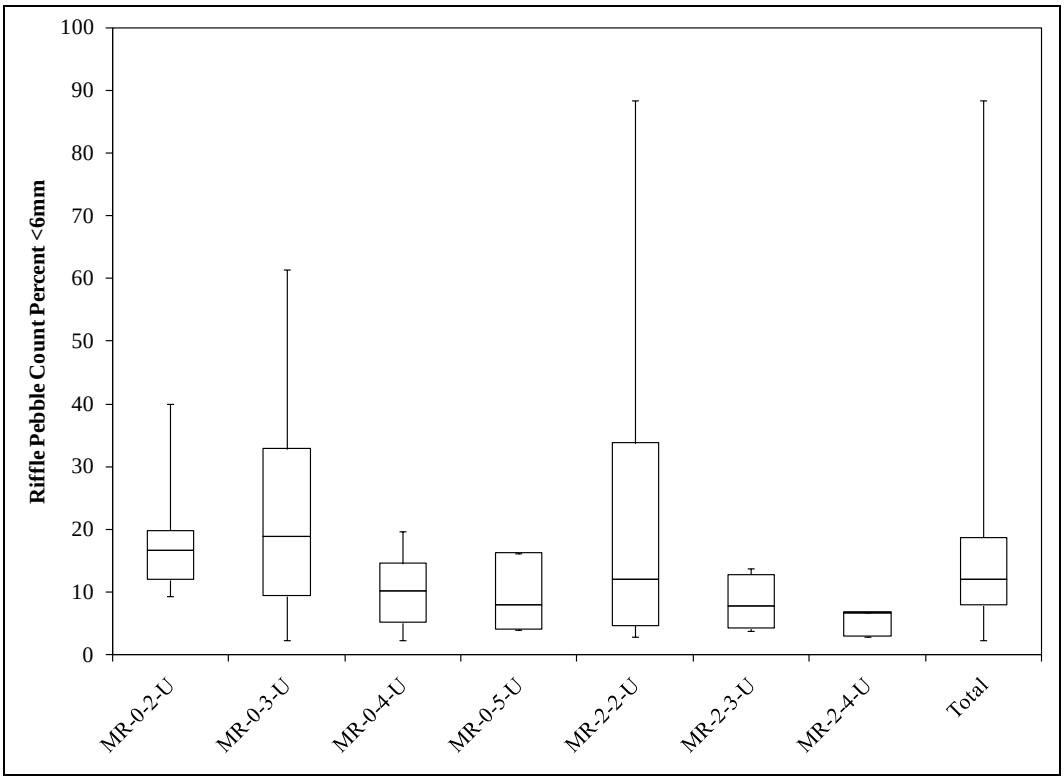


Figure 3-5. Riffle pebble count (% <6 mm) by reach type.

Table 3-5. Summary statistics of riffle pebble count (% <6 mm) by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	15	9.3	11.9	16.7	19.8	40.0
MR-0-3-U	6	18	2.3	9.4	18.8	32.9	61.5
MR-0-4-U	5	14	2.3	5.1	10.2	14.5	19.7
MR-0-5-U	1	3	4.0	4.0	7.9	16.3	16.3
MR-2-2-U	4	12	2.9	4.7	12.0	33.8	88.4
MR-2-3-U	2	6	3.9	4.2	7.8	12.8	13.8
MR-2-4-U	1	3	3.0	3.0	6.6	6.9	6.9
Total	24	71	2.3	7.9	11.9	18.8	88.4

3.2.6 Riffle Pebble Count: D50

The D50 represents the median (50th percentile) particle size of a riffle as determined by the Wolman pebble count. This value can be used to evaluate the suitability of a riffle as spawning gravel for salmonids. Kondolf and Wolman (1993) state that the appropriate size of spawning gravels varies based on stream size and fish species, since larger fish are capable of moving larger particles. In general, appropriate sized spawning gravels should be less than approximately 40 mm for salmonids.

Results of the riffle pebble count D50 are presented below by reach type in **Figure 3-6** and summary statistics are provided in **Table 3-6**.

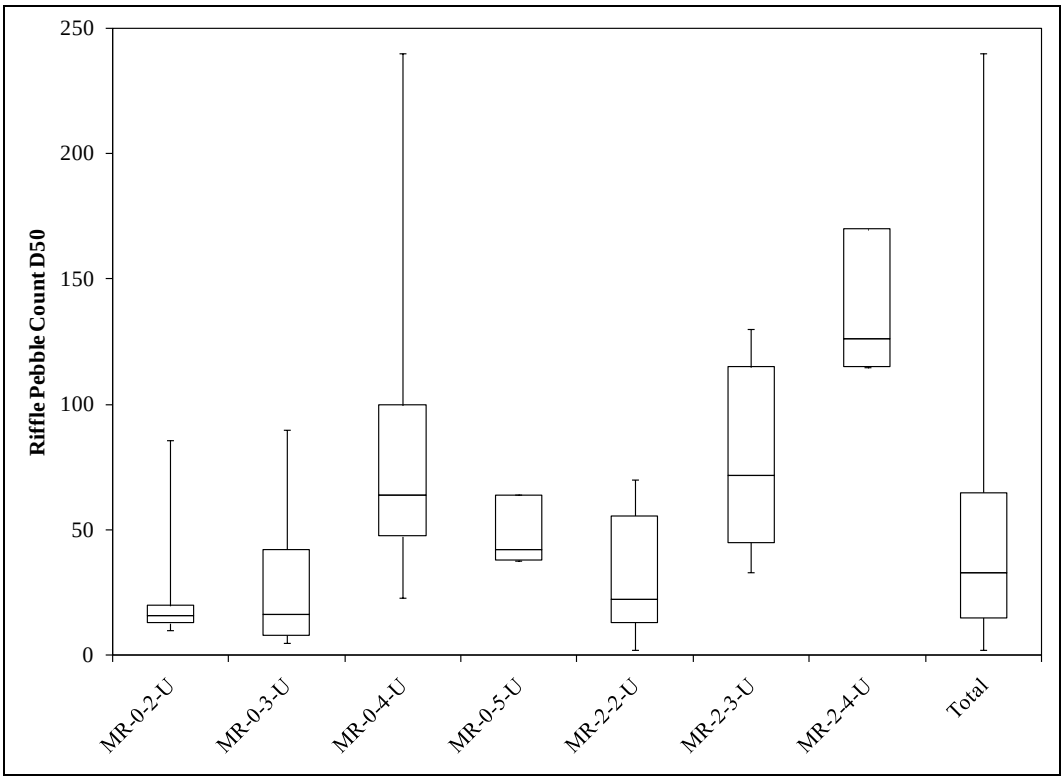


Figure 3-6. Riffle pebble count D50 (mm) by reach type.

Table 3-6. Summary statistics of riffle pebble count D50 (mm) by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	15	10	13	16	20	86
MR-0-3-U	6	18	5	8	17	42	90
MR-0-4-U	5	14	23	48	64	100	240
MR-0-5-U	1	3	38	38	42	64	64
MR-2-2-U	4	12	2	13	23	56	70
MR-2-3-U	2	6	33	45	72	115	130
MR-2-4-U	1	3	115	115	126	170	170
Total	24	71	2	15	33	65	240

3.2.7 Riffle Stability Index

The riffle stability index (RSI) is used to evaluate riffle particle mobility in an area receiving excessive sediment input (Kappesser 2002). The mobile fraction in a riffle is estimated by comparing the particle sizes in the riffle to the arithmetic mean of the largest mobile particles on an adjacent depositional bar. Riffle particles of the size class smaller than the largest particles on a depositional bar are interpreted as mobile, and the RSI value represents the percent of mobile

particles within a riffle. Riffles that have received excessive sediment from upstream eroding banks have a higher percent of mobile particles than riffles in equilibrium. The following breaks are provided as general guidelines for interpreting RSI values:

RSI Value	Description
< 40	High bedrock component to riffle (very stabile system) or channel has been scoured
40 – 70	Stream is in dynamic equilibrium – good channel and watershed stability
70 – 85	Riffle is somewhat loaded with excessive sediment
> 85	Riffle is loaded with excessive sediment

Limited RSI data were collected during this field effort due to the frequency of poorly developed point bars downstream of riffles and actively eroding banks. The riffle stability index results for all reaches are provided below in **Table 3-7**.

Table 3-7. Riffle stability index results for all reaches.

Reach ID	Cell	Reach Type	Arithmetic Mean (cm)	Riffle Stability Index
FLIN 19-01	1	MR-0-5-U	84	37
FRED 29-02	1	MR-0-2-U	123	71
FRED 29-02	3	MR-0-2-U	121	70
SMAR 13-01	2	MR-2-2-U	48	88

3.2.8 Riffle Grid Toss: Substrate Fines (% <6 mm)

The wire grid toss is a standard procedure frequently used in aquatic habitat assessment to approximate the percent fine material in a stream. The grid toss measurement does not cover the entire channel width as in the Wolman pebble count, but rather provides a more focused measurement of surface fines in a subsample of the cross-section.

The riffle grid toss results for sediment fines (% <6 mm) are presented below in **Figure 3-7** and summary statistics are provided in **Table 3-8**.

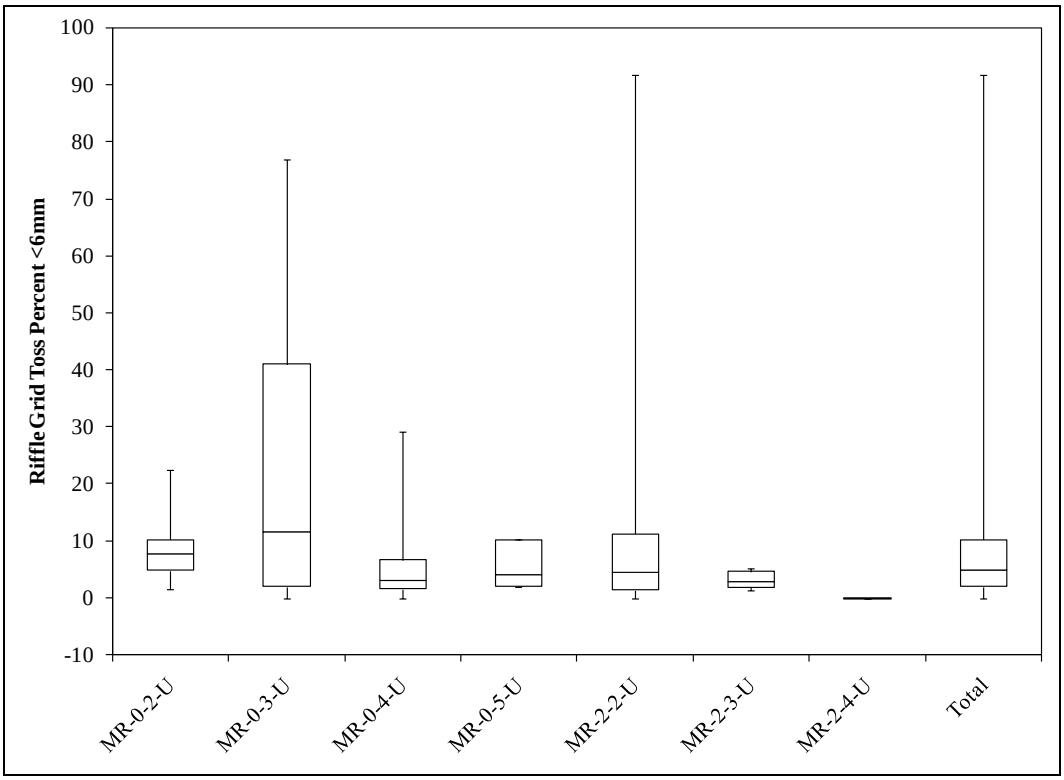


Figure 3-7. Riffle grid toss (% <6 mm) by reach type.

Table 3-8. Summary statistics of riffle grid toss (% <6 mm) by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	15	1.5	4.8	7.7	10.2	22.5
MR-0-3-U	6	18	0.0	2.0	11.6	41.0	76.9
MR-0-4-U	5	14	0.0	1.5	3.0	6.6	29.3
MR-0-5-U	1	3	2.0	2.0	4.1	10.2	10.2
MR-2-2-U	4	12	0.0	1.4	4.4	11.2	91.8
MR-2-3-U	2	6	1.4	1.9	2.7	4.6	5.1
MR-2-4-U	1	3	0.0		0.0		0.0
Total	24	71	0.0	2.0	4.8	10.2	91.8

3.2.9 Pool Grid Toss within Depositional Spawning Areas: Sediment Fines (% <6 mm)

Grid toss measurements in depositional spawning areas provide a measure of fine sediment accumulation in potential spawning sites. Excess surface fines may have detrimental impacts on aquatic habitat by cementing spawning gravels, thus reducing their accessibility, preventing flushing of toxins in egg beds, reducing oxygen and nutrient delivery to eggs and embryos, and impairing emergence of fry (Meehan 1991). Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of material less than 6.35mm and the emergence success of westslope cutthroat trout and bull trout.

Grid toss results for sediment fines (% <6 mm) found within depositional spawning areas are provided below in **Figure 3-8** and summary statistics are provided in **Table 3-9**. The data presented represents only pool tails that were identified as having the appropriate sized gravels to support spawning. There were three assessed reaches (BARN 11-01, FRED 29-02, and DOUS 19-02) where spawning gravels did not exist.

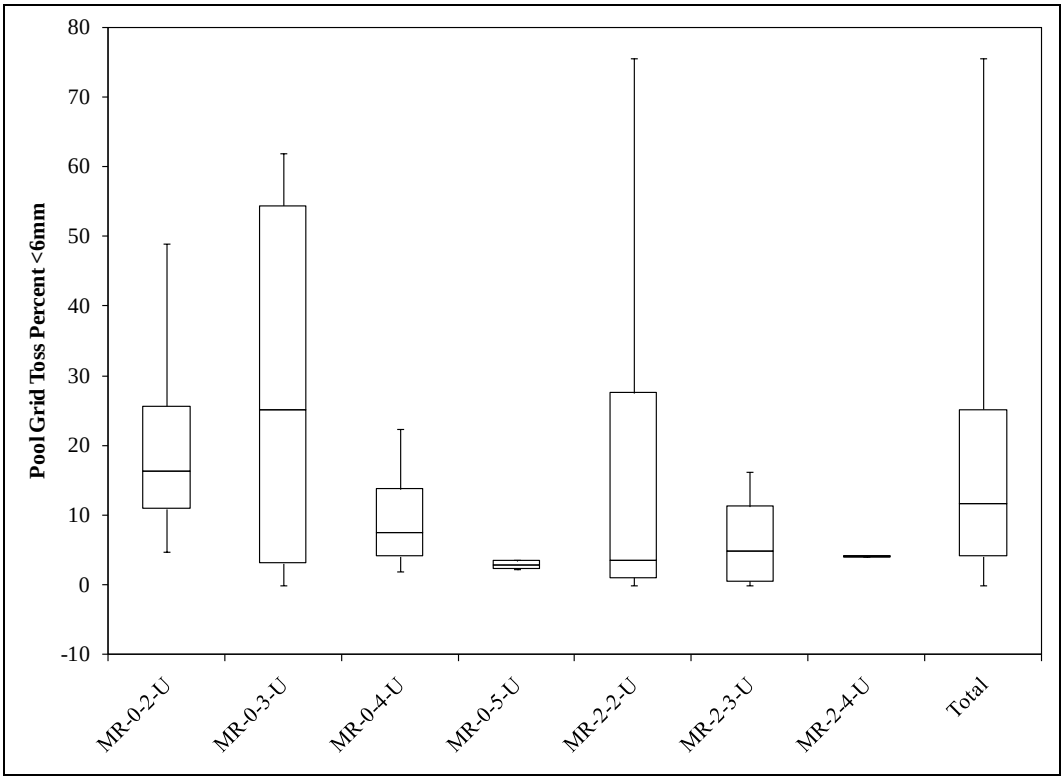


Figure 3-8. Pool grid toss (% <6 mm) by reach type.

Table 3-9 Summary statistics of pool grid toss (% <6 mm) by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	4	38	4.8	10.9	16.3	25.7	49.0
MR-0-3-U	5	16	0.0	3.1	25.2	54.4	61.9
MR-0-4-U	5	9	1.9	4.1	7.5	13.8	22.5
MR-0-5-U	1	4	2.2	2.3	2.8	3.4	3.6
MR-2-2-U	3	17	0.0	1.1	3.4	27.6	75.5
MR-2-3-U	2	6	0.0	0.5	4.8	11.2	16.3
MR-2-4-U	1	1	4.1		4.1		4.1
Total	21	91	0.0	4.1	11.6	25.2	75.5

3.2.10 Pool Residual Depth

Residual pool depth, defined as the difference between pool maximum depth and crest depth, is a discharge-independent measure of pool depth and an indicator of the quality of pool habitat. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes and high flow periods. Pool residual depth is also an indirect measurement of sediment inputs to listed streams. An increase in sediment loading would be expected to cause pools to fill, thus decreasing residual pool depth over time.

Data are presented below in **Figure 3-9** and **Table 3-10**. Note that the data presented represents the mean residual pool depth for each reach, so some reach types have only one data point. Residual pool depths were not calculated for dammed pools.

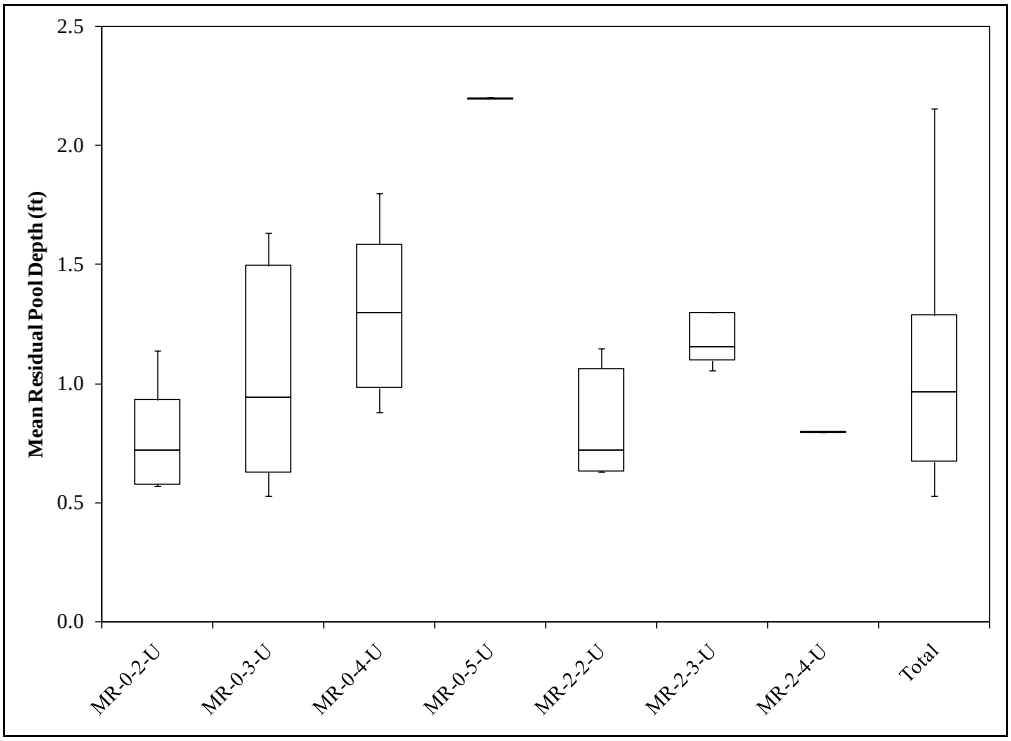


Figure 3-9. Residual pool depth (ft) by reach type.

Table 3-10. Summary statistics of residual pool depth (ft) by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	5	0.6	0.6	0.7	0.9	1.1
MR-0-3-U	6	6	0.5	0.6	0.9	1.5	1.6
MR-0-4-U	5	5	0.9	1.0	1.3	1.6	1.8
MR-0-5-U	1	1	2.2		2.2		2.2
MR-2-2-U	4	4	0.6	0.6	0.7	1.1	1.2
MR-2-3-U	2	2	1.1		1.2		1.3
MR-2-4-U	1	1	0.8		0.8		0.8
Total	24	24	0.5	0.7	1.0	1.3	2.2

3.2.11 Pool Frequency

Pool frequency is a measure of the availability of pools within a reach to provide rearing habitat, cover, and refugia for salmonids. Pool frequency is related to channel complexity, availability of stable obstacles, and sediment supply. Excessive erosion and sediment deposition can reduce pool frequency by filling in smaller pools. Pool frequency can also be affected adversely by riparian habitat degradation resulting in a reduced supply of large woody debris or scouring from stable root masses in streambanks.

The pool frequencies per 1,000 ft for each reach type are presented in below **Figure 3-10** and summary statistics are provided in **Table 3-11**. As with residual pool depth, some reach types are represented by only a single value.

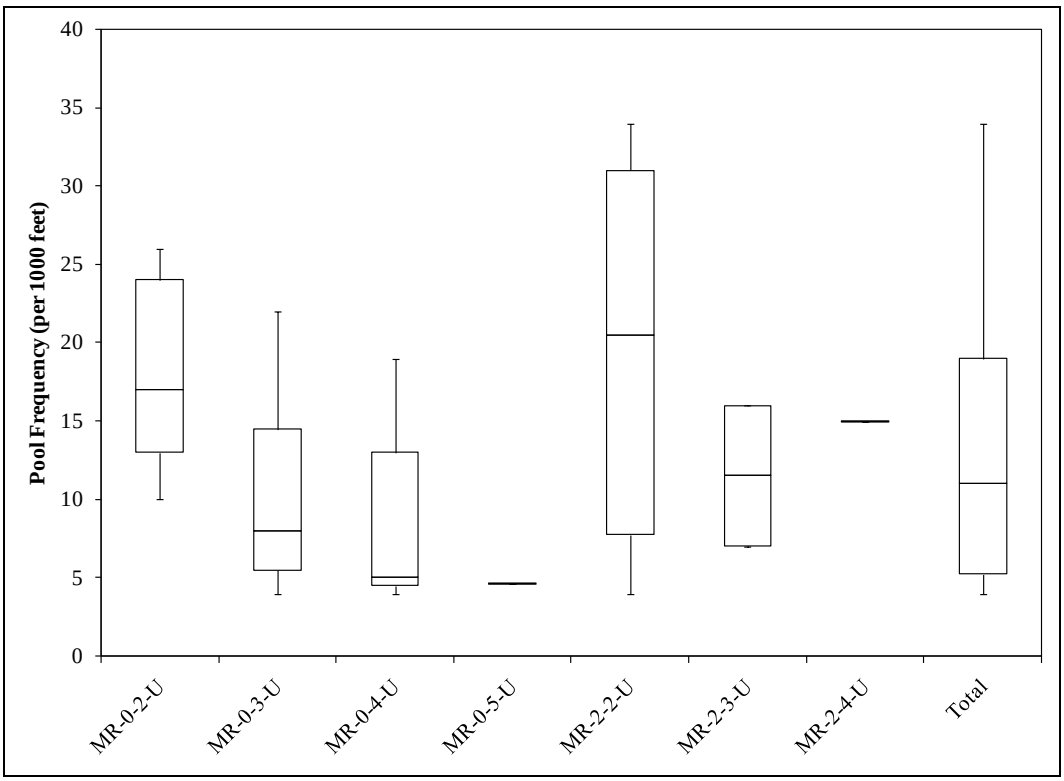


Figure 3-10. Pool frequency (per 1,000 ft) by reach type.

Table 3-11. Summary statistics of pool frequency by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	5	10.0	13.0	17.0	24.0	26.0
MR-0-3-U	6	6	4.0	5.5	8.0	14.5	22.0
MR-0-4-U	5	5	4.0	4.5	5.0	13.0	19.0
MR-0-5-U	1	1	4.7		4.7		4.7
MR-2-2-U	4	4	4.0	7.8	20.5	31.0	34.0

Table 3-11. Summary statistics of pool frequency by reach type.							
Reach Type	**Reaches**	**Count**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
MR-2-3-U	2	2	7.0		11.5		16.0
MR-2-4-U	1	1	15.0		15.0		15.0
Total	24	24	4.0	5.3	11.0	19.0	34.0

3.2.12 Large Woody Debris Frequency

Large woody debris (LWD) is a critical component of salmonid habitat, providing stream complexity, pool habitat, cover, and long-term nutrient inputs. LWD also constitutes a primary influence on stream function, including sediment and organic material transport, channel form, bar formation and stabilization, and flow dynamics (Bilby and Ward 1989). LWD frequency can be measured and compared to reference reaches or literature values to determine if more or less LWD is present than would be expected under reference conditions. Too little or too much LWD may indicate riparian habitat impairment or upstream influences on habitat quality.

Target values for LWD span a broad range of values, even for streams of similar size. A guideline value of approximately 150 pieces of LWD per mile, or approximately 28 pieces of LWD per 1000 feet, represents an average of target values from other studies. Results for LWD should be interpreted with caution, as the guideline value for this parameter is tied to a high degree of variability due to land use, vegetative community and soils, among other factors.

The LWD frequencies for each reach type are provided below in **Figure 3-11** and summary statistics are provided in **Table 3-12**.

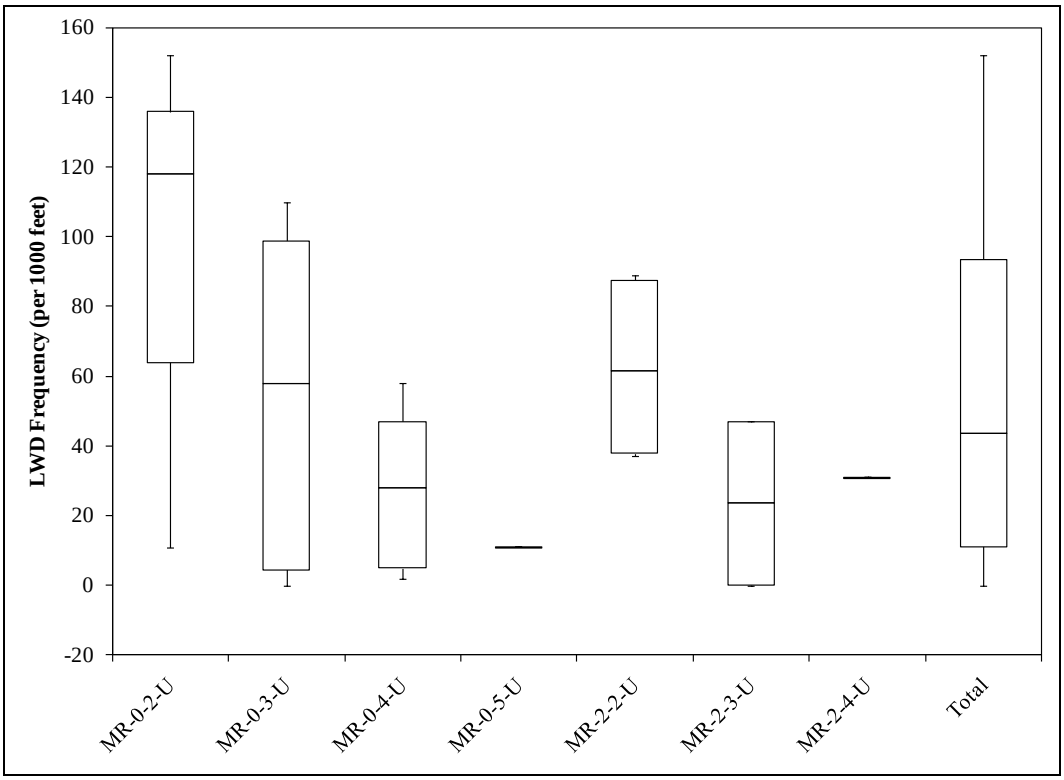


Figure 3-11. LWD frequency (per 1,000 ft) by reach type.

Table 3-12. Summary statistics of LWD frequency by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	5	11.0	64.0	118.0	136.0	152.0
MR-0-3-U	6	6	0.0	4.5	58.0	98.8	110.0
MR-0-4-U	5	5	2.0	5.0	28.0	47.0	58.0
MR-0-5-U	1	1	11.1		11.1		11.1
MR-2-2-U	4	4	37.0	37.8	61.5	87.5	89.0
MR-2-3-U	2	2	0.0		23.5		47.0
MR-2-4-U	1	1	31.0		31.0		31.0
Total	24	24	0.0	11.0	43.5	93.5	152.0

3.2.13 Greenline Inventory: Percent Understory Shrub Cover

Riparian shrub cover is an important factor on streambank stability. Removal of riparian shrub cover can dramatically increase streambank erosion and increase channel width/depth ratios. Shrubs stabilize streambanks by holding soil and armoring lower banks with their roots, and reduce scouring energy of water by slowing flows with their branches. Good riparian shrub cover is also important for fish habitat. Riparian shrubs provide shade which reduce solar inputs and help maintain cooler water temperatures. The dense network of fibrous roots of riparian shrubs allows streambanks to remain intact while water scours the lowest portion of streambanks, creating important fish habitat in the form of overhanging banks and lateral scour pools.

Overhanging branches of riparian shrubs provide important cover for aquatic species. In addition, riparian shrubs provide critical inputs of food for fish and other aquatic life. Terrestrial insects falling from riparian shrubs provide one main food source for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are also an important food source for fish.

The Greenline understory shrub cover percentages by reach type are presented in **Figure 3-12**. The summary data are also presented in **Table 3-13**.

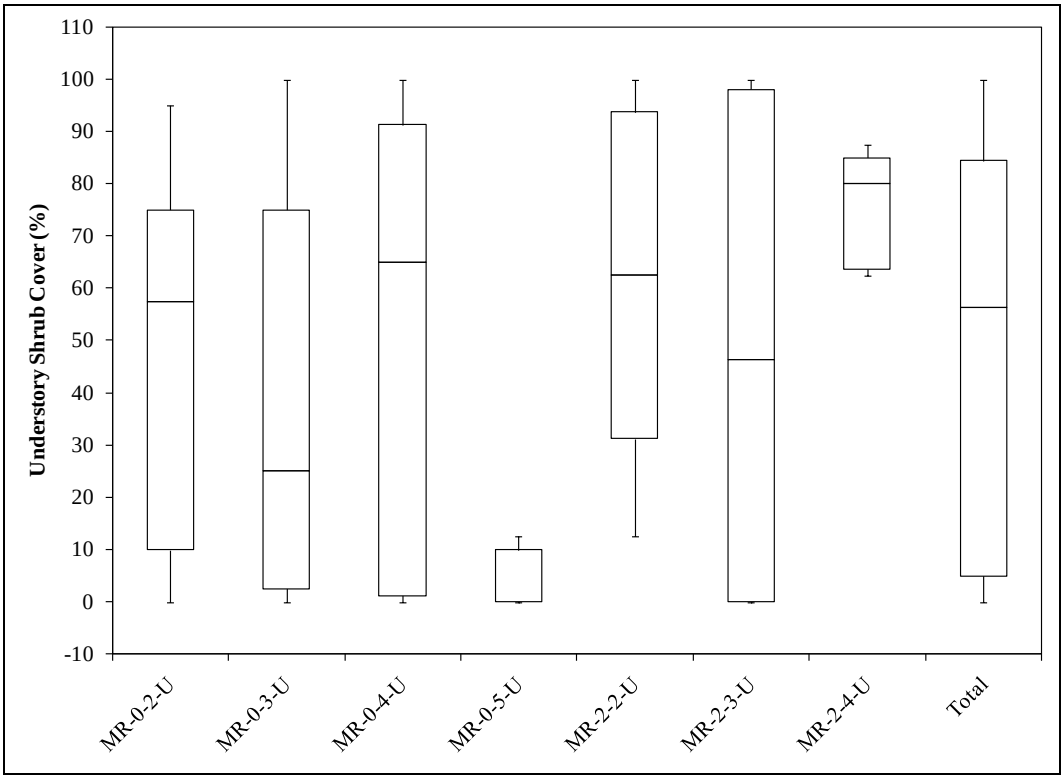


Figure 3-12. Greenline understory shrub cover (%) by reach type.

Table 3-13. Summary statistics of understory shrub cover (%) by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	25.0	0.0	10.0	57.5	75.0	95.0
MR-0-3-U	6	30.0	0.0	2.5	25.0	75.0	100.0
MR-0-4-U	5	25.0	0.0	1.3	65.0	91.3	100.0
MR-0-5-U	1	5.0	0.0	0.0	0.0	10.0	12.5
MR-2-2-U	4	20.0	12.5	31.3	62.5	93.8	100.0
MR-2-3-U	2	10.0	0.0	0.0	46.3	98.1	100.0
MR-2-4-U	1	5.0	62.5	63.8	80.0	85.0	87.5
Total	24	120.0	0.0	5.0	56.3	84.4	100.0

3.2.14 Greenline Inventory: Percent Bare/Disturbed Ground

Percent bare ground is an important indicator of erosion potential, as well as an indicator of land management influences on riparian habitat. Bare ground was noted in the Greenline inventory in cases where recent ground disturbance was observed, leaving bare soil exposed. Bare ground is often caused by trampling from livestock or wildlife, fallen trees, recent bank failure, new sediment deposits from overland or overbank flow, or severe disturbance in the riparian area, such as past mining, road-building, or fire. Ground cover on streambanks is important to prevent sediment recruitment to stream channels. Sediment can wash in from unprotected areas due to snowmelt, storm runoff, or flooding. Bare areas are also much more susceptible to erosion from hoof shear. Most stream reaches have a small amount of naturally-occurring bare ground. As conditions are highly variable, this measurement is most useful when compared to reference values from best available conditions within the study area or literature values.

Results of the Greenline survey for percent bare/disturbed ground are provided by reach type below in **Figure 3-13**, and tabular data are presented in **Table 3-14**.

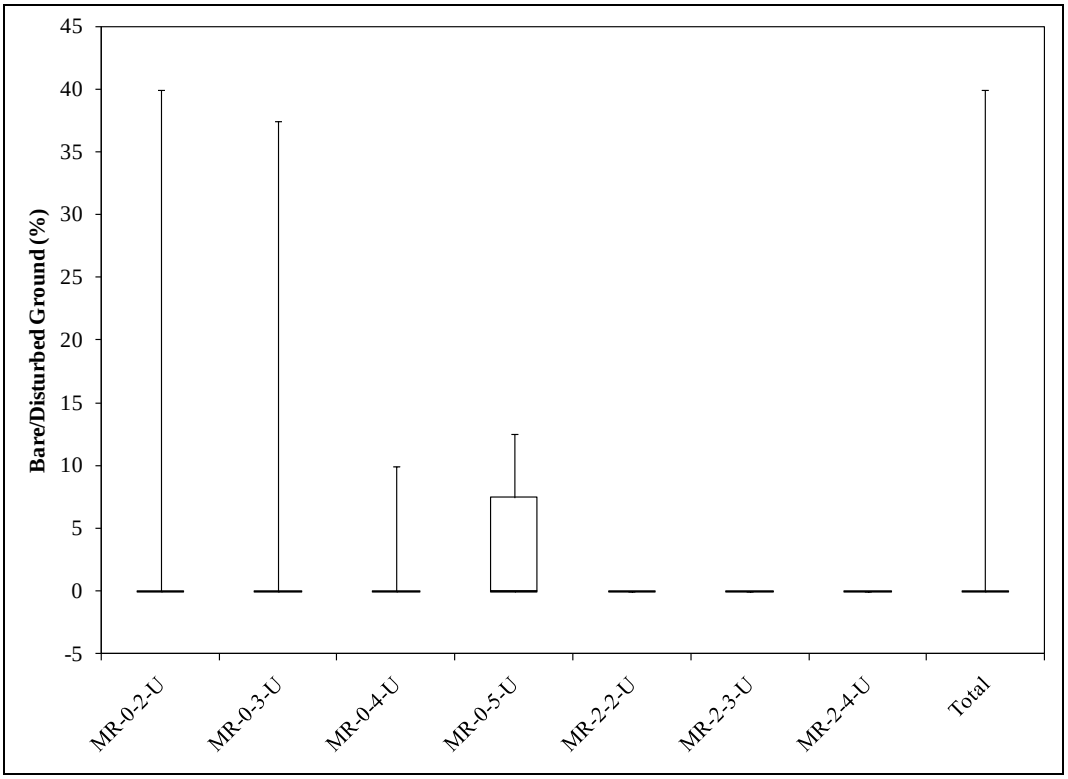


Figure 3-13. Greenline bare/disturbed ground (%) by reach type.

Table 3-14. Summary statistics of bare/disturbed ground (%) by reach type.

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
MR-0-2-U	5	25	0.0	0.0	0.0	0.0	40.0
MR-0-3-U	6	30	0.0	0.0	0.0	0.0	37.5
MR-0-4-U	5	25	0.0	0.0	0.0	0.0	10.0

Table 3-14. Summary statistics of bare/disturbed ground (%) by reach type.							
MR-0-5-U	1	5	0.0	0.0	0.0	7.5	12.5
MR-2-2-U	4	20	0.0	0.0	0.0	0.0	0.0
MR-2-3-U	2	10	0.0	0.0	0.0	0.0	0.0
MR-2-4-U	1	5	0.0	0.0	0.0	0.0	0.0
Total	24	120	0.0	0.0	0.0	0.0	40.0

3.3 Assessment Reach Field Descriptions

The following sections provide brief descriptions of each sampled reach. Descriptions are provided for human impacts, stream channel conditions, and riparian vegetation conditions. Stream bank erosion conditions are provided with sediment loading results in **Section 4.6**. Assessment reaches are organized by water body and reach location starting at the upstream end and moving downstream.

3.3.1 Barnes Creek

BARN 11-01

Description of human impacts and their severity:
Site has heavy grazing impacts with significant hoof shear and hummocking. Banks in some areas are completely trampled. Turbid water exists throughout sample reach. Site is in very poor condition.

Description of stream channel conditions:
This reach is a C4/C5 type channel with small gravels and coarse sand, moderate sinuosity, and channel slope of 1.5 to 2%. The uppermost cell has a low width/depth ratio resembling an E4 type channel, but the potential stream type for this reach is C4. Site has poorly developed features, and riffles are difficult to discern. Site has minimal pool development, no spawning gravels, heavy fine sediment, and split channels in places. Several seeps and springs were noted along entire reach.

Description of streambank erosion conditions:
Streambanks are heavily impacted by grazing, including extensive hummocking. Banks have minimal vegetation, especially in upper two cells. A fenceline exists near station 250. Banks are in better condition downstream of the fenceline. A few old irrigation structures exist in reach.

Description of riparian vegetation conditions:
Lower cells (1-3) have a mix of grass and woody vegetation, including alder, chokecherry, willow, timothy, brome, fescue, and burdock. Upper cells (4-5) have minimal grass, some woody vegetation (although sparse), and significant bare ground from hoof shear.

BARN 13-01

Description of human impacts and their severity:
Site has moderate to heavy grazing impacts with significant hummocking and grazed riparian vegetation, however, overall impacts to streams are not as significant as upper Barnes Creek. This site is a good candidate for riparian fencing.

Description of stream channel conditions:
Stream is a highly sinuous E4 type channel, although significant fines make it close to E5. Stream has many undercut banks, and pools predominantly occur on outside meander bends with undercuts. Riffles are short and poorly developed, and runs are long and deep.

Description of streambank erosion conditions:
Reach has minimal natural bank erosion, and most streambank erosion is from hoof shear. Soils are composed of fine clays that create vertical and undercut banks that have some active erosion, although most banks were slowly eroding.

Description of riparian vegetation conditions:
Riparian vegetation is predominantly grasses and sedges with minimal woody species. Some willow exist that help stabilize banks, although most have been grazed.

BARN 13-03

Description of human impacts and their severity:
Site is adjacent to alfalfa hay field, which has been mowed approximately 50 feet from stream on river left. Field is not mowed on river right. There is no evidence of current grazing. A culvert exists at the road crossing immediately upstream of the sampled reach, which creates some impacts in cell 5.

Description of stream channel conditions:
The potential Rosgen stream type for this reach is likely E4, but because of entrenchment portions of this reach resemble types B4c and G4c. Stream is slightly entrenched in most of reach, and very entrenched in cell 2. Stream has poorly developed riffle and pool habitat. Woody debris is common and has impacted channel form. Some transverse bars are evident in upper cells (4 and 5).

Description of streambank erosion conditions:
Stream channel is generally stable with minimal streambank erosion, which is primarily caused by woody debris. Consistent slowly eroding banks were noted. Soils are hard packed clay with low erosion potential.

Description of riparian vegetation conditions:
Lots of woody debris exists throughout reach (mostly willow). Upper cells are grass only, but other cells are mix of woody species and grass. Adjacent field has been mowed for hay on river left, but an approximate 50’ buffer exists between stream and field with tall grass.

3.3.2 Boulder Creek

BOUL 16-01

Description of human impacts and their severity:
This site contains no immediately noticeable human impacts. Several camp sites exist on the lower portion of the reach, and a small foot trail parallels the stream; however, these activities appear to have minimal impact on the stream reach. Lower end of reach has a bridge and road crossing with some localized over-widening of the stream channel. As a whole, reach appears to be a B channel in near reference condition.

Description of stream channel conditions:
This site has moderate entrenchment, high slope (3-4%), and large cobble substrate. The estimated Rosgen stream type for this reach is B3, although areas with a larger floodplain resemble a C3b channel type. Stream is a step-pool, riffle-run complex with pools formed by boulders and some large woody debris. Pools are primarily pocket pools of moderate habitat quality, although a few deep, large plunge pools do exist. Channel has low sinuosity and stream velocities are relatively fast throughout the reach.

Description of streambank erosion conditions:
Stream banks are very well armored with heavy cobble and boulders acting as natural rip-rap. Few areas of slowly eroding natural banks were noted, typically at the base of large coniferous trees near the streambank edge. Root structure and cobbles hold together undercut banks where bank erosion was noted.

Description of riparian vegetation conditions:
Site was heavily forested with a well developed understory and canopy, and a mix of age classes throughout. Riparian grasses and small woody vegetation were also abundant along banks, including raspberry bushes, sedges, and various forbs. Overstory canopy was mostly Douglas fir.

BOUL 21-02

Description of human impacts and their severity:
A paved road exists approximately 20-200 feet from the right side of the stream, and a large primitive campsite and parking area exist in the center of the reach. A power line also cuts through the reach, and there is some evidence of wood cutting. Historic mining activity existed upstream, but not immediately within the reach. The road is encroaching the stream in lower portion of reach and is causing aggradation, braiding, and over-widening in places.

Description of stream channel conditions:
The potential stream type for this reach is likely B3, although much of the stream has a high width/depth ratio and has access to its floodplain, so most areas resemble a C3 type channel. Road encroachment in the lower reach causes aggradation which has lowered the slope through this reach. Stream reach is riffle/run dominated with large substrate and very few fines. Most pools are large lateral scour pools and small pocket pools behind boulders. Only one pool with spawning gravels exists within the reach.

Description of streambank erosion conditions:
Reach has only slowly eroding banks with primarily natural sources of erosion. Some banks are armored with heavy cobbles, while others are undercut with fine sediment supporting bank. Some human influences from the campsite and road encroachment were noted.

Description of riparian vegetation conditions:
Overall, riparian vegetation is in good condition with tall canopy of fir, thick understory, and many grasses and forbs on banks. Vegetation has been cleared in power line right of way and near campsite.

3.3.3 Douglas Creek (North)

DOUN 07-01
Description of human impacts and their severity:
Reach has historically experienced significant flow alteration due to reservoirs upstream and downstream of reach. An old road parallels the stream approximately 100 feet away on river left, while the existing road parallels the stream approximately 150 feet away. Extensive grazing exists throughout reach with hoof shear and hummocking in many places. Mines have existed in upper watershed and possibly near stream reach, although no obvious mining impacts were noted.

Description of stream channel conditions:
The stream channel through this site is nearly straight with slopes of 2.5 to 3%. The potential Rosgen stream type for this reach is B4. Site has many cattle crossings, and substrate is somewhat embedded with fines. Woody debris creates diverse pool habitat, although pools are commonly shallow and have many fine materials in pools and tail-outs. Very few good spawning gravels exist. Log jams downstream of site create large pools. Riffles are poorly developed.

Description of streambank erosion conditions:
Site has many cattle crossings and is heavily trampled, creating many eroding banks. Three main bank types exist, including slowly eroding natural banks, actively eroding sloped banks, and actively eroding vertical banks. Some natural erosion exists, but most streambank erosion is attributed to cattle and riparian grazing.

Description of riparian vegetation conditions:
Site has thick canopy and understory, but grasses are grazed to almost nothing. Some bare ground exists due to hoof shear and over-grazing. Riparian vegetation is primarily willow, alder, and juniper with some fir in the canopy and many weeds, including toadflax, knapweed, mullein and thistle.

DOUN 08-02
Description of human impacts and their severity:
Site has extensive cattle grazing with hoof shear and hummocking present in all areas. Numerous livestock crossings exist throughout the reach. Stream flow has historically been altered by reservoirs above and below the site. An old railroad bed confines the stream on river right in the

two lowest cells, and a road exists approximately 100’ away on river left. A culvert exists just downstream of the study site. Local area and upper watershed have historically been mined for phosphate and other minerals, but no direct evidence of mining on site.

Description of stream channel conditions:
This reach has moderate sinuosity, small gravel substrate, and channel slope of approximately 1.5%. The potential stream type for this reach is C4. Stream has many fines in all pool tails. Large substrate is embedded except at active cattle crossings. Stream channel is over-widened at cattle crossings, and entrenched through much of the reach. Stream is confined by railroad bed on river right in downstream portion of the site. Channel has lots of woody debris and several dammed pools.

Description of streambank erosion conditions:
Site has many active eroding banks with two primary types, including tall steep banks, and low angle hoof-trodden banks. Almost all streambank erosion is due to cattle grazing, including hoof shear on banks and grazing of riparian vegetation. Some erosion may also be attributed to historic flow alteration. Streambanks are composed of fine substrate, but no riparian grasses exist to stabilize banks.

Description of riparian vegetation conditions:
Riparian grasses are severely grazed on all banks. Understory is fairly dense, with alder, rose and chokecherry. Noxious weeds were present throughout the study area, including mullein, thistle and knapweed.

3.3.4 Douglas Creek (South)

DOUS 19-02
Description of human impacts and their severity:
This reach has been dramatically altered by channelization. River right is confined by an abandoned railroad bed or dirt road, while river left has residential yards and fenced hayfields within 10’ of the stream channel. The top of the reach is cut short 50’ by a culvert at a road crossing, and at the bottom of the reach the stream is almost completely diverted through a hay field. Stream is channelized or confined to a culvert for the remainder of its course to Flint Creek. Some willows dot the banks, but most streamside vegetation has been removed and currently only grasses exist on the banks. Channel is completely full of sandy sediment, which is likely sourced from roads and historic mining operations in the upper watershed. Some urban trash is also accumulating in the stream channel.

Description of stream channel conditions:
The stream channel in this reach is straight and narrow with low width/depth ratios and a channel slope of 2 to 2.5%. The potential stream type for this reach is E4, but the existing channel has hardly any sinuosity and resembles a G4 type channel in places. Channel is entrenched throughout the reach with varying levels of severity. Some small pools exist where woody debris has lodged and created plunge pools or scoured the banks. Substrate is dominated by fines throughout the reach. Any large substrate that does exist is deeply embedded.

Description of streambank erosion conditions:
Hard pack clay soil and good grassy vegetation keeps streambanks relatively stable. Site has alternating undercut and near vertical banks throughout the reach, but minimal sediment production is expected from this site.

Description of riparian vegetation conditions:
Site has good grassy vegetation along riparian corridor and some interspersed alder and willow, although little to no mature woody vegetation. No woody vegetation occurs outside of approximately 5' from the stream channel.

3.3.5 Flint Creek

FLIN 06-01
Description of human impacts and their severity:
The most immediate and obvious human impact on this site is from the dam just upstream at Georgetown Lake. Flow releases from the dam have created an unnatural flow regime that has resulted in anomalies in channel form and function. Site is also parallel to a popular campground with a road that continues past the monitoring site. The road confines the stream on river left, especially in the upper cells, and a berm appears to have been constructed to limit flooding of the road and campground during high water. The highway also runs parallel to the stream on river right, but it is elevated and quite distant from the stream. Below the sample site, remnants of old buildings and structures remain in and near the stream channel. The culvert at the USGS gauging station appears to create aggradation and braiding downstream of the study site.

Description of stream channel conditions:
Stream channel is confined in upper portion of site with low width/depth ratio and fast flows. Channel is wider in lower reaches, and splits in places forming mid-channel bars and islands. Stream presently is Rosgen type C3b channel with access to its floodplain in most places; however, should likely be type B3 channel. Some pools are formed by large woody debris. Channel is mostly composed of large cobble substrate, although fines and gravels occur in pockets of slow water.

Description of streambank erosion conditions:
River left has sections of old fill with loose gravel and cobbles that are actively eroding at high flows. Adjacent road certainly influences streambank erosion in many places, and non-normal flow releases from upstream dam may also contribute. Banks on river right are primarily slowly eroding and well protected by cobble and strong root matrix.

Description of riparian vegetation conditions:
Reach has a mix of grasses and weeds. Some mid-story woody vegetation (willow) exists, along with a mature coniferous overstory. Vegetation has established good root network in most places; however, river left adjacent to the road is dominated by weak rooted weeds and non-native species.

FLIN 09-02

Description of human impacts and their severity:

A number of human influences influence the stream in this reach. Riparian grazing has occurred in the area as evidenced by invasive weeds, few grasses, and little woody vegetation throughout the site. Some tall cottonwoods remain. A bridge occurs just upstream of the study area and may influence some channel features in the top of cell 5. Cattle grazing occurs just below the sample reach, and a flowing irrigation ditch exists in cell 1. A dirt road parallels the stream on river left, and several residences exist in the area. A barn or equipment shed exists below cell 1, and a gravel yard operates within the floodplain on river right. Flow alteration from Georgetown Lake may also influence sediment delivery and channel form in this reach.

Description of stream channel conditions:

Stream channel is moderately sloped (~1.5%) throughout reach with mostly long runs and intermixed riffles. The existing and potential stream type for this reach is C4. Few quality pools exist, although some deep holding water occurs at bends and around large wood debris (although rare). Only one pool contained potential spawning gravels. Substrate is mostly large gravels with some embeddedness. Patches of algae were present in some areas.

Description of streambank erosion conditions:

Some streambank erosion occurs at outside bends or constricted sections of stream channel. Erosion is largely influenced by lack of good riparian vegetation. Large cobbles provide some surface protection in some areas. Banks are generally low profile and contributing moderate to low amounts of sediment where erosion occurs.

Description of riparian vegetation conditions:

Bank vegetation is primarily composed of non-native grasses and weeds, which also dominate the floodplain. Very little mid-story vegetation exists, and sparse cottonwoods provide some overstory.

FLIN 11-01

Description of human impacts and their severity:

Flint Creek is confined by both the highway and railroad just upstream of this site. Stream channel is confined by railroad on river left within the study reach, with the railroad entering the existing stream channel in one location. Adjacent landowner says ice scour is common during periods of thaw in winter and spring. Site has evidence of historic grazing, although presently riparian grazing is very minimal. A power line crosses through the reach, and the highway is several hundred feet away on river right.

Description of stream channel conditions:

The stream channel in this reach has a high sinuosity and low channel slope similar to a Rosgen E4 type channel, but most cross-sections have high width/depth ratios that are more similar to a C4 type channel. Site has poor riffle development with long lateral scour pools on outside meander bends. Substrate is somewhat embedded. Stream channel appears relatively unstable with evidence of old and recent oxbow cutoffs. Site has almost no large woody debris and has clay substrate on banks.

Description of streambank erosion conditions:
Site has many eroding banks, including primarily long actively eroding banks on outside meander bends, and some slowly eroding banks on inside undercuts. Bank substrate is mostly composed of fine material with no obvious stratification, and shallow grass roots with low root density.

Description of riparian vegetation conditions:
Banks have primarily grasses, sedges and few forbs. Site has no understory or overstory, and few weeds on the floodplain (primarily thistle).

FLIN 11-04
Description of human impacts and their severity:
Stream is adjacent to railroad on river right, which creates some encroachment in places, although the effects of the railroad appear to be minimal. A few residences also occur on river right, although they are distant from the study reach. Mining activity exists in the area, although there are no obvious effects on site.

Description of stream channel conditions:
Site is a steep (2.5% slope), boulder-dominated C3b type channel with few well-developed pools, although many small step pools. Site has minimal wood within the channel, but a log jam in cell 5 creates overwidening, and a log pool exists in cell 3. Pool tails have few fines due to the high stream velocity, and also have few spawning-sized gravels.

Description of streambank erosion conditions:
Site has minimal streambank erosion with only slowly eroding banks and natural erosion sources. Banks are well armored with large cobble, good vegetation cover and deep roots.

Description of riparian vegetation conditions:
Overall, riparian area has good diversity. Banks have tall grasses and woody shrubs, and overstory has mature Ponderosa pine, Douglas fir and cottonwood. Knapweed and toadflax occurs on railroad bed but not in riparian areas.

FLIN 17-01
Description of human impacts and their severity:
No human impacts were noted within stream channel, although agricultural land (hay fields and livestock grazing) exists approximately 50 to 100’ away on both sides of stream. An irrigation return exists just downstream of the study reach, and several ditches were noted in the area. Study reach has riparian fencing on both sides of stream.

Description of stream channel conditions:
Stream channel is boulder/cobble dominated with slopes of 3-4%. Channel is predominantly Rosgen type C3b or B3, but is downcutting and entrenched in cell 2 resembling type F3b channel. Riffle features dominate throughout the study reach. Pools are infrequent and small,

commonly forming behind large boulders. Most pools have no tail feature. Site has good wood recruitment from cottonwoods. Groundwater seepage was noted along both banks just above bankfull elevation.

Description of streambank erosion conditions:
No actively eroding banks were noted in this reach, only several small slowly eroding banks. Streambanks are primarily composed of boulders and cobbles and cobbles which help armor the banks.

Description of riparian vegetation conditions:
Site has good riparian condition with multiple grasses (timothy, fescue), alder understory, and a mature cottonwood overstory. The left bank has a narrow riparian buffer adjoining agricultural land, but riparian vegetation is in good condition. Some historic beaver activity is noted.

FLIN 18-02
Description of human impacts and their severity:
Site is adjacent to agricultural land (hay fields) on river right with narrow riparian buffer. Grazing impacts are minor. An irrigation ditch contributes return flow in the upper end of the reach on the right bank. Some rip-rap has been placed on right bank of cell 3.

Description of stream channel conditions:
Stream channel is a moderately entrenched B3c type channel with channel slope of 1.5 to 2%. Reach is riffle dominated with minimal pools, all of which are formed by boulders or woody debris. Some debris dams occur within the reach.

Description of streambank erosion conditions:
Site has very minimal streambank erosion, with only slowly eroding, well armored banks with dense root mass. Erosion sources are mostly natural, although agriculture land on right bank has some influence. Banks are mostly large gravels and cobbles with minimal fines. Rip-rap in cell 3 appears to be stable.

Description of riparian vegetation conditions:
Riparian vegetation is in good condition with good mix of grasses and shrubs, including alder, willow, chokecherry, wild rose, and buffalo berry. Lower cells have conifers on left bank, but overstory is sparse on the right bank.

FLIN 18-05
Description of human impacts and their severity:
Site is adjacent to agriculture land, but has riparian fencing throughout the reach. Site may have historically been grazed, but has recovered well. Two irrigation returns occur within the reach. Overall, human impacts are minimal.

Description of stream channel conditions:
Stream varies between C3 and B3c type channel based on entrenchment, but its potential stream type is likely B3c. Substrate is predominantly gravel and cobble with some embeddedness in areas. Site has good riffle development. Minimal spawning gravels were noted.

Description of streambank erosion conditions:
Most eroding banks were slowly eroding undercut banks protected with woody debris. Most banks have cobble substrate, although one was composed of fine substrate that may be from an old beaver dam. Most erosion sources are natural, but historic grazing and agricultural practices have some contribution.

Description of riparian vegetation conditions:
Site has good riparian vegetation due to riparian fencing. Right bank has more deciduous trees than left bank, primarily willow and cottonwood. The left bank has less diversity and a smaller buffer (~10') with mostly grass and willow, although many cottonwoods exist in lower part of reach where riparian buffer is wider.

FLIN 19-01
Description of human impacts and their severity:
Reach has riparian fencing on river left with approximately 10-100' of riparian buffer, although there is evidence of historic grazing on river left. River right is unfenced hay and pasture land with little evidence of riparian grazing.

Description of stream channel conditions:
Site has decent pool habitat, but not much woody debris. Channel may be over-widened in places, but appears to be recovering. Reach has good riffle development with some point bars. Substrate is mainly large gravel and small cobble, and substrate is not embedded as it was in upstream reaches. This reach is predominantly a C4 type channel, although cells 4 and 5 resemble B4c and F4 channel types, respectively, due to entrenchment.

Description of streambank erosion conditions:
This reach has long stretches of actively eroding banks on meander bends, and few slowly eroding streambanks. Banks have good protection from cobbles, but some areas have little riparian vegetation to help stabilize banks. Some past hoof shear is evident in places. One area has approximately 80-100' of rip-rap, with a fence falling into the stream channel.

Description of riparian vegetation conditions:
Site has mostly grasses and sedges on both banks. This reach is not heavily grazed, although one cattle crossing occurs in lower reach. River left is fenced with 10-100' riparian buffer, including many cottonwoods. River right is a hay field that has no riparian buffer. Some knapweed was noticed in places.

3.3.6 Fred Burr Creek

FRED 29-02

Description of human impacts and their severity:
Stream channel has been routed between highway and pasture/hay field in the upper 2 cells. Irrigation withdrawal above the reach also diverts some water through the hay field. The confinement of the road and hay field has probably resulted in the biggest impact toward streambank erosion through this reach. Lower cells may have historically been grazed, but currently have good riparian condition with tall, dense grasses and mid-sized woody shrubs.

Description of stream channel conditions:
The stream channel in this reach has become entrenched and is down-cutting due to unnatural confinement. Stream is primarily slow moving with low slope sections interrupted by occasional drops in elevation, resulting in short step-pool systems. Large woody debris is also forming dams and split channels and rerouting the stream in several areas. Site is mostly cobble dominated, but lots of fines and sandy material occurs in pools and slow water. Upper cells are armored with cobble, but lower cells appear much less stable. The potential Rosgen stream type for this reach is likely C4, but because of entrenchment it currently resembles a F4 or B4c/B3c channel type.

Description of streambank erosion conditions:
Lots of streambank erosion occurs in lower cells as stream channel is migrating around log jams and other obstructions. Cell 5 is mostly well armored with little erosion. Site has both slow and actively eroding streambanks. Slowly eroding banks are composed of fine substrate, while actively eroding banks typically have more sand or cobble. Site has plenty of woody debris and riparian vegetation, but unstable nature of channel is creating increased erosion. An extreme rain and runoff event this summer may have destabilized the channel since there is evidence of high scour lines and recent flood inundation.

Description of riparian vegetation conditions:
Upper cells (4-5) have some cottonwood and willow with assorted grasses, wetland species, and a few invasive weeds. The lower cells have dense grasses and woody vegetation (willow) with mature and diverse age classes, suggesting good riparian condition above is transitioning into more mature and complex riparian condition in the lower cells. Upper cells had a number of mid-age deciduous trees which were cut at ~6’ level leaving only the trunks. Some beaver activity was noticed on older tree trunks in the upper cells.

3.3.7 Lower Willow Creek

LOWI 02-05

Description of human impacts and their severity:
This reach has recently been grazed and has evidence of historic grazing impacts, including several cattle crossings within the reach. Some bank modification and rip-rap exists which has altered stream channel and immediate floodplain. The stream is controlled by a reservoir, and has an extensive network of irrigation ditches upstream. Immediately upstream of the reach is a highway and railroad bridge crossing. The upper watershed has historically been mined upstream

of the reservoir, although no immediate mining impacts are evident in this reach. Site is also influenced by an abnormally large population of domestic cats.

Description of stream channel conditions:
Stream channel is riffle/run dominated C3 channel with low sinuosity, cobble substrate and little spawning habitat. Aquatic vegetation has covered whatever potential spawning habitat does exist. Stream channel slope is approximately 1.5%.

Description of streambank erosion conditions:
Site has relatively little streambank erosion, but where it is occurring it is generally actively eroding slumping banks where channel is moving laterally. Banks are not stabilized by woody vegetation, only short grasses and weeds. Causes of erosion are largely due to grazing, flow alteration, and modifications made to stream channel.

Description of riparian vegetation conditions:
Site has little woody vegetation and is dominated by short grasses and weeds. A few alder and cottonwoods exist, but understory and canopy vegetation is almost non-existent.

3.3.8 Smart Creek

SMAR 13-01
Description of human impacts and their severity:
A road parallels the stream for much of the reach, although road impacts appear minor. Cattle grazing is obvious throughout the reach with hoof prints, fresh cow manure, and animal trails along the stream and throughout the riparian area. Invasive weeds are present throughout the reach, and a campsite exists in cell 1. Upper watershed has historically seen mining and logging activity.

Description of stream channel conditions:
This reach is a Rosgen B4 channel type with moderate entrenchment, small gravel substrate, and channel slopes of 2-2.5%. Cell 2 has a low width/depth ratio and channel form more similar to an F4b type channel, and has a large conifer that has fallen into the stream. Reach appears to be downcutting. Channel has long riffles, small pools, some point bar development, and good spawning gravel. The best pool habitat is formed by sloughed vegetation and woody debris in the channel.

Description of streambank erosion conditions:
Site has many tall eroding banks. Soil composition is primarily fines with stratified layer of gravel and small cobble that is highly erosive. Eroding streambanks have limited protection with poor vegetation holding banks together, and basically no root mass or length.

Description of riparian vegetation conditions:
This reach has very limited good quality woody vegetation throughout the riparian corridor. Some conifers and woody shrubs exist; however, vegetation is dominated by invasive weeds and some grasses. Improvements to riparian vegetation in this reach would be very beneficial to reducing sediment loads in this stream.

SMAR 18-01-1

Description of human impacts and their severity:

This is a 500' unfenced reach, and is paired with the fenced 500' reach immediately upstream (SMAR 18-01-2). This reach is extensively grazed with lots of hummocking and hoof shear. Stream channel is over-widened in many places. A dirt road exists within 150' of stream, and portions of forest have been cleared to accommodate a power line. An old mine exists on river left above the road and the upper watershed has historically been mined, but there is no direct evidence of mining influences within the reach.

Description of stream channel conditions:

This reach is a Rosgen C4b type channel that is over-widened in places and also shows evidence of aggradation (especially in cell 3). Channel slopes are approximately 2%. Potential stream type is likely B4. Reach has poorly developed pools. Pools tails were trampled by cattle and had some spawning gravels, but most pool tails also had a significant percentage of fines. Larger substrate is not overly embedded and shows signs of trampling. Some woody debris exists in stream channel, but it is mostly poor quality and provides little habitat.

Description of streambank erosion conditions:

Streambank erosion is fairly limited and all noticeable erosion is caused by hoof shear and cattle grazing. Some banks have been grazed to nothing. Bank substrate is mostly fine clay. Eroding banks are short and low angle from trampling, but don't contribute much sediment due to amount of fine materials.

Description of riparian vegetation conditions:

Banks are grazed very short. Some grasses and sedges are established on slumped banks. Some weeds occur throughout the riparian area, including thistle, knapweed and mullein. Understory is mostly alder, and sparse conifers exist on river right.

SMAR 18-01-2

Description of human impacts and their severity:

This is a 500' reach with riparian fencing, and was paired with the unfenced 500' reach immediately downstream (SMAR 18-01-1). Site has some evidence of past grazing, although effects are minor. A dirt road exists parallel to the stream, approximately 100-150' away on river left. Old mines exist in the area and the upper watershed, although none occur within the sample reach. A power line crosses the bottom of the reach.

Description of stream channel conditions:

Site is a Rosgen B4 channel type with small gravel substrate and channel slope of 1.5 to 2%; however, some cross sections have low width/depth ratios resembling an E4b channel type. Reach has well developed pools and riffles and good spawning gravels, although pools are somewhat shallow. A log jam has created an aggraded area in the upper cell, and a new channel is forming on river left. The log jam creates a significant drop of approximately 4' in elevation. Substrate size is consistent throughout the reach except in upper cell where aggradation has occurred and fine materials are accumulating.

Description of streambank erosion conditions:
Site has only four eroding streambanks with 100% natural sources of erosion. Banks are well vegetated and appear to have minimal sediment contribution to the stream.

Description of riparian vegetation conditions:
Site has good diversity of riparian vegetation with functional woody debris in the stream channel, a mix of grasses and sedges on banks, and both conifers and deciduous species in the understory and canopy. Some weeds do occur including thistle and mullein.

SMAR 21-01
Description of human impacts and their severity:
This site has a headgate at the top of the reach, and appears to be affected by irrigation practices. Reach also has evidence of past or rotational grazing, but is not currently being grazed. Sheep and llama are grazing pasture downstream of reach. A pivot line runs through the reach and crosses the creek with numerous small bridges to accommodate the pivot wheels. A dirt road is parallel to the stream but distant (~500' away).

Description of stream channel conditions:
Stream channel has downcut and is now entrenched with slumping banks. Sedges are well established on the slumped banks. The potential Rosgen stream type for this reach is likely E4, but because of entrenchment some areas resemble F4 or G4c stream types. The reach has small gravels and a channel slope of 1.5 to 2%. Site has poor riffle and pool development, and resembles a step-pool type system in places. The headgate at the upper end of the reach may cause some overwidening, and woody debris in the upper reach also causes some backwater effects. Substrate is fairly consistent throughout the reach, and is not embedded.

Description of streambank erosion conditions:
Site has many eroding streambanks, most of which are slumped banks covered with sedges and tall steep banks behind the slumping areas. Changes in stream energy from irrigation practices are likely responsible for altering channel form which has contributed to current streambank erosion. There is no evidence of hoof shear, but site is periodically grazed by sheep. Landowner says some ice scour does occur during periods of thaw, but there was little direct evidence of ice scour at time of sampling.

Description of riparian vegetation conditions:
Site has dense grass on banks (timothy and fescue) which was previously grazed. Slumped areas are covered with dense sedges. A few weedy species were noted, including mullein, thistle and knapweed. Sparse aspen and old willows exist in the upper portion of the reach below the headgate. Site is fenced on both sides approximately 100-150' from the stream.

3.3.9 Trout Creek

TROU 09-03

Description of human impacts and their severity:

This stream receives flow augmentation from a trans-basin diversion to supplement irrigation in the Flint Creek valley. As a consequence, the stream channel within this reach appears to be nearly twice the size that would be expected based on regional curve information. Some cultivated agriculture fields exist upstream, and the upper watershed has historically been logged. This reach may have historically been grazed, although there is little direct evidence. Some aquatic vegetation and algae occur on the stream bottom, which suggests possible impairment from nutrients, temperature or shading. A highway crosses the stream just downstream of the study area.

Description of stream channel conditions:

The stream in this reach is a highly sinuous, low slope E4 type channel, although some areas are overwidened and have a high width/depth ratio resembling a C4 type channel. The potential stream type for this reach is E4. The stream becomes anastamosed and even more sinuous downstream of the study area. The channel is riffle/run dominated. The runs on outside bends were deep and fast and typically had no defined pool crest, although the few pools that were noted occurred on outside bends. Site has good spawning gravel. One pool had embedded fines, but most riffle and pool substrate was not embedded.

Description of streambank erosion conditions:

This site has low to moderate streambank erosion, typically occurring on outside meander bends where vegetation is dominated by weedy species and root density is poor. As a whole, channel and bank stability appears to be quite good in this reach. The channel is very sinuous and is migrating across the valley, so a few slowly eroding banks could be expected with this channel type.

Description of riparian vegetation conditions:

Riparian vegetation is dominated by wetland species at bank edge. There is no understory or overstory within this reach. Some knapweed exists which contributes to poor bank stability and streambank erosion.

TROU 10-01

Description of human impacts and their severity:

This site is not far downstream from TROU 09-03, and similar impacts from flow-augmentation apply to this reach. Effects of irrigation withdrawal are evident at this site, since cross-sectional areas in this reach were lower than the study reach upstream. Irrigation sprinkler systems border the reach on both sides, and several seeps and springs were noticed in the lower cells of the reach. There are no obvious signs of riparian grazing, although the site may have been historically been grazed. This reach has noticeably more algae and aquatic vegetation than the reach upstream.

Description of stream channel conditions:
This reach is a C4 channel type with fairly high sinuosity, medium to large gravel substrate, and channel slope of 1 to 1.5%. Some sections of stream have a low/width ratio and resemble E4 channel type, although the potential type for this reach is C4. The stream is a riffle/run type system with relatively fast flows as seen upstream. This reach has fewer areas with appropriately sized spawning gravels, and substrate is generally larger and more embedded than above.

Description of streambank erosion conditions:
Only two eroding streambanks were noted in this reach. The eroding streambanks were near-vertical banks on outside meander bends with very fine clay composition. The erosion on these banks was attributed to irrigation and riparian grazing. The areas with weak bank structure are a result of non-native encroachment typical of grazed areas, although there is little direct evidence of grazing on site.

Description of riparian vegetation conditions:
Riparian vegetation in this reach is dominated by deeply-rooted grasses and sedges. Some weedy species do occur, including knapweed and thistle, although weeds are not as prolific in this reach as they were in TROU 09-03.

3.4 Sampling Parameter Summaries by Individual Reach

The following **Figures 3-13** to **3-21** display statistical boxplots of stream channel and riparian zone parameters that were measured in each of the monitored sites. Individual reaches are also grouped by reach type and displayed below the reach names on each boxplot.

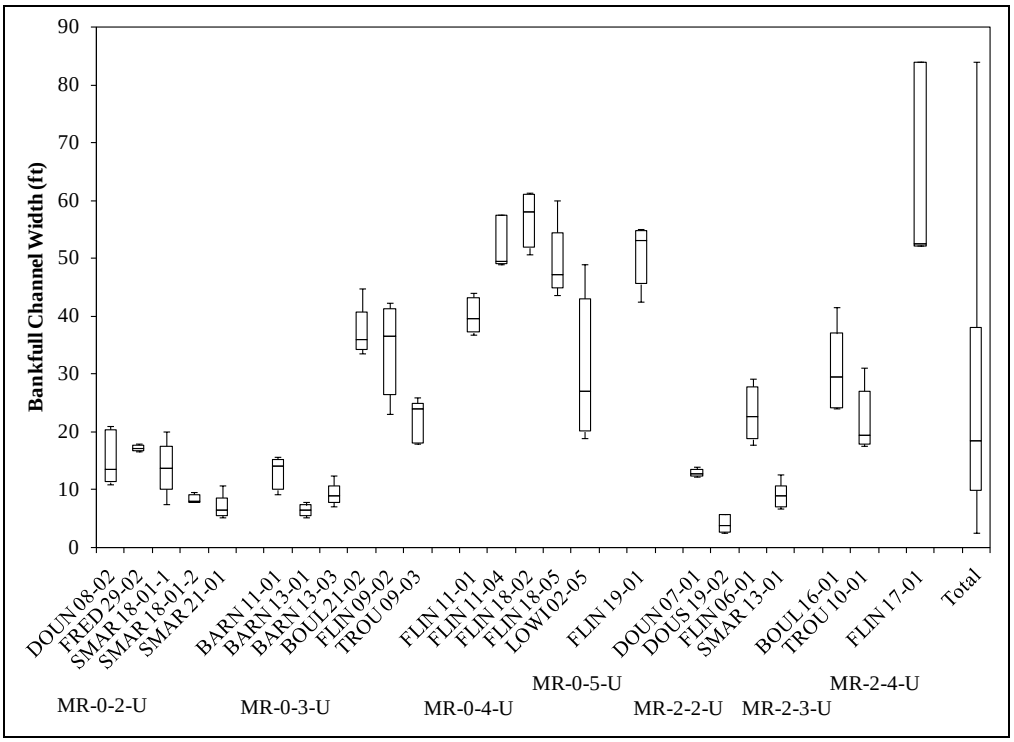


Figure 3-13. Bankfull channel width by reach.

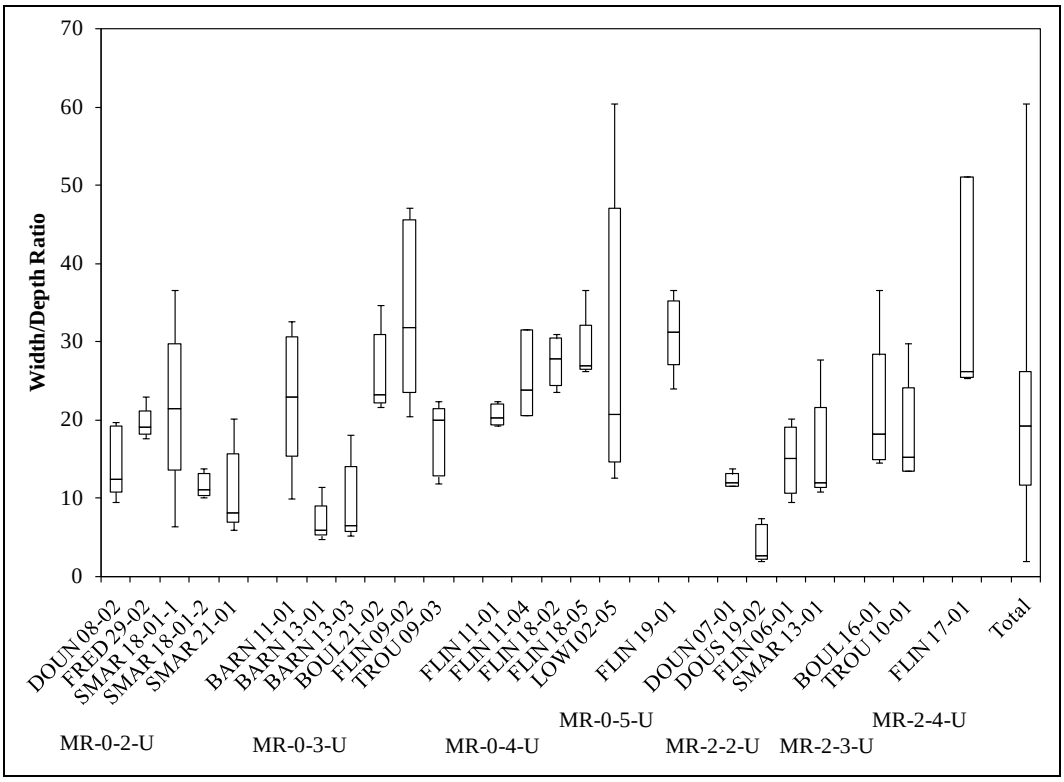


Figure 3-14. Width/depth ratio by reach.

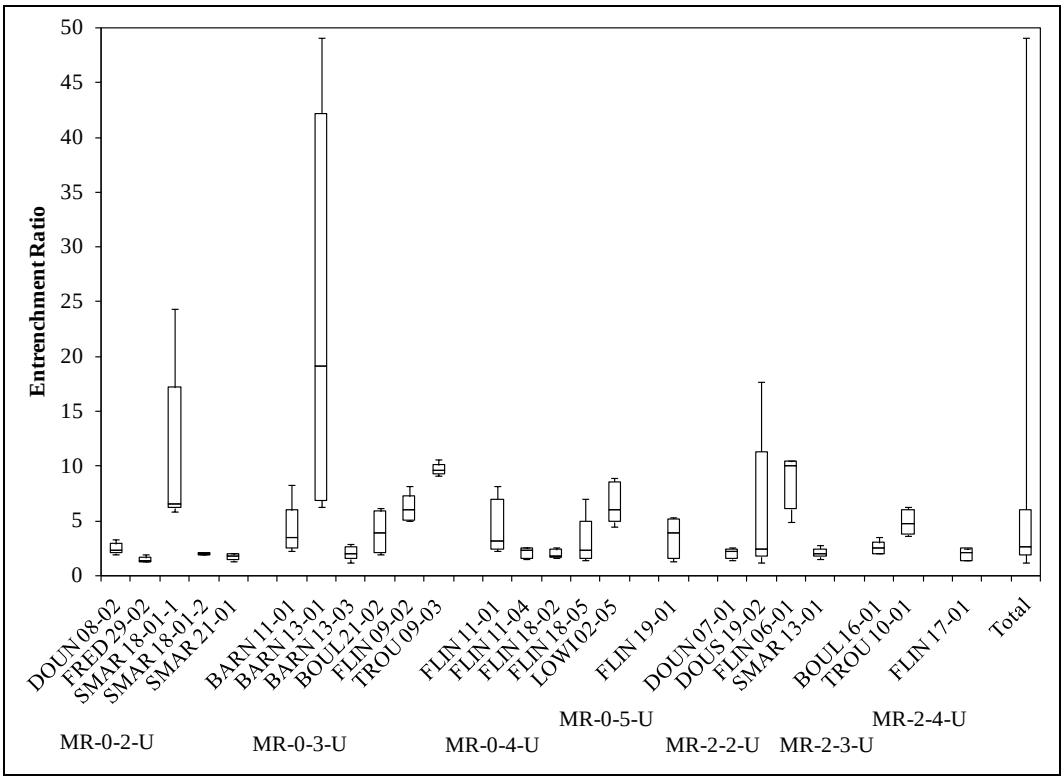


Figure 3-15. Entrenchment ratio by reach.

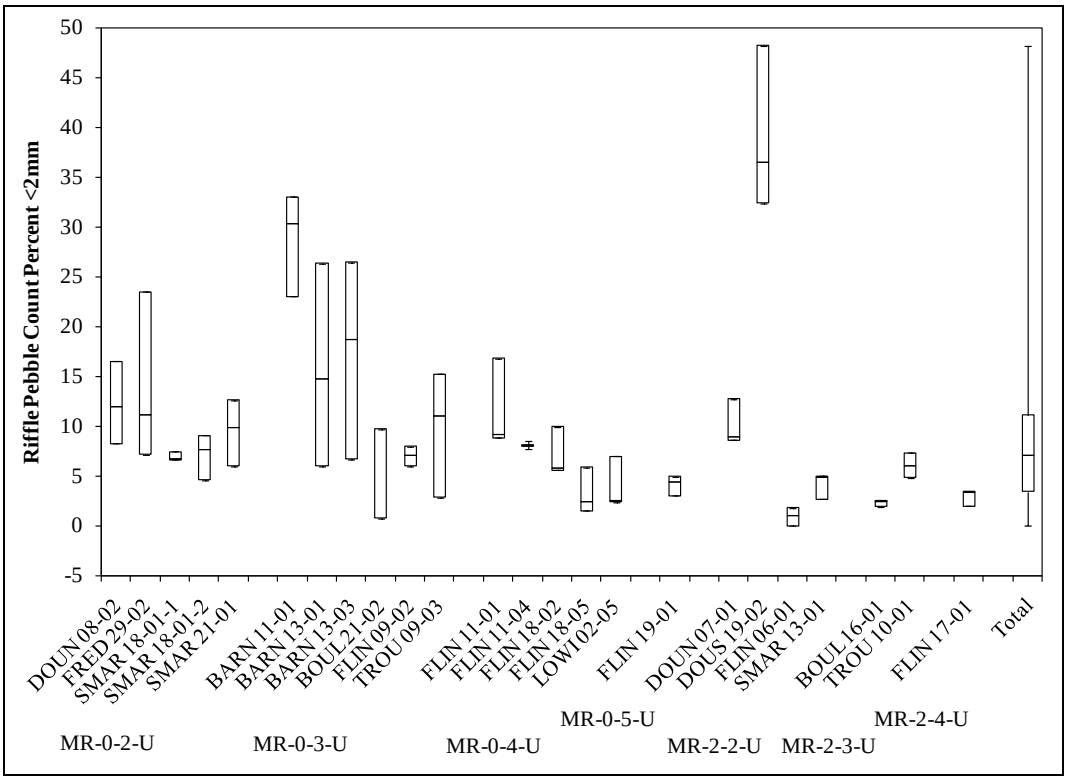


Figure 3-16. Riffle pebble count (% <2 mm) by reach.

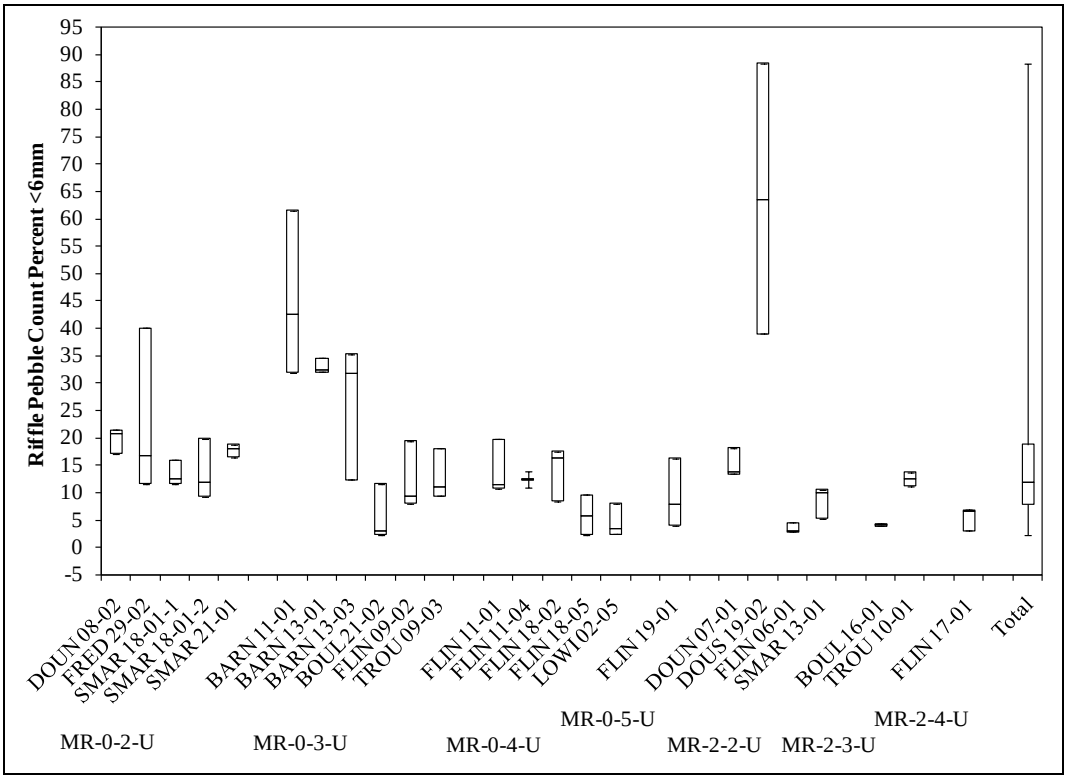


Figure 3-17. Riffle pebble count (% <6 mm) by reach.

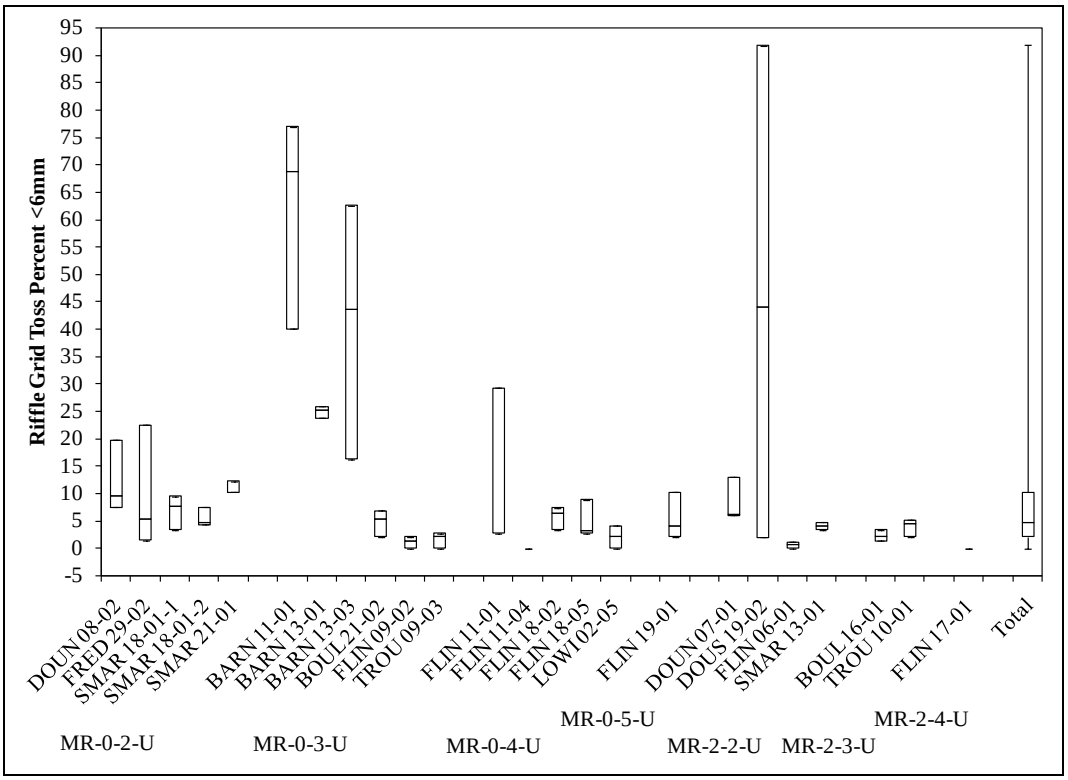


Figure 3-18. Riffle grid toss (% <6 mm) by reach.

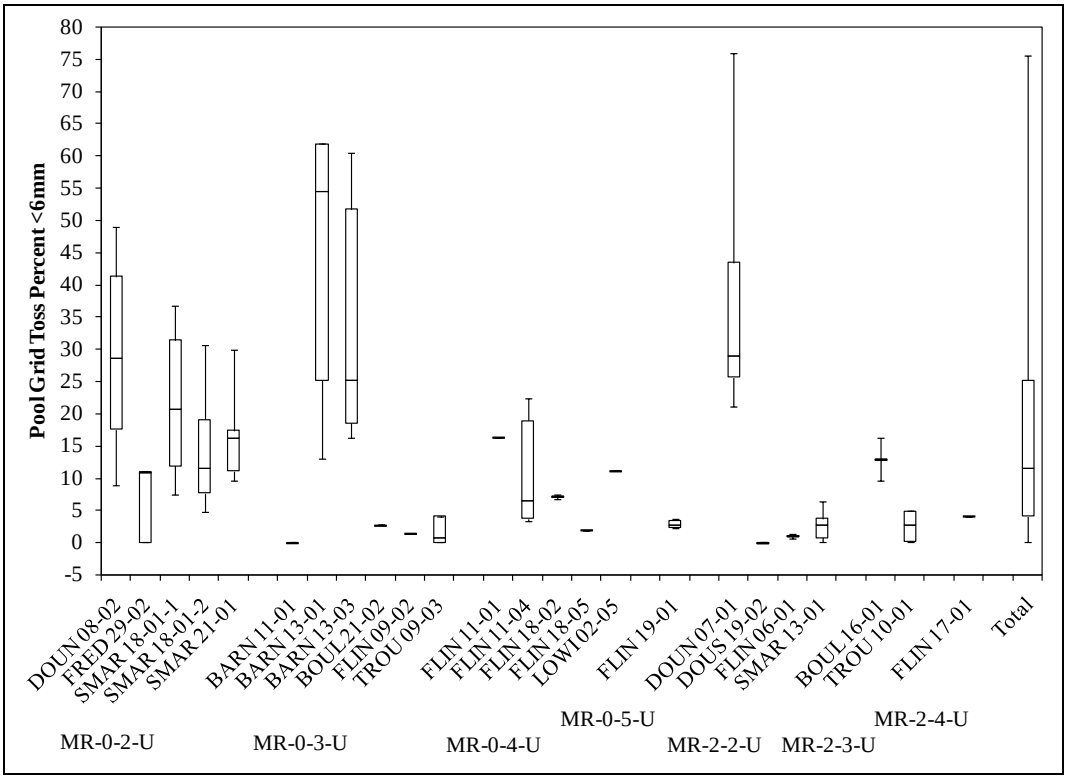


Figure 3-19. Pool grid toss (% <6 mm) by reach.

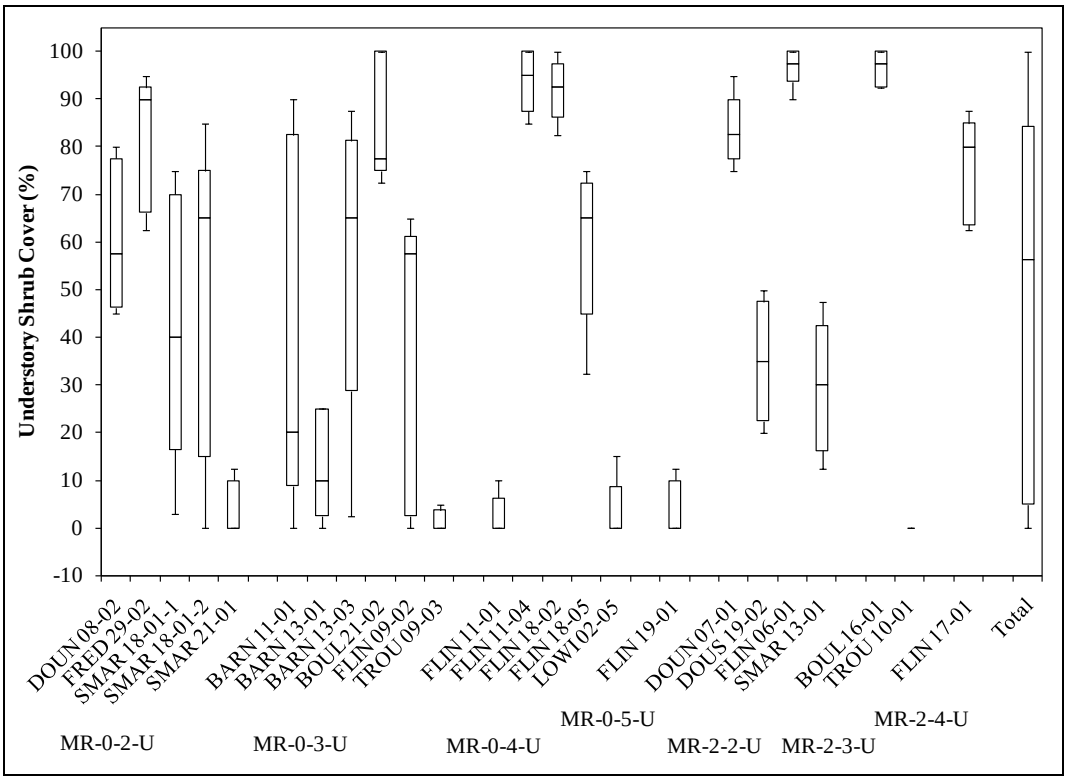


Figure 3-20. Greenline understory shrub cover (%) by reach.

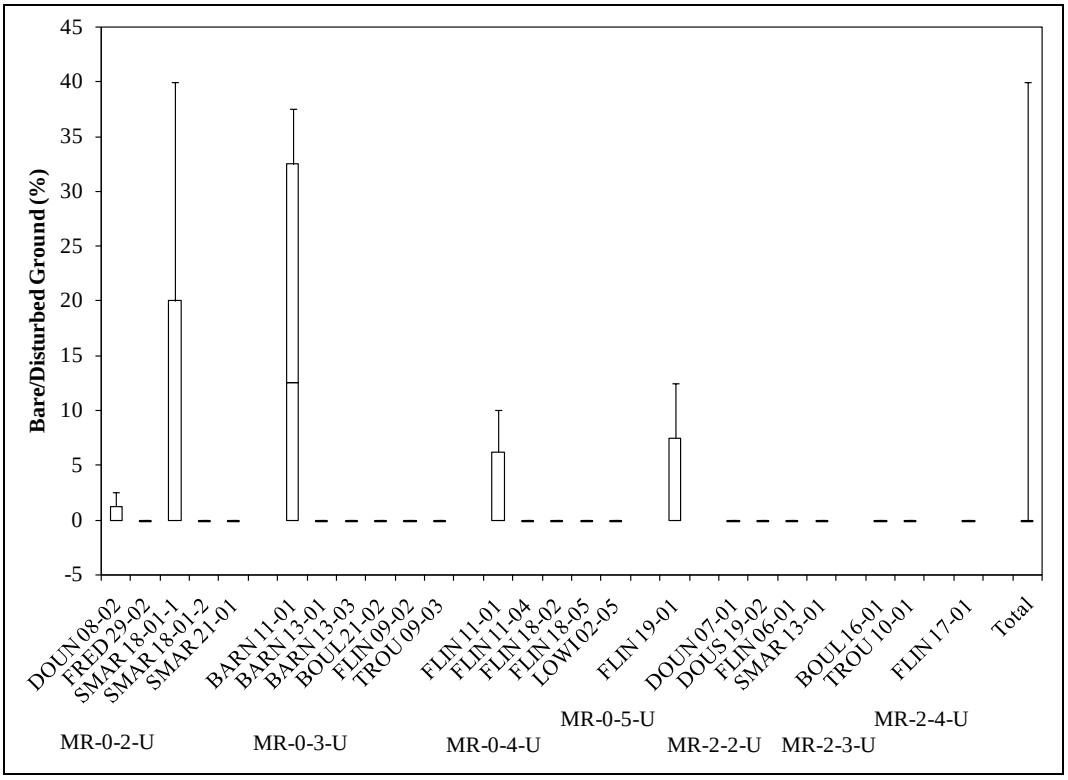


Figure 3-21. Greenline bare/disturbed ground (%) by reach.

4.0 STREAMBANK EROSION SOURCE ASSESSMENT

For each monitoring reach assessed during the study, measurements were collected to calculate the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) in accordance with guidelines provided in *Watershed Assessment of River Stability and Sediment Supply* (Rosgen 2006). These measurements were used in conjunction with streambank length and erosion source notes to determine sediment loads per 1,000 feet within each surveyed reach.

For sites within the Flint Creek TPA, eroding banks were identified as "actively eroding" or "slowly eroding". Eroding bank sites within each reach were evaluated based on the variability of streambank conditions within the reach. The banks selected for evaluation provide a representative sample of conditions throughout the reach, and banks which are similar to the evaluated banks are measured and recorded as "additional banks". At each eroding bank, photos were taken from locations perpendicular and upstream/downstream of the streambank. Photos were labeled according to the streambank site and position of the photograph.

4.1 Field Measurements and Loading Calculations

4.1.1 Field Measurements

Within each sampled reach, eroding streambanks were identified by the field team and supporting measurements were recorded for the following metrics:

- Bank condition (includes actively eroding or slowly eroding/undercut/vegetated banks)
- Bank height
- Bankfull height
- Root depth
- Root density
- Bank angle
- Surface protection
- Material adjustments
- Bankfull mean depth
- Near bank maximum depth
- Stationing
- Mean height
- Bank composition (size classes)
- Hoof shear presence
- Sources of streambank instability (%): transportation, grazing, cropland, irrigation, natural, urban, railroad

4.1.2 Determination of BEHI Scores

To determine the BEHI score for each eroding bank, the following parameters are used:

- Bank height/bankfull height

- Root depth/bank height
- Weighted root density (root density * root depth/bank height)
- Bank angle
- Surface protection

These five bank erosion parameters are used to determine a numerical BEHI index score that ranks erosion potential from very low to extreme based on relationships provided by Rosgen (2006) (**Table 4-1**).

Table 4-1. BEHI score and rating system for individual parameters.

Parameter		Very Low	Low	Moderate	High	Very High	Extreme
Bank Height Ratio	Value	1.0 – 1.1	1.11 – 1.19	1.2 – 1.5	1.6 – 2.0	2.1 – 2.8	> 2.8
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Root Depth Ratio	Value	1.0 – 0.9	0.89 – 0.5	0.49 – 0.3	0.29 – 0.15	0.14 – 0.05	<0.05
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Weighted Root Density	Value	100 – 80	79 – 55	54 – 30	29 – 15	14 – 5	<5
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Bank Angle	Value	0 – 20	21 – 60	61 – 80	81 – 90	91 – 119	>119
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Surface Protection	Value	100 – 80	79 – 55	54 – 30	29 – 15	14 – 10	<10
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10

After obtaining the BEHI index score for each individual parameter, the index scores are summed to produce a total BEHI score. Bank material factors are then considered, and total BEHI scores may be adjusted up or down. Banks comprised of bedrock, boulders, or cobble have very low erosion potential, and total BEHI scores for banks composed of these materials may be adjusted down by up to 10 points. Banks composed of cobble and/or gravel with a high fraction of sand have increased erosion potential, and total BEHI scores may be adjusted up by 5 to 10 points depending on the amount of sand present and whether the sandy material is exposed to erosion. Stratified banks containing layers of unstable material also have greater erosion potential, and total BEHI scores may be adjusted up by 5 to 10 points if stratified banks are present. After all material adjustments are made to the total BEHI score, the erosion potential is ranked from very low to extreme based on the scale provided below (**Table 4-2**). Photos of example streambanks with each BEHI rating are provided in **Attachment D**.

Table 4-2. Total BEHI score and rating system.

Rating	Very Low	Low	Moderate	High	Very High	Extreme
Score	5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5	40 - 45	46 - 50

4.1.3 Near Bank Stress (NBS) Determination

To calculate Near Bank Stress (NBS) for each eroding bank, the following relationship is used:

NBS = Near Bank Maximum Bankfull Depth (ft) / Bankfull Mean Depth (ft)

As with the BEHI scores, the resulting NBS values correspond to a categorical rating that ranks the erosion potential from very low to extreme (**Table 4-3)**. If appropriate measurements are not recorded for NBS determination, the NBS rating is estimated in the field or from photos using best professional judgment.

Table 4-3. Near bank stress (NBS) rating system.

NBS Value	Rating
< 1.0	very low
1.0 - 1.5	low
1.51 - 1.8	moderate
1.81 - 2.5	high
2.51 - 3.0	very high
> 3.0	extreme

4.1.4 Retreat Rate

Once respective BEHI and NBS ratings are found for each eroding bank, the ratings are used to derive the average retreat rate of each streambank based on empirical relationships derived by Rosgen (2006). The average retreat rates (ft/yr) based on BEHI and NBS ratings are provided below in **Table 4-4**.

Table 4-4. Streambank retreat rate (ft/yr) based on BEHI and NBS rating.

	Near Bank Stress					
BEHI	Very Low	Low	Moderate	High	Very High	Extreme
Very Low	NA	NA	NA	NA	NA	NA
Low	0.02	0.04	0.07	0.16	0.32	0.67
Moderate	0.09	0.15	0.25	0.42	0.70	1.16
High-Very High	0.17	0.25	0.38	0.58	0.87	1.32
Extreme	0.16	0.42	1.07	2.75	7.03	17.97

4.1.5 Sediment Loading Calculation

Once retreat rate is determined from the BEHI and NBS ratings, the dimensions of the eroding stream bank are used to find the total mass eroding from each bank per year. The total mass eroded from each streambank is calculated using the following equation:

*mass eroded (tons/yr) = bank length (ft) * bank height (ft) * retreat rate (ft/yr) * material density (tons/ft^3)*

The sediment load from each streambank is filtered into two bank erosion type categories including actively eroding banks or slowly eroding/undercut/vegetated banks. The total loads for

each bank erosion type and for the entire reach are then calculated in tons of sediment per year per 1000 feet of reach.

4.2 Sediment Loading Results by Assessment Reach

The following sections provide sediment loading results for each sampled stream. One data table is included for each stream which includes data from each reach summarizing bank erosion and sediment loading for each bank erosion type (active or slowly eroding) and for the total reach. Information provided includes the number of eroding banks identified, the mean BEHI rating for each erosion type, the percent of reach that has eroding streambanks, the percent contribution from each erosion source present, and the sediment load per 1000 feet. The percentage of reach with eroding streambanks was calculated by summing the total footage of eroding banks (active and slow) and dividing the total by the total bank footage in the reach, including both right and left banks (i.e., a 1000' reach has 2000' of bank). Identified sources of streambank erosion within the Flint Creek TPA included transportation, riparian grazing, irrigation, natural sources, or those classified as "other". Additional sources such as cropland, mining and silviculture were evaluated but not identified at any sample locations; however, these sources may contribute to streambank erosion in other parts of the watershed.

4.2.1 Sediment Loading Results for Barnes Creek

4.2.1.1 BARN 11-01

Eroding banks are generally similar throughout the reach with major pugging and hummocking. Three bank types were identified in this reach including near vertical banks in downcutting straight sections, exposed banks on outside meander bends, and the primary type included low angle banks that were trodden down by cattle. Typical eroding streambank conditions are depicted for this reach in **Figure 4-1** and sediment loading results are provided in **Table 4-5**.



Figure 4-1. Typical eroding streambank conditions in Barnes Creek Reach 11-01.

4.2.1.2 BARN 13-01

Three primary bank types were identified in this reach, including near vertical banks on meander bends, banks that were trodden by cattle, and one low angle bank at a cattle crossing. Typical eroding streambank conditions are depicted in **Figure 4-2** and sediment loading results are provided in **Table 4-5**.



Figure 4-2. Typical eroding streambank conditions in Barnes Creek Reach 13-01.

4.2.1.3 BARN 13-03

Three primary bank types were identified in this reach, including two actively eroding types and a heavily vegetated slowly eroding bank type. Most streambank erosion was associated with large woody debris. Bank composition was primarily fines which create a stable bank. Typical eroding streambank conditions are depicted in **Figure 4-3** and sediment loading results are provided in **Table 4-5**.



Figure 4-3. Typical eroding streambank conditions in Barnes Creek Reach 13-03.

Table 4-5. Sediment loading results for Barnes Creek.

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Transpor-tation	Riparian Grazing	Irrigation	Natural	Other	
BARN 11-01	Active	12	moderate	16.9	0.0	95.9	0.6	3.5	0.0	8.4
	Slow	1	high	0.3	0.0	100.0	0.0	0.0	0.0	0.2
	Total	13	moderate	17.2	0.0	96.0	0.6	3.4	0.0	8.6
BARN 13-01	Active	5	moderate	3.5	0.0	81.2	0.0	18.8	0.0	1.8
	Slow	5	moderate	2.2	0.0	77.3	0.0	22.7	0.0	0.7
	Total	10	moderate	5.7	0.0	80.1	0.0	19.9	0.0	2.6
BARN 13-03	Active	6	high	3.2	0.0	0.0	10.0	90.0	0.0	4.0
	Slow	2	high	1.8	0.0	0.0	7.1	92.9	0.0	2.5
	Total	8	high	5.0	0.0	0.0	8.9	91.1	0.0	6.5

4.2.2 Sediment Loading Results for Boulder Creek

4.2.2.1 BOUL 16-01

Only three slowly eroding banks were identified in this reach. Banks are well armored with large cobbles and boulders, and erosion sources are 100% natural. Eroding banks typically occur at base of large conifers. Typical eroding streambank conditions are depicted for this reach in **Figure 4-4** and sediment loading results are provided in **Table 4-6**.



Figure 4-4. Typical eroding streambank conditions in Boulder Creek Reach 16-01.

4.2.2.2 BOUL 21-02

Nine slowly eroding banks were noted in this reach. Some were well armored with large cobbles and boulders. Many eroding banks are undercut, but banks are held in place by fine materials or

root wads. Typical eroding streambank conditions are depicted for this reach in **Figure 4-5** and sediment loading results are provided in **Table 4-6**.



Figure 4-5. Typical eroding streambank conditions in Boulder Creek Reach 21-02.

Table 4-6. Sediment loading results for Boulder Creek.

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Transpor-tation	Riparian Grazing	Irrigation	Natural	Other	
BOUL 16-01	Active	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Slow	3	low	4.2	0.0	0.0	0.0	100.0	0.0	0.4
	Total	3	low	4.2	0.0	0.0	0.0	100.0	0.0	0.4
BOUL 21-02	Active	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Slow	9	high	11.2	5.0	4.0	0.0	91.0	0.0	10.3
	Total	9	high	11.2	5.0	4.0	0.0	91.0	0.0	10.3

4.2.3 Sediment Loading Results for Douglas Creek (North)

4.2.3.1 DOUN 07-01

This site has 18 total eroding banks and 3 primary bank types, including slowly eroding banks that are near vertical and held together with vegetation or clay, heavily trampled low angle banks with pugging and hummocking, and one trampled bank on an outside bend. Typical eroding streambank conditions are depicted for this reach in **Figure 4-6** and sediment loading results are provided in **Table 4-7**.



Figure 4-6. Typical eroding streambank conditions in Douglas Creek (North) Reach 07-01.

4.2.3.2 DOUN 08-02

This site has 15 eroding streambanks and 2 primary bank types, including tall moderately-angled actively eroding banks, and short near-vertical banks typically occurring in slower water. Typical eroding streambank conditions are depicted for this reach in **Figure 4-7** and sediment loading results are provided in **Table 4-7**.



Figure 4-7. Typical eroding streambank conditions in Douglas Creek (North) Reach 08-02.

Table 4-7. Sediment loading results for Douglas Creek (North).

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Transpor-tation	Riparian Grazing	Irrigation	Natural	Other	
DOUN 07-01	Active	11	high	8.2	0.0	90.5	0.0	9.5	0.0	4.3
	Slow	7	high	4.5	0.0	39.9	0.0	60.1	0.0	8.8
	Total	18	high	12.7	0.0	56.4	0.0	43.6	0.0	13.1
DOUN 08-02	Active	8	high	9.3	0.0	87.6	0.0	12.4	0.0	19.2
	Slow	7	moderate	6.9	0.0	83.6	0.0	16.4	0.0	4.1
	Total	15	high	16.2	0.0	86.9	0.0	13.1	0.0	23.3

4.2.4 Sediment Loading Results for Douglas Creek (South)

4.2.4.1 DOUS 19-02

One 500' reach was evaluated on Douglas Creek (South). This reach is straight and channelized, and much of the reach is alternating between near vertical and undercut slowly eroding banks; however, bank composition is primarily fine material. Typical eroding streambank conditions are depicted in **Figure 4-8** and sediment loading results are provided in **Table 4-8**.



Figure 4-8. Typical eroding streambank conditions in Douglas Creek (South) Reach 19-02.

Table 4-8. Sediment loading results for Douglas Creek (South).

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Transpor-tation	Riparian Grazing	Irrigation	Natural	Other	
DOUS 19-02	Active	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Slow	20	high	30.4	50.0	0.0	50.0	0.0	0.0	16.1
	Total	20	high	30.4	50.0	0.0	50.0	0.0	0.0	16.1

4.2.5 Sediment Loading Results for Flint Creek

4.2.5.1 FLIN 06-02

This reach recorded 7 eroding streambanks and 2 primary bank types, including actively eroding banks with low root density and exposed cobble soil, and slowly eroding banks (sometimes undercut) in forested areas with high root density and fine substrate. Typical eroding streambank conditions are depicted in **Figure 4-9** and sediment loading results are provided in **Table 4-9**.



Figure 4-9. Typical eroding streambank conditions in Flint Creek Reach 06-02.

4.2.5.2 FLIN 09-02

This reach has 7 eroding banks and 3 primary eroding bank types, including actively eroding undercut banks with some cobble, actively eroding banks that are sloped or near vertical with fine bank material, and slowly eroding banks on outside meander bends with good protection from cobbles. Typical eroding streambank conditions are depicted in **Figure 4-10** and sediment loading results are provided in **Table 4-9**.



Figure 4-10. Typical eroding streambank conditions in Flint Creek Reach 09-02.

4.2.5.3 FLIN 11-01

This reach has 9 long actively eroding streambanks and 3 primary bank types, including tall undercut banks primarily occurring on outside bends, tall sloped banks, and one very tall long bank that is undercutting an abandoned railroad bed. Typical eroding streambank conditions are depicted in **Figure 4-11** and sediment loading results are provided in **Table 4-9**.



Figure 4-11. Typical eroding streambank conditions in Flint Creek Reach 11-01.

4.2.5.3 FLIN 11-04

This site has very minimal streambank erosion with only two slowly eroding banks that are protected by cobble and dense roots. Typical eroding streambank conditions are depicted in **Figure 4-12** and sediment loading results are provided in **Table 4-9**.



Figure 4-12. Typical eroding streambank conditions in Flint Creek Reach 11-04.

4.2.5.4 FLIN 17-01

This reach has 8 slowly eroding banks and 2 primary bank types. One bank type is slightly undercut with cobble armor, and occurs in small areas throughout the reach where the bank is influenced by high stream velocities. The other bank type includes sloped banks downstream of inside bends that are also heavily protected by cobble. Typical eroding streambank conditions are depicted in **Figure 4-13** and sediment loading results are provided in **Table 4-9**.



Figure 4-13. Typical eroding streambank conditions in Flint Creek Reach 17-01.

4.2.5.5 FLIN 18-02

This reach has five slowly eroding banks of the same bank type. These banks are very stable, heavily armored, well vegetated, and have a dense root mass. Typical eroding streambank conditions are depicted in **Figure 4-14** and sediment loading results are provided in **Table 4-9**.



Figure 4-14. Typical eroding streambank conditions in Flint Creek Reach 18-02.

4.2.5.6 FLIN 18-05

This reach has 7 eroding banks and 3 bank types, although most are slowly eroding undercut banks protected by woody debris. Most banks have cobble substrate, although one is composed of fine material and may occur in an area previously dammed by beavers. Typical eroding streambank conditions are depicted in **Figure 4-15** and sediment loading results are provided in **Table 4-9**.



Figure 4-15. Typical eroding streambank conditions in Flint Creek Reach 18-05.

4.2.5.7 FLIN 19-01

This reach has 7 eroding banks and 4 primary banks types including slowly eroding low angle banks with cobble, actively eroding near vertical banks with little vegetation, actively eroding near vertical banks with cobble, and actively eroding banks with rip-rap and concrete slabs for protection. Typical eroding streambank conditions are depicted in **Figure 4-16** and sediment loading results are provided in **Table 4-9**.



Figure 4-16. Typical eroding streambank conditions in Flint Creek Reach 19-01.

Table 4-9. Sediment loading results for Flint Creek.

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Transpor-tation	Riparian Grazing	Irrigation	Natural	Other	
FLIN 06-01	Active	3	very high	6.6	0.0	0.0	70.0	1.1	28.9	6.7
	Slow	4	moderate	5.1	0.0	0.0	70.0	10.0	20.0	4.9
	Total	7	high	11.7	0.0	0.0	70.0	4.8	25.2	11.6
FLIN 09-02	Active	5	high	5.1	0.0	80.0	0.0	20.0	0.0	3.2
	Slow	2	high	1.0	0.0	63.3	0.0	36.7	0.0	0.7
	Total	7	high	6.1	0.0	77.1	0.0	22.9	0.0	3.9
FLIN 11-01	Active	6	high	29.9	19.6	38.1	0.0	42.3	0.0	71.4
	Slow	3	high	6.0	13.5	20.0	0.0	66.5	0.0	7.4
	Total	9	high	35.8	19.0	36.4	0.0	44.6	0.0	78.8
FLIN 11-04	Active	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Slow	2	low	3.4	0.0	0.0	0.0	100.0	0.0	1.4
	Total	2	low	3.4	0.0	0.0	0.0	100.0	0.0	1.4
FLIN 17-01	Active	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Slow	8	low	10.0	0.0	0.0	20.0	80.0	0.0	0.8
	Total	8	low	10.0	0.0	0.0	20.0	80.0	0.0	0.8
FLIN 18-02	Active	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Slow	5	low	7.8	0.0	0.0	0.0	100.0	0.0	0.5
	Total	5	low	7.8	0.0	0.0	0.0	100.0	0.0	0.5
FLIN 18-05	Active	4	high	4.3	0.0	0.0	0.0	80.0	20.0	2.8
	Slow	3	low	6.6	0.0	0.0	0.0	84.0	16.0	2.5
	Total	7	moderate	10.9	0.0	0.0	0.0	81.9	18.1	5.3
FLIN 19-01	Active	6	moderate	19.0	0.0	86.3	0.0	13.7	0.0	23.6
	Slow	2	moderate	1.5	0.0	46.1	0.0	42.3	11.6	0.4
	Total	8	moderate	20.5	0.0	85.6	0.0	14.2	0.2	23.9

4.2.6 Sediment Loading Results for Fred Burr Creek

4.2.6.1 FRED 29-02

This reach has 12 eroding streambanks and 4 primary bank types, including slowly eroding near vertical banks, slowly eroding undercut banks, actively eroding tall banks with some vegetation, and tall actively eroding banks with mixed substrate and poor root density. Typical eroding streambank conditions are shown in **Figure 4-17** and sediment loading results are provided in **Table 4-10**.



Figure 4-17. Typical eroding streambank conditions in Fred Burr Creek Reach 29-02.

Table 4-10. Sediment loading results for Fred Burr Creek.

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Transpor-tation	Riparian Grazing	Irrigation	Natural	Other	
FRED 29-02	Active	3	high	5.5	27.8	0.0	0.0	72.2	0.0	11.7
	Slow	9	high	10.4	54.0	0.0	0.0	46.0	0.0	16.9
	Total	12	high	15.9	43.3	0.0	0.0	56.7	0.0	28.6

4.2.7 Sediment Loading Results for Lower Willow Creek

4.2.7.1 LOWI 02-05

This reach has 6 eroding banks and 3 bank types, including short slowly eroding banks that are near vertical, undercut actively eroding banks, and tall actively eroding banks. All banks have some protection from cobble substrate. Typical eroding streambank conditions are depicted in **Figure 4-18** and sediment loading results are provided in **Table 4-11**.



Figure 4-18. Typical eroding streambank conditions in Lower Willow Creek Reach 02-05.

Table 4-11. Sediment loading results for Lower Willow Creek.

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Transpor-tation	Riparian Grazing	Irrigation	Natural	Other	
LOWI 02-05	Active	4	moderate	6.3	0.0	43.1	32.3	24.6	0.0	3.4
	Slow	2	moderate	2.9	0.0	59.3	40.7	0.0	0.0	0.5
	Total	6	moderate	9.1	0.0	45.3	33.4	21.3	0.0	3.9

4.2.8 Sediment Loading Results for Smart Creek

4.2.8.1 SMAR 13-01

This reach has 10 actively eroding streambanks and 4 primary bank types, including banks with fine substrate and little vegetative cover, banks with fine substrate and some surface cover, stratified banks on outside meander bends, and a tall eroding bank under a tree. Eroding banks in this reach are quite tall for the size of the stream with little vegetative cover, low root density, and stratification of bank substrate. Typical eroding streambank conditions are depicted in **Figure 4-19** and sediment loading results are provided in **Table 4-12**.



Figure 4-19. Typical eroding streambank conditions in Smart Creek Reach 13-01.

4.2.8.2 SMAR 18-01-1

This reach is the unfenced section paired with fenced reach SMAR 18-01-2 upstream. This reach has 7 eroding banks and 2 bank types including slowly eroding low angle grassy banks that have been exposed to hoof shear, and actively eroding banks similar to those above but occurring on outside meander bends. Typical eroding streambank conditions are shown in **Figure 4-20** and sediment loading results are provided in **Table 4-12**.



Figure 4-20. Typical eroding streambank conditions in Smart Creek Reach 18-01-1.

4.2.8.3 SMAR 18-01-2

This reach has riparian fencing and is paired with unfenced reach SMAR 18-01-1 downstream. Only four eroding banks were recorded in this reach, including both active and slowly eroding types with good surface protection. Typical eroding streambank conditions are depicted in **Figure 4-21** and sediment loading results are provided in **Table 4-12**.



Figure 4-21. Typical eroding streambank conditions in Smart Creek Reach 18-01-2.

4.2.8.4 SMAR 21-01

This reach has 12 eroding streambanks and 3 primary bank types, including actively eroding banks with moderate angle and fine substrate, actively eroding undercut banks with gravel and cobble substrate, and slowly eroding undercut banks occurring on outside bends where banks have previously slumped. Typical eroding streambank conditions are depicted in **Figure 4-22** and sediment loading results are provided in **Table 4-12**.



Figure 4-22. Typical eroding streambank conditions in Smart Creek Reach 21-01.

Table 4-12. Sediment loading results for Smart Creek.

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Transpor-tation	Riparian Grazing	Irrigation	Natural	Other	
SMAR 13-01	Active	10	very high	10.7	20.9	50.0	0.0	29.1	0.0	40.8
	Slow	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	10	very high	10.7	20.9	50.0	0.0	29.1	0.0	40.8
SMAR 18-01-1	Active	5	moderate	6.8	0.0	100.0	0.0	0.0	0.0	2.6
	Slow	2	high	2.7	0.0	100.0	0.0	0.0	0.0	2.3
	Total	7	moderate	9.5	0.0	100.0	0.0	0.0	0.0	4.9
SMAR 18-01-2	Active	2	high	2.6	0.0	0.0	0.0	100.0	0.0	2.7
	Slow	2	moderate	1.4	0.0	0.0	0.0	100.0	0.0	0.6
	Total	4	moderate	4.0	0.0	0.0	0.0	100.0	0.0	3.3
SMAR 21-01	Active	10	high	8.9	0.0	50.0	50.0	0.0	0.0	28.6
	Slow	2	very high	0.9	0.0	50.0	50.0	0.0	0.0	0.8
	Total	12	high	9.8	0.0	50.0	50.0	0.0	0.0	29.4

4.2.9 Sediment Loading Results for Trout Creek

4.2.9.1 TROU 09-03

This reach is highly sinuous and has 10 eroding banks and 2 primary bank types, including slowly eroding undercut or near vertical banks that are well vegetated, and similar banks that have less vegetative protection that typically occur on outside meander bends with invasive plant species. Typical eroding streambank conditions are depicted in **Figure 4-23** and sediment loading results are provided in **Table 4-13**.



Figure 4-23. Typical eroding streambank conditions in Trout Creek Reach 09-03.

4.2.9.2 TROU 10-01

This reach has only two eroding streambanks which are actively eroding, near vertical, and have little surface protection. Typical eroding streambank conditions are depicted in **Figure 4-24** and sediment loading results are provided in **Table 4-13**.



Figure 4-24. Typical eroding streambank conditions in Trout Creek Reach 10-01.

Table 4-13. Sediment loading results for Trout Creek.

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Transpor-tation	Riparian Grazing	Irrigation	Natural	Other	
TROU 09-03	Active	5	high	5.4	0.0	81.5	0.0	18.5	0.0	3.9
	Slow	5	high	3.0	0.0	16.0	0.0	84.0	0.0	2.3
	Total	10	high	8.4	0.0	57.6	0.0	42.4	0.0	6.2
TROU 10-01	Active	2	high	4.0	0.0	70.0	30.0	0.0	0.0	7.6
	Slow	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	2	high	4.0	0.0	70.0	30.0	0.0	0.0	7.6

4.3 Sediment Loading Results by Reach Type

The following sections provide sediment loading results organized by reach type. Data provided includes sediment load per 1000 feet for each bank type (active, slow and total) and the dominant influence (anthropogenic or natural). If <75% of the bank erosion-influenced load was attributed to natural sources, the load is considered to be anthropogenically influenced.

4.3.1 Sediment Loading Results for Reach Type MR-0-2-U

Five sites were sampled of reach type MR-0-2-U. This reach type is in the Middle Rockies Ecoregion, has low valley slope (<2%), and includes 2nd order streams within unconfined valleys. Loading results are provided below in **Table 4-14**.

Table 4-14. Sediment loading results for reach type MR-0-2-U.

Reach ID	Sediment Load per 1000 ft (tons/year)			Dominant Influence	
	Active	Slow	Total	Anthropogenic	Natural
DOUN 08-02	19.2	4.1	23.3	X	
FRED 29-02	11.7	16.9	28.6	X	
SMAR 18-01-1	2.6	2.3	4.9	X	
SMAR 18-01-2	2.7	0.6	3.3		X
SMAR 21-01	28.6	0.8	29.4	X	
Reach Type Average	13.0	4.9	17.9	21.5	3.3

4.3.2 Sediment Loading Results for Reach Type MR-0-3-U

Six reaches were sampled of reach type MR-0-3-U. This reach type is in the Middle Rockies Ecoregion, has low valley slope (<2%), and includes 3rd order streams within unconfined valleys. Loading results are provided below in **Table 4-15**.

Table 4-15. Sediment loading results for reach type MR-0-3-U.

Reach ID	Sediment Load per 1000 ft (tons/year)			Dominant Influence	
	Active	Slow	Total	Anthropogenic	Natural
BARN 11-01	8.4	0.2	8.6	X	
BARN 13-01	1.8	0.7	2.6	X	
BARN 13-03	4.0	2.5	6.5		X
BOUL 21-02	0.0	10.3	10.3		X
FLIN 09-02	3.2	0.7	3.9	X	
TROU 09-03	3.9	2.3	6.2	X	
Reach Type Average	2.6	3.3	5.9	5.3	8.4

4.3.3 Sediment Loading Results for Reach Type MR-0-4-U

Five reaches were sampled of reach type MR-0-4-U, primarily on Flint Creek. This reach type is in the Middle Rockies Ecoregion, has low valley slope (<2%), and includes 4th order streams within unconfined valley types. Loading results are provided below in **Table 4-16**.

Table 4-16. Sediment loading results for reach type MR-0-4-U.

Reach ID	Sediment Load per 1000 ft (tons/year)			Dominant Influence	
	Active	Slow	Total	Anthropogenic	Natural
FLIN 11-01	71.4	7.4	78.8	X	
FLIN 11-04	0.0	1.4	1.4		X
FLIN 18-02	0.0	0.5	0.5		X
FLIN 18-05	2.8	2.5	5.3		X
LOWI 02-05	3.4	0.5	3.9	X	
Reach Type Average	15.5	2.5	18.0	41.3	2.4

4.3.4 Sediment Loading Results for Reach Type MR-0-5-U

One site was sampled of reach type MR-0-5-U. This reach type is in the Middle Rockies Ecoregion, has low valley slope (<2%), and includes 5th order streams within unconfined valleys. Loading results are provided below in **Table 4-17**.

Table 4-17. Sediment loading results for reach type MR-0-5-U.

Reach ID	Sediment Load per 1000 ft (tons/year)			Dominant Influence	
	Active	Slow	Total	Anthropogenic	Natural
FLIN 19-01	23.6	0.4	23.9	X	
Reach Type Average	23.6	0.4	23.9	23.9	NA

4.3.5 Sediment Loading Results for Reach Type MR-2-2-U

Four sites were sampled of reach type MR-2-2-U. This reach type is in the Middle Rockies Ecoregion, has moderate valley slope (2-4%), and includes 2nd order streams within unconfined valley types. Loading results are provided below in **Table 4-18**.

Table 4-18. Sediment loading results for reach type MR-2-2-U.

Reach ID	Sediment Load per 1000 ft (tons/year)			Dominant Influence	
	Active	Slow	Total	Anthropogenic	Natural
DOUN 07-01	4.3	8.8	13.1	X	
DOUS 19-02	0.0	16.1	16.1	X	
FLIN 06-01	6.7	4.9	11.6	X	

Table 4-18. Sediment loading results for reach type MR-2-2-U.					
Reach ID	Sediment Load per 1000 ft (tons/year)			Dominant Influence	
	Active	Slow	Total	Anthropogenic	Natural
SMAR 13-01	40.8	0.0	40.8	X	
Reach Type Average	12.9	7.5	20.4	20.4	NA

4.3.6 Sediment Loading Results for Reach Type MR-2-3-U

Two sites were sampled of reach type MR-2-3-U. This reach type is in the Middle Rockies Ecoregion, has moderate valley slope (2-4%), and includes 3rd order streams within unconfined valley types. Loading results are provided below in **Table 4-19**.

Table 4-19. Sediment loading results for reach type MR-2-3-U.					
Reach ID	Sediment Load per 1000 ft (tons/year)			Dominant Influence	
	Active	Slow	Total	Anthropogenic	Natural
BOUL 16-01	0.0	0.4	0.4		X
TROU 10-01	7.6	0.0	7.6	X	
Reach Type Average	3.8	0.2	4.0	7.6	0.4

4.3.7 Sediment Loading Results for Reach Type MR-2-4-U

One reach was sampled of reach type MR-2-4-U. This reach type is in the Middle Rockies Ecoregion, has moderate valley slope (2-4%), and includes 4th order streams within unconfined valley types. Loading results are provided below in **Table 4-20**.

Table 4-20. Sediment loading results for reach type MR-2-4-U.					
Reach ID	Sediment Load per 1000 ft (tons/year)			Dominant Influence	
	Active	Slow	Total	Anthropogenic	Natural
FLIN 17-01	0.0	0.8	0.8		X
Reach Type Average	0.0	0.8	0.8	NA	0.8

4.3.8 Summarized Loading Results for All Reaches

Table 4-21. Summarized BEHI sediment loads for all reaches.

Erosion Source	Sediment Load per 1000 Feet		
	Active	Slow	Total
Predominantly Anthropogenic Average Load	14.8	4.1	18.9
Predominantly Natural Average Load	1.2	2.4	3.6
Total Average Load	10.3	3.5	13.8

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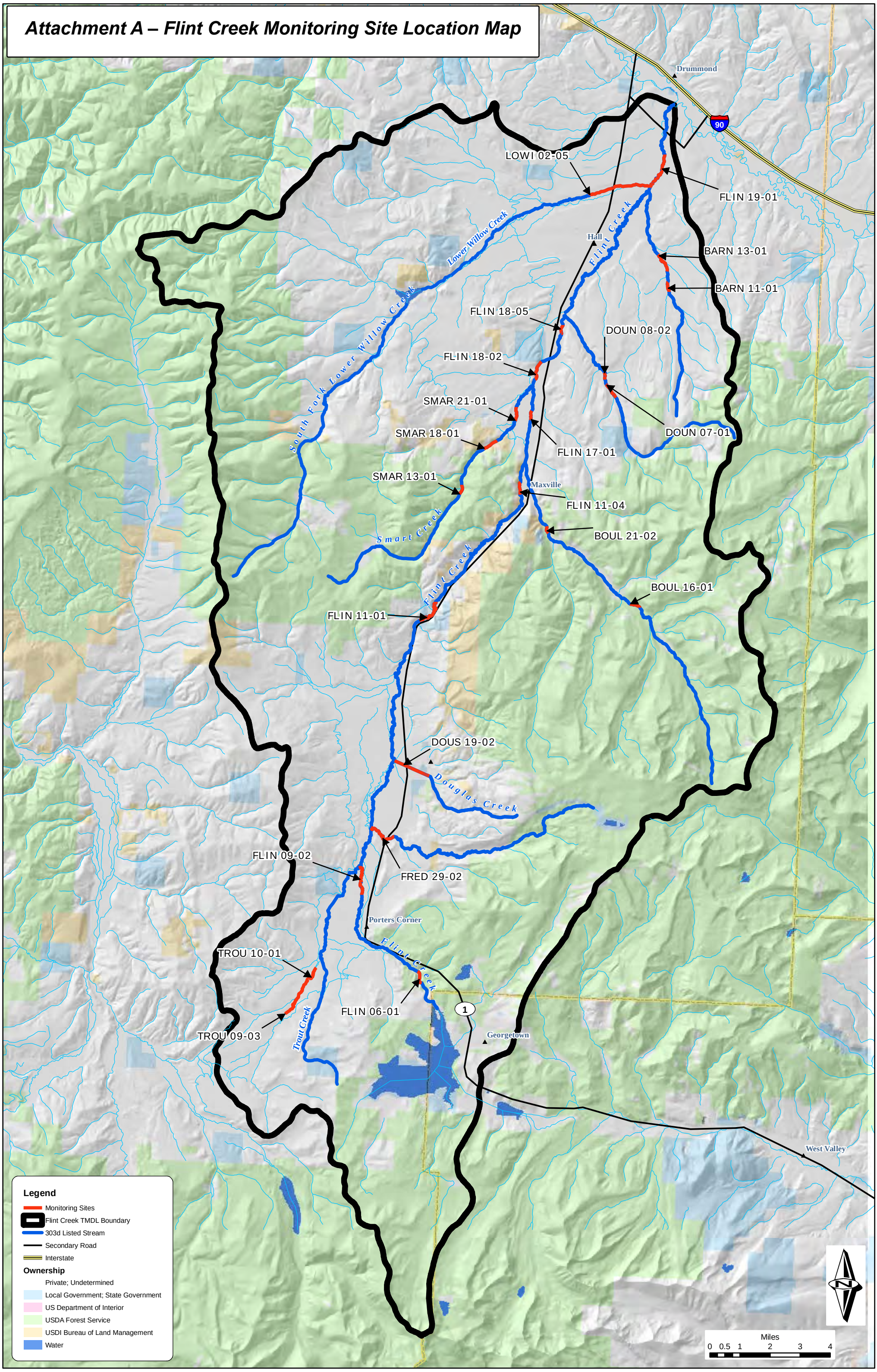
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ATTACHMENT A – Flint Creek Monitoring Site Location Map

Attachment A – Flint Creek Monitoring Site Location Map



ATTACHMENT B – Field Data Sheets

Aerial Stratification Data														
Stream	Reach	Reach ID	Primary Ecoregion	Secondary Ecoregion	Strahler Stream Order	Confinement	Gradient	Reach Type	Break Trigger	Break Trigger Comments	Dominant Land Use	Left Bank Vegetation	Right Bank Vegetation	Length (feet)
Barnes Creek	11-1	BARN 11-01	17ak	17am	3	U	<2	MR-0-3-U	stream order	ag land	confined livestock	shrubs	shrubs	1845
Barnes Creek	13-1	BARN 13-01	17ak	17am	3	U	<2	MR-0-3-U	gradient		rural residence	grass	grass	3884
Barnes Creek	13-3	BARN 13-03	17ak	17am	3	U	<2	MR-0-3-U	rip veg/land use	ag land	hay	grass	grass	8179
Boulder Creek	16-1	BOUL 16-01	17am		3	U	2-<4	MR-2-3-U	gradient		forest	mature coniferous	mature coniferous	2489
Boulder Creek	21-2	BOUL 21-02	17am		3	U	<2	MR-0-3-U	land use	residential start	rural residence	mature coniferous	mature coniferous	1328
Douglas Creek (north)	7-1	DOUN 07-01	17ak	17am	2	U	2-<4	MR-2-2-U	gradient		range	shrubs	shrubs	3018
Douglas Creek (north)	8-2	DOUN 08-02	17ak	17am	2	U	<2	MR-0-2-U	land use	irrigation	range	bare	bare	1245
Douglas Creek (south)	19-2	DOUS 19-02	17ak	17am	2	U	2-<4	MR-2-2-U	land use	ditch begins	urban	bare	bare	6618
Flint Creek	6-1	FLIN 06-01	17am		2	U	2-<4	MR-2-2-U	gradient		rural residence	shrubs	mature coniferous	2435
Flint Creek	9-2	FLIN 09-02	17ak	17am	3	U	<2	MR-0-3-U	land use	ag land	hay	grass	grass	5986
Flint Creek	11-1	FLIN 11-01	17am	17ak-17am	4	U	<2	MR-0-4-U	ecoregion		hay	grass	grass	6486
Flint Creek	11-4	FLIN 11-04	17am	17ak-17am	4	U	<2	MR-0-4-U	ecoregion		mine	bare	mature coniferous	2280
Flint Creek	17-1	FLIN 17-01	17ak	17am-17ak-17am	4	U	2-<4	MR-2-4-U	gradient		hay	shrubs	shrubs	1715
Flint Creek	18-2	FLIN 18-02	17ak	17am-17ak-17am	4	U	<2	MR-0-4-U	land use	cropland	hay	shrubs	shrubs	3677
Flint Creek	18-5	FLIN 18-05	17ak	17am-17ak-17am	4	U	<2	MR-0-4-U	land use	begin ranch	rural residence	grass	shrubs	1642
Flint Creek	19-1	FLIN 19-01	17ak	17am-17ak-17am	5	U	<2	MR-0-5-U	stream order		hay	grass	grass	7032
Fred Burr Creek	29-2	FRED 29-02	17ak	17am	2	U	<2	MR-0-2-U	rip veg/land use	ranch ends	hay	grass	grass	6195
Lower Willow Creek	2-5	LOWI 02-05	17ak	17x	4	U	<2	MR-0-4-U	riparian veg		hay	grass	grass	11417
Smart Creek	13-1	SMAR 13-01	17am	17x	2	U	2-<4	MR-2-2-U	confinement		forest	mature coniferous	mature coniferous	1864
Smart Creek	18-1	SMAR 18-01-1	17ak	17am-17x	2	U	<2	MR-0-2-U	gradient		forest	shrubs	mature coniferous	2741
Smart Creek	18-1	SMAR 18-01-2	17ak	17am-17x	2	U	<2	MR-0-2-U	gradient		forest	shrubs	mature coniferous	2741
Smart Creek	21-2	SMAR 21-02	17ak	17am-17x	2	U	<2	MR-0-2-U	land use	end crop land	hay	grass	grass	5352
Trout Creek	9-3	TROU 09-03	17ak	17am	3	U	<2	MR-0-3-U	land use	irrigation	range	grass	grass	8924
Trout Creek	10-1	TROU 10-01	17ak	17am	3	U	2-<4	MR-2-3-U	gradient		hay	grass	grass	2021

Site Information												
Stream	**Reach ID**	**Date**	**Reach Type**	**Existing Stream Type**	**Estimated Potential Stream Type**	**Downstream End Latitude**	**Downstream End Longitude**	**Upstream End Latitude**	**Upstream End Longitude**	**Site Length (Feet)**	**Field Slope (Percent)**	**Calculated Sinuosity**
Barnes Creek	BARN 11-01	09/08/09	MR-0-3-U	C4	C4	46.56731	-113.14476	46.56527	-113.14401	1000	1.8	1.3
Barnes Creek	BARN 13-01	09/09/09	MR-0-3-U	E4	E4	46.57840	-113.14911	46.57780	-113.14722	1000	1.5	1.9
Barnes Creek	BARN 13-03	09/08/09	MR-0-3-U	B4c	E4	46.59338	-113.16063	46.59129	-113.16000	1000	1.0	1.3
Boulder Creek	BOUL 16-01	09/15/09	MR-2-3-U	C3b	B3	46.41268	-113.15819	46.41204	-113.15488	1000	3.5	1.2
Boulder Creek	BOUL 21-02	09/15/09	MR-0-3-U	C3	B3	46.44856	-113.22076	46.44657	-113.22074	1000	1.6	1.4
Douglas Creek (north)	DOUN 07-01	09/11/09	MR-2-2-U	B4	B4	46.51684	-113.18282	46.51361	-113.17968	1000	2.8	1.0
Douglas Creek (north)	DOUN 08-02	09/14/09	MR-0-2-U	C4	C4	46.52017	-113.18610	46.51849	-113.18466	1000	1.5	1.4
Douglas Creek (south)	DOUS 19-02	09/16/09	MR-2-2-U	E4	E4	46.32859	-113.30053	46.32802	-113.29893	500	2.2	1.1
Flint Creek	FLIN 06-01	09/16/09	MR-2-2-U	C3b	B3	46.23042	-113.29404	46.22783	-113.29433	1000	2.3	1.1
Flint Creek	FLIN 09-02	09/16/09	MR-0-3-U	C4	C4	46.26886	-113.33697	46.26654	-113.33646	1000	1.5	1.2
Flint Creek	FLIN 11-01	09/14/09	MR-0-4-U	C4	C4	46.40148	-113.30263	46.40034	-113.30396	1000	1.0	1.9
Flint Creek	FLIN 11-04	09/14/09	MR-0-4-U	C3b	C3b	46.46990	-113.23986	46.46761	-113.24050	1000	2.5	1.2
Flint Creek	FLIN 17-01	09/11/09	MR-2-4-U	C3b	C3b	46.50417	-113.23433	46.50194	-113.23571	1000	3.2	1.1
Flint Creek	FLIN 18-02	09/11/09	MR-0-4-U	B3c	B3c	46.52206	-113.23361	46.51980	-113.23251	1000	1.6	1.2
Flint Creek	FLIN 18-05	09/09/09	MR-0-4-U	C3	B3c	46.54589	-113.21600	46.54367	-113.21794	1000	1.1	1.1
Flint Creek	FLIN 19-01	09/09/09	MR-0-5-U	C4	C4	46.62829	-113.15137	46.62461	-113.15215	1500	1.1	1.1
Fred Burr Creek	FRED 29-02	09/16/09	MR-0-2-U	F4	C4	46.29488	-113.31992	46.29553	-113.31689	1000	1.4	1.3
Lower Willow Creek	LOWI 02-05	09/15/09	MR-0-4-U	C3	C3	46.61448	-113.17083	46.61391	-113.17430	1000	1.5	1.1
Smart Creek	SMAR 13-01	09/10/09	MR-2-2-U	B4	B4	46.46451	-113.27998	46.46271	-113.28158	1000	2.1	1.3
Smart Creek	SMAR 18-01-1	09/10/09	MR-0-2-U	C4b	B4	46.48538	-113.26367	46.48472	-113.26499	500	2.0	1.2
Smart Creek	SMAR 18-01-2	09/10/09	MR-0-2-U	B4	B4	46.48484	-113.26503	46.48421	-113.26663	500	1.7	1.1
Smart Creek	SMAR 21-01	09/10/09	MR-0-2-U	F4	E4	46.50000	-113.24517	46.49809	-113.24619	1000	1.6	1.3
Trout Creek	TROU 09-03	09/17/09	MR-0-3-U	E4	E4	46.21495	-113.37883	46.21347	-113.38013	1000	1.1	1.6
Trout Creek	TROU 10-01	09/17/09	MR-2-3-U	C4	C4	46.22948	-113.36731	46.22765	-113.36763	1000	1.3	1.5

Channel Cross Section Data													
Reach ID	Date	Reach Type	Cell	Latitude	Longitude	Feature	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio
BARN 11-01	09/08/09	MR-0-3-U	1	46.56734	-113.14473	riffle	14.8	7.6	0.5	28.7	1.2	32.8	2.2
BARN 11-01	09/08/09	MR-0-3-U	2	46.56600	-113.14462	riffle	15.6	7.5	0.5	32.6	1.3	53.6	3.4
BARN 11-01	09/08/09	MR-0-3-U	3	46.56607	-113.14449	riffle	14.0	8.5	0.6	23.0	1.3	40.0	2.9
BARN 11-01	09/08/09	MR-0-3-U	4	46.56611	-113.14430	riffle	10.8	5.6	0.5	20.8	1.0	88.8	8.2
BARN 11-01	09/08/09	MR-0-3-U	5	46.56539	-113.14423	riffle	9.2	8.5	0.9	9.9	1.1	34.2	3.7
BARN 13-01	09/09/09	MR-0-3-U	1	46.57839	-113.14915	riffle	6.9	8.3	1.2	5.8	1.5	131.9	19.1
BARN 13-01	09/09/09	MR-0-3-U	2	46.57819	-113.14894	riffle	5.2	5.7	1.1	4.8	1.7	255.2	49.1
BARN 13-01	09/09/09	MR-0-3-U	3	46.57833	-113.14811	riffle	6.0	5.3	0.9	6.8	1.8	212.0	35.3
BARN 13-01	09/09/09	MR-0-3-U	4	46.57786	-113.14764	riffle	6.5	7.1	1.1	6.0	1.6	40.5	6.2
BARN 13-01	09/09/09	MR-0-3-U	5	46.57786	-113.14727	riffle	7.8	5.4	0.7	11.4	1.7	58.8	7.5
BARN 13-03	09/08/09	MR-0-3-U	1	46.59336	-113.16065	riffle	8.9	12.2	1.4	6.5	2.0	25.9	2.9
BARN 13-03	09/08/09	MR-0-3-U	2	46.59263	-113.16093	riffle	7.0	9.5	1.4	5.1	1.9	8.5	1.2
BARN 13-03	09/08/09	MR-0-3-U	3	46.59232	-113.16074	riffle	8.5	7.1	0.8	10.1	1.7	17.0	2.0
BARN 13-03	09/08/09	MR-0-3-U	4	46.59194	-113.16041	riffle	8.9	12.1	1.4	6.6	2.0	15.9	1.8
BARN 13-03	09/08/09	MR-0-3-U	5	46.59148	-113.16008	riffle	12.4	8.5	0.7	18.1	1.4	29.4	2.4
BOUL 16-01	09/15/09	MR-2-3-U	1	46.41269	-113.15826	riffle	29.5	43.2	1.5	20.1	2.4	74.5	2.5
BOUL 16-01	09/15/09	MR-2-3-U	2	46.41241	-113.15708	riffle	24.0	39.7	1.7	14.5	2.3	48.0	2.0
BOUL 16-01	09/15/09	MR-2-3-U	3	46.41276	-113.15600	riffle	24.3	38.1	1.6	15.5	2.2	48.3	2.0
BOUL 16-01	09/15/09	MR-2-3-U	4	46.41253	-113.15585	riffle	32.6	58.3	1.8	18.2	2.3	112.6	3.5
BOUL 16-01	09/15/09	MR-2-3-U	5	46.41220	-113.15987	riffle	41.5	47.1	1.1	36.6	2.1	106.5	2.6
BOUL 21-02	09/15/09	MR-0-3-U	1	46.44841	-113.22076	riffle	36.9	58.5	1.6	23.3	2.4	69.9	1.9
BOUL 21-02	09/15/09	MR-0-3-U	2	46.44796	-113.22054	riffle	44.7	57.7	1.3	34.6	1.7	104.7	2.3
BOUL 21-02	09/15/09	MR-0-3-U	3	46.44754	-113.22009	riffle	36.0	47.5	1.3	27.3	2.5	140.0	3.9
BOUL 21-02	09/15/09	MR-0-3-U	4	46.44706	-113.22075	riffle	33.5	51.9	1.5	21.6	2.2	186.5	5.6
BOUL 21-02	09/15/09	MR-0-3-U	5	46.44654	-113.22079	riffle	35.0	53.7	1.5	22.8	2.2	215.0	6.1
DOUN 07-01	09/11/09	MR-2-2-U	1	46.51570	-113.18127	riffle	12.8	14.1	1.1	11.6	1.5	32.8	2.6
DOUN 07-01	09/11/09	MR-2-2-U	2	46.51505	-113.18091	riffle	14.0	14.1	1.0	13.9	1.8	23.0	1.6
DOUN 07-01	09/11/09	MR-2-2-U	3	46.51470	-113.18072	riffle	12.3	12.6	1.0	12.0	1.3	26.3	2.1
DOUN 07-01	09/11/09	MR-2-2-U	4	46.51411	-113.18022	riffle	12.4	13.3	1.1	11.5	1.3	17.4	1.4
DOUN 07-01	09/11/09	MR-2-2-U	5	46.51386	-113.18011	riffle	13.0	13.7	1.1	12.4	1.4	29.0	2.2
DOUN 08-02	09/14/09	MR-0-2-U	1	46.52011	-113.18613	riffle	20.9	23.3	1.1	18.8	1.7	48.9	2.3
DOUN 08-02	09/14/09	MR-0-2-U	2	46.51990	-113.18544	riffle	10.9	12.5	1.1	9.5	1.7	20.9	1.9
DOUN 08-02	09/14/09	MR-0-2-U	3	46.51977	-113.18478	riffle	20.0	20.3	1.0	19.7	1.5	50.0	2.5
DOUN 08-02	09/14/09	MR-0-2-U	4	46.51925	-113.18446	riffle	13.5	14.6	1.1	12.4	1.7	29.5	2.2
DOUN 08-02	09/14/09	MR-0-2-U	5	46.51855	-113.18473	riffle	11.8	11.5	1.0	12.1	2.1	39.3	3.3
DOUS 19-02	09/16/09	MR-2-2-U	1	46.32858	-113.30047	riffle	3.0	3.6	1.2	2.5	1.4	53.0	17.7
DOUS 19-02	09/16/09	MR-2-2-U	2	46.32846	-113.30004	riffle	5.8	5.6	1.0	6.0	1.4	6.8	1.2
DOUS 19-02	09/16/09	MR-2-2-U	3	46.32827	-113.29931	riffle	3.8	5.4	1.4	2.7	1.7	8.8	2.3
DOUS 19-02	09/16/09	MR-2-2-U	4	46.32816	-113.29924	riffle	5.8	4.6	0.8	7.4	1.7	13.8	2.4
DOUS 19-02	09/16/09	MR-2-2-U	5	46.32809	-113.29910	riffle	2.5	3.2	1.3	2.0	1.5	12.5	5.0
FLIN 06-01	09/16/09	MR-2-2-U	1	46.23037	-113.29398	riffle	17.8	33.2	1.9	9.6	2.5	172.8	9.7
FLIN 06-01	09/16/09	MR-2-2-U	2	46.22964	-113.29397	riffle	23.8	34.7	1.5	16.3	2.3	248.8	10.5
FLIN 06-01	09/16/09	MR-2-2-U	3	46.22927	-113.29392	riffle	21.6	33.3	1.5	14.0	2.3	104.6	4.8
FLIN 06-01	09/16/09	MR-2-2-U	4	46.22874	-113.29396	riffle	29.2	42.4	1.5	20.1	2.3	299.2	10.2
FLIN 09-02	09/16/09	MR-0-3-U	1	46.26858	-113.33695	riffle	42.2	37.8	0.9	47.1	1.9	252.2	6.0
FLIN 09-02	09/16/09	MR-0-3-U	2	46.26808	-113.33704	riffle	23.0	25.9	1.1	20.4	2.0	188.0	8.2
FLIN 09-02	09/16/09	MR-0-3-U	3	46.26783	-113.33727	riffle	36.6	42.1	1.2	31.8	1.9	188.6	5.2
FLIN 09-02	09/16/09	MR-0-3-U	4	46.26730	-113.33716	riffle	30.0	33.9	1.1	26.5	1.7	189.0	6.3
FLIN 09-02	09/16/09	MR-0-3-U	5	46.26689	-113.33681	riffle	40.5	37.1	0.9	44.2	1.8	200.5	5.0
FLIN 11-01	09/14/09	MR-0-4-U	1	46.40149	-113.30267	riffle	38.4	66.0	1.7	22.3	2.7	313.4	8.2
FLIN 11-01	09/14/09	MR-0-4-U	2	46.40145	-113.30346	riffle	40.7	85.7	2.1	19.3	2.7	115.7	2.8
FLIN 11-01	09/14/09	MR-0-4-U	3	46.40105	-113.30309	riffle	36.8	70.1	1.9	19.3	2.4	82.8	2.3
FLIN 11-01	09/14/09	MR-0-4-U	5	46.40041	-113.30389	riffle	44.0	91.3	2.1	21.2	2.6	149.0	3.4
FLIN 11-04	09/14/09	MR-0-4-U	1	46.46981	-113.23981	riffle	49.5	119.3	2.4	20.5	4.0	125.5	2.5
FLIN 11-04	09/14/09	MR-0-4-U	2	46.46929	-113.23988	riffle	57.5	104.7	1.8	31.6	3.2	87.5	1.5
FLIN 11-04	09/14/09	MR-0-4-U	3	46.46866	-113.24037	riffle	49.0	100.7	2.1	23.8	3.4	111.0	2.3
FLIN 17-01	09/11/09	MR-2-4-U	1	46.50414	-113.23422	riffle	52.1	103.9	2.0	26.1	3.1	130.1	2.5
FLIN 17-01	09/11/09	MR-2-4-U	2	46.50354	-113.23512	riffle	84.0	138.2	1.6	51.1	2.7	114.0	1.4
FLIN 17-01	09/11/09	MR-2-4-U	5	46.50232	-113.23582	riffle	52.6	108.9	2.1	25.4	3.3	109.6	2.1
FLIN 18-02	09/11/09	MR-0-4-U	1	46.52201	-113.23360	riffle	60.6	118.5	2.0	31.0	3.0	96.6	1.6
FLIN 18-02	09/11/09	MR-0-4-U	3	46.52100	-113.23338	riffle	61.3	130.3	2.1	28.8	2.8	156.3	2.5
FLIN 18-02	09/11/09	MR-0-4-U	4	46.52058	-113.23278	riffle	55.4	114.0	2.1	26.9	2.8	93.4	1.7
FLIN 18-02	09/11/09	MR-0-4-U	5	46.52004	-113.23255	riffle	50.7	109.1	2.2	23.6	2.7	88.7	1.7
FLIN 18-05	09/09/09	MR-0-4-U	1	46.54572	-113.21595	riffle	60.0	98.4	1.6	36.6	2.6	180.0	3.0
FLIN 18-05	09/09/09	MR-0-4-U	2	46.54515	-113.21636	riffle	46.2	80.2	1.7	26.6	2.4	66.2	1.4
FLIN 18-05	09/09/09	MR-0-4-U	3	46.54465	-113.21709	riffle	49.0	86.7	1.8	27.7	2.4	112.0	2.3
FLIN 18-05	09/09/09	MR-0-4-U	4	46.54406	-113.21742	riffle	47.2	82.6	1.8	27.0	2.5	80.2	1.7
FLIN 18-05	09/09/09	MR-0-4-U	5	46.54364	-113.21788	riffle	43.6	72.3	1.7	26.3	2.4	303.6	7.0

Channel Cross Section Data													
Reach ID	Date	Reach Type	Cell	Latitude	Longitude	Feature	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio
FLIN 19-01	09/09/09	MR-0-5-U	1	46.62816	-113.15131	riffle	54.6	87.6	1.6	34.0	2.0	290.6	5.3
FLIN 19-01	09/09/09	MR-0-5-U	2	46.62698	-113.15106	riffle	55.0	96.8	1.8	31.3	2.5	276.0	5.0
FLIN 19-01	09/09/09	MR-0-5-U	3	46.62601	-113.15095	riffle	48.7	78.7	1.6	30.1	2.4	188.7	3.9
FLIN 19-01	09/09/09	MR-0-5-U	4	46.62514	113.15154	riffle	42.5	75.4	1.8	24.0	2.7	79.5	1.9
FLIN 19-01	09/09/09	MR-0-5-U	5	46.62477	-113.15192	riffle	53.1	77.1	1.5	36.6	2.2	70.6	1.3
FRED 29-02	09/16/09	MR-0-2-U	1	46.29480	-113.31979	riffle	18.0	16.8	0.9	19.3	1.2	23.2	1.3
FRED 29-02	09/16/09	MR-0-2-U	2	46.29482	-113.31919	riffle	17.5	16.1	0.9	19.0	1.3	32.7	1.9
FRED 29-02	09/16/09	MR-0-2-U	3	46.29502	-113.31826	riffle	16.5	11.9	0.7	23.0	1.4	21.0	1.3
FRED 29-02	09/16/09	MR-0-2-U	4	46.29516	-113.31755	riffle	17.2	16.8	1.0	17.7	1.3	22.2	1.3
FRED 29-02	09/16/09	MR-0-2-U	5	46.29543	-113.31713	riffle	16.8	15.1	0.9	18.7	1.4	24.2	1.4
LOWI 02-05	09/15/09	MR-0-4-U	1	46.61455	-113.17088	riffle	21.4	27.3	1.3	16.8	1.9	191.4	8.9
LOWI 02-05	09/15/09	MR-0-4-U	2	46.61412	-113.17213	riffle	27.0	35.1	1.3	20.8	2.1	162.0	6.0
LOWI 02-05	09/15/09	MR-0-4-U	3	46.61399	-113.17240	riffle	18.8	28.1	1.5	12.6	2.2	153.8	8.2
LOWI 02-05	09/15/09	MR-0-4-U	4	46.61397	-113.17320	riffle	49.0	39.7	0.8	60.5	1.6	219.0	4.5
LOWI 02-05	09/15/09	MR-0-4-U	5	46.61404	-113.17370	riffle	37.0	40.5	1.1	33.8	1.9	199.0	5.4
SMAR 13-01	09/10/09	MR-2-2-U	1	46.46448	-113.27997	riffle	12.5	5.6	0.5	27.8	0.9	24.0	1.9
SMAR 13-01	09/10/09	MR-2-2-U	2	46.46391	-113.28060	riffle	7.6	4.8	0.6	12.0	0.9	11.6	1.5
SMAR 13-01	09/10/09	MR-2-2-U	3	46.46344	-113.28075	riffle	9.0	5.2	0.6	15.5	0.9	17.0	1.9
SMAR 13-01	09/10/09	MR-2-2-U	4	46.46305	-113.28107	riffle	9.0	6.8	0.8	12.0	1.3	19.0	2.1
SMAR 13-01	09/10/09	MR-2-2-U	5	46.46278	-113.28162	riffle	6.6	4.0	0.6	10.8	0.9	18.0	2.7
SMAR 18-01-1	09/10/09	MR-0-2-U	1	46.48533	-113.26371	riffle	12.7	7.1	0.6	22.9	1.2	82.7	6.5
SMAR 18-01-1	09/10/09	MR-0-2-U	2	46.48513	-113.26399	riffle	13.7	9.0	0.7	20.8	1.3	88.7	6.5
SMAR 18-01-1	09/10/09	MR-0-2-U	3	46.48488	-113.26447	riffle	20.0	10.9	0.5	36.6	1.1	117.0	5.9
SMAR 18-01-1	09/10/09	MR-0-2-U	4	46.48498	-113.26456	riffle	7.5	8.8	1.2	6.4	1.5	182.5	24.3
SMAR 18-01-1	09/10/09	MR-0-2-U	5	46.48487	-113.26489	riffle	15.0	10.5	0.7	21.4	1.0	150.0	10.0
SMAR 18-01-2	09/10/09	MR-0-2-U	1	46.48479	-113.26529	riffle	7.8	6.0	0.8	10.1	1.1	15.8	2.0
SMAR 18-01-2	09/10/09	MR-0-2-U	2	46.48469	-113.26555	riffle	9.6	6.7	0.7	13.8	1.2	18.1	1.9
SMAR 18-01-2	09/10/09	MR-0-2-U	3	46.48466	-113.26584	riffle	8.0	5.6	0.7	11.4	1.1	16.5	2.1
SMAR 18-01-2	09/10/09	MR-0-2-U	4	46.48450	-113.26596	riffle	8.0	5.9	0.7	10.8	1.1	15.0	1.9
SMAR 21-01	09/10/09	MR-0-2-U	1	46.49998	-113.24517	riffle	6.5	3.7	0.6	11.4	1.4	12.5	1.9
SMAR 21-01	09/10/09	MR-0-2-U	2	46.49923	-113.24541	riffle	6.5	5.2	0.8	8.2	1.4	10.5	1.6
SMAR 21-01	09/10/09	MR-0-2-U	3	46.49877	-113.24541	riffle	6.0	4.6	0.8	7.9	1.3	10.5	1.8
SMAR 21-01	09/10/09	MR-0-2-U	4	46.49839	-113.24567	riffle	5.1	4.3	0.8	6.0	1.3	10.1	2.0
SMAR 21-01	09/10/09	MR-0-2-U	5	46.49813	-113.24606	riffle	10.6	5.6	0.5	20.1	1.0	13.1	1.2
TROU 09-03	09/17/09	MR-0-3-U	1	46.21471	-113.37885	riffle	24.0	28.8	1.2	20.0	1.7	219.0	9.1
TROU 09-03	09/17/09	MR-0-3-U	2	46.21432	-113.37905	riffle	26.0	30.2	1.2	22.4	1.7	246.0	9.5
TROU 09-03	09/17/09	MR-0-3-U	3	46.21404	-113.37909	riffle	24.0	28.1	1.2	20.5	1.9	254.0	10.6
TROU 09-03	09/17/09	MR-0-3-U	4	46.21359	-113.37934	riffle	18.0	27.3	1.5	11.9	1.8	172.0	9.6
TROU 09-03	09/17/09	MR-0-3-U	5	46.21354	-113.37979	riffle	18.0	23.6	1.3	13.7	1.7	173.0	9.6
TROU 10-01	09/17/09	MR-2-3-U	1	46.22899	-113.36753	riffle	18.2	21.8	1.2	15.2	1.9	113.2	6.2
TROU 10-01	09/17/09	MR-2-3-U	2	46.22890	-113.36768	riffle	31.0	32.2	1.0	29.8	1.6	113.0	3.6
TROU 10-01	09/17/09	MR-2-3-U	3	46.22858	-113.36716	riffle	17.6	22.8	1.3	13.6	1.5	101.6	5.8
TROU 10-01	09/17/09	MR-2-3-U	4	46.22828	-113.36725	riffle	19.5	28.2	1.4	13.5	1.9	74.5	3.8
TROU 10-01	09/17/09	MR-2-3-U	5	46.22773	-113.36740	riffle	23.0	28.5	1.2	18.5	1.9	108.0	4.7

Riffle Substrate Data								
Reach ID	**Date**	**Reach Type**	**Cell**	**Riffle Pebble Count D50**	**Riffle Pebble Count Percent <2mm**	**Riffle Pebble Count Percent <6mm**	**Riffle Grid Toss Percent <6mm**	**Riffle Stability Index**
BARN 11-01	09/08/09	MR-0-3-U	1	5	30	61	69	
BARN 11-01	09/08/09	MR-0-3-U	3	7	33	42	40	
BARN 11-01	09/08/09	MR-0-3-U	5	8	23	32	77	
BARN 13-01	09/09/09	MR-0-3-U	1	7	6	32	25	
BARN 13-01	09/09/09	MR-0-3-U	3	10	15	32	24	
BARN 13-01	09/09/09	MR-0-3-U	5	10	26	35	26	
BARN 13-03	09/08/09	MR-0-3-U	1	9	26	35	63	
BARN 13-03	09/08/09	MR-0-3-U	3	11	7	12	16	
BARN 13-03	09/08/09	MR-0-3-U	5	8	19	32	44	
BOUL 16-01	09/15/09	MR-2-3-U	1	90	2	4	1	
BOUL 16-01	09/15/09	MR-2-3-U	3	110	3	4	2	
BOUL 16-01	09/15/09	MR-2-3-U	5	130	3	4	3	
BOUL 21-02	09/15/09	MR-0-3-U	1	55	10	12	7	
BOUL 21-02	09/15/09	MR-0-3-U	3	90	1	3	2	
BOUL 21-02	09/15/09	MR-0-3-U	5	80	1	2	5	
DOUN 07-01	09/11/09	MR-2-2-U	1	26	13	18	6	
DOUN 07-01	09/11/09	MR-2-2-U	3	21	9	13	13	
DOUN 07-01	09/11/09	MR-2-2-U	5	28	9	14	6	
DOUN 08-02	09/14/09	MR-0-2-U	1	15	17	21	20	
DOUN 08-02	09/14/09	MR-0-2-U	3	17	8	21	7	
DOUN 08-02	09/14/09	MR-0-2-U	5	20	12	17	10	
DOUS 19-02	09/16/09	MR-2-2-U	1	4	37	63	44	
DOUS 19-02	09/16/09	MR-2-2-U	4	2	48	88	92	
DOUS 19-02	09/16/09	MR-2-2-U	5	11	32	39	2	
FLIN 06-01	09/16/09	MR-2-2-U	1	65	0	3	0	
FLIN 06-01	09/16/09	MR-2-2-U	3	70	2	5	1	
FLIN 06-01	09/16/09	MR-2-2-U	4	65	1	3	1	
FLIN 09-02	09/16/09	MR-0-3-U	1	23	8	19	2	
FLIN 09-02	09/16/09	MR-0-3-U	3	38	7	9	1	
FLIN 09-02	09/16/09	MR-0-3-U	5	55	6	8	0	
FLIN 11-01	09/14/09	MR-0-4-U	1	40	9	11	3	
FLIN 11-01	09/14/09	MR-0-4-U	3	38	9	11	3	
FLIN 11-01	09/14/09	MR-0-4-U	5	23	17	20	29	
FLIN 11-04	09/14/09	MR-0-4-U	1	240	8	14	0	
FLIN 11-04	09/14/09	MR-0-4-U	3	88	8	11	0	
FLIN 17-01	09/11/09	MR-2-4-U	1	170	2	3	0	
FLIN 17-01	09/11/09	MR-2-4-U	3	126	3	7		
FLIN 17-01	09/11/09	MR-2-4-U	5	115	3	7		
FLIN 18-02	09/11/09	MR-0-4-U	1	115	6	8	6	
FLIN 18-02	09/11/09	MR-0-4-U	3	59	6	18	3	
FLIN 18-02	09/11/09	MR-0-4-U	5	68	10	16	7	
FLIN 18-05	09/09/09	MR-0-4-U	1	64	2	2	9	
FLIN 18-05	09/09/09	MR-0-4-U	3	98	6	10	3	
FLIN 18-05	09/09/09	MR-0-4-U	5	105	2	6	3	
FLIN 19-01	09/09/09	MR-0-5-U	1	38	3	4	2	37
FLIN 19-01	09/09/09	MR-0-5-U	3	64	4	8	4	
FLIN 19-01	09/09/09	MR-0-5-U	5	42	5	16	10	

Riffle Substrate Data								
Reach ID	**Date**	**Reach Type**	**Cell**	**Riffle Pebble Count D50**	**Riffle Pebble Count Percent <2mm**	**Riffle Pebble Count Percent <6mm**	**Riffle Grid Toss Percent <6mm**	**Riffle Stability Index**
FRED 29-02	09/16/09	MR-0-2-U	1	63	7	12	1	71
FRED 29-02	09/16/09	MR-0-2-U	3	50	23	40	22	70
FRED 29-02	09/16/09	MR-0-2-U	5	86	11	17	5	
LOWI 02-05	09/15/09	MR-0-4-U	1	64	2	2	4	
LOWI 02-05	09/15/09	MR-0-4-U	3	64	3	3	2	
LOWI 02-05	09/15/09	MR-0-4-U	5	50	7	8	0	
SMAR 13-01	09/10/09	MR-2-2-U	1	20	3	5	5	88
SMAR 13-01	09/10/09	MR-2-2-U	3	24	5	10	3	
SMAR 13-01	09/10/09	MR-2-2-U	5	20	5	11	4	
SMAR 18-01-1	09/10/09	MR-0-2-U	1	12	7	16	10	
SMAR 18-01-1	09/10/09	MR-0-2-U	3	12	7	13	3	
SMAR 18-01-1	09/10/09	MR-0-2-U	5	15	7	12	8	
SMAR 18-01-2	09/10/09	MR-0-2-U	1	16	8	9	4	
SMAR 18-01-2	09/10/09	MR-0-2-U	3	16	5	12	7	
SMAR 18-01-2	09/10/09	MR-0-2-U	5	10	9	20	5	
SMAR 21-01	09/10/09	MR-0-2-U	1	15	13	17	10	
SMAR 21-01	09/10/09	MR-0-2-U	3	18	6	18	10	
SMAR 21-01	09/10/09	MR-0-2-U	5	13	10	19	12	
TROU 09-03	09/17/09	MR-0-3-U	1	27	3	9	2	
TROU 09-03	09/17/09	MR-0-3-U	3	30	11	11	3	
TROU 09-03	09/17/09	MR-0-3-U	5	22	15	18	0	
TROU 10-01	09/17/09	MR-2-3-U	1	49	5	13	2	
TROU 10-01	09/17/09	MR-2-3-U	3	53	6	11	4	
TROU 10-01	09/17/09	MR-2-3-U	5	33	7	14	5	

Pool and Large Woody Debris Data																
Reach ID	Date	Reach Type	Cell	Mean Residual Pool Depth	Number of Pools per 1000 Feet	Number of Individual Pieces of LWD per 1000 Feet	Number of LWD Aggregates per 1000 Feet	Total Number of LWD per 1000 Feet	Number of Pools per 500 Feet	Number of Individual Pieces of LWD per 500 Feet	Number of LWD Aggregates per 500 Feet	Total Number of LWD per 500 Feet	Number of Pools per 1500 Feet	Number of Individual Pieces of LWD per 1500 Feet	Number of LWD Aggregates per 1500 Feet	Total Number of LWD per 1500 Feet
BARN 11-01	09/08/09	MR-0-3-U	1-5	0.53	9	50	8	110								
BARN 13-01	09/09/09	MR-0-3-U	1-5	0.70	22	4	0	6								
BARN 13-03	09/08/09	MR-0-3-U	1-5	0.66	12	27	5	95								
BOUL 16-01	09/15/09	MR-2-3-U	1-5	1.06	16	22	6	47								
BOUL 21-02	09/15/09	MR-0-3-U	1-5	1.18	7	22	8	63								
DOUN 07-01	09/11/09	MR-2-2-U	1-5	0.81	22	37	12	89								
DOUN 08-02	09/14/09	MR-0-2-U	1-5	0.73	16	44	14	118								
DOUS 19-02	09/16/09	MR-2-2-U	1-5	0.63	34	0	2	40	17	0	1	20				
FLIN 06-01	09/16/09	MR-2-2-U	1-5	1.15	4	21	2	83								
FLIN 09-02	09/16/09	MR-0-3-U	1-5	1.63	6	32	5	53								
FLIN 11-01	09/14/09	MR-0-4-U	1-5	1.38	4	2	0	2								
FLIN 11-04	09/14/09	MR-0-4-U	1-5	1.08	19	16	3	28								
FLIN 17-01	09/11/09	MR-2-4-U	1-5	0.80	15	26	2	31								
FLIN 18-02	09/11/09	MR-0-4-U	1-5	1.80	7	14	10	58								
FLIN 18-05	09/09/09	MR-0-4-U	1-5	1.30	5	14	6	36								
FLIN 19-01	09/09/09	MR-0-5-U	1-5	2.16	5	9	1	11					7	13	2	17
FRED 29-02	09/16/09	MR-0-2-U	1-5	1.14	10	21	13	117								
LOWI 02-05	09/15/09	MR-0-4-U	1-5	0.88	5	1	2	8								
SMAR 13-01	09/10/09	MR-2-2-U	1-5	0.64	19	19	3	37								
SMAR 18-01-1	09/10/09	MR-0-2-U	1-5	0.72	22	40	4	120	11	20	2	60				
SMAR 18-01-2	09/10/09	MR-0-2-U	1-5	0.57	26	50	4	152	13	25	2	76				
SMAR 21-01	09/10/09	MR-0-2-U	1-5	0.59	17	4	2	11								
TROU 09-03	09/17/09	MR-0-3-U	1-5	1.45	4	0	0	0								
TROU 10-01	09/17/09	MR-2-3-U	1-5	1.25	7	0	0	0								

Fine Sediment in Pool Tail-outs						
Reach ID	**Date**	**Reach Type**	**Cell**	**Pool Grid Toss Percent <6mm**	**Spawning Gravels Present (Y or ?)**	
BARN 13-01	09/09/09	MR-0-3-U	1	52	Y	no data for BARN 11-01
BARN 13-01	09/09/09	MR-0-3-U	1	54	Y	no data for FRED 29-02
BARN 13-01	09/09/09	MR-0-3-U	1	54	Y	no data for DOUS 19-02
BARN 13-01	09/09/09	MR-0-3-U	2	13	Y	
BARN 13-01	09/09/09	MR-0-3-U	2	25	Y	
BARN 13-01	09/09/09	MR-0-3-U	4	62	Y	
BARN 13-01	09/09/09	MR-0-3-U	4	62	Y	
BARN 13-03	09/08/09	MR-0-3-U	1	25	Y	
BARN 13-03	09/08/09	MR-0-3-U	2	25	Y	
BARN 13-03	09/08/09	MR-0-3-U	4	61	Y	
BARN 13-03	09/08/09	MR-0-3-U	5	16	Y	
BOUL 16-01	09/15/09	MR-2-3-U	1	10	Y	
BOUL 16-01	09/15/09	MR-2-3-U	3	16	Y	
BOUL 21-02	09/15/09	MR-0-3-U	2	3	Y	
DOUN 07-01	09/11/09	MR-2-2-U	1	33	Y	
DOUN 07-01	09/11/09	MR-2-2-U	2	27	Y	
DOUN 07-01	09/11/09	MR-2-2-U	3	30	Y	
DOUN 07-01	09/11/09	MR-2-2-U	3	28	Y	
DOUN 07-01	09/11/09	MR-2-2-U	4	21	Y	
DOUN 07-01	09/11/09	MR-2-2-U	5	76	?	
DOUN 08-02	09/14/09	MR-0-2-U	1	24	Y	
DOUN 08-02	09/14/09	MR-0-2-U	1	49	Y	
DOUN 08-02	09/14/09	MR-0-2-U	3	33	Y	
DOUN 08-02	09/14/09	MR-0-2-U	4	20	Y	
DOUN 08-02	09/14/09	MR-0-2-U	5	9	Y	
DOUN 08-02	09/14/09	MR-0-2-U	5	39	Y	
FLIN 06-01	09/16/09	MR-2-2-U	1	1	Y	
FLIN 06-01	09/16/09	MR-2-2-U	5	1	Y	
FLIN 09-02	09/16/09	MR-0-3-U	3	1	Y	
FLIN 11-01	09/14/09	MR-0-4-U	5	16	Y	
FLIN 11-04	09/14/09	MR-0-4-U	3	22	Y	
FLIN 11-04	09/14/09	MR-0-4-U	4	8	Y	
FLIN 11-04	09/14/09	MR-0-4-U	4	5	Y	
FLIN 11-04	09/14/09	MR-0-4-U	5	3	Y	
FLIN 17-01	09/11/09	MR-2-4-U	1	4	Y	
FLIN 18-02	09/11/09	MR-0-4-U	4	7	Y	
FLIN 18-02	09/11/09	MR-0-4-U	5	7	Y	
FLIN 18-05	09/09/09	MR-0-4-U	4	2	Y	
FLIN 19-01	09/09/09	MR-0-5-U	1	3	Y	
FLIN 19-01	09/09/09	MR-0-5-U	2	4	?	
FLIN 19-01	09/09/09	MR-0-5-U	2	2	Y	
FLIN 19-01	09/09/09	MR-0-5-U	3	3	Y	
LOWI 02-05	09/15/09	MR-0-4-U	4	11	Y	
SMAR 13-01	09/10/09	MR-2-2-U	1	3	Y	
SMAR 13-01	09/10/09	MR-2-2-U	2	3	Y	
SMAR 13-01	09/10/09	MR-2-2-U	2	1	Y	

Fine Sediment in Pool Tail-outs					
Reach ID	**Date**	**Reach Type**	**Cell**	**Pool Grid Toss Percent <6mm**	**Spawning Gravels Present (Y or ?)**
SMAR 13-01	09/10/09	MR-2-2-U	2	6	Y
SMAR 13-01	09/10/09	MR-2-2-U	3	0	Y
SMAR 13-01	09/10/09	MR-2-2-U	3	2	Y
SMAR 13-01	09/10/09	MR-2-2-U	3	1	Y
SMAR 13-01	09/10/09	MR-2-2-U	3	4	Y
SMAR 13-01	09/10/09	MR-2-2-U	3	3	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	1	7	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	1	16	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	2	11	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	2	12	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	2	37	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	3	33	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	3	26	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	4	15	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	4	26	Y
SMAR 18-01-1	09/10/09	MR-0-2-U	5	31	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	1	31	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	1	9	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	2	7	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	3	8	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	3	16	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	4	12	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	4	19	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	5	12	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	5	5	Y
SMAR 18-01-2	09/10/09	MR-0-2-U	5	19	Y
SMAR 21-01	09/10/09	MR-0-2-U	1	16	Y
SMAR 21-01	09/10/09	MR-0-2-U	1	18	Y
SMAR 21-01	09/10/09	MR-0-2-U	1	17	Y
SMAR 21-01	09/10/09	MR-0-2-U	1	12	Y
SMAR 21-01	09/10/09	MR-0-2-U	3	16	Y
SMAR 21-01	09/10/09	MR-0-2-U	3	10	Y
SMAR 21-01	09/10/09	MR-0-2-U	3	24	Y
SMAR 21-01	09/10/09	MR-0-2-U	4	12	Y
SMAR 21-01	09/10/09	MR-0-2-U	4	16	Y
SMAR 21-01	09/10/09	MR-0-2-U	4	11	Y
SMAR 21-01	09/10/09	MR-0-2-U	4	10	Y
SMAR 21-01	09/10/09	MR-0-2-U	5	30	Y
TROU 09-03	09/17/09	MR-0-3-U	1	0	Y
TROU 09-03	09/17/09	MR-0-3-U	2	4	Y
TROU 09-03	09/17/09	MR-0-3-U	4	1	Y
TROU 10-01	09/17/09	MR-2-3-U	1	5	Y
TROU 10-01	09/17/09	MR-2-3-U	2	0	Y
TROU 10-01	09/17/09	MR-2-3-U	5	1	Y
TROU 10-01	09/17/09	MR-2-3-U	5	5	Y

Riparian Greenline Data									
Reach ID	Date	Reach Type	Cell	Percent Understory Shrub Cover	Percent Bare/Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width	Left Bank Mean Riparian Zone Width
BARN 11-01	09/08/09	MR-0-3-U	1	90	0	0	63	34	43
BARN 11-01	09/08/09	MR-0-3-U	2	75	0	0	43	68	29
BARN 11-01	09/08/09	MR-0-3-U	3	18	13	0	43	1	1
BARN 11-01	09/08/09	MR-0-3-U	4	0	28	0	18	0	0
BARN 11-01	09/08/09	MR-0-3-U	5	20	38	0	23	0	0
BARN 13-01	09/09/09	MR-0-3-U	1	25	0	0	0	1	1
BARN 13-01	09/09/09	MR-0-3-U	2	0	0	0	0	0	0
BARN 13-01	09/09/09	MR-0-3-U	3	10	0	0	0	0	0
BARN 13-01	09/09/09	MR-0-3-U	4	25	0	0	0	0	0
BARN 13-01	09/09/09	MR-0-3-U	5	5	0	0	0	0	0
BARN 13-03	09/08/09	MR-0-3-U	1	75	0	0	58	45	14
BARN 13-03	09/08/09	MR-0-3-U	2	88	0	0	25	63	18
BARN 13-03	09/08/09	MR-0-3-U	3	55	0	0	55	125	45
BARN 13-03	09/08/09	MR-0-3-U	4	65	0	0	60	126	40
BARN 13-03	09/08/09	MR-0-3-U	5	3	0	0	0	88	43
BOUL 16-01	09/15/09	MR-2-3-U	1	100	0	0	13	135	73
BOUL 16-01	09/15/09	MR-2-3-U	2	93	0	0	53	200	125
BOUL 16-01	09/15/09	MR-2-3-U	3	98	0	0	60	200	163
BOUL 16-01	09/15/09	MR-2-3-U	4	93	0	0	83	200	200
BOUL 16-01	09/15/09	MR-2-3-U	5	100	0	0	45	200	200
BOUL 21-02	09/15/09	MR-0-3-U	1	100	0	0	23	94	200
BOUL 21-02	09/15/09	MR-0-3-U	2	73	0	0	48	125	200
BOUL 21-02	09/15/09	MR-0-3-U	3	78	0	0	30	100	200
BOUL 21-02	09/15/09	MR-0-3-U	4	78	0	0	78	150	200
BOUL 21-02	09/15/09	MR-0-3-U	5	100	0	0	38	150	200
DOUN 07-01	09/11/09	MR-2-2-U	1	75	0	0	23	0	0
DOUN 07-01	09/11/09	MR-2-2-U	2	80	0	0	10	3	3
DOUN 07-01	09/11/09	MR-2-2-U	3	95	0	0	10	0	0
DOUN 07-01	09/11/09	MR-2-2-U	4	83	0	0	3	0	0
DOUN 07-01	09/11/09	MR-2-2-U	5	85	0	0	18	0	0
DOUN 08-02	09/14/09	MR-0-2-U	1	45	3	0	0	3	0
DOUN 08-02	09/14/09	MR-0-2-U	2	80	0	0	3	8	1
DOUN 08-02	09/14/09	MR-0-2-U	3	48	0	0	3	1	3
DOUN 08-02	09/14/09	MR-0-2-U	4	58	0	0	3	4	6
DOUN 08-02	09/14/09	MR-0-2-U	5	75	0	0	15	8	3
DOUS 19-02	09/16/09	MR-2-2-U	1	35	0	0	0	0	5
DOUS 19-02	09/16/09	MR-2-2-U	2	20	0	0	0	3	3
DOUS 19-02	09/16/09	MR-2-2-U	3	45	0	0	0	0	5
DOUS 19-02	09/16/09	MR-2-2-U	4	50	0	0	35	3	5
DOUS 19-02	09/16/09	MR-2-2-U	5	25	0	0	0	0	5
FLIN 06-01	09/16/09	MR-2-2-U	1	100	0	0	18	163	150
FLIN 06-01	09/16/09	MR-2-2-U	2	90	0	0	20	200	125
FLIN 06-01	09/16/09	MR-2-2-U	3	100	0	0	38	200	100
FLIN 06-01	09/16/09	MR-2-2-U	4	98	0	0	23	200	79
FLIN 06-01	09/16/09	MR-2-2-U	5	98	0	0	55	200	71
FLIN 09-02	09/16/09	MR-0-3-U	1	0	0	0	0	0	0
FLIN 09-02	09/16/09	MR-0-3-U	2	5	0	0	5	5	0
FLIN 09-02	09/16/09	MR-0-3-U	3	58	0	0	53	14	1
FLIN 09-02	09/16/09	MR-0-3-U	4	65	0	0	43	0	0
FLIN 09-02	09/16/09	MR-0-3-U	5	58	0	0	40	0	6
FLIN 11-01	09/14/09	MR-0-4-U	1	0	0	0	0	0	0
FLIN 11-01	09/14/09	MR-0-4-U	2	10	3	0	0	0	0
FLIN 11-01	09/14/09	MR-0-4-U	3	3	10	0	0	0	0
FLIN 11-01	09/14/09	MR-0-4-U	4	0	0	0	0	0	0
FLIN 11-01	09/14/09	MR-0-4-U	5	0	0	0	0	3	0
FLIN 11-04	09/14/09	MR-0-4-U	1	100	0	0	13	94	74
FLIN 11-04	09/14/09	MR-0-4-U	2	90	0	0	13	88	103
FLIN 11-04	09/14/09	MR-0-4-U	3	85	0	0	18	188	69
FLIN 11-04	09/14/09	MR-0-4-U	4	95	0	0	23	200	36
FLIN 11-04	09/14/09	MR-0-4-U	5	100	0	0	38	200	66

Riparian Greenline Data									
Reach ID	Date	Reach Type	Cell	Percent Understory Shrub Cover	Percent Bare/Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width	Left Bank Mean Riparian Zone Width
FLIN 17-01	09/11/09	MR-2-4-U	1	63	0	0	55	78	74
FLIN 17-01	09/11/09	MR-2-4-U	2	65	0	0	93	105	66
FLIN 17-01	09/11/09	MR-2-4-U	3	88	0	0	35	133	30
FLIN 17-01	09/11/09	MR-2-4-U	4	83	0	0	40	150	40
FLIN 17-01	09/11/09	MR-2-4-U	5	80	0	0	88	96	124
FLIN 18-02	09/11/09	MR-0-4-U	1	95	0	0	10	14	40
FLIN 18-02	09/11/09	MR-0-4-U	2	93	0	0	5	11	61
FLIN 18-02	09/11/09	MR-0-4-U	3	90	0	0	0	11	200
FLIN 18-02	09/11/09	MR-0-4-U	4	100	0	0	3	14	200
FLIN 18-02	09/11/09	MR-0-4-U	5	83	0	0	0	14	200
FLIN 18-05	09/09/09	MR-0-4-U	1	70	0	0	25	79	96
FLIN 18-05	09/09/09	MR-0-4-U	2	33	0	0	0	88	49
FLIN 18-05	09/09/09	MR-0-4-U	3	65	0	0	8	123	34
FLIN 18-05	09/09/09	MR-0-4-U	4	58	0	0	0	88	29
FLIN 18-05	09/09/09	MR-0-4-U	5	75	0	0	63	88	26
FLIN 19-01	09/09/09	MR-0-5-U	1	13	0	0	55	0	0
FLIN 19-01	09/09/09	MR-0-5-U	2	8	0	0	10	0	0
FLIN 19-01	09/09/09	MR-0-5-U	3	0	0	10	8	0	0
FLIN 19-01	09/09/09	MR-0-5-U	4	0	13	0	15	0	0
FLIN 19-01	09/09/09	MR-0-5-U	5	0	3	0	0	0	0
FRED 29-02	09/16/09	MR-0-2-U	1	95	0	0	0	150	200
FRED 29-02	09/16/09	MR-0-2-U	2	70	0	0	28	70	106
FRED 29-02	09/16/09	MR-0-2-U	3	63	0	0	5	81	88
FRED 29-02	09/16/09	MR-0-2-U	4	90	0	0	3	33	18
FRED 29-02	09/16/09	MR-0-2-U	5	90	0	0	35	13	0
LOWI 02-05	09/15/09	MR-0-4-U	1	0	0	0	0	0	0
LOWI 02-05	09/15/09	MR-0-4-U	2	15	0	0	0	0	0
LOWI 02-05	09/15/09	MR-0-4-U	3	0	0	0	5	0	0
LOWI 02-05	09/15/09	MR-0-4-U	4	3	0	0	0	0	0
LOWI 02-05	09/15/09	MR-0-4-U	5	0	0	0	0	0	0
SMAR 13-01	09/10/09	MR-2-2-U	1	38	0	0	5	19	0
SMAR 13-01	09/10/09	MR-2-2-U	2	20	0	0	8	5	5
SMAR 13-01	09/10/09	MR-2-2-U	3	30	0	0	5	26	0
SMAR 13-01	09/10/09	MR-2-2-U	4	48	0	0	13	63	0
SMAR 13-01	09/10/09	MR-2-2-U	5	13	0	0	5	200	13
SMAR 18-01-1	09/10/09	MR-0-2-U	1	75	0	0	0	0	0
SMAR 18-01-1	09/10/09	MR-0-2-U	2	65	0	0	0	0	0
SMAR 18-01-1	09/10/09	MR-0-2-U	3	30	0	0	0	0	0
SMAR 18-01-1	09/10/09	MR-0-2-U	4	3	0	0	0	0	0
SMAR 18-01-1	09/10/09	MR-0-2-U	5	40	40	0	0	0	0
SMAR 18-01-2	09/10/09	MR-0-2-U	1	0	0	0	0	200	93
SMAR 18-01-2	09/10/09	MR-0-2-U	2	65	0	0	0	200	100
SMAR 18-01-2	09/10/09	MR-0-2-U	3	85	0	0	0	200	175
SMAR 18-01-2	09/10/09	MR-0-2-U	4	30	0	0	0	200	163
SMAR 18-01-2	09/10/09	MR-0-2-U	5	65	0	0	0	200	163
SMAR 21-01	09/10/09	MR-0-2-U	1	0	0	0	0	0	0
SMAR 21-01	09/10/09	MR-0-2-U	2	0	0	0	0	0	0
SMAR 21-01	09/10/09	MR-0-2-U	3	0	0	0	0	0	0
SMAR 21-01	09/10/09	MR-0-2-U	4	8	0	0	10	0	0
SMAR 21-01	09/10/09	MR-0-2-U	5	13	0	0	38	0	0
TROU 09-03	09/17/09	MR-0-3-U	1	3	0	0	0	0	0
TROU 09-03	09/17/09	MR-0-3-U	2	0	0	0	0	0	0
TROU 09-03	09/17/09	MR-0-3-U	3	0	0	0	0	0	0
TROU 09-03	09/17/09	MR-0-3-U	4	5	0	0	0	0	0
TROU 09-03	09/17/09	MR-0-3-U	5	0	0	0	0	0	0
TROU 10-01	09/17/09	MR-2-3-U	1	0	0	0	0	0	0
TROU 10-01	09/17/09	MR-2-3-U	2	0	0	0	0	0	0
TROU 10-01	09/17/09	MR-2-3-U	3	0	0	0	0	0	0
TROU 10-01	09/17/09	MR-2-3-U	4	0	0	0	0	0	0
TROU 10-01	09/17/09	MR-2-3-U	5	0	0	0	0	0	0

Streambank Erosion Data																															
Reach ID	Date	Reach Type	Erosion Rate	Number of Banks	Mean BEHI Score	Mean Rating	Length of Eroding Bank (Feet)	Percent of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)	Reach Transporation Load (Tons/Year)	Transporation Load (Percent)	Reach Riparian Grazing Load (Tons/Year)	Riparian Grazing Load (Percent)	Reach Cropland Load (Tons/Year)	Cropland Load (Percent)	Reach Mining Load (Tons/Year)	Mining Load (Percent)	Reach Silviculture Load (Tons/Year)	Silviculture Load (Percent)	Reach Irrigation Load (Tons/Year)	Irrigation Load (Percent)	Reach Natural Load (Tons/Year)	Natural Load (Percent)	Reach "Other" Load (Tons/Year)	"Other" Load (Percent)	Coarse Gravel >6mm Load (Tons/Year)	Coarse Gravel >6mm (Percent)	Fine Gravel 6-2mm Load (Tons/Year)	Fine Gravel 6-2mm (Percent)	Sand/Clay <2mm Load (Tons/Year)	Sand/Clay <2mm (Percent)
BARN 11-01	09/08/09	MR-0-3-U	Active	12	29.0	moderate	338	16.9	8.4	8.4	0.0	0.0	8.0	95.9	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.3	3.5	0.0	0.0	0.0	0.0	0.8	10.0	7.5	90.0
BARN 11-01	09/08/09	MR-0-3-U	Slow	1	36.3	high	6	0.3	0.2	0.2	0.0	0.0	0.2	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.2	90.0
BARN 11-01	09/08/09	MR-0-3-U	Total	13	29.5	moderate	344	17.2	8.6	8.6	0.0	0.0	8.2	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.3	3.4	0.0	0.0	0.0	0.0	0.9	10.0	7.7	90.0
BARN 13-01	09/09/09	MR-0-3-U	Active	5	26.7	moderate	70	3.5	1.8	1.8	0.0	0.0	1.5	81.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	18.8	0.0	0.0	0.0	0.0	0.2	10.0	1.7	90.0
BARN 13-01	09/09/09	MR-0-3-U	Slow	5	25.7	moderate	43	2.2	0.7	0.7	0.0	0.0	0.6	77.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	22.7	0.0	0.0	0.0	0.0	0.1	10.0	0.7	90.0
BARN 13-01	09/09/09	MR-0-3-U	Total	10	26.2	moderate	113	5.7	2.6	2.6	0.0	0.0	2.1	80.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	19.9	0.0	0.0	0.0	0.0	0.3	10.0	2.3	90.0
BARN 13-03	09/08/09	MR-0-3-U	Active	6	31.7	high	64	3.2	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	10.0	3.6	90.0	0.0	0.0	0.4	10.0	0.4	10.0	3.2	80.0
BARN 13-03	09/08/09	MR-0-3-U	Slow	2	35.9	high	35	1.8	2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	7.1	2.3	92.9	0.0	0.0	0.3	10.0	0.3	10.0	2.0	80.0
BARN 13-03	09/08/09	MR-0-3-U	Total	8	32.7	high	99	5.0	6.5	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	8.9	5.9	91.1	0.0	0.0	0.6	10.0	0.6	10.0	5.2	80.0
BOUL 16-01	09/15/09	MR-2-3-U	Active	0			0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BOUL 16-01	09/15/09	MR-2-3-U	Slow	3	18.6	low	84	4.2	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	100.0	0.0	0.0	0.2	66.9	0.0	10.0	0.1	23.1
BOUL 16-01	09/15/09	MR-2-3-U	Total	3	18.6	low	84	4.2	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	100.0	0.0	0.0	0.2	66.9	0.0	10.0	0.1	23.1
BOUL 21-02	09/15/09	MR-0-3-U	Active	0			0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BOUL 21-02	09/15/09	MR-0-3-U	Slow	9	32.7	high	223	11.2	10.3	10.3	0.5	5.0	0.4	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	91.0	0.0	0.0	2.2	21.1	1.2	12.0	6.9	66.9
BOUL 21-02	09/15/09	MR-0-3-U	Total	9	32.7	high	223	11.2	10.3	10.3	0.5	5.0	0.4	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	91.0	0.0	0.0	2.2	21.1	1.2	12.0	6.9	66.9
DOUN 07-01	09/11/09	MR-2-2-U	Active	11	31.8	high	164	8.2	4.3	4.3	0.0	0.0	3.9	90.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	9.5	0.0	0.0	0.1	2.4	0.4	10.0	3.7	87.6
DOUN 07-01	09/11/09	MR-2-2-U	Slow	7	33.7	high	90	4.5	8.8	8.8	0.0	0.0	3.5	39.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	60.1	0.0	0.0	0.0	0.0	0.9	10.0	8.0	90.0
DOUN 07-01	09/11/09	MR-2-2-U	Total	18	32.5	high	254	12.7	13.1	13.1	0.0	0.0	7.4	56.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	43.6	0.0	0.0	0.1	0.8	1.3	10.0	11.7	89.2
DOUN 08-02	09/14/09	MR-0-2-U	Active	8	34.4	high	186	9.3	19.2	19.2	0.0	0.0	16.8	87.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	12.4	0.0	0.0	0.0	0.0	1.9	10.0	17.3	90.0
DOUN 08-02	09/14/09	MR-0-2-U	Slow	7	29.5	moderate	137	6.9	4.1	4.1	0.0	0.0	3.4	83.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	16.4	0.0	0.0	0.4	10.0	0.4	10.0	3.3	80.0
DOUN 08-02	09/14/09	MR-0-2-U	Total	15	32.1	high	323	16.2	23.3	23.3	0.0	0.0	20.2	86.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	13.1	0.0	0.0	0.4	1.8	2.3	10.0	20.6	88.2
DOUS 19-02	09/16/09	MR-2-2-U	Active	0			0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DOUS 19-02	09/16/09	MR-2-2-U	Slow	20	31.6	high	314	31.4	8.0	16.1	4.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	10.0	7.2	90.0
DOUS 19-02	09/16/09	MR-2-2-U	Total	20	31.6	high	314	31.4	8.0	16.1	4.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	10.0	7.2	90.0
FLIN 06-01	09/16/09	MR-2-2-U	Active	3	42.1	very high	132	6.6	6.7	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	70.0	0.1	1.1	1.9	28.9	2.7	40.0	2.0	30.0	2.0	30.0
FLIN 06-01	09/16/09	MR-2-2-U	Slow	4	25.4	moderate	101	5.1	4.9	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	70.0	0.5	10.0	1.0	20.0	1.0	20.0	0.5	10.0	3.4	70.0
FLIN 06-01	09/16/09	MR-2-2-U	Total	7	32.6	high	233	11.7	11.6	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	70.0	0.6	4.8	2.9	25.2	3.7	31.6	2.5	21.6	5.4	46.9
FLIN 09-02	09/16/09	MR-0-3-U	Active	5	33.2	high	101	5.1	3.2	3.2	0.0	0.0	2.5	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	20.0	0.0	0.0	0.9	29.0	0.3	10.0	1.9	61.0
FLIN 09-02	09/16/09	MR-0-3-U	Slow	2	31.3	high	20	1.0	0.7	0.7	0.0	0.0	0.4	63.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	36.7	0.0	0.0	0.3	40.0	0.1	10.0	0.3	50.0
FLIN 09-02	09/16/09	MR-0-3-U	Total	7	32.7	high	121	6.1	3.9	3.9	0.0	0.0	3.0	77.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	22.9	0.0	0.0	1.2	30.9	0.4	10.0	2.3	59.1
FLIN 11-01	09/14/09	MR-0-4-U	Active	6	37.0	high	597	29.9	71.4	71.4	14.0	19.6	27.2	38.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.2	42.3	0.0	0.0	16.5	23.0	7.9	11.1	47.0	65.9
FLIN 11-01	09/14/09	MR-0-4-U	Slow	3	33.5	high	119	6.0	7.4	7.4	1.0	13.5	1.5	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	66.5	0.0	0.0	0.0	0.0	0.7	10.0	6.7	90.0
FLIN 11-01	09/14/09	MR-0-4-U	Total	9	35.8	high	716	35.8	78.8	78.8	15.0	19.0	28.7	36.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.1	44.6	0.0	0.0	16.5	20.9	8.6	11.0	53.7	68.2
FLIN 11-04	09/14/09	MR-0-4-U	Active	0			0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FLIN 11-04	09/14/09	MR-0-4-U	Slow	2	17.1	low	67	3.4	1.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	100.0	0.0	0.0	1.0	70.0	0.1	10.0	0.3	20.0
FLIN 11-04	09/14/09	MR-0-4-U	Total	2	17.1	low	67	3.4	1.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	100.0	0.0	0.0	1.0	70.0	0.1	10.0	0.3	20.0
FLIN 17-01	09/11/09	MR-2-4-U	Active	0			0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FLIN 17-01	09/11/09	MR-2-4-U	Slow	8	11.7	low	200	10.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	20.0	0.6	80.0	0.0	0.0	0.6	74.5	0.1	12.7	0.1	12.7
FLIN 17-01	09/11/09	MR-2-4-U	Total	8	11.7	low	200	10.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	20.0	0.6	80.0	0.0	0.0	0.6	74.5	0.1	12.7	0.1	12.7
FLIN 18-02	09/11/09	MR-0-4-U	Active	0			0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FLIN 18-02	09/11/09	MR-0-4-U	Slow	5	15.0	low	156	7.8	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	100.0	0.0	0.0	0.4	70.0	0.1	10.0	0.1	20.0
FLIN 18-02	09/11/09	MR-0-4-U	Total	5	15.0	low	156	7.8	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	100.0	0.0	0.0	0.4	70.0	0.1	10.0	0.1	20.0
FLIN 18-05	09/09/09	MR-0-4-U	Active	4	32.0	high	86	4.3	2.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	80.0	0.6	20.0	0.6	21.9	0.6	19.7	1.6	58.5
FLIN 18-05	09/09/09	MR-0-4-U	Slow	3	18.7	low	132	6.6	2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	84.0	0.4	16.0	1.8	70.0	0.3	10.0	0.5	20.0
FLIN 18-05	09/09/09	MR-0-4-U	Total	7	26.3	moderate	218	10.9	5.3	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	81.9	1.0	18.1	2.4	44.7	0.8	15.1	2.1	40.2
FLIN 19-01	09/09/09	MR-0-5-U	Active	6	26.3	moderate	569	19.0	35.3	23.6	0.0	0.0	30.5	86.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	13.7	0.0	0.0	11.1	31.3	7.1	20.0	17.2	48.7
FLIN 19-01	09/09/09	MR-0-5-U	Slow	2	20.9	moderate	46	1.5	0.6	0.4	0.0	0.0	0.3	46.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	42.3	0.1	11.6	0.2	30.0	0.1	20.0	0.3	50.0
FLIN 19-01	09/09/09	MR-0-5-U	Total	8	24.9	moderate	615	20.5	35.9	23.9	0.0	0.0	30.7	85.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	14.2	0.1	0.2	11.2	31.3	7.2	20.0	17.5	48.7
FRED 29-02	09/16/09	MR-0-2-U	Active	3	38.0	high	110	5.5	11.7	11.7	3.2	27.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	72.2	0.0	0.0	0.9	7.7	1.2	10.0	9.6	82.3
FRED 29-02	09/16/09	MR-0-2-U	Slow	9	35.2	high	208	10.4	16.9	16.9	9.1	54.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	46.0	0.0	0.0	4.3	25.4	0.9	5.5	11.7	69.1
FRED 29-02	09/16/09	MR-0-2-U	Total	12	35.9	high	318	15.9	28.6	28.6	12.4	43.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.2	56.7	0.0	0.0	5.2	18.2	2.1	7.3	21.3	74.5
LOWI 02-05	09/15/09	MR-0-4-U	Active	4	26.0	moderate	125	6.3	3.4	3.4	0.0	0.0	1.4	43.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	32.3	0.8	24.6	0.0	0.0	1.6	48.4	0.6	18.4	1.1	33.2
LOWI 02-05	09/15/09	MR-0-4-U	Slow	2	22.8	moderate	57	2.9	0.5	0.5	0.0	0.0	0.3	59.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	40.7	0.0	0.0	0.0	0.0	0.1	20.0	0.1	20.0	0.3	60.0
LOWI 02-05	09/15/09	MR-0-4-U	Total	6	25.0	moderate	182	9.1	3.9	3.9	0.0	0.0	1.8	45.3	0.0	0.0	0.0	0.0	0.0	0.0	1.3	33.4	0.8	21.3	0.0	0.0	1.7	44.7	0.7	18.6	1.4	36.7
SMAR 13-01	09/10/09	MR-2-2-U	Active	10	43.3	very high	213	10.7	40.8	40.8	8.5	20.9	20.4	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.9	29.1	0.0	0.0	3.1	7.6	13.7	33.5	24.1	59.0
SMAR 13-01	09/10/09	MR-2-2-U	Slow	0			0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SMAR 13-01	09/10/09	MR-2-2-U	Total	10	43.3	very high	213	10.7	40.8	40.8	8.5	20.9	20.4	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.9	29.1	0.0	0.0	3.1	7.6	13.7	33.5	24.1	59.0
SMAR 18-01-1	09/10/09	MR-0-2-U	Active	5	25.7	moderate	68	6.8	1.3	2.6	0.0	0.0	1.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	30.0	0.1	10.0	0.8	60.0
SMAR 18-01-1	09/10/09	MR-0-2-U	Slow	2	32.3	high	27	2.7	1.1	2.3	0.0	0.0	1.1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	100.0
SMAR 18-01-1	09/10/09	MR-0-2-U	Total	7	27.6	moderate	95	9.5	2.4	4.9	0.0	0.0	2.4	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	16.1	0.1	5.4	1.9	78.6
SMAR 18-01-2	09/10/09	MR-0-2-U	Active	2	30.1	high	26	2.6	1.4	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	100.0	0.0	0.0	0.4	26.5	0.1	10.0	0.9	63.5
SMAR 18-01-2	09/10/09	MR-0-2-U	Slow	2	23.3	moderate	14	1.4	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	100.0	0.0	0.0	0.1	20.0	0.1	20.0	0.2	60.0
SMAR 18-01-2	09/10/09	MR-0-2-U	Total	4	26.7	moderate	40	4.0	1.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	100.0	0.0	0.0	0.4	25.4	0.2	11.7	1.0	62.9
SMAR 21-01	09/10/09	MR-0-2-U	Active	10	35.9	high	177	8.9	28.6	28.6	0.0	0.0	14.3	50.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	50.0	0.0	0.0	0.0	0.0	6.1	21.2	3.0	10.6	19.5	68.2
SMAR 21-01	09/10/09	MR-0-2-U	Slow	2	41.0	very high	18	0.9	0.8	0.8	0.0	0.0	0.4	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	50.0	0.0	0.0	0.0	0.0	0.1	10.0	0.2	20.0	0.5	70.0
SMAR 21-01	09/10/09	MR-0-2-U	Total	12	36.7	high	195	9.8	29.4	29.4	0.0	0.0	14.7	50.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7	50.0	0.0	0.0	0.0	0.0	6.1	20.9	3.2	10.8	20.1	68.3
TROU 09-03	09/17/09	MR-0-3-U	Active	5	39.2	high	108	5.4	3.9	3.9	0.0	0.0	3.2	81.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	18.5	0.0	0.0	0.4	10.0	0.0	0.0	3.5	90.0
TROU 09-03	09/17/09	MR-0-3-U	Slow	5	32.3	high	59	3.0	2.3	2.3	0.0	0.0	0.4	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	84.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	100.0
TROU 09-03	09/17/09	MR-0-3-U	Total	10	35.7	high	167	8.4	6.2	6.2	0.0	0.0	3.6	57.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	42.4	0.0	0.0	0.4	6.4	0.0	0.0	5.8	93.6
TROU 10-01	09/17/09	MR-2-3-U	Active	2	39.8	high	79	4.0	7.6	7.6	0.0	0.0	5.3	70.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	30.0	0.0	0.0	0.0	0.0	0.2	2.0	0.1	1.0	7.3	97.0
TROU 10-01	09/17/09	MR-2-3-U	Slow	0			0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TROU 10-01	09/17/09	MR-2-3-U	Total	2	39.8	high	79	4.0	7.6	7.6	0.0	0.0	5.3	70.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	30.0	0.0	0.0	0.0	0.0	0.2	2.0	0.1	1.0	7.3	97.0

ATTACHMENT C – Photo Log

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	132	bank 1
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	133	bank 1 u/s
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	134	bank 2
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	135	bank 2 d/s
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	136	bank 3
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	137	bank 3 u/s
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	138	bank 4
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	139	bank 4 u/s
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	140	bank 5
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	141	bank 5 d/s
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	142	bank 6
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	143	bank 6 d/s
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	144	bank 7
Barnes Creek	BARN 13-03	9/8/2009	BEHI1	145	bank 7 d/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	148	bank 1
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	149	bank 1 d/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	150	bank 2
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	151	bank 2 u/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	152	bank 3
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	153	bank 3 u/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	154	bank 4
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	155	bank 4 d/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	156	bank 5
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	157	bank 5 d/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	158	bank 6
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	159	bank 6 d/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	160	bank 7
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	161	bank 7 u/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	162	bank 8
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	163	bank 8 u/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	164	cell 5 u/s view
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	165	bank 9
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	166	bank 9 u/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	167	bank 10
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	168	bank 10 u/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	169	bank 11
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	170	bank 12 d/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	171	bank 12
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	172	bank 13 d/s
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	173	bank 13
Barnes Creek	BARN 11-01	9/8/2009	BEHI1	174	bank 13 d/s
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	175	bank 1
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	176	bank 1 d/s
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	177	bank 2
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	178	bank 2 u/s
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	179	bank 3

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	180	bank 3 u/s
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	181	bank 4
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	182	bank 4 d/s
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	183	bank 4
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	184	bank 5
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	185	bank 5 d/s
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	186	bank 6
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	187	bank 6 d/s
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	188	bank 8
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	189	bank 8 u/s
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	190	bank 9
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	191	bank 9 u/s
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	192	bank 10
Barnes Creek	BARN 13-01	9/9/2009	BEHI1	193	bank 10 u/s
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	194	bank 1
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	195	bank 1 d/s
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	196	bank 2
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	197	bank 2 d/s
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	198	bank 3
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	199	bank 3 d/s
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	200	bank 4
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	201	bank 4 d/s
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	202	bank 5
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	203	bank 5 d/s
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	204	bank 6
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	205	bank 6 d/s
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	206	bank 7
Flint Creek	FLIN 18-05	9/9/2009	BEHI1	207	bank 7 d/s
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	208	bank 1
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	209	bank 1 d/s
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	210	bank 2
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	211	bank 2 d/s
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	212	bank 3
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	213	bank 3 d/s
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	214	bank 4
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	215	bank 4 d/s
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	216	bank 5
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	217	bank 5 d/s
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	218	bank 6
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	219	bank 6 d/s
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	220	bank 7
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	221	bank 7 d/s
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	222	bank 8
Flint Creek	FLIN 19-01	9/9/2009	BEHI1	223	bank 8 d/s
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	224	bank 1
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	225	bank 1 d/s

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	226	bank 2
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	227	bank 2 d/s
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	228	bank 3
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	229	bank 3 d/s
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	230	bank 4
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	231	bank 4 d/s
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	232	bank 5
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	233	bank 5 d/s
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	234	bank 6
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	235	bank 6 d/s
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	236	bank 7
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	237	bank 7 d/s
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	238	bank 8
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	239	bank 8 d/s
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	240	bank 9
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	241	bank 9 d/s
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	242	bank 10
Smart Creek	SMAR 13-01	9/10/2009	BEHI1	243	bank 10 d/s
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	244	bank 1
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	245	bank 1 d/s
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	246	bank 2
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	247	bank 2 d/s
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	248	bank 3
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	249	bank 3 d/s
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	250	bank 4
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	251	bank 4 d/s
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	252	bank 5
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	253	bank 5 d/s
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	254	bank 6
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	255	bank 6 d/s
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	256	bank 7
Smart Creek	SMAR 18-01-01	9/10/2009	BEHI1	257	bank 7 u/s
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	258	bank 1
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	259	bank 1 d/s
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	260	bank 2
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	261	bank 2 d/s
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	262	bank 3
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	263	bank 3 d/s
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	264	bank 4
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	265	bank 4 d/s
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	266	log jam and sediment at 411'
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	267	log jam and sediment at 411'
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	268	log jam and sediment at 411'
Smart Creek	SMAR 18-01-02	9/10/2009	BEHI1	269	log jam and sediment at 411'
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	270	bank 1
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	271	bank 1 d/s

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	272	bank 2
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	273	bank 2 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	274	bank 3
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	275	bank 3 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	276	bank 4
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	277	bank 4 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	278	bank 5
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	279	bank 5 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	280	bank 6
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	281	bank 6 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	282	bank 7
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	283	bank 7 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	284	bank 8
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	285	bank 8 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	286	bank 9
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	287	bank 9 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	288	bank 10
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	289	bank 10 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	290	bank 11
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	291	bank 11 d/s
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	292	bank 12
Smart Creek	SMAR 21-01	9/10/2009	BEHI1	293	bank 12 d/s
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	294	bank 1
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	295	bank 1 d/s
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	296	bank 3
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	297	bank 4
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	298	bank 5
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	299	bank 5
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	300	bank 6
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	301	bank 6 d/s
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	302	bank 7
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	303	bank 8
Flint Creek	FLIN 17-01	9/11/2009	BEHI1	304	bank 8 d/s
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	305	bank 1
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	306	bank 1 d/s
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	307	bank 2 u/s
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	308	bank 2
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	309	bank 3
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	310	bank 3 d/s
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	311	bank 4
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	312	bank 4 d/s
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	313	bank 5
Flint Creek	FLIN 18-02	9/11/2009	BEHI1	314	bank 5 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	315	bank 1
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	316	bank 1 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	317	bank 2

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	318	bank 2 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	319	bank 2 d/s second shot
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	320	bank 3
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	321	bank 3 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	322	bank 4
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	323	bank 4 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	324	bank 5
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	325	bank 5 u/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	326	bank 7
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	327	bank 7 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	328	bank 8
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	329	bank 8 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	330	bank 9
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	331	bank 9 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	332	bank 10
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	333	bank 10 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	334	bank 11
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	335	bank 11 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	336	bank 12
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	337	bank 12 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	338	bank 13
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	339	bank 13 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	340	bank 14
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	341	bank 14 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	342	bank 15
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	343	bank 15 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	344	bank 16
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	345	bank 16 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	346	bank 17
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	347	bank 17 d/s
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	348	bank 18
Douglas Creek (north)	DOUN 07-01	9/11/2009	BEHI1	349	bank 18 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	350	bank 1
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	351	bank 1 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	352	bank 2
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	353	bank 2 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	354	bank 3
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	355	bank 3 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	356	bank 4
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	357	bank 4 u/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	358	bank 5
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	359	bank 5 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	360	bank 6
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	361	bank 6 u/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	362	bank 7
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	363	bank 7 u/s

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	364	bank 8
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	365	bank 8 u/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	366	bank 9
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	367	bank 9 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	368	bank 10
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	369	bank 10 u/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	370	bank 11
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	371	bank 11 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	372	bank 12
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	373	bank 12 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	374	bank 13
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	375	bank 13 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	376	bank 14
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	377	bank 14 d/s
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	378	bank 15
Douglas Creek (north)	DOUN 08-02	9/14/2009	BEHI1	379	bank 15 d/s
Flint Creek	FLIN 11-04	9/14/2009	BEHI1	380	bank 1
Flint Creek	FLIN 11-04	9/14/2009	BEHI1	381	bank 1 u/s
Flint Creek	FLIN 11-04	9/14/2009	BEHI1	382	bank 2
Flint Creek	FLIN 11-04	9/14/2009	BEHI1	383	bank 2 d/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	384	bank 1
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	385	bank 1 d/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	386	bank 2
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	387	bank 2 d/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	388	bank 3
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	389	bank 3 d/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	390	bank 4
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	391	bank 4 d/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	392	bank 5
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	393	bank 5 d/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	394	bank 5 u/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	395	bank 5
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	396	bank 6
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	397	bank 6 d/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	398	bank 7 u/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	399	bank 7
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	400	bank 8
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	401	bank 8 d/s
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	402	bank 9
Flint Creek	FLIN 11-01	9/14/2009	BEHI1	403	bank 9 d/s
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	404	bank 1
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	405	bank 1 u/s
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	406	bank 2
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	407	bank 2 u/s
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	408	bank 3
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	409	bank 3 u/s

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	410	bank 4
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	411	bank 4 u/s
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	412	bank 5
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	413	bank 5 u/s
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	414	bank 6
Lower Willow Creek	LOWI 02-05	9/15/2009	BEHI1	415	bank 6 d/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	416	bank 1
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	417	bank 1 d/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	418	bank 2
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	419	bank 2 d/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	420	bank 3
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	421	bank 3 d/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	422	bank 4
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	423	bank 4 d/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	424	bank 5
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	425	bank 5 d/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	426	bank 6
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	427	bank 6 d/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	428	bank 7
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	429	bank 7 d/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	430	bank 7 u/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	431	bank 8
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	432	bank 8 d/s
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	433	bank 9
Boulder Creek	BOUL 21-02	9/15/2009	BEHI1	434	bank 9 d/s
Boulder Creek	BOUL 16-01	9/15/2009	BEHI1	435	bank 1
Boulder Creek	BOUL 16-01	9/15/2009	BEHI1	436	bank 1 u/s
Boulder Creek	BOUL 16-01	9/15/2009	BEHI1	437	bank 2
Boulder Creek	BOUL 16-01	9/15/2009	BEHI1	438	bank 2 u/s
Boulder Creek	BOUL 16-01	9/15/2009	BEHI1	439	bank 3
Boulder Creek	BOUL 16-01	9/15/2009	BEHI1	440	bank 3 u/s
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	441	bank 1
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	442	bank 1 d/s
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	443	bank 2
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	444	bank 2 d/s
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	445	bank 3
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	446	bank 3 d/s
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	447	bank 4
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	448	bank 4 d/s
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	449	bank 4 d/s
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	450	bank 5
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	451	bank 5 d/s
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	452	bank 6
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	453	bank 6 d/s
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	454	bank 7
Flint Creek	FLIN 09-02	9/16/2009	BEHI1	455	bank 7 d/s

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	456	bank 1
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	457	bank 1 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	458	bank 2
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	459	bank 2 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	460	bank 3
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	461	bank 3 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	462	bank 4
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	463	bank 4 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	464	bank 5
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	465	bank 5 u/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	466	bank 6
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	467	bank 6 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	468	bank 7
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	469	bank 7 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	470	bank 8
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	471	bank 8 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	472	bank 9
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	473	bank 9 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	474	bank 10
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	475	bank 10 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	476	bank 11
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	477	bank 11 d/s
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	478	bank 12
Fred Burr Creek	FRED 29-02	9/16/2009	BEHI1	479	bank 12 d/s
Douglas Creek (south)	DOUS 09-02	9/16/2009	BEHI1	480	bank 1
Douglas Creek (south)	DOUS 09-02	9/16/2009	BEHI1	481	bank 1 d/s
Douglas Creek (south)	DOUS 09-02	9/16/2009	BEHI1	482	bank 2
Douglas Creek (south)	DOUS 09-02	9/16/2009	BEHI1	483	bank 2 d/s
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	484	bank 1
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	485	bank 1 d/s
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	486	bank 2
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	487	bank 2 d/s
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	488	bank 3
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	489	bank 3 d/s
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	490	bank 4
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	491	bank 4 d/s
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	492	bank 5
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	493	bank 5 d/s
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	494	bank 6
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	495	bank 6 d/s
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	496	bank 7
Flint Creek	FLIN 06-01	9/16/2009	BEHI1	497	bank 7 d/s
Trout Creek	TROU 09-03	9/17/2009	BEHI2	1	bank 1
Trout Creek	TROU 09-03	9/17/2009	BEHI2	2	bank 1 d/s
Trout Creek	TROU 09-03	9/17/2009	BEHI2	3	bank 1 close-up
Trout Creek	TROU 09-03	9/17/2009	BEHI2	4	bank 2

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Trout Creek	TROU 09-03	9/17/2009	BEHI2	5	bank 2 d/s
Trout Creek	TROU 09-03	9/17/2009	BEHI2	6	bank 3
Trout Creek	TROU 09-03	9/17/2009	BEHI2	7	bank 3 d/s
Trout Creek	TROU 09-03	9/17/2009	BEHI2	8	bank 4
Trout Creek	TROU 09-03	9/17/2009	BEHI2	9	bank 4 d/s
Trout Creek	TROU 09-03	9/17/2009	BEHI2	10	bank 5
Trout Creek	TROU 09-03	9/17/2009	BEHI2	11	bank 5 d/s
Trout Creek	TROU 09-03	9/17/2009	BEHI2	12	bank 6
Trout Creek	TROU 09-03	9/17/2009	BEHI2	13	bank 6 d/s
Trout Creek	TROU 09-03	9/17/2009	BEHI2	14	bank 7
Trout Creek	TROU 09-03	9/17/2009	BEHI2	15	bank 7 d/s
Trout Creek	TROU 09-03	9/17/2009	BEHI2	16	bank 8
Trout Creek	TROU 09-03	9/17/2009	BEHI2	17	bank 8 d/s
Trout Creek	TROU 10-01	9/17/2009	BEHI2	22	bank 1
Trout Creek	TROU 10-01	9/17/2009	BEHI2	23	bank 1 d/s
Trout Creek	TROU 10-01	9/17/2009	BEHI2	24	bank 2
Trout Creek	TROU 10-01	9/17/2009	BEHI2	25	bank 2 d/s
Barnes Creek	BARN 13-03	9/8/2009	XS1	2365	reach bottom, u/s view
Barnes Creek	BARN 13-03	9/8/2009	XS1	2366	reach bottom, d/s view
Barnes Creek	BARN 13-03	9/8/2009	XS1	2367	xs1 from rb
Barnes Creek	BARN 13-03	9/8/2009	XS1	2368	xs1 u/s view
Barnes Creek	BARN 13-03	9/8/2009	XS1	2369	xs2 from lb
Barnes Creek	BARN 13-03	9/8/2009	XS1	2370	xs2 u/s view
Barnes Creek	BARN 13-03	9/8/2009	XS1	2371	xs3 from lb
Barnes Creek	BARN 13-03	9/8/2009	XS1	2372	xs3 u/s view
Barnes Creek	BARN 13-03	9/8/2009	XS1	2373	xs4 from rb
Barnes Creek	BARN 13-03	9/8/2009	XS1	2374	xs4 u/s view
Barnes Creek	BARN 13-03	9/8/2009	XS1	2375	xs5 from rb
Barnes Creek	BARN 13-03	9/8/2009	XS1	2376	xs5 u/s view
Barnes Creek	BARN 13-03	9/8/2009	XS1	2377	reach top, u/s view
Barnes Creek	BARN 13-03	9/8/2009	XS1	2378	reach top, d/s view
Barnes Creek	BARN 11-01	9/8/2009	XS1	2379	reach bottom, d/s view
Barnes Creek	BARN 11-01	9/8/2009	XS1	2380	reach bottom, u/s view
Barnes Creek	BARN 11-01	9/8/2009	XS1	2381	xs1 from lb
Barnes Creek	BARN 11-01	9/8/2009	XS1	2382	xs1 u/s view
Barnes Creek	BARN 11-01	9/8/2009	XS1	2383	xs2 from lb
Barnes Creek	BARN 11-01	9/8/2009	XS1	2384	xs2 u/s view
Barnes Creek	BARN 11-01	9/8/2009	XS1	2385	xs3 from rb
Barnes Creek	BARN 11-01	9/8/2009	XS1	2386	xs3 u/s view
Barnes Creek	BARN 11-01	9/8/2009	XS1	2387	xs4 from rb
Barnes Creek	BARN 11-01	9/8/2009	XS1	2388	xs4 u/s view
Barnes Creek	BARN 11-01	9/8/2009	XS1	2389	reach top, u/s view
Barnes Creek	BARN 11-01	9/8/2009	XS1	2390	reach top, d/s view
Barnes Creek	BARN 11-01	9/8/2009	XS1	2391	xs5 from rb
Barnes Creek	BARN 11-01	9/8/2009	XS1	2392	xs5 u/s view
Barnes Creek	BARN 13-01	9/9/2009	XS1	2393	reach bottom, u/s view

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Barnes Creek	BARN 13-01	9/9/2009	XS1	2394	reach bottom, d/s view
Barnes Creek	BARN 13-01	9/9/2009	XS1	2395	xs1 from lb
Barnes Creek	BARN 13-01	9/9/2009	XS1	2396	xs1 u/s view
Barnes Creek	BARN 13-01	9/9/2009	XS1	2397	xs2 from rb
Barnes Creek	BARN 13-01	9/9/2009	XS1	2398	xs2 u/s view
Barnes Creek	BARN 13-01	9/9/2009	XS1	2399	xs3 from rb
Barnes Creek	BARN 13-01	9/9/2009	XS1	2400	xs3 u/s view
Barnes Creek	BARN 13-01	9/9/2009	XS1	2401	xs4 from lb
Barnes Creek	BARN 13-01	9/9/2009	XS1	2402	xs4 u/s view
Barnes Creek	BARN 13-01	9/9/2009	XS1	2403	xs5 from lb
Barnes Creek	BARN 13-01	9/9/2009	XS1	2404	xs5 u/s view
Barnes Creek	BARN 13-01	9/9/2009	XS1	2405	reach top, u/s view
Barnes Creek	BARN 13-01	9/9/2009	XS1	2406	reach top, d/s view
Flint Creek	FLIN 18-05	9/9/2009	XS1	2407	reach bottom, d/s view
Flint Creek	FLIN 18-05	9/9/2009	XS1	2408	reach bottom, u/s view
Flint Creek	FLIN 18-05	9/9/2009	XS1	2409	xs1 from rb
Flint Creek	FLIN 18-05	9/9/2009	XS1	2410	xs1 u/s view
Flint Creek	FLIN 18-05	9/9/2009	XS1	2411	xs2 from rb
Flint Creek	FLIN 18-05	9/9/2009	XS1	2412	xs2 u/s view
Flint Creek	FLIN 18-05	9/9/2009	XS1	2413	xs3 from lb
Flint Creek	FLIN 18-05	9/9/2009	XS1	2414	xs3 u/s view
Flint Creek	FLIN 18-05	9/9/2009	XS1	2415	xs4 from rb
Flint Creek	FLIN 18-05	9/9/2009	XS1	2416	xs4 d/s view
Flint Creek	FLIN 18-05	9/9/2009	XS1	2417	reach top, u/s view
Flint Creek	FLIN 18-05	9/9/2009	XS1	2418	reach top, d/s view
Flint Creek	FLIN 18-05	9/9/2009	XS1	2419	xs5 from rb
Flint Creek	FLIN 18-05	9/9/2009	XS1	2420	xs5 u/s view
Flint Creek	FLIN 19-01	9/9/2009	XS1	2421	reach bottom, d/s view
Flint Creek	FLIN 19-01	9/9/2009	XS1	2422	reach bottom, u/s view
Flint Creek	FLIN 19-01	9/9/2009	XS1	2423	xs1 from rb
Flint Creek	FLIN 19-01	9/9/2009	XS1	2424	xs1 u/s view
Flint Creek	FLIN 19-01	9/9/2009	XS1	2425	xs2 from rb
Flint Creek	FLIN 19-01	9/9/2009	XS1	2426	xs2 u/s view
Flint Creek	FLIN 19-01	9/9/2009	XS1	2427	xs3 from rb
Flint Creek	FLIN 19-01	9/9/2009	XS1	2428	xs3 u/s view
Flint Creek	FLIN 19-01	9/9/2009	XS1	2429	xs4 from rb
Flint Creek	FLIN 19-01	9/9/2009	XS1	2430	xs4 u/s view
Flint Creek	FLIN 19-01	9/9/2009	XS1	2431	xs5 from rb
Flint Creek	FLIN 19-01	9/9/2009	XS1	2432	xs5 u/s view
Flint Creek	FLIN 19-01	9/9/2009	XS1	2433	reach top, u/s view
Flint Creek	FLIN 19-01	9/9/2009	XS1	2434	reach top, d/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2435	reach bottom, u/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2436	reach bottom, d/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2437	xs1 from lb
Smart Creek	SMAR 13-01	9/10/2009	XS1	2438	xs1 u/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2439	xs2 from lb

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Smart Creek	SMAR 13-01	9/10/2009	XS1	2440	xs2 u/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2441	xs3 u/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2442	xs3 u/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2443	xs3 from lb
Smart Creek	SMAR 13-01	9/10/2009	XS1	2444	xs4 from lb
Smart Creek	SMAR 13-01	9/10/2009	XS1	2445	xs4 u/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2446	reach top, u/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2447	reach top, d/s view
Smart Creek	SMAR 13-01	9/10/2009	XS1	2448	xs5 from lb
Smart Creek	SMAR 13-01	9/10/2009	XS1	2449	xs5 u/s view
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2450	reach bottom, d/s view
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2451	reach bottom, u/s view
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2452	xs1 from rb
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2453	xs1 u/s view
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2454	xs2 from lb
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2455	xs2 u/s view
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2456	xs3 from lb
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2457	xs3 u/s view
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2458	xs4 from lb
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2459	xs4 u/s view
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2460	xs5 from lb
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2461	xs5 u/s view
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2462	reach top, u/s view
Smart Creek	SMAR 18-01-01	9/10/2009	XS1	2463	reach top, d/s view
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2464	reach bottom, d/s view
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2465	reach bottom, u/s view
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2466	xs1 from lb
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2467	xs1 u/s view
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2468	xs2 from lb
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2469	xs2 u/s view
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2470	xs3 from lb
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2471	xs3 d/s view
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2472	xs4 from lb
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2473	xs4 u/s view
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2474	xs5 from rb
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2475	xs5 u/s view
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2476	reach top, u/s view
Smart Creek	SMAR 18-01-02	9/10/2009	XS1	2477	reach top, d/s view
Smart Creek	SMAR 21-01	9/10/2009	XS1	2478	reach bottom, d/s view
Smart Creek	SMAR 21-01	9/10/2009	XS1	2479	reach bottom, u/s view
Smart Creek	SMAR 21-01	9/10/2009	XS1	2480	xs1 from lb
Smart Creek	SMAR 21-01	9/10/2009	XS1	2481	xs1 u/s view
Smart Creek	SMAR 21-01	9/10/2009	XS1	2482	xs2 from rb
Smart Creek	SMAR 21-01	9/10/2009	XS1	2483	xs2 u/s view
Smart Creek	SMAR 21-01	9/10/2009	XS1	2484	xs3 from rb
Smart Creek	SMAR 21-01	9/10/2009	XS1	2485	xs3 u/s view

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Smart Creek	SMAR 21-01	9/10/2009	XS1	2486	xs4 from rb
Smart Creek	SMAR 21-01	9/10/2009	XS1	2487	xs4 u/s view
Smart Creek	SMAR 21-01	9/10/2009	XS1	2488	reach top, u/s view
Smart Creek	SMAR 21-01	9/10/2009	XS1	2489	reach top, d/s view
Smart Creek	SMAR 21-01	9/10/2009	XS1	2490	xs5 from rb
Smart Creek	SMAR 21-01	9/10/2009	XS1	2491	xs5 u/s view
Flint Creek	FLIN 17-01	9/11/2009	XS1	2492	reach bottom, u/s view (old)
Flint Creek	FLIN 17-01	9/11/2009	XS1	2493	reach bottom, d/s view (old)
Flint Creek	FLIN 17-01	9/11/2009	XS1	2494	reach bottom, u/s view (new)
Flint Creek	FLIN 17-01	9/11/2009	XS1	2495	reach bottom, d/s view (new)
Flint Creek	FLIN 17-01	9/11/2009	XS1	2496	xs1 from lb
Flint Creek	FLIN 17-01	9/11/2009	XS1	2497	xs1 u/s view
Flint Creek	FLIN 17-01	9/11/2009	XS1	2498	xs2 from lb
Flint Creek	FLIN 17-01	9/11/2009	XS1	2499	xs2 d/s view
Flint Creek	FLIN 17-01	9/11/2009	XS1	2500	reach top, u/s view
Flint Creek	FLIN 17-01	9/11/2009	XS1	2501	reach top, d/s view
Flint Creek	FLIN 17-01	9/11/2009	XS1	2502	xs5 from lb
Flint Creek	FLIN 17-01	9/11/2009	XS1	2503	xs5 u/s view
Flint Creek	FLIN 18-02	9/11/2009	XS1	2504	reach bottom, u/s view
Flint Creek	FLIN 18-02	9/11/2009	XS1	2505	reach bottom, d/s view
Flint Creek	FLIN 18-02	9/11/2009	XS1	2506	xs1 u/s view
Flint Creek	FLIN 18-02	9/11/2009	XS1	2507	xs1 from lb
Flint Creek	FLIN 18-02	9/11/2009	XS1	2508	xs3 from lb
Flint Creek	FLIN 18-02	9/11/2009	XS1	2509	xs3 u/s view
Flint Creek	FLIN 18-02	9/11/2009	XS1	2510	xs4 from lb
Flint Creek	FLIN 18-02	9/11/2009	XS1	2511	xs4 u/s view
Flint Creek	FLIN 18-02	9/11/2009	XS1	2512	xs5 from lb
Flint Creek	FLIN 18-02	9/11/2009	XS1	2513	xs5 u/s view
Flint Creek	FLIN 18-02	9/11/2009	XS1	2514	irrigation return
Flint Creek	FLIN 18-02	9/11/2009	XS1	2515	reach top, u/s view
Flint Creek	FLIN 18-02	9/11/2009	XS1	2516	reach top, d/s view
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2519	reach bottom, u/s view
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2520	reach bottom, d/s view
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2521	xs1 from lb
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2522	xs1 u/s view
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2523	xs2 from rb
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2524	xs2 d/s view
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2525	xs3 from lb
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2526	xs3 d/s view
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2527	xs4 from rb
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2528	xs4 u/s view
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2529	reach top, u/s view
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2530	reach top, d/s view
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2531	xs5 from lb
Douglas Creek (north)	DOUN 07-01	9/11/2009	XS1	2532	xs5 u/s view
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2533	reach bottom, u/s view

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2534	reach bottom, d/s view
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2535	xs1 from lb
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2536	xs1 u/s view
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2537	xs2 from lb
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2538	xs2 u/s view
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2539	xs3 from lb
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2540	xs3 d/s view
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2541	xs4 from rb
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2542	xs4 u/s view
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2543	xs5 from lb
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2544	xs5 d/s view
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2545	reach top, u/s view
Douglas Creek (north)	DOUN 08-02	9/14/2009	XS1	2546	reach top, d/s view
Flint Creek	FLIN 11-04	9/14/2009	XS1	2547	reach bottom, u/s view
Flint Creek	FLIN 11-04	9/14/2009	XS1	2548	reach bottom, d/s view
Flint Creek	FLIN 11-04	9/14/2009	XS1	2549	xs1 from rb
Flint Creek	FLIN 11-04	9/14/2009	XS1	2550	xs1 u/s view
Flint Creek	FLIN 11-04	9/14/2009	XS1	2551	xs2 from rb
Flint Creek	FLIN 11-04	9/14/2009	XS1	2552	xs2 u/s view
Flint Creek	FLIN 11-04	9/14/2009	XS1	2553	xs3 from rb
Flint Creek	FLIN 11-04	9/14/2009	XS1	2554	xs3 u/s view
Flint Creek	FLIN 11-04	9/14/2009	XS1	2555	reach top, u/s view
Flint Creek	FLIN 11-04	9/14/2009	XS1	2556	reach top, d/s view
Flint Creek	FLIN 11-01	9/14/2009	XS1	2557	reach bottom, u/s view
Flint Creek	FLIN 11-01	9/14/2009	XS1	2558	reach bottom, d/s view
Flint Creek	FLIN 11-01	9/14/2009	XS1	2559	xs1 from rb
Flint Creek	FLIN 11-01	9/14/2009	XS1	2560	xs1 u/s view
Flint Creek	FLIN 11-01	9/14/2009	XS1	2561	xs2 from rb
Flint Creek	FLIN 11-01	9/14/2009	XS1	2562	xs2 u/s view
Flint Creek	FLIN 11-01	9/14/2009	XS1	2563	xs3 from rb
Flint Creek	FLIN 11-01	9/14/2009	XS1	2564	xs3 u/s view
Flint Creek	FLIN 11-01	9/14/2009	XS1	2565	xs5 from rb
Flint Creek	FLIN 11-01	9/14/2009	XS1	2566	xs5 u/s view
Flint Creek	FLIN 11-01	9/14/2009	XS1	2567	reach top, u/s view
Flint Creek	FLIN 11-01	9/14/2009	XS1	2568	reach top, d/s view
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2569	reach bottom, u/s view
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2570	reach bottom, d/s view
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2571	xs1 from lb
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2572	xs1 u/s view
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2573	xs2 from rb
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2574	xs2 u/s view
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2575	xs3 from rb
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2576	xs3 u/s view
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2577	xs4 from rb
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2578	xs4 u/s view
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2579	reach top, u/s view

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2580	reach top, d/s view
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2581	xs5 from rb
Lower Willow Creek	LOWI 02-05	9/15/2009	XS1	2582	xs5 u/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2583	reach bottom, d/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2584	reach bottom, u/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2585	xs1 from lb
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2586	xs1 u/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2587	xs2 main channel from lb
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2588	xs2 main channel u/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2589	xs2 side channel from rb
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2590	xs2 side channel u/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2591	xs3 from lb
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2592	xs3 u/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2593	xs4 from rb
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2594	xs4 u/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2595	reach top, u/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2596	reach top, d/s view
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2597	xs5 from rb
Boulder Creek	BOUL 21-02	9/15/2009	XS1	2598	xs5 u/s view
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2599	reach bottom, u/s view
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2600	reach bottom, d/s view
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2601	xs1 from rb
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2602	xs1 u/s view
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2603	xs2 from lb
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2604	xs2 u/s view
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2605	xs3 u/s view
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2606	xs3 from lb
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2607	xs4 from lb
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2608	xs4 u/s view
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2609	reach top, u/s view
Boulder Creek	BOUL 16-01	9/15/2009	XS1	2610	reach top, d/s view
Flint Creek	FLIN 09-02	9/16/2009	XS1	2613	reach bottom, u/s view
Flint Creek	FLIN 09-02	9/16/2009	XS1	2614	reach bottom, d/s view
Flint Creek	FLIN 09-02	9/16/2009	XS1	2615	xs1 from rb
Flint Creek	FLIN 09-02	9/16/2009	XS1	2616	xs1 d/s view
Flint Creek	FLIN 09-02	9/16/2009	XS1	2617	xs2 from rb
Flint Creek	FLIN 09-02	9/16/2009	XS1	2618	xs2 u/s view
Flint Creek	FLIN 09-02	9/16/2009	XS1	2619	xs3 from rb
Flint Creek	FLIN 09-02	9/16/2009	XS1	2620	xs3 u/s view
Flint Creek	FLIN 09-02	9/16/2009	XS1	2621	xs4 from lb
Flint Creek	FLIN 09-02	9/16/2009	XS1	2622	xs4 d/s view
Flint Creek	FLIN 09-02	9/16/2009	XS1	2623	xs5 from lb
Flint Creek	FLIN 09-02	9/16/2009	XS1	2624	xs5 u/s view
Flint Creek	FLIN 09-02	9/16/2009	XS1	2625	reach top, u/s view
Flint Creek	FLIN 09-02	9/16/2009	XS1	2626	reach top, d/s view
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	45	reach bottom, u/s view

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	46	reach bottom, d/s view
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	47	xs1 from rb
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	48	xs1 u/s view
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	49	xs2 from rb
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	50	xs2 u/s view
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	51	xs3 from rb
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	52	xs3 u/s view
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	53	xs4 from rb
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	54	xs4 u/s view
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	55	xs5 from rb
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	56	xs5 u/s view
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	57	reach top, u/s view
Fred Burr Creek	FRED 29-02	9/16/2009	XS2	58	reach top, d/s view
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	59	reach bottom, u/s view
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	60	reach bottom, d/s view
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	61	xs1 from rb
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	62	xs1 u/s view
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	63	xs2 from rb
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	64	xs2 u/s view
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	65	xs3 from rb
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	66	xs3 u/s view
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	67	xs4 from rb
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	68	xs4 u/s view
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	69	xs5 from rb
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	70	xs5 u/s view
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	71	reach top, u/s view
Douglas Creek (south)	DOUS 09-02	9/16/2009	XS2	72	reach top, d/s view
Flint Creek	FLIN 06-01	9/16/2009	XS2	73	reach bottom, u/s view
Flint Creek	FLIN 06-01	9/16/2009	XS2	74	reach bottom, d/s view
Flint Creek	FLIN 06-01	9/16/2009	XS2	75	xs1 from rb
Flint Creek	FLIN 06-01	9/16/2009	XS2	76	xs1 u/s view
Flint Creek	FLIN 06-01	9/16/2009	XS2	77	xs2 from rb
Flint Creek	FLIN 06-01	9/16/2009	XS2	78	xs2 d/s view
Flint Creek	FLIN 06-01	9/16/2009	XS2	79	xs3 from rb
Flint Creek	FLIN 06-01	9/16/2009	XS2	80	xs3 u/s view
Flint Creek	FLIN 06-01	9/16/2009	XS2	81	xs4 from rb
Flint Creek	FLIN 06-01	9/16/2009	XS2	82	xs4 d/s view
Flint Creek	FLIN 06-01	9/16/2009	XS2	83	reach top, u/s view
Flint Creek	FLIN 06-01	9/16/2009	XS2	84	reach top, d/s view
Trout Creek	TROU 09-03	9/17/2009	XS2	85	reach bottom, d/s view
Trout Creek	TROU 09-03	9/17/2009	XS2	86	reach bottom, u/s view
Trout Creek	TROU 09-03	9/17/2009	XS2	87	xs1 from lb
Trout Creek	TROU 09-03	9/17/2009	XS2	88	xs1 d/s view
Trout Creek	TROU 09-03	9/17/2009	XS2	89	xs2 from lb
Trout Creek	TROU 09-03	9/17/2009	XS2	90	xs2 d/s view
Trout Creek	TROU 09-03	9/17/2009	XS2	91	xs3 from lb

Table C-1. Photo log.

Stream	Reach ID	Date	Camera	Photo #	Description
Trout Creek	TROU 09-03	9/17/2009	XS2	92	xs3 d/s view
Trout Creek	TROU 09-03	9/17/2009	XS2	93	xs4 from lb
Trout Creek	TROU 09-03	9/17/2009	XS2	94	xs4 d/s view
Trout Creek	TROU 09-03	9/17/2009	XS2	95	xs5 from lb
Trout Creek	TROU 09-03	9/17/2009	XS2	96	xs5 d/s view
Trout Creek	TROU 09-03	9/17/2009	XS2	97	reach top, u/s view
Trout Creek	TROU 09-03	9/17/2009	XS2	98	reach top, d/s view
Trout Creek	TROU 10-01	9/17/2009	XS2	99	reach bottom, d/s view
Trout Creek	TROU 10-01	9/17/2009	XS2	100	reach bottom, u/s view
Trout Creek	TROU 10-01	9/17/2009	XS2	101	xs1 from lb
Trout Creek	TROU 10-01	9/17/2009	XS2	102	xs1 d/s view
Trout Creek	TROU 10-01	9/17/2009	XS2	103	xs2 from rb
Trout Creek	TROU 10-01	9/17/2009	XS2	104	xs2 d/s view
Trout Creek	TROU 10-01	9/17/2009	XS2	105	xs3 from rb
Trout Creek	TROU 10-01	9/17/2009	XS2	106	xs3 u/s view
Trout Creek	TROU 10-01	9/17/2009	XS2	107	xs4 from rb
Trout Creek	TROU 10-01	9/17/2009	XS2	108	xs4 d/s view
Trout Creek	TROU 10-01	9/17/2009	XS2	109	xs5 from lb
Trout Creek	TROU 10-01	9/17/2009	XS2	110	xs5 u/s view
Trout Creek	TROU 10-01	9/17/2009	XS2	111	reach top, u/s view
Trout Creek	TROU 10-01	9/17/2009	XS2	112	reach top, d/s view

ATTACHMENT D – Quality Assurance/Quality Control Review

General Description of Field Activities

Sediment and habitat monitoring was conducted in the Flint Creek TMDL Planning Area in the summer of 2009. Two separate field visits were conducted as part of this assessment. On August 11-12, 2009, a field reconnaissance crew consisting of Jim Bond (DEQ), John Babcock and Josh Vincent (Water & Environmental Technologies) conducted site visits of potential field assessment sites which were previously identified using aerial photography and GIS. Sites were inspected for their sampling feasibility and ability to gain access to private property. On September 8-18, 2009, a sediment and habitat field crew consisting of Jim Bond, Steve Cook, and Christina Staten (DEQ), and Josh Vincent, John Trudnowski, John Babcock, and Ty DeBoo (Water & Environmental Technologies) conducted field assessments on 24 stream reaches according to the Sampling and Analysis Plan prepared for this project.

Field Variance from SAP

During the field assessments, all primary sites identified during field reconnaissance were evaluated with the exception of sites BARN 12-01, DOUS 14-01, and SMAR 17-01. Secondary site BARN 11-01 was evaluated instead of BARN 12-01 to provide greater spatial coverage of Barnes Creek. Access to private land could not be gained for DOUS 14-01 nor for any suitable alternative sites. SMAR 17-01 was not evaluated; instead, SMAR 18-01 was divided into two 500’ paired reaches (SMAR 18-01-1 and SMAR 18-01-2) to evaluate differences between fenced and unfenced sections within a similar landscape.

Data Adjustments

The following table provides adjustments made to the field data during data entry and analysis. During the field component of this project, several parameters were erroneously omitted from the data entry forms, and in these cases, field values were later estimated from photos.

Table D-1. Data adjustments.

Reach	Location	Parameter	Original Value	Adjusted Value	Rationale
BARN 13-01	Bank 2	bank height	not included	2.0’	estimated from photos
DOUN 08-02	Cell 3, Pool 4	maximum depth	not included	1.0’	estimated from photos
DOUN 08-02	Station 650	riparian buffer width	not included	0’	estimated from photos
FLIN 09-02	Cell 5	floodprone distance	not included	10’ on LB 150’ on RB	estimated from photos
FLIN 18-02	Cell 4	RB floodprone distance	not included	20’	estimated from photos
SMAR 13-01	Cell 3, Pool 6	pool length	not included	6’	estimated from photos

ATTACHMENT B – FLINT CREEK WATERSHED SEDIMENT ASSESSMENT: UPLAND SEDIMENT ASSESSMENT AND MODELING AND BMP EFFECTIVENESS AND PERCENT REDUCTION POTENTIAL

ERRATA SHEET FOR THE FLINT CREEK WATERSHED SEDIMENT ASSESSMENT: UPLAND SEDIMENT ASSESSMENT AND MODELING AND BMP EFFECTIVENESS AND PERCENT REDUCTION POTENTIAL

The public comment period for the Draft Flint Creek Planning Area Sediment and Metals TMDLs and Framework Water Quality Improvement Plan occurred from February 17th, 2012 to April 2nd, 2012. During that time the DEQ received a number of comments on information presented within that document. The report Flint Creek Watershed Sediment Assessment : Upland Sediment Assessment and Modeling And BMP Effectiveness and Percent Reduction Potential was included in the TMDL document as Attachment B, and served as the basis for the upland sediment load quantification. One comment in particular called to question the attribution of land as "Cultivated Crops" throughout the Flint watershed. Based on their review, the acreage attributed to Cultivated Crops was significantly in error. As a result of this comment, a review was conducted and it was determined that acreage described as Cultivated Crops, was by and large incorrect, and should have been attributed as "Pasture/Hay". This errata sheet presents revised tables where acreage previously attributed to Cultivated Crops has been converted to Pasture/Hay. For each subwatershed, the loading rate from the original Pasture/Hay category was applied to the Cultivated Crops to simulate that land use as Pasture/Hay, and calculate the corresponding sediment load. This was done for both existing and BMP scenarios. The tables below reflect these changes in loads and percent reductions and should be used in lieu of the original document tables.

Table 2-1. Land-Use Types Present in the Flint Creek Watershed.

Land-Use Type	Area (acres)	Percent
Barren Land (Rock/Sand/Clay)	92.76	0.0%
~~Cultivated Crops~~*	~~16662.05~~*	~~5.4%~~*
Deciduous Forest	20.26	0.0%
Developed, Low Intensity	782.98	0.3%
Developed, Medium Intensity	58.98	0.0%
Developed, High Intensity	5.24	0.0%
Developed, Open Space	3512.65	1.1%
Evergreen Forest	159659.61	51.8%
Grasslands/Herbaceous	53786.34	17.4%
Mixed Forest	2.69	0.0%
Open Water	3243.28	1.1%
Pasture/Hay	31865.37	10.3%
Shrub/Scrub	53844.24	17.5%
Woody Wetlands	1519.83	0.5%
Total	**308424.26**	**100.0%**

* Added to Pasture/Hay totals

Table 3-1. Base Results of the USLE Model for the Flint Creek Watershed.								
Sub-Watershed	**Land Use Type**	**Area (acres)**	**Percent of Watershed**	**Existing Conditions Load (Tons/Year)**	**Existing Conditions Load (Tons/Acre/Year)**	**Desired Conditions Load (Tons/Year)**	**Desired Conditions Load (Tons/Acre/Year)**	**Percent Reduction from Existing to Desired**
Barnes Creek	Cultivated Crops*	725	7%	17.10	0.02	11.12	0.02	35%
	Developed, Low Intensity	6	0%	0.04	0.01	0.04	0.01	0%
	Developed, Open Space	172	2%	1.50	0.01	1.50	0.01	0%
	Evergreen Forest	2015	20%	77.25	0.04	77.25	0.04	0%
	Grasslands/ Herbaceous	4589	45%	564.64	0.12	470.53	0.10	17%
	Pasture/Hay	645	6%	15.21	0.02	9.89	0.02	35%
	Shrub/Scrub	2096	20%	631.65	0.30	489.53	0.23	22%
	Woody Wetlands	49	0%	0.79	0.02	0.79	0.02	0%
	Total Sub-Watershed	**10298**	**100%**	**1308.17**	**0.13**	**1060.64**	**0.10**	**19%**
Boulder Creek	Barren Land	72	0%	0.22	0.00	0.22	0.00	0%
	Cultivated Crops*	3	0%	0.00	0.00	0.00	0.00	-
	Developed, Low Intensity	22	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	24	0%	0.14	0.01	0.14	0.01	0%
	Evergreen Forest	39068	92%	732.95	0.02	732.95	0.02	0%
	Grasslands/ Herbaceous	555	1%	51.95	0.09	43.29	0.08	17%
	Open Water	71	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	28	0%	0.96	0.03	0.62	0.02	35%
	Shrub/Scrub	2352	6%	406.31	0.17	314.89	0.13	23%
	Woody Wetlands	45	0%	0.33	0.01	0.33	0.01	0%
	Total Sub-Watershed	**42240**	**100%**	**1192.86**	**0.03**	**1092.45**	**0.03**	**8%**
Douglas Creek North	Cultivated Crops*	27	0%	0.59	0.02	0.38	0.01	35%
	Developed, Low Intensity	2	0%	0.00	0.00	0.00	0.00	0%
	Developed, Med. Intensity	1	0%	0.01	0.01	0.01	0.01	0%
	Developed, Open Space	75	1%	4.24	0.06	4.24	0.06	0%
	Evergreen Forest	5122	55%	194.84	0.04	194.84	0.04	0%
	Grasslands/ Herbaceous	2086	22%	313.68	0.15	261.40	0.13	17%
	Open Water	3	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	65	1%	1.41	0.02	0.92	0.01	35%
	Shrub/Scrub	1992	21%	549.40	0.28	425.79	0.21	22%
	Woody Wetlands	2	0%	0.01	0.00	0.01	0.00	0%
	Total Sub-Watershed	**9376**	**100%**	**1064.18**	**0.11**	**887.58**	**0.09**	**17%**

Douglas Creek-Philipsburg	Barren Land	3	0%	0.00	0.00	0.00	0.00	0%
	Cultivated Crops*	57	1%	0.11	0.00	0.07	0.00	35%
	Developed, High Intensity	1	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	28	1%	0.07	0.00	0.07	0.00	0%
	Developed, Med. Intensity	7	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	109	3%	1.82	0.02	1.82	0.02	0%
	Evergreen Forest	3382	83%	37.67	0.01	37.67	0.01	0%
	Grasslands/ Herbaceous	85	2%	8.73	0.10	7.28	0.09	17%
	Pasture/Hay	47	1%	0.09	0.00	0.06	0.00	35%
	Shrub/Scrub	378	9%	54.43	0.14	42.19	0.11	22%
	Total Sub-Watershed	**4096**	**100%**	**102.93**	**0.03**	**89.16**	**0.02**	**13%**
Fred Burr Creek	Barren Land	2	0%	0.00	0.00	0.00	0.00	-
	Cultivated Crops*	68	1%	1.76	0.03	1.14	0.02	35%
	Developed, Low Intensity	6	0%	0.01	0.00	0.01	0.00	0%
	Developed, Open Space	33	0%	0.19	0.01	0.19	0.01	0%
	Evergreen Forest	9218	92%	113.01	0.01	113.01	0.01	0%
	Grasslands/ Herbaceous	128	1%	4.47	0.03	3.73	0.03	17%
	Open Water	140	1%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	63	1%	1.61	0.03	1.05	0.02	35%
	Shrub/Scrub	329	3%	30.66	0.09	23.76	0.07	22%
	Woody Wetlands	65	1%	0.51	0.01	0.51	0.01	0%
	Total Sub-Watershed	**10053**	**100%**	**152.22**	**0.02**	**143.40**	**0.01**	**6%**
Georgetown Lake	Barren Land	4	0%	0.03	0.01	0.03	0.01	0%
	Cultivated Crops*	16	0%	0.92	0.06	0.37	0.02	35%
	Deciduous Forest	4	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	17	0%	0.20	0.01	0.20	0.01	0%
	Developed, Med. Intensity	4	0%	0.18	0.04	0.18	0.04	0%
	Developed, Open Space	105	0%	1.06	0.01	1.06	0.01	0%
	Evergreen Forest	15767	72%	125.93	0.01	125.93	0.01	0%
	Grasslands/ Herbaceous	959	4%	38.40	0.04	32.00	0.03	17%
	Open Water	2877	13%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	15	0%	0.84	0.06	0.54	0.04	35%
	Shrub/Scrub	1983	9%	126.84	0.06	98.30	0.05	22%
	Woody Wetlands	24	0%	0.03	0.00	0.03	0.00	0%
	Total Sub-Watershed	**21776**	**100%**	**294.41**	**0.01**	**258.86**	**0.01**	**12%**

Lower Flint Creek	Barren Land	9	0%	0.00	0.00	0.00	0.00	0%
	Cultivated Crops*	6886	17%	84.17	0.01	54.71	0.01	35%
	Deciduous Forest	6	0%	0.01	0.00	0.01	0.00	0%
	Developed, Low Intensity	258	1%	0.17	0.00	0.17	0.00	0%
	Developed, Med. Intensity	8	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	992	2%	3.26	0.00	3.26	0.00	0%
	Evergreen Forest	5282	13%	158.40	0.03	158.40	0.03	0%
	Grasslands/ Herbaceous	13659	34%	2314.75	0.17	1928.96	0.14	17%
	Mixed Forest	1	0%	0.00	0.00	0.00	0.00	68%
	Open Water	4	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	5642	14%	68.96	0.01	44.82	0.01	35%
	Shrub/Scrub	7108	18%	1830.75	0.26	1418.83	0.20	23%
	Woody Wetlands	572	1%	3.25	0.01	3.25	0.01	0%
	Total Sub-Watershed	**40427**	**100%**	**4463.71**	**0.11**	**3612.41**	**0.09**	**19%**
Lower Willow Creek	Cultivated Crops*	2900	13%	74.27	0.03	48.27	0.02	35%
	Deciduous Forest	4	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	22	0%	0.01	0.00	0.01	0.00	0%
	Developed, Open Space	302	1%	1.45	0.00	1.45	0.00	0%
	Evergreen Forest	2555	12%	24.41	0.01	24.41	0.01	0%
	Grasslands/ Herbaceous	8354	39%	1217.10	0.15	1014.25	0.12	17%
	Open Water	134	1%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	1810	8%	46.37	0.03	30.14	0.02	35%
	Shrub/Scrub	5322	25%	896.94	0.17	695.13	0.13	23%
	Woody Wetlands	108	1%	0.47	0.00	0.47	0.00	0%
	Total Sub-Watershed	**21511**	**100%**	**2261.01**	**0.11**	**1814.13**	**0.08**	**20%**
Middle Flint Creek	Cultivated Crops*	2796	6%	59.50	0.02	38.68	0.01	35%
	Developed, High Intensity	4	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	306	1%	1.10	0.00	1.10	0.00	0%
	Developed, Med. Intensity	32	0%	0.01	0.00	0.01	0.00	0%
	Developed, Open Space	971	2%	7.98	0.01	7.98	0.01	0%
	Evergreen Forest	21036	43%	600.22	0.03	600.22	0.03	0%
	Grasslands/ Herbaceous	9693	20%	1790.51	0.18	1492.09	0.15	17%
	Mixed Forest	2	0%	0.00	0.00	0.00	0.00	-
	Open Water	12	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	2853	6%	60.72	0.02	39.47	0.01	35%
	Shrub/Scrub	10645	22%	3740.73	0.35	2899.07	0.27	22%
	Woody Wetlands	348	1%	4.25	0.01	4.25	0.01	0%

	Total Sub-Watershed	**48696**	**100%**	**6265.02**	**0.13**	**5082.86**	**0.10**	**19%**
Princeton Gulch	Evergreen Forest	2819	96%	131.56	0.05	131.56	0.05	0%
	Grasslands/ Herbaceous	8	0%	1.63	0.22	1.36	0.18	17%
	Shrub/Scrub	110	4%	135.15	1.23	104.74	0.95	23%
	Total Sub-Watershed	**2937**	**100%**	**268.34**	**0.09**	**237.66**	**0.08**	**11%**
Smart Creek	Barren Land	4	0%	0.01	0.00	0.01	0.00	0%
	Cultivated Crops*	221	1%	7.38	0.03	4.79	0.02	35%
	Developed, Low Intensity	3	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	46	0%	0.25	0.01	0.25	0.01	0%
	Evergreen Forest	9321	60%	218.55	0.02	218.55	0.02	0%
	Grasslands/ Herbaceous	1774	11%	212.29	0.12	176.91	0.10	17%
	Pasture/Hay	203	1%	6.77	0.03	4.40	0.02	35%
	Shrub/Scrub	4015	26%	1051.10	0.26	814.61	0.20	22%
	Woody Wetlands	38	0%	0.23	0.01	0.23	0.01	0%
	Total Sub-Watershed	**15626**	**100%**	**1496.59**	**0.10**	**1219.76**	**0.08**	**18%**
Trout Creek	Cultivated Crops*	2064	9%	90.10	0.04	58.56	0.03	35%
	Developed, Low Intensity	40	0%	0.08	0.00	0.08	0.00	0%
	Developed, Open Space	325	1%	2.71	0.01	2.71	0.01	0%
	Evergreen Forest	5890	26%	21.85	0.00	21.85	0.00	0%
	Grasslands/ Herbaceous	5212	23%	1022.73	0.20	852.27	0.16	17%
	Open Water	2	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	2718	12%	118.63	0.04	77.11	0.03	35%
	Shrub/Scrub	6260	28%	1852.35	0.30	1435.57	0.23	22%
	Woody Wetlands	49	0%	0.82	0.02	0.82	0.02	0%
	Total Sub-Watershed	**22560**	**100%**	**3109.26**	**0.14**	**2448.97**	**0.11**	**21%**
Upper Flint Creek	Cultivated Crops*	713	5%	9.44	0.01	6.13	0.01	35%
	Developed, Low Intensity	67	0%	0.10	0.00	0.10	0.00	0%
	Developed, Med. Intensity	2	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	353	3%	2.09	0.01	2.09	0.01	0%
	Evergreen Forest	9028	66%	50.26	0.01	50.26	0.01	0%
	Grasslands/ Herbaceous	945	7%	140.56	0.15	117.13	0.12	17%
	Pasture/Hay	1004	7%	13.30	0.01	8.64	0.01	35%
	Shrub/Scrub	1506	11%	134.52	0.09	104.25	0.07	23%
	Woody Wetlands	69	1%	0.57	0.01	0.57	0.01	0%
	Total Sub-Watershed	**13687**	**100%**	**350.84**	**0.03**	**289.19**	**0.02**	**18%**

Upper Willow Creek	Cultivated Crops*	196	0%	6.72	0.03	4.37	0.02	35%
	Deciduous Forest	5	0%	0.00	0.00	0.00	0.00	-
	Evergreen Forest	29213	65%	851.54	0.03	851.54	0.03	0%
	Grasslands/ Herbaceous	5735	13%	829.06	0.14	690.88	0.12	17%
	Pasture/Hay	153	0%	5.27	0.03	3.42	0.02	35%
	Shrub/Scrub	9726	22%	3440.31	0.35	2666.24	0.27	22%
	Woody Wetlands	152	0%	0.77	0.01	0.77	0.01	0%
	Total Sub-Watershed	**45180**	**100%**	**5133.67**	**0.11**	**4217.23**	**0.09**	**18%**
Total Flint Creek Watershed		**308461**	**100%**	**27463.23**	**0.089**	**22454.29**	**0.07**	**18%**

*Cultivated Crops treated as Pasture/Hay. Loading rates mirror that of Pasture/Hay.

Table 3-2. Results of the USLE Model with Riparian Health Incorporation.

Sub-Watershed	Existing Condition Load (tons/yr)	Desired Condition Load (tons/yr)	Scenario 1		Scenario 2		Scenario 3		Total Load Reduction with use of Upland and Riparian BMPs
			Existing Upland Load with Existing Riparian Condition (tons/yr)	Percent Load Reduction with use of Riparian Condition	Desired Upland Load with Existing Riparian Condition (tons/yr)	Percent Load Reduction with use of Upland BMPs	Desired Upland Load with Improved Riparian Health (tons/yr)	Percent Load Reduction with use of Riparian BMPs	
Barnes Creek	1308.17	1060.64	605	54%	491	19%	265	46%	56%
Boulder Creek	1192.86	1092.45	494	59%	452	8%	279	38%	44%
Douglas Creek - North	1064.18	887.58	535	50%	446	17%	244	45%	54%
Douglas Creek-	102.93	89.16	58	44%	50	13%	34	33%	42%
Fred Burr	155.22	143.40	61	61%	57	8%	36	36%	41%
Georgetown Lake	294.41	258.86	146	50%	129	12%	74	42%	49%
Lower Flint	4463.71	3612.41	2276	49%	1842	19%	948	49%	58%
Lower Willow Creek	2261.01	1814.13	1121	50%	900	20%	467	48%	58%
Middle Flint Creek	6265.02	5082.86	3195	49%	2592	19%	1334	49%	58%
Princeton	268.34	237.66	124	54%	110	11%	62	44%	50%
Smart Creek	1496.59	1219.76	685	54%	558	18%	305	45%	55%
Trout Creek	3109.26	2448.97	1555	50%	1224	21%	612	50%	61%
Upper Flint	350.84	289.19	179	49%	147	18%	76	49%	58%
Upper Willow Creek	5133.67	4217.23	2554	50%	2098	18%	1212	42%	53%
Total Watershed	**27463.23**	**22454.29**	**15104**	**50%**	**11171**	**18%**	**6456**	**42%**	**53%**

ATTACHMENT B – FLINT CREEK WATERSHED SEDIMENT ASSESSMENT: UPLAND SEDIMENT ASSESSMENT AND MODELING AND BMP EFFECTIVENESS AND PERCENT REDUCTION POTENTIAL

ERRATA SHEET FOR THE FLINT CREEK WATERSHED SEDIMENT ASSESSMENT: UPLAND SEDIMENT ASSESSMENT AND MODELING AND BMP EFFECTIVENESS AND PERCENT REDUCTION POTENTIAL

The public comment period for the Draft Flint Creek Planning Area Sediment and Metals TMDLs and Framework Water Quality Improvement Plan occurred from February 17th, 2012 to April 2nd, 2012. During that time the DEQ received a number of comments on information presented within that document. The report Flint Creek Watershed Sediment Assessment : Upland Sediment Assessment and Modeling And BMP Effectiveness and Percent Reduction Potential was included in the TMDL document as Attachment B, and served as the basis for the upland sediment load quantification. One comment in particular called to question the attribution of land as "Cultivated Crops" throughout the Flint watershed. Based on their review, the acreage attributed to Cultivated Crops was significantly in error. As a result of this comment, a review was conducted and it was determined that acreage described as Cultivated Crops, was by and large incorrect, and should have been attributed as "Pasture/Hay". This errata sheet presents revised tables where acreage previously attributed to Cultivated Crops has been converted to Pasture/Hay. For each subwatershed, the loading rate from the original Pasture/Hay category was applied to the Cultivated Crops to simulate that land use as Pasture/Hay, and calculate the corresponding sediment load. This was done for both existing and BMP scenarios. The tables below reflect these changes in loads and percent reductions and should be used in lieu of the original document tables.

Table 2-1. Land-Use Types Present in the Flint Creek Watershed.

Land-Use Type	Area (acres)	Percent
Barren Land (Rock/Sand/Clay)	92.76	0.0%
~~Cultivated Crops~~*	~~16662.05~~*	~~5.4%~~*
Deciduous Forest	20.26	0.0%
Developed, Low Intensity	782.98	0.3%
Developed, Medium Intensity	58.98	0.0%
Developed, High Intensity	5.24	0.0%
Developed, Open Space	3512.65	1.1%
Evergreen Forest	159659.61	51.8%
Grasslands/Herbaceous	53786.34	17.4%
Mixed Forest	2.69	0.0%
Open Water	3243.28	1.1%
Pasture/Hay	31865.37	10.3%
Shrub/Scrub	53844.24	17.5%
Woody Wetlands	1519.83	0.5%
Total	**308424.26**	**100.0%**

* Added to Pasture/Hay totals

Table 3-1. Base Results of the USLE Model for the Flint Creek Watershed.								
Sub-Watershed	**Land Use Type**	**Area (acres)**	**Percent of Watershed**	**Existing Conditions Load (Tons/Year)**	**Existing Conditions Load (Tons/Acre/Year)**	**Desired Conditions Load (Tons/Year)**	**Desired Conditions Load (Tons/Acre/Year)**	**Percent Reduction from Existing to Desired**
Barnes Creek	Cultivated Crops*	725	7%	17.10	0.02	11.12	0.02	35%
	Developed, Low Intensity	6	0%	0.04	0.01	0.04	0.01	0%
	Developed, Open Space	172	2%	1.50	0.01	1.50	0.01	0%
	Evergreen Forest	2015	20%	77.25	0.04	77.25	0.04	0%
	Grasslands/ Herbaceous	4589	45%	564.64	0.12	470.53	0.10	17%
	Pasture/Hay	645	6%	15.21	0.02	9.89	0.02	35%
	Shrub/Scrub	2096	20%	631.65	0.30	489.53	0.23	22%
	Woody Wetlands	49	0%	0.79	0.02	0.79	0.02	0%
	Total Sub-Watershed	**10298**	**100%**	**1308.17**	**0.13**	**1060.64**	**0.10**	**19%**
Boulder Creek	Barren Land	72	0%	0.22	0.00	0.22	0.00	0%
	Cultivated Crops*	3	0%	0.00	0.00	0.00	0.00	-
	Developed, Low Intensity	22	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	24	0%	0.14	0.01	0.14	0.01	0%
	Evergreen Forest	39068	92%	732.95	0.02	732.95	0.02	0%
	Grasslands/ Herbaceous	555	1%	51.95	0.09	43.29	0.08	17%
	Open Water	71	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	28	0%	0.96	0.03	0.62	0.02	35%
	Shrub/Scrub	2352	6%	406.31	0.17	314.89	0.13	23%
	Woody Wetlands	45	0%	0.33	0.01	0.33	0.01	0%
	Total Sub-Watershed	**42240**	**100%**	**1192.86**	**0.03**	**1092.45**	**0.03**	**8%**
Douglas Creek North	Cultivated Crops*	27	0%	0.59	0.02	0.38	0.01	35%
	Developed, Low Intensity	2	0%	0.00	0.00	0.00	0.00	0%
	Developed, Med. Intensity	1	0%	0.01	0.01	0.01	0.01	0%
	Developed, Open Space	75	1%	4.24	0.06	4.24	0.06	0%
	Evergreen Forest	5122	55%	194.84	0.04	194.84	0.04	0%
	Grasslands/ Herbaceous	2086	22%	313.68	0.15	261.40	0.13	17%
	Open Water	3	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	65	1%	1.41	0.02	0.92	0.01	35%
	Shrub/Scrub	1992	21%	549.40	0.28	425.79	0.21	22%
	Woody Wetlands	2	0%	0.01	0.00	0.01	0.00	0%
	Total Sub-Watershed	**9376**	**100%**	**1064.18**	**0.11**	**887.58**	**0.09**	**17%**

Douglas Creek-Philipsburg	Barren Land	3	0%	0.00	0.00	0.00	0.00	0%
	Cultivated Crops*	57	1%	0.11	0.00	0.07	0.00	35%
	Developed, High Intensity	1	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	28	1%	0.07	0.00	0.07	0.00	0%
	Developed, Med. Intensity	7	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	109	3%	1.82	0.02	1.82	0.02	0%
	Evergreen Forest	3382	83%	37.67	0.01	37.67	0.01	0%
	Grasslands/ Herbaceous	85	2%	8.73	0.10	7.28	0.09	17%
	Pasture/Hay	47	1%	0.09	0.00	0.06	0.00	35%
	Shrub/Scrub	378	9%	54.43	0.14	42.19	0.11	22%
	Total Sub-Watershed	**4096**	**100%**	**102.93**	**0.03**	**89.16**	**0.02**	**13%**
Fred Burr Creek	Barren Land	2	0%	0.00	0.00	0.00	0.00	-
	Cultivated Crops*	68	1%	1.76	0.03	1.14	0.02	35%
	Developed, Low Intensity	6	0%	0.01	0.00	0.01	0.00	0%
	Developed, Open Space	33	0%	0.19	0.01	0.19	0.01	0%
	Evergreen Forest	9218	92%	113.01	0.01	113.01	0.01	0%
	Grasslands/ Herbaceous	128	1%	4.47	0.03	3.73	0.03	17%
	Open Water	140	1%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	63	1%	1.61	0.03	1.05	0.02	35%
	Shrub/Scrub	329	3%	30.66	0.09	23.76	0.07	22%
	Woody Wetlands	65	1%	0.51	0.01	0.51	0.01	0%
	Total Sub-Watershed	**10053**	**100%**	**152.22**	**0.02**	**143.40**	**0.01**	**6%**
Georgetown Lake	Barren Land	4	0%	0.03	0.01	0.03	0.01	0%
	Cultivated Crops*	16	0%	0.92	0.06	0.37	0.02	35%
	Deciduous Forest	4	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	17	0%	0.20	0.01	0.20	0.01	0%
	Developed, Med. Intensity	4	0%	0.18	0.04	0.18	0.04	0%
	Developed, Open Space	105	0%	1.06	0.01	1.06	0.01	0%
	Evergreen Forest	15767	72%	125.93	0.01	125.93	0.01	0%
	Grasslands/ Herbaceous	959	4%	38.40	0.04	32.00	0.03	17%
	Open Water	2877	13%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	15	0%	0.84	0.06	0.54	0.04	35%
	Shrub/Scrub	1983	9%	126.84	0.06	98.30	0.05	22%
	Woody Wetlands	24	0%	0.03	0.00	0.03	0.00	0%
	Total Sub-Watershed	**21776**	**100%**	**294.41**	**0.01**	**258.86**	**0.01**	**12%**

Lower Flint Creek	Barren Land	9	0%	0.00	0.00	0.00	0.00	0%
	Cultivated Crops*	6886	17%	84.17	0.01	54.71	0.01	35%
	Deciduous Forest	6	0%	0.01	0.00	0.01	0.00	0%
	Developed, Low Intensity	258	1%	0.17	0.00	0.17	0.00	0%
	Developed, Med. Intensity	8	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	992	2%	3.26	0.00	3.26	0.00	0%
	Evergreen Forest	5282	13%	158.40	0.03	158.40	0.03	0%
	Grasslands/ Herbaceous	13659	34%	2314.75	0.17	1928.96	0.14	17%
	Mixed Forest	1	0%	0.00	0.00	0.00	0.00	68%
	Open Water	4	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	5642	14%	68.96	0.01	44.82	0.01	35%
	Shrub/Scrub	7108	18%	1830.75	0.26	1418.83	0.20	23%
	Woody Wetlands	572	1%	3.25	0.01	3.25	0.01	0%
	Total Sub-Watershed	**40427**	**100%**	**4463.71**	**0.11**	**3612.41**	**0.09**	**19%**
Lower Willow Creek	Cultivated Crops*	2900	13%	74.27	0.03	48.27	0.02	35%
	Deciduous Forest	4	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	22	0%	0.01	0.00	0.01	0.00	0%
	Developed, Open Space	302	1%	1.45	0.00	1.45	0.00	0%
	Evergreen Forest	2555	12%	24.41	0.01	24.41	0.01	0%
	Grasslands/ Herbaceous	8354	39%	1217.10	0.15	1014.25	0.12	17%
	Open Water	134	1%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	1810	8%	46.37	0.03	30.14	0.02	35%
	Shrub/Scrub	5322	25%	896.94	0.17	695.13	0.13	23%
	Woody Wetlands	108	1%	0.47	0.00	0.47	0.00	0%
	Total Sub-Watershed	**21511**	**100%**	**2261.01**	**0.11**	**1814.13**	**0.08**	**20%**
Middle Flint Creek	Cultivated Crops*	2796	6%	59.50	0.02	38.68	0.01	35%
	Developed, High Intensity	4	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	306	1%	1.10	0.00	1.10	0.00	0%
	Developed, Med. Intensity	32	0%	0.01	0.00	0.01	0.00	0%
	Developed, Open Space	971	2%	7.98	0.01	7.98	0.01	0%
	Evergreen Forest	21036	43%	600.22	0.03	600.22	0.03	0%
	Grasslands/ Herbaceous	9693	20%	1790.51	0.18	1492.09	0.15	17%
	Mixed Forest	2	0%	0.00	0.00	0.00	0.00	-
	Open Water	12	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	2853	6%	60.72	0.02	39.47	0.01	35%
	Shrub/Scrub	10645	22%	3740.73	0.35	2899.07	0.27	22%
	Woody Wetlands	348	1%	4.25	0.01	4.25	0.01	0%

	Total Sub-Watershed	**48696**	**100%**	**6265.02**	**0.13**	**5082.86**	**0.10**	**19%**
Princeton Gulch	Evergreen Forest	2819	96%	131.56	0.05	131.56	0.05	0%
	Grasslands/ Herbaceous	8	0%	1.63	0.22	1.36	0.18	17%
	Shrub/Scrub	110	4%	135.15	1.23	104.74	0.95	23%
	Total Sub-Watershed	**2937**	**100%**	**268.34**	**0.09**	**237.66**	**0.08**	**11%**
Smart Creek	Barren Land	4	0%	0.01	0.00	0.01	0.00	0%
	Cultivated Crops*	221	1%	7.38	0.03	4.79	0.02	35%
	Developed, Low Intensity	3	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	46	0%	0.25	0.01	0.25	0.01	0%
	Evergreen Forest	9321	60%	218.55	0.02	218.55	0.02	0%
	Grasslands/ Herbaceous	1774	11%	212.29	0.12	176.91	0.10	17%
	Pasture/Hay	203	1%	6.77	0.03	4.40	0.02	35%
	Shrub/Scrub	4015	26%	1051.10	0.26	814.61	0.20	22%
	Woody Wetlands	38	0%	0.23	0.01	0.23	0.01	0%
	Total Sub-Watershed	**15626**	**100%**	**1496.59**	**0.10**	**1219.76**	**0.08**	**18%**
Trout Creek	Cultivated Crops*	2064	9%	90.10	0.04	58.56	0.03	35%
	Developed, Low Intensity	40	0%	0.08	0.00	0.08	0.00	0%
	Developed, Open Space	325	1%	2.71	0.01	2.71	0.01	0%
	Evergreen Forest	5890	26%	21.85	0.00	21.85	0.00	0%
	Grasslands/ Herbaceous	5212	23%	1022.73	0.20	852.27	0.16	17%
	Open Water	2	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	2718	12%	118.63	0.04	77.11	0.03	35%
	Shrub/Scrub	6260	28%	1852.35	0.30	1435.57	0.23	22%
	Woody Wetlands	49	0%	0.82	0.02	0.82	0.02	0%
	Total Sub-Watershed	**22560**	**100%**	**3109.26**	**0.14**	**2448.97**	**0.11**	**21%**
Upper Flint Creek	Cultivated Crops*	713	5%	9.44	0.01	6.13	0.01	35%
	Developed, Low Intensity	67	0%	0.10	0.00	0.10	0.00	0%
	Developed, Med. Intensity	2	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	353	3%	2.09	0.01	2.09	0.01	0%
	Evergreen Forest	9028	66%	50.26	0.01	50.26	0.01	0%
	Grasslands/ Herbaceous	945	7%	140.56	0.15	117.13	0.12	17%
	Pasture/Hay	1004	7%	13.30	0.01	8.64	0.01	35%
	Shrub/Scrub	1506	11%	134.52	0.09	104.25	0.07	23%
	Woody Wetlands	69	1%	0.57	0.01	0.57	0.01	0%
	Total Sub-Watershed	**13687**	**100%**	**350.84**	**0.03**	**289.19**	**0.02**	**18%**

Upper Willow Creek	Cultivated Crops*	196	0%	6.72	0.03	4.37	0.02	35%
	Deciduous Forest	5	0%	0.00	0.00	0.00	0.00	-
	Evergreen Forest	29213	65%	851.54	0.03	851.54	0.03	0%
	Grasslands/ Herbaceous	5735	13%	829.06	0.14	690.88	0.12	17%
	Pasture/Hay	153	0%	5.27	0.03	3.42	0.02	35%
	Shrub/Scrub	9726	22%	3440.31	0.35	2666.24	0.27	22%
	Woody Wetlands	152	0%	0.77	0.01	0.77	0.01	0%
	Total Sub-Watershed	**45180**	**100%**	**5133.67**	**0.11**	**4217.23**	**0.09**	**18%**
Total Flint Creek Watershed		**308461**	**100%**	**27463.23**	**0.089**	**22454.29**	**0.07**	**18%**

*Cultivated Crops treated as Pasture/Hay. Loading rates mirror that of Pasture/Hay.

Table 3-2. Results of the USLE Model with Riparian Health Incorporation.

Sub-Watershed	Existing Condition Load (tons/yr)	Desired Condition Load (tons/yr)	Scenario 1		Scenario 2		Scenario 3		Total Load Reduction with use of Upland and Riparian BMPs
			Existing Upland Load with Existing Riparian Condition (tons/yr)	Percent Load Reduction with use of Riparian Condition	Desired Upland Load with Existing Riparian Condition (tons/yr)	Percent Load Reduction with use of Upland BMPs	Desired Upland Load with Improved Riparian Health (tons/yr)	Percent Load Reduction with use of Riparian BMPs	
Barnes Creek	1308.17	1060.64	605	54%	491	19%	265	46%	56%
Boulder Creek	1192.86	1092.45	494	59%	452	8%	279	38%	44%
Douglas Creek - North	1064.18	887.58	535	50%	446	17%	244	45%	54%
Douglas Creek-	102.93	89.16	58	44%	50	13%	34	33%	42%
Fred Burr	155.22	143.40	61	61%	57	8%	36	36%	41%
Georgetown Lake	294.41	258.86	146	50%	129	12%	74	42%	49%
Lower Flint	4463.71	3612.41	2276	49%	1842	19%	948	49%	58%
Lower Willow Creek	2261.01	1814.13	1121	50%	900	20%	467	48%	58%
Middle Flint Creek	6265.02	5082.86	3195	49%	2592	19%	1334	49%	58%
Princeton	268.34	237.66	124	54%	110	11%	62	44%	50%
Smart Creek	1496.59	1219.76	685	54%	558	18%	305	45%	55%
Trout Creek	3109.26	2448.97	1555	50%	1224	21%	612	50%	61%
Upper Flint	350.84	289.19	179	49%	147	18%	76	49%	58%
Upper Willow Creek	5133.67	4217.23	2554	50%	2098	18%	1212	42%	53%
Total Watershed	**27463.23**	**22454.29**	**15104**	**50%**	**11171**	**18%**	**6456**	**42%**	**53%**

Flint Creek Watershed Sediment Assessment: Upland Sediment Assessment and Modeling and BMP Effectiveness and Percent Reduction Potential

Final Modeling Summary Report



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September 2010

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1.0 Introduction

This report presents results of the Flint Creek Watershed upland sediment modeling assessment. This upland sediment model was developed to provide Total Maximum Daily Load (TMDL) estimations of existing annual sediment loads from each of the various upland land cover/land use types in the watershed, and to estimate potential sediment reduction that may occur through land use changes and implementation of best management practices (BMPs) designed to improve upland land condition or riparian health.

Under Montana law, an impaired water body is defined as a water body for which sufficient and credible data indicates non-compliance with applicable water quality standards (MCA 75-5-103). Section 303 of the Federal Clean Water Act requires states to submit a list of impaired water bodies or stream segments to the U.S. Environmental Protection Agency (EPA) every two years. Prior to 2004, this list was referred to as the "303(d) list", but is now named the "Integrated Report". The Montana Water Quality Act further directs states to develop TMDLs for all water bodies appearing on the 303(d) list as impaired or threatened by "pollutants" (MCA 75-5-703). If sufficient credible data exists to support the sediment impairment determinations for the 1996 listed streams, then sediment TMDLs will be developed. If sufficient data does not exist, then data will be collected to confirm or deny the 1996 listings and TMDLs will be developed for all streams determined to be impaired. In 2009, Montana Department of Environmental Quality (DEQ) initiated an effort to collect data to support the development of sediment TMDLs for listed streams within the Flint Creek TMDL Planning Area (TPA). This included data collection efforts to estimate sediment delivery to streams from both streambank erosion and from upland sediment production, which is described within this report. The data provided in this report is intended to assist DEQ in evaluating the impairment status of tributary streams in the Flint Creek TPA and for developing TMDLs where necessary.

The Flint Creek TPA encompasses an area of approximately 500 square miles in southwestern Montana (**Figure 1-1**) and lies almost entirely in Granite County with a small portion in Deer Lodge County. The Flint Creek watershed originates in the Flint Creek Mountains to the east, the Pintlar Mountains to the south, and the Sapphire and John Long Mountains to the west. Flint Creek drains from Georgetown Lake and bisects two large agricultural valleys, the Philipsburg Valley and the Drummond Valley, which are separated by a narrow bedrock canyon. Flow in upper Flint Creek is primarily controlled by the outlet structure at Georgetown Lake, and flow is seasonally augmented by a trans-basin diversion from the East Fork of Rock Creek. Approximately 2,200 residents reside within the Flint Creek TPA, with Philipsburg (pop. 911) and Drummond (pop. 315) as the largest towns. Other population centers include Maxville and Hall. Land ownership in the Flint Creek TPA is primarily private and U.S. Forest Service (Beaverhead-Deer Lodge National Forest), with a small amount of land managed by Bureau of Land Management (BLM) and the State of Montana. Private lands are located predominantly in the lower elevation areas where wide, low-gradient valleys are conducive to agriculture and development. The land use of the Flint TPA is dominated by evergreen forest (52%), shrub/scrub land (17%), and grassland/herbaceous land (17%).

The 303(d) streams listed for sediment in the Flint Creek watershed include Barnes Creek, Douglas Creek (near Philipsburg), Smart Creek, and Flint Creek. For the purposes of this project,

the Flint Creek TPA was partitioned into smaller sub-watersheds in order to spatially evaluate upland sediment loading. The sub-watersheds evaluated in this study include Georgetown Lake, Upper Flint Creek, Trout Creek, Fred Burr Creek, Douglas Creek-Philipsburg, Middle Flint Creek, Boulder Creek, Princeton Gulch, Smart Creek, Lower Flint Creek, Douglas Creek-North, Upper Willow Creek, Lower Willow Creek, and Barnes Creek, as shown below in **Figure 1-2**.

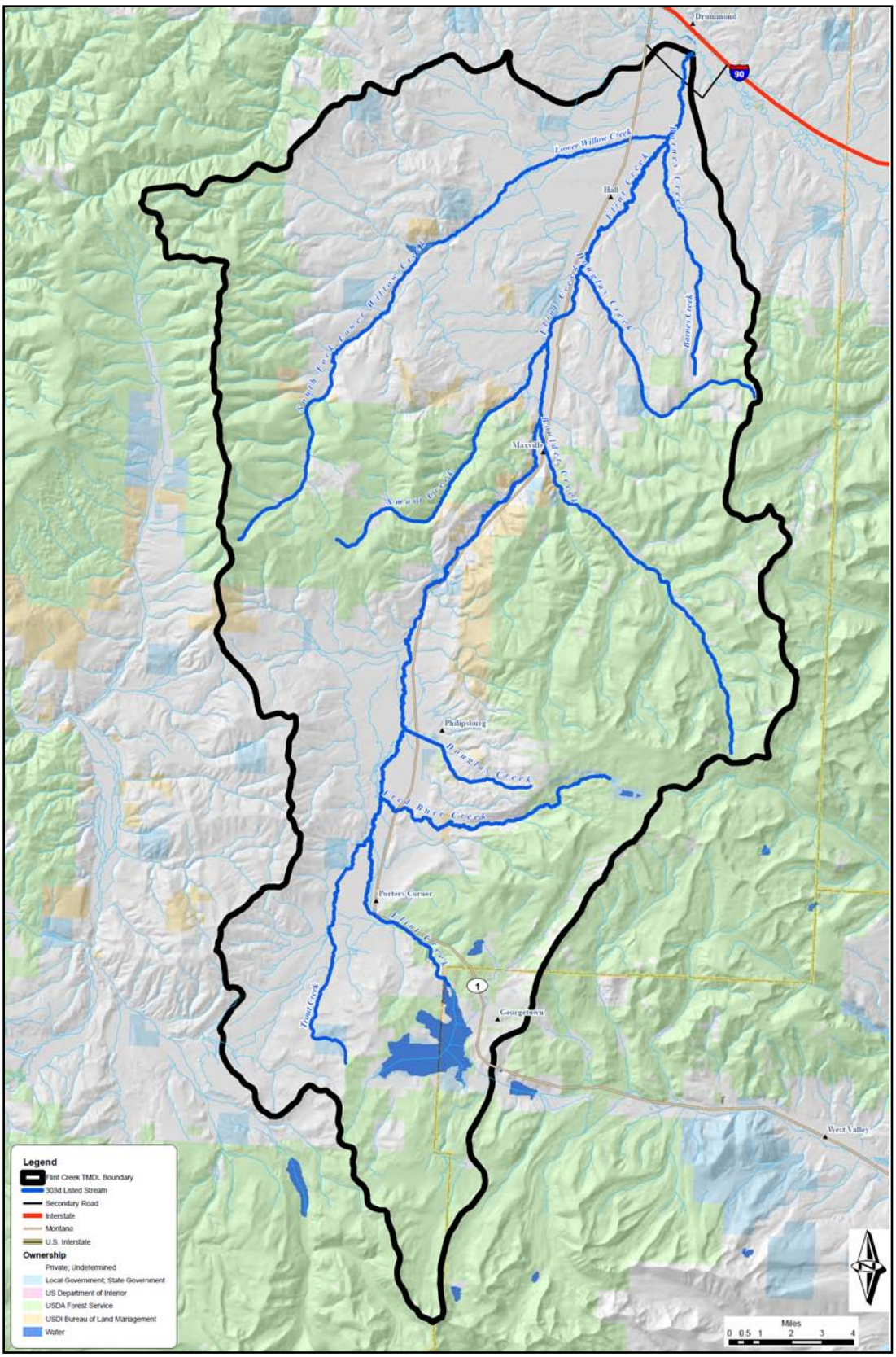


Figure 1-1. Flint Creek Watershed.

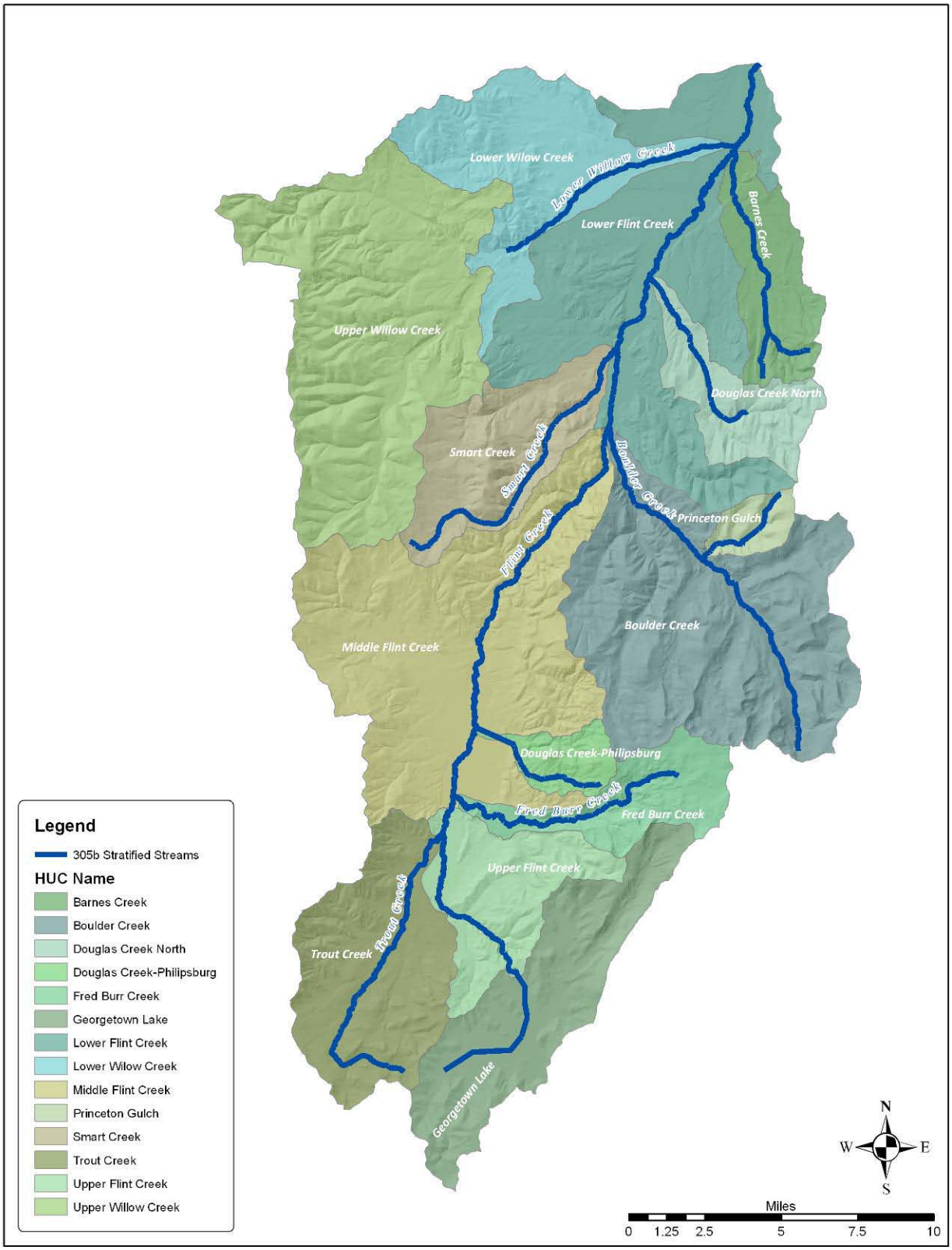


Figure 1-2. Sub-Basins of the Flint Creek Watershed.

2.0 Model Approach

Sediment delivery from upland erosion was modeled using a Universal Soil Loss Equation (USLE) based model. The USLE was originally developed by the USDA Agricultural Research Service based on data from agricultural plots under natural rainfall, and later incorporated data from simulated rainfall experiments to evaluate the effectiveness of conservation tillage and construction practices for controlling soil erosion. The USLE model was later refined to include non-agricultural settings, such as developed land, forests, and rangeland. For this modeling effort, the USLE was implemented as a watershed-scale, raster-based, GIS model using ArcView software. The USLE model requires five landscape factors which are combined to predict upland soil loss, including a rainfall factor (R), soil erodibility factor (K), length and slope factors (LS), a cropping factor (C), and a management practices factor (P). The general form of the USLE equation has been widely used for upland sediment erosion modeling and is presented as (Brooks et al. 1997):

$$A = RK(LS)CP \text{ (in tons per acre per year).}$$

The USLE model estimates sediment production from upland erosion sources. However, in order to extrapolate to the watershed scale, results of the model were combined with a sediment delivery ratio (SDR) to estimate the quantity of sediment that actually reaches the stream. Previous studies (Dube et al. 2004) have determined that the percent of sediment delivered to streams decreases with distance, so a distance-based sediment delivery ratio was applied to the USLE model results. Furthermore, the USLE model does not evaluate the effect of vegetated riparian buffers at removing sediment, so model results were combined with a riparian health condition to evaluate the effect of existing and improved riparian buffers at filtering sediment.

Three scenarios were modeled during this analysis to quantify sediment delivery under existing and improved conditions. These scenarios were chosen to estimate the reduction of upland erosion that may be accomplished with the implementation of BMPs that are intended to improve upland erosion conditions or riparian health. An example of a BMP practice intended to improve upland condition would be a reduction of grazing that increased the percent ground cover. A BMP strategy to improve riparian health might include riparian fencing that is designed to exclude grazing animals and increase the quality and size of the vegetated riparian buffer. The three scenarios modeled in this exercise include:

- Scenario 1) an Existing Conditions scenario that quantifies sediment delivery under the existing upland land cover and the existing riparian health condition,

- Scenario 2) an Upland BMP Conditions scenario that quantifies sediment delivery using a desired upland land cover that represents the implementation of upland management BMPs and the existing riparian health condition, and

- Scenario 3) an Improved Riparian and Upland BMP Conditions scenario using the desired upland land cover with implementation of BMPs and an improved riparian health condition with use of riparian BMPs.

2.1 Data Sources

The following sections provide data sources and results of the individual parameter data collected for the Flint Creek USLE model.

2.1.1 R – Rainfall Factor

The R-factor characterizes the effect of raindrop impact and runoff rates associated with a rainstorm. It is determined using the kinetic energy of a rainfall event (hundreds of ft-tons per acre per year) and the maximum 30-minute rainfall intensity (inches per hour) for an area. The total kinetic energy of a rain event is obtained by multiplying the kinetic energy per inch of rainfall by the depth of rainfall during each intensity period. The rainfall and runoff factor grid for the Flint Creek watershed was obtained from the NRCS and is based on PRISM (Parameter-elevation Regressions on Independent Slopes Model) precipitation data developed by the Spatial Climate Analysis Service at Oregon State University (SCAS) at 4 km grid cell resolution. For the purposes of this analysis, the SCAS R-factor grid was projected to Montana State Plane Coordinates (NAD83), resampled to a 10m analytic cell size and clipped to the extent of the Flint Creek watershed to match the project's standard grid definition. The R-Factor for the Flint Creek watershed is shown below in **Figure 2-1**.

2.1.2 K – Soil Erodibility Factor

The K-factor is a soil erodibility factor that quantifies the susceptibility of soil to resist erosion. It is a measure of the average soil loss (tons per acre per hundreds of ft-tons per acre of rainfall intensity) from a particular soil in continuous fallow, and has been derived from previous experimental data. A high value K-factor will result in more erosion than a low value K-factor. Polygon data for the K-factor were obtained from the NRCS Soil Survey Geographic database (SSURGO), which is the most detailed level of soil data developed by the National Cooperative Soil Survey. Soils data were summarized and interpolated to 10m grid format. The K-factor for the Flint Creek watershed is shown below in **Figure 2-2.**

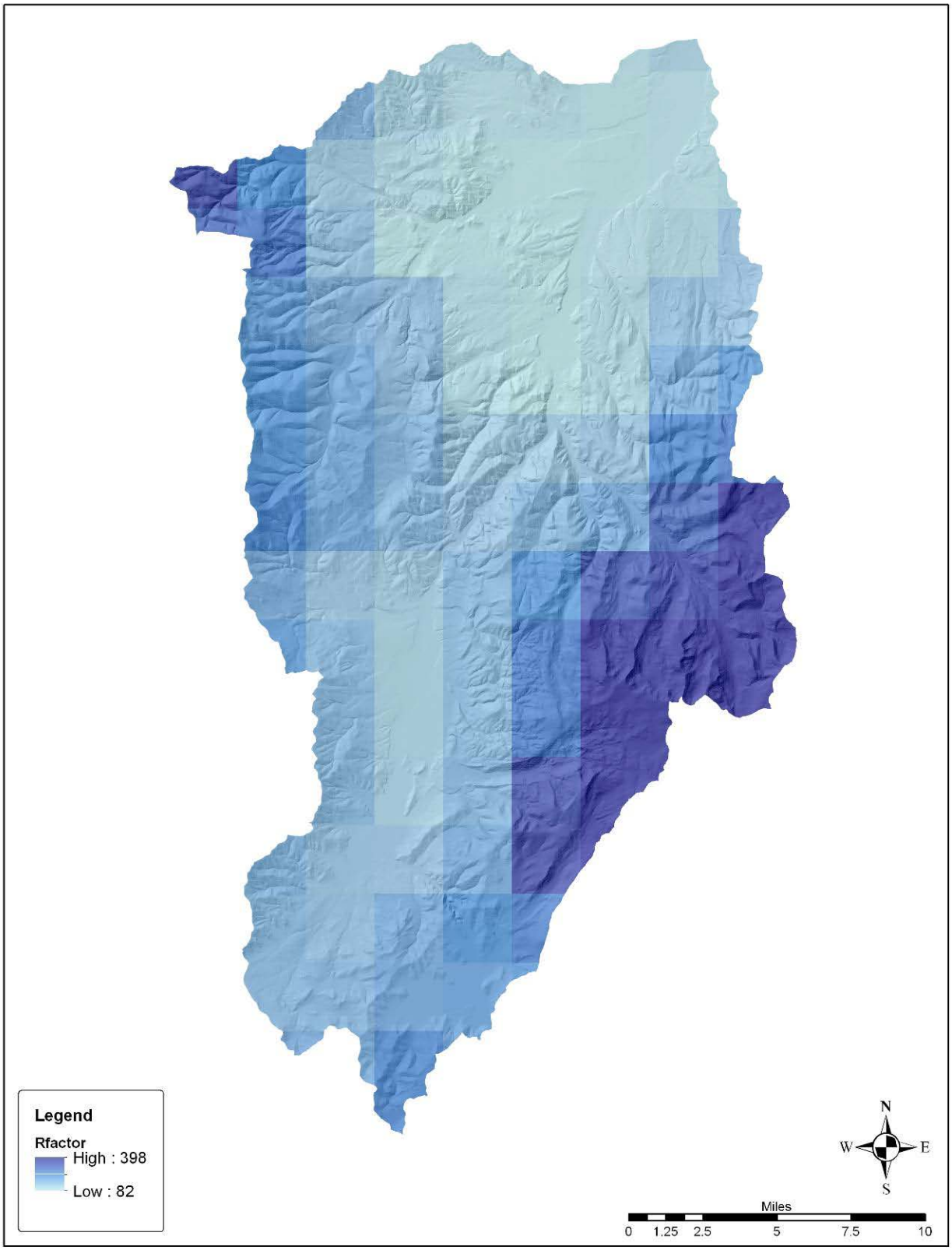


Figure 2-1. USLE R-factor for the Flint Creek Watershed.

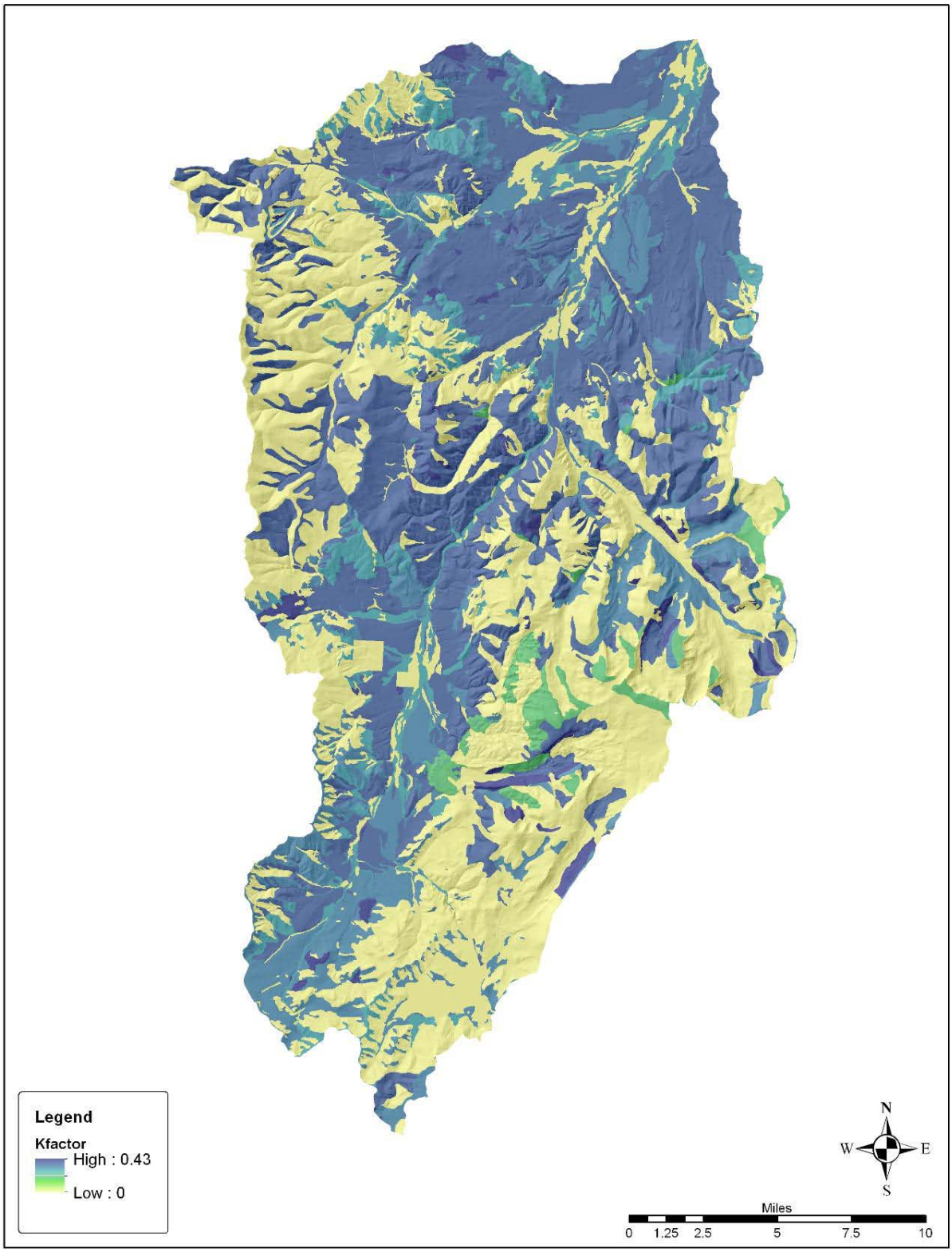


Figure 2-2. USLE K-factor for the Flint Creek Watershed.

2.1.3 LS – Length and Slope Factors

The LS-factor is a function of the slope and flow length of the eroding slope or cell. For the purpose of computing the LS-factor, slope is defined as the average land surface gradient across the cell based on the elevations of neighboring cells. The flow length refers to the distance between where overland flow originates and runoff reaches a defined channel or depositional zone. A longer slope length and steeper slopes translates into higher soil erosion rates. The equation used for calculating the length and slope factor (LS) was provided by Lim, et al. (2005) using a method developed by Moore and Burch (1986 a, b). The equation used to calculate LS is provided below; where A is flow length multiplied by cell size, and Θ is slope angle in degrees.

$$LS = \left(\frac{A}{22.13} \right)^{0.4} * \left(\frac{\sin \Theta}{0.0896} \right)^{1.3}$$

The LS-factor was derived from the digital elevation model (DEM) of the Flint Creek watershed. The USGS 30m DEM was used for these analyses, which was later interpolated to a 10m analytic grid cell to render the delineated stream network more representative of the actual size of Flint Creek watershed streams and to minimize resolution dependent stream network anomalies. The National Elevation Dataset (NED) is the primary elevation data product produced and distributed by the USGS and provides the best available public domain raster elevation data of the conterminous United States, Alaska, Hawaii, and territorial islands in a seamless format. The length and slope factors are calculated from the DEM within the model. Results of the DEM for the Flint Creek watershed is provided below in **Figure 2-3.**

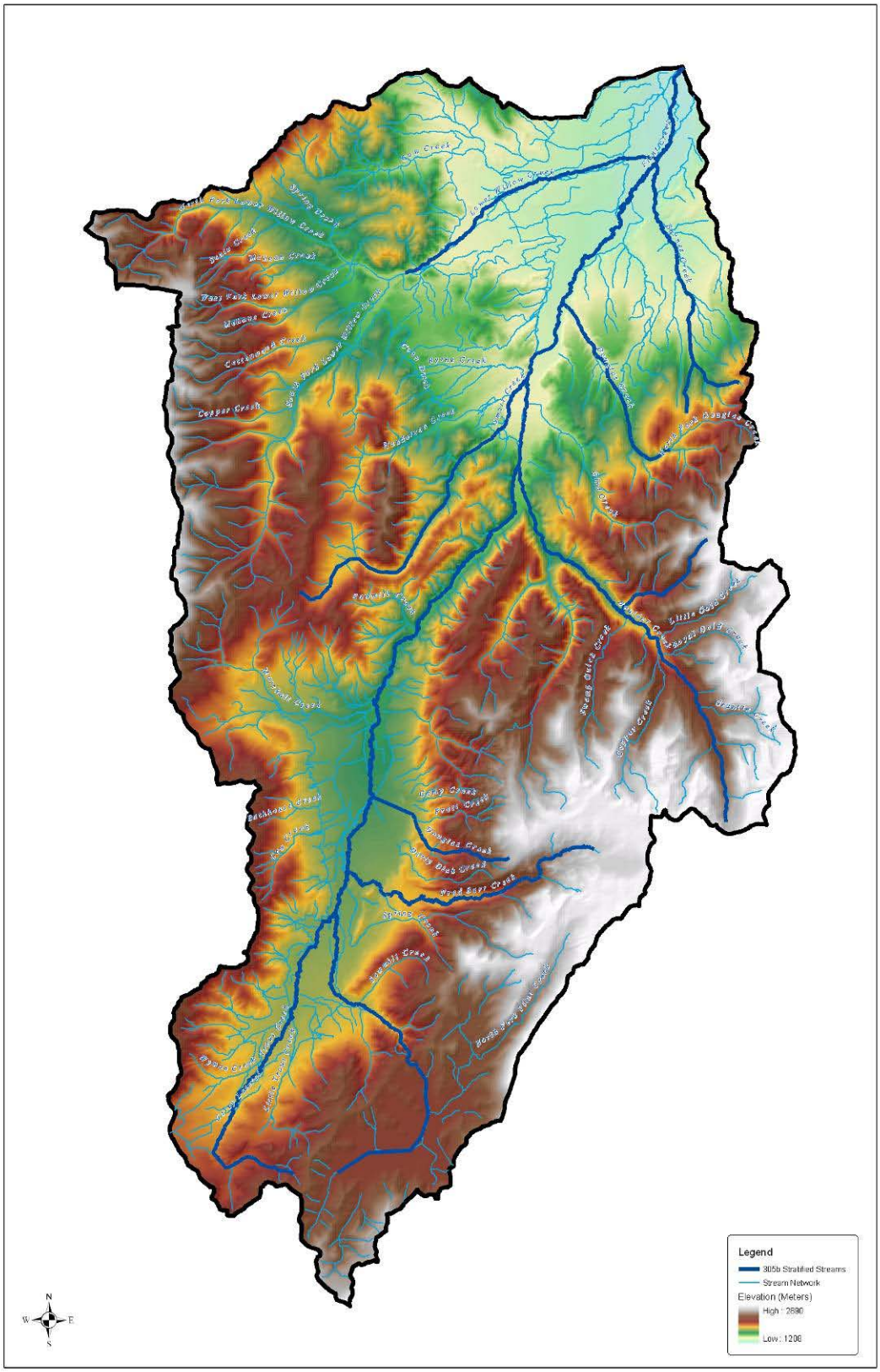


Figure 2-3. Digital Elevation Model (DEM) of the Flint Creek Watershed.

2.1.4 NLCD – National Land Cover Dataset

The 2001 National Land Cover Dataset (NLCD) was obtained from USGS and is developed through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of nine federal agencies. This layer provides land-use categories that are used to establish USLE C-factors for the Flint Creek watershed. The NLCD is a categorized 30 meter Landsat Thematic Mapper image shot in 2001. The NLCD image was reprojected to Montana State plane projection/coordinate system, and resampled to the project standard 10m grid. Results of the NLCD are shown below in **Figure 2-4.** NLCD land cover classification codes present in the Flint Creek watershed are described below and the percent distribution of each category is provided in **Table 2-1**.

11. Open Water - areas of open water, generally with less than 25% cover of vegetation or soil.

21. Developed, Open Space - Includes areas with a mixture of constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

22. Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

23. Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.

24. Developed, High Intensity - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80-100 percent of the total cover.

31. Barren Land (Rock/Sand/Clay) – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.

41. Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

52. Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

71. Grasslands/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

82. Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

90. Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Table 2-1. Land-Use Types Present in the Flint Creek Watershed.

Land-Use Type	Area (acres)	Percent
Barren Land (Rock/Sand/Clay)	92.76	0.0%
Cultivated Crops	16662.05	5.4%
Deciduous Forest	20.26	0.0%
Developed, Low Intensity	782.98	0.3%
Developed, Medium Intensity	58.98	0.0%
Developed, High Intensity	5.24	0.0%
Developed, Open Space	3512.65	1.1%
Evergreen Forest	159659.61	51.8%
Grasslands/Herbaceous	53786.34	17.4%
Mixed Forest	2.69	0.0%
Open Water	3243.28	1.1%
Pasture/Hay	15233.32	4.9%
Shrub/Scrub	53844.24	17.5%
Woody Wetlands	1519.83	0.5%
Total	**308424.26**	**100.0%**

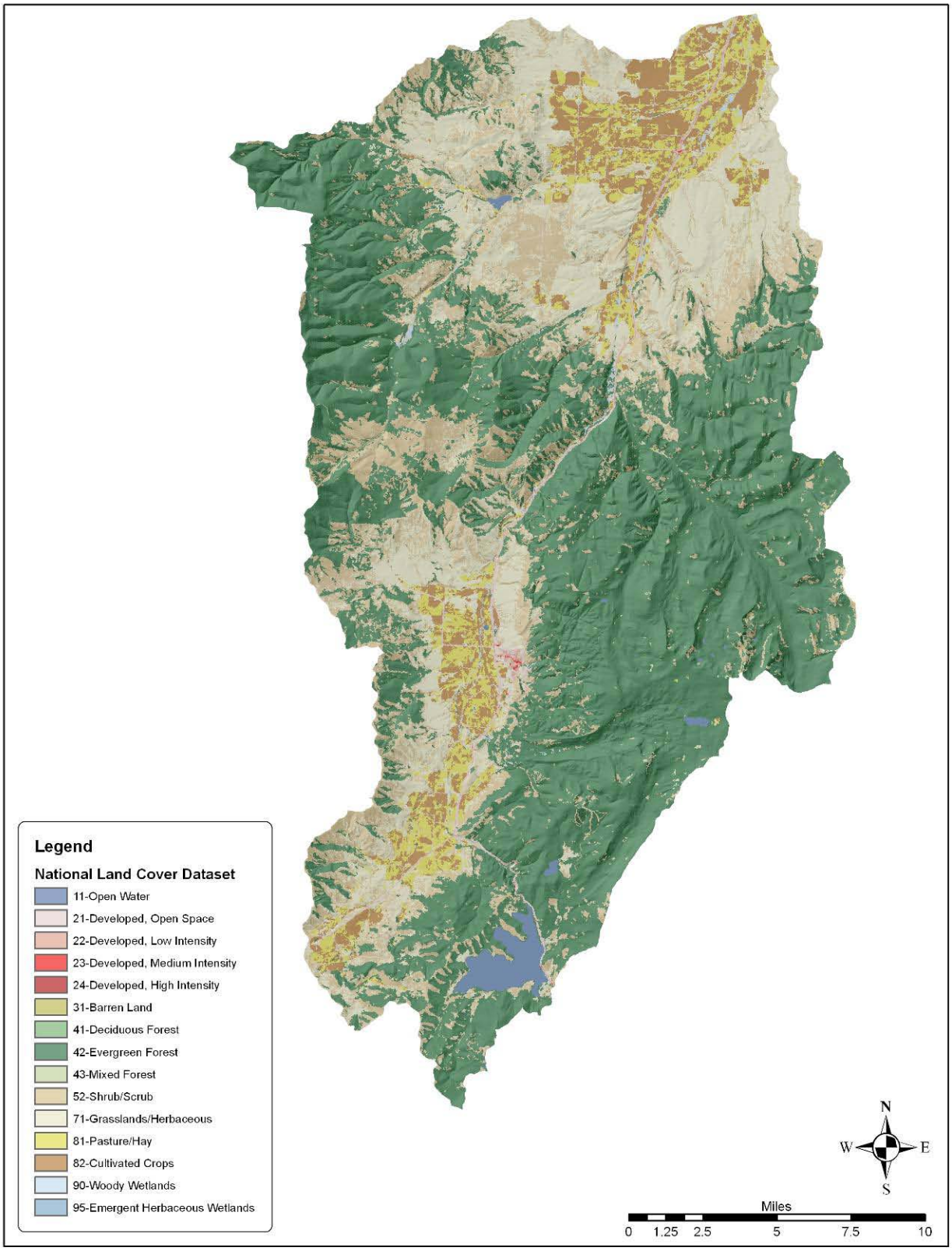


Figure 2-4. National Land Cover Dataset (2001) for the Flint Creek Watershed.

2.1.5 C – Crop Management Factor

The C-factor is a crop management value that represents the ratio of soil erosion from a specific cover type compared to the erosion that would occur on a clean-tilled fallow under identical slope and rainfall. A high value C-factor will result in more soil erosion than a low value C-factor. The C-factor integrates a number of variables that influence erosion, including vegetative cover, plant litter, soil surface, and land management. The original C-factors for USLE were experimentally determined for agricultural crops, and have since been modified to include rangeland and forest cover. It is now referred to as the vegetation management factor (VM) for non-agricultural settings (Brooks et al. 1997). Three primary variables are considered when determining the VM-factor, including: (1) canopy cover effects, (2) effects of low-growing vegetal cover, mulch, and litter, and (3) rooting structure.

A classification scheme was used to assign USLE C-factors to the NLCD land-use types present in the Flint Creek watershed. This classification scheme was initially developed based on ground and canopy cover percentages established by the Soil Conservation Service (USDA 1977, published in Brooks et al. 1997), and has been refined for the Flint Creek watershed based on recommendations from NRCS and/or other local land management agency staff and best professional judgment.

In order to estimate the potential sediment reduction that might be accomplished under BMP scenarios, the model was run using C-factors assigned to both the existing and desired upland condition. To determine C-factors for the desired upland condition, C-factors for the existing upland condition were adjusted to reflect the ground and canopy cover that best represents an improved land condition in the Flint Creek watershed with implementation of BMPs. For example, ground and canopy cover percentages for shrub/scrub and grassland/herbaceous land would increase 10% with the reduction of grazing pressure, while ground cover percentages for mixed forest would increase 5%. Ground cover percentages for pasture/hay and cultivated crop land would increase 10% and 20%, respectively, with the implementation of BMP practices designed to reduce erosion, such as conservation tillage or crop stripping. C-factor values for the existing and improved condition are provided below in **Table 2-2**, along with their respective canopy and ground cover percentages.

Table 2-2. C-Factor Classification Scheme for the Flint Creek Watershed.

Land-Use Description	Canopy Cover (%)		Ground Cover (%)		C-Factor	
	Existing	Improved	Existing	Improved	Existing	Improved
Barren Land (Rock)	-	-	-	-	0.001	0.001
Developed, Open Space	0	0	95	95	0.003	0.003
Developed Land (Low, Medium, or High Intensity)	-	-	-	-	0.001	0.001
Deciduous or Evergreen Forest	75	75	90	90	0.003	0.003
Mixed Forest	75	75	**90**	**95**	**0.003**	**0.001**
Shrub/Scrub	**25**	**35**	**55**	**65**	**0.04**	**0.031**
Grasslands/Herbaceous	**0**	**10**	**55**	**65**	**0.042**	**0.035**
Pasture/Hay	0	0	**70**	**80**	**0.02**	**0.013**
Cultivated Crops	0	0	**20**	**40**	**0.24**	**0.15**
Woody Wetlands	35	35	70	70	0.003	0.003

2.1.6 P – Conservation Practices Factor

The P-factor is a conservation practices factor that considers interaction of supporting land management practices and slope. This factor incorporates the use of erosion control practices such as strip-cropping, terracing and contouring, and is applicable only to agricultural lands. The P-factor will be set to one for this analysis since land-management practices designed to reduce upland erosion are not heavily used within the Flint Creek watershed, and alterations in C-factor values for agricultural land use categories are used to represent the BMP applications.

2.1.7 SDR – Sediment Delivery Ratio

USLE model results were combined with a sediment delivery ratio (**SDR**) to predict sediment delivery to streams. The USLE model was derived from experimental data on small agricultural plots, and the SDR enables us to extrapolate sediment delivery from upland sources to the watershed scale. The SDR is derived for each grid cell based on the distance from the cell to the nearest stream. This distance-based relationship was established during development of the WARSEM road sediment model by integrating previous studies which evaluated sediment delivery down slope of forest roads (Dube et al. 2004). These studies determined that the percent of sediment delivered to streams decreases with distance based on the relationship shown in **Table 2-3**. This relationship has been applied in previous USLE models for TMDL development, and is considered to be a conservative estimate of sediment delivery from upland erosion. For this exercise, the SDR is incorporated into the GIS model and is included in the USLE base results prior to the incorporation of the riparian health condition.

Table 2-3. Sediment Delivery vs. Distance from Stream.

Distance from Stream (ft)	Percent of Sediment Delivered to Stream
0	100
35	70
70	50
105	35
140	25
175	18
210	10
245	4
280	3
315	2
350	1

2.1.8 Riparian Health Incorporation

Well vegetated riparian buffers act as filters that effectively trap sediment from overland flow. The ability of riparian buffers to trap sediment is generally proportional to their width and overall health. Previous studies (Castelle and Johnson 2000) have estimated that approximately 80% of sediment and 65% of particulate organic matter can be removed across a healthy riparian buffer. Studies within Montana suggest that sediment generated from upland erosional sources can be reduced by 25% (Middle Blackfoot TMDL) to 90% (Hook 2003). The USLE model does not specifically incorporate riparian function of stream corridors, but rather looks at the land use and land cover as a whole. Since we are viewing sediment production at the watershed scale and determining the ultimate sediment load delivered to streams, the existing riparian health condition and potential changes to riparian health are included within these estimations.

A riparian health factor was applied to the base results of the USLE model to evaluate the reduction of sediment input to streams based on the condition of their riparian vegetation. A coarse level riparian health assessment was previously conducted for the Flint Creek watershed by Montana DEQ. Ratings of poor, fair, and good were assigned to the left and right bank of all delineated reaches on each surveyed stream. Results of this analysis are shown below in **Table 2-4**. For this analysis, the Upper, Middle, and Lower Flint Creek sub-watersheds were given the riparian health condition derived for all of Flint Creek. The Upper Willow Creek and Georgetown Lake sub-watersheds were not evaluated for riparian health condition, and were assigned the watershed wide riparian health condition for the purposes of this incorporation.

Table 2-4. Riparian Health Condition of the Flint Creek Watershed.

Watershed	Riparian Condition Percent Distribution		
	Good	Fair	Poor
Barnes Creek	15	85	-
Boulder Creek	36	62	2
Douglas Creek (North)	7	83	10
Douglas Creek (Philipsburg)	15	34	51
Flint Creek	0	95	5
Fred Burr	43	56	1
Lower Willow Creek	4	93	3
Princeton Gulch	18	78	4
Smart Creek	17	83	-
Trout Creek	-	100	-
Watershed Wide Average	**19**	**76**	**10**

To incorporate riparian health data into the base USLE results, riparian condition estimates identified in the stream stratification effort are tallied for each watershed of interest, and a buffering efficiency (i.e. sediment delivery reduction) is assumed for each riparian category (good=75%, fair=50%, poor=30%). This value was multiplied to the sediment load corresponding to the percentage of riparian condition within each watershed. For example, Barnes Creek was found to have 15% "good" riparian condition and 85% "fair" riparian condition. If 100 tons/year of sediment were determined from the base USLE model to enter the stream from upland sources, then 15 tons would be reduced by 75% (a total of 3.75 tons remaining) to account for the "good" riparian condition, and 85 tons would be reduced by 50% (42.5 tons remaining) to account for the "fair" riparian condition. This leaves a total buffered sediment load of 46.25 tons delivered to the stream, or a reduction of 53.75% as a result of riparian buffer conditions.

To estimate sediment delivery under improved riparian conditions that would result from implementation of riparian BMPs, the riparian buffer conditions of each stream are increased from "fair" to "good" and from "poor" to "fair". In the case above for Barnes Creek, the improved riparian buffer would be adjusted to reflect 100% "good" riparian condition, and therefore, a 75% reduction would be applied to the total sediment load. The concept is that through the application of riparian BMPs, the health of the vegetated riparian buffer will increase, hence increasing its sediment reduction efficiency.

2.1.9 Management Scenarios

The results of the USLE model with the riparian health incorporation form the basis for TMDL estimations and potential sediment reductions. Three scenarios were modeled in order to provide TMDL estimations for upland sediment delivery under existing and improved conditions. These scenarios were chosen to estimate the reduction of upland erosion that may be accomplished with the implementation of BMPs that are intended to improve upland erosion conditions or riparian health. An example of a BMP practice intended to improve upland condition would be a reduction of grazing pressure that increased the percent ground cover. A BMP strategy to improve riparian health might include riparian fencing that is designed to exclude grazing

animals and increase the quality and size of the vegetated riparian buffer. The three scenarios modeled in this exercise include:

- Scenario 1) an Existing Conditions scenario that quantifies sediment delivery under the existing upland land cover and the existing riparian health condition,

- Scenario 2) an Upland BMP Conditions scenario that quantifies sediment delivery using a desired upland land cover that represents the implementation of upland management BMPs and the existing riparian health condition, and

- Scenario 3) an Improved Riparian and Upland BMP Conditions scenario using the desired upland land cover with implementation of BMPs and an improved riparian health condition with use of riparian BMPs.

3.0 Results

Sediment loading results for the existing and desired upland conditions are provided below in **Table 3-1**. This table presents the base results of the USLE model (including the SDR) before the incorporation of the riparian health condition. Results of the USLE model with the riparian health incorporation follow in **Table 3-2**. Results are presented by sub-watershed and land-use type. It should be noted that the sub-watersheds listed are not additive of watershed areas upstream, and include only the total for the sub-watershed listed. Sediment loads for existing upland conditions in individual sub-watersheds ranged from 107.9 tons/year (Douglas Creek - Philipsburg) to 6740.4 tons/year (Middle Flint Creek), with a total watershed sediment load of 30,360 tons/year. Using the desired upland condition, minimum and maximum sediment loads for individual sub-watersheds were reduced to 92.3 tons/year (Douglas Creek - Philipsburg) and 5378.5 tons/year (Middle Flint Creek), with a total watershed sediment load of 24,256 tons/year. Sediment loading rates for existing upland conditions ranged from 0.014 tons/acre/year in the Georgetown Lake sub-watershed to 0.18 tons/acre/year in Trout Creek, with a total watershed average of 0.098 tons/acre/year. Under desired upland conditions, these values were reduced to 0.012 and 0.14 tons/acre/year for Georgetown Lake and Trout Creek sub-watersheds, respectively, with a total watershed average of 0.079 tons/acre/year.

Results of the USLE model with the riparian health incorporation are presented in **Table 3-2**, including results of the three model scenarios. These results form the basis for TMDL estimations and potential sediment reductions. Under Scenario 1, existing upland sediment loads were reduced by 44-61% when the buffering capacity of the existing riparian health condition is considered. Under Scenario 2, upland sediment loads were reduced by 8-25% with the use of upland management BMPs that result in the desired upland condition. Under Scenario 3, upland sediment loads were reduced by 33-50% with the use of BMPs that improve riparian health condition and increase the riparian buffering capacity. The total load reduction potential with the use of both upland and riparian BMPs ranged from 42-63% for the sub-watersheds.

Table 3-1. Base Results of the USLE Model for the Flint Creek Watershed.

Sub-Watershed	Land Use Type	Area (acres)	Percent of Watershed	Existing Conditions Load (Tons/Year)	Existing Conditions Load (Tons/Acre /Year)	Desired Conditions Load (Tons/Year)	Desired Conditions Load (Tons/Acre /Year)	Percent Reduction from Existing to Desired
Barnes Creek	Cultivated Crops	725	7%	82.20	0.11	51.38	0.07	37%
	Developed, Low Intensity	6	0%	0.04	0.01	0.04	0.01	0%
	Developed, Open Space	172	2%	1.50	0.01	1.50	0.01	0%
	Evergreen Forest	2015	20%	77.25	0.04	77.25	0.04	0%
	Grasslands/Herbaceous	4589	45%	564.64	0.12	470.53	0.10	17%
	Pasture/Hay	645	6%	15.21	0.02	9.89	0.02	35%
	Shrub/Scrub	2096	20%	631.65	0.30	489.53	0.23	22%
	Woody Wetlands	49	0%	0.79	0.02	0.79	0.02	0%
	Total Sub-Watershed	**10298**	**100%**	**1373.27**	**0.13**	**1100.90**	**0.11**	**20%**
Boulder Creek	Barren Land	72	0%	0.22	0.00	0.22	0.00	0%
	Cultivated Crops	3	0%	0.00	0.00	0.00	0.00	-
	Developed, Low Intensity	22	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	24	0%	0.14	0.01	0.14	0.01	0%
	Evergreen Forest	39068	92%	732.95	0.02	732.95	0.02	0%
	Grasslands/Herbaceous	555	1%	51.95	0.09	43.29	0.08	17%
	Open Water	71	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	28	0%	0.96	0.03	0.62	0.02	35%
	Shrub/Scrub	2352	6%	406.31	0.17	314.89	0.13	23%
	Woody Wetlands	45	0%	0.33	0.01	0.33	0.01	0%
	Total Sub-Watershed	**42240**	**100%**	**1192.86**	**0.03**	**1092.45**	**0.03**	**8%**
Douglas Creek North	Cultivated Crops	27	0%	3.96	0.15	2.48	0.09	38%
	Developed, Low Intensity	2	0%	0.00	0.00	0.00	0.00	0%
	Developed, Med. Intensity	1	0%	0.01	0.01	0.01	0.01	0%
	Developed, Open Space	75	1%	4.24	0.06	4.24	0.06	0%
	Evergreen Forest	5122	55%	194.84	0.04	194.84	0.04	0%
	Grasslands/Herbaceous	2086	22%	313.68	0.15	261.40	0.13	17%
	Open Water	3	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	65	1%	1.41	0.02	0.92	0.01	35%
	Shrub/Scrub	1992	21%	549.40	0.28	425.79	0.21	22%
	Woody Wetlands	2	0%	0.01	0.00	0.01	0.00	0%
	Total Sub-Watershed	**9376**	**100%**	**1067.55**	**0.11**	**889.68**	**0.09**	**17%**
Douglas Creek-Philipsburg	Barren Land	3	0%	0.00	0.00	0.00	0.00	0%
	Cultivated Crops	57	1%	5.07	0.09	3.17	0.06	38%
	Developed, High Intensity	1	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	28	1%	0.07	0.00	0.07	0.00	0%
	Developed, Med. Intensity	7	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	109	3%	1.82	0.02	1.82	0.02	0%

Table 3-1. Base Results of the USLE Model for the Flint Creek Watershed.

Sub-Watershed	Land Use Type	Area (acres)	Percent of Watershed	Existing Conditions Load (Tons/Year)	Existing Conditions Load (Tons/Acre /Year)	Desired Conditions Load (Tons/Year)	Desired Conditions Load (Tons/Acre /Year)	Percent Reduction from Existing to Desired
	Evergreen Forest	3382	83%	37.67	0.01	37.67	0.01	0%
	Grasslands/Herbaceous	85	2%	8.73	0.10	7.28	0.09	17%
	Pasture/Hay	47	1%	0.09	0.00	0.06	0.00	35%
	Shrub/Scrub	378	9%	54.43	0.14	42.19	0.11	22%
	Total Sub-Watershed	**4096**	**100%**	**107.90**	**0.03**	**92.26**	**0.02**	**14%**
Fred Burr Creek	Barren Land	2	0%	0.00	0.00	0.00	0.00	-
	Cultivated Crops	68	1%	23.10	0.34	14.44	0.21	37%
	Developed, Low Intensity	6	0%	0.01	0.00	0.01	0.00	0%
	Developed, Open Space	33	0%	0.19	0.01	0.19	0.01	0%
	Evergreen Forest	9218	92%	113.01	0.01	113.01	0.01	0%
	Grasslands/Herbaceous	128	1%	4.47	0.03	3.73	0.03	17%
	Open Water	140	1%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	63	1%	1.61	0.03	1.05	0.02	35%
	Shrub/Scrub	329	3%	30.66	0.09	23.76	0.07	22%
	Woody Wetlands	65	1%	0.51	0.01	0.51	0.01	0%
	Total Sub-Watershed	**10053**	**100%**	**173.56**	**0.02**	**156.69**	**0.02**	**10%**
Georgetown Lake	Barren Land	4	0%	0.03	0.01	0.03	0.01	0%
	Cultivated Crops	16	0%	0.59	0.04	0.37	0.02	38%
	Deciduous Forest	4	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	17	0%	0.20	0.01	0.20	0.01	0%
	Developed, Med. Intensity	4	0%	0.18	0.04	0.18	0.04	0%
	Developed, Open Space	105	0%	1.06	0.01	1.06	0.01	0%
	Evergreen Forest	15767	72%	125.93	0.01	125.93	0.01	0%
	Grasslands/Herbaceous	959	4%	38.40	0.04	32.00	0.03	17%
	Open Water	2877	13%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	15	0%	0.84	0.06	0.54	0.04	35%
	Shrub/Scrub	1983	9%	126.84	0.06	98.30	0.05	22%
	Woody Wetlands	24	0%	0.03	0.00	0.03	0.00	0%
	Total Sub-Watershed	**21776**	**100%**	**294.09**	**0.01**	**258.63**	**0.01**	**12%**
Lower Flint Creek	Barren Land	9	0%	0.00	0.00	0.00	0.00	0%
	Cultivated Crops	6886	17%	827.85	0.12	517.41	0.08	37%
	Deciduous Forest	6	0%	0.01	0.00	0.01	0.00	0%
	Developed, Low Intensity	258	1%	0.17	0.00	0.17	0.00	0%
	Developed, Med. Intensity	8	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	992	2%	3.26	0.00	3.26	0.00	0%
	Evergreen Forest	5282	13%	158.40	0.03	158.40	0.03	0%
	Grasslands/Herbaceous	13659	34%	2314.75	0.17	1928.96	0.14	17%

Table 3-1. Base Results of the USLE Model for the Flint Creek Watershed.

Sub-Watershed	Land Use Type	Area (acres)	Percent of Watershed	Existing Conditions Load (Tons/Year)	Existing Conditions Load (Tons/Acre /Year)	Desired Conditions Load (Tons/Year)	Desired Conditions Load (Tons/Acre /Year)	Percent Reduction from Existing to Desired
	Mixed Forest	1	0%	0.00	0.00	0.00	0.00	68%
	Open Water	4	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	5642	14%	68.96	0.01	44.82	0.01	35%
	Shrub/Scrub	7108	18%	1830.75	0.26	1418.83	0.20	23%
	Woody Wetlands	572	1%	3.25	0.01	3.25	0.01	0%
	Total Sub-Watershed	**40427**	**100%**	**5207.39**	**0.13**	**4075.10**	**0.10**	**22%**
Lower Willow Creek	Cultivated Crops	2900	13%	523.68	0.18	327.30	0.11	37%
	Deciduous Forest	4	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	22	0%	0.01	0.00	0.01	0.00	0%
	Developed, Open Space	302	1%	1.45	0.00	1.45	0.00	0%
	Evergreen Forest	2555	12%	24.41	0.01	24.41	0.01	0%
	Grasslands/Herbaceous	8354	39%	1217.10	0.15	1014.25	0.12	17%
	Open Water	134	1%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	1810	8%	46.37	0.03	30.14	0.02	35%
	Shrub/Scrub	5322	25%	896.94	0.17	695.13	0.13	23%
	Woody Wetlands	108	1%	0.47	0.00	0.47	0.00	0%
	Total Sub-Watershed	**21511**	**100%**	**2710.43**	**0.13**	**2093.16**	**0.10**	**23%**
Middle Flint Creek	Cultivated Crops	2796	6%	534.82	0.19	334.26	0.12	38%
	Developed, High Intensity	4	0%	0.00	0.00	0.00	0.00	0%
	Developed, Low Intensity	306	1%	1.10	0.00	1.10	0.00	0%
	Developed, Med. Intensity	32	0%	0.01	0.00	0.01	0.00	0%
	Developed, Open Space	971	2%	7.98	0.01	7.98	0.01	0%
	Evergreen Forest	21036	43%	600.22	0.03	600.22	0.03	0%
	Grasslands/Herbaceous	9693	20%	1790.51	0.18	1492.09	0.15	17%
	Mixed Forest	2	0%	0.00	0.00	0.00	0.00	-
	Open Water	12	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	2853	6%	60.72	0.02	39.47	0.01	35%
	Shrub/Scrub	10645	22%	3740.73	0.35	2899.07	0.27	22%
	Woody Wetlands	348	1%	4.25	0.01	4.25	0.01	0%
	Total Sub-Watershed	**48696**	**100%**	**6740.34**	**0.14**	**5378.45**	**0.11**	**20%**
Princeton Gulch	Evergreen Forest	2819	96%	131.56	0.05	131.56	0.05	0%
	Grasslands/Herbaceous	8	0%	1.63	0.22	1.36	0.18	17%
	Shrub/Scrub	110	4%	135.15	1.23	104.74	0.95	23%
	Total Sub-Watershed	**2937**	**100%**	**268.34**	**0.09**	**237.66**	**0.08**	**11%**
Smart Creek	Barren Land	4	0%	0.01	0.00	0.01	0.00	0%
	Cultivated Crops	221	1%	43.43	0.20	27.15	0.12	37%
	Developed, Low Intensity	3	0%	0.00	0.00	0.00	0.00	0%

Table 3-1. Base Results of the USLE Model for the Flint Creek Watershed.

Sub-Watershed	Land Use Type	Area (acres)	Percent of Watershed	Existing Conditions Load (Tons/Year)	Existing Conditions Load (Tons/Acre /Year)	Desired Conditions Load (Tons/Year)	Desired Conditions Load (Tons/Acre /Year)	Percent Reduction from Existing to Desired
	Developed, Open Space	46	0%	0.25	0.01	0.25	0.01	0%
	Evergreen Forest	9321	60%	218.55	0.02	218.55	0.02	0%
	Grasslands/Herbaceous	1774	11%	212.29	0.12	176.91	0.10	17%
	Pasture/Hay	203	1%	6.77	0.03	4.40	0.02	35%
	Shrub/Scrub	4015	26%	1051.10	0.26	814.61	0.20	22%
	Woody Wetlands	38	0%	0.23	0.01	0.23	0.01	0%
	Total Sub-Watershed	**15626**	**100%**	**1532.65**	**0.10**	**1242.11**	**0.08**	**19%**
Trout Creek	Cultivated Crops	2064	9%	1033.23	0.50	645.77	0.31	37%
	Developed, Low Intensity	40	0%	0.08	0.00	0.08	0.00	0%
	Developed, Open Space	325	1%	2.71	0.01	2.71	0.01	0%
	Evergreen Forest	5890	26%	21.85	0.00	21.85	0.00	0%
	Grasslands/Herbaceous	5212	23%	1022.73	0.20	852.27	0.16	17%
	Open Water	2	0%	0.00	0.00	0.00	0.00	-
	Pasture/Hay	2718	12%	118.63	0.04	77.11	0.03	35%
	Shrub/Scrub	6260	28%	1852.35	0.30	1435.57	0.23	22%
	Woody Wetlands	49	0%	0.82	0.02	0.82	0.02	0%
	Total Sub-Watershed	**22560**	**100%**	**4052.40**	**0.18**	**3036.18**	**0.13**	**25%**
Upper Flint Creek	Cultivated Crops	713	5%	93.14	0.13	58.21	0.08	37%
	Developed, Low Intensity	67	0%	0.10	0.00	0.10	0.00	0%
	Developed, Med. Intensity	2	0%	0.00	0.00	0.00	0.00	0%
	Developed, Open Space	353	3%	2.09	0.01	2.09	0.01	0%
	Evergreen Forest	9028	66%	50.26	0.01	50.26	0.01	0%
	Grasslands/Herbaceous	945	7%	140.56	0.15	117.13	0.12	17%
	Pasture/Hay	1004	7%	13.30	0.01	8.64	0.01	35%
	Shrub/Scrub	1506	11%	134.52	0.09	104.25	0.07	23%
	Woody Wetlands	69	1%	0.57	0.01	0.57	0.01	0%
	Total Sub-Watershed	**13687**	**100%**	**434.54**	**0.03**	**341.27**	**0.02**	**21%**
Upper Willow Creek	Cultivated Crops	196	0%	77.64	0.40	48.53	0.25	37%
	Deciduous Forest	5	0%	0.00	0.00	0.00	0.00	-
	Evergreen Forest	29213	65%	851.54	0.03	851.54	0.03	0%
	Grasslands/Herbaceous	5735	13%	829.06	0.14	690.88	0.12	17%
	Pasture/Hay	153	0%	5.27	0.03	3.42	0.02	35%
	Shrub/Scrub	9726	22%	3440.31	0.35	2666.24	0.27	22%
	Woody Wetlands	152	0%	0.77	0.01	0.77	0.01	0%
	Total Sub-Watershed	**45180**	**100%**	**5204.59**	**0.12**	**4261.38**	**0.09**	**18%**
Total Flint Creek Watershed		**308461**	**100%**	**30359.91**	**0.098**	**24255.92**	**0.08**	**20%**

Table 3-2. Results of the USLE Model with Riparian Health Incorporation.

Sub-Watershed	Existing Condition Load (tons/yr)	Desired Condition Load (tons/yr)	Scenario 1		Scenario 2		Scenario 3		Total Load Reduction with use of Upland and Riparian BMPs
			Existing Upland Load with Existing Riparian Condition (tons/yr)	Percent Load Reduction with use of Riparian Condition	Desired Upland Load with Existing Riparian Condition (tons/yr)	Percent Load Reduction with use of Upland BMPs	Desired Upland Load with Improved Riparian Health (tons/yr)	Percent Load Reduction with use of Riparian BMPs	
Barnes Creek	1373.27	1100.90	635	54%	509	20%	275	46%	57%
Boulder Creek	1192.86	1092.45	494	59%	452	8%	279	38%	44%
Douglas Creek - North	1067.55	889.68	536	50%	447	17%	245	45%	54%
Douglas Creek-Philipsburg	107.90	92.26	61	44%	52	14%	35	33%	43%
Fred Burr Creek	173.56	156.69	68	61%	62	10%	40	36%	42%
Georgetown Lake	294.09	258.63	146	50%	129	12%	74	42%	49%
Lower Flint Creek	5207.39	4075.10	2656	49%	2078	22%	1070	49%	60%
Lower Willow Creek	2710.43	2093.16	1344	50%	1038	23%	539	48%	60%
Middle Flint Creek	6740.34	5378.45	3438	49%	2743	20%	1412	49%	59%
Princeton Gulch	268.34	237.66	124	54%	110	11%	62	44%	50%
Smart Creek	1532.65	1242.11	701	54%	568	19%	311	45%	56%
Trout Creek	4052.40	3036.18	2026	50%	1518	25%	759	50%	63%
Upper Flint Creek	434.54	341.27	222	49%	174	21%	90	49%	60%
Upper Willow Creek	5204.59	4261.38	2589	50%	2120	18%	1225	42%	53%
Total Watershed	**30359.91**	**24255.92**	**15104**	**50%**	**12067**	**20%**	**6974**	**42%**	**54%**

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